



TEST REPORT IEC 62368-1

Audio/video, information and communication technology equipment Part 1: Safety requirements

Report Number E322375-A6029-CB-1

Date of issue: 2024-07-24

Total number of pages 71

Name of Testing Laboratory UL Solutions Melville

preparing the Report.....

Applicant's name...... DIODES INC

Address: SUITE 200

4949 HEDGCOXE RD PLANO TX 75024 UNITED STATES

Test specification:

Standard: IEC 62368-1: 2018

Test procedure.....: CB Scheme

Non-standard test method.....: N/A

TRF template used IECEE OD-2020-F1:2021, Ed.1.4

Test Report Form No.....: IEC62368_1E

Test Report Form(s) Originator...: UL(US)

Master TRF...... Dated 2022-04-14

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This report is not valid as a CB Test Report unless signed by an approved CB Testing Laboratory and appended to a CB Test Certificate issued by an NCB in accordance with IECEE 02.

General disclaimer:

The test results presented in this report relate only to the object tested.

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Test Item Description: IC Current Limiter

Trade Mark(s):

Manufacturer....:

DIODES INC

SUITE 200

4949 HEDGCOXE RD

PLANO, TX 75024

United States

Model/Type reference:

AP21X, Where X can be 0,1,4,5,6,7,8 or 9, followed by 1, 1A, 6 or 10, followed by MP, S, W, FM or M8, and or additional characters that do not affect the safety features of the device.

AP21X1D, Where X can be 4, 5, 6, 7, 8 or 9, followed by FM, W, MP, M8 or S, and or additional characters that do not affect the safety features of the device.

Ratings::

(Markings Optional)

AP21410/AP21510/AP2141/AP2151/AP2161/AP2171/AP2181/A P2191/AP2146/AP2156

Input Voltage: 2.7 - 5.5Vdc

Output Continuous Rating: 0.2A to 1.5A

Output Current Limit: 0.5 to 3.0A Operating Temperature: -40C to 85C

AP2101/AP2111

Input Voltage: 2.7 - 3.0Vdc Output Continuous Rating: 2A Output Current Limit: 2.9 to 5A

Operating Temperature: -40C to 85C

Input Voltage: 3.1 - 5.5Vdc Output Continuous Rating: 2A Output Current Limit: 2.1 to 2.9A Operating Temperature: -40C to 85C

AP2141D/AP2151D

Input Voltage: 2.7 - 5.5Vdc Output Continuous Rating: 0.5A Output Current Limit: 1.0A

Operating Temperature: -40C to 85C

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	P2161D/AP2171D/AP2181D/AP2191D Apput Voltage: 2.7 - 5.5Vdc Output Continuous Rating: 1A to 1.5A Output Current Limit:1.9 to 2.6A Operating Temperature: -40C to 85C		
·			
Responsible Testing Laboratory (as applicab	le), testing procedure and	d testing location(s):	
Testing location/ address:	UL Solutions Melville 1285 Walt Whitman Road	d, Melville, NY, 11747, USA	
Tested by (name, function, signature):	Daniel Szanto / Project Handler	D. Szanto Dean Baker	
Approved by (name, function, signature):	Dean Baker / Reviewer	Dean Baker	
☐ Testing procedure: CTF Stage 1:			
Testing location/ address:			
Tested by (name, function, signature):			
Approved by (name, function, signature):			
☐ Testing procedure: CTF Stage 2:			
Testing location/ address:			
Tested by (name, function, signature):			
Witnessed by (name, function, signature).:			
Approved by (name, function, signature):			
☐ Testing procedure: CTF Stage 3:			
☐ Testing procedure: CTF Stage 4:			
Testing location/ address:			
Tested by (name, function, signature):			
Witnessed by (name, function, signature).:			
Approved by (name, function, signature):			
Supervised by (name, function, signature) :			

List of Attachments (including a total number of	pages in each attachment):
National Differences (8 pages)	
Enclosures (252 pages)	
Summary of testing:	
Tests performed (name of test and test clause):	Testing Location: Unless otherwise noted, test are all conducted in CBTL: UL Solutions Melville 1285 Walt Whitman Road, Melville, NY, 11747, USA
B.2.6, 5.4.1.4, 6.3, 9.3, B.1.5 – NORMAL OPERATING CONDITIONS TEMPERATURE MEASUREMENT	
B.3 – SIMULATED ABNORMAL OPERATING CONDITIONS	
B.4 – SIMULATED SINGLE FAULT CONDITIONS	
G.9 – IC CURRENT LIMITERS	
Summary of compliance with National Difference United States of America - US, Canada - CA The product fulfils the requirements of CSA/U	
Use of uncertainty of measurement for decisions	s on conformity (decision rule) :
No decision rule is specified by the IEC standard, limit according to the specification in that standard. measurement uncertainty ("simple acceptance" deci	when comparing the measurement result with the applicable The decisions on conformity are made without applying the
Information on uncertainty of measurement:	
5014 for test equipment and application of test meth IEC Guide 115 provides guidance on the application	the laboratory based on application of criteria given by OD- ods, decision sheets and operational procedures of IECEE. on of measurement uncertainty principles and applying the EEE scheme, noting that the reporting of the measurement as required by the test standard or customer.
Calculations leading to the reported values are on fil testing.	e with the NCB and testing laboratory that conducted the

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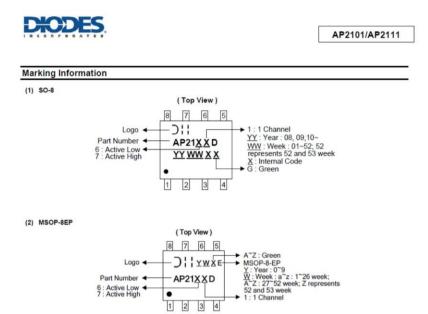
Report Reference #

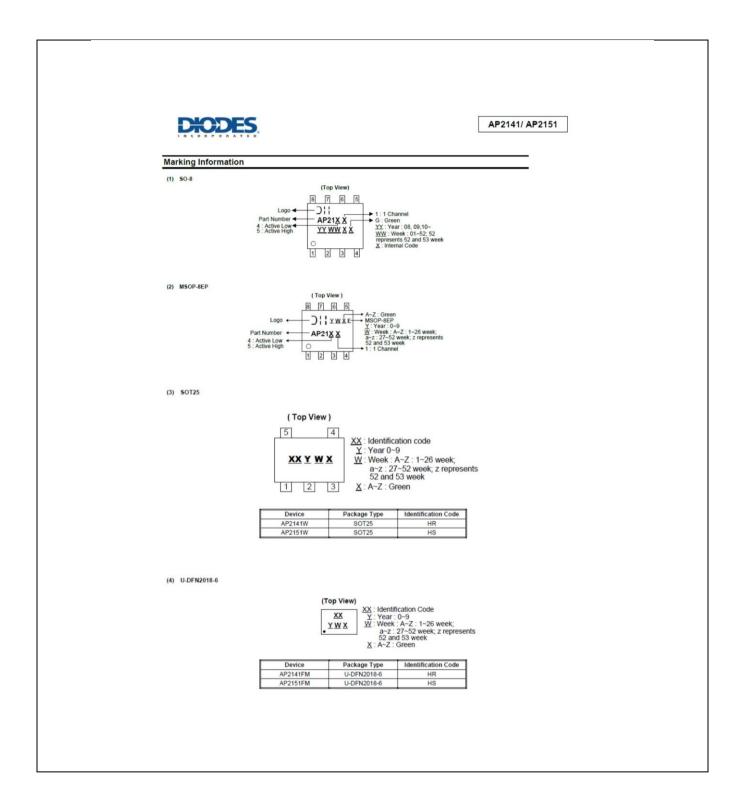
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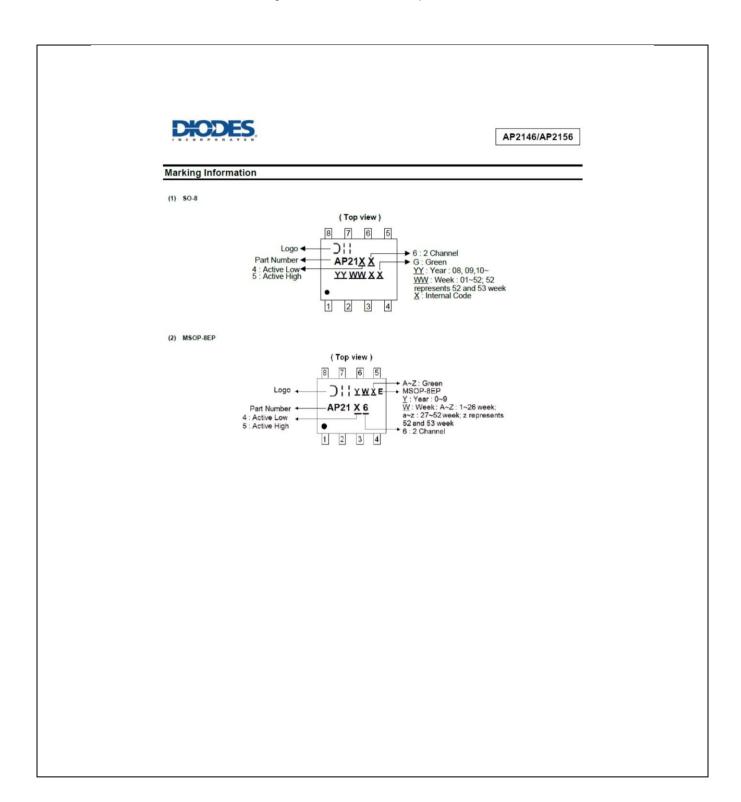
Copy of marking plate:

The artwork below may be only a draft. The use of certification marks on a product must be authorized by the respective NCBs that own these marks.

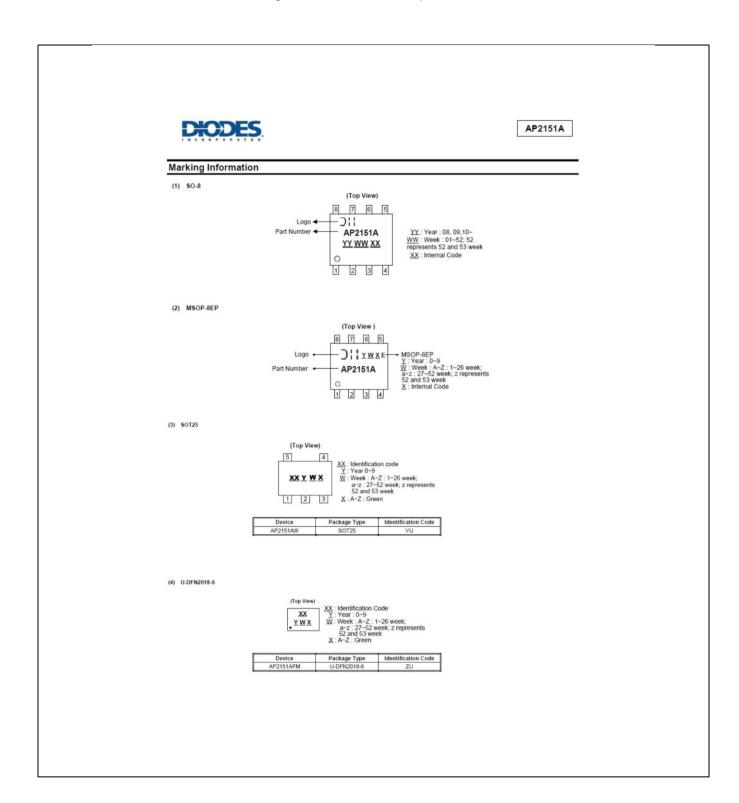




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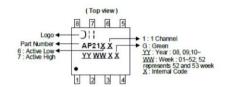




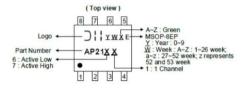
AP2161/ AP2171

Marking Information

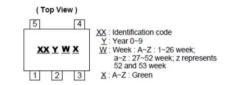




(2) MSOP-8EP

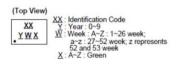


(3) SOT25

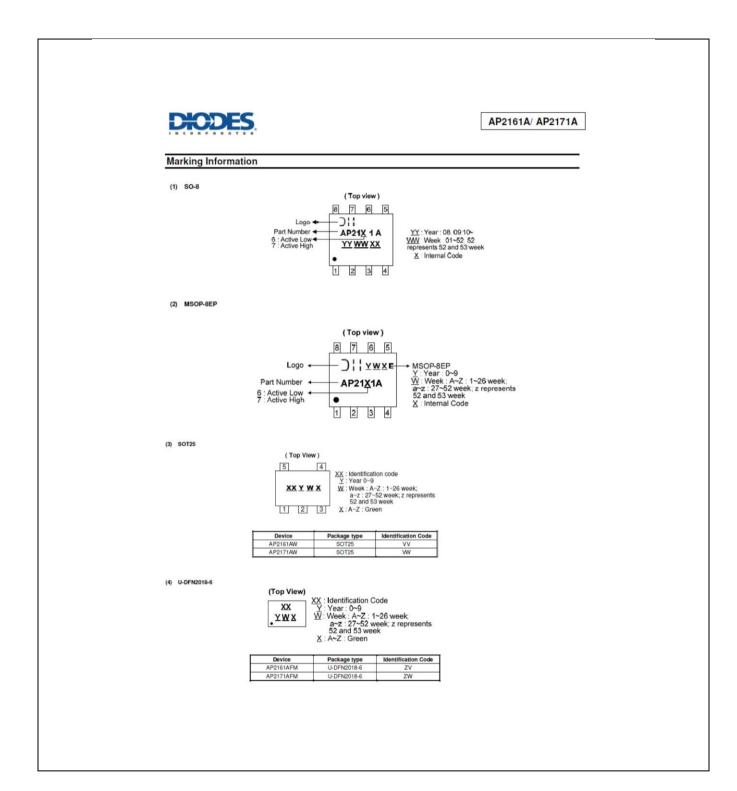


Device	Package type	Identification Code
AP2161W	SOT25	HT
AP2171W	SOT25	HU

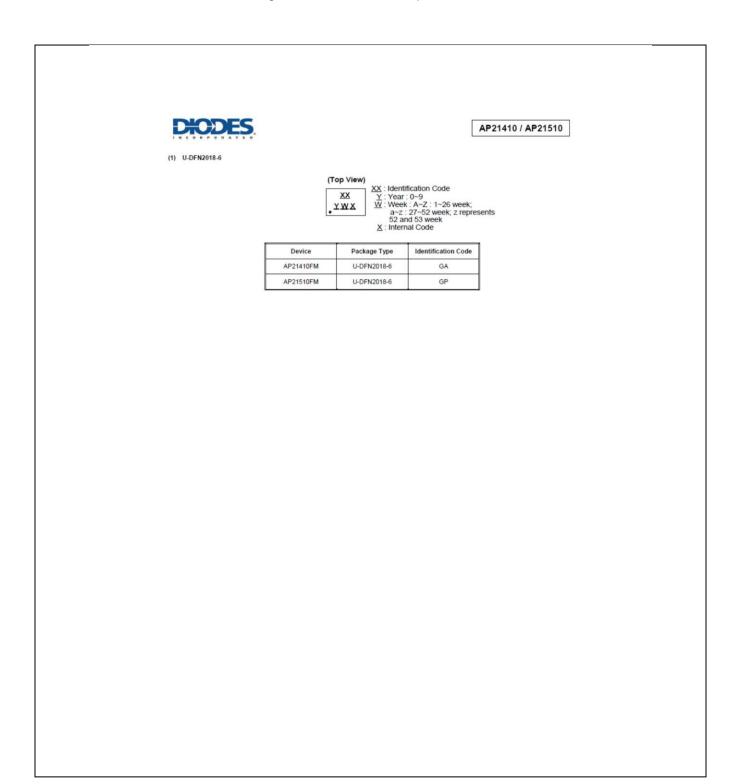
(4) U-DFN2018-6



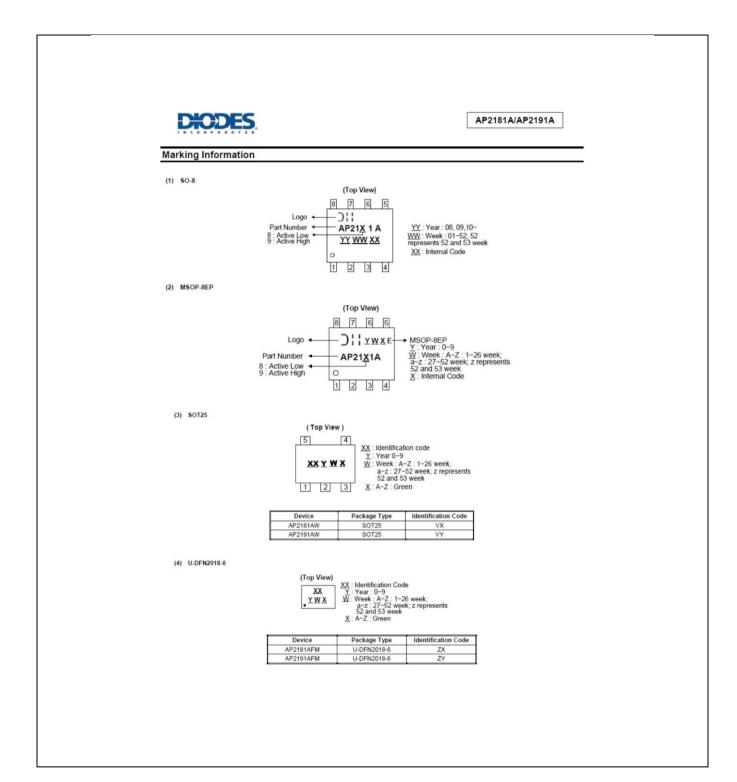
Device	Package type	Identification Code
AP2161FM	U-DFN2018-6	HT
AP2171FM	U-DFN2018-6	HU

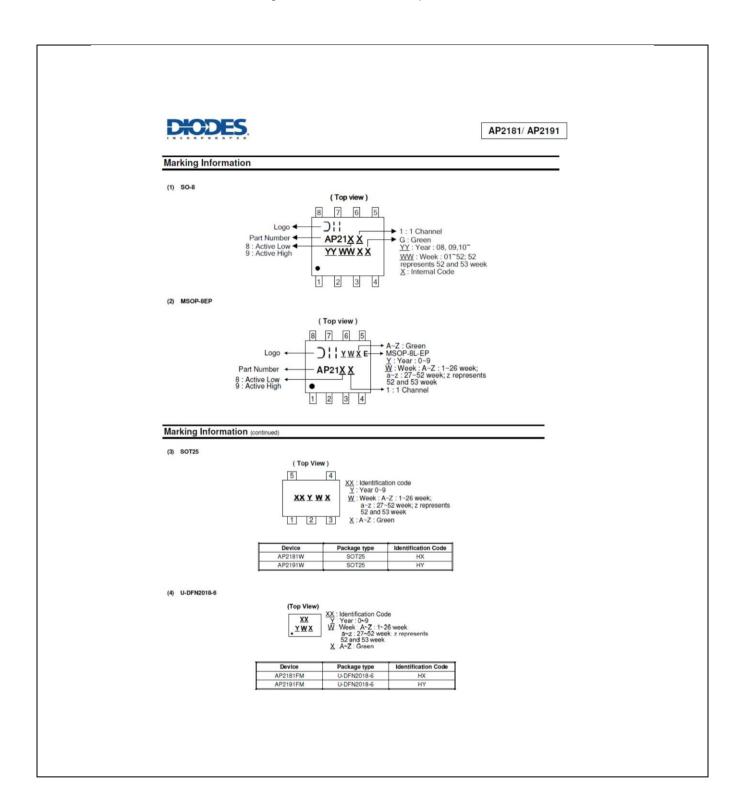


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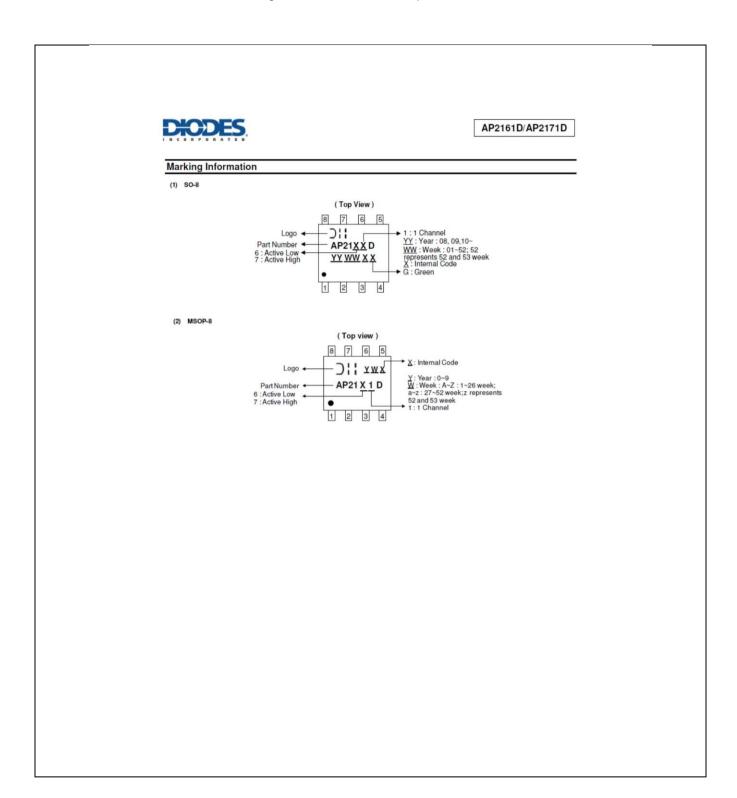


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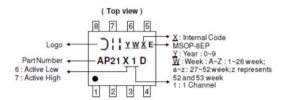




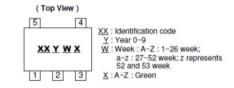
AP2161D/AP2171D

Marking Information (continued)

(3) MSOP-8EP



(4) SOT25



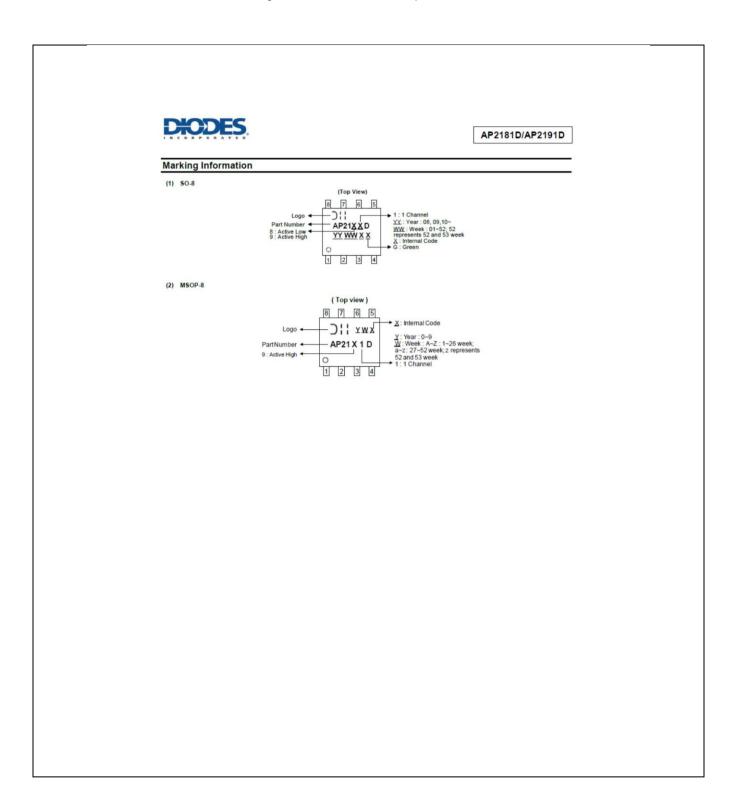
Device	Package Type	Identification Code
AP2161DW	SOT25	JC
AP2171DW	SOT25	JD

(5) U-DFN2018-6



Device	Package Type	Identification Code
AP2161DFM	U-DFN2018-6	JC
AP2171DFM	U-DFN2018-6	JD

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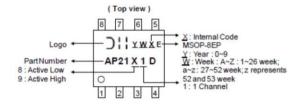




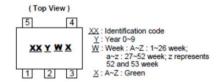
AP2181D/AP2191D

Marking Information (Cont.)

(3) MSOP-8EP



(4) SOT25



Device	Package Type	Identification Code
AP2181DW	SOT25	JE
AP2191DW	SOT25	JF

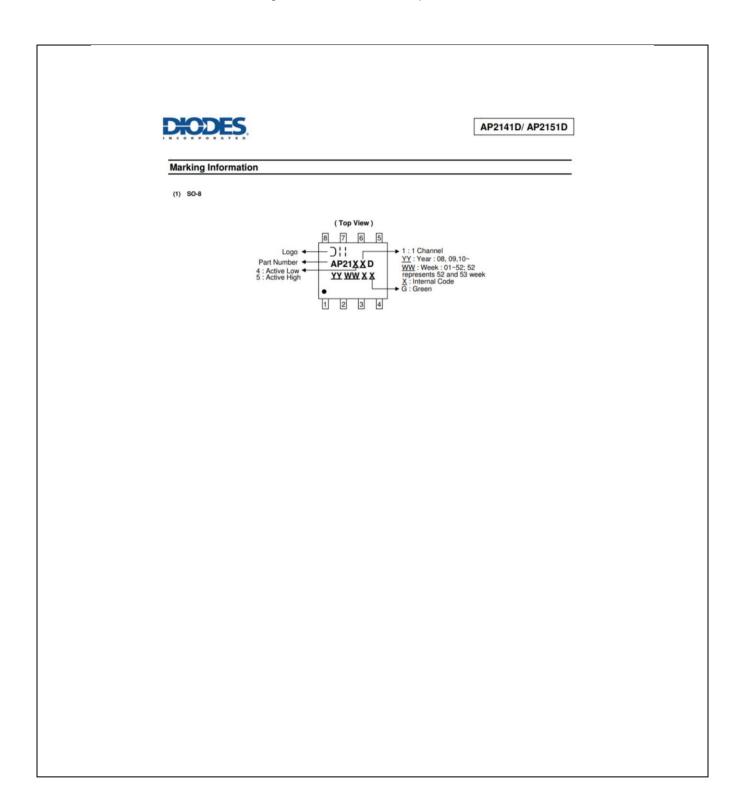
(5) U-DFN2018-6



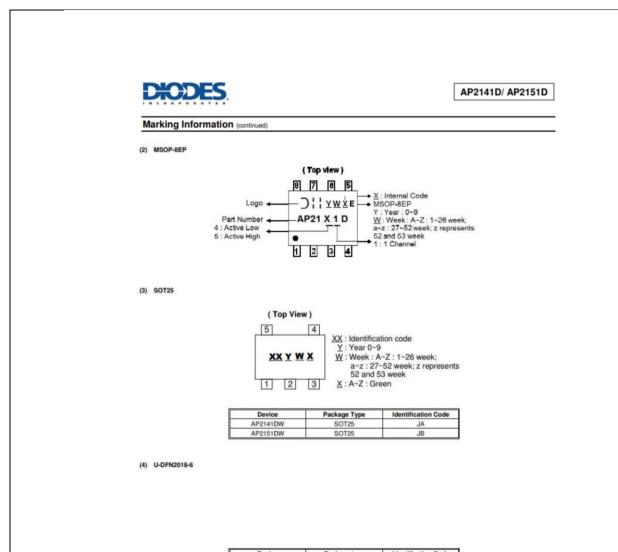
XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Green

Device	Package Type	Identification Code
AP2181DFM	U-DFN2018-6	JE
AP2101DEM	LLDEN2019-8	IE

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Device	Package type	Identification Code
AP2141DFM	U-DFN2018-6	JA
AP2151DFM	U-DFN2018-6	JB

Note: The above markings are the minimum requirements required by the safety lab. For the final production samples, the additional markings which do not give rise to misunderstanding may be added.

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Test item particulars:	
Product group	built-in component
Classification of use by	Ordinary person
Supply Connection	not mains connected: ES1
Supply tolerance	None
Supply connection – type	N/A
Considered current rating of protective device	N/A A;
Equipment mobility	for building-in
Over voltage category (OVC)	OVC I
Class of equipment	Class III
Special installation location	N/A
Pollution degree (PD)	PD 2
Manufacturer's specified Tma (°C)	85°C
IP protection class	IPX0
Power systems	not AC mains
Altitude during operation (m)	2000 m or less
Altitude of test laboratory (m)	2000 m or less
Mass of equipment (kg)	<0.1kg
Possible test case verdicts:	
- test case does not apply to the test object:	N/A
- test object does meet the requirement:	P (Pass)
- test object does not meet the requirement:	F (Fail)
Testing:	
Date of receipt of test item:	2010-07-13,2010-01-20,2015-05-04,2023-05-09,2024-04- 01
Date (s) of performance of tests:	2010-07-13 TO 2010-09-03, 2010-01-20 TO 2010-03-03, 2015-05-12 TO 2015-05-21, 2023-10-05 TO 2024-06-25,2024-05-31 TO 2024-06-12
General remarks:	
"(See Enclosure #)" refers to additional information app "(See appended table)" refers to a table appended to the	
Throughout this report a \square comma / \boxtimes point is us	sed as the decimal separator.
Manufacturer's Declaration per sub-clause 4.2.5 of I	ECEE 02:

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The application for obtaining a CB Test Certificate includes more than one factory location and a declaration from the Manufacturer stating that the sample(s) submitted for evaluation is (are) representative of the products from each factory has been provided	☐ Yes ☐ Not applicable
When differences exist; they shall be identified in th	e General product information section.
Name and address of factory (ies):	DIODES SHANGHAI CO LTD
	No 1 Lane 18 San Zhuang Rd
	Songjiang, Shanghai, 201600
	China
General product information and other remarks:	
Product Description	
The component power distribution switch (IC Current L output ratings. These devices provide current limiting a	

Model Differences

circuits only.

Model AP21410 is identical to Model AP21510 except Model AP21410 is Enable Active Low while Model AP21510 is Enable Active high.

source (e.g., 250 VA) in accordance with those specified for LPS outputs. These devices are for use in ES1

Model AP2141 is identical to Model AP2151 except Model AP2141 is Enable Active Low while Model AP2151 is Enable Active high.

Model AP2141A is identical to Model AP2151A except Model AP2141A is Enable Active Low while Model AP2151A is Enable Active high.

Model AP2146 is identical to Model AP2156 except Model AP2146 is Enable Active Low while Model AP2156 is Enable Active high.

Model AP2161 is identical to Model AP2171 except Model AP2161 is Enable Active Low while Model AP2171 is Enable Active high.

Model AP2161A is identical to Model AP2171A except Model AP2161A is Enable Active Low while Model AP2171A is Enable Active high.

Model AP2181 is identical to Model AP2191 except Model AP2181 is Enable Active Low while Model AP2191 is Enable Active high.

Model AP2181A is identical to Model AP2191A except Model AP2181A is Enable Active Low while Model AP2191A is Enable Active high.

Model AP2101 is identical to Model AP2111 except Model AP2101 is Enable Active Low while Model AP2111 is Enable Active high.

Model AP2141D is identical to Model AP2151D except Model AP2141D is Enable Active Low while Model AP2151D is Enable Active high.

Model AP2161D is identical to Model AP2171D except Model AP2161D is Enable Active Low while Model AP2171D is Enable Active high.

Model AP2181D is identical to Model AP2191D except Model AP2181D is Enable Active Low while Model AP2191D is Enable Active high.

Additional Information

Manufacturer's Specification Sheet is available per request.

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MARKING: The Recognized Company, trade name (Diodes), trademark, catalog number, and Recognized Component Mark on the smallest package or reel. Electrical ratings, including voltage range, maximum continuous current, protective current and operating temperatures shall be provided on the manufacturer's device specific datasheet. Electrical ratings are optional. The datasheet maybe web-based provided it is publicly accessible on the internet.

Technical Considerations

• The product was submitted and evaluated for use at the maximum ambient temperature (Tma) permitted by the manufacturer's specification of: 85

Engineering Conditions of Acceptability

When installed in an end-product, consideration must be given to the following:

- These devices are integrated circuits and electrical spacings within the device are not specified.
- These devices are entirely electronic in nature and have no means for manual operation or reset.
- The terminals of these devices are for factory wiring only and are intended to be mounted on printed wiring board.
- These devices have only been evaluated for supplementary overcurrent protection of secondary circuits supplied by the load side of a transformer or battery, and have not been evaluated for branch-circuit protection.
- Use on secondary supply circuits with a higher power capability requires additional evaluation for reliability, such as are contained in the Standard for Safety-Related Controls Employing Solid-State Controls, UL 991.
- These devices limit currents to values less than the overcurrent protection rating of 5 amperes.
- These devices have not been subjected Tests for Telecom applications and their suitability for connection to telecommunication networks with outside plant connections should be determined in the end-use.
- These devices were evaluated with respect to continuous current operation at the current levels shown in the electrical ratings section of this report.

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OVERVIEW OF ENERGY SOURCE	CES AND SAFEGUARDS			
Clause	Possible Hazard			
5	Electrically-caused injury			
Class and Energy Source	Body Part Safeguards			
(e.g. ES3: Primary circuit)	(e.g. Ordinary)	В	S	R
ES1: Input Circuits	Ordinary	N/A	N/A	N/A
ES1: Output Circuits	Ordinary	N/A	N/A	N/A
6	Electrically-caused fire			
Class and Energy Source	Material part		Safeguards	
(e.g. PS2: 100 Watt circuit)	(e.g. Printed board)	В	1 st S	2 nd S
PS2	Output Circuits	See sub- clause 6.3.	For building- in. The relevant energy to be evaluated in end-product.	N/A
7	Injury caused by hazardous substances			
Class and Energy Source	Body Part (e.g., Skilled)	Safeguards		
(e.g. Ozone)		В	S	R
N/A	N/A	N/A	N/A	N/A
8	Mechanically-caused injury			
Class and Energy Source	Body Part		Safeguards	
(e.g. MS3: Plastic fan blades)	(e.g. Ordinary)	В	S	R
N/A	N/A	N/A	N/A	N/A
9	Thermal burn			
Class and Energy Source	Body Part	Safeguards		
(e.g. TS1: Keyboard caps)	(e.g., Ordinary)	В	S	R
N/A (For building-in. The relevant energy to be evaluated in end-product.)	N/A	N/A	N/A	N/A
10	Radiation			
Class and Energy Source	Body Part	Safeguards		
(e.g. RS1: PMP sound output)	(e.g., Ordinary)	В	S	R
N/A	N/A	N/A	N/A	N/A
Supplementary Information:				
"B" – Basic Safeguard; "S" – Supp	lementary Safeguard; "R" – R	einforced Safe	guard	

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		ENERGY	SOURCE DI	AGRAM	
	are betwe	•	_	•	declared energy sources and am be provided included in power
Insert diagram below. Examp drawings	ole diagrar	m designs are	e; Block diag	rams; image	(s) with layered data; mechanical
[☐ ES	☐ PS	□ MS	□тѕ	□RS

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		IEC 62368-1		
Clause	Requirement + Test		Result - Remark	Verdict

4	GENERAL REQUIREMENTS	Pass	
4.1.1	Acceptance of materials, components and subassemblies		Pass
4.1.2	Use of components		Pass
4.1.3	Equipment design and construction		Pass
4.1.4	Specified ambient temperature for outdoor use (°C)		N/A
4.1.5	Constructions and components not specifically covered		N/A
4.1.8	Liquids and liquid filled components (LFC)		N/A
4.1.15	Markings and instructions	(See Annex F)	Pass
4.4.3	Safeguard robustness		N/A
4.4.3.1	General		N/A
4.4.3.2	Steady force tests		N/A
4.4.3.3	Drop tests		N/A
4.4.3.4	Impact tests		N/A
4.4.3.5	Internal accessible safeguard tests		N/A
4.4.3.6	Glass impact tests		N/A
4.4.3.7	Glass fixation tests		N/A
	Glass impact test (1J)		N/A
	Push/pull test (10 N)		N/A
4.4.3.8	Thermoplastic material tests		N/A
4.4.3.9	Air comprising a safeguard		N/A
4.4.3.10	Accessibility, glass, safeguard effectiveness		N/A
4.4.4	Displacement of a safeguard by an insulating liquid		N/A
4.4.5	Safety interlocks		N/A
4.5	Explosion		N/A
4.5.1	General		N/A
4.5.2	No explosion during normal/abnormal operating condition		N/A
	No harm by explosion during single fault conditions		N/A
4.6	Fixing of conductors		N/A
	Fix conductors not to defeat a safeguard		N/A

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	IEC 62368-1		
Clause	Requirement + Test	Result - Remark	Verdict
	Compliance is checked by test:		N/A
4.7	Equipment for direct insertion into mains socker	t-outlets	N/A
4.7.2	Mains plug part complies with relevant standard:		N/A
4.7.3	Torque (Nm)		N/A
4.8	Equipment containing coin/button cell batteries		N/A
4.8.1	General		N/A
4.8.2	Instructional safeguard		N/A
4.8.3	Battery compartment door/cover construction		N/A
	Open torque test		N/A
4.8.4.2	Stress relief test		N/A
4.8.4.3	Battery replacement test		N/A
4.8.4.4	Drop test		N/A
4.8.4.5	Impact test		N/A
4.8.4.6	Crush test		N/A
4.8.5	Compliance		N/A
	30N force test with test probe		N/A
	20N force test with test hook		N/A
4.9	Likelihood of fire or shock due to entry of conductive object		N/A
4.10	Component requirements		N/A
4.10.1	Disconnect Device		N/A
4.10.2	Switches and relays		N/A
5	ELECTRICALLY-CAUSED INJURY		Pass
5.2	Classification and limits of electrical energy sour	ces	N/A
5.2.2	ES1, ES2 and ES3 limits	Outputs complied with ES1.	N/A

5	ELECTRICALLY-CAUSED INJURY		Pass
5.2	Classification and limits of electrical energy sources		N/A
5.2.2	ES1, ES2 and ES3 limits	Outputs complied with ES1.	N/A
5.2.2.2	Steady-state voltage and current limits:		N/A
5.2.2.3	Capacitance limits		N/A
5.2.2.4	Single pulse limits		N/A
5.2.2.5	Limits for repetitive pulses		N/A
5.2.2.6	Ringing signals		N/A
5.2.2.7	Audio signals		N/A

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	IEC 623	368-1	
Clause	Requirement + Test	Result - Remark	Verdict

5.3	Protection against electrical energy sources		N/A
5.3.1	General Requirements for accessible parts to ordinary, instructed and skilled persons	For building-in. To be evaluated in end-product.	N/A
5.3.1 a)	Accessible ES1/ES2 derived from ES2/ES3 circuits		N/A
5.3.1 b)	Skilled persons not unintentional contact ES3 bare conductors		N/A
5.3.2.1	Accessibility to electrical energy sources and safeguards		N/A
	Accessibility to outdoor equipment bare parts		N/A
5.3.2.2	Contact requirements		N/A
	Test with test probe from Annex V		_
5.3.2.2 a)	Air gap – electric strength test potential (V):		N/A
5.3.2.2 b)	Air gap – distance (mm):		N/A
5.3.2.3	Compliance		N/A
5.3.2.4	Terminals for connecting stripped wire		N/A
5.4	Insulation materials and requirements	1	Pass
5.4.1.2	Properties of insulating material		Pass
5.4.1.3	Material is non-hygroscopic		N/A
5.4.1.4	Maximum operating temperature for insulating materials	(See Table 5.4.1.4, 9.3, B.1.5, B.2.6)	Pass
5.4.1.5	Pollution degrees	PD 2	Pass
5.4.1.5.2	Test for pollution degree 1 environment and for an insulating compound		N/A
5.4.1.5.3	Thermal cycling test		N/A
5.4.1.6	Insulation in transformers with varying dimensions		N/A
5.4.1.7	Insulation in circuits generating starting pulses		N/A
5.4.1.8	Determination of working voltage		N/A
5.4.1.9	Insulating surfaces		N/A
5.4.1.10	Thermoplastic parts on which conductive metallic parts are directly mounted		N/A
5.4.1.10.2	Vicat test		N/A
5.4.1.10.3	Ball pressure test		N/A
5.4.2	Clearances		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.4.2.1	General requirements		N/A
	Clearances in circuits connected to AC Mains, Alternative method		N/A
5.4.2.2	Procedure 1 for determining clearance		N/A
	Temporary overvoltage:		_
5.4.2.3	Procedure 2 for determining clearance		N/A
5.4.2.3.2.2	a.c. mains transient voltage		_
5.4.2.3.2.3	d.c. mains transient voltage		_
5.4.2.3.2.4	External circuit transient voltage:		_
5.4.2.3.2.5	Transient voltage determined by measurement:		_
5.4.2.4	Determining the adequacy of a clearance using an electric strength test		N/A
5.4.2.5	Multiplication factors for clearances and test voltages		N/A
5.4.2.6	Clearance measurement		N/A
5.4.3	Creepage distances		N/A
5.4.3.1	General		N/A
5.4.3.3	Material group		_
5.4.3.4	Creepage distances measurement		N/A
5.4.4	Solid insulation		N/A
5.4.4.1	General requirements		N/A
5.4.4.2	Minimum distance through insulation		N/A
5.4.4.3	Insulating compound forming solid insulation		N/A
5.4.4.4	Solid insulation in semiconductor devices		N/A
5.4.4.5	Insulating compound forming cemented joints		N/A
5.4.4.6	Thin sheet material		N/A
5.4.4.6.1	General requirements		N/A
5.4.4.6.2	Separable thin sheet material		N/A
	Number of layers (pcs):		N/A
5.4.4.6.3	Non-separable thin sheet material		N/A
	Number of layers (pcs):		N/A
5.4.4.6.4	Standard test procedure for non-separable thin sheet material:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.4.4.6.5	Mandrel test		N/A
5.4.4.7	Solid insulation in wound components		N/A
5.4.4.9	Solid insulation at frequencies >30 kHz, <i>E</i> _P , <i>K</i> _R , <i>d</i> , <i>V</i> _{PW} (V):		N/A
	Alternative by electric strength test, tested voltage (V), K_R :		N/A
5.4.5	Antenna terminal insulation		N/A
5.4.5.1	General		N/A
5.4.5.2	Voltage surge test		N/A
5.4.5.3	Insulation resistance (M Ω):		N/A
	Electric strength test:		N/A
5.4.6	Insulation of internal wire as part of supplementary safeguard		N/A
5.4.7	Tests for semiconductor components and for cemented joints		N/A
5.4.8	Humidity conditioning		N/A
	Relative humidity (%), temperature (°C), duration (h):		_
5.4.9	Electric strength test		N/A
5.4.9.1	Test procedure for type test of solid insulation:		N/A
5.4.9.2	Test procedure for routine test		N/A
5.4.10	Safeguards against transient voltages from external circuits		N/A
5.4.10.1	Parts and circuits separated from external circuits		N/A
5.4.10.2	Test methods		N/A
5.4.10.2.1	General		N/A
5.4.10.2.2	Impulse test:		N/A
5.4.10.2.3	Steady-state test:		N/A
5.4.10.3	Verification for insulation breakdown for impulse test:		N/A
5.4.11	Separation between external circuits and earth		N/A
5.4.11.1	Exceptions to separation between external circuits and earth		N/A
5.4.11.2	Requirements		N/A

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Clause Requirement + Test Result - Remark SPDs bridge separation between external circuit and earth Rated operating voltage U _{op} (V)	Verdict
and earth Rated operating voltage U _{op} (V)	
Nominal voltage U _{peak} (V)	N/A
Max increase due to variation ΔU _{sp}	_
Max increase due to ageing ΔU _{sa}	_
5.4.11.3 Test method and compliance	_
5.4.12 Insulating liquid 5.4.12.1 General requirements 5.4.12.2 Electric strength of an insulating liquid	_
5.4.12.1 General requirements 5.4.12.2 Electric strength of an insulating liquid	N/A
5.4.12.2 Electric strength of an insulating liquid	N/A
5.4.12.3 Compatibility of an insulating liquid	N/A
5.4.12.4 Container for insulating liquid	N/A
5.5 Components as safeguards 5.5.1 General 5.5.2 Capacitors and RC units 5.5.2.1 General requirement 5.5.2.2 Safeguards against capacitor discharge after	N/A
5.5.1 General 5.5.2 Capacitors and RC units 5.5.2.1 General requirement 5.5.2.2 Safeguards against capacitor discharge after	N/A
5.5.2 Capacitors and RC units 5.5.2.1 General requirement 5.5.2.2 Safeguards against capacitor discharge after	N/A
5.5.2.1 General requirement 5.5.2.2 Safeguards against capacitor discharge after	N/A
5.5.2.2 Safeguards against capacitor discharge after	N/A
	N/A
dissolitional of a confident minimum.	N/A
5.5.3 Transformers	N/A
5.5.4 Optocouplers	N/A
5.5.5 Relays	N/A
5.5.6 Resistors	N/A
5.5.7 SPDs	N/A
5.5.8 Insulation between the mains and an external circuit consisting of a coaxial cable:	N/A
5.5.9 Safeguards for socket-outlets in outdoor equipment	N/A
RCD rated residual operating current (mA):	_
5.6 Protective conductor	N/A
5.6.2 Requirement for protective conductors	N/A
5.6.2.1 General requirements	N/A
5.6.2.2 Colour of insulation	N/A
5.6.3 Requirement for protective earthing conductors	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	Post of the second state of the 2		
	Protective earthing conductor size (mm²):		_
	Protective earthing conductor serving as a reinforced safeguard		N/A
	Protective earthing conductor serving as a double safeguard		N/A
5.6.4	Requirements for protective bonding conductors		N/A
5.6.4.1	Protective bonding conductors		N/A
	Protective bonding conductor size (mm²):		_
5.6.4.2	Protective current rating (A):		N/A
5.6.5	Terminals for protective conductors		N/A
5.6.5.1	Terminal size for connecting protective earthing conductors (mm):		N/A
	Terminal size for connecting protective bonding conductors (mm)		N/A
5.6.5.2	Corrosion		N/A
5.6.6	Resistance of the protective bonding system		N/A
5.6.6.1	Requirements		N/A
5.6.6.2	Test Method:		N/A
5.6.6.3	Resistance (Ω) or voltage drop:		N/A
5.6.7	Reliable connection of a protective earthing conductor		N/A
5.6.8	Functional earthing		N/A
	Conductor size (mm²):		N/A
	Class II with functional earthing marking:		N/A
	Appliance inlet cl & cr (mm):		N/A
5.7	Prospective touch voltage, touch current and prote	ective conductor current	N/A
5.7.2	Measuring devices and networks		N/A
5.7.2.1	Measurement of touch current		N/A
5.7.2.2	Measurement of voltage		N/A
5.7.3	Equipment set-up, supply connections and earth connections		N/A
5.7.4	Unearthed accessible parts:		N/A
5.7.5	Earthed accessible conductive parts:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
5.7.6	Requirements when touch current exceeds ES2 limits		N/A
	Protective conductor current (mA):		N/A
	Instructional Safeguard:		N/A
5.7.7	Prospective touch voltage and touch current associated with external circuits		N/A
5.7.7.1	Touch current from coaxial cables		N/A
5.7.7.2	Prospective touch voltage and touch current associated with paired conductor cables		N/A
5.7.8	Summation of touch currents from external circuits		N/A
	a) Equipment connected to earthed external circuits, current (mA):		N/A
	b) Equipment connected to unearthed external circuits, current (mA):		N/A
5.8	Backfeed safeguard in battery backed up suppli	es	N/A
	Mains terminal ES		N/A
	Air gap (mm):		N/A

6	ELECTRICALLY- CAUSED FIRE		Pass
6.2	Classification of PS and PIS		N/A
6.2.2	Power source circuit classifications		N/A
6.2.3	Classification of potential ignition sources		N/A
6.2.3.1	Arcing PIS		N/A
6.2.3.2	Resistive PIS		N/A
6.3	Safeguards against fire under normal operating and abnormal operating conditions		Pass
6.3.1	No ignition and attainable temperature value less than 90 % defined by ISO 871 or less than 300 °C for unknown materials	(See Table 5.4.1.4, 9.3, B.1.5, B.2.6)	Pass
	Combustible materials outside fire enclosure:		N/A
6.4	Safeguards against fire under single fault conditions		N/A
6.4.1	Safeguard method	Control of fire spread method used.	N/A
6.4.2	Reduction of the likelihood of ignition under single fault conditions in PS1 circuits		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
6.4.3	Reduction of the likelihood of ignition under single fault conditions in PS2 and PS3 circuits		N/A
6.4.3.1	Supplementary safeguards		N/A
6.4.3.2	Single Fault Conditions:	(See Table B.3, B.4)	N/A
	Special conditions for temperature limited by fuse		N/A
6.4.4	Control of fire spread in PS1 circuits		N/A
6.4.5	Control of fire spread in PS2 circuits		N/A
6.4.5.2	Supplementary safeguards		N/A
6.4.6	Control of fire spread in PS3 circuits		N/A
6.4.7	Separation of combustible materials from a PIS		N/A
6.4.7.2	Separation by distance		N/A
6.4.7.3	Separation by a fire barrier		N/A
6.4.8	Fire enclosures and fire barriers		N/A
6.4.8.2	Fire enclosure and fire barrier material properties		N/A
6.4.8.2.1	Requirements for a fire barrier		N/A
6.4.8.2.2	Requirements for a fire enclosure		N/A
6.4.8.3	Constructional requirements for a fire enclosure and a fire barrier		N/A
6.4.8.3.1	Fire enclosure and fire barrier openings		N/A
6.4.8.3.2	Fire barrier dimensions		N/A
6.4.8.3.3	Top openings and properties		N/A
	Openings dimensions (mm):		N/A
6.4.8.3.4	Bottom openings and properties		N/A
	Openings dimensions (mm):		N/A
	Flammability tests for the bottom of a fire enclosure		N/A
	Instructional Safeguard:		N/A
6.4.8.3.5	Side openings and properties		N/A
	Openings dimensions (mm):		N/A
6.4.8.3.6	Integrity of a fire enclosure, condition met: a), b) or c)		N/A
6.4.8.4	Separation of a PIS from a fire enclosure and a fire barrier distance (mm) or flammability rating:		N/A
6.4.9	Flammability of insulating liquid:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
	T		
6.5	Internal and external wiring		N/A
6.5.1	General requirements		N/A
6.5.2	Requirements for interconnection to building wiring		N/A
6.5.3	Internal wiring size (mm²) for socket-outlets:		N/A
6.6	Safeguards against fire due to the connection to	additional equipment	N/A
7	INJURY CAUSED BY HAZARDOUS SUBSTANCE	<u> </u>	N/A
7.2	Reduction of exposure to hazardous substances		N/A
7.3	· · · · · · · · · · · · · · · · · · ·		N/A
7.4	Ozone exposure Use of personal safeguards or personal protective equipment (PPE)		N/A
7.4	Personal safeguards and instructions:		IN/A
7.5	Use of instructional safeguards and instructions		N/A
7.5	Instructional safeguard (ISO 7010):		IN/A
7.6			N/A
7.0	Batteries and their protection circuits		IN/A
8	MECHANICALLY-CAUSED INJURY		N/A
8.2	Mechanical energy source classifications		N/A
8.3	Safeguards against mechanical energy sources		N/A
8.4	Safeguards against parts with sharp edges and corners		N/A
8.4.1	Safeguards		N/A
	Instructional Safeguard:		N/A
8.4.2	Sharp edges or corners		N/A
8.5	Safeguards against moving parts		N/A
8.5.1	Fingers, jewellery, clothing, hair, etc., contact with MS2 or MS3 parts		N/A
	MS2 or MS3 part required to be accessible for the function of the equipment		N/A
	Moving MS3 parts only accessible to skilled person		N/A
8.5.2	Instructional safeguard		N/A
8.5.4	Special categories of equipment containing moving parts		N/A
8.5.4.1	General		N/A
8.5.4.2	Equipment containing work cells with MS3 parts		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
8.5.4.2.1	Protection of persons in the work cell		N/A
8.5.4.2.2	Access protection override		N/A
8.5.4.2.2.1	Override system		
	<u> </u>		N/A
8.5.4.2.2.2	Visual indicator		N/A
8.5.4.2.3	Emergency stop system		N/A
	Maximum stopping distance from the point of activation (m)		N/A
	Space between end point and nearest fixed mechanical part (mm)		N/A
8.5.4.2.4	Endurance requirements		N/A
	Mechanical system subjected to 100 000 cycles of operation		N/A
	- Mechanical function check and visual inspection		N/A
	- Cable assembly		N/A
8.5.4.3	Equipment having electromechanical device for destruction of media		N/A
8.5.4.3.1	Equipment safeguards		N/A
8.5.4.3.2	Instructional safeguards against moving parts		N/A
8.5.4.3.3	Disconnection from the supply		N/A
8.5.4.3.4	Cut type and test force (N)		N/A
8.5.4.3.5	Compliance		N/A
8.5.5	High pressure lamps		N/A
	Explosion test		N/A
8.5.5.3	Glass particles dimensions (mm)		N/A
8.6	Stability of equipment		N/A
8.6.1	General		N/A
	Instructional safeguard:		N/A
8.6.2	Static stability		N/A
8.6.2.2	Static stability test		N/A
8.6.2.3	Downward force test		N/A
8.6.3	Relocation stability		N/A
	Wheels diameter (mm):		
	Tilt test		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
8.6.4	Glass slide test		N/A
8.6.5	Horizontal force test		N/A
8.7	Equipment mounted to wall, ceiling or other struc	l ture	N/A
8.7.1	Mount means type		N/A
8.7.2	Test methods		N/A
	Test 1, additional downwards force (N)		N/A
	Test 2, number of attachment points and test force (N)		N/A
	Test 3 Nominal diameter (mm) and applied torque (Nm)		N/A
8.8	Handles strength		N/A
8.8.1	General		N/A
8.8.2	Handle strength test		N/A
	Number of handles		_
	Force applied (N):		_
8.9	Wheels or casters attachment requirements		N/A
8.9.2	Pull test		N/A
8.10	Carts, stands and similar carriers		N/A
8.10.1	General		N/A
8.10.2	Marking and instructions		N/A
8.10.3	Cart, stand or carrier loading test		N/A
	Loading force applied (N)		N/A
8.10.4	Cart, stand or carrier impact test		N/A
8.10.5	Mechanical stability		N/A
	Force applied (N)		_
8.10.6	Thermoplastic temperature stability		N/A
8.11	Mounting means for slide-rail mounted equipment	t (SRME)	N/A
8.11.1	General		N/A
8.11.2	Requirements for slide rails		N/A
	Instructional Safeguard:		N/A
8.11.3	Mechanical strength test		N/A
8.11.3.1	Downward force test, force (N) applied:		N/A

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Clause	Requirement + Test	Result - Remark	Verdic
0.14.0.0			
8.11.3.2	Lateral push force test		N/A
8.11.3.3	Integrity of slide rail end stops		N/A
8.11.4	Compliance		N/A
8.12	Telescoping or rod antennas		N/A
	Button/ball diameter (mm)		_
9	THERMAL BURN INJURY		N/A
9.2	Thermal energy source classifications		N/A
9.3	Touch temperature limits		N/A
9.3.1	Touch temperatures of accessible parts		N/A
9.3.2	Test method and compliance		N/A
9.4	Safeguards against thermal energy sources		N/A
9.5	Requirements for safeguards		N/A
9.5.1	Equipment safeguard		N/A
9.5.2	Instructional safeguard		N/A
9.6	Requirements for wireless power transmitters		N/A
9.6.1	General		N/A
9.6.2	Specification of the foreign objects		N/A
9.6.3	Test method and compliance:		N/A
10	RADIATION		N/A
10.2	Radiation energy source classification		N/A
10.2.1	General classification		N/A
	Lasers:		_
	Lamps and lamp systems:		_
	Image projectors		

10.2	Radiation energy source classification	IN/A
10.2.1	General classification	N/A
	Lasers:	
	Lamps and lamp systems:	
	Image projectors:	
	X-Ray:	
	Personal music player:	_
10.3	Safeguards against laser radiation	N/A
	The standard(s) equipment containing laser(s) comply:	N/A
10.4	Safeguards against optical radiation from lamps and lamp systems (including LED types)	N/A

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Clause Requirement + Test Result - Remark 10.4.1 General requirements Instructional safeguard provided for accessible radiation level needs to exceed Risk group marking and location	Verdict
Instructional safeguard provided for accessible radiation level needs to exceed Risk group marking and location	
radiation level needs to exceed Risk group marking and location	N/A
Information for safe operation and installation 10.4.2 Requirements for enclosures UV radiation exposure	N/A
10.4.2 Requirements for enclosures UV radiation exposure	N/A
UV radiation exposure: 10.4.3 Instructional safeguard: 10.5 Safeguards against X-radiation 10.5.1 Requirements Instructional safeguard for skilled persons: 10.5.3 Maximum radiation (pA/kg): 10.6 Safeguards against acoustic energy sources 10.6.1 General	N/A
10.4.3 Instructional safeguard: 10.5 Safeguards against X-radiation 10.5.1 Requirements Instructional safeguard for skilled persons: 10.5.3 Maximum radiation (pA/kg): 10.6 Safeguards against acoustic energy sources 10.6.1 General	N/A
10.5 Safeguards against X-radiation 10.5.1 Requirements Instructional safeguard for skilled persons	N/A
10.5.1 Requirements Instructional safeguard for skilled persons: 10.5.3 Maximum radiation (pA/kg): 10.6 Safeguards against acoustic energy sources 10.6.1 General	N/A
Instructional safeguard for skilled persons: 10.5.3 Maximum radiation (pA/kg): 10.6 Safeguards against acoustic energy sources 10.6.1 General	N/A
10.5.3 Maximum radiation (pA/kg)	N/A
10.6 Safeguards against acoustic energy sources 10.6.1 General	_
10.6.1 General	_
	N/A
10.00	N/A
10.6.2 Classification	N/A
Acoustic output L _{Aeq,T} , dB(A):	N/A
Unweighted RMS output voltage (mV):	N/A
Digital output signal (dBFS):	N/A
10.6.3 Requirements for dose-based systems	N/A
10.6.3.1 General requirements	N/A
10.6.3.2 Dose-based warning and automatic decrease	N/A
10.6.3.3 Exposure-based warning and requirements	N/A
30 s integrated exposure level (MEL30):	N/A
Warning for MEL ≥ 100 dB(A):	N/A
10.6.4 Measurement methods	N/A
10.6.5 Protection of persons	N/A
Instructional safeguards:	N/A
10.6.6 Requirements for listening devices (headphones, earphones, etc.)	N/A
10.6.6.1 Corded listening devices with analogue input	N/A
Listening device input voltage (mV):	N/A
10.6.6.2 Corded listening devices with digital input	

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Clause	Requirement + Test	Result - Remark	Verdict
			т
	Max. acoustic output $L_{Aeq,T}$, dB(A)		N/A
10.6.6.3	Cordless listening devices		N/A
	Max. acoustic output L _{Aeq,T} , dB(A)		N/A

В	NORMAL OPERATING CONDITION TESTS, ABNORMAL OPERATING CONDITION TESTS AND SINGLE FAULT CONDITION TESTS	Pass
B.1	General	N/A
B.1.5	Temperature measurement conditions	N/A
B.2	Normal operating conditions	N/A
B.2.1	General requirements:	N/A
	Audio Amplifiers and equipment with audio amplifiers:	N/A
B.2.3	Supply voltage and tolerances	N/A
B.2.5	Input test:	N/A
B.3	Simulated abnormal operating conditions	N/A
B.3.1	General	N/A
B.3.2	Covering of ventilation openings	N/A
	Instructional safeguard:	N/A
B.3.3	DC mains polarity test	N/A
B.3.4	Setting of voltage selector	N/A
B.3.5	Maximum load at output terminals	N/A
B.3.6	Reverse battery polarity	N/A
B.3.7	Audio amplifier abnormal operating conditions	N/A
B.3.8	Safeguards functional during and after abnormal operating conditions:	N/A
B.4	Simulated single fault conditions	Pass
B.4.1	General	Pass
B.4.2	Temperature controlling device	N/A
B.4.3	Blocked motor test	N/A
B.4.4	Functional insulation	N/A
B.4.4.1	Short circuit of clearances for functional insulation	N/A
B.4.4.2	Short circuit of creepage distances for functional insulation	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
B.4.4.3	Short circuit of functional insulation on coated printed boards		N/A
B.4.5	Short-circuit and interruption of electrodes in tubes and semiconductors		N/A
B.4.6	Short circuit or disconnection of passive components		N/A
B.4.7	Continuous operation of components		N/A
B.4.8	Compliance during and after single fault conditions	(See Table B.3, B.4)	Pass
B.4.9	Battery charging and discharging under single fault conditions		N/A
С	UV RADIATION		N/A
C.1	Protection of materials in equipment from UV rac	diation	N/A
C.1.2	Requirements		N/A
C.1.3	Test method		N/A
C.2	UV light conditioning test	1	N/A
C.2.1	Test apparatus:		N/A
C.2.2	Mounting of test samples		N/A
C.2.3	Carbon-arc light-exposure test		N/A
C.2.4	Xenon-arc light-exposure test		N/A
D	TEST GENERATORS		N/A
D.1	Impulse test generators		N/A
D.2	Antenna interface test generator		N/A
D.3	Electronic pulse generator		N/A
E	TEST CONDITIONS FOR EQUIPMENT CONTAINI	NG AUDIO AMPLIFIERS	N/A
E.1	Electrical energy source classification for audio	signals	N/A
	Maximum non-clipped output power (W):		_
	Rated load impedance (Ω):		
	Open-circuit output voltage (V):		_
	Instructional safeguard:		_
E.2	Audio amplifier normal operating conditions	1	N/A
	Audio signal source type:		_
	Audio output power (W):		_
	Audio output power (w)		_

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Clause	Requirement + Test	Result - Remark	Verdict
	Audio output voltage (V):		_
	Rated load impedance (Ω):		
	Requirements for temperature measurement		N/A
E.3	Audio amplifier abnormal operating conditions		N/A
F	EQUIPMENT MARKINGS, INSTRUCTIONS, AND I	NSTRUCTIONAL SAFEGUARDS	Pass
F.1	General		N/A
	Language:		
F.2	Letter symbols and graphical symbols		N/A
F.2.1	Letter symbols according to IEC60027-1		N/A
F.2.2	Graphic symbols according to IEC, ISO or manufacturer specific		N/A
F.3	Equipment markings		Pass
F.3.1	Equipment marking locations		Pass
F.3.2	Equipment identification markings		Pass
F.3.2.1	Manufacturer identification:	See 'Trademark' for details.	Pass
F.3.2.2	Model identification:	See 'Models and Ratings' for details.	Pass
F.3.3	Equipment rating markings		N/A
F.3.3.1	Equipment with direct connection to mains		N/A
F.3.3.2	Equipment without direct connection to mains		N/A
F.3.3.3	Nature of the supply voltage:		N/A
F.3.3.4	Rated voltage:		N/A
F.3.3.5	Rated frequency:		N/A
F.3.3.6	Rated current or rated power:		N/A
F.3.3.7	Equipment with multiple supply connections		N/A
F.3.4	Voltage setting device		N/A
F.3.5	Terminals and operating devices		N/A
F.3.5.1	Mains appliance outlet and socket-outlet markings		N/A
F.3.5.2	Switch position identification marking:		N/A
F.3.5.3	Replacement fuse identification and rating markings		N/A
	Instructional safeguards for neutral fuse:		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
F.3.5.4	Replacement battery identification marking:		N/A
F.3.5.5	Neutral conductor terminal		
			N/A
F.3.5.6	Terminal marking location		N/A
F.3.6	Equipment markings related to equipment classification		N/A
F.3.6.1	Class I equipment		N/A
F.3.6.1.1	Protective earthing conductor terminal:		N/A
F.3.6.1.2	Protective bonding conductor terminals:		N/A
F.3.6.2	Equipment class marking:		N/A
F.3.6.3	Functional earthing terminal marking:		N/A
F.3.7	Equipment IP rating marking:		N/A
F.3.8	External power supply output marking:		N/A
F.3.9	Durability, legibility and permanence of marking		N/A
F.3.10	Test for permanence of markings		N/A
F.4	Instructions	1	N/A
	a) Information prior to installation and initial use		N/A
	b) Equipment for use in locations where children not likely to be present		N/A
	c) Instructions for installation and interconnection		N/A
	d) Equipment intended for use only in restricted access area		N/A
	e) Equipment intended to be fastened in place		N/A
	f) Instructions for audio equipment terminals		N/A
	g) Protective earthing used as a safeguard		N/A
	h) Protective conductor current exceeding ES2 limits		N/A
	i) Graphic symbols used on equipment		N/A
	j) Permanently connected equipment not provided with all-pole mains switch		N/A
	k) Replaceable components or modules providing safeguard function		N/A
	Equipment containing insulating liquid		N/A
	m) Installation instructions for outdoor equipment		N/A
F.5	Instructional safeguards		N/A

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Clause	Requirement + Test	Result - Remark	Verdict

G	COMPONENTS	Pass
G.1	Switches	N/A
G.1.1	General	N/A
G.1.2	Ratings, endurance, spacing, maximum load	N/A
G.1.3	Test method and compliance	N/A
G.2	Relays	N/A
G.2.1	Requirements	N/A
G.2.2	Overload test	N/A
G.2.3	Relay controlling connectors supplying power to other equipment	N/A
G.2.4	Test method and compliance	N/A
G.3	Protective devices	N/A
G.3.1	Thermal cut-offs	N/A
	Thermal cut-outs separately approved according to IEC 60730 with conditions indicated in a) & b)	N/A
	Thermal cut-outs tested as part of the equipment as indicated in c)	N/A
G.3.1.2	Test method and compliance	N/A
G.3.2	Thermal links	N/A
G.3.2.1	a) Thermal links tested separately according to IEC 60691 with specifics	N/A
	b) Thermal links tested as part of the equipment	N/A
G.3.2.2	Test method and compliance	N/A
G.3.3	PTC thermistors	N/A
G.3.4	Overcurrent protection devices	N/A
G.3.5	Safeguards components not mentioned in G.3.1 to G.3.4	N/A
G.3.5.1	Non-resettable devices suitably rated and marking provided	N/A
G.3.5.2	Single faults conditions:	N/A
G.4	Connectors	N/A
G.4.1	Spacings	N/A
G.4.2	Mains connector configuration:	N/A

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Clause	Requirement + Test	Result - Remark	Verdict
G.4.3	Plug is shaped that insertion into mains socket- outlets or appliance coupler is unlikely		N/A
G.5	Wound components		N/A
G.5.1	Wire insulation in wound components		N/A
G.5.1.2	Protection against mechanical stress		N/A
G.5.2	Endurance test		N/A
G.5.2.1	General test requirements		N/A
G.5.2.2	Heat run test		N/A
	Test time (days per cycle):		_
	Test temperature (°C):		_
G.5.2.3	Wound components supplied from the mains		N/A
G.5.2.4	No insulation breakdown		N/A
G.5.3	Transformers		N/A
G.5.3.1	Compliance method:		N/A
	Position:		N/A
	Method of protection		N/A
G.5.3.2	Insulation		N/A
	Protection from displacement of windings:		_
G.5.3.3	Transformer overload tests		N/A
G.5.3.3.1	Test conditions		N/A
G.5.3.3.2	Winding temperatures		N/A
G.5.3.3.3	Winding temperatures - alternative test method		N/A
G.5.3.4	Transformers using FIW		N/A
G.5.3.4.1	General		N/A
	FIW wire nominal diameter:		_
G.5.3.4.2	Transformers with basic insulation only		N/A
G.5.3.4.3	Transformers with double insulation or reinforced insulation:		N/A
G.5.3.4.4	Transformers with FIW wound on metal or ferrite core		N/A
G.5.3.4.5	Thermal cycling test and compliance		N/A
G.5.3.4.6	Partial discharge test		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
G.5.3.4.7	Routine test		N/A
G.5.4	Motors		N/A
G.5.4.1	General requirements		N/A
G.5.4.2	Motor overload test conditions		N/A
G.5.4.3	Running overload test		N/A
G.5.4.4.2	Locked-rotor overload test		N/A
	Test duration (days)		_
G.5.4.5	Running overload test for DC motors		N/A
G.5.4.5.2	Tested in the unit		N/A
G.5.4.5.3	Alternative method		N/A
G.5.4.6	Locked-rotor overload test for DC motors		N/A
G.5.4.6.2	Tested in the unit		N/A
	Maximum Temperature		N/A
G.5.4.6.3	Alternative method		N/A
G.5.4.7	Motors with capacitors		N/A
G.5.4.8	Three-phase motors		N/A
G.5.4.9	Series motors		N/A
	Operating voltage		_
G.6	Wire Insulation	1	N/A
G.6.1	General		N/A
G.6.2	Enamelled winding wire insulation		N/A
G.7	Mains supply cords	1	N/A
G.7.1	General requirements		N/A
	Туре		_
G.7.2	Cross sectional area (mm² or AWG):		N/A
G.7.3	Cord anchorages and strain relief for non- detachable power supply cords		N/A
G.7.3.2	Cord strain relief		N/A
G.7.3.2.1	Requirements		N/A
	Strain relief test force (N)		N/A
G.7.3.2.2	Strain relief mechanism failure		N/A
G.7.3.2.3	Cord sheath or jacket position, distance (mm):		N/A

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Clause	Requirement + Test	Result - Remark	Verdict
G.7.3.2.4	Strain relief and cord anchorage material		N/A
G.7.4	Cord Entry		N/A
G.7.5	Non-detachable cord bend protection		N/A
G.7.5.1	Requirements		N/A
G.7.5.1	Test method and compliance		N/A
0.7.0.2	Overall diameter or minor overall dimension, <i>D</i> (mm)		_
	Radius of curvature after test (mm):		_
G.7.6	Supply wiring space		N/A
G.7.6.1	General requirements		N/A
G.7.6.2	Stranded wire		N/A
G.7.6.2.1	Requirements		N/A
G.7.6.2.2	Test with 8 mm strand		N/A
G.8	Varistors	1	N/A
G.8.1	General requirements		N/A
G.8.2	Safeguards against fire		N/A
G.8.2.1	General		N/A
G.8.2.2	Varistor overload test		N/A
G.8.2.3	Temporary overvoltage test		N/A
G.9	Integrated circuit (IC) current limiters		Pass
G.9.1	Requirements		Pass
	IC limiter output current (max. 5A):	See "Models and Ratings" for details.	_
	Manufacturers' defined drift:	See "Models and Ratings" for details.	_
G.9.2	Test Program		Pass
G.9.3	Compliance		Pass
G.10	Resistors	•	N/A
G.10.1	General		N/A
G.10.2	Conditioning		N/A
G.10.3	Resistor test		N/A
G.10.4	Voltage surge test		N/A
	1	1	1

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Clause	Requirement + Test	Result - Remark	Verdict
G.10.5	Impulse test	1	N/A
G.10.6	Overload test		N/A
G.11	Capacitors and RC units		N/A
G.11.1	General requirements	1	N/A
G.11.2	Conditioning of capacitors and RC units		N/A
G.11.3	Rules for selecting capacitors		N/A
G.12	Optocouplers		N/A
G.12	<u> </u>		N/A
	Optocouplers comply with IEC 60747-5-5 with specifics		IN/A
	Type test voltage V _{ini,a} :		_
	Routine test voltage, V _{ini, b} :		_
G.13	Printed boards	1	N/A
G.13.1	General requirements		N/A
G.13.2	Uncoated printed boards		N/A
G.13.3	Coated printed boards		N/A
G.13.4	Insulation between conductors on the same inner surface		N/A
G.13.5	Insulation between conductors on different surfaces		N/A
	Distance through insulation:		N/A
	Number of insulation layers (pcs):		_
G.13.6	Tests on coated printed boards		N/A
G.13.6.1	Sample preparation and preliminary inspection		N/A
G.13.6.2	Test method and compliance		N/A
G.14	Coating on components terminals		N/A
G.14.1	Requirements:		N/A
G.15	Pressurized liquid filled components		N/A
G.15.1	Requirements		N/A
G.15.2	Test methods and compliance		N/A
G.15.2.1	Hydrostatic pressure test		N/A
G.15.2.2	Creep resistance test		N/A
G.15.2.3	Tubing and fittings compatibility test		N/A
G.15.2.4	Vibration test		N/A

	IEC 62368-1	T				
Clause	Requirement + Test Result - Remark	Verdict				
G.15.2.5	Thermal cycling test	N/A				
G.15.2.6	Force test	N/A				
G.15.3	Compliance	N/A				
G.16	IC including capacitor discharge function (ICX)	N/A				
G.16.1	Condition for fault tested is not required	N/A				
	ICX with associated circuitry tested in equipment	N/A				
	ICX tested separately	N/A				
G.16.2	Tests	N/A				
	Smallest capacitance and smallest resistance specified by ICX manufacturer for impulse test:	_				
	Mains voltage that impulses to be superimposed on:	_				
	Largest capacitance and smallest resistance for ICX tested by itself for 10000 cycles test:	_				
G.16.3	Capacitor discharge test:	N/A				
Н	CRITERIA FOR TELEPHONE RINGING SIGNALS					
H.1	General	N/A				
H.2	Method A	N/A				
H.3	Method B	N/A				
H.3.1	Ringing signal	N/A				
H.3.1 H.3.1.1	Frequency (Hz):	N/A				
		N/A — — —				
H.3.1.1 H.3.1.2	Frequency (Hz)	N/A — — — — —				
H.3.1.1	Frequency (Hz)	N/A — — — — — — —				
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4	Frequency (Hz)	N/A — — — — N/A				
H.3.1.1 H.3.1.2 H.3.1.3	Frequency (Hz)					
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4 H.3.2 H.3.2.1	Frequency (Hz): Voltage (V): Cadence; time (s) and voltage (V): Single fault current (mA):: Tripping device and monitoring voltage Conditions for use of a tripping device or a					
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4 H.3.2 H.3.2.1	Frequency (Hz): Voltage (V): Cadence; time (s) and voltage (V): Single fault current (mA):: Tripping device and monitoring voltage Conditions for use of a tripping device or a monitoring voltage					
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4 H.3.2 H.3.2.1 H.3.2.2 H.3.2.3	Frequency (Hz)					
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4 H.3.2	Frequency (Hz)					
H.3.1.1 H.3.1.2 H.3.1.3 H.3.1.4 H.3.2 H.3.2.1 H.3.2.2 J	Frequency (Hz)					

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Clause	Requirement + Test	Result - Remark	Verdict
	Solid square and rectangular (flatwise bending) winding wire, cross-sectional area (mm²):		N/A
J.2/J.3	Tests and Manufacturing		_
K	SAFETY INTERLOCKS	1	N/A
K.1	General requirements		N/A
	Instructional safeguard:		N/A
K.2	Components of safety interlock safeguard mech	anism	N/A
K.3	Inadvertent change of operating mode		N/A
K.4	Interlock safeguard override		N/A
K.5	Fail-safe		N/A
K.5.1	Under single fault condition		N/A
K.6	Mechanically operated safety interlocks		N/A
K.6.1	Endurance requirement		N/A
K.6.2	Test method and compliance:		N/A
K.7	Interlock circuit isolation		N/A
K.7.1	Separation distance for contact gaps & interlock circuit elements		N/A
	In circuit connected to mains, separation distance for contact gaps (mm):		N/A
	In circuit isolated from mains, separation distance for contact gaps (mm)		N/A
	Electric strength test before and after the test of K.7.2		N/A
K.7.2	Overload test, Current (A):		N/A
K.7.3	Endurance test		N/A
K.7.4	Electric strength test		N/A
L	DISCONNECT DEVICES	1	N/A
L.1	General requirements		N/A
L.2	Permanently connected equipment		N/A
L.3	Parts that remain energized		N/A
L.4	Single-phase equipment		N/A
L.5	Three-phase equipment		N/A
L.6	Switches as disconnect devices		N/A

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Clause	Requirement + Test	Result - Remark	Verdict				
L.7	Plugs as disconnect devices		N/A				
L.8	Multiple power sources		N/A				
	Instructional safeguard		N/A				
M	EQUIPMENT CONTAINING BATTERIES AND THE	IR PROTECTION CIRCUITS	N/A				
M.1	General requirements						
M.2	Safety of batteries and their cells		N/A				
M.2.1	Batteries and their cells comply with relevant IEC standards		N/A				
M.3	Protection circuits for batteries provided within	the equipment	N/A				
M.3.1	Requirements		N/A				
M.3.2	Test method		N/A				
	Overcharging of a rechargeable battery		N/A				
	Excessive discharging		N/A				
	Unintentional charging of a non-rechargeable battery		N/A				
	Reverse charging of a rechargeable battery		N/A				
M.3.3	Compliance		N/A				
M.4	Additional safeguards for equipment containing battery	a portable secondary lithium	N/A				
M.4.1	General		N/A				
M.4.2	Charging safeguards		N/A				
M.4.2.1	Requirements		N/A				
M.4.2.2	Compliance ::		N/A				
M.4.3	Fire enclosure:		N/A				
M.4.4	Drop test of equipment containing a secondary lithium battery		N/A				
M.4.4.2	Preparation and procedure for the drop test		N/A				
M.4.4.3	Drop, Voltage on reference and dropped batteries (V); voltage difference during 24 h period (%)::		N/A				
M.4.4.4	Check of the charge/discharge function		N/A				
M.4.4.5	Charge / discharge cycle test		N/A				
M.4.4.6	Compliance		N/A				
M.5	Risk of burn due to short-circuit during carrying		N/A				

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Clause	Requirement + Test Result - Remark	Verdict					
M.5.1	Requirement	N/A					
M.5.2	Test method and compliance	N/A					
M.6	Safeguards against short-circuits						
M.6.1	External and internal faults	N/A N/A					
M.6.2	Compliance	N/A					
M.7	Risk of explosion from lead acid and NiCd batteries	N/A					
M.7.1	Ventilation preventing explosive gas concentration	N/A					
101.7.1	Calculated hydrogen generation rate:	N/A					
M 7.0	, , ,						
M.7.2	Test method and compliance	N/A					
	Minimum air flow rate, Q (m³/h):	N/A					
M.7.3	Ventilation tests	N/A					
M.7.3.1	General	N/A					
M.7.3.2	Ventilation test – alternative 1	N/A					
	Hydrogen gas concentration (%):	N/A					
M.7.3.3	Ventilation test – alternative 2	N/A					
	Obtained hydrogen generation rate:	N/A					
M.7.3.4	Ventilation test – alternative 3	N/A					
	Hydrogen gas concentration (%):	N/A					
M.7.4	Marking:	N/A					
M.8	Protection against internal ignition from external spark sources of batteries with aqueous electrolyte	N/A					
M.8.1	General	N/A					
M.8.2	Test method	N/A					
M.8.2.1	General	N/A					
M.8.2.2	Estimation of hypothetical volume V_Z (m³/s):						
M.8.2.3	Correction factors:						
M.8.2.4	Calculation of distance d (mm):	_					
M.9	Preventing electrolyte spillage	N/A					
M.9.1	Protection from electrolyte spillage	N/A					
M.9.2	Tray for preventing electrolyte spillage	N/A					
M.10	Instructions to prevent reasonably foreseeable misuse	N/A					

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Clause	Requirement + Test Result - Remark	Verdict
		N1/A
	Instructional safeguard:	N/A
N	ELECTROCHEMICAL POTENTIALS	N/A
	Material(s) used:	_
0	MEASUREMENT OF CREEPAGE DISTANCES AND CLEARANCES	N/A
	Value of <i>X</i> (mm):	_
Р	SAFEGUARDS AGAINST CONDUCTIVE OBJECTS	N/A
P.1	General	N/A
P.2	Safeguards against entry or consequences of entry of a foreign object	N/A
P.2.1	General	N/A
P.2.2	Safeguards against entry of a foreign object	N/A
	Location and Dimensions (mm):	—
P.2.3	Safeguards against the consequences of entry of a foreign object	N/A
P.2.3.1	Safeguard requirements	N/A
	The ES3 and PS3 keep-out volume in Figure P.3 not applicable to transportable equipment	N/A
	Transportable equipment with metalized plastic parts:	N/A
P.2.3.2	Consequence of entry test:	N/A
P.3	Safeguards against spillage of internal liquids	N/A
P.3.1	General	N/A
P.3.2	Determination of spillage consequences	N/A
P.3.3	Spillage safeguards	N/A
P.3.4	Compliance	N/A
P.4	Metallized coatings and adhesives securing parts	N/A
P.4.1	General	N/A
P.4.2	Tests	N/A
	Conditioning, T _C (°C):	_
	Duration (weeks)	_
Q	CIRCUITS INTENDED FOR INTERCONNECTION WITH BUILDING WIRING	N/A
Q.1	Limited power sources	N/A
Q.1.1	Requirements	N/A
	I I	1

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Clause	Requirement + Test Result - F	Remark Verdict				
	a) Inherently limited output	N/A				
	b) Impedance limited output	N/A				
	c) Regulating network limited output	N/A				
	d) Overcurrent protective device limited output	N/A				
	e) IC current limiter complying with G.9	N/A				
Q.1.2	Test method and compliance:	N/A				
	Current rating of overcurrent protective device (A)	N/A				
Q.2	Test for external circuits – paired conductor cable	N/A				
	Maximum output current (A):	N/A				
	Current limiting method:	_				
R	LIMITED SHORT CIRCUIT TEST	N/A				
R.1	General	N/A				
R.2	Test setup	N/A				
	Overcurrent protective device for test:	_				
R.3	Test method	N/A				
	Cord/cable used for test:	_				
R.4	Compliance	N/A				
S	TESTS FOR RESISTANCE TO HEAT AND FIRE	N/A				
S.1	Flammability test for fire enclosures and fire barrier mater where the steady state power does not exceed 4 000 W	rials of equipment N/A				
	Samples, material:	_				
	Wall thickness (mm):	_				
	Conditioning (°C)	_				
	Test flame according to IEC 60695-11-5 with conditions as set out	N/A				
	- Material not consumed completely	N/A				
	- Material extinguishes within 30s	N/A				
	- No burning of layer or wrapping tissue	N/A				
S.2	Flammability test for fire enclosure and fire barrier integrity					
	Samples, material:	_				

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Clause	Requirement + Test Result - Remark	Verdict					
	Wall thickness (mm):	_					
	Conditioning (°C):						
S.3	Flammability test for the bottom of a fire enclosure	N/A					
	-						
S.3.1	Mounting of samples	N/A					
S.3.2	Test method and compliance	N/A					
	Mounting of samples:	_					
	Wall thickness (mm):	_					
S.4	Flammability classification of materials	N/A					
S.5	Flammability test for fire enclosure materials of equipment with a steady state power exceeding 4 000 W	N/A					
	Samples, material:	_					
	Wall thickness (mm):	_					
	Conditioning (°C):	_					
Т	MECHANICAL STRENGTH TESTS						
T.1	General	N/A					
T.2	Steady force test, 10 N:	N/A					
T.3	Steady force test, 30 N:	N/A					
T.4	Steady force test, 100 N:	N/A					
T.5	Steady force test, 250 N:	N/A					
T.6	Enclosure impact test	N/A					
	Fall test	N/A					
	Swing test	N/A					
T.7	Drop test:	N/A					
T.8	Stress relief test:	N/A					
T.9	Glass Impact Test:	N/A					
T.10	Glass fragmentation test	N/A					
	Number of particles counted:	N/A					
T.11	Test for telescoping or rod antennas	N/A					
	Torque value (Nm):	N/A					
U	MECHANICAL STRENGTH OF CATHODE RAY TUBES (CRT) AND PROTECTION AGAINST THE EFFECTS OF IMPLOSION	N/A					
U.1	General	N/A					

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	IEC 62368-1						
Clause	Requirement + Test	Result - Remark	Verdict				
	Instructional safeguard:		N/A				
U.2	Test method and compliance for non-intrinsically	protected CRTs	N/A				
U.3	Protective screen						
V	DETERMINATION OF ACCESSIBLE PARTS		N/A				
V.1	Accessible parts of equipment						
V.1.1	General		N/A				
V.1.2	Surfaces and openings tested with jointed test probes		N/A				
V.1.3	Openings tested with straight unjointed test probes		N/A				
V.1.4	Plugs, jacks, connectors tested with blunt probe		N/A				
V.1.5	Slot openings tested with wedge probe		N/A				
V.1.6	Terminals tested with rigid test wire		N/A				
V.2	Accessible part criterion		N/A				
Х	ALTERNATIVE METHOD FOR DETERMINING CLE CIRCUITS CONNECTED TO AN AC MAINS NOT E RMS)		N/A				
	Clearance:		N/A				
Υ	CONSTRUCTION REQUIREMENTS FOR OUTDOO	OR ENCLOSURES	N/A				
Y.1	General		N/A				
Y.2	Resistance to UV radiation		N/A				
Y.3	Resistance to corrosion	1	N/A				
Y.3.1	Metallic parts of outdoor enclosures are resistant to effects of water-borne contaminants by:		N/A				
Y.3.2	Test apparatus		N/A				
Y.3.3	Water – saturated sulphur dioxide atmosphere		N/A				
Y.3.4	Test procedure:		N/A				
Y.3.5	Compliance		N/A				
Y.4	Gaskets		N/A				
Y.4.1	General		N/A				
Y.4.2	Gasket tests		N/A				
Y.4.3	Tensile strength and elongation tests		N/A				
	Alternative test methods:		N/A				
Y.4.4	Compression test		N/A				
		•	•				

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Clause	Requirement + Test	Result - Remark	Verdict				
Y.4.5	Oil resistance		N/A				
Y.4.6	Securing means		N/A				
Y.5	Protection of equipment within an outdoor enclose	Protection of equipment within an outdoor enclosure					
Y.5.1	General		N/A				
Y.5.2	Protection from moisture		N/A				
	Relevant tests of IEC 60529 or Y.5.3:		N/A				
Y.5.3	Water spray test		N/A				
Y.5.4	Protection from plants and vermin		N/A				
Y.5.5	Protection from excessive dust		N/A				
Y.5.5.1	General		N/A				
Y.5.5.2	IP5X equipment		N/A				
Y.5.5.3	IP6X equipment		N/A				
Y.6	Mechanical strength of enclosures		N/A				
Y.6.1	General		N/A				
Y.6.2	Impact test		N/A				

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					IEC	6236	3-1							
Clause		-	Requirem	ent +	Test	Result - Rema			nark	nark Verdict		t		
5.2	TABL	E: Classif	fication o	cation of electrical energy sources								N/A		
Supply		Location (e.g. Test conditions				3, 3			Para	ameters			ES	3
		circuit designatio	nn)			U (V	(V) I (mA)		N) Type ¹⁾		Additional Info 2)		— Clas	SS
Supplementary information:														
5.4.1.8	TA	BLE: Wo	rking vol	tage	measurer	nent							N/A	
Location				R	MS voltag (V)	je Pe	ak vo (V)	_	F	requency (Hz)		Comr	nents	
Supplemen	tary info	rmation:												
5.4.1.10.2	TABLI	E: Vicat s	oftening	temp	erature o	f therm	opla	stics					N/A	
Method						:	18	SO 306	/ B5	50			_	
Object/ Par	t No./Ma	aterial	Manu	factu	rer/tradem	nark	Thickness (mm)			T softening		ng (°C)		
Supplemen	tary info	rmation:												
5.4.1.10.3	TABLE	E. Ball pr	occuro to	et of	thermopl	actics							N/A	
Allowed imp		<u> </u>			<u> </u>			≤ 2 m	m				IN/A	
Object/Part			<u> </u>		/trademarl		kness	s (mm)		est temper	ature	Imr	ression	
						K THICKIESS (IIIII		()	(°C)			diamet)
Supplemen	tary info	rmation:												
5.4.2, 5.4.3					-						_		N/A	
Clearance creepage d (cr) at/of/be	listance	Up (V)			Freq ¹⁾ (kHz)	Requ cl (m		cl (mm))	E.S. ²⁾ (V)		uired mm)	cr (mm)	
Supplemen	tarv info	rmation:												

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					IEC 623	368-1						
Clause		R	equirement -	+ Test				Result	t - Re	mark		Verdict
	1											1
5.4.4.2			m distance									N/A
Distance th (DTI) at/of:	rough ins	ulation	Peak vo	Itage (V)	ln	sulatior	1		uired DTI (mm)	Me	easured DT (mm)
Supplemen	tary inform	nation:										
	lary iriiori	nauon.										
5.4.4.9	TABLE	: Solid in	sulation at	freque	encies >	30 kHz						N/A
Insulation n	naterial		E _P		equency (kHz)	K	Ŕ	Thicknes (mm)		Insulation	n	V _{PW} (Vpk)
Supplemen	tary inforn	nation:										
5.4.9	TABLE:	Electric	strength te	sts								N/A
Test voltage	e applied	between:			(Surge,	age sha Impuls C, etc.	e, AC,	Test	volta	ge (V)		reakdown Yes / No
Supplemen	tary infori	mation:										
	_											
5.5.2.2	TABLE:	Stored d	lischarge o	n capa	acitors							N/A
Location		Supply \	/oltage (V)		ating and condition			vitch sition		Measured Itage (Vp		ES Class
_												
Supplemen	tary infor	mation:										
5.6.6	TABLE:	Resistan	nce of prote	ctive c	onducto	ors and	termin	ations				N/A
	Location		-	st curre (A)		Dura (m	ation		tage (V)	drop	Re	sistance (Ω)
Supplemen												

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			IFC	62368	R-1						
Clause		Require	ment + Test	02000			Result - R	emark			Verdict
Oladoc		require	TIONE 1 TOOL				Tresuit Tr	CITICITY			Verdiet
5.7.4	TABLE	: Unearthed acc	cessible parts								N/A
Location		Operating and					Paramete	ers			ES
		fault condition	s Voltage (V)	,	Volta	•	Curr		Fre		class
				(V _{rms} or	V _{pk})	(Arms O	r A _{pk})	(H	Z)	
0	· : - f										
Supplement	ary inforn	nation:									
5.7.5	TARIE	· Farthad acces	ssible conductive	nart							N/A
			ssible colludelive	part							
			[] Single Phas	e; [] T	hree P	hase;	[] Delta; []	Wye			
		ystem:		[][T						
Location			Fault Condition	n No ir	n IEC	Touc	ch current		Com	me	nt
			60990 clause	6.2.2							
-											
Supplemen	tary Infor	mation:									
5.8	TABLE	: Backfeed safe	eguard in battery	/ back	ed up	suppl	ies				N/A
Location	1	Supply voltage (V)	Operating and fa	ult	Time (s)	Open-circu voltage (V		Γouch rent (A)	ES Class
Supplement	ary inforr	nation:									
6.2.2	TABLE	. Dawar agura	circuit classific	otions							N/A
Location		erating and fault			Current	. /^\	Max.	Ti.	ma (S)		PS class
Location		dition	Voltage (V)		Currern		Power ¹⁾ (W		me (S)		PS Class
Supplement	ary inforn	nation:									
6.2.3.1			n of Arcing PIS	N 4			Cali	lata -l	alus		N/A
L	ocation	•	n circuit voltage fter 3 s (Vpk)		asured current		Calcu	lated v	alue		cing PIS? Yes / No

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Clause	Requirement + Test	Result - Remark	Verdict
Supplement	ary information:		

6.2.3.2	Table: Determin	nation of Resistive PIS		N/A
Location		Operating and fault condition	Dissipate power (W)	Resistive PIS? Yes/No
Supplemen	tary Information:			

8.5.5	TABLE: High Pre	ssure Lamp			N/A
Lamp manu	facturer	Lamp type	Explosion method	Longest axis of glass particle (mm)	Particle found beyond 1 m Yes / No?
Supplement	ary information:				

9.6	TABLE:	Temperatu	ıre measur	ements fo	r wireless p	ower trans	mitters		N/A	
Supply volta	ge (V)			:					_	
Max. transm	it power o	of transmitte	r (W)	:					_	
	w/o receiver and wirect contact						ver and at of 2 mm		iver and at e of 5 mm	
Foreign o	bjects	Object (°C)	Ambient (°C)	Object (°C)	Ambient (°C)	Object (°C)	Ambient (°C)	Object (°C)	Ambient (°C)	
Supplementa	Supplementary information:									

5.4.1.4, 9.3, B.1.5, B.2.6	TABLE: Temperature measurements	5				Pass			
Supply volta	age (V):	2.7Vdc	5.5Vdc	2.7Vdc	5.5Vdc	_			
Ambient ten	Ambient temperature during test T_{amb} (°C)								
Model AP21	510	26.2	27.5	86.4	88.3	130			

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	IEC 62368-1												
Clause	Clause Requirement + Test						R	esul	t - Rema	ark		Verdict	
Model AP21	Model AP2111						35.7 91.5 9		91.	.7	130		
Model AP21	81D			31.1		28.6 90		90.	1	88.	.7	130	
Temperature	T of winding:	t ₁ (°C)	R	1 (Ω)	t ₂ ('	°C)	R ₂ (Ω	2)	T (°C)		Allowed T _{max} (°C)	Insulation class	
										-	-		
Supplementa	Supplementary information:												
	-												

B.2.5		TABLE: Inpu	ABLE: Input test								
U (V)	Hz	I (A)	I rated (A)	P (W)	P rated (W)	Fuse No	I fuse (A)	Conditi	on/status		
Supple	menta	ary informatio	n:								

B.3, B.4 T	ABLE: Abnormal o	operating	and fault	condition t	tests		Pass
Ambient tempe	erature T _{amb} (°C)				: 23C		_
Power source	for EUT: Manufact	urer, model	/type, out	put rating .	: -		_
Component No	o. Condition	Supply voltage (V)	Test time	Fuse no.	Fuse current (A)	Observation	
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Overload	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP2191D (Current Limit:2.6A)	Overload	2.7 – 5.5Vdc	50 cycles	N/A	50 cycles complete d. There was no fire or shock hazard for all outputs tested.	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP2151 (Current Limit:0.5A)	0 Overload	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles complete was no fire or shock ha outputs tested.	

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			IEC	62368-1			
Clause	Requ	irement +	Test		Re	esult - Remark	Verdict
	To Maximum Rated Load, Enable Pin Off to On						
Model AP2191D (Current Limit:2.6A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded To Maximum Rated Load, Enable Pin Off to On	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles complete was no fire or shock has outputs tested.	
Model AP21510 (Current Limit:0.5A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded To Maximum Rated Load, Enable Pin Off to On	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles complete was no fire or shock has outputs tested.	
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Off to On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP2191D (Current Limit:2.6A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Off to On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP21510 (Current Limit:0.5A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Off to On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	
Model AP2111 (Current Limit:5A and	Tamb = -40°C Enable pin – Cycle: Power On with	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. T no fire or shock hazard outputs tested.	

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	IEC 62368-1							
Clause		Requ	irement +	Test		R	esult - Remark	Verdict
Current Limit:2.9A)		Output Short- Circuited, Enable Pin Of						
Model AP2191D (Current Limit:2.6A)		Tamb = -40°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Of	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP21: (Current Limit:0.5A)	510	Tamb = -40°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Of	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP21 (Current Limit:5A and Current Limit:2.9A)		Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP2191D (Current Limit:2.6A)		Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP21: (Current Limit:0.5A)	510	Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP21 (Current Limit:5A and Current Limit:2.9A)		Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	
Model AP2191D (Current Limit:2.6A)		Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.	

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	IEC 62368-1		
Clause	Requirement + Test	Result - Remark	Verdict

<u> </u>						
	to Circuit Off to Power On					
Model AP21510 (Current Limit:0.5A)	Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2191D (Current Limit:2.6A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP21510 (Current Limit:0.5A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A	The current did not display any significant change after 7 days of operation and the device was capable of performing its intended function.
Model AP2191D (Current Limit:2.6A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A	The current did not display any significant change after 7 days of operation and the device was capable of performing its intended function.
Model AP21510 (Current Limit:0.5A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A	The current did not display any significant change after 7 days of operation and the device was capable of performing its intended function.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Overload	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.

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IEC 62368-1								
Clause	Requ	irement +	Test		R	esult - Remark	Verdict	
Model AP2191D (Current Limit:2.6A)	Overload	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.		
Model AP21510 (Current Limit:0.5A)	Overload	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. To fire or shock hazard outputs tested.		
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded To Maximum Rated Load, Enable Pin Off to On	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles completed. There was no fire or shock hazard for all outputs tested.		
Model AP2191D (Current Limit:2.6A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded To Maximum Rated Load, Enable Pin Off to On	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles completed. There was no fire or shock hazard for all outputs tested.		
Model AP21510 (Current Limit:0.5A)	Tamb = 25°CEnable pin – Cycle: Power On with Loaded To Maximum Rated Load, Enable Pin Off to On	2.7 – 5.5Vdc	10,000 cycles	N/A	N/A	10,000 cycles completed. There was no fire or shock hazard for all outputs tested.		
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Off to On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.		
Model AP2191D (Current Limit:2.6A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited,	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.		

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Clause	Requirement + Test	Result - Remark	Verdict

	Enable Pin Off to On					
Model AP21510 (Current Limit:0.5A)	Tamb = 85°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Off to On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = -40°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Of	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2191D (Current Limit:2.6A)	Tamb = -40°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Of	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP21510 (Current Limit:0.5A)	Tamb = -40°C Enable pin – Cycle: Power On with Output Short- Circuited, Enable Pin Of	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2191D (Current Limit:2.6A)	Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP21510 (Current Limit:0.5A)	Tamb = 85°C Input Power pin – Cycle: Output Short- Circuit, Power	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.

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Clause	Requirement + Test	Result - Remark	Verdict

	to Circuit Off to Power On					
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2191D (Current Limit:2.6A)	Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP21510 (Current Limit:0.5A)	Tamb = -40°C Input Power pin – Cycle: Output Short- Circuit, Power to Circuit Off to Power On	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2191D (Current Limit:2.6A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP21510 (Current Limit:0.5A)	Tamb = 85°C Input power pin – cycle: Power On with Output Open Circuit to Short	2.7 – 5.5Vdc	50 cycles	N/A	N/A	50 cycles completed. There was no fire or shock hazard for all outputs tested.
Model AP2111 (Current Limit:5A and Current Limit:2.9A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A	The current did not display any significant change after 7 days of operation and the device was capable of performing its intended function.

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IEC 62368-1								
Clause	Requ	uirement + 7	Test	Result - Remark		Verdict		
Model AP2191D (Current Limit:2.6A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A	The current did not disp significant change after operation and the devic capable of performing i function.	7 days of ce was	
Model AP21510 (Current Limit:0.5A)	Output Short Circuit to Ground	6.05Vdc	7 Days	N/A	N/A The current did not display any significant change after 7 days o operation and the device was capable of performing its intende function.		7 days of ce was	
Supplementary information:								
-	-							

M.3	TABLE: Pro	tection circuit	s fo	r batteries	provided	with	in the	equipn	nent		N/A
Is it possible to install the battery in a reverse polarity position?:									_		
	Charging										
Equipment Specification			Vo	oltage (V)			Current (A)				
					Battery	spec	ificatio	on			
		Non-recharge	able	batteries			Recl	hargeabl	e batteries		
	Discharging	Unintentional		Charging		ging		Discharging		Reverse	
Manufactu	ırer/type	current (A)	charging current (A)		Voltage (V) Cu		Curr	ent (A)	current (A)		charging urrent (A)
Note: The tests	s of M.3.2 are	applicable only	whe	en above ap	propriate o	data	is not	available	€.		
Specified batte	ery temperatu	ıre (°C)			:						
Component No.	Charge/ Test discharge mode		Test time	Temp. (°C)		rrent (A)	Voltage (V)	e Obse	rva	tion	
Supplementary	Supplementary information:										
	-										

M.4.2	TABLE: Charging safeguards for equipment containing a secondary lithium battery			
Maximum specified charging voltage (V):				
Maximum specified charging current (A):				
Highest specified charging temperature (°C):				
Lowest spec	ified charging temperature (°C):			

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	IEC 62368-1									
Clause		Requiren	nent + Test	Result -	- Remark	Verdict				
Battery Operating Meas		Measureme	ent	Observat	ion					

Battery manufacturer/type	Operating	_			Observation						
	and fault condition	Charging voltage (V)	Charging current (A)	Temp. (°C)							
Supplementary information	Supplementary information:										

Q.1	TABLE: Circuits intended for interconnection with building wiring (LPS)									
Output Circuit	Condition	U _{oc} (V)	Time (s)	I _{sc} (A)		S (VA)			
	Condition			Meas.	Limit	Meas.	Limit			
Supplemen	Supplementary Information:									

T.2, T.3, T.4, T.5	TABLE	TABLE: Steady force test								
Location/Part		Material	Thickness (mm)	Probe	Force (N)	Test Duration (s)	Obse	ervation		
Supplementary information:										

T.6, T.9	TABLE: Impact test									
Location/Part		Material	Thickness (mm)	Height (mm)	Observation	1				
Supplementa	Supplementary information:									

T.7	TABLE: Drop	test			N/A				
Location/Part		Material	Thickness (mm)	Height (mm)	Observation				
Supplementa	Supplementary information:								

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IEC 62368-1							
Clause	Requirement + Test	Result - Remark	Verdict				

T.8	TABLE	TABLE: Stress relief test								
Location/Part		Material	Thickness (mm)	Oven Temperature (°C)	Duration (h)	Obser	vation			
Supplementa	Supplementary information:									

Х	TABLE: Alternative method for determining minimum clearances distances N/A						
Clearance distanced between:		Peak of working voltage (V)	Required cl (mm)	Measure (mm)			
Supplementa	ary information:						
	•						

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	IEC 62368-1		
Clause	Requirement + Test	Result - Remark	Verdict

4.1.2	TAB	LE: Critical components information						
Object / part No.		Manufacturer/ trademark	Type / model	Technical data	Standard		k(s) of formity ¹⁾	
Housing/Molo Compound	ded	Interchangeable	Interchangeable	130 degree C	UL 746C (6th)+	- , U	L, N/A	
+ Indicates U standard has requirements meet or except the relevant requirements IEC standard Column.	that ed in					, -	-	

Supplementary information:

¹⁾ Provided evidence ensures the agreed level of compliance. See OD-CB2039.

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Enclosure National Differences

USA / Canada



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IEC62368_1E - ATTACHMENT				
Clause	Requirement + Test	Result - Remark	Verdict	

	IEC 62368-1 - US and Canadian National Differences Special National Conditions based on Regulations and Other National Differences					
1 (1DV.1) (1.3)	All equipment is to be designed to allow installation in accordance with the National Electrical Code (NEC), ANSI/NFPA 70, the Canadian Electrical Code (CEC), Part 1, CAN/CSA C22.1, and when applicable, the National Electrical Safety Code, IEEE C2. Also, for such equipment marked or otherwise identified, installation is allowed per the Standard for the Protection of Information Technology Equipment, ANSI/NFPA 75.	N/A				
1 (1DV.2.1)	This standard includes additional requirements for equipment used for entertainment purposes intended for installation in general patient care areas of health care facilities. See Annex DVB.	N/A				
1 (1DV.2.2)	This standard includes additional requirements for equipment intended for mounting under cabinets. See Annex DVC.	N/A				
1 (1DV.2.3)	IEC 62368-3 clause 5 for DC power transfer at ES1 or ES2 voltage levels is considered informative. IEC 62368-3 clause 6 for remote power feeding telecommunication (RFT) circuits is considered normative (see ITU K.50). Alternatively, equipment with RFT circuits are given in either UL 2391 or CSA/UL 60950-21. RFT-C circuits are not permitted unless the RFT-C circuit complies with RFT-V limits (≤ 200V per conductor to earth).	N/A				
1 (1DV.3)	For protection against direct lightning strikes, reference is made to NFPA 780 and CAN/CSA-B72 for additional requirements.	N/A				

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IEC62368_1E – ATTACHMENT						
Clause	Requirement + Test	Result - Remark	Verdict			
1 (1DV.5)	Additional requirements apply to some forms of power distribution equipment, including subassemblies.		N/A			
4.1 (4.1.17)	For lengths exceeding 3.05 m, external interconnecting cable assemblies are required to be a suitable cable type (e.g., DP, CL2) specified in the NEC.		N/A			
	For lengths 3.05 m or less, external interconnecting cable assemblies that are not types specified in the NEC generally are required to have special construction features and identification markings.		N/A			
4.6 (4.6.2)	Wire-wrap terminals have special construction and performance requirements.		N/A			
4.8 (4.8.3, 4.8.4.5, 4.8.5)	Coin / button cell batteries have modified special construction and performance requirements.		N/A			
5.4.2.3.2 (5.4.2.3.2.1)	Surge Arrestors and Transient Voltage Surge Suppressors installed external to the equipment are required to comply with the appropriate NEC and CEC requirements.		N/A			
5.5.9	Receptacles, rated 125-V, single phase, 15- or 20-A accessible to either ordinary, instructed, or skilled persons are required to be provided with GFCI Protection for Personnel if the equipment containing the receptacles is installed outdoors. The protection devices are required to comply with UL 943, and CAN/CSA C22.2 No.144.		N/A			
5.6.3	Protective earthing conductors comply with the minimum conductor sizes in Table G.7, except as required by Table G.7ADV.1 for cord connected equipment, or Annex DVH for permanently connected equipment.		N/A			
5.7.8 (5.7.8.1)	Equipment intended to receive telecommunication ringing signals is required to comply with a special touch current measurement tests.		N/A			
6.5.1	PS3 wiring outside a fire enclosure is required to comply with single fault testing in B.4, or be current limited per one of the permitted methods.		N/A			
Annex F (F.3.3.9)	Output terminals provided for supply of other equipment, except mains supply, are required to be marked with a maximum rating or reference to equipment permitted to be connected.		N/A			
Annex F (F.3.7)	Outdoor Enclosures are required to be classified and marked in accordance with UL 50 or 50E, or CAN/CSA C22.2 No. 94.1 or 94.2.		N/A			
Annex G (G.7)	Permanent connection of equipment to the mains supply by a power supply cord is not permitted, except for certain equipment, such as ATMs.		N/A			

	IEC62368_1E - ATTACHMENT					
Clause	Requirement + Test	Result - Remark	Verdict			
	Power supply cords are required to have attachment plugs rated not less than 125 percent of the rated current of the equipment.		N/A			
	Flexible power supply cords are required to be compatible with Article 400 of the NEC, and Tables 11 and 12 of the CEC.		N/A			
	Minimum cord length is required to be 1.5 m, with certain constructions such as external power supplies allowed to consider both input and output cord lengths into the requirement. Power supply cords are required to be no longer than 4.5 m in length if used in ITE Rooms.		N/A			
	Power supply cords for outdoor equipment are required to be suitable outdoor use type as required by Section 400.4 of the NEC and Rule 4-012 of the CEC, i.e., marked "W."		N/A			
Annex H.2	Continuous ringing signals under normal operating conditions up to 16 mA only are permitted if the equipment is subjected to special installation and performance restrictions.		N/A			
Annex H.4	For circuits with other than ringing signals and with voltages exceeding 42.4 Vpeak or 60 Vd.c., the maximum acceptable current through a 2000 ohm resistor (or greater) connected across the voltage source with other loads disconnected is 7.1 mA peak or 30 mA d.c. under normal operating conditions.		N/A			
Annex Q (Q.3)	Equipment with paired conductor and/or coax communications cables/wiring connected to building wiring are required to have special voltage, current, power and marking requirements.		N/A			
Annex DVA (1)	Equipment that is designed such that it may be powered from a separate electrical service, is required to meet applicable requirements for service equipment for control and protection of services and their installation and complies with Article 230 of the National Electrical Code (NEC), NFPA 70 and Section 6 of the Canadian Electrical Code, Part I, CSA C22.1.		N/A			
	Equipment intended for use in spaces used for environmental air (plenums) are subjected to special flammability requirements for heat and visible smoke release.		N/A			
	For ITE room applications, automated information storage systems with combustible media greater than 0.76 m³ (27 cu ft) are required to have a provision for connection of either automatic sprinklers or a gaseous agent extinguishing system with an extended discharge.		N/A			
	Consumer products designed or intended primarily for children 12 years of age or younger are subject to additional requirements in accordance with U.S. and Canadian Regulations.		N/A			

	IEC62368_1E - ATTACHMENT					
Clause	Requirement + Test	Result - Remark	Verdict			
	Baby monitors are required to additionally comply with ASTM F2951, Consumer Safety Specification for Baby Monitors.		N/A			
	Storage batteries and battery management equipment, other than associated with lead-acid batteries, and including battery backup systems that are not an integral part of stationary AV and ICT equipment, such as provided in separate cabinets, are required to be certified (listed) to the appropriate standard(s) for such storage batteries and equipment.		N/A			
Annex DVA (5.6)	For Pluggable Equipment Type A, the protection in the installation is assumed to be 20A.		N/A			
Annex DVA (6.3)	The maximum quantity of flammable liquid stored in equipment is required to comply with NFPA 30.		N/A			
Annex DVA (6.4.8)	For ITE room applications, enclosures with combustible material measuring greater than 0.9 m ² (10 sq ft) or a single dimension greater than 1.8 m (6 ft) are required to have a flame spread rating of 50 or less. For equipment with the same dimensions for other applications, an external surface that is not a fire enclosure requires a minimum flammability classification of V-1.		N/A			
Annex DVA (10.3)	Equipment with lasers is required to meet the U.S. Code of Federal Regulations 21 CFR 1040 (and the Canadian Radiation Emitting Devices Act, REDR C1370).		N/A			
Annex DVA (10.5)	Equipment that produces ionizing radiation is required to comply with the U.S. Code of Federal Regulations, 21 CFR 1020 (and the Canadian Radiation Emitting Devices Act, REDR C1370).		N/A			
Annex DVA (F.3.3.4)	Equipment for use on a.c. mains supply systems with a neutral and more than one phase conductor (e.g. 120/240 V, 3-wire) require a special marking format for electrical ratings. Additional considerations apply for voltage ratings that exceed the attachment cap rating or that are lower than the "Normal Operating Condition" in Table 2 of CAN/CSA C22.2 No. 235."		N/A			
Annex DVA (F.3.3.6)	Equipment identified for ITE (computer) room installation is required to be marked with the rated current.		N/A			
Annex DVA (G.1)	Vertically-mounted disconnect switches and circuit breakers are required to have the "on" position indicated by the handle in the up position, where mounted in an enclosure, vertically mounted disconnect switches and circuit breakers with vertical operating means extending outside the enclosure are required to indicate in a location visible when accessing the external operating means whether the switch or circuit breaker is in the open (off) or closed (on) position.		N/A			

	IEC62368_1E – ATTACHM	ENT	
Clause	Requirement + Test	Result - Remark	Verdict
Annex DVA (G.3.4)	Suitable NEC/CEC branch circuit protection rated at the maximum circuit rating is required for all standard supply outlets and receptacles (such as supplied in power distribution units) if the supply branch circuit protection is not suitable.		N/A
	Where a fuse is used to provide Class 2 or Class 3 current limiting, it is not operator-accessible unless it is non- interchangeable.		N/A
Annex DVA (G.4.2)	Equipment with isolated ground (earthing) receptacles is required to comply with NEC 250.146(D) and CEC 10-400 and 10-612.		N/A
Annex DVA (G.4.3)	Interconnection of units by conductors supplied by a limited power source, or a Class 2 circuit defined in the NEC/CEC may have field wiring connections other than specified in DVH.3, such as wire-wrap and crimp-on types, if the limited power source and Class 2 circuits are separated from all other circuits by barriers, routing or fixing.		N/A
Annex DVA (G.5.3)	Power distribution transformers distributing power at 100 volts or more, and rated 10 kVA or more, require special transformer overcurrent protection.		N/A
Annex DVA (G.5.4)	Motor control devices are required for cord-connected equipment with a mains-connected motor if the equipment is rated more than 12 A, or if the equipment has a nominal voltage rating greater than 120 V, or if the motor is rated more than 1/3 hp (locked rotor current over 43 A).		N/A
Annex DVA (G.7)	Flexible cords used outdoors are required to have the suffix "W" marked on the flexible cord.		N/A
Annex DVA (M)	For ITE room applications, equipment with battery systems capable of supplying 750 VA for five minutes are required to have a battery disconnect means that may be connected to the ITE room remote power-off circuit.		N/A
Annex DVA (Q)	If applicable per NEC 725.121(C), some limited power sources supplied from AV/ICT equipment are required to have a label indicating the maximum voltage and rated current output per conductor for each connection point. Where multiple connection points have the same rating, a single label is permitted to be used.		N/A
	Wiring terminals intended to supply Class 2 outputs in accordance with the NEC or CEC Part 1 are required to be marked with the voltage rating and "Class 2" or equivalent. The marking is located adjacent to the terminals and visible during wiring.		N/A
	Applicable parts of Chapter 8 of the NEC, and Rules 54 and 60 of the CEC, may be applicable to ITE installed outdoors with connections to communication systems.		N/A
Annex DVB (1)	Additional requirements apply for equipment used for entertainment purposes intended for		N/A

	IEC62368_1E - ATTACHMENT					
Clause	Requirement + Test	Result - Remark	Verdict			
	installation in general patient care areas of health					
	care facilities.					
Annex DVC (1)	Additional requirements apply for equipment intended for mounting under kitchen cabinets.		N/A			
Annex DVE (4.1.1)	Some equipment, components, sub-assemblies and materials associated with the risk of fire, electric shock, or personal injury are required to have component or material ratings in accordance with the applicable national (U.S. and Canadian) component or material requirements. These equipment and components include: appliance couplers, attachment plugs, battery backup systems, circuit breakers, communication circuit accessories, connectors (used for current interruption of non-LPS circuits), direct plug-in equipment, electrochemical capacitor modules (energy storage modules with ultracapacitors), enclosures (outdoor), flexible cords and cables, fuses (branch circuit), ground-fault current interrupters, interconnecting cables, modular data centers, power supply cords, some power distribution equipment, printed wiring, protectors for communications circuits, receptacles, surge protective devices, vehicle battery adapters, wire connectors, and wire and cables.		N/A			
Annex DVH	Equipment for permanent connection to the mains supply is subjected to additional requirements.		N/A			
Annex DVH (DVH.1)	Wiring methods (terminals, leads, etc.) used for the connection of the equipment to the mains are required to be in accordance with the NEC/CEC.		N/A			
Annex DVH (DVH.2.1)	For safe and reliable connection to a mains, permanently connected equipment is to be provided.		N/A			
Annex DVH (DVH.2.2)	Additional considerations for D.C. mains.		N/A			
Annex DVH (DVH.3.2.1)	Terminals for permanent wiring, including protective earthing terminals, are required to be suitable for U.S./Canadian wire gauge sizes, rated 125 percent of the equipment rating, and be specially marked when specified.		N/A			
Annex DVH (DVH.3.2.3)	Wire binding screws are not permitted to attach conductors larger than 10 AWG (5.3 mm ²).		N/A			
Annex DVH (DVH.3.2.4)	All associated mains supply terminals are located in proximity to each other and to the main protective earthing terminal, if any.		N/A			
Annex DVH (DVH.3.2.5)	Terminals are located, guarded or insulated so that, should a strand of a conductor escape when the conductor is fitted, there is no likelihood of accidental contact between such a strand and accessible conductive parts or unearthed conductive parts separated from accessible conductive parts by supplementary insulation only.		N/A			

	IEC62368_1E - ATTAC	CHMENT		
Clause	Requirement + Test	Result - Remark	Verdict	
Annex DVH (DVH.3.3)	When field connection to an external circuit is via wires (example, free conductors), the wires are not smaller than 18 AWG (0.82 mm²) and the free length of the wire inside an outlet box or wiring compartment is 150 mm or more.		N/A	
Annex DVH (DVH.3.4)	Size of protective earthing conductors and terminals	(See sub-clause 5.6.5)	N/A	
Annex DVH (DVH.4)	Permanently connected equipment is required to have a suitable wiring compartment and wire bending space.		N/A	
Annex DVH (DVH.4.1)	Wire bending space		N/A	
Annex DVH (DVH.4.2)	Volume of wiring compartment		N/A	
Annex DVH (DVH.4.3)	Separation of circuits		N/A	
Annex DVH (DVH.5)	Equipment markings and instructional safeguards		N/A	
Annex DVH (DVH.5.1)	Identification of protective earthing terminal		N/A	
Annex DVH (DVH.5.2)	Identification of terminal for earthed conductor (neutral)		N/A	
Annex DVH (DVH.5.3)	Identification of terminals for aluminium conductors		N/A	
Annex DVH (DVH.5.4)	Wire temperature ratings		N/A	
Annex DVH (DVH.5.5)	Equipment connected to a centralized d.c. power system, and having one pole of the DC mains input terminal connected to the main protective earthing terminal in the equipment, is required to comply with special earthing, wiring, marking and installation instruction requirements.		N/A	
Annex DVI (6.7)	Equipment intended for connection to telecommunication network outside plant cable is required to be protected against overvoltage from power line crosses.		N/A	
Annex DVJ (10.6.1)	Equipment connected to a telecommunication and cable distribution networks and supplied with an earphone intended to be held against, or in the ear is required to comply with special acoustic pressure requirements.		N/A	

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Enclosures

Enclosures

Туре	Supplement Id	Description	
Photographs	03-01	Overall view of Evaluation Board	
Schematics + PWB	05-01	Test Schematic	
Manuals	06-01	Datasheet AP2141 and AP2151	
Manuals	06-02	Datasheet AP2161A and AP2171A	
Manuals	06-03	Datasheet AP2181 and AP2191	
Manuals	06-04	Datasheet AP21410 and AP21510	
Manuals	06-05	Datasheet AP2101 and AP2111	
Manuals	06-06	Datasheet AP2141D and AP2151D	
Manuals	06-07	Datasheet AP2161D and AP2171D	
Manuals	06-08	Datasheet AP2181D and AP2191D	
Manuals	06-09	Datasheet AP2146 and AP2156	
Manuals	06-10	Datasheet AP2151A	
Manuals	06-11	Datasheet AP2161 and AP2171	
Manuals	06-12	Datasheet AP2181A and AP2191A	
Miscellaneous	07-01	Draft CB Report Certificate Information	
Miscellaneous	07-04	Packaging	
Miscellaneous	07-05	Annex - G9	

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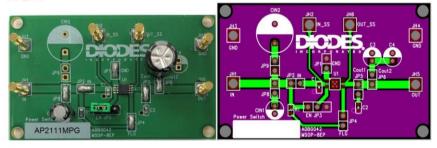
Enclosures

Photographs ID 03-01

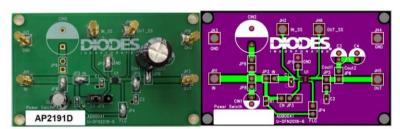
AP21510



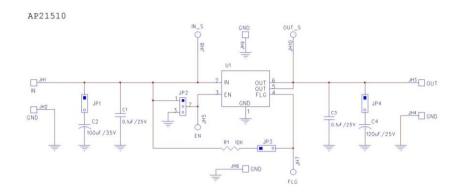
AP2111



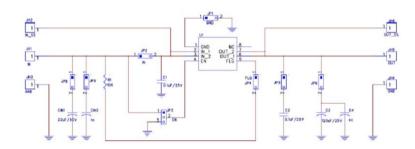
AP2191D



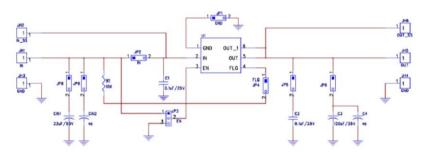
Schematics + PWB ID 05-01



AP2111



AP2191D



Manuals ID 06-01



2024-07-24



AP2141/ AP2151

0.5A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2141 and AP2151 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. This family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25 and U-DFN2018-6 packages.

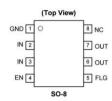
Features

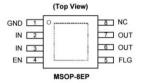
- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 0.8A Accurate Current Limiting
- Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) with Blanking Time (7ms Typ)
- ESD Protection: 4kV HBM, 400V MM
- Active High (AP2151) or Active Low (AP2141) Enable
- Ambient Temperature Range -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- 15kV ESD Protection per IEC 61000-4-2 (With External
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

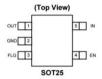
Applications

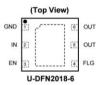
- Consumer Electronics LCD TV & Monitor, Game Machines
- Communications Set-Top Box, GPS, Smartphone
- Computing Laptop, Desktop, Servers, Printers, Docking Station, HUB

Pin Assignments









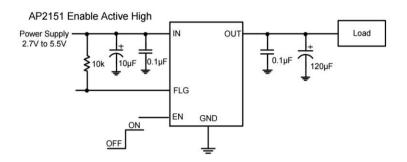
- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
- 2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free
- 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds

Manuals ID 06-01



AP2141/ AP2151

Typical Applications Circuit



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2141	1	Active Low	0.8A	0.5A
AP2151	1	Active High	0.8A	0.5A

Pin Descriptions

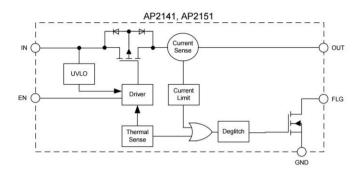
Pin		Pin Nu	umber		Fire-Man	
Name	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Function	
GND	1	1	2	1	Ground	
IN	2, 3	2, 3	5	2	Voltage Input Pin (all IN pins must be tied together externally)	
EN	4	4	4	3	Enable Input Active Low (AP2141) or Active High (AP2151)	
FLG	5	5	3	4	Over-Current and Over-Temperature Fault Report Open-Drain flag is active low when triggered	
OUT	6, 7	6, 7	1	5, 6	Voltage Output Pin (all OUT pins must be tied together externally)	
NC	8	8	_	_	No internal connection; recommend tie to OUT pins	
Exposed Pad	-	Exposed Pad	-	Exposed Pad	Exposed Pad It should be externally connected to GND plane and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

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Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol		Parameter		Ratings	Units
	НВМ	Human Body Model ESD Protection	4	kV	
	ММ	Machine Model ESD Protection for SO-8, MSOP-8EP, SOT25 Packages	400	٧	
ESD	ММ	Machine Model ESD Protection for U-DFN2018-6, SO-8 Packages			V
	IEC System	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Air	15	kV
	Level	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Contact	8	kV
VIN	Input Voltage			6.5	V
V _{OUT}	Output Voltag	ge		V _{IN} +0.3	V
VEN, VFLG	Enable Voltag	ge		6.5	V
I _{LOAD}	Maximum Co	ntinuous Load Current	Internal Limited	Α	
$T_{J(MAX)}$	Maximum Jur	nction Temperature	+150	°C	
T _{ST}	Storage Tem	perature Range (Note 4)		-65 to +150	°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time. Caution:

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

- 4. UL Recognized Rating from -30°C to +70°C (Diodes qualified T_{ST} from -65°C to +150°C).
 5. External capacitors need to be connected to the output, EVM board tested with capacitor 2.2µF 50V 0805. This level is a pass test only and not a limit.

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units
VIN	Input Voltage	2.7	5.5	٧
lout	Output Current	0	500	mA
TA	Operating Ambient Temperature	-40	+85	°C
VIL	EN Input Logic Low Voltage	0	0.8	V
VIH	EN Input Logic High Voltage	2	Vin	٧

AP2141/ AP2151 Document number: DS31562 Rev. 10 - 2

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$\begin{tabular}{ll} \textbf{Electrical Characteristics} & \textbf{(@TA = +25^{\circ}C, V_{IN} = 5.0V, unless otherwise specified.)} \\ \end{tabular}$

Symbol	Parameter	Conditions		Min	Тур	Max	Unit	
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$	$R_{LOAD} = 1k\Omega$		1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OU}	Disabled, I _{OUT} = 0		-	0.5	1	μA
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0			45	70	μA
I _{LEAK}	Input Leakage Current	Disabled, OU	T Grounded		i —		1	μA
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} =	5V, I _{REV} at V _{IN}		1	_	μА
		V - 51	T _A = +25°C	SOT25, SO-8, MSOP-8EP	11.	95	115	
		$V_{IN} = 5V$, $I_{OUT} = 0.5A$	1A = +25 C	U-DFN2018-6	1	90	110	
R _{DS(ON)}	Switch On-Resistance	1001 - 0.5A	-40°C ≤ T _A ≤	+85°C	1-	_	140	mΩ
		$V_{IN} = 3.3V$	$T_A = +25^{\circ}C$			120	140	
		$I_{OUT} = 0.5A$	-40°C ≤ T _A ≤	+85°C	-	_	170	
I _{SHORT}	Short-Circuit Current Limit	Enabled into	Short Circuit,	C _L = 22µF	-	0.6	<u> </u>	Α
LIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OU}	$V_{IN} = 5V$, $V_{OUT} = 4.8V$, $C_L = 22\mu F$, $-40^{\circ}C \le T_A \le +85^{\circ}C$		0.6	0.8	1.0	Α
I _{TRIG}	Current Limiting Trigger Threshold	Output Currer	Output Current Slew Rate (<100A/s), C _L = 22µF		_	1.0	_	Α
I _{SINK}	EN Input Leakage	V _{EN} = 5V		_	_	1	μА	
t _{D(ON)}	Output Turn-On Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		1	0.05		ms	
t _R	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		1	0.6	1.5	ms	
t _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			1-	0.01	_	ms
t _F	Output Turn-Off Fall Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		_	0.05	0.1	ms	
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA			_	20	40	Ω
t BLANK	FLG Blanking Time	C _{IN} = 10µF, C _L = 22µF		4	7	15	ms	
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$		_	+140	_	°C	
THYS	Thermal Shutdown Hysteresis	_		-	+25		°C	
		SO-8 (Note 6)			110	=	°C/W	
0	Thermal Resistance Junction-to-	MSOP-8EP (Note 7)			1. Total	60	-	°C/W
θ_{JA}	Ambient	SOT25 (Note	8)		<u> </u>	157	_	°C/W
			(Note 9)			70	_	°C/W

Notes:

^{6.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
7. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
8. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
9. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0"x1.4" ground plane.

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Typical Performance Characteristics

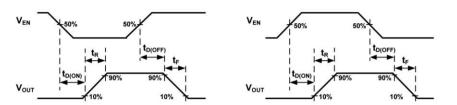
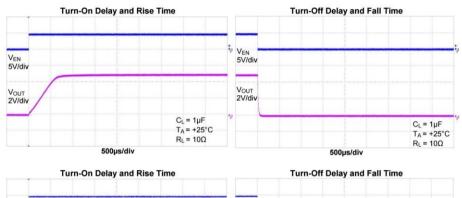
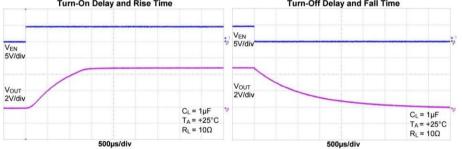


Figure 1. Voltage Waveforms: AP2141 (Left), AP2151 (Right)

All Enable Plots are for AP2151 Active High





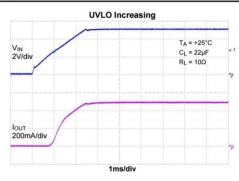
Manuals ID 06-01

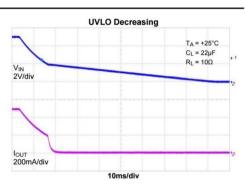


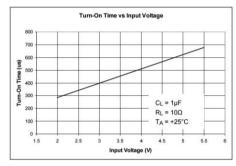


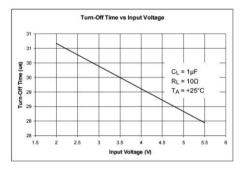
AP2141/ AP2151

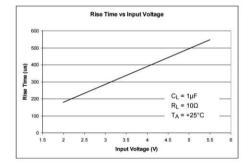
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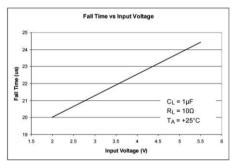










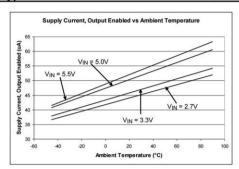


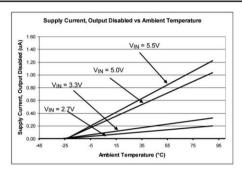
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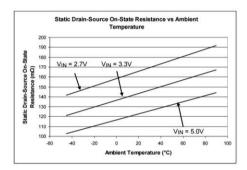


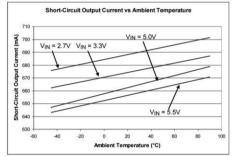
AP2141/ AP2151

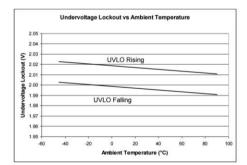
Typical Performance Characteristics (Cont.)

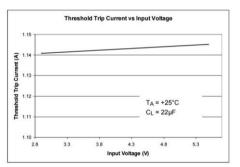










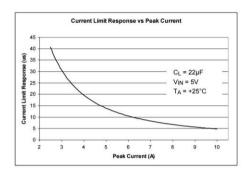


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AP2141/ AP2151

Typical Performance Characteristics (Cont.)



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AP2141/ AP2151

Application Information

Power Supply Considerations

A $0.01\mu F$ to $0.1\mu F$ X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input ($10\mu F$ minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a $0.01\mu F$ to $0.1\mu F$ ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2141/AP2151 senses the short circuit and immediately clamps output current to a certain safe level namely I_{SHORT} .

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current limit is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the device switches into current limiting mode and the current is clamped at Internal Control of the current limiting mode and the current limiting mode

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2141/AP2151 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT}.

Note that when the output has been shorted to GND at extremely low temperature (< -30°C), a minimum 120µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7ms deglitch timeout. The FLG will be triggered at above 500mA to indicate possible Over-Current condition. The AP2141/AP2151 is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where

 T_A = Ambient temperature °C $R_{\theta JA}$ = Thermal resistance P_D = Total power dissipation

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Application Information (Cont.)

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2141/AP2151 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition, the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7ms deglitch.

Under-Voltage Lockout (UVLO)

Undervoltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and self-powered hubs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

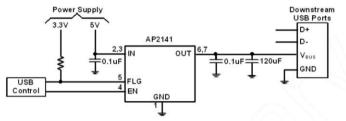


Figure 2. Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall times of the AP2141/AP2151, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2141/AP2151 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2141/AP2151 between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

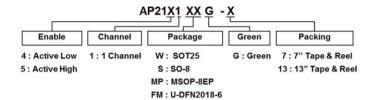
AP2141/AP2151 is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a non-recommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. If a voltage is maintained across the output of the AP2141/AP2151 when the output is disabled and the V_{IN} of the device is subsequently ramped up, an overstress condition to the AP2141/AP2151 may result.

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Ordering Information

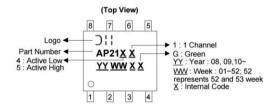


Don't Name have	Deelessa Code	Declaries (Note 40)	7" / 13" Ta	pe and Reel
Part Number	Package Code	Packaging (Note 10)	Quantity	Part Number Suffix
AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1FMG-7	FM	U-DFN2018-6	3.000/Tape & Reel	-7

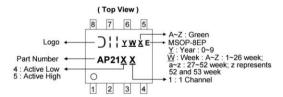
Note: 10. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information

(1) SO-8



(2) MSOP-8EP



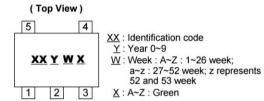
Manuals ID 06-01



AP2141/ AP2151

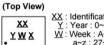
Marking Information (Cont.)

(3) SOT25



Device	Package Type	Identification Code
AP2141W	SOT25	HR
AP2151W	SOT25	HS

(4) U-DFN2018-6



XX: Identification Code
Y: Year: 0-9
W: Week: A-Z: 1-26 week;
a-z: 27-52 week; z represents
52 and 53 week
X: A-Z: Green

Device	Package Type	Identification Code
AP2141FM	U-DFN2018-6	HR
AP2151FM	U-DFN2018-6	HS

Manuals ID 06-01

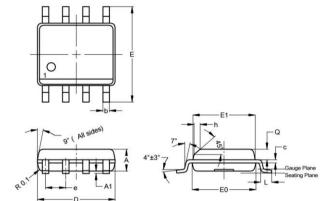


AP2141/ AP2151

Package Outline Dimensions

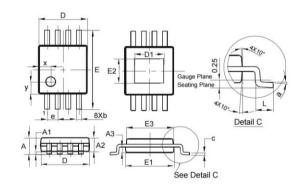
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SO-



	SO-	-8		
Dim	Min	Max	Тур	
Α	1.40	1.50	1.45	
A1	0.10	0.20	0.15	
b	0.30	0.50	0.40	
С	0.15	0.25	0.20	
D	4.85	4.95	4.90	
E	5.90	6.10	6.00	
E1	3.80	3.90	3.85	
E0	3.85	3.95	3.90	
е			1.27	
h	- *		0.35	
L	0.62	0.82	0.72	
Q	0.60	0.70	0.65	
All Dimensions in mm				

(2) MSOP-8EP



MSOP-8EP				
Dim	Min	Max	Тур	
Α	-	1.10		
A1	0.05	0.15	0.10	
A2	0.75	0.95	0.86	
A3	0.29	0.49	0.39	
b	0.22	0.38	0.30	
С	0.08	0.23	0.15	
D	2.90	3.10	3.00	
D1	1.60	2.00	1.80	
E	4.70	5.10	4.90	
E1	2.90	3.10	3.00	
E2	1.30	1.70	1.50	
E3	2.85	3.05	2.95	
е	-	-	0.65	
L	0.40	0.80	0.60	
а	0°	8°	4°	
х	-	-	0.750	
У	-	- 1	0.750	
All Dimensions in mm				

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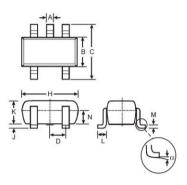


AP2141/ AP2151

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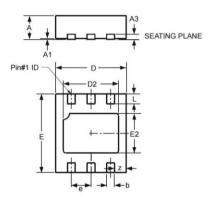
Please see http://www.diodes.com/package-outlines.html for the latest version.

(3) SOT25



SOT25					
Dim	Min	Max	Тур		
Α	0.35	0.50	0.38		
В	1.50	1.70	1.60		
С	2.70	3.00	2.80		
D	_	_	0.95		
Н	2.90	3.10	3.00		
J	0.013	0.10	0.05		
K	1.00	1.30	1.10		
L	0.35	0.55	0.40		
M	0.10	0.20	0.15		
N	0.70	0.80	0.75		
α	0°	8°	-		
All Dimensions in mm					

(4) U-DFN2018-6



	U-DFN2018-6				
Dim	Min	Max	Тур		
Α	0.545	0.605	0.575		
A1	0	0.05	0.02		
A3	_	_	0.13		
b	0.15	0.25	0.20		
D	1.750	1.875	1.80		
D2	1.30	1.50	1.40		
е	1		0.50		
E	1.95	2.075	2.00		
E2	0.90	1.10	1.00		
L	0.20	0.30	0.25		
z	_	_	0.30		
All Dimensions in mm					

Manuals ID 06-01

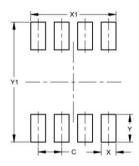


AP2141/ AP2151

Suggested Pad Layout

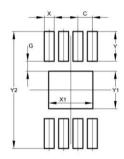
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(1) SO-8



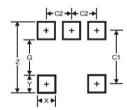
Dimensions	Value (in mm)
С	1.27
Х	0.802
X1	4.612
Y	1.505
Y1	6.50

(2) MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Υ	1.350
Y1	1.700
Y2	5.300

(3) SOT25



Dimensions	Value
Z	3.20
G	1.60
Х	0.55
Y	0.80
C1	2.40
C2	0.95

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Enclosures

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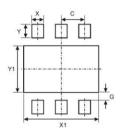


AP2141/ AP2151

Suggested Pad Layout (Cont.)

Please see http://www.diodes.com/package-outlines.html for the latest version.

(4) U-DFN2018-6



Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Υ	0.35
V4	1.20

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AP2141/ AP2151

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Manuals ID 06-02



2024-07-24



AP2161A/ AP2171A

1A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2161A and AP2171A are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25, and U-DFN2018-6 packages.

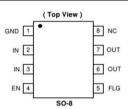
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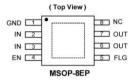
- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 1.5A Accurate Current Limiting
- Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- FSD Protection: 4kV HBM, 300V MM
- Active Low (AP2161A) or Active High (AP2171A) Enable
- Ambient Temperature Range: -40 ℃ to +85 ℃
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

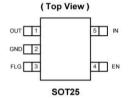
Applications

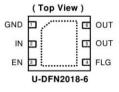
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking

Pin Assignments









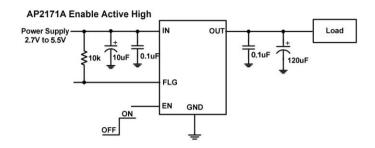
- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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AP2161A/ AP2171A

Typical Applications Circuit



Available Options

Part Number Channel		Enable Pin (EN)	Current Limit (typ)	Recommended Maximum Continuous Load Current
AP2161A	1	Active Low	1.5A	1.0A
AP2171A	1	Active High	1.5A	1.0A

Pin Descriptions

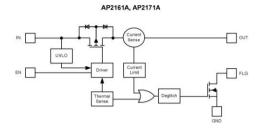
Pin Name S		Pin Number			F			
	me SO-8 MSOP-8EP SOT25 U-DFN2018-6			U-DFN2018-6	Function			
GND	1	1	2	1	Ground			
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)			
EN	4	4	4	3	Enable input, active low (AP2161A) or active high (AP2171A)			
FLG	5	5	3	4	Over-current and over-temperature fault report; open-drain flag is active low when triggered			
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)			
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins			
Exposed tab	-	Exposed tab		Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.			

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AP2161A/ AP2171A

Functional Block Diagram



Absolute Maximum Ratings (@TA = +25 ℃, unless otherwise specified.)

Symbol	Parameter	Ratings	Units	
ESD HBM	Human Body Model ESD Protection	4	kV	
ESD MM	Machine Model ESD Protection for MSOP-8EP, SOT25 packages	400	V	
ESD WW	Machine Model ESD Protection for U-DFN2018-6, SO-8 packages	300	V	
VIN	Input Voltage	6.5	V	
Vout	Output Voltage	V _{IN} +0.3	V	
V _{EN} , V _{FLG}	Enable Voltage	6.5	V	
ILOAD	Maximum Continuous Load Current	Internal Limited	A	
$T_{J(MAX)}$	Maximum Junction Temperature	150	℃	
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	∞	

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time. Semiconductor devices are ESDs sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

4. UL Recognized Rating from -30 °C to +70 °C (Diodes qualified TST from -65 °C to +150 °C).

Recommended Operating Conditions (@T_A = +25 ℃, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units	
VIN	Input Voltage	2.7	5.5		
lout	Output Current	0	1.0	Α	
TA	Operating Ambient Temperature	-40	+85	°C	
V _{IH}	High-Level Input Voltage on EN or EN	2.0	V _{IN}	V	
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V	

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AP2161A/ AP2171A

$\textbf{Electrical Characteristics} \ \ (@T_A = +25\, ^{\circ}\!\!\text{C}, \ V_{IN} = +5\text{V}, \ unless \ otherwise \ specified.})$

Symbol	Parameter	Test Conditions			Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$			1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0			-	0.5	1	uA
Iq	Input Quiescent Current	Enabled, I _{OUT} = 0		_	45	70	μΑ	
I _{LEAK}	Input Leakage Current	Disabled, OUT grounded			1 -	-	1	μΑ
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V, V _{OUT} = 5V, I _{REV} at V _{IN}			_	1	_	μΑ
		V _{IN} = 5V,	T _A = +25℃	SOT25, MSOP-8EP, SO-8	_	95	115	
				U-DFN2018-6	_	90	110]
R _{DS(ON)}	Switch On-Resistance	1001 = 174	-40 °C ≤ T _A ≤	-40 °C ≤ T _A ≤ +85 °C		S-10	140	mΩ
		$V_{IN} = 3.3V$, $I_{OUT} = 1A$	T _A = +25 ℃		_	120	140	
			-40 °C ≤ T _A ≤ +85 °C		_	1-	170	
I _{SHORT}	Short-Circuit Current Limit	Enabled into short circuit, C _L = 68µF			-	1.2	_	Α
ILIMIT	Over-Load Current Limit	$V_{IN} = 5V$, $V_{OUT} = 4.6V$, $C_L = 68\mu F$, $-40 ^{\circ}C \le T_A \le +85 ^{\circ}C$			1.1	1.5	1.9	Α
I _{Trig}	Current Limiting Trigger Threshold	Output Current Slew rate (<100A/s) , C _L =68μF			_	2.0	_	Α
I _{SINK}	EN Input Leakage	V _{EN} = 5V			-	_	1	μΑ
tD(ON)	Output Turn-On Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.05	-	ms
t _R	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			1-	0.6	1.5	ms
t _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.01	_	ms
t _F	Output Turn-Off Fall Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			-	0.05	0.1	ms
Fault Flag	99	100			tic.	200		
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} = 10mA			_	20	40	Ω
t _{Blank}	FLG Blanking Time	C _{IN} = 10μF, C _L = 68μF			4	7	15	ms
Over-Temp	erature Protection	5:						
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$			_	140	_	℃
THYS	Thermal Shutdown Hysteresis	-			_	25	_	°C
		SO-8 (Note 5)			110	_	%C/W	
θμΑ	Thermal Resistance Junction-to- Ambient	MSOP-8EP (Note 6)			_	60	_	°C/W
JJA		SOT25 (Note 7)			_	157	_	°C/W
		U-DFN2018-6 (Note 8)			_	70	_	%C/W

Notes:

- 5. Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
 6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
 7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
 8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0"x1.4" ground plane.

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Manuals ID 06-02



AP2161A/ AP2171A

Typical Performance Characteristics

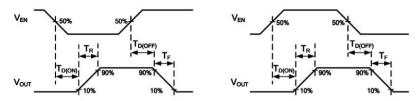
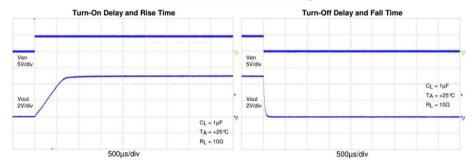
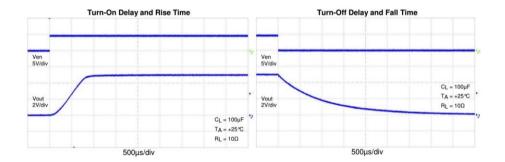


Figure 1 Voltage Waveforms: AP2161A (left), AP2171A (right)

All Enable Plots are for AP2171A Active High



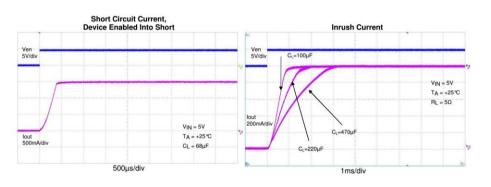


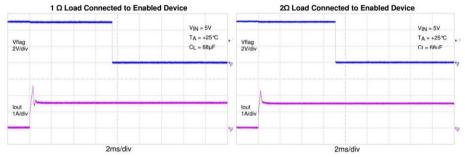
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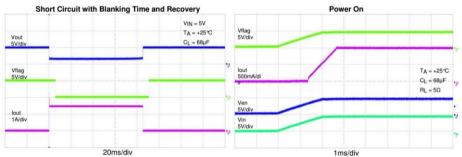


AP2161A/ AP2171A

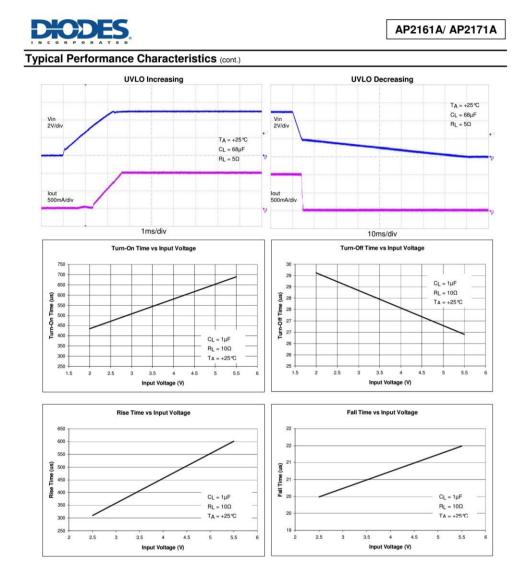
Typical Performance Characteristics (continued)







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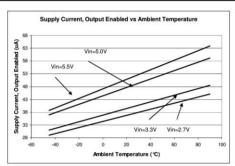


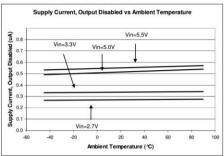
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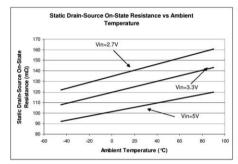


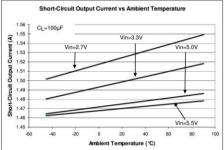
AP2161A/ AP2171A

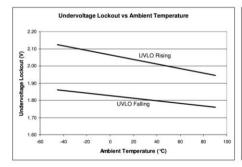
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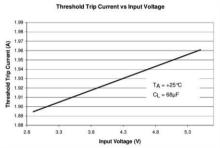












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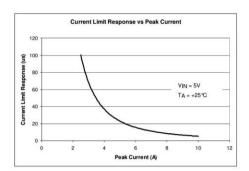
Enclosures

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AP2161A/ AP2171A

Typical Performance Characteristics (cont.)



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AP2161A/ AP2171A

Application Information

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before VIN has been applied. The AP2161A/AP2171A senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2161A/AP2171A is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I I MITT.

Note that when the output has been shorted to GND at an extremely low temperature (< -30 °C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than a 10% variation of capacitance change when operated at extremely low temperatures. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2161A/AP2171A is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

 T_A = Ambient Temperature $^{\circ}$ C R_{BJA} = Thermal Resistance P_D = Total Power Dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2161A/AP2171A implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 145°C due to excessive power dissipation in an over-current or short-circuit condition, the internal thermal sense circuitry turns the power switch for, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately 25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7-ms deglitch.

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AP2161A/ AP2171A

Application Information (continued)

Undervoltage Lockout (UVLO)

The undervoltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered And Bus-Powered HUBs

Hosts and self-powered hubs have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

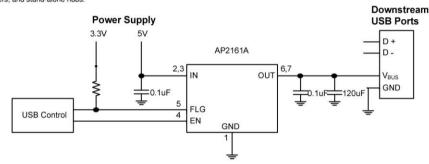


Figure 2 Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP2161A/AP2171A, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2161A/AP2171A also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2161A/AP2171A between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

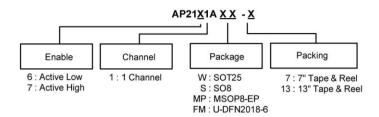
AP2161A/AP2171A is suitable for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of this is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. In such dual-purpose port applications, it is important to insure Vin of the AP2161A/AP2171A is ramped to its operating voltage prior to enabling the output.

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AP2161A/ AP2171A

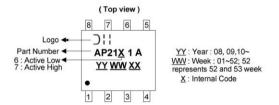
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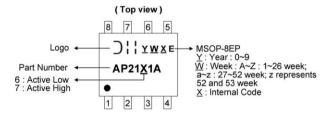
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Г	AP21X1AS-13	S	SO-8	2,500/Tape & Reel	-13
Г	AP21X1AMP-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
	AP21X1AFM-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Marking Information

(1) SO-8



(2) MSOP-8EP



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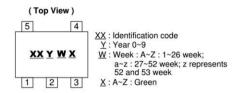
Manuals ID 06-02



AP2161A/ AP2171A

Marking Information (continued)

(3) SOT25



Device	Package type	Identification Code
AP2161AW	SOT25	VV
AP2171AW	SOT25	VW

(4) U-DFN2018-6

(Top View)

×× ×w× XX: Identification Code
Y: Year: 0~9
W: Week: A~Z: 1~26 week;
a~z: 27~52 week; z represents
52 and 53 week
X: A~Z: Green

Device	Package type	Identification Code
AP2161AFM	U-DFN2018-6	ZV
AP2171AFM	U-DFN2018-6	ZW

Manuals ID 06-02

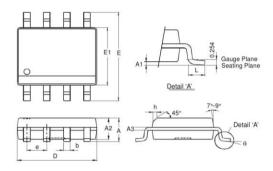


AP2161A/ AP2171A

Package Outline Dimensions (All dimensions in mm.)

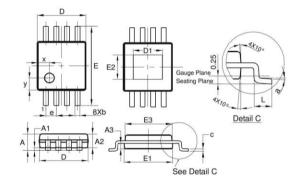
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(1) Package Type: SO-8



SO-8				
Dim	Min	Max		
Α	-	1.75		
A1	0.10	0.20		
A2	1.30	1.50		
A3	0.15	0.25		
b	0.3	0.5		
D	4.85	4.95		
E	5.90	6.10		
E1	3.85	3.95		
е	1.27	Тур		
h	-	0.35		
L	0.62	0.82		
θ	0°	8°		
All Dimensions in mm				

(2) Package Type: MSOP-8EP



MSOP-8EP					
Dim	Min	Max	Тур		
Α	-	1.10	-		
A1	0.05	0.15	0.10		
A2	0.75	0.95	0.86		
A3	0.29	0.49	0.39		
b	0.22	0.38	0.30		
С	0.08	0.23	0.15		
D	2.90	3.10	3.00		
D1	1.60	2.00	1.80		
E	4.70	5.10	4.90		
E1	2.90	3.10	3.00		
E2	1.30	1.70	1.50		
E3	2.85	3.05	2.95		
е		-	0.65		
L	0.40	0.80	0.60		
а	0°	8°	4°		
х		-	0.750		
У	-	-	0.750		
All Dimensions in mm					

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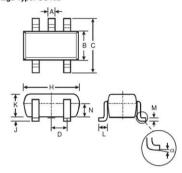


AP2161A/ AP2171A

Package Outline Dimensions (continued) (All dimensions in mm.)

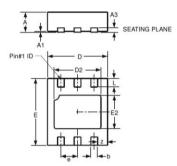
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(3) Package Type: SOT25



	SOT25					
Dim	Min	Max	Тур			
Α	0.35	0.50	0.38			
В	1.50	1.70	1.60			
С	2.70	3.00	2.80			
D	_	S	0.95			
Н	2.90	3.10	3.00			
J	0.013	0.10	0.05			
K	1.00	1.30	1.10			
L	0.35	0.55	0.40			
M	0.10	0.20	0.15			
N	0.70	0.80	0.75			
α	0°	8°	-			
All Dimensions in mm						

(4) Package Type: U-DFN2018-6



U-DFN2018-6				
Dim	Min	Max	Тур	
Α	0.545	0.605	0.575	
A1	0	0.05	0.02	
A3			0.13	
b	0.15	0.25	0.20	
D	1.750	1.875	1.80	
D2	1.30	1.50	1.40	
е	_	_	0.50	
Е	1.95	2.075	2.00	
E2	0.90	1.10	1.00	
L	0.20	0.30	0.25	
z	_	_	0.30	
All Dimensions in mm				

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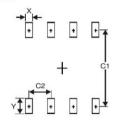


AP2161A/ AP2171A

Suggested Pad Layout

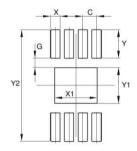
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: SO-8



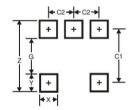
Dimensions	Value (in mm)
X	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)	
С	0.650	
G	0.450	
X	0.450	
X1	2.000	
Υ	1.350	
Y1	1.700	
Y2	5.300	

(3) Package Type: SOT25



Dimensions	Value (in mm)	
Z	3.20	
G	1.60	
Х	0.55	
Y	0.80	
C1	2.40	
C2	0.95	

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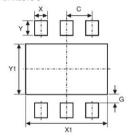


AP2161A/ AP2171A

Suggested Pad Layout (continued)

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

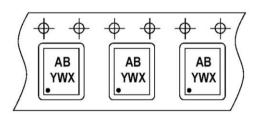
(4) Package Type: U-DFN2018-6

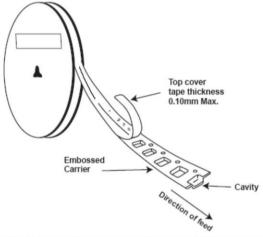


Dimensions	Value (in mm)	
С	0.50	
G	0.20	
Х	0.25	
X1	1.60	
Y	0.35	
Y1	1.20	

Taping Orientation (Note 9)

For U-DFN2018-6





Notes: 9. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2161A/ AP2171A

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March 2015

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2024-07-24

AP2161/ AP2171

1A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2161 and AP2171 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short-circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false overcurrent reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25, and U-DFN2018-6 packages

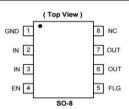
Features

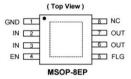
- Single USB Port Power Switches
- Overcurrent and Thermal Protection
- 1.5A Accurate Current Limiting Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- ESD Protection: 4kV HBM, 300V MM
- Active Low (AP2161) or Active High (AP2171) Enable
- Ambient Temperature Range: -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

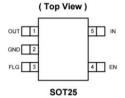
Applications

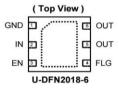
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Station, HUB

Pin Assignments









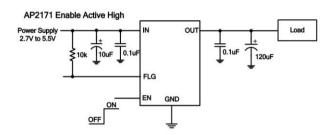
- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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AP2161/ AP2171

Typical Applications Circuit



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (typ)	Recommended Maximum Continuous Load Current
AP2161	1	Active Low	1.5A	1.0A
AP2171	1	Active High	1.5A	1.0A

Pin Descriptions

Pin		Pin Number			
Name SO	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Function
GND	1	1	2	1	Ground
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)
EN	4	4	4	3	Enable input, active low (AP2161) or active high (AP2171)
FLG	5	5	3	4	Overcurrent and over-temperature fault report; open-drain flag is active low when triggered
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins
Exposed tab	-	Exposed tab	-	Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.

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AP2161/ AP2171

Functional Block Diagram

AP2161, AP2171 IN Current Sense OUT EN Driver Current Limit Thermal Sense Out GND

Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Units
ESD HBM Human Body Model ESD Protection		4	kV
ECD MM	Machine Model ESD Protection for MSOP-8EP, SOT25 packages	400	V
ESD MM	Machine Model ESD Protection for U-DFN2018-6, SO-8 packages	300	V
VIN	Input Voltage	6.5	V
Vout	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
I _{LOAD}	Maximum Continuous Load Current	Internal Limited	Α
T _{J(MAX)}	Maximum Junction Temperature	+150	°C
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

Note: 4. UL Recognized Rating from -30°C to +70°C (Diodes qualified T_{ST} from -65°C to +150°C).

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units
VIN	Input Voltage	2.7	5.5	V
lout	Output Current	0	1.0	Α
TA	Operating Ambient Temperature	-40	+85	°C
VIH	High-Level Input Voltage on EN or EN	2.0	VIN	V
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V

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AP2161/ AP2171

Electrical Characteristics (@ $T_A = +25^{\circ}C$, $V_{IN} = +5V$, unless otherwise specified.)

Symbol	Parameter		Test Conditions		Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$	$R_{LOAD} = 1k\Omega$		1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, Iour	Disabled, I _{OUT} = 0		1.5	0.5	1	uA
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		100	45	70	μА
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded		-	-	1	μА
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5	V, I _{REV} at V _{IN}	100	1	-	μA
			T	SOT25, MSOP-8EP, SO-8	1-1	95	115	
		V _{IN} = 5V,	T _A = +25°C	U-DFN2018-6	((*)	90	110]
RDS(ON)	Switch on-resistance	I _{OUT} = 1A	-40°C ≤ T _A ≤	+85°C	1000	-	140	mΩ
		$V_{IN} = 3.3V$	T _A = +25°C		-	120	140	
		I _{OUT} = 1A	-40°C ≤ T _A ≤	+85°C	-	-	170	1
ISHORT	Short-Circuit Current Limit	Enabled into	short circuit, CL	= 68µF	-	1.2	-	Α
ILIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OU}	V _{IN} = 5V, V _{OUT} = 4.6V, C _L = 68µF, -40°C ≤ T _A ≤ +85°C		1.1	1.5	1.9	Α
I _{Trig}	Current limiting trigger threshold	Output Currer	Output Current Slew rate (<100A/s) , CL=68µF		(-	2.0	-	Α
Isink	EN Input leakage	V _{EN} = 5V		-	-	1	μА	
t _{D(ON)}	Output turn-on delay time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.05	-	ms	
t _R	Output turn-on rise time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.6	1.5	ms	
t _{D(OFF)}	Output turn-off delay time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.01	-	ms	
t _F	Output turn-off fall time	C _L = 1µF, R _{LC}	DAD = 10Ω		-	0.05	0.1	ms
R _{FLG}	FLG output FET on-resistance	I _{FLG} = 10mA			-	20	40	Ω
t _{Blank}	FLG blanking time	C _{IN} = 10µF, C	L = 68µF		4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$			140	-	°C	
THYS	Thermal Shutdown Hysteresis	-		-	25	-	°C	
	1	SO-8 (Note 5)		-	110	-	°C/W	
0	Thermal Resistance Junction-to-	MSOP-8EP (Note 6)		- 100	60	-	°C/W	
$AL\theta$	Ambient	SOT25 (Note	SOT25 (Note 7)		-	157	-	°CM
		U-DFN2018-6	U-DFN2018-6 (Note 8)		-	70	-	°CM

Notes:

^{5.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0" x 1.4" ground plane.

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Typical Performance Characteristics

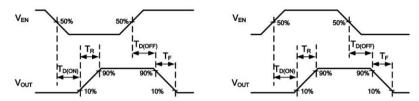
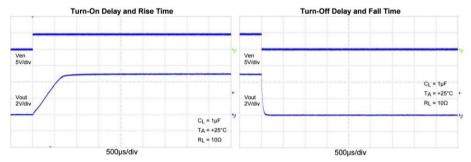
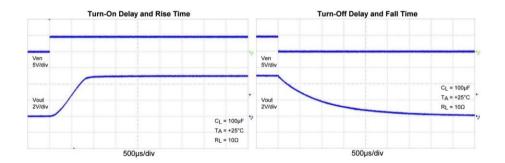


Figure 1 Voltage Waveforms: AP2161 (left), AP2171 (right)

All Enable Plots are for AP2171 Active High

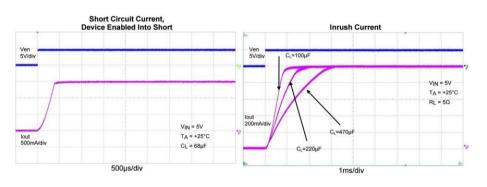


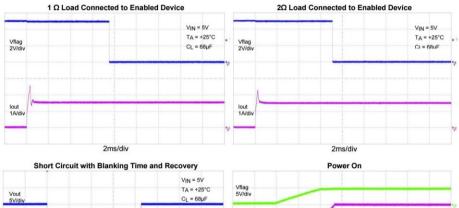


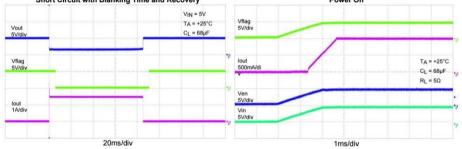
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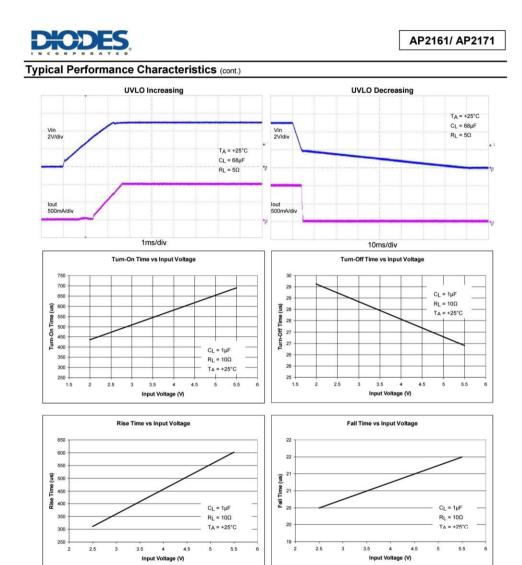
Typical Performance Characteristics (continued)







Manuals ID 06-02

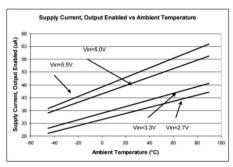


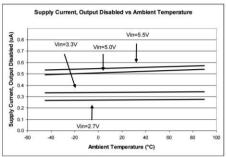
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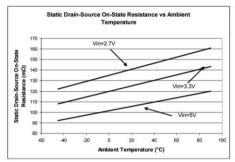


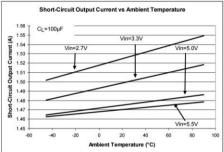
AP2161/ AP2171

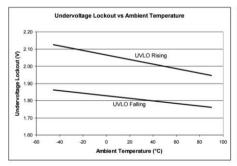
Typical Performance Characteristics (cont.)

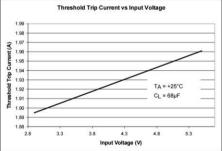












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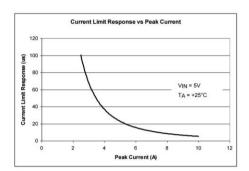
Enclosures

Manuals ID 06-02



AP2161/ AP2171

Typical Performance Characteristics (cont.)



Manuals ID 06-02



AP2161/ AP2171

Application Information

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Overcurrent and Short Circuit Protection

An internal sensing FET is employed to check for overcurrent conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2161/AP2171 senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIC}) is reached or until the thermal limit of the device is exceeded. The AP2161/AP2171 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at lower.

Note that when the output has been shorted to GND at an extremely low temperature (< -30°C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an overcurrent or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both overcurrent and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary overcurrent condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2161/AP2171 is designed to eliminate false overcurrent reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature °C R_{BJA} = Thermal resistance

P_D = Total power dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2161/AP2171 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +145°C due to excessive power dissipation in an overcurrent or short-circuit condition, the internal thermal sense circuitry turns the power switch forf, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shuldown or overcurrent occurs with 7-ms deglitch.

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AP2161/ AP2171

Application Information (continued)

Undervoltage Lockout (UVLO)

Undervoltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered And Bus-Powered HUBs

Hosts and self-powered hubs have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

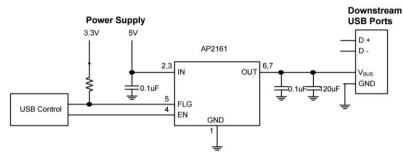


Figure 2 Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall times of the AP2161/AP2171, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2161/AP2171 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2161/AP2171 between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

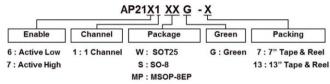
AP2161/AP2171 is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a non-recommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. If a voltage is maintained across the output of the AP2161/AP2171 when the output is disabled and the V_{IN} of the device is subsequently ramped up, an overstress condition to the AP2161/AP2171 may result.

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AP2161/ AP2171

Ordering Information

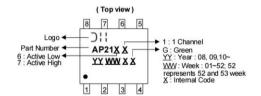


FM : U-DFN2018-6

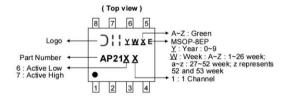
	Part Number	Paskage Code Paskaging	Dockoning	7"/13" Tape and Reel		
	Part Number	Package Code	Packaging	Quantity	Part Number Suffix	
1	AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7	
1	AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13	
•	AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13	
B	AP21X1FMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7	

Marking Information

(1) SO-8



(2) MSOP-8EP



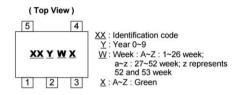
Manuals ID 06-02



AP2161/ AP2171

Marking Information (cont.)

(3) SOT25



Device	Package type	Identification Code
AP2161W	SOT25	HT
AP2171W	SOT25	HU

(4) U-DFN2018-6

(Top View)



XX: Identification Code
Y: Year: 0~9
W: Week: A~Z: 1~26 week;
a~z: 27~52 week; z represents
52 and 53 week
X: A~Z: Green

Device	Package type	Identification Code
AP2161FM	U-DFN2018-6	HT
AP2171FM	U-DFN2018-6	HU

Manuals ID 06-02

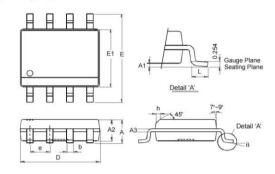


AP2161/ AP2171

Package Outline Dimensions (All dimensions in mm.)

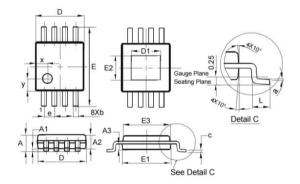
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(1) Package Type: SO-8



	SO-8				
Dim	Min	Max			
Α	-	1.75			
A1	0.10	0.20			
A2	1.30	1.50			
A3	0.15	0.25			
b	0.3	0.5			
D	4.85	4.95			
E	5.90	6.10			
E1	3.85	3.95			
е	1.27	Тур			
h	-	0.35			
L	0.62	0.82			
θ	0°	8°			
All Di	mensions	in mm			

(2) Package Type: MSOP-8EP



MSOP-8EP				
Dim	Min	Max	Тур	
Α	100	1.10	-	
A1	0.05	0.15	0.10	
A2	0.75	0.95	0.86	
A3	0.29	0.49	0.39	
b	0.22	0.38	0.30	
С	0.08	0.23	0.15	
D	2.90	3.10	3.00	
D1	1.60	2.00	1.80	
E	4.70	5.10	4.90	
E1	2.90	3.10	3.00	
E2	1.30	1.70	1.50	
E3	2.85	3.05	2.95	
е	1175	1.5	0.65	
L	0.40	0.80	0.60	
а	0°	8°	4°	
x	1073	1.50	0.750	
У	-	-	0.750	
ΔII Γ	imens	ions in	mm	

Manuals ID 06-02

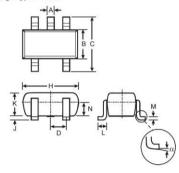


AP2161/ AP2171

Package Outline Dimensions (All dimensions in mm.)

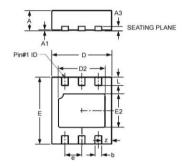
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(3) Package Type: SOT25



	SOT25					
Dim	Min	Max	Тур			
Α	0.35	0.50	0.38			
В	1.50	1.70	1.60			
С	2.70	3.00	2.80			
D	22-	-	0.95			
н	2.90	3.10	3.00			
J	0.013	0.10	0.05			
K	1.00	1.30	1.10			
L	0.35	0.55	0.40			
M	0.10	0.20	0.15			
N	0.70	0.80	0.75			
α	α 0° 8° —					
All D	All Dimensions in mm					

(4) Package Type: U-DFN2018-6



U-DFN2018-6					
Dim	Min	Max	Тур		
Α	0.545	0.605	0.575		
A1	0	0.05	0.02		
A3	_	_	0.13		
b	0.15	0.25	0.20		
D	1.750	1.875	1.80		
D2	1.30	1.50	1.40		
е	_	_	0.50		
Е	1.95	2.075	2.00		
E2	0.90	1.10	1.00		
L	0.20	0.30	0.25		
z	_=		0.30		
All D	imens	ions ir	nmm		

Manuals ID 06-02

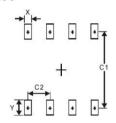


AP2161/ AP2171

Suggested Pad Layout

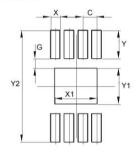
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: SO-8



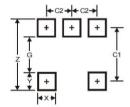
Dimensions	Value (in mm)
Х	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Y	1.350
Y1	1.700
Y2	5.300

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
х	0.55
Y	0.80
C1	2.40
C2	0.95

Page 56 of 252 Enclosures

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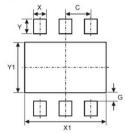


AP2161/ AP2171

Suggested Pad Layout (continued)

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

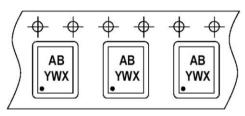
(4) Package Type: U-DFN2018-6

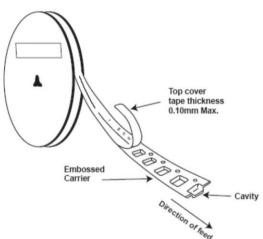


Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Υ	0.35
Y1	1.20

Taping Orientation (Note 9)

For U-DFN2018-6





Note: 9. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2161/ AP2171

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Manuals ID 06-03



AP2181/ AP2191

1.5A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2181 and AP2191 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and under-voltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25 and U-DFN2018-6 packages.

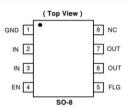
Features

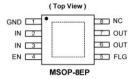
- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 2.1A Accurate Current Limiting
- Reverse Current Blocking
- $95m\Omega$ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- FSD Protection: 4kV HBM, 300V MM
- Active Low (AP2181) or Active High (AP2191) Enable
- Ambient Temperature Range: -40 ℃ to +85 ℃
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

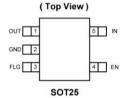
Applications

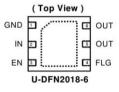
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS Systems, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking

Pin Assignments









- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 S. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

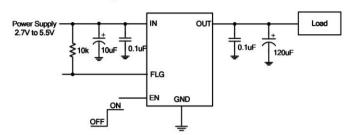
Manuals ID 06-03



AP2181/ AP2191

Typical Applications Circuit

AP2191 Enable Active High



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (typ)	Recommended Maximum Continuous Load Current
AP2181	1	Active Low	2.1A	1.5A
AP2191	1	Active High	2.1A	1.5A

Pin Descriptions

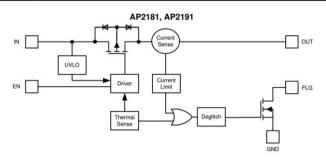
Pin Name	Pin Number				Function		
	SO-8 MSOP-8EP S		SOT25	U-DFN2018-6	Function		
GND	1	1	2	1	Ground		
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)		
EN	4	4	4	3	Enable input, active low (AP2181) or active high (AP2191)		
FLG	5	5	3	4	Over-current and over-temperature fault report. Open-drain flag is active low when triggered		
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)		
NC	8	8	N/A	N/A	No internal connection. Recommend tie to OUT pins		
Exposed tab	((4)	Exposed tab		Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.		

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AP2181/ AP2191

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25 ℃, unless otherwise specified.)

Symbol	Parameter	Ratings	Units
ESD HBM	Human Body Model ESD Protection	4	kV
505.444	Machine Model ESD Protection for MSOP-8EP, SOT25 Packages	400	V
ESD MM	Machine Model ESD Protection for U-DFN2018-6, SO-8 Packages	300	V
VIN	Input Voltage	6.5	V
V _{OUT}	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG} Enable Voltage		6.5	V
I _{LOAD} Maximum Continuous Load Current		Internal Limited	A
T _{J(MAX)}	Maximum Junction Temperature	+150	℃
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	.€

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

Note: 4. UL Recognized Rating from -30 °C to +70 °C (Diodes qualified T_{ST} from -65 °C to +150 °C).

Recommended Operating Conditions (@T_A = +25 ℃, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units	
VIN	Input Voltage	2.7	5.5	V	
Іоит	Output Current	0	1.5	Α	
TA	Operating Ambient Temperature	-40	+85	∞	
VIH	High-Level Input Voltage on EN or EN	2.0	V _{IN}	V	
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V	

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AP2181/ AP2191

Electrical Characteristics (@T_A = +25 ℃, VIN = +5V, unless otherwise specified.)

Symbol	Parameter	Test Conditions			Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$			1.6	1.9	2.5	V
Ishdn	Input Shutdown Current	Disabled, I _{OUT} = 0		-	0.5	1	μА	
IQ	Input Quiescent Current	Enabled, I _{OUT} = 0			45	70	μΑ	
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded			1-0	1	μΑ
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5V	, I _{REV} at V _{IN}	_	1	-	μΑ
2		V 5V	T _A = +25 °C	SOT25, MSOP-8EP, SO-8		95	115	
		$V_{IN} = 5V$, $I_{OUT} = 1.5A$	1A = +23 C	U-DFN2018-6		90	110]
R _{DS(ON)}	Switch On-Resistance	10UT= 1.5A	-40°C ≤ T _A ≤ -	+85℃		-	140	mΩ
		$V_{IN} = 3.3V$,	T _A = +25℃	T _A = +25℃		120	140	
		I _{OUT} = 1.5A	-40°C ≤ T _A ≤ +85°C		_	_	170	
ISHORT	Short-Circuit Current Limit	Enabled into short circuit, C _L = 100μF			_	2.0	_	Α
ILIMIT	Over-Load Current Limit	$V_{IN} = 5V$, $V_{OUT} = 4.5V$, $C_L = 120 \mu F$, $-40 ^{\circ}\text{C} \le T_A \le +85 ^{\circ}\text{C}$			1.6	2.1	2.6	Α
I _{Trig}	Current Limiting Trigger Threshold	Output Current Slew Rate (<100A/s) , C _L = 100µF			2.6	-	Α	
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V			ST. 30	0.8	V	
V _{IH}	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V		2	1-		V	
Isink	EN Input Leakage	V _{EN} = 5V			7-7	1	μΑ	
T _{D(ON)}	Output Turn-On Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.05	-	ms	
TR	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			0.6	1.5	ms	
T _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.01	_	ms	
T _F	Output Turn-Off Fall Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.05	0.1	ms	
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} = 10mA, C _L = 100μF			-	20	40	Ω
T _{Blank}	FLG Blanking Time	C _{IN} = 10μF, C _L = 100μF			4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$			===	+140	_	∞
THYS	Thermal Shutdown Hysteresis	_				+25	_	∞
	Thermal Resistance Junction-to- Ambient	SO-8 (Note 5)		_	110	_	°C/W	
۵		MSOP-8EP (Note 6)			60	-	°C/W	
θ_{JA}		SOT25 (Note 7)			157	:	%C/W	
		U-DFN2018-6 (Note 8)		-	70	2. 	∘C/W	

^{5.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0"x1.4" ground plane.

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AP2181/ AP2191

Typical Performance Characteristics

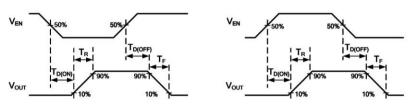
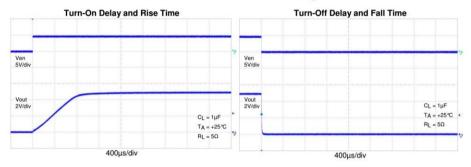
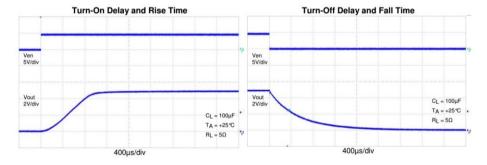


Figure 1 Voltage Waveforms: AP2181 (left), AP2191 (right)

All Enable Plots are for AP2191 Active High





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AP2181/ AP2191

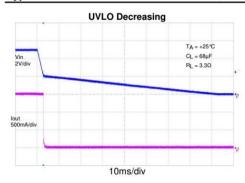


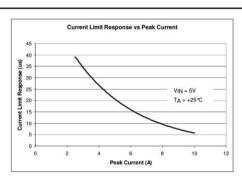
Manuals ID 06-03

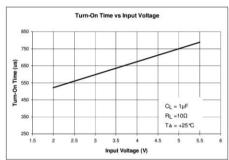


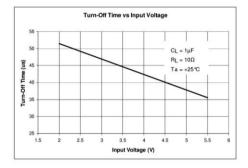
AP2181/ AP2191

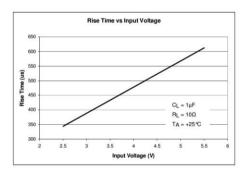
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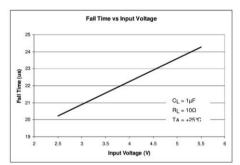










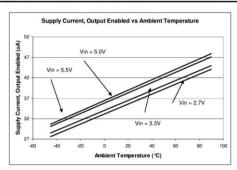


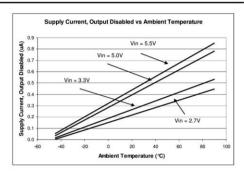
Manuals ID 06-03

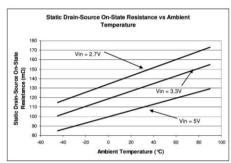


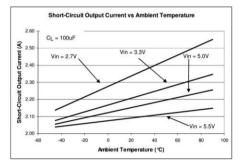
AP2181/ AP2191

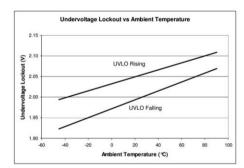
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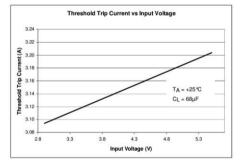












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AP2181/ AP2191

Application Information

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before VIN has been applied. The AP2181/AP2191 senses the short circuit and immediately clamps output current to a certain safe level namely ILIMIT.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIO}) is reached or until the thermal limit of the device is exceeded. The AP2181/AP2191 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I I MUTT.

Note that when the output has been shorted to GND at extremely low temperature (< -30 °C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2181/AP2191 is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature ℃

 $R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

Thermal Protectio

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2181/AP2191 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately 25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7-ms deglitch.

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AP2181/ AP2191

Application Information (continued)

Under-Voltage Lockout (UVLO)

The under-voltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and self-powered hubs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs

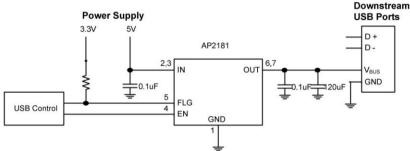


Figure 2 Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP2181/AP2191, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2181/AP2191 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2181/AP2191 between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

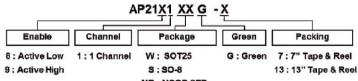
AP2181/AP2191 is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of a non-recommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. If a voltage is maintained across the output of the AP2181/AP2191 when the output is disabled and the Vin of the device is subsequently ramped up, an overstress condition to the AP2181/AP2191 may result

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AP2181/ AP2191

Ordering Information

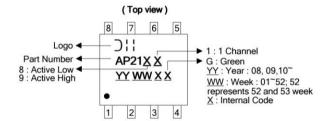


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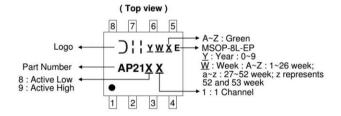
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0	AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7	
(Pa)	AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13	
(B)	AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13	
(Pg)	AP21X1FMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7	

Marking Information

(1) SO-8



(2) MSOP-8EP



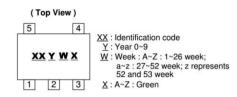
Manuals ID 06-03



AP2181/ AP2191

Marking Information (continued)

(3) SOT25



Device	Package type	Identification Code
AP2181W	SOT25	HX
AP2191W	SOT25	HY

(4) U-DFN2018-6





XX: Identification Code
Y: Year: 0~9
W: Week: A~Z: 1~26 week;
a~z: 27~52 week; z represents
52 and 53 week
X: A~Z: Green

Device	Package type	Identification Code
AP2181FM	U-DFN2018-6	HX
AP2191FM	U-DFN2018-6	HY

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Enclosures

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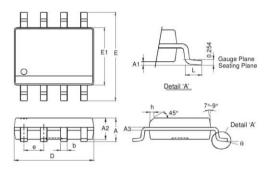


AP2181/ AP2191

Package Outline Dimensions (All dimensions in mm.)

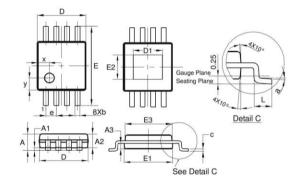
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(1) Package Type: SO-8



SO-8				
Dim	Min	Max		
Α	-	1.75		
A1	0.10	0.20		
A2	1.30	1.50		
A3	0.15	0.25		
b	0.3	0.5		
D	4.85	4.95		
Е	5.90	6.10		
E1	3.85	3.95		
е	1.27	Тур		
h	-	0.35		
L	0.62	0.82		
θ	0°	8°		
All Dimensions in mm				

(2) Package Type: MSOP-8EP



MSOP-8EP					
Dim	Min	Max	Тур		
Α	1 -	1.10	-		
A1	0.05	0.15	0.10		
A2	0.75	0.95	0.86		
A3	0.29	0.49	0.39		
b	0.22	0.38	0.30		
С	0.08	0.23	0.15		
D	2.90	3.10	3.00		
D1	1.60	2.00	1.80		
E	4.70	5.10	4.90		
E1	2.90	3.10	3.00		
E2	1.30	1.70	1.50		
E3	2.85	3.05	2.95		
е	-	-	0.65		
L	0.40	0.80	0.60		
а	0°	8°	4°		
х	-	-	0.750		
у	-	-	0.750		
All Dimensions in mm					

Manuals ID 06-03

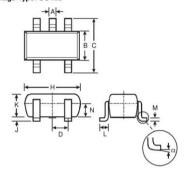


AP2181/ AP2191

Package Outline Dimensions (All dimensions in mm.)

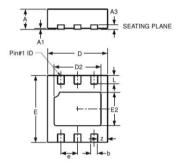
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(3) Package Type: SOT25



SOT25					
Dim	Min	Max	Тур		
Α	0.35	0.50	0.38		
В	1.50	1.70	1.60		
С	2.70	3.00	2.80		
D	-	-	0.95		
Н	2.90	3.10	3.00		
J	0.013	0.10	0.05		
K	1.00	1.30	1.10		
L	0.35	0.55	0.40		
M	0.10	0.20	0.15		
N	0.70	0.80	0.75		
α	0°	8°	-		
All Dimensions in mm					

(4) Package Type: U-DFN2018-6



U-DFN2018-6				
Dim	Min	Max	Тур	
Α	0.545	0.605	0.575	
A1	0	0.05	0.02	
A3	_		0.13	
b	0.15	0.25	0.20	
D	1.750	1.875	1.80	
D2	1.30	1.50	1.40	
е		_	0.50	
E	1.95	2.075	2.00	
E2	0.90	1.10	1.00	
L	0.20	0.30	0.25	
z	_	_	0.30	
All Dimensions in mm				

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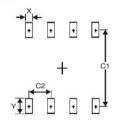


AP2181/ AP2191

Suggested Pad Layout

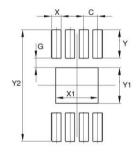
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: SO-8



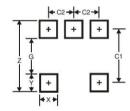
Dimensions	Value (in mm)
Х	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)	
С	0.650	
G	0.450	
Х	0.450	
X1	2.000	
Υ	1.350	
Y1	1.700	
Y2	5.300	

(3) Package Type: SOT25



Dimensions	Value (in mm)
z	3.20
G	1.60
Х	0.55
Y	0.80
C1	2.40
C2	0.95

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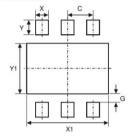


AP2181/ AP2191

Suggested Pad Layout (continued)

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

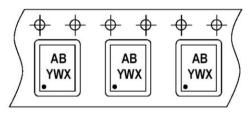
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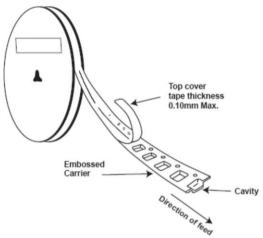


Dimensions	Value (in mm)	
С	0.50	
G	0.20	
Х	0.25	
X1	1.60	
Υ	0.35	
Y1	1.20	

Taping Orientation

For U-DFN2018-6





Notes: 9. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2181/ AP2191

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Description

The AP2181A and AP2191A are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. This family of devices complies with USB 2.0 and is available with both polarities of Enable input. The AP2181A and AP2191A offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25 and U-DFN2018-6 packages.

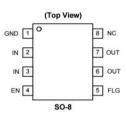
Features

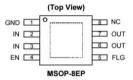
- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 2.1A Accurate Current Limiting
- Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- . 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) with Blanking Time (7ms Typ)
- ESD Protection: 4kV HBM, 300V MM
- Active Low (AP2181A) or Active High (AP2191A) Enable
- Ambient Temperature Range: -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

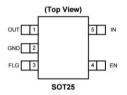
Applications

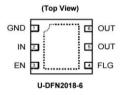
- Consumer Electronics LCD TV & Monitor, Game Machines
- Communications Set-Top Box, GPS, Smartphone
- Computing Laptop, Desktop, Servers, Printers, Docking Station HUB

Pin Assignments









Notes:

- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
- See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
- Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

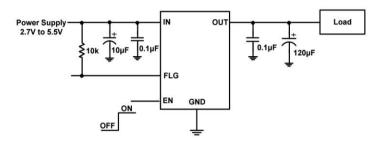
Manuals ID 06-03



AP2181A/AP2191A

Typical Applications Circuit

AP2191A Enable Active High



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typ)	Recommended Maximum Continuous Load Current
AP2181A	1	Active Low	2.1A	1.5A
AP2191A	1	Active High	2.1A	1.5A

Pin Descriptions

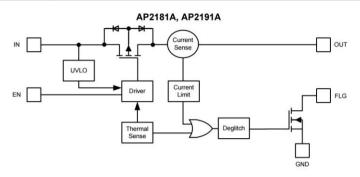
Pin	Pin Pin Number			Function		
Name	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Function	
GND	1	1	2	1 Ground		
IN	2, 3	2, 3	5	2	Voltage Input Pin (all IN pins must be tied together externally)	
EN	4	4	4	3	Enable input, active low (AP2181A) or active high (AP2191A)	
FLG	5	5	3	4	Over-current and over-temperature fault report; open-drain flag is active low when triggered	
OUT	6, 7	6, 7	1	5, 6	Voltage Output Pin (all OUT pins must be tied together externally)	
NC	8	8	N/A	N/A No internal connection; recommend tie to OUT pins		
Exposed Tab	_	Exposed Tab	-	Exposed Tab	Exposed Pad It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

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AP2181A/AP2191A

Functional Block Diagram



Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	4	kV
ESD MM	Machine Model ESD Protection for MSOP-8EP, SOT25 Packages	400	V
E2D MM	Machine Model ESD Protection for U-DFN2018-6, SO-8 Packages	300	V
VIN	Input Voltage	6.5	V
V _{OUT}	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
ILOAD	Maximum Continuous Load Current	Internal Limited	Α
T _{J(MAX)}	Maximum Junction Temperature	+150	°C
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Note: 4. UL Recognized Rating from -30°C to +70°C (Diodes Incorporated qualified T_{ST} from -65°C to +150°C).

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V
Гоит	Output Current	0	1.5	Α
TA	Operating Ambient Temperature	-40	+85	°C
VIH	High-Level Input Voltage on EN or EN	2.0	Vin	V
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V

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AP2181A/AP2191A

$\textbf{Electrical Characteristics} \ \ (\textcircled{@T}_{A} = +25^{\circ}\text{C}, \ V_{IN} = 5\text{V}, \ unless \ otherwise \ specified.})$

Symbol	Parameter		Test Conditions		Min	Тур	Max	Unit
Vuvlo	Input UVLO	R _{LOAD} = 1kΩ	$R_{LOAD} = 1k\Omega$		1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OU1}	Disabled, I _{OUT} = 0		_	0.5	1	Α
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		-	45	70	μΑ
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded		-	_	1	μA
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5\	/, I _{REV} at V _{IN}	_	1	_	μΑ
			T - 105°C	SOT25, MSOP-8EP, SO-8	_	95	115	
		V _{IN} = 5V,	$T_A = +25^{\circ}C$	U-DFN2018-6	_	90	110	
R _{DS(ON)}	Switch On-Resistance	I _{OUT} = 1.5A	-40°C ≤ T _A ≤	+85°C	-	_	140	mΩ
		V _{IN} = 3.3V,	T _A = +25°C		_	120	140	
		$I_{OUT} = 1.5A$	-40°C ≤ T _A ≤	+85°C		_	170	
ISHORT	Short-Circuit Current Limit	Enabled into s	short circuit, C _L	= 100µF	_	2.0	_	Α
ILIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OU}	$V_{IN} = 5V$, $V_{OUT} = 4.5V$, $C_L = 120 \mu F$, $-40^{\circ}C \le T_A \le +85^{\circ}C$		1.6	2.1	2.6	Α
I _{Trig}	Current Limiting Trigger Threshold	Output Currer	Output Current Slew Rate (<100A/s), C _L = 100µF			2.6		Α
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to	V _{IN} = 2.7V to 5.5V		-	-	0.8	V
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to	V _{IN} = 2.7V to 5.5V		2	_	-	V
ISINK	EN Input Leakage	V _{EN} = 5V	V _{EN} = 5V			1	1	μΑ
t _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _{LC}	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		_	0.05	_	ms
t _R	Output Turn-On Rise Time	$C_L = 1\mu F, R_{LC}$	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		_	0.6	1.5	ms
tD(OFF)	Output Turn-Off Delay Time	C _L = 1µF, R _{LC}	_{DAD} = 10Ω		77	0.01		ms
t _F	Output Turn-Off Fall Time	$C_L = 1\mu F, R_{LC}$	_{OAD} = 10Ω			0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} = 10mA,	I _{FLG} = 10mA, C _L = 100μF			20	40	Ω
t BLANK	FLG Blanking Time	C _{IN} = 10µF, C	C _{IN} = 10μF, C _L = 100μF		4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$			+140		°C	
T _{HYS}	Thermal Shutdown Hysteresis	_		_	+25	_	°C	
		SO-8 (Note 5)	SO-8 (Note 5)		_	110	_	°CM
0	Thermal Resistance Junction-to-	MSOP-8EP (N	MSOP-8EP (Note 6)		2_3	60	-	°CM
θ_{JA}	Ambient	SOT25 (Note	7)		_	157	_	°CM
		U-DFN2018-6	(Note 8)		_	70	-	°C/W

Notes

^{5.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0"x1.4" ground plane.

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AP2181A/AP2191A

Typical Performance Characteristics

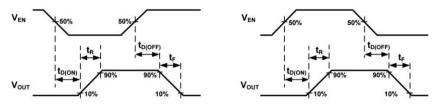
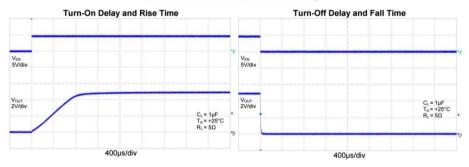
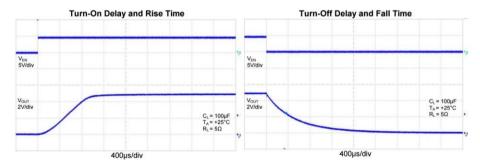


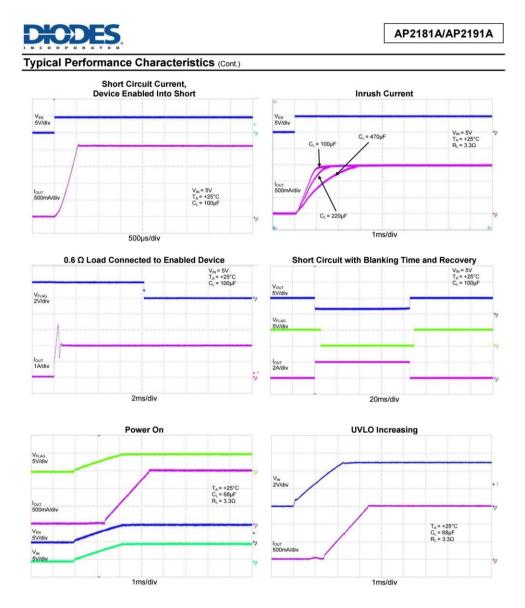
Figure 1. Voltage Waveforms: AP2181A (Left), AP2191A (Right)

All Enable Plots are for AP2191A Active High





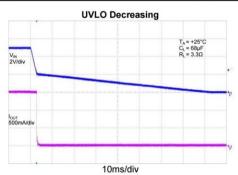
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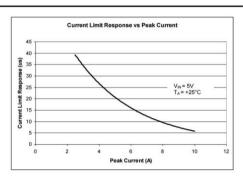


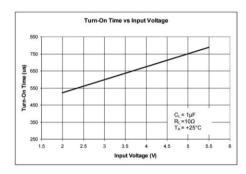


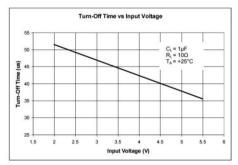
AP2181A/AP2191A

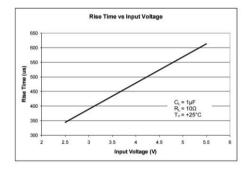
Typical Performance Characteristics (Cont.)

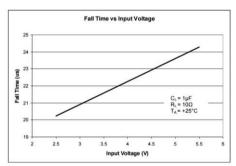










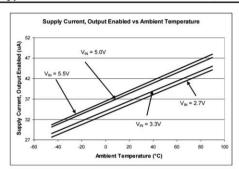


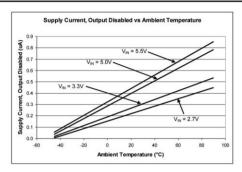
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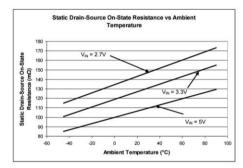


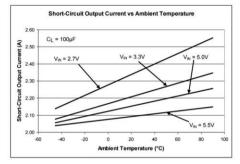
AP2181A/AP2191A

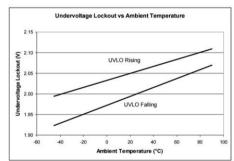
Typical Performance Characteristics (Cont.)

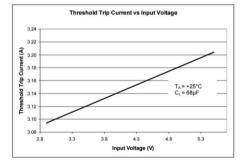












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AP2181A/AP2191A

Application Information

Power Supply Considerations

A 0.01µF to 0.1µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2181A/AP2191A senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT} .

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2181A/AP2191A is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT}.

Note that when the output has been shorted to GND at extremely low temperature (< -30°C), a minimum 120µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7ms deglitch timeout. The AP2181A/AP2191A is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and $R_{DS(ON)}$, the power dissipation can be calculated by:

PD = RDS(ON) × I

Finally, calculate the junction temperature:

T_J = P_D x R₀JA + T_A

Where

 T_A = Ambient temperature °C $R_{\theta JA}$ = Thermal resistance P_D = Total power dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2181A/AP2191A implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7ms deglitch.

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AP2181A/AP2191A

Application Information (Cont.)

Undervoltage Lockout (UVLO)

Undervoltage Lockout (UVLO) function keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and Self-Powered HUBs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

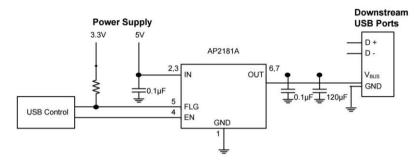


Figure 2. Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall time of the AP2181A/AP2191A, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2181A/AP2191A also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2181A/AP2191A between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

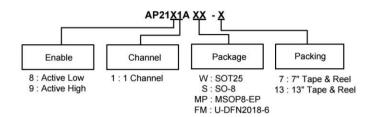
AP2181A/AP2191A is suitable for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of this is a shared HDMI/MHL (Mobile High-Definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. In such dual-purpose port applications, it is important to insure V_{IN} of the AP2181A/AP2191A is ramped to its operating voltage prior to enabling the output.

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AP2181A/AP2191A

Ordering Information



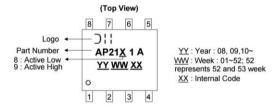
Part Number	Package	Dookene Code	7"/13" T	Status	
Part Number	(Note 10)	Package Code	Quantity	Part Number Suffix	(Note 9)
AP2181AW-7	SOT25	W	3000	-7	In Production
AP2181AS-13	SO-8	S	2500	-13	In Production
AP2181AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2181AFM-7	U-DFN2018-6	FM	3000	-7	In Production
AP2191AW-7	SOT25	W	3000	-7	In Production
AP2191AS-13	SO-8	S	2500	-13	In Production
AP2191AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2191AFM-7	U-DFN2018-6	FM	3000	-7	End of Life

otes: 9. AP2191AFM-7 is End of Life (EOL) and recommended alternative is AP2181AFM-7.

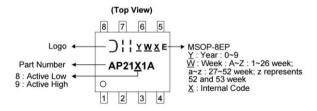
10. For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

(1) SO-8



(2) MSOP-8EP



AP2181A/AP2191A Document number: DS37618 Rev. 2 - 2 11 of 17 www.diodes.com May 2018 © Diodes Incorporated

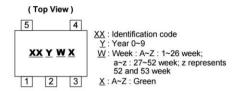
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AP2181A/AP2191A

Marking Information (Cont.)

(3) SOT25



Device	Package Type	Identification Code
AP2181AW	SOT25	VX
AP2191AW	SOT25	VY

(4) U-DFN2018-6





XX: Identification Code
Y: Year: 0~9
W: Week: A~Z: 1~26 week;
a~Z: 27~52 week; z represents
52 and 53 week
X: A~Z: Green

Device	Package Type	Identification Code
AP2181AFM	U-DFN2018-6	ZX
AP2191AFM	U-DFN2018-6	ZY

Manuals ID 06-03

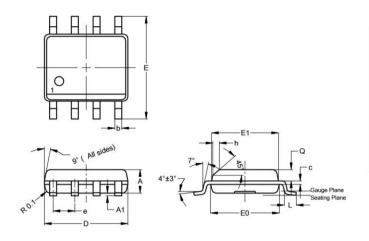


AP2181A/AP2191A

Package Outline Dimensions

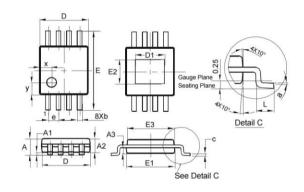
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



	S	D-8	-07
Dim	Min	Max	Тур
Α	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
С	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
е			1.27
h			0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All	Dimens	ions in	mm

(2) Package Type: MSOP-8EP



	MSO	P-8EP	
Dim	Min	Max	Тур
Α	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
С	0.08	0.23	0.15
D	2.90	3.10	3.00
D1	1.60	2.00	1.80
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E2	1.30	1.70	1.50
E3	2.85	3.05	2.95
е	-	-	0.65
٦	0.40	0.80	0.60
а	0°	8°	4°
x	-	-	0.750
У	-	-	0.750
All D	Dimens	ions in	mm

Page 88 of 252 **Enclosures**

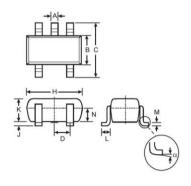
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AP2181A/AP2191A

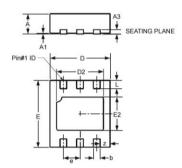
Please see http://www.diodes.com/package-outlines.html for the latest version.

(3) Package Type: SOT25



	SOT25					
Dim	Min	Max	Тур			
Α	0.35	0.50	0.38			
В	1.50	1.70	1.60			
С	2.70	3.00	2.80			
D	_	_	0.95			
Н	2.90	3.10	3.00			
J	0.013	0.10	0.05			
K	1.00	1.30	1.10			
L	0.35	0.55	0.40			
M	0.10	0.20	0.15			
N	0.70	0.80	0.75			
α	0°	8°	_			
All C	imensi	ons in	mm			

(4) Package Type: U-DFN2018-6



U-DFN2018-6				
Dim	Min	Max	Тур	
Α	0.545	0.605	0.575	
A1	0	0.05	0.02	
A3	_	_	0.13	
b	0.15	0.25	0.20	
D	1.750	1.875	1.80	
D2	1.30	1.50	1.40	
е	_	_	0.50	
Е	1.95	2.075	2.00	
E2	0.90	1.10	1.00	
L	0.20	0.30	0.25	
z	_	_	0.30	
All D	imens	ions ir	mm n	

Manuals ID 06-03

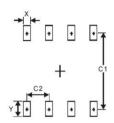


AP2181A/AP2191A

Suggested Pad Layout

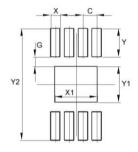
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



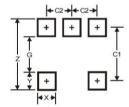
Dimensions	Value (in mm)
Х	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)		
С	0.650		
G	0.450		
Х	0.450		
X1	2.000		
Υ	1.350		
Y1	1.700		
Y2	5.300		

(3) Package Type: SOT25



Dimensions	Value (in mm)		
Z	3.20		
G	1.60		
х	0.55		
Y	0.80		
C1	2.40		
C2	0.95		

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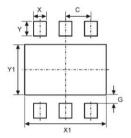


AP2181A/AP2191A

Suggested Pad Layout (Cont.)

Please see http://www.diodes.com/package-outlines.html for the latest version.

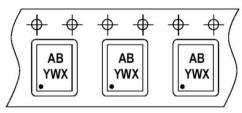
(4) Package Type: U-DFN2018-6

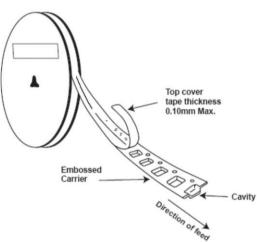


Dimensions	Value (in mm)		
С	0.50		
G	0.20		
Х	0.25		
X1	1.60		
Y	0.35		
Y1	1.20		

Taping Orientation

For U-DFN2018-6





Note: 11. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2181A/AP2191A

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May 2018

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AP21410 / AP21510

June 2015

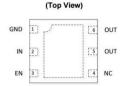
0.2A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP21410 and AP21510 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality.

All devices are available in U-DFN2018-6 packages.

Pin Assignments



U-DFN2018-6

Features

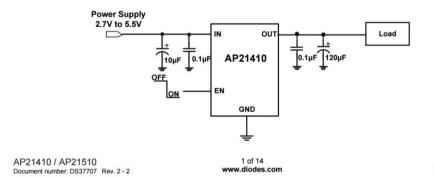
- Single USB Port Power Switches
- Overcurrent and Thermal Protection
- 0.4A Typical Current Limiting Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- 0.4ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- ESD Protection: 4KV HBM, 400V MM
- Active Low (AP21410) or Active High (AP21510) Enable
- Ambient Temperature Range -40°C to +85°C
- U-DFN2018-6: Available in "Green" Molding Compound (No Br,
- 15kV ESD Protection per IEC 61000-4-2 (with External Capacitance)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)

Applications

- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Stations, HUBs

- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + CI) and <1000ppm antimony compounds.

Typical Applications Circuit



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AP21410 / AP21510

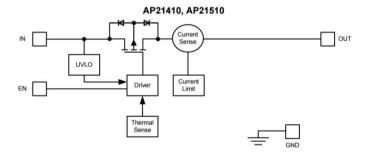
Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typical) Recommended Maximum Continuous Load	
AP21410	1	Active Low	0.4A	0.2A
AP21510	1	Active High	0.4A	0.2A

Pin Descriptions

Pin Number Pin Name		Function			
1	GND	Ground			
2	IN	Voltage Input Pin (all IN pins must be tied together externally).			
3	EN	Enable Input. Active Low (AP21410) and Active High (AP21510)			
4	NC	No internal connection			
5, 6	OUT	Voltage Output Pin (all OUT pins must be tied together externally).			
Exposed Pad	Exposed Pad	Exposed Pad. It should be externally connected to GND plane and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.			

Functional Block Diagram



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AP21410 / AP21510

Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter			Ratings	Units
	НВМ	Human Body Model ESD Protection		4	kV
	ММ	Machine Model ESD Protection	400	V	
ESD	IEC System Level	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Air	15	kV
		Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Contact	8	kV
VIN	Input Voltage	Input Voltage			V
Vout	Output Voltag	Output Voltage			V
V _{EN}	Enable Voltage			6.5	V
I _{LOAD}	Maximum Continuous Load Current			Internal Limited	Α
$T_{J(MAX)}$	Maximum Junction Temperature			+150	°C
T _{ST}	Storage Temperature Range (Note 4)		-65 to +150	°C	

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Notes:

- UL Recognized Rating from -30°C to +70°C (Diodes qualified T_{ST} from -65°C to +150°C).
 External capacitors need to be connected to the output, EVM board was tested with capacitor 2.2μF 50V 0805. This level is a pass test only and not a limit.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units
VIN	Input Voltage	2.7	5.5	٧
I _{OUT}	Output Current	0	200	mA
TA	Operating Ambient Temperature	-40	+85	°C
VIL	EN Input Logic Low Voltage	0	0.8	V
VIH	EN Input Logic High Voltage	2	VIN	V

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AP21410 / AP21510

Electrical Characteristics (@TA = +25°C, VIN = +5.0V, unless otherwise specified.)

Symbol	Parameter	Conditions			Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$			1.6	1.9	2.5	٧
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT}	= 0		1-	0.5	1	μA
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		1-	45	70	μA
I _{LEAK}	Input Leakage Current	Disabled, OUT	Grounded		-	_	1	μA
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V, V _{OUT} = 5V, I _{REV} at V _{IN}			_	0.01	1	μA
		V _{IN} = 5V.	T _A = +25°C	U-DFN2018-6	-	80	110	
	Switch On-Resistance	I _{OUT} = 0.2A	-40°C ≤ T _A ≤ +85°C		-	_	140	mΩ
R _{DS(ON)}		V _{IN} = 3.3V, I _{OUT} = 0.2A	T _A = +25°C		-	100	140	
			-40°C ≤ T _A ≤ +85°C		_	_	170	
I _{SHORT}	Short-Circuit Current Limit	Enabled into S	hort Circuit		_	250	_	mA
T _{SHORT}	Short-Circuit Response Time	Vout = 0V to lout = ISHORT (OUT shorted to ground) Note: See Figure 2			1-	2		μs
I _{LIMIT}	Over-Load Current Limit	V _{IN} = 5V, V _{OUT} = 4.5V, -40°C ≤ T _A ≤ +85°C			300	400	500	mA
Isink	EN Input Leakage	V _{EN} = 5V			-	_	1	μА
t _{D(ON)}	Output Turn-On Delay Time	$R_{LOAD} = 25\Omega$			-	0.05	_	ms
t _R	Output Turn-On Rise Time	R _{LOAD} = 25Ω			-	0.4	1.5	ms
t _{D(OFF)}	Output Turn-Off Delay Time	R _{LOAD} = 25Ω				0.14	_	ms
tF	Output Turn-Off Fall Time	R _{LOAD} = 25Ω			-	0.04	0.1	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, R _{LOAD} = 1kΩ			-	+140		°C
T _{HYS}	Thermal Shutdown Hysteresis	_			-	+25		°C
θЈΑ	Thermal Resistance Junction-to- Ambient	U-DFN2018-6 (Note 6)			-	70		°C/W

Note:
6. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0" x 1.4" ground plane.

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AP21410 / AP21510

Performance Characteristics

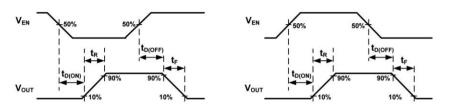


Figure 1. Voltage Waveforms: AP21410 (Left), AP21510 (Right)

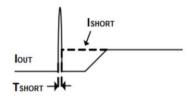
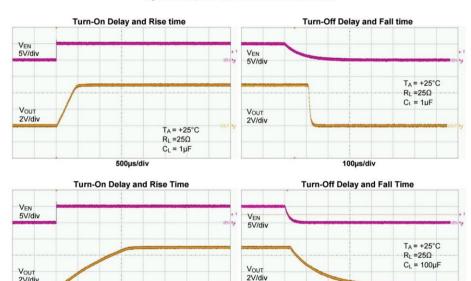


Figure 2. Response Time to Short Circuit Waveform



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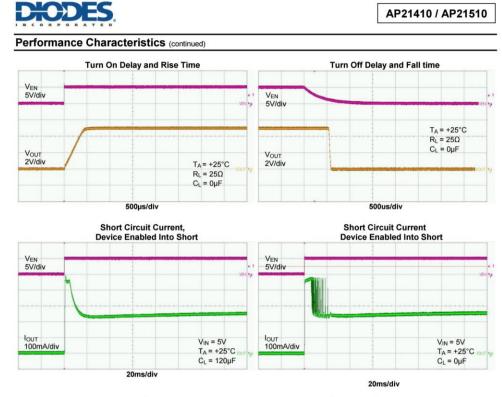
T_A = +25°C R_L =25Ω C_L = 100μF

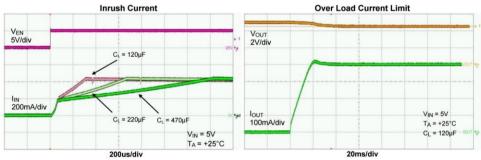
500µs/div

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2ms/div

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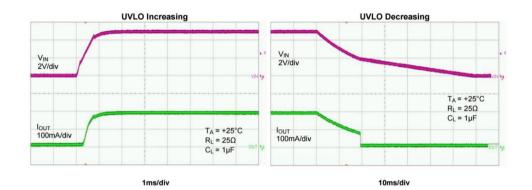
Enclosures

Manuals ID 06-04



AP21410 / AP21510

Performance Characteristics (cont.) Power On Ven SV/div Voor 2V/div $T_A = +25^{\circ}C$ $C_L = 120 \mu F$ $R_L = 25\Omega$ S00us/div Power On Power On Ven SV/div Voor 2V/div Toomal To



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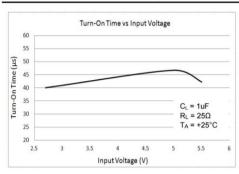
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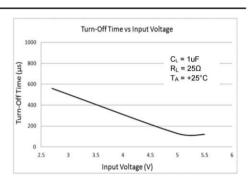
Manuals ID 06-04

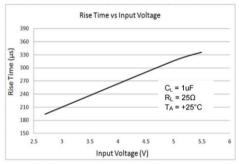


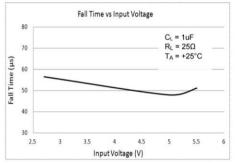
AP21410 / AP21510

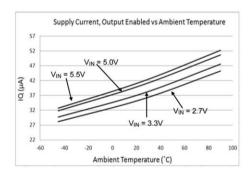
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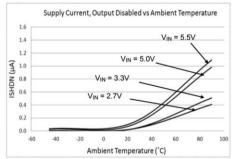










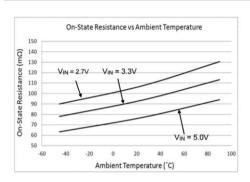


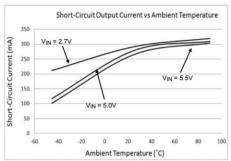
Manuals ID 06-04

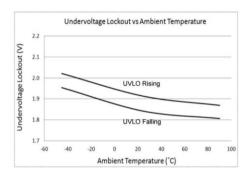


AP21410 / AP21510

Performance Characteristics (cont.)







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AP21410 / AP21510

Application Information

Power Supply Considerations

A 0.01µF to 0.1µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Overcurrent and Short Circuit Protection

An internal sensing FET is employed to check for overcurrent conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP21410 / AP21510 short circuit and clamps output current to a certain safe level namely I_{SHORT} .

In the second condition, an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current-limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold is reached or until the thermal limit of the device is exceeded. The AP21410 / AP21510 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into overload current limiting mode and is set at ILIMIT. If the load current keeps going higher, the device will switch into short-circuit current limiting mode and is set at ILIMIT.

Note that when the output has been shorted to GND at extremely low temperatures (< -30°C), a minimum 120µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that the capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D x R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature °C

R_{BJA} = Thermal resistance

P_D = Total power dissipation

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AP21410 / AP21510

Application Information (continued)

Thermal Protection

Thermal protection prevents the IC from damage when heavy overload or short-circuit faults are present for extended periods of time. The AP21410 / AP21510 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an overcurrent or short-circuit condition, the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed.

Undervoltage Lockout (UVLO)

Undervoltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP21410 / AP21510, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP21410 / AP21510 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP21410 / AP21510 between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

AP21410/AP21510 is suitable for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of this is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. In such dual-purpose port applications, it is important to insure Vin of the AP21410/AP21510 is ramped to its operating voltage prior to enabling the output.

No Output Capacitor Applications

For certain applications, no output capacitor is allowed. It is recommended to add a schottky diode at the output pin to prevent the device damaged by output accidently short to ground.

Note: All previous Typical Performance Characteristics charts marked C_L=0µF have the schottky diode added.

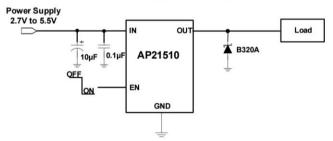


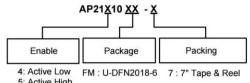
Figure 3. No Output Capacitor Application

Manuals ID 06-04



AP21410 / AP21510

Ordering Information (Note 7)



5: Active High

Part Number	Package Code Packaging		7" Tape and Reel	
Part Number	Package Code	Packaging -	Quantity	Part Number Suffix
AP21410FM-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7
AP21510FM-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

7. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information

(1) U-DFN2018-6

(Top View)

XX XX : Identification Code
Y: Year : 0-9
W: Week : A-Z : 1~26 week;
a-z : 27~52 week; z represents
52 and 53 week
X: Internal Code

Device	Package Type	Identification Code
AP21410FM	U-DFN2018-6	GA
AP21510FM	U-DFN2018-6	GP

Manuals ID 06-04

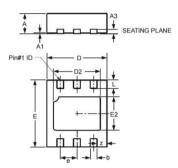


AP21410 / AP21510

Package Outline Dimensions (All dimensions in mm.)

Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(1) Package Type: U-DFN2018-6

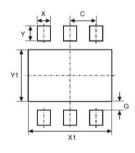


	U-DFN	2018-6						
Dim	Min	Max	Тур					
Α	0.545	0.605	0.575					
A1	0	0.05	0.02					
A3	_	_	0.13					
b	0.15	0.25	0.20					
D	1.750	1.875	1.80					
D2	1.30	1.50	1.40					
е	_	-	0.50					
E	1.95	2.075	2.00					
E2	0.90	1.10	1.00					
L	0.20	0.30	0.25					
z	_	_	0.30					
All D	imens	ions ir	All Dimensions in mm					

Suggested Pad Layout

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: U-DFN2018-6



Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Y	0.35
Y1	1.20

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AP21410 / AP21510

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2A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

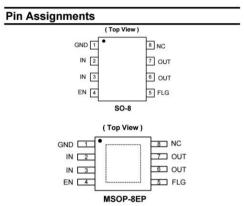
The AP2101 and AP2111 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time, under-voltage lockout and auto-discharge functionalities. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8 and MSOP-8EP packages.

Features

- Single USB port power switches with auto-discharge
- Short-circuit current and thermal protection
- 2.45A accurate current limiting
- Fast transient response time: 5µs
- $90m\Omega$ on-resistance
- Reverse Current Blocking
- Input voltage range: 2.7V 5.5V
- 0.6ms typical rise time
- Very low shutdown current: 1µA (max)
- Fault report (FLG) with blanking time (7ms typ)
- ESD protection: 4kV HBM, 300V MM
- Active low (AP2101) or active high (AP2111) enable
- Ambient temperature range: -35°C to 85°C
- SO-8 and MSOP-8EP (Exposed Pad): Available in "Green" Molding Compound (No Br. Sb)
 - Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
 - Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

AP2101/AP2111

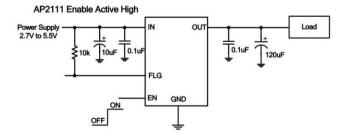


Applications

- Consumer electronics LCD TV & Monitor, Game Machines
- Communications Set-Top-Box, GPS, Smartphone
- Computing Laptop, Desktop, Servers, Printers, Docking Station, HUB

EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant. All applicable RoHS exemptions applied.
 See http://www.diodes.com for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit



AP2101/AP2111 ent number: DS32015 Rev. 3 - 2 1 of 14

January 2013

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AP2101/AP2111

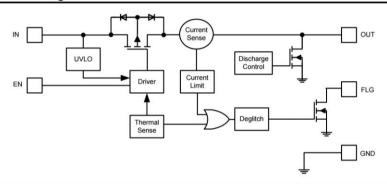
Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2101	1	Active Low	2.45A	2.0A
AP2111	1	Active High	2.45A	2.0A

Pin Descriptions

Pin	Pin Number		Functions	
Name	SO-8	MSOP-8EP	Functions	
GND	1	1	Ground	
IN	2, 3	2, 3	Voltage input pin (all IN pins must be tied together externally)	
EN	4	4	Enable input, active low (AP2101) or active high (AP2111)	
FLG	5	5	Over-current and over-temperature fault report; open-drain flag is active low when triggered	
OUT	6, 7	6, 7	Voltage output pin (all OUT pins must be tied together externally)	
NC	8	8	No internal connection; recommend tie to OUT pins	
Exposed tab	-	Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

Functional Block Diagram



Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Units
ESD HBM	Human Body Model ESD Protection	4	kV
ESD MM	Machine Model ESD Protection	300	V
VIN	Input Voltage	6.5	V
Vout	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
ILOAD	Maximum Continuous Load Current	Internal Limited	A
T _{J(MAX)}	Maximum Junction Temperature	150	°C
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time. Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

4. UL Recognized Rating from -30°C to 70°C (Diodes qualified T_{ST} from -65°C to 150°C) Caution:

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AP2101/AP2111

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units
ViN	Input voltage	2.7	5.5	V
lout	Output Current	0	2.0	Α
TA	Operating Ambient Temperature	-35	85	°C
VIL	EN Input Logic Low Voltage	0	0.8	V
VIH	EN Input Logic High Voltage	2	V _{IN}	V

Electrical Characteristics (@TA = +25°C, VIN = +5.0V, unless otherwise specified.)

Symbol	Parameter	Test Co	nditions (Note	5)	Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	R _{LOAD} = 1kΩ			1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0				0.5	1	μΑ
IQ	Input Quiescent Current	Enabled, I _{OUT} = 0				45	70	μΑ
I _{LEAK}	Input Leakage Current	Disabled, OUT grounded					1	μА
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V, V _{OUT}	= 5V, I _{REV} at V _{II}	N		0.05		μA
			T _A = +25°C	MSOP8-EP		90	115	
	Switch On-Resistance	V _{IN} = 5V, I _{OUT} = 1.5A	1A = +25 C	SO-8		95	115	
R _{DS(ON)}	Switch On-Resistance		-40°C ≤ T _A ≤	+85°C			140	mΩ
		V = 2.2V I = 4.5A	T _A = 25°C			115	140	
		V _{IN} = 3.3V, I _{OUT} = 1.5A	-40°C ≤ T _A ≤	+85°C			170	
I _{LIMIT}	Over-Load Current Limit	V _{IN} = 5V, V _{OUT} = 4.5V, C _L	=120µF		2.1	2.45	2.8	Α
ITRIG	Current Limiting Trigger Threshold	Output Current Slew rate	(<100A/s), C _L :	= 100µF		2.5		Α
I _{SHORT}	Short-Circuit Current Limit	Enabled into short circuit,	C _L = 100µF			2.5		Α
T _{SHORT}	Short-Circuit Response Time	V _{OUT} = 0V to I _{OUT} = I _{LIMIT}	(short applied t	o output)		5		μs
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V	***************************************				0.8	V
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V			2			V
Isink	EN Input leakage	V _{EN} = 5V					1	μA
T _{D(ON)}	Output Turn-On Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$				50		μs
T _R	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$				0.6	1.5	ms
T _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$				4		μs
T _F	Output Turn-Off Fall Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$				0.03	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA, C _L =100μF				20	40	Ω
T _{BLANK}	FLG Blanking Time	C _{IN} = 10µF, C _L = 100µF			4	7	15	ms
R _{DIS}	Discharge Resistance (Note 6)	V _{IN} = 5V, disabled, I _{OUT} =	1mA			290		Ω
T _{SHDN}	Thermal Shutdown Threshold	Enabled, R _{LOAD} = 1kΩ				140		°C
T _{HYS}	Thermal Shutdown Hysteresis					25		°C
0	Thermal Resistance Junction-to-	SO-8 (Note 7)				110		°C/W
θ_{JA}	Ambient	MSOP-8EP (Note 8)				60		°C/W

Notes:

- 5. Pulse-testing techniques maintain junction temperature close to ambient temperature; thermal effects must be taken into account separately.

 6. The discharge function is active when the device is disabled (when enable is de-asserted). The discharge function offers a resistive discharge path for the external storage capacitor. This is suitable only to discharge filter capacitors for limited time and cannot dissipate steady state currents greater than 8mA.

 7. Test condition for SC-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.

 8. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

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AP2101/AP2111

Typical Performance Characteristics

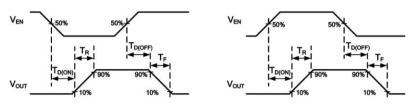
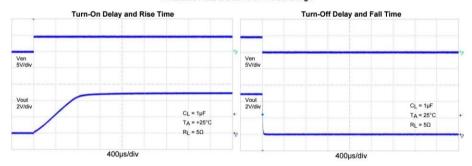
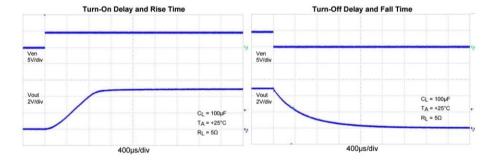


Figure 1. Voltage Waveforms: AP2101 (left), AP2111 (right)

All Enable Plots are for AP2111 Active High

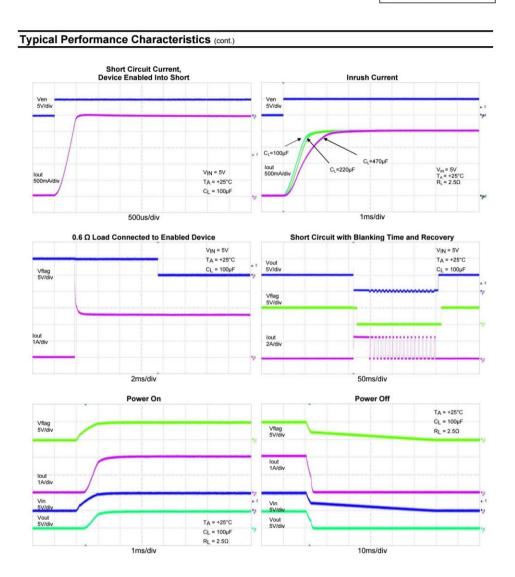




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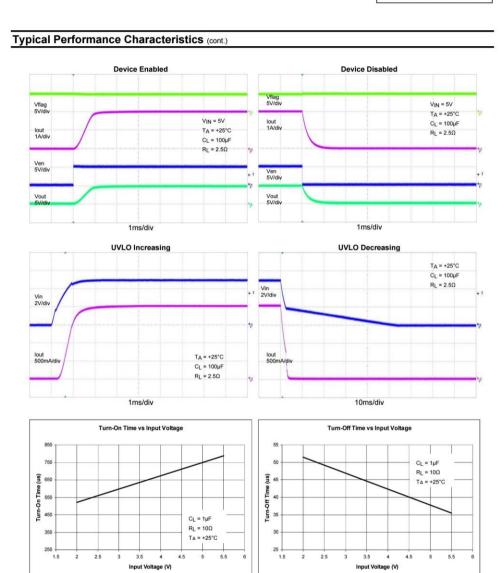
AP2101/AP2111



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AP2101/AP2111

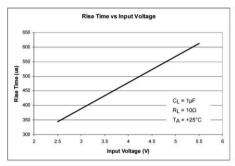


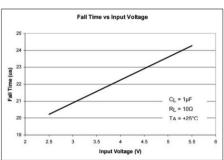
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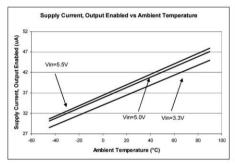


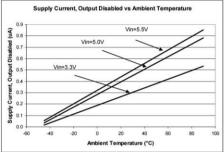
AP2101/AP2111

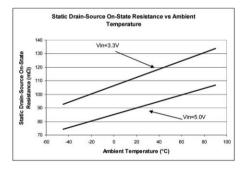
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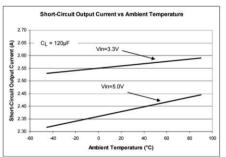










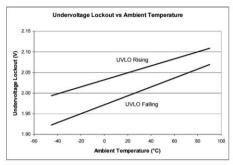


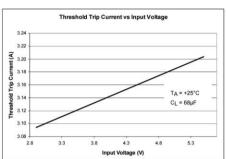


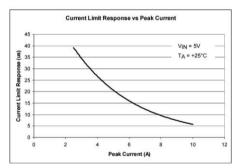


AP2101/AP2111

Typical Performance Characteristics (cont.)







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AP2101/AP2111

Application Information

Power Supply Considerations

A 0.1-µF to 1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before VIN has been applied. The AP2101/AP2111 senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{I MMT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2101/AP2111 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{I,MIT}.

To protect against short circuit to GND at extremely low temperature (< -30°C), a minimum 120-μF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

At low input voltage condition (V_{IN} < 3V), the short circuit protection current may rise as high as twice the typical value.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2101/AP2111 is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and $R_{DS(ON)}$, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A= Ambient temperature °C

 $R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

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Enclosures

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AP2101/AP2111

Application Information (cont.)

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2101/AP2111 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately 25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7-ms deglitch.

Under-Voltage Lockout (UVLO)

Under-voltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and self-powered hubs (SPH) have a local power supply that powers the embedded functions and the downstream ports. This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP2101/AP2111, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2101/AP2111 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

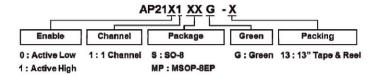
By placing the AP2101/AP2111 between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

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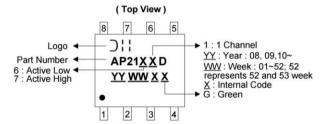
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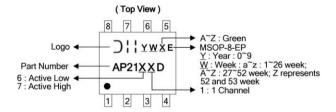
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	Part Number	Package Code	Packaging	Quantity	Part Number Suffix
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,	AP21X1MPG-13	MP	MSOP-8EP	2500/Tape & Reel	-13

Marking Information

(1) SO-8



(2) MSOP-8EP



Manuals ID 06-05

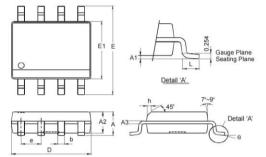


AP2101/AP2111

Package Outline Dimensions (All dimensions in mm.)

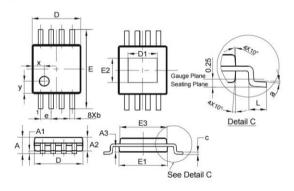
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(1) SO-8



	SO-8				
Dim	Min	Max			
Α	-	1.75			
A1	0.10	0.20			
A2	1.30	1.50			
A3	0.15	0.25			
b	0.3	0.5			
D	4.85	4.95			
E	5.90	6.10			
E1	3.85	3.95			
е	1.27	Тур			
h	()	0.35			
L	0.62	0.82			
θ	0°	8°			
All Di	mensions	in mm			

(2) MSOP-8EP



	MSO	P-8EP	15
Dim	Min	Max	Тур
Α	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
С	0.08	0.23	0.15
D	2.90	3.10	3.00
D1	1.60	2.00	1.80
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E2	1.30	1.70	1.50
E3	2.85	3.05	2.95
е	-	-	0.65
L	0.40	0.80	0.60
а	0°	8°	4°
х	- 5	-	0.750
У		-	0.750
All E	imens	ions ir	mm

Manuals ID 06-05

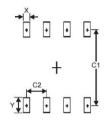


AP2101/AP2111

Suggested Pad Layout

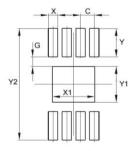
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) SO-8



Dimensions	Value (in mm)
Х	0.60
Υ	1.55
C1	5.4
C2	1.27

(2) MSOP-8-EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Υ	1.350
Y1	1.700
V2	5 300

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AP2101/AP2111

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2024-07-24



AP2141D/ AP2151D

0.5 SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH WITH OUTPUT DISCHARGE

Description

The AP2141D and AP2151D are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SOT25, SO-8, MSOP-8EP, and U-DFN2018-6 packages

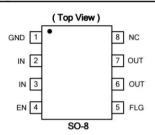
Features

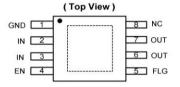
- Single USB Port Power Switches with Output Discharge
- Over-Current and Thermal Protection
- 0.8A Accurate Current Limiting
- Fast Transient Response
- Reverse Current Blocking
- 90mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- ESD Protection: 4kV HBM, 300V MM
- Active High (AP2151D) or Active Low (AP2141D) enable
- Ambient Temperature Range -40 ℃ to +85 ℃
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- 15kV ESD Protection per IEC 61000-4-2 (with external capacitance)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

Applications

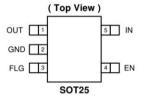
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Stations, HUBs

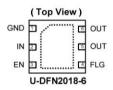
Pin Assignments





MSOP-8EP Note: Latter with Exposed Pad (Dotted Line)





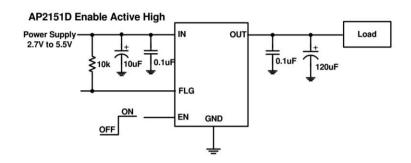
- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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AP2141D/ AP2151D

Typical Applications Circuit



Part Number	Channel	Enable Pin (EN)	Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2141D	1	Active Low	0.8A	0.5A
AP2151D	1	Active High	0.8A	0.5A

Pin Descriptions

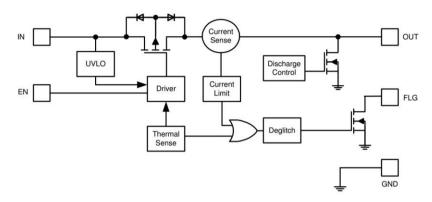
Pin		Pin N	lumber		B	
Name	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Descriptions	
GND	1	1	2	1	Ground	
IN	2, 3	2, 3	5	2	Voltage Input Pin. (all IN pins must be tied together externally)	
EN	4	4	4	3	Enable Input, active low (AP2141D) or active high (AP2151D).	
FLG	5	5	3	4	Over-current and over-temperature fault report; open-drain flag is active low when triggered.	
OUT	6, 7	6, 7	1	5, 6	Voltage Output Pin (all OUT pins must be tied together externally).	
NC	8	8	N/A	N/A	No Internal Connection; recommend tie to OUT pins.	
Exposed tab	1743	Exposed tab	-	Exposed tab	Exposed pad. Internally connected to GND. It should be externally connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

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AP2141D/ AP2151D

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25 °C, unless otherwise specified.)

Symbol		Parameter		Ratings	Units
	НВМ	Human Body Model ESD Protection	Human Body Model ESD Protection		kV
	MM	Machine Model ESD Protection	Machine Model ESD Protection		V
ESD	IEC System	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Air	15	kV
	Level	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Contact	8	kV
V _{IN}	Input Voltage			6.5	V
Vout	Output Voltag	ge		V _{IN} +0.3	٧
V _{EN} , V _{FLG}	Enable Volta	ge		6.5	٧
ILOAD	Maximum Continuous Load Current			Internal Limited	Α
T _{J(MAX)}	Maximum Junction Temperature			+150	℃
T _{ST}	Storage Tem	perature Range (Note 4)		-65 to +150	%

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices Caution:

Notes:

Recommended Operating Conditions (@T_A = +25 °C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V _{IN}	Input Voltage	2.7	5.5	V
lout	Output Current	0	500	mA
TA	Operating Ambient Temperature	-40	+85	℃
VIH	High-Level Input Voltage on EN or EN	2.0	VIN	٧
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V

UL Recognized Rating from -30 °C to +70 °C (Diodes qualified T_{ST} from -65 °C to +150 °C)
 External capacitors need to be connected to the output, EVM board was tested with capacitor 2.2μF 50V 0805. This level is a pass test only and not a limit.

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AP2141D/ AP2151D

$\begin{tabular}{ll} \textbf{Electrical Characteristics} & (@T_A = +25\,^\circ\!\!C,\ V_{IN} = +5V,\ unless\ otherwise\ specified.) \end{tabular}$

Symbol	Parameter		Test Condit	ions	Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	_			1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0			_	0.5	1	μΑ
ΙQ	Input Quiescent Current	Enabled, I _{OUT} = 0			_	45	70	μΑ
ILEAK	Input Leakage Current	Disabled, OUT gro	unded		_	0.1	1	μΑ
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V,	V _{OUT} = 5V, I	REV at VIN	-	0.1	1	μА
		V _{IN} = 5V.	T _A = +25°C	SOT25, MSOP-8, MSOP-8EP, SO-8	_	95	115	
		I _{OUT} = 0.5A	1000	U-DFN2018-6	_	90	110]
R _{DS(ON)}	Switch On-Resistance		-40°C ≤ T _A ≤	+85℃		_	140	mΩ
		V _{IN} = 3.3V, I _{OUT} =	T _A = +25 °C		_	120	140]
		0.5A	-40°C ≤ T _A ≤	£ +85℃	_	_	170	1
I _{SHORT}	Short-Circuit Current Limit	Enabled into short	circuit, C _L = 2	2μF	-	0.6	1-1	Α
I _{LIMIT}	Over-Load Current Limit	V _{IN} = 5V, V _{OUT} = 4.	.0V, C _L = 120	μF, -40 °C ≤ T _A ≤ +85 °C	0.6	0.8	1.0	Α
I _{TRIG}	Current Limiting Trigger Threshold	Output Current Sle	w Rate (<100	A/s) , C _L = 22μF	-	1.0	_	Α
ISINK	EN Input Leakage	V _{EN} = 5V			-	_	1	μА
t _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _{LOAD} =	10Ω		_	0.05	_	ms
tR	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.6	1.5	ms
tD(OFF)	Output Turn-Off Delay Time	C _L = 1µF, R _{LOAD} =	10Ω		-	0.05	_	ms
tF	Output Turn-Off Fall Time	C _L = 1µF, R _{LOAD} =	10Ω			0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA			_	20	40	Ω
t BLANK	FLG Blanking Time	$C_{IN} = 10 \mu F$, $C_L = 2$	2μF		4	7	15	ms
RDIS	Discharge Resistance (Note 6)	V _{IN} = 5V, disabled,	I _{OUT} = 1mA		_	100	_	Ω
t _{DIS}	Discharge Time	$C_L = 1\mu F$, $V_{IN} = 5V$, disabled to $V_{OUT} < 0.5V$		_	0.6	-	ms	
TSHDN	Thermal Shutdown Threshold	Enabled, R _{LOAD} = 1kΩ		_	140	_	∞	
T _{HYS}	Thermal Shutdown Hysteresis	_		_	25	_	∞	
		SOT25 (Note 7)		_	170	_		
θЈΑ	Thermal Resistance Junction-to-	SO-8 (Note 7)			-	127	_	°C/W
Ambient Ambient	Ambient	MSOP-8EP (Note 8)		_	67	_	-0/ vv	
		U-DFN2018-6 (Not	U-DFN2018-6 (Note 8)		_	70	_	

^{6.} The discharge function is active when the device is disabled (when enable is de-asserted). The discharge function offers a resistive discharge path for the external storage capacitor.
7. Device mounted on FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.
8. Device mounted on 2" x 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

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AP2141D/ AP2151D

Typical Performance Characteristics

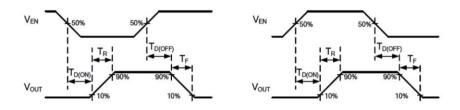
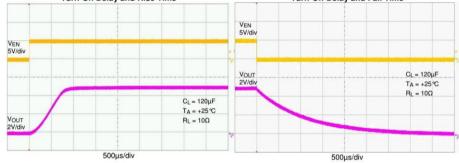


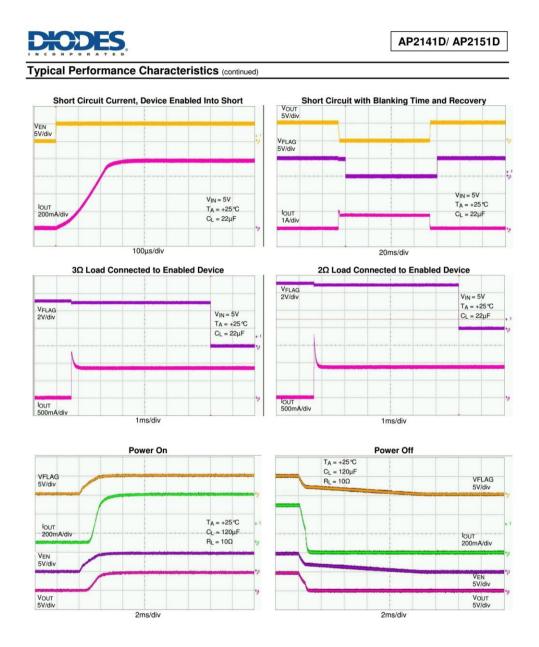
Figure 1 Voltage Waveforms: AP2141D (left), AP2151D (right)

All Enable Plots are for AP2151D Active High

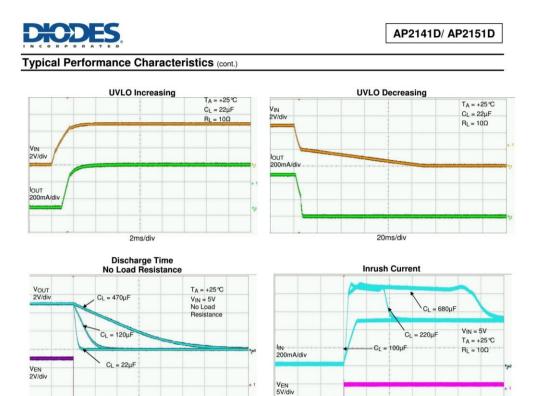




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100ms/div

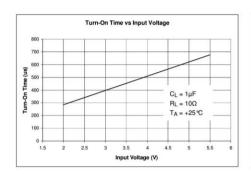


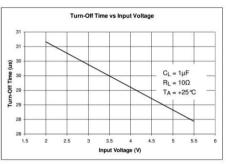
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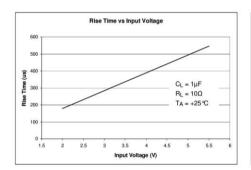


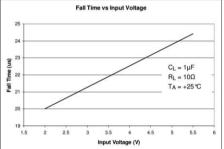
AP2141D/ AP2151D

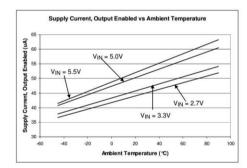
Typical Performance Characteristics (cont.)

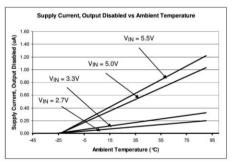












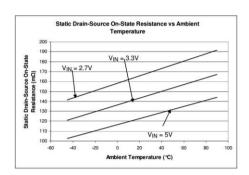


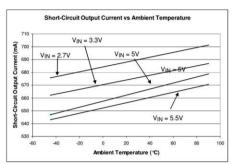
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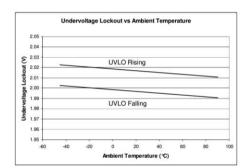


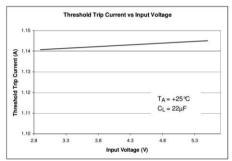
AP2141D/ AP2151D

Typical Performance Characteristics (cont.)









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AP2141D/ AP2151D

Application Information

The AP2141D and AP2151D are integrated high-side power switches optimized for Universal Serial Bus (USB) that require protection functions. The power switches are equipped with a driver that controls the gate voltage and incorporates slew-rate limitation. This, along with the various protection features and special functions, make these power switches ideal for hot-swap or hot-plug applications.

Protection Features:

Undervoltage Lockout (UVLO)

Undervoltage lockout function (UVLO) guarantees that the internal power switch is initially off during start-up. The UVLO functions only when the switch is enabled. Even if the switch is enabled, the switch is not turned ON until the power supply has reached at least 1.9V. Whenever the input voltage falls below approximately 1.9V, the power switch is turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

The different overload conditions and the corresponding response of the AP2141D/2151D are outlined below:

S.NO	Conditions	Explanation	Behavior of the AP2141D/2151D
1	Short circuit condition at start-up	Output is shorted before input voltage is applied or before the part is enabled	The IC senses the short circuit and immediately clamps output current to a certain safe level namely I _{LIMIT} .
2	Short-circuit or Overcurrent condition	Short-Circuit or Overload condition that occurs when the part is enabled.	At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at LIMIT.
3	Gradual increase from nominal operating current to I _{LIMIT}	Load increases gradually until the current-limit threshold.(I _{TRIG})	The current rises until I_{TRIG} or thermal limit. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT} .

Note that when the output has been shorted to GND at extremely low temperatures (< -20°C), a minimum 120 µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than a 10% variation of capacitance change when operated at extremely low temperatures. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

Thermal Protection

Thermal protection prevents the IC from damage when the die temperature exceeds safe margins. This mainly occurs when heavy-overload or short-circuit faults are present for extended periods of time. The AP2141D/AP2151D implements thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 140°C, the Thermal protection feature gets activated as follows: The internal thermal sense circuitry turns the power switch off and the FLG output is asserted thus preventing the power switch from damage. Hysteresis in the thermal sense circuit allows the device to cool down to approximately 25°C before the output is turned back on. The built-in thermal hysteresis feature avoids undesirable oscillations of the thermal protection circuit. The switch continues to cycle in this manner until the load fault is removed, resulting in a pulsed output. The FLG open-drain output is asserted when an over-current occurs with 7-ms deglitch.

Reverse Current Protection

In a normal MOSFET switch, current can flow in reverse direction (from the output side to the input side) when the output side voltage is higher than the input side, even when the switch is turned off. A reverse-current blocking feature is implemented in the AP21x1 series to prevent such back currents. This circuit is activated by the difference between the output voltage and the input voltage. When the switch is disabled, this feature blocks reverse current flow from the output back to the input.

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Enclosures

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AP2141D/ AP2151D

Application Information (continued)

Special Functions:

Discharge Function

When enable is de-asserted, the discharge function is active. The output capacitor is discharged through an internal NMOS that has a discharge resistance of 100Ω. Hence, the output voltage drops down to zero. The time taken for discharge is dependent on the RC time constant of the resistance and the output capacitor.

FLG Response

The FLG open-drain output goes active low for any of the two conditions: Over-Current or Over-Temperature. The time from when a fault condition is encountered to when the FLG output goes low is 7-ms (typ). The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary Over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The 7-ms timeout is also applicable for Over-current recovery and Thermal recovery. The AP2141D/AP2151D are designed to eliminate erroneous Over-current reporting without the need for external components, such as an RC delay network.

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. This limits the input voltage drop during line transients. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution also reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients. This capacitor also prevents the output from going negative during turn-off due to inductive parasitics.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and $R_{DS(ON)}$, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

The junction temperature can be calculated by:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where

T_A= Ambient Temperature ^oC R_{θJA} = Thermal Resistance P_D = Total Power Dissipation

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges as seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp up the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall times of the AP2141D/AP2151D, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2141D/AP2151D also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2141D/AP2151D between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls the system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

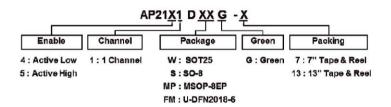
AP2141D/AP2151D is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a non-recommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. Since the AP2141D/AP2151D includes an embedded discharge feature that discharges the output load of the device when the device is disabled, the batteries of the connected peripheral device will be subject to continual discharge whenever the AP2141D/AP2151D is disabled. An overstress condition to the device's discharge MOS transistor may result. In addition, if the output of the AP2141D/AP2151D is subjected to a constant voltage that would be present during a dual-purpose port application such as MHL, an overstress condition to the device may result.

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AP2141D/ AP2151D

Ordering Information

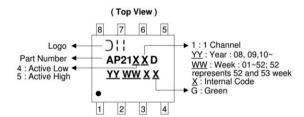


Part Number	Deekens Cada	Deskanian	7"/13" Tape	and Reel
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1DSG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1DMPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1DWG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1DFMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Note: 9. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Marking Information

(1) SO-8



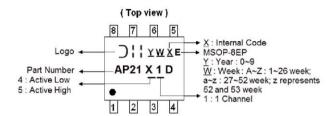
Manuals ID 06-06



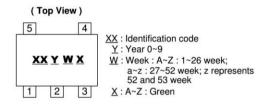
AP2141D/ AP2151D

Marking Information (continued)

(2) MSOP-8EP



(3) SOT25



Device	Package Type	Identification Code
AP2141DW	SOT25	JA
AP2151DW	SOT25	JB

(4) U-DFN2018-6

Device	Package type	Identification Code
AP2141DFM	U-DFN2018-6	JA
AP2151DFM	U-DFN2018-6	JB

Manuals ID 06-06

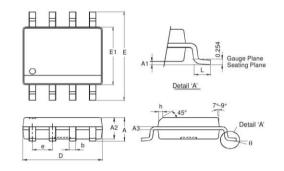


AP2141D/ AP2151D

Package Outline Dimensions (All dimensions in mm.)

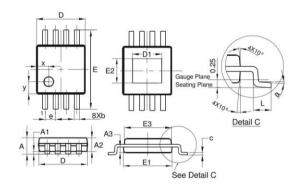
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(1) Package type: SO-8



	SO-8					
Dim	Min	Max				
Α	(2)	1.75				
A1	0.10	0.20				
A2	1.30	1.50				
A3	0.15	0.25				
b	0.3	0.5				
D	4.85	4.95				
E	5.90	6.10				
E1	3.85	3.95				
е	1.27	Тур				
h	-	0.35				
L	0.62	0.82				
θ	0°	8°				
All Di	mensions	in mm				

(2) Package Type: MSOP-8EP



MSOP-8EP			
Dim	Min	Max	Тур
Α	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
С	0.08	0.23	0.15
D	2.90	3.10	3.00
D1	1.60	2.00	1.80
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E2	1.30	1.70	1.50
E3	2.85	3.05	2.95
е		-	0.65
L	0.40	0.80	0.60
а	0°	8°	4°
x		-	0.750
у	747	7-2	0.750
All Dimensions in mm			

Manuals ID 06-06

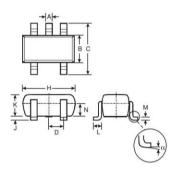


AP2141D/ AP2151D

Package Outline Dimensions (continued) (All dimensions in mm.)

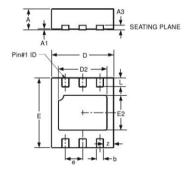
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(3) Package Type: SOT25



SOT25			
Dim	Min	Max	Тур
Α	0.35	0.50	0.38
В	1.50	1.70	1.60
С	2.70	3.00	2.80
D	-		0.95
Н	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	1
All Dimensions in mm			

(4) Package Type: U-DFN2018-6



U-DFN2018-6			
Dim	Min	Max	Тур
Α	0.545	0.605	0.575
A1	0	0.05	0.02
A3	_	-	0.13
b	0.15	0.25	0.20
D	1.750	1.875	1.80
D2	1.30	1.50	1.40
е	_	_	0.50
E	1.95	2.075	2.00
E2	0.90	1.10	1.00
L	0.20	0.30	0.25
z	_	_	0.30
All Dimensions in mm			

Manuals ID 06-06

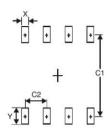


AP2141D/ AP2151D

Suggested Pad Layout

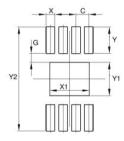
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: SO-8



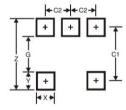
Dimensions	Value (in mm)
X	0.60
Υ	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Y	1.350
Y1	1.700
Y2	5.300

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
Х	0.55
Υ	0.80
C1	2.40
C2	0.95

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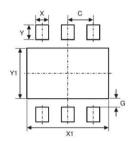


AP2141D/ AP2151D

Suggested Pad Layout (continued)

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

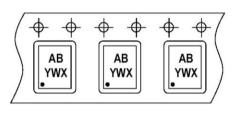
(4) Package type: U-DFN2018-6

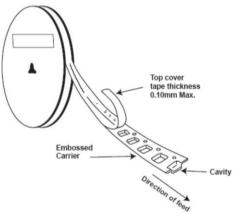


Dimensions	Value (in mm)
С	0.50
G	0.20
X	0.25
X1	1.60
Υ	0.35
Y1	1.20

Taping Orientation (Note 10)

For U-DFN2018-6





Note: 10. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2141D/ AP2151D

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March 2015

Manuals ID 06-07



2024-07-24



AP2161D/AP2171D

1A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH WITH OUTPUT DISCHARGE

Description

The AP2161D and AP2171D are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SOT25, SO-8, MSOP-8, MSOP-8EP, and U-DFN2018-6 packages.

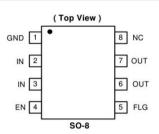
Features

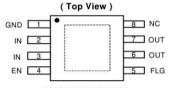
- Single USB Port Power Switches with Output Discharge
- Over-Current and Thermal Protection
- 1.5A Accurate Current Limiting
- Fast Transient Response
- Reverse Current Blocking
- 90mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- ESD Protection: 4kV HBM, 300V MM
- Active High (AP2171D) or Active Low (AP2161D) Enable
- Ambient Temperature Range -40 ℃ to +85 ℃
- SOT25, SO-8, MSOP-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound
- (No Br. Sb)
- Lead-Free Finish; RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

Applications

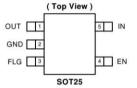
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Stations HUBs

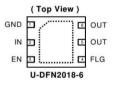
Pin Assignments





MSOP-8 / MSOP-8EP Note: Latter with Exposed Pad (Dotted Line)





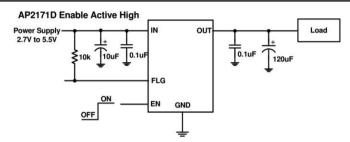
- EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant. All applicable RoHS exemptions applied.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 S. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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AP2161D/AP2171D

Typical Applications Circuit



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2161D	1	Active Low	1.5A	1A
AP2171D	1	Active High	1.5A	1A

Pin Descriptions

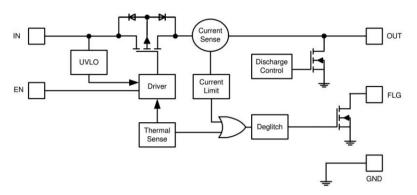
Pin		Pin Number				
Name	SO-8 MSOP-8	MSOP-8EP	SOT25	U-DFN2018-6	Functions	
GND	1	1	2	1	Ground	
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)	
EN	4	4	4	3	Enable input, active low (AP2161D) or active high (AP2171D)	
FLG	5	5	3	4	Over-current and over-temperature fault report; open-drain flag is active low when triggered	
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)	
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins	
Exposed tab	-	Exposed tab		Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

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AP2161D/AP2171D

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25 °C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	4	kV
ESD MM	Machine Model ESD Protection	300	V
VIN	Input Voltage	6.5	V
Vout	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
I _{LOAD}	Maximum Continuous Load Current	Internal Limited	А
T _{JMAX}	Maximum Junction Temperature	150	℃
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	∞

Note: 4. UL Recognized Rating from -30 $^{\circ}$ C to +70 $^{\circ}$ C (Diodes qualified T_{ST} from -65 $^{\circ}$ C to +150 $^{\circ}$ C).

Recommended Operating Conditions (@T_A = +25 ℃, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V
lout	Output Current	0	1.0	Α
VIL	EN Input Logic Low Voltage	0	0.8	٧
V _{IH}	EN Input Logic High Voltage	2	V _{IN}	V
TA	Operating Ambient Temperature	-40	+85	∞

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AP2161D/AP2171D

Symbol	Parameter		Test Cond	litions	Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	_			1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0		_	0.5	1	μА	
ΙQ	Input Quiescent Current	Enabled, I _{OUT} = 0			_	45	70	μА
ILEAK	Input Leakage Current	Disabled, OUT gr	rounded		_	0.1	1	μА
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0	V, V _{OUT} = 5V,	I _{REV} at V _{IN}	_	0.1	1	μА
		V _{IN} = 5V,	T _A = +25℃	SOT25, MSOP-8, MSOP-8EP, SO-8		95	115	
		I _{OUT} = 1A		U-DFN2018-6	_	90	110	
R _{DS} (ON)	Switch On-Resistance		-40°C ≤ T _A ≤	+85℃		_	140	mΩ
		V _{IN} = 3.3V, I _{OUT} =	T _A = +25 ℃		_	120	140	
		1A	-40°C ≤ T _A ≤	+85℃	1-		170]
ISHORT	Short-Circuit Current Limit	Enabled into short	t circuit, C _L =	22μF	_	1.2	_	Α
ILIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OUT} =	4.0V, C _L = 12	0μF, -40 °C ≤ T _A ≤ +85 °C	1.1	1.5	1.9	Α
ITrig	Current Limiting Trigger Threshold	Output Current S	lew rate (<100	0A/s) , C _L = 22μF	_	2.0	-	Α
V _{IL}	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V		_	-	0.8	V	
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V		2		i .—-	V	
ISINK	EN Input Leakage	V _{EN} = 5V		-		1	μА	
T _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _{LOAD} :	= 10Ω		_	0.05	_	ms
TR	Output Turn-On Rise Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.6	1.5	ms
T _{D(OFF)}	Output Turn-Off Delay Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.05	_	ms
T _F	Output Turn-Off Fall Time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			_	0.05	0.1	ms
RFLG	FLG Output FET On-Resistance	I _{FLG} = 10mA			-	20	40	Ω
T _{Blank}	FLG Blanking Time	C _{IN} = 10µF, C _L =	22μF		4	7	15	ms
R _{DIS}	Discharge Resistance (Note 5)	V _{IN} = 5V, disable	d, I _{OUT} = 1mA		-	100	i .—.	Ω
T _{DIS}	Discharge Time	CL = 1μF, VIN = 5V, disabled to VOUT < 0.5V		_	0.6	-	ms	
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$		_	140	-	∞	
T _{HYS}	Thermal Shutdown Hysteresis	_		_	25	_	∞	
12		SOT25 (Note 6)		_	170	7-		
		SO-8 (Note 6)		_	127	_		
θЈА	Thermal Resistance Junction-to- Ambient	MSOP-8 (Note 6)			_	118	_	.c∖M
	Table Transport	MSOP-8EP (Note	- 1		_	67	_	
		U-DFN2018-6 (N	ote 7)		1-1	70	-	

Notes:

^{5.} The discharge function is active when the device is disabled (when enable is de-asserted). The discharge function offers a resistive discharge path for the external storage capacitor.

6. Device mounted on FR-4 4 substrate PCB, 2oz copper, with minimum recommended pad layout.

7. Device mounted on 2° x 2° FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

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AP2161D/AP2171D

Typical Performance Characteristics

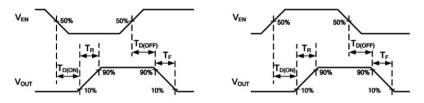
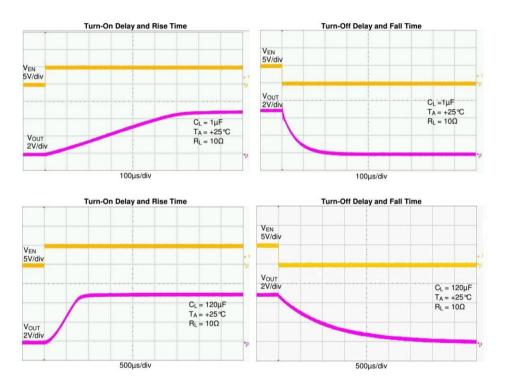
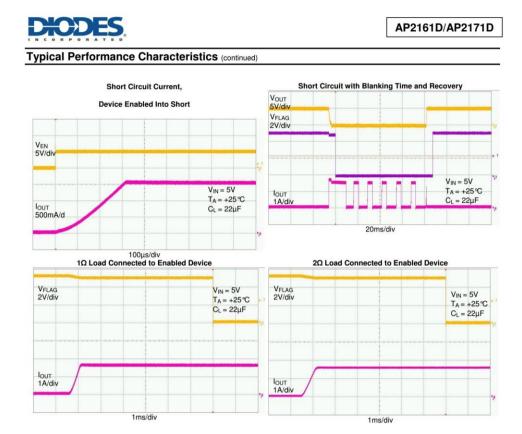


Figure 1 Voltage Waveforms: AP2161D (left), AP2171D (right)

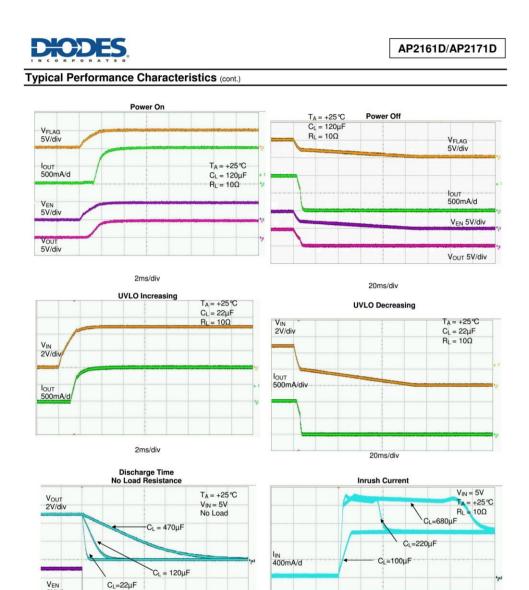
All Enable Plots are for AP2171D Active High



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Manuals ID 06-07





100ms/div

V_{EN} 5V/div

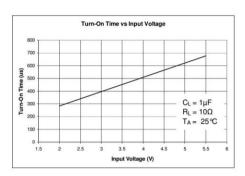
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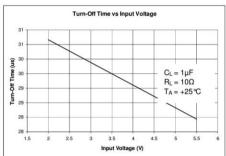
Manuals ID 06-07

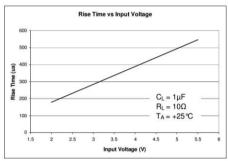


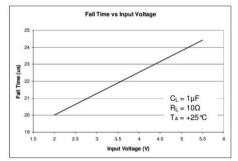
AP2161D/AP2171D

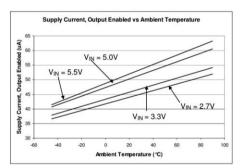
Typical Performance Characteristics (cont.)

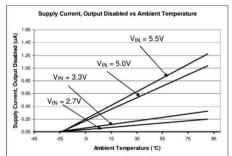










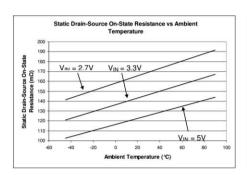


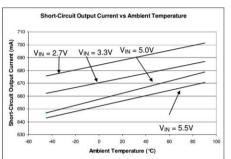
Manuals ID 06-07

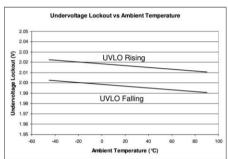


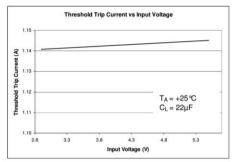
AP2161D/AP2171D

Typical Performance Characteristics (cont.)









Manuals ID 06-07



AP2161D/AP2171D

Application Note

The AP2161D and AP2171D are integrated high-side power switches optimized for Universal Serial Bus (USB) that require protection functions. The power switches are equipped with a driver that controls the gate voltage and incorporates slew-rate limitation. This, along with the various protection features and special functions, makes these power switches ideal for hot-swap or hot-plug applications.

Protection Features:

Undervoltage Lockout (UVLO)

Undervoltage lockout function (UVLO) guarantees that the internal power switch is initially off during start-up. The UVLO functions only when the switch is enabled. Even if the switch is enabled, the switch is not turned ON until the power supply has reached at least 1.9V. Whenever the input voltage falls below approximately 1.9V, the power switch is turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Over-current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an over-current condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

The different overload conditions and the corresponding response of the AP2161D/2171D are outlined below:

S.NO	Conditions	Explanation	Behavior of the AP2161D/2171D
1	Short circuit condition at start-up	Output is shorted before input voltage is applied or before the part is enabled	The IC senses the short circuit and immediately clamps output current to a certain safe level namely I _{LIMIT} .
2	Short-circuit or over-current condition	Short-Circuit or Overload condition that occurs when the part is enabled.	At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I _{LIMIT} .
3	Gradual increase from nominal operating current to ILIMIT	Load increases gradually until the current-limit threshold.(I _{TRIG})	The current rises until I_{TRIG} or thermal limit. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT} .

Note that when the output has been shorted to GND at an extremely low temperature (< -30°C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than a 10% variation of capacitance change when operated at extremely low temperatures. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

Thermal Protection

Thermal protection prevents the IC from damage when the die temperature exceeds safe margins. This mainly occurs when heavy-overload or short-circuit faults are present for extended periods of time. The AP2161D/AP2171D implements thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately 140°C, the Thermal protection feature gets activated as follows: The internal thermal sense circuitry turns the power switch forf and the FLG output is asserted thus preventing the power switch from damage. Hysteresis in the thermal sense circuit allows the device to cool down to approximately 25°C before the output is turned back on. The built-in thermal hysteresis feature avoids undesirable oscillations of the thermal protection circuit. The switch continues to cycle in this manner until the load fault is removed, resulting in a pulsed output. The FLG open-drain output is asserted when an over-current occurs with 7-ms deglitch.

Reverse Current Protection

In a normal MOSFET switch, current can flow in reverse direction (from the output side to the input side) when the output side voltage is higher than the input side, even when the switch is turned off. A reverse-current blocking feature is implemented in the AP21x1 series to prevent such back currents. This circuit is activated by the difference between the output voltage and the input voltage. When the switch is disabled, this feature blocks reverse current flow from the output back to the input.

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Enclosures

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AP2161D/AP2171D

Application Note (continued)

Special Functions:

Discharge Function

When enable is de-asserted, the discharge function is active. The output capacitor is discharged through an internal NMOS that has a discharge resistance of 100Ω. Hence, the output voltage drops down to zero. The time taken for discharge is dependent on the RC time constant of the resistance and the output capacitor.

FI G Resnonse

The FLG open-drain output goes active low for any of the two conditions: Over-Current or Over-Temperature. The time from when a fault condition is encountered to when the FLG output goes low is 7-ms (TYP). The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary Over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The 7-ms timeout is also applicable for Over-current recovery and Thermal recovery. The AP2161D/AP2171D are designed to eliminate erroneous Over-current reporting without the need for external components, such as an RC delay network.

Applications Information:

Power Supply Considerations

A 0.01-μF to 0.1-μF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. This limits the input voltage drop during line transients. Placing a high-value electrolytic capacitor on the input (10-μF minimum) and output pin(s) is recommended when the output load is heavy. This precaution also reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-μF to 0.1-μF ceramic capacitor improves the immunity of the device to short-circuit transients. This capacitor also prevents output from going negative during turn-off due to inductive parasitics.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

The junction temperature can be calculated by:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient Temperature ^oC R_{BJA} = Thermal Resistance P_D = Total Power Dissipation

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges as seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp up the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall times of the AP2161D/AP2171D, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2161D/AP2171D also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2161D/AP2171D between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls the system surge current and provides a hot-plugging mechanism for any device.

Manuals ID 06-07



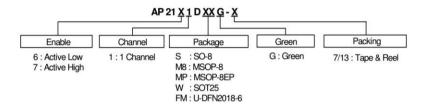
AP2161D/AP2171D

Application Note (cont.)

Dual-Purpose Port Applications

AP2161D/AP2171D is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a non-recommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. Since the AP2161D/AP2171D includes an embedded discharge feature that discharges the output load of the device when the device is disabled, the batteries of the connected peripheral device will be subject to continual discharge whenever the AP2161D/AP2171D is disabled. An overstress condition to the device's discharge MOS transistor may result. In addition, if the output of the AP2161D/AP2171D is subjected to a constant voltage that would be present during a dual-purpose port application such as MHL, an overstress condition to the device may result.

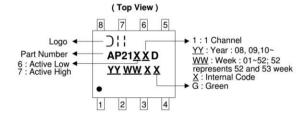
Ordering Information



Part Number	Backens Code Backening		7"/13" Tap	oe and Reel
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1DSG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1DM8G-13	M8	MSOP-8	2,500/Tape & Reel	-13
AP21X1DMPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1DWG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1DFMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Marking Information

(1) SO-8

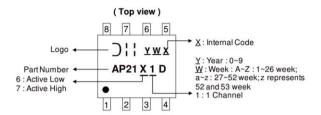


Manuals ID 06-07



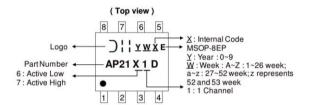
AP2161D/AP2171D

(2) MSOP-8

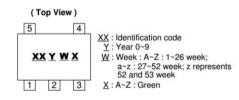


Marking Information (continued)

(3) MSOP-8EP

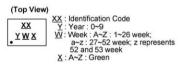


(4) SOT25



Device	Package Type	Identification Code
AP2161DW	SOT25	JC
AP2171DW	SOT25	JD

(5) U-DFN2018-6



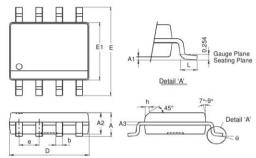
Device	Package Type	Identification Code
AP2161DFM	U-DFN2018-6	JC
AP2171DFM	U-DFN2018-6	JD

Manuals ID 06-07



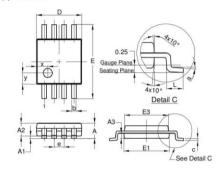
AP2161D/AP2171D

Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.



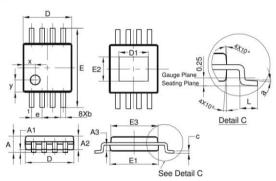
	SO-8				
Dim	Min	Max			
Α	-	1.75			
A1	0.10	0.20			
A2	1.30	1.50			
A3	0.15	0.25			
b	0.3	0.5			
D	4.85	4.95			
E	5.90	6.10			
E1	3.85	3.95			
е	1.27	Тур			
h	-	0.35			
L	0.62	0.82			
θ	0°	8°			
All Dir	All Dimensions in mm				

(2) MSOP-8



	MSOP-8					
Dim	Min	Max	Тур			
Α	-	1.10	-			
A1	0.05	0.15	0.10			
A2	0.75	0.95	0.86			
A3	0.29	0.49	0.39			
b	0.22	0.38	0.30			
С	0.08	0.23	0.15			
D	2.90	3.10	3.00			
E	4.70	5.10	4.90			
E1	2.90	3.10	3.00			
E3	2.85	3.05	2.95			
е	-	-	0.65			
L	0.40	0.80	0.60			
а	0°	8°	4°			
х	-	- 0	0.750			
У	-		0.750			
All C	Dimen:	sions	in mm			

(3) MSOP-8EP



	MSC	MSOP-8EP							
Dim	Min	Max	Тур						
Α	70	1.10	-						
A1	0.05	0.15	0.10						
A2	0.75	0.95	0.86						
A3	0.29	0.49	0.39						
b	0.22	0.38	0.30						
С	0.08	0.23	0.15						
D	2.90	3.10	3.00						
D1	1.60	2.00	1.80						
E	4.70	5.10	4.90						
E1	2.90	3.10	3.00						
E2	1.30	1.70	1.50						
E3	2.85	3.05	2.95						
е	-	-	0.65						
L	0.40	0.80	0.60						
а	0°	8°	4°						
X	-	-	0.750						
У		-	0.750						
All Dimensions in mm									

AP2161D/AP2171D Document number: DS32250 Rev. 6 - 2

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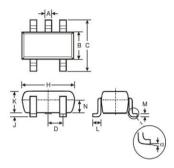
Manuals ID 06-07



AP2161D/AP2171D

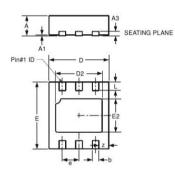
Package Outline Dimensions (cont.) (All dimensions in mm.)
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(4) SOT25



SOT25						
Dim Min Max Typ						
A	0.35	0.50	0.38			
В	1.50	1.70	1.60			
C	2.70	3.00	2.80			
D	-	_	0.95			
Н	2.90	3.10	3.00			
J	0.013	0.10	0.05			
K	1.00	1.30	1.10			
L	0.35	0.55	0.40			
М	0.10	0.20	0.15			
N	0.70	0.80	0.75			
α	0°	8°				
All D	imensi	ons in	mm			

(5) U-DFN2018-6



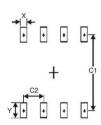
	U-DFN	2018-6	;
Dim	Min	Max	Тур
Α	0.545	0.605	0.575
A1	0	0.05	0.02
A3	_	-	0.13
b	0.15	0.25	0.20
D	1.750	1.875	1.80
D2	1.30	1.50	1.40
е	_	_	0.50
E	1.95	2.075	2.00
E2	0.90	1.10	1.00
L	0.20	0.30	0.25
Z	_	-	0.30
All D	imens	ions ir	n mm

Manuals ID 06-07



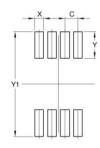
AP2161D/AP2171D

Suggested Pad Layout
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.



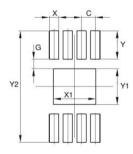
Dimensions	Value (in mm)
X	0.60
Y	1.55
C1	5.4
C2	1.27

(2) MSOP-8



Dimensions	Value (in mm)
С	0.650
X	0.450
Y	1.350
Y1	5.300

(3) MSOP-8-EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Υ	1.350
Y1	1.700
Y2	5.300

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Enclosures

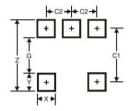
Manuals ID 06-07



AP2161D/AP2171D

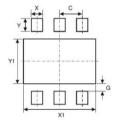
Suggested Pad Layout (continued)
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(4) SOT25



Dimensions	Value (in mm)
z	3.20
G	1.60
х	0.55
Υ	0.80
C1	2.40
C2	0.95

(5) U-DFN2018-6



Dimensions	Value (in mm)
С	0.50
G	0.20
X	0.25
X1	1.60
Υ	0.35
V1	1.20

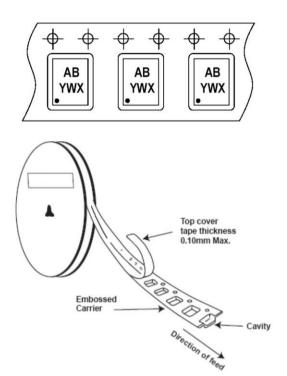
Manuals ID 06-07



AP2161D/AP2171D

Taping Orientation (Note 8)

For U-DFN2018-6



Note: 8. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf

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AP2161D/AP2171D

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Manuals ID 06-08





AP2181D/AP2191D

1.5A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH WITH OUTPUT DISCHARGE

Description

The AP2181D and AP2191D are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and under-voltage lockout functionality. A 7ms deglitch capability on the open-drain flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8, MSOP-8EP, SOT25, and U-DFN2018-6 packages.

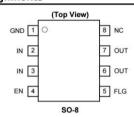
Features

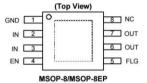
- Single USB Port Power Switches with Output Discharge
- Over-Current and Thermal Protection
- 2.1A Accurate Current Limiting
- Fast Transient Response
- Reverse Current Blocking
- 90mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) with Blanking Time (7ms Typ)
- ESD Protection: 4kV HBM, 300V MM
- Active High (AP2191D) or Active Low (AP2181D) Enable
- Ambient Temperature Range -40°C to +85°C
- SOT25, SO-8, MSOP-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Lead-Free Finish; RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

Applications

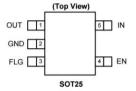
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS Systems, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Stations, HUBs

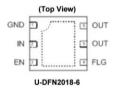
Pin Assignments





Note: Latter with Exposed Pad (Dotted Line)





Notes:

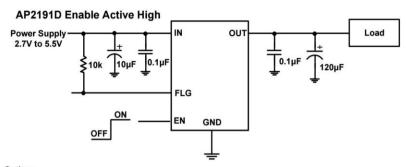
- 1. EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant. All applicable RoHS exemptions applied.
- 2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
- 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Manuals ID 06-08



AP2181D/AP2191D

Typical Applications Circuit



Available Options

Part Number	Channel Enable Pin (EN)		Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2181D	1	Active Low	2.1A	1.5A
AP2191D	1	Active High	2.1A	1.5A

Pin Descriptions

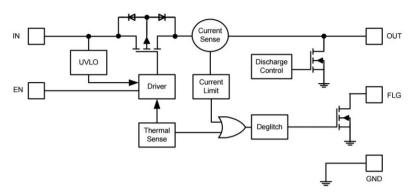
Di-	Pin Number							
Pin Name	SO-8 MSOP-8	MSOP-8EP	SOT25	U-DFN2018-6	Functions			
GND	1	1	2	1	Ground			
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)			
EN	4	4	4	3	Enable input, active low (AP2181D) or active high (AP2191D)			
FLG	5	5	3	4	Over-current and over-temperature fault report; open-drain flag is active low when triggered			
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)			
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins			
Exposed Tab	-	Exposed Tab	-	Exposed Tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.			

Manuals ID 06-08



AP2181D/AP2191D

Functional Block Diagram



Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	4	kV
ESD MM	Machine Model ESD Protection	300	V
VIN	Input Voltage	6.5	V
Vout	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
ILOAD	Maximum Continuous Load Current	Internal Limited	A
T _{JMAX}	Maximum Junction Temperature	150	°C
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESDs sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Note: 4. UL Recognized Rating from -30 °C to +70 °C (Diodes Incorporated qualified T_{ST} from -65 °C to +150 °C).

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V A V
I _{OUT}	Output Current	0	1.5	Α
VIL	EN Input Logic Low Voltage	0	0.8	V
VIH	EN Input Logic High Voltage	2	VIN	V
ΤΔ	Operating Ambient Temperature	-40	+85	°C

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AP2181D/AP2191D

Electrical Characteristics (@T_A = +25°C, V_{IN} = +5.0V, unless otherwise specified.)

Symbol	Parameter		Test Conditions			Тур	Max	Unit
V _{UVLO}	Input UVLO	_		1.6	1.9	2.5	V	
ISHDN	Input Shutdown Current	Disabled, Iout	Disabled, I _{OUT} = 0		_	0.5	1	μA
IQ	Input Quiescent Current	Enabled, I _{OUT}	Enabled, I _{OUT} = 0		-	45	70	μA
I _{LEAK}	Input Leakage Current	Disabled, OUT	Disabled, OUT grounded		_	0.1	1	μА
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5	/, I _{REV} at V _{IN}	_	0.1	1	μA
		V _{IN} = 5V.	T _A = +25°C	SOT25, MSOP-8, SO-8, MSOP-8-EP	_	95	115	
		I _{OUT} = 1.5A		U-DFN2018-6	_	90	110]
R _{DS(ON)}	Switch On-Resistance	**************************************	-40°C ≤ T _A ≤	+85°C	_	_	140	mΩ
		$V_{IN} = 3.3V$	$T_A = +25^{\circ}C$		_	120	140	
		I _{OUT} = 1.5A	-40°C ≤ T _A ≤	+85°C	-	_	170	
I _{SHORT}	Short-Circuit Current Limit	Enabled into s	hort circuit, CL	=120µF	_	2.0	-	Α
LIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OUT}	$V_{IN} = 5V$, $V_{OUT} = 4V$, $C_L = 120\mu F$, $-40^{\circ}C \le T_A \le +85^{\circ}C$		1.6	2.1	2.6	Α
I _{Trig}	Current Limiting Trigger Threshold	Output Curren	Output Current Slew Rate (<100A/s) , C _L = 120µF		_	2.6		Α
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V		-	_	0.8	V	
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V		2	-	-	V	
I _{SINK}	EN Input Leakage	V _{EN} = 5V	V _{EN} = 5V		_	-	1	μA
t _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _{LO}	_{AD} = 10Ω		_	0.05		ms
t _R	Output Turn-On Rise Time	C _L = 1µF, R _{LO}	_{AD} = 10Ω		_	0.6	1.5	ms
t _{D(OFF)}	Output Turn-Off Delay Time	C _L = 1µF, R _{LO}	_{AD} = 10Ω		-	0.05	_	ms
tF	Output Turn-Off Fall Time	C _L = 1µF, R _{LO}	_{AD} = 10Ω		_	0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA			_	20	40	Ω
t _{Blank}	FLG Blanking Time	C _{IN} = 10µF, C _I	_ = 22F		4	7	15	ms
t _{DIS}	Discharge Time	C _L = 1µF, V _{IN}	= 5V, disabled	to V _{OUT} < 0.5V	-	0.6	-	ms
RDIS	Discharge Resistance (Note 5)	V _{IN} = 5V, disal	bled, lout = 1m	A	_	100	-	Ω
T _{SHDN}	Thermal Shutdown Threshold	Enabled, RLOA	Enabled, R _{LOAD} = 1kΩ		-	+140	-	°C
T _{HYS}	Thermal Shutdown Hysteresis	_			_	+25	-	°C
	-	SOT25 (Note	6)		-	170	_	
		SO-8 (Note 6)		-	127	-	°CW	
θ_{JA}	Thermal Resistance Junction-to- Ambient	MSOP-8 (Note 6)			118	-		
		MSOP-8-EP (Note 7)		_	67	1-1		
		U-DFN2018-6	U-DFN2018-6 (Note 7)		_	70	-	<u> </u>

The discharge function is active when the device is disabled (when enable is de-asserted). The discharge function offers a resistive discharge path for the external storage capacitor.

6. Device mounted on FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.

7. Device mounted on 2" x 2" FR-4 substrate PCB, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

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AP2181D/AP2191D

Typical Performance Characteristics

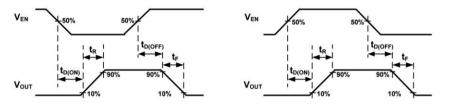
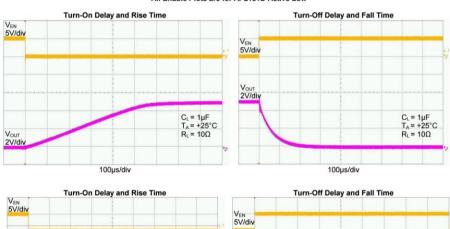
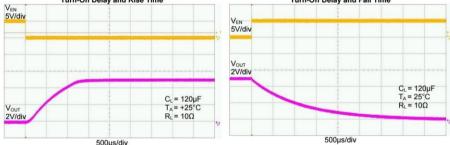


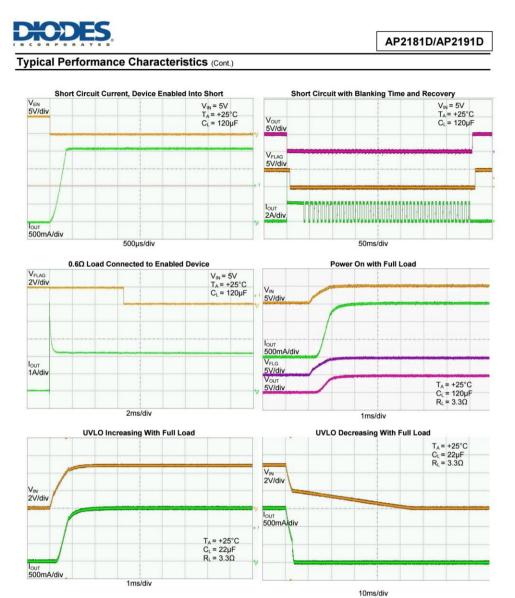
Figure 1. Voltage Waveforms: AP2181D (Left), AP2191D (Right)

All Enable Plots are for AP2181D Active Low





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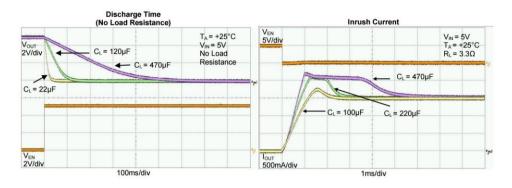


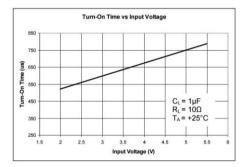
Manuals ID 06-08

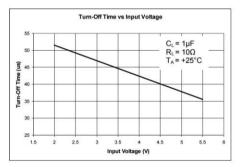


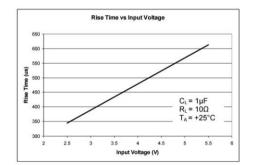
AP2181D/AP2191D

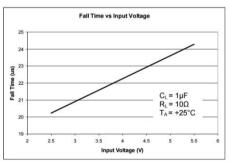
Typical Performance Characteristics (Cont.)









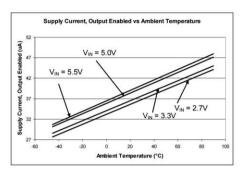


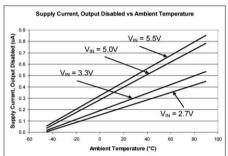
Manuals ID 06-08

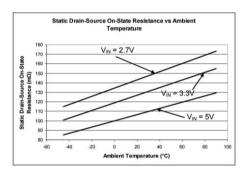


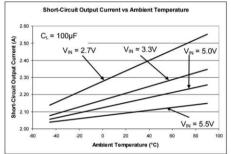
AP2181D/AP2191D

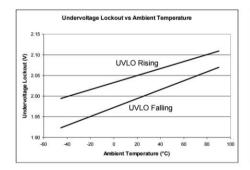
Typical Performance Characteristics (Cont.)

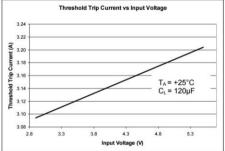












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AP2181D/AP2191D

Application Note

The AP2181D and AP2191D are integrated high-side power switches optimized for Universal Serial Bus (USB) that require protection functions. The power switches are equipped with a driver that controls the gate voltage and incorporates slew-rate limitation. This, along with the various protection features and special functions, make these power switches ideal for hot-swap or hot-plug applications.

Protection Features:

Under-Voltage Lockout (UVLO)

Under-voltage lockout function (UVLO) guarantees that the internal power switch is initially off during start-up. The UVLO functions only when the switch is enabled. Even if the switch is enabled, the switch is not turned ON until the power supply has reached at least 1.9V. Whenever the input voltage falls below approximately 1.9V, the power switch is turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

The different overload conditions and the corresponding response of the AP2181D/AP2191D are outlined below:

S. NO	Conditions	Explanation	Behavior of the AP2181D/AP2191D
1	Short circuit condition at start-up	Output is shorted before input voltage is applied or before the part is enabled.	The IC senses the short circuit and immediately clamps output current to a certain safe level namely I _{LIMIT} .
2	Short-circuit or over current condition	Short-circuit or overload condition that occurs when the part is enabled.	At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I _{LIMIT} .
3	Gradual increase from nominal operating current to I _{LIMIT}	Load increases gradually until the current-limit threshold.(I _{TRIG})	The current rises until I_{TRIG} or thermal limit. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT} .

Note that when the output has been shorted to GND at an extremely low temperature (< -20°C), a minimum 120 μ F electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than a 10% variation of capacitance change when operated at extremely low temperatures. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

Thermal Protection

Thermal protection prevents the IC from damage when the die temperature exceeds safe margins. This mainly occurs when heavy-overload or short-circuit faults are present for extended periods of time. The AP2181D/AP2191D implements thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C, the Thermal protection feature gets activated as follows: The internal thermal sense circuitry turns the power switch off and the FLG output is asserted thus preventing the power switch from damage. Hysteresis in the thermal sense circuit allows the device to cool down to approximately +25°C before the output is turned back on. The built-in thermal hysteresis feature avoids undesirable oscillations of the thermal protection circuit. The switch continues to cycle in this manner until the load fault is removed, resulting in a pulsed output. The FLG open-drain output is asserted when an over-current occurs with 7ms dealitch.

Reverse Current Protection

In a normal MOSFET switch, current can flow in reverse direction (from the output side to the input side) when the output side voltage is higher than the input side, even when the switch is turned off. A reverse-current blocking feature is implemented in the AP21x1 series to prevent such back currents. This circuit is activated by the difference between the output voltage and the input voltage. When the switch is disabled, this feature blocks reverse current flow from the output back to the input.

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AP2181D/AP2191D

Application Note (Cont.)

Special Functions:

Discharge Function

When enable is de-asserted, the discharge function is active. The output capacitor is discharged through an internal NMOS that has a discharge resistance of 100Ω. Hence, the output voltage drops down to zero. The time taken for discharge is dependent on the RC time constant of the resistance and the output capacitor.

FLG Response

The FLG open-drain output goes active low for any of the two conditions: Over-Current or Over-Temperature. The time from when a fault condition is encountered to when the FLG output goes low is 7ms (TYP). The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary Over-current condition, which does not trigger the FLG due to the 7ms deglitch timeout. This 7ms timeout is also applicable for Over-current recovery and Thermal recovery. The AP2181D/AP2191D is designed to eliminate erroneous Over-current reporting without the need for external components, such as an RC delay network

Power Supply Considerations

A 0.01µF to 0.1µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. This limits the input voltage drop during line transients. Placing a high-value electrolytic capacitor on the input (10µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution also reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients. This capacitor also prevents output from going negative during turn-off due to inductive parasitics.

Power Dissipation and Junction Temperature
The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

The junction temperature can be calculated by:

TJ = PD x ReJA + TA

Where:

T_A= Ambient Temperature °C R_{0JA} = Thermal Resistance P_D = Total Power Dissipation

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges as seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp up the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall time of the AP2181D/AP2191D, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2181D/AP2191D also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2181D/AP2191D between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls the system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

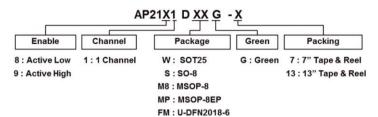
AP2181D/AP2191D is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a nonrecommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. Since the AP2181D/AP2191D includes an embedded discharge feature that discharges the output load of the device when the device is disabled, the batteries of the connected peripheral device will be subject to continual discharge whenever the AP2181D/AP2191D is disabled. In addition, if the output of the AP2181D/AP2191D is subjected to a constant voltage that would be present during a dual-purpose port application such as MHL, an overstress condition to the device's discharge MOS transistor may result.

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AP2181D/AP2191D

Ordering Information

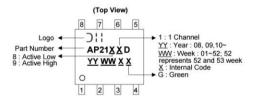


Part Number	Package (Note 9)	Package Code	7"/13" Tape and Reel Quantity	Status (Note 8)
AP2181DWG-7	SOT25	S	3000	In Production
AP2181DSG-13	SO-8	SN	2500	In Production
AP2181DMPG-13	MSOP-8EP	MP	2500	In Production
AP2181DFMG-7	U-DFN2018-6	FM	3000	In Production
AP2191DWG-7	SOT25	S	3000	In Production
AP2191DSG-13	SO-8	SN	2500	In Production
AP2191DM8G-13	MSOP-8	M8	2500	In Production
AP2191DMPG-13	MSOP-8EP	MP	2500	In Production
AP2191DFMG-7	U-DFN2018-6	FM	3000	In Production

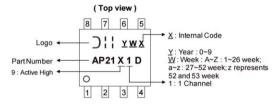
Notes: 8. AP2181DM8C-13 is End of Life (ECL) and recommended alternative is AP2181DMPG-13 or AP2191DM8G-13.
9. For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/

Marking Information

(1) SO-8



(2) MSOP-8



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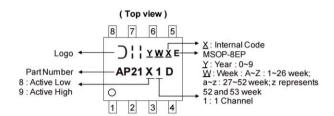
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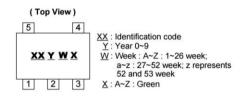
AP2181D/AP2191D

Marking Information (Cont.)

(3) MSOP-8EP



(4) SOT25



Device	Package Type	Identification Code
AP2181DW	SOT25	JE
AP2191DW	SOT25	JF

(5) U-DFN2018-6

(Top View)



XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Green

Device	Package Type	Identification Code
AP2181DFM	U-DFN2018-6	JE
AP2191DFM	U-DFN2018-6	JF

Manuals ID 06-08



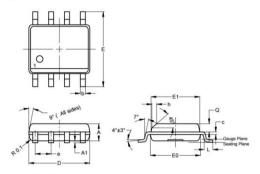
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AP2181D/AP2191D

Package Outline Dimensions

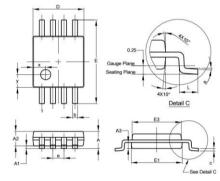
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SO-8



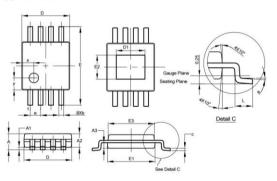
	S	O-8	
Dim	Min	Max	Тур
Α	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
С	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
е		-	1.27
h		-	0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All	Dimens	sions in	mm

(2) MSOP-8



	MS	OP-8	
Dim	Min	Max	Тур
Α	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
С	0.08	0.23	0.15
D	2.90	3.10	3.00
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E3	2.85	3.05	2.95
е	-	-	0.65
L	0.40	0.80	0.60
а	0°	8°	4°
х	-	-	0.750
У	-	-	0.750
All D	Dimen:	sions	in mm

(3) MSOP-8EP



MSOP-8EP			
Dim	Min	Max	Тур
Α	-	1.10	-
A1	0.05	0.15	0.10
A2	0.75	0.95	0.86
A3	0.29	0.49	0.39
b	0.22	0.38	0.30
С	0.08	0.23	0.15
D	2.90	3.10	3.00
D1	1.60	2.00	1.80
E	4.70	5.10	4.90
E1	2.90	3.10	3.00
E2	1.30	1.70	1.50
E3	2.85	3.05	2.95
е	2	=	0.65
L	0.40	0.80	0.60
а	0°	8°	4°
х	-2	-	0.750
У		-	0.750
All [Dimens	sions i	n mm

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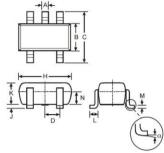


AP2181D/AP2191D

Package Outline Dimensions (Cont.)

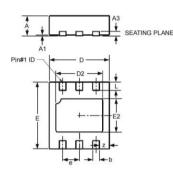
Please see http://www.diodes.com/package-outlines.html for the latest version.

(4) SOT25



	SOT	725	
Dim	Min	Max	Тур
A	0.35	0.50	0.38
В	1.50	1.70	1.60
С	2.70	3.00	2.80
D	-	-	0.95
Н	2.90	3.10	3.00
7	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
M	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	- 2
All D	imensi	ons in	mm

(5) U-DFN2018-6

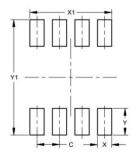


	U-DFN	12018-6	
Dim	Min	Max	Тур
Α	0.545	0.605	0.575
A1	0	0.05	0.02
A3	-	-	0.13
b	0.15	0.25	0.20
D	1.750	1.875	1.80
D2	1.30	1.50	1.40
е	1.50	(*)	0.50
E	1.95	2.075	2.00
E2	0.90	1.10	1.00
L	0.20	0.30	0.25
z	-	-	0.30
All	Dimens	sions in	mm

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) SO-8



Dimensions	Value (in mm)
С	1.27
Х	0.802
X1	4.612
Y	1.505
V1	6.50

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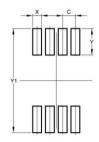
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AP2181D/AP2191D

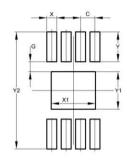
Suggested Pad Layout (Cont.)
Please see http://www.diodes.com/package-outlines.html for the latest version.

(2) MSOP-8



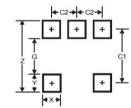
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Х	0.450
Y	1.350
Y1	5.300

(3) MSOP-8-EP



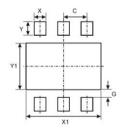
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G	0.450	
Х	0.450	
X1	2.000	
Υ	1.350	
Y1	1.700	
Y2	5.300	

(4) SOT25



Dimensions	Value
Z	3.20
G	1.60
Х	0.55
Y	0.80
C1	2.40
C2	0.95

(5) U-DFN2018-6



Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Υ	0.35
Y1	1.20

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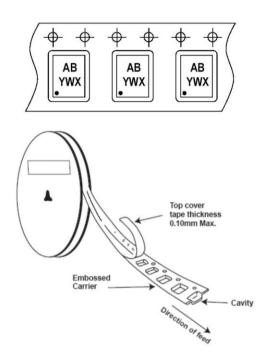
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AP2181D/AP2191D

Taping Orientation (Note 10)

For U-DFN2018-6



Note: 10. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2181D/AP2191D

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AP2146/AP2156

0.5A DUAL CHANNEL CURRENT-LIMITED POWER SWITCH

Description

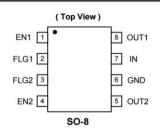
The AP2146 and AP2156 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and available with both polarities of Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and under-voltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

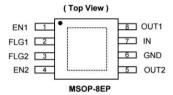
All devices are available in SO-8 and MSOP-8EP packages.

Features

- Dual USB port power switches
- Over-Current and Thermal Protection
- 0.8A Accurate Current Limiting
- Reverse Current Blocking
- 90mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) With Blanking Time (7ms Typ)
- ESD Protection: 6KV HBM, 300V MM
- Active Low (AP2146) or Active High (AP2156) Enable
- Ambient Temperature Range -40°C to +85°C
- SO-8 and MSOP-8EP (Exposed Pad): Available in "Green" Molding Compound (No Br, Sb)
 - Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
 - Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

Pin Assignments



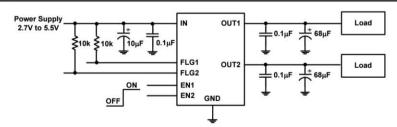


Applications

- Consumer Electronics LCD TV & Monitor, Game Machines
- Communications Set-Top-Box, GPS, Smartphone
- Computing Laptop, Desktop, Servers, Printers, Docking Station,

- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Typical Applications Circuit



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AP2146/AP2156

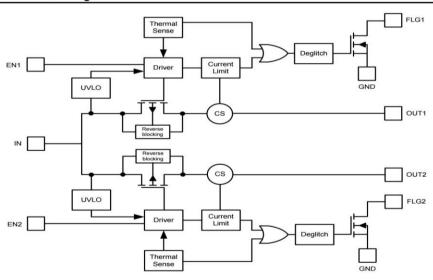
Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typ)	Recommended Maximum Continuous Load Current
AP2146	2	Active Low	0.8A	0.5A
AP2156	2	Active High	0.8A	0.5A

Pin Descriptions

Pin Name	Pin Number		Function	
Pin Name	SO-8	MSOP-8EP	Function	
EN1	1	1	Switch 1 enable input, active low (AP2146) or active high (AP2156)	
FLG1	2	2	Switch 1 over-current and over-temperature fault report, open-drain	
FLG2	3	3	Switch 2 over-current and over-temperature fault report, open-drain	
EN2	4	4	Switch 2 enable input, active low (AP2146) or active high (AP2156)	
OUT2	5	5	Switch 2 voltage output pin	
GND	6	6	Ground	
IN	7	7	Voltage input pin	
OUT1	8	8	Switch 1 voltage output pin	
Exposed Pad	-	Exposed Pad	Exposed Pad: It should be connected externally to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

Functional Block Diagram



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Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Rating	Unit	
ESD HBM	Human Body Model ESD Protection	6	kV	
ESD MM	Machine Model ESD Protection	300	V	
V _{IN} Input Voltage V _{OUT} Output Voltage V _{EN} , V _{FLG} Enable Voltage		6.5	V	
		V _{IN} +0.3		
		6.5	V	
ILOAD	Maximum Continuous Load Current	Internal Limited	A	
T _{J(MAX)}	Maximum Junction Temperature	+150	°C	
T _{ST} Storage Temperature Range (Note 4)		-65 to +150	°C	

Note: 4. UL Recognized Rating from -30°C to +70°C (Diodes qualified T_{ST} from -65°C to +150°C).

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V
Гоит	Output Current	0	500	mA
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V
VIH	High-Level Input Voltage on EN or EN	2	V _{IN}	V
TA	Operating Ambient Temperature	-40	+85	°C

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Symbol	Parameter	Test Conditions			Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$			1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0		-	0.5	1	μA
lα	Input Quiescent Current, Dual	Enabled, I _{OUT} = 0		1.7	95	140	μA
I _{LEAK}	Input Leakage Current	Disabled, OUT grounded		: e)		1	μA
I _{REV}	Reverse Leakage Current	Disabled, V _{IN} = 0V, V _{OUT} = 5V, I _{REV} at V _{IN}	77 - S	-	1	-	μA
		V _{IN} = 5V, I _{OUT} = 0.5A, -40°C ≤ T _A ≤ +85°C	MSOP-8EP		90	135	mΩ
R _{DS(ON)}	Switch On-Resistance	VIN = 5V, IOUT = 0.5A, -40 C S TAS +85 C	SO-8	270	100	135	mΩ
		$V_{IN} = 3.3V$, $I_{OUT} = 0.5A$, $-40^{\circ}C \le T_A \le +85^{\circ}C$		(0.00)	120	160	mΩ
I _{SHORT}	Short-Circuit Current Limit	Enabled into short circuit, C _L = 68µF		10-1	0.7		Α
I _{LIMIT}	Over-Load Current Limit	$V_{IN} = 5V$, $V_{OUT} = 4.8V$, $C_L = 120 \mu F$, $-40 ^{\circ}C \le$	T _A ≤ +85°C	0.6	0.8	1.0	Α
I _{Trig}	Current Limiting Trigger Threshold	V _{IN} = V _{EN} , Output Current Slew rate (<100AWS), C _L = 22μF		-	1.0		Α
TSHORT	Short-Circuit Response Time	V _{OUT} = 0V to I _{OUT} = I _{LIMIT} (short applied to output), C _L = 22μF			20	-	μs
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V		-	-	0.8	٧
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V		2	- 3	-	V
Isink	EN Input Leakage	V _{EN} = 5V		-		1	μА
T _{D(ON)}	Output Turn-On Delay Time	$C_L=1\mu F$, $R_{LOAD}=10\Omega$		-	0.05		ms
T _R	Output Turn-On Rise Time	$C_L=1\mu F$, $R_{LOAD}=10\Omega$			0.6	1.5	ms
T _{D(OFF)}	Output Turn-Off Delay Time	$C_L=1\mu F$, $R_{LOAD}=10\Omega$		-	0.01		ms
T _F	Output Turn-Off Fall Time	$C_L=1\mu F$, $R_{LOAD}=10\Omega$		-	0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA		-	20	40	Ω
T _{Blank}	FLG Blanking Time	C _{IN} =10µF, C _L = 68µF		4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, R _{LOAD} = 1kΩ		0.50	+140	0.50	°C
T _{HYS}	Thermal Shutdown Hysteresis	-			+25	3.73	°C
	Theres I Desistance I westing to Austinate	SO-8 (Note 5)		3.5	110		°C/W
θ_{JA}	Thermal Resistance Junction-to-Ambient MSOP-8EP (Note 6)			(57.)	60	10.75	°C/W

Notes:

Test condition for SO-8; Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad layout.
 Test condition for MSOP-8EP: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer ground plane.

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AP2146/AP2156

Typical Performance Characteristics

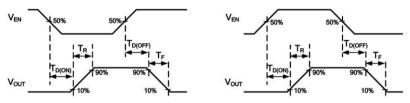
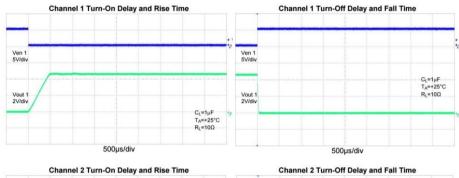
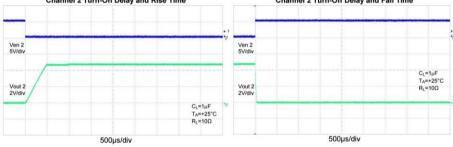


Figure 1. Voltage Waveforms: AP2146 (Left), AP2156 (Right)

All Enable Plots are for AP2146 Active Low

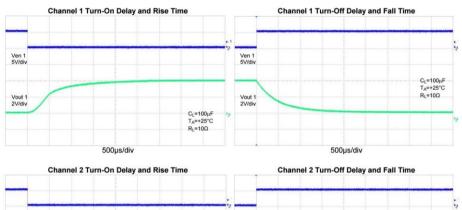


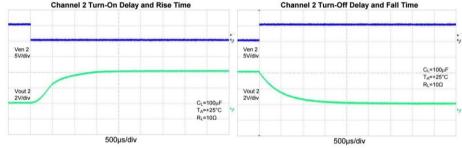


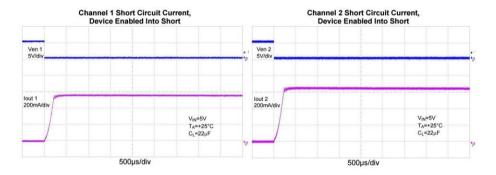
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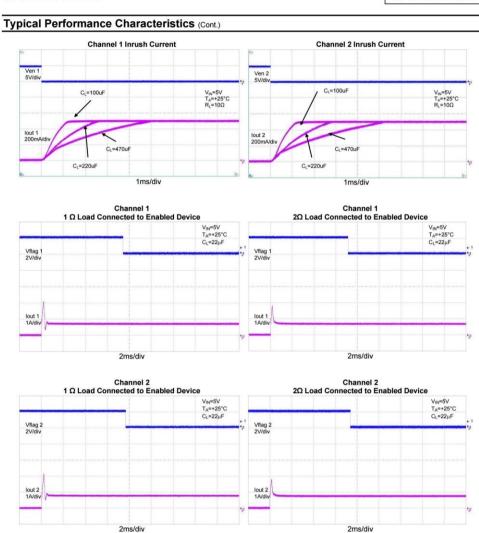




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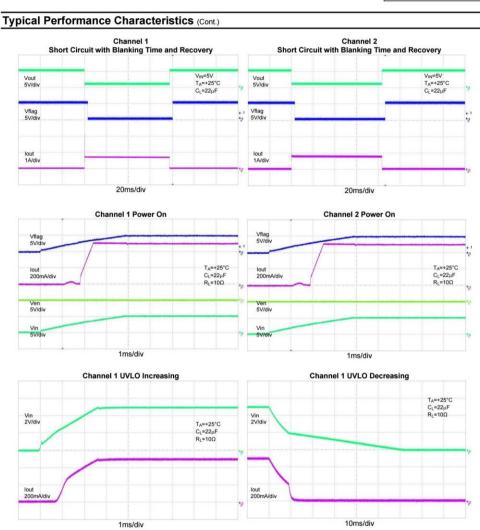
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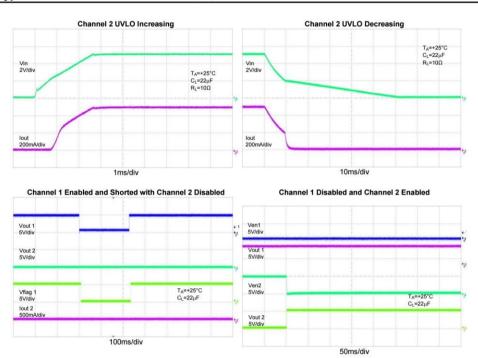
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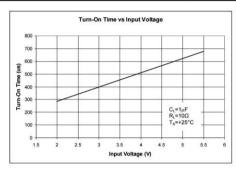
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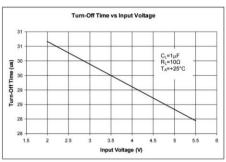


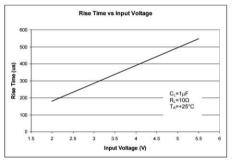
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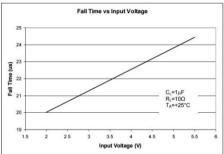


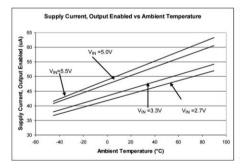
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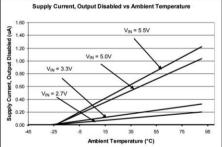


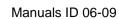






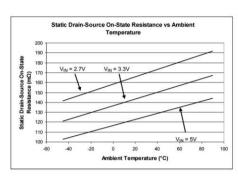


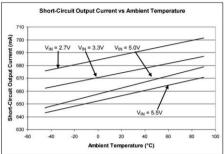


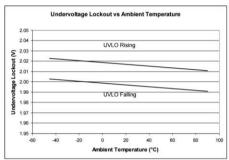


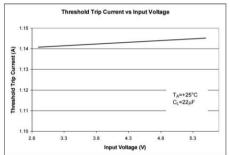


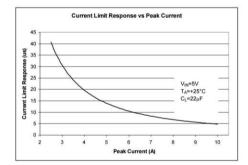
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AP2146/AP2156

Application Information

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2146/AP2156 senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2146/AP2156 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I I IMIT.

Note that when the output has been shorted to GND at extremely low temperature (< -30°C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2146/AP2156 is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature °C

 $R_{\theta JA}$ = Thermal resistance

P_D = Total power dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2146/AP2156 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch forf, thus preventing the power switch from damage, theysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7-ms deglitch.

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AP2146/AP2156

Application Information (Cont.)

Under-Voltage Lockout (UVLO)

Under-voltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and self-powered hubs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

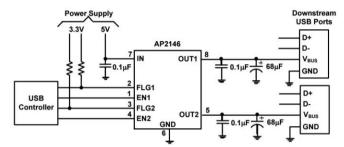


Figure 2. Typical Two-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP2146/AP2156, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2146/AP2156 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

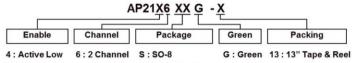
By placing the AP2146/AP2156 between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

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AP2146/AP2156

Ordering Information

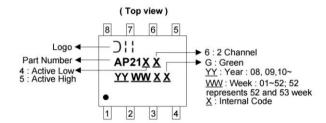


5 : Active High MP : MSOP-8EP

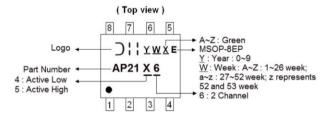
Part Number	Deckers Code	Deelesias	13" Tap	e and Reel
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X6SG-13	S	SO-8	2500/Tape & Reel	-13
AP21X6MPG-13	MP	MSOP-8EP	2500/Tape & Reel	-13

Marking Information

(1) SO-8



(2) MSOP-8EP



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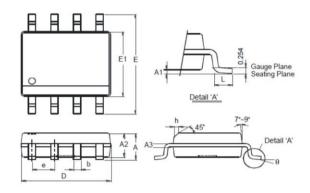


AP2146/AP2156

Package Outline Dimensions (All dimensions in mm.)

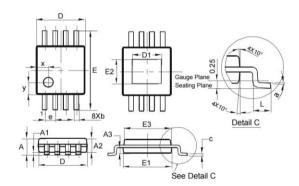
Please see AP02001 at http://www.diodes.com/_files/datasheets/ap02001.pdf for the latest version.

(1) Package type: SO-8



	SO-8				
Dim	Min	Max			
Α	- 1.75				
A1	0.10	0.20			
A2	1.30	1.50			
A3	0.15 0.25				
b	0.3	0.5			
D	4.85	4.95			
E	5.90	6.10			
E1	3.85	3.95			
е	1.27	Тур			
h		0.35			
L	0.62	0.82			
θ	0°	8°			
All Di	All Dimensions in mm				

(2) Package type: MSOP-8EP



	MSOP-8EP				
Dim	Min	Max	Тур		
Α	-	1.10	-		
A1	0.05	0.15	0.10		
A2	0.75	0.95	0.86		
A3	0.29	0.49	0.39		
b	0.22	0.38	0.30		
С	0.08	0.23	0.15		
D	2.90	3.10	3.00		
D1	1.60	2.00	1.80		
E	4.70	5.10	4.90		
E1	2.90	3.10	3.00		
E2	1.30	1.70	1.50		
E3	2.85	3.05	2.95		
е	-	-	0.65		
L	0.40	0.80	0.60		
а	0°	8°	4°		
X	-	-	0.750		
У	1/2	-	0.750		
All E	Dimens	ions in	mm		

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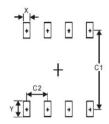


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Suggested Pad Layout

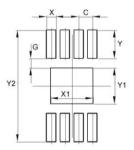
Please see AP02001 at http://www.diodes.com/_files/datasheets/ap02001.pdf for the latest version.

(1) Package type: SO-8



Dimensions	Value (in mm)
Х	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package type: MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Υ	1.350
Y1	1.700
Y2	5 300

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AP2151A

0.5A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2151A is an integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with active high Enable input. They offer current and thermal limiting and short circuit protection as well as controlled rise time and under-voltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

AP2151A is available in SO-8, MSOP-8EP, SOT25 and U-DFN2018-6 packages.

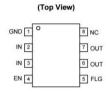
Features

- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 0.8A Accurate Current Limiting
- Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) with Blanking Time (7ms Typ)
- ESD Protection: 4kV HBM, 400V MM
- Active High Enable
- Ambient Temperature Range -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad) and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- 15kV ESD Protection per IEC 61000-4-2 (With External Capacitance)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

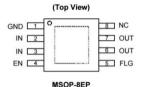
Applications

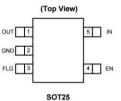
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS Systems, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Stations, HUBs

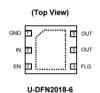
Pin Assignments



SO-8







Notes:

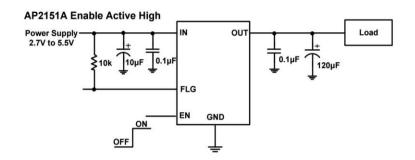
- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
- 2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
- 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

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AP2151A

Typical Applications Circuit



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typical)	Recommended Maximum Continuous Load Current
AP2151A	1	Active High	0.8A	0.5A

Pin Descriptions

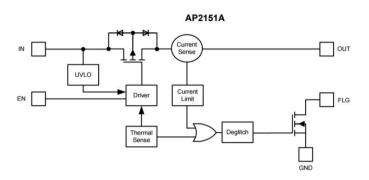
Pin		Pin N	umber		Function
Name	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Function
GND	1	1	2	1	Ground
IN	2, 3	2, 3	5	2	Voltage Input Pin (all IN pins must be tied together externally).
EN	4	4	4	3	Enable Input. Active High (AP2151A).
FLG	5	5	3	4	Over-Current and Over-Temperature Fault Report. Open-Drain Flag is Active Low When Triggered
OUT	6, 7	6, 7	1	5, 6	Voltage Output Pin (all OUT pins must be tied together externally).
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins
Exposed Pad	_	Exposed Pad	. 	Exposed Pad	Exposed Pad. It should be externally connected to GND plane and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.

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AP2151A

Functional Block Diagram



Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.)

Symbol		Parameter		Ratings	Unit
25	НВМ	Human Body Model ESD Protection		4	kV
	ММ	Machine Model ESD Protection for SO-8, MSOP-8EP, SOT25 packages	400	V	
ESD	ММ	Machine Model ESD Protection for U-DFN2018-6, SO-8 packages		300	V
	IEC system	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Air	15	kV
	level	Surges per EN61000-4-2. 1999 applied to output terminals of EVM (Note 5)	Contact	8	kV
VIN	Input Voltage			6.5	V
Vout	Output Voltag	ge		V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltag	ge		6.5	V
I _{LOAD}	Maximum Co	ntinuous Load Current		Internal Limited	Α
T _{J(MAX)}	Maximum Junction Temperature			+150	°C
T _{ST}	Storage Tem	perature Range (Note 4)		-65 to +150	°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

- UL Recognized Rating from -30°C to +70°C (Diodes Incorporated qualified T_{ST} from -65°C to +150°C).
 External capacitors need to be connected to the output, EVM board was tested with capacitor 2.2μF 50V 0805. This level is a pass test only and not a limit.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V
lout	Output Current	0	500	mA
TA	Operating Ambient Temperature	-40	+85	°C
VIL	EN Input Logic Low Voltage	0	0.8	V
VIH	EN Input Logic High Voltage	2	VIN	V

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AP2151A

Symbol	Parameter		Con	ditions	Min	Тур	Max	Unit
Vuvlo	Input UVLO	$R_{LOAD} = 1k\Omega$		1.6	1.9	2.5	V	
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT} = 0		-	0.5	1	μА	
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		10-00	45	70	μA
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded		-	_	1	μА
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} =	5V, I _{REV} at V _{IN}		1	_	μА
			T _A = +25°C	SOT25, SO-8, MSOP-8EP	11.	95	115	
		$V_{IN} = 5V$, $I_{OUT} = 0.5A$	1A = +25°C	U-DFN2018-6	-	90	110	
R _{DS(ON)}	Switch On-Resistance	10UT = 0.5A	-40°C ≤ T _A ≤	+85°C	-	_	140	mΩ
		$V_{IN} = 3.3V$,	T _A = +25°C			120	140	
		$I_{OUT} = 0.5A$	-40°C ≤ T _A ≤	+85°C	1-	_	170	
I _{SHORT}	Short-Circuit Current Limit	Enabled into	Enabled into short circuit, C _L = 22μF		-	0.6	<u></u>	Α
ILIMIT	Over-Load Current Limit	$V_{IN} = 5V$, $V_{OUT} = 4.8V$, $C_L = 22\mu F$, $-40^{\circ}C \le T_A \le +85^{\circ}C$		0.6	0.8	1.0	Α	
I _{TRIG}	Current Limiting Trigger Threshold	Output Currer	Output Current Slew Rate (<100A/s), C _L = 22µF		_	1.0	_	Α
I _{SINK}	EN Input Leakage	V _{EN} = 5V			-	_	1	μA
t _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _L	DAD = 10Ω		10	0.05		ms
t _R	Output Turn-On Rise Time	C _L = 1µF, R _{LC}	DAD = 10Ω		y. -	0.6	1.5	ms
t _{D(OFF)}	Output Turn-Off delay Time	C _L = 1µF, R _{LC}	DAD = 10Ω		1-	0.01	-	ms
t _F	Output Turn-Off Fall Time	C _L = 1µF, R _{LC}	DAD = 10Ω		-	0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} =10mA			_	20	40	Ω
t BLANK	FLG Blanking Time	C _{IN} = 10µF, C	L = 22μF		4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$		_	+140	_	°C	
THYS	Thermal Shutdown Hysteresis	_			+25		°C	
		SO-8 (Note 6))		-	110	_	°C/W
0	Thermal Resistance Junction-to-	MSOP-8EP (I	Note 7)			60	-	°C/W
θ_{JA}	Ambient	SOT25 (Note	8)		-	157	-	°C/W
		U-DFN2018-6	(Note 9)		-	70		°C/W

Notes:

^{6.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
7. Test condition for SO-8, MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
8. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
9. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0" x 1.4" ground plane.

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Typical Performance Characteristics

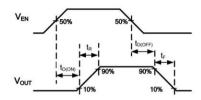
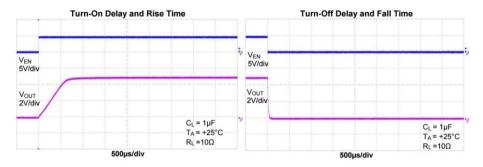
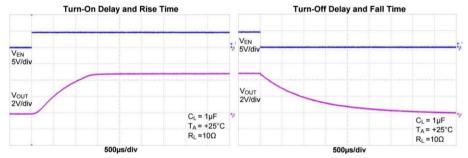
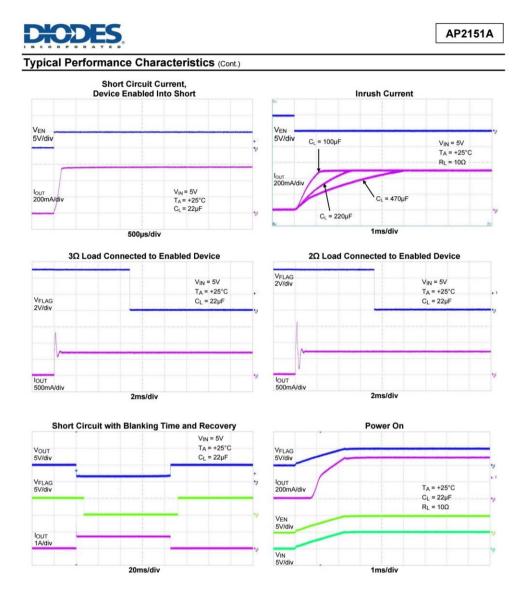


Figure 1. Voltage Waveforms: AP2151A All Enable Plots are for AP2151A Active High





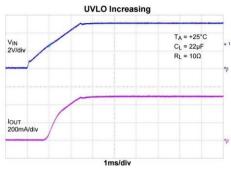
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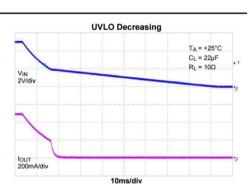


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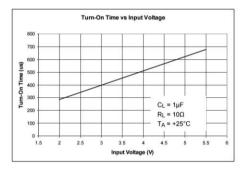


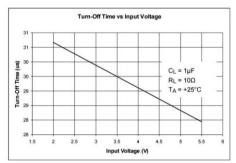
Typical Performance Characteristics (Cont.)

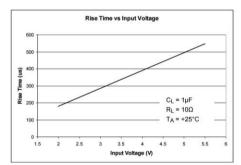


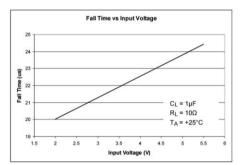


AP2151A





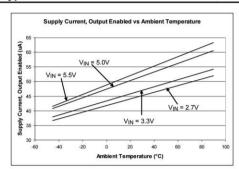


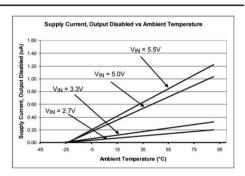


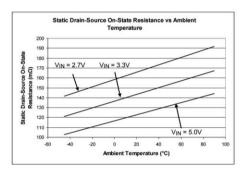
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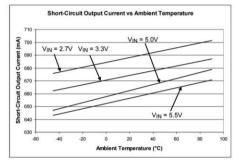


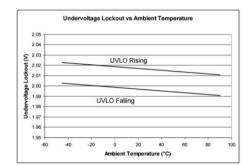
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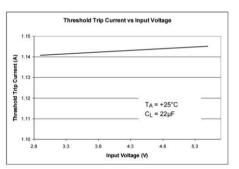












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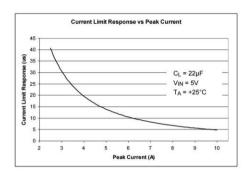
Enclosures

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AP2151A

Typical Performance Characteristics (Cont.)



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AP2151A

Application Information

Power Supply Considerations

A 0.01µF to 0.1µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2151A senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the over-current trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2151A is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_I war.

Note that when the output has been shorted to GND at an extremely low temperature (< -30°C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than a 10% variation of capacitance change when operated at extremely low temperatures. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7ms deglitch timeout. The AP2151A is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

 T_A = Ambient Temperature °C $R_{\theta JA}$ = Thermal Resistance P_D = Total Power Dissipation

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AP2151A

Application Information (Cont.)

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2151A implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch off, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7ms deglitch.

Under-Voltage Lockout (UVLO)

Under-voltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and self-powered hubs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

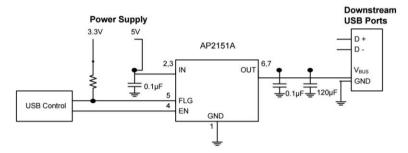


Figure 2. Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise times and fall times of the AP2151A, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2151A also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2151A between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

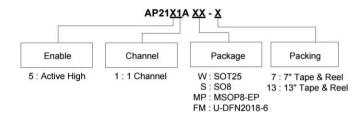
AP2151A is suitable for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of this is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. In such dual-purpose port applications, it is important to insure Vin of the AP2151A is ramped to its operating voltage prior to enabling the output.

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AP2151A

Ordering Information

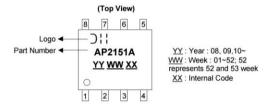


Part Number	Package (Note 11)	Package Code	7"/13" Tape and Reel Quantity	Status (Note 10)
AP2151AW-7	SOT25	W	3000	In Production
AP2151AS-13	SO-8	S	2500	In Production
AP2151AMP-13	MSOP-8EP	MP	2500	In Production
AP2151AFM-7	U-DFN2018-6	FM	3000	In Production

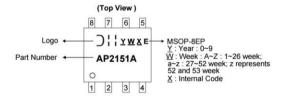
All variants of AP2141A are End of Life and recommended alternatives are AP2141.
 For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

(1) SO-8



(2) MSOP-8EP



AP2151A Document number: DS37615 Rev. 2 - 2 12 of 18 www.diodes.com January 2018
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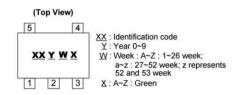
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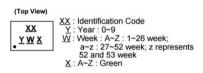
Marking Information (Cont.)

(3) SOT25



Device	Package Type	Identification Code
AP2151AW	SOT25	VU

(4) U-DFN2018-6



Device	Package Type	Identification Code
AP2151AFM	U-DFN2018-6	ZU

Manuals ID 06-10



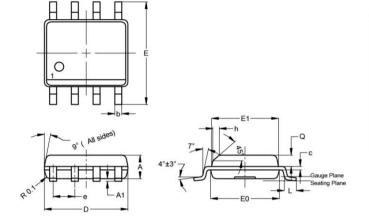
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AP2151A

Package Outline Dimensions

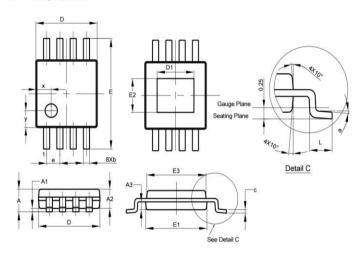
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



SO-8				
Dim	Min	Max	Тур	
Α	1.40	1.50	1.45	
A1	0.10	0.20	0.15	
b	0.30	0.50	0.40	
С	0.15	0.25	0.20	
D	4.85	4.95	4.90	
Е	5.90	6.10	6.00	
E1	3.80	3.90	3.85	
E0	3.85	3.95	3.90	
е			1.27	
h			0.35	
L	0.62	0.82	0.72	
Q	0.60	0.70	0.65	
All	Dimens	ions in	mm	

(2) Package Type: MSOP-8EP



	MSOP-8EP				
Dim	Min	Max	Тур		
Α	120	1.10	-		
A1	0.05	0.15	0.10		
A2	0.75	0.95	0.86		
A3	0.29	0.49	0.39		
b	0.22	0.38	0.30		
С	0.08	0.23	0.15		
D	2.90	3.10	3.00		
D1	1.60	2.00	1.80		
E	4.70	5.10	4.90		
E1	2.90	3.10	3.00		
E2	1.30	1.70	1.50		
E3	2.85	3.05	2.95		
е	-	-	0.65		
L	0.40	0.80	0.60		
а	0°	8°	4°		
X	-	-	0.750		
у	-	-	0.750		
All [Dimens	sions ii	n mm		

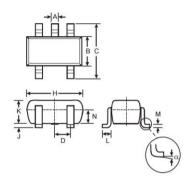
Manuals ID 06-10



AP2151A

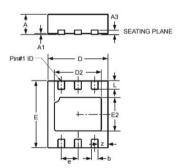
Package Outline Dimensions (Cont.)
Please see http://www.diodes.com/package-outlines.html for the latest version.

(3) Package Type: SOT25



	SO	Γ25	
Dim	Min	Max	Тур
Α	0.35	0.50	0.38
В	1.50	1.70	1.60
С	2.70	3.00	2.80
D	_	_	0.95
Н	2.90	3.10	3.00
J	0.013	0.10	0.05
K	1.00	1.30	1.10
L	0.35	0.55	0.40
М	0.10	0.20	0.15
N	0.70	0.80	0.75
α	0°	8°	1-
All D	imensi	ons in	mm

(4) U-DFN2018-6



	U-DFN2018-6				
Dim	Min	Max	Тур		
Α	0.545	0.605	0.575		
A1	0	0.05	0.02		
A3	-	-	0.13		
b	0.15	0.25	0.20		
D	1.750	1.875	1.80		
D2	1.30	1.50	1.40		
е	_	_	0.50		
E	1.95	2.075	2.00		
E2	0.90	1.10	1.00		
L	0.20	0.30	0.25		
z	-	_	0.30		
All D	imens	ions ir	mm		

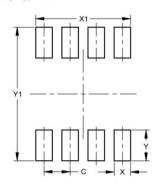
Manuals ID 06-10



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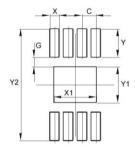
Suggested Pad Layout
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



Dimensions	Value (in mm)
С	1.27
Х	0.802
X1	4.612
Y	1.505
Y1	6.50

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm) 0.650	
С		
G	0.450	
Х	0.450	
X1	2.000	
Υ	1.350	
Y1	1.700	
Y2	5 300	

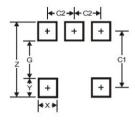
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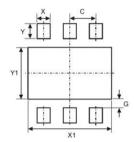
Suggested Pad Layout (Cont.)
Please see http://www.diodes.com/package-outlines.html for the latest version.

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
Х	0.55
Y	0.80
C1	2.40
C2	0.95

(4) Package Type: U-DFN2018-6



Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Y	0.35
1//	

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AP2151A

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Manuals ID 06-11



AP2161/ AP2171

1A SINGLE CHANNEL CURRENT-LIMITED POWER SWITCH

Description

The AP2161 and AP2171 are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. The family of devices complies with USB 2.0 and is available with both polarities of Enable input. They offer current and thermal limiting and short-circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false overcurrent reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25, and U-DFN2018-6 packages

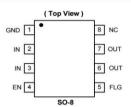
Features

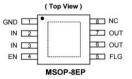
- Single USB Port Power Switches
- Overcurrent and Thermal Protection
- 1.5A Accurate Current Limiting
- Reverse Current Blocking 95mΩ On-Resistance
- Input Voltage Range: 2.7V 5.5V
- 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (max)
- Fault Report (FLG) with Blanking Time (7ms typ)
- ESD Protection: 4kV HBM, 300V MM
- Active Low (AP2161) or Active High (AP2171) Enable
- Ambient Temperature Range: -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

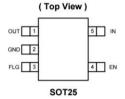
Applications

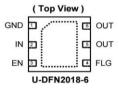
- Consumer Electronics LCD TVs & Monitors, Game Machines
- Communications Set-Top-Boxes, GPS, Smartphones
- Computing Laptops, Desktops, Servers, Printers, Docking Station, HUB

Pin Assignments









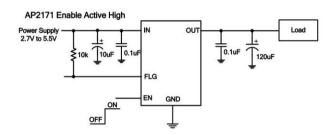
- No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
 See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
 Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

Manuals ID 06-11



AP2161/ AP2171

Typical Applications Circuit



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (typ)	Recommended Maximum Continuous Load Current
AP2161	1	Active Low	1.5A	1.0A
AP2171	1	Active High	1.5A	1.0A

Pin Descriptions

Pin		Pin Number			Formation	
Name SO-8		SO-8 MSOP-8EP SOT25		U-DFN2018-6	Function	
GND	1	1	2	1	Ground	
IN	2, 3	2, 3	5	2	Voltage input pin (all IN pins must be tied together externally)	
EN	4	4	4	3	Enable input, active low (AP2161) or active high (AP2171)	
FLG	5	5	3	4	Overcurrent and over-temperature fault report; open-drain flag is active low when triggered	
OUT	6, 7	6, 7	1	5, 6	Voltage output pin (all OUT pins must be tied together externally)	
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins	
Exposed tab	-	Exposed tab	-	Exposed tab	Exposed pad. It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.	

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AP2161/ AP2171

Functional Block Diagram

AP2161, AP2171 IN Current Sense Deglitch Deglitch GND

Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Units
ESD HBM	Human Body Model ESD Protection	4	
Machine Model ESD Protection for MSOP-8EP, SOT25 packages		400	
ESD MIM	Machine Model ESD Protection for U-DFN2018-6, SO-8 packages	300	V
VIN	Input Voltage	6.5	V
Vout	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
I _{LOAD} Maximum Continuous Load Current		Internal Limited	Α
T _{J(MAX)} Maximum Junction Temperature		+150	
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices

Note: 4. UL Recognized Rating from -30°C to +70°C (Diodes qualified T_{ST} from -65°C to +150°C).

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Units
VIN	Input Voltage	2.7	5.5	V
lout	Output Current	0	1.0	Α
TA	Operating Ambient Temperature	-40	+85	°C
VIH	High-Level Input Voltage on EN or EN	2.0	VIN	V
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V

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AP2161/ AP2171

Electrical Characteristics (@ $T_A = +25^{\circ}C$, $V_{IN} = +5V$, unless otherwise specified.)

Symbol	Parameter		Test C	onditions	Min	Тур	Max	Unit
V _{UVLO}	Input UVLO	$R_{LOAD} = 1k\Omega$	$R_{LOAD} = 1k\Omega$		1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, Iou	Disabled, I _{OUT} = 0		1.5	0.5	1	uA
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		10=0	45	70	μА
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded		-	-	1	μА
IREV	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5	V, I _{REV} at V _{IN}	-	1	-	μΑ
			T _A = +25°C	SOT25, MSOP-8EP, SO-8	-	95	115	
		$V_{IN} = 5V$, $I_{OUT} = 1A$	1A = +25 C	U-DFN2018-6	-	90	110	
RDS(ON)	Switch on-resistance	IOUT - IA	-40°C ≤ T _A ≤	+85°C		-	140	mΩ
		$V_{IN} = 3.3V$	T _A = +25°C		-	120	140	
		I _{OUT} = 1A	-40°C ≤ T _A ≤	+85°C	-		170	
ISHORT	Short-Circuit Current Limit	Enabled into	Enabled into short circuit, C _L = 68µF		-	1.2	-	Α
ILIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OUT} = 4.6V, C _L = 68µF, -40°C ≤ T _A ≤ +85°C		1.1	1.5	1.9	Α	
I _{Trig}	Current limiting trigger threshold	Output Current Slew rate (<100A/s), CL=68µF		(-)	2.0	-	Α	
Isink	EN Input leakage	V _{EN} = 5V		-	-	1	μA	
t _{D(ON)}	Output turn-on delay time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.05	-	ms	
t _R	Output turn-on rise time	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.6	1.5	ms	
t _{D(OFF)}	Output turn-off delay time	C _L = 1µF, R _{LC}	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		-	0.01	-	ms
t _F	Output turn-off fall time	C _L = 1µF, R _{LC}	DAD = 10Ω		-	0.05	0.1	ms
R _{FLG}	FLG output FET on-resistance	I _{FLG} = 10mA			-	20	40	Ω
t _{Blank}	FLG blanking time	C _{IN} = 10µF, C	L = 68µF		4	7	15	ms
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$		-	140	-	°C	
T _{HYS}	Thermal Shutdown Hysteresis	-			25	-	°C	
		SO-8 (Note 5))		-	110	-	°CM
0	Thermal Resistance Junction-to-	MSOP-8EP (Note 6)		85	60	-	°CM	
$AL\theta$	Ambient	SOT25 (Note	7)		-	157	-	°CM
		U-DFN2018-6	(Note 8)		-	70	-	°CM

Notes:

^{5.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.
7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.
8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0" x 1.4" ground plane.

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AP2161/ AP2171

Typical Performance Characteristics

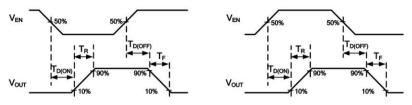
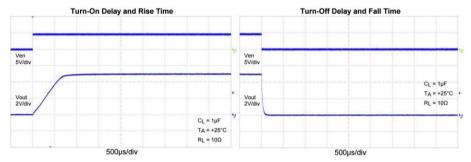
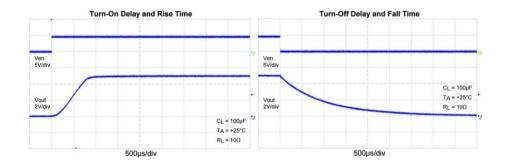


Figure 1 Voltage Waveforms: AP2161 (left), AP2171 (right)

All Enable Plots are for AP2171 Active High



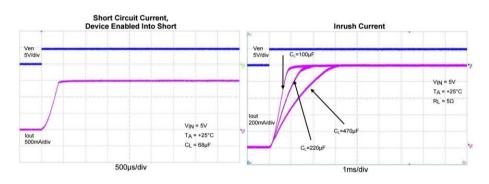


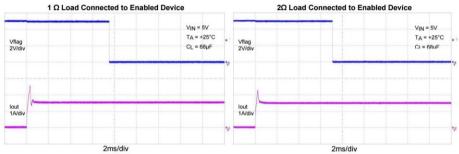
Manuals ID 06-11

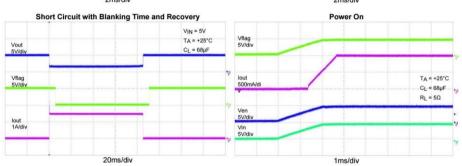


AP2161/ AP2171

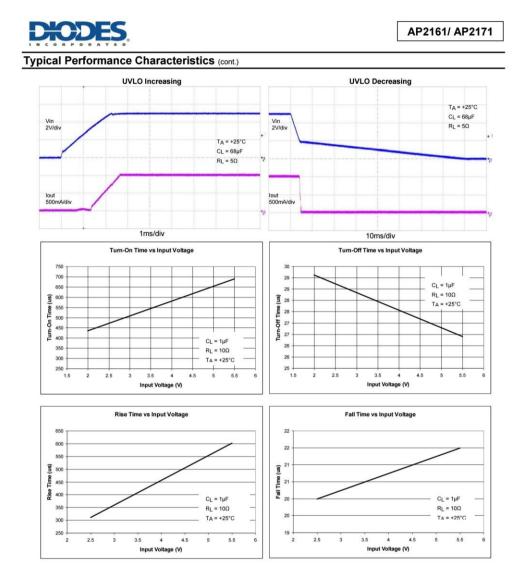
Typical Performance Characteristics (continued)







Manuals ID 06-11

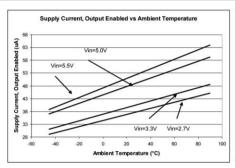


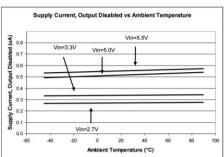
Manuals ID 06-11

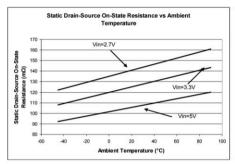


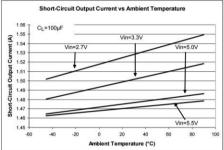
AP2161/ AP2171

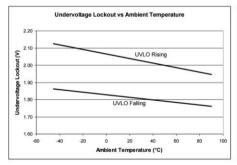
Typical Performance Characteristics (cont.)

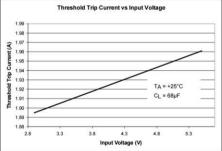










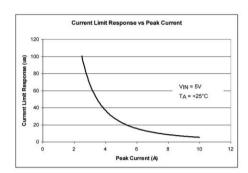


Manuals ID 06-11



AP2161/ AP2171

Typical Performance Characteristics (cont.)



Manuals ID 06-11



AP2161/ AP2171

Application Information

Power Supply Considerations

A 0.01-µF to 0.1-µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10-µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01-µF to 0.1-µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Overcurrent and Short Circuit Protection

An internal sensing FET is employed to check for overcurrent conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2161/AP2171 senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT}.

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIC}) is reached or until the thermal limit of the device is exceeded. The AP2161/AP2171 is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at 1 justs.

Note that when the output has been shorted to GND at an extremely low temperature (< -30°C), a minimum 120-µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an overcurrent or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7-ms deglitch timeout. The FLG output remains low until both overcurrent and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary overcurrent condition, which does not trigger the FLG due to the 7-ms deglitch timeout. The AP2161/AP2171 is designed to eliminate false overcurrent reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and R_{DS(ON)}, the power dissipation can be calculated by:

 $P_D = R_{DS(ON)} \times I^2$

Finally, calculate the junction temperature:

 $T_J = P_D \times R_{\theta JA} + T_A$

Where:

T_A = Ambient temperature °C R_{BJA} = Thermal resistance

P_D = Total power dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2161/AP2171 implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +145°C due to excessive power dissipation in an overcurrent or short-circuit condition, the internal thermal sense circuitry turns the power switch forf, thus preventing the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shuldown or overcurrent occurs with 7-ms deglitch.

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AP2161/ AP2171

Application Information (continued)

Undervoltage Lockout (UVLO)

Undervoltage lockout function (UVLO) keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered And Bus-Powered HUBs

Hosts and self-powered hubs have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

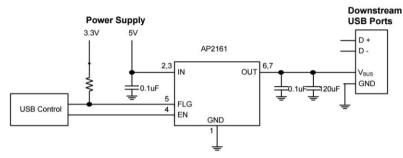


Figure 2 Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or pc boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall times of the AP2161/AP2171, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2161/AP2171 also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2161/AP2171 between the V_{CC} input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

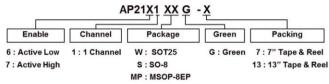
AP2161/AP2171 is not recommended for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of such a nonrecommended application is a shared HDMI/MHL (Mobile High-definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. If a voltage is maintained across the output of the AP2161/AP2171 when the output is disabled and the V_{IN} of the device is subsequently ramped up, an overstress condition to the AP2161/AP2171 may result.

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AP2161/ AP2171

Ordering Information

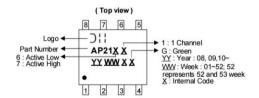


FM : U-DFN2018-6

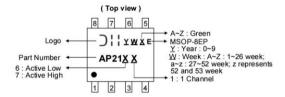
	Part Number	har Baskaga Cada Baskaging	Deeleeries	7"/13" Tap	e and Reel
	Part Number	Package Code	Packaging	Quantity	Part Number Suffix
1	AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7
0,	AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13
0,	AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
B	AP21X1FMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Marking Information

(1) SO-8



(2) MSOP-8EP



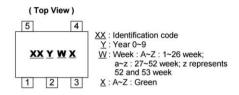
Manuals ID 06-11



AP2161/ AP2171

Marking Information (cont.)

(3) SOT25



Device	Package type	Identification Code
AP2161W	SOT25	HT
AP2171W	SOT25	HU

(4) U-DFN2018-6

(Top View)



XX: Identification Code
Y: Year: 0~9
W: Week: A~Z: 1~26 week;
a~z: 27~52 week; z represents
52 and 53 week
X: A~Z: Green

Device	Package type	Identification Code
AP2161FM	U-DFN2018-6	HT
AP2171FM	U-DFN2018-6	HU

Manuals ID 06-11

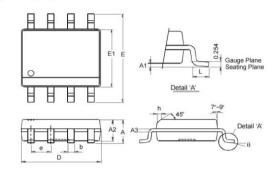


AP2161/ AP2171

Package Outline Dimensions (All dimensions in mm.)

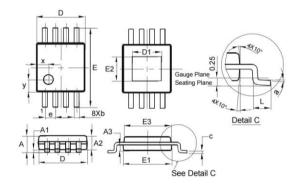
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for the latest version.

(1) Package Type: SO-8



	SO-8					
Dim	Min	Max				
Α	-	1.75				
A1	0.10	0.20				
A2	1.30	1.50				
A3	0.15	0.25				
b	0.3	0.5				
D	4.85	4.95				
E	5.90	6.10				
E1	3.85	3.95				
е	1.27	Тур				
h	-	0.35				
L	0.62	0.82				
θ	0°	8°				
All Di	mensions	in mm				

(2) Package Type: MSOP-8EP



	MSO	P-8EP					
Dim	Min	Max	Тур				
Α	7.7	1.10	-				
A1	0.05	0.15	0.10				
A2	0.75	0.95	0.86				
A3	0.29	0.49	0.39				
b	0.22	0.38	0.30				
С	0.08	0.23	0.15				
D	2.90	3.10	3.00				
D1	1.60	2.00	1.80				
E	4.70	5.10	4.90				
E1	2.90	3.10	3.00				
E2	1.30	1.70	1.50				
E3	2.85	3.05	2.95				
е	1173		0.65				
L	0.40	0.80	0.60				
а	0°	8°	4°				
х	1173	1.5	0.750				
у	(in the control of t	-	0.750				
All C	All Dimensions in mm						

Manuals ID 06-11

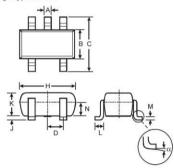


AP2161/ AP2171

Package Outline Dimensions (All dimensions in mm.)

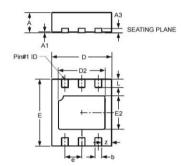
Please see AP02002 at http://www.diodes.com/datasheets/ap02002.pdf for latest version.

(3) Package Type: SOT25



SOT25						
Dim	Min	Max	Тур			
Α	0.35	0.50	0.38			
В	1.50	1.70	1.60			
С	2.70	3.00	2.80			
D	22-	-	0.95			
Н	2.90	3.10	3.00			
J	0.013	0.10	0.05			
K	1.00	1.30	1.10			
L	0.35	0.55	0.40			
M	0.10	0.20	0.15			
N	0.70	0.80	0.75			
α	0°	8°	Ī			
All D	imensi	ons in	mm			

(4) Package Type: U-DFN2018-6



	U-DFN	2018-6	;
Dim	Min	Max	Тур
Α	0.545	0.605	0.575
A1	0	0.05	0.02
A3	_	_	0.13
b	0.15	0.25	0.20
D	1.750	1.875	1.80
D2	1.30	1.50	1.40
е	_	_	0.50
E	1.95	2.075	2.00
E2	0.90	1.10	1.00
L	0.20	0.30	0.25
z			0.30
All D	imens	ions ir	mm i

Manuals ID 06-11

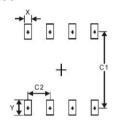


AP2161/ AP2171

Suggested Pad Layout

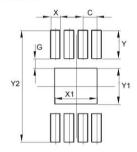
Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

(1) Package Type: SO-8



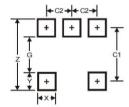
Dimensions	Value (in mm)
Х	0.60
Y	1.55
C1	5.4
C2	1.27

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Y	1.350
Y1	1.700
Y2	5.300

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
х	0.55
Y	0.80
C1	2.40
C2	0.95

Manuals ID 06-11

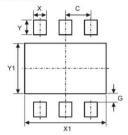


AP2161/ AP2171

Suggested Pad Layout (continued)

Please see AP02001 at http://www.diodes.com/datasheets/ap02001.pdf for the latest version.

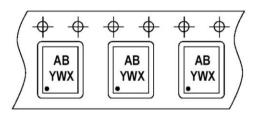
(4) Package Type: U-DFN2018-6

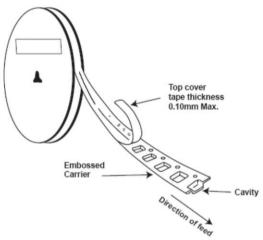


Dimensions	Value (in mm)	
С	0.50	
G	0.20	
Х	0.25	
X1	1.60	
Y	0.35	
Y1	1.20	

Taping Orientation (Note 9)

For U-DFN2018-6





Note: 9. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

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AP2161/ AP2171

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Manuals ID 06-12



2024-07-24



Description

The AP2181A and AP2191A are integrated high-side power switches optimized for Universal Serial Bus (USB) and other hot-swap applications. This family of devices complies with USB 2.0 and is available with both polarities of Enable input. The AP2181A and AP2191A offer current and thermal limiting and short circuit protection as well as controlled rise time and undervoltage lockout functionality. A 7ms deglitch capability on the open-drain Flag output prevents false over-current reporting and does not require any external components.

All devices are available in SO-8, MSOP-8EP, SOT25 and U-DFN2018-6 packages.

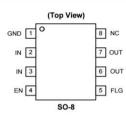
Features

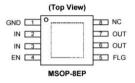
- Single USB Port Power Switches
- Over-Current and Thermal Protection
- 2.1A Accurate Current Limiting
- Reverse Current Blocking
- 95mΩ On-Resistance
- Input Voltage Range: 2.7V to 5.5V
- . 0.6ms Typical Rise Time
- Very Low Shutdown Current: 1µA (Max)
- Fault Report (FLG) with Blanking Time (7ms Typ)
- . ESD Protection: 4kV HBM, 300V MM
- Active Low (AP2181A) or Active High (AP2191A) Enable
- Ambient Temperature Range: -40°C to +85°C
- SOT25, SO-8, MSOP-8EP (Exposed Pad), and U-DFN2018-6: Available in "Green" Molding Compound (No Br, Sb)
- Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)
- Halogen and Antimony Free. "Green" Device (Note 3)
- UL Recognized, File Number E322375
- IEC60950-1 CB Scheme Certified

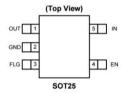
Applications

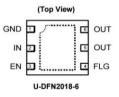
- Consumer Electronics LCD TV & Monitor, Game Machines
- Communications Set-Top Box, GPS, Smartphone
- Computing Laptop, Desktop, Servers, Printers, Docking Station HUB

Pin Assignments









Notes:

- 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
- 2. See https://www.diodes.com/quality/lead-free/ for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
- 3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

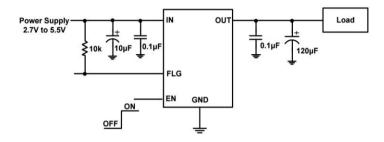
Manuals ID 06-12



AP2181A/AP2191A

Typical Applications Circuit

AP2191A Enable Active High



Available Options

Part Number	Channel	Enable Pin (EN)	Current Limit (Typ)	Recommended Maximum Continuous Load Current
AP2181A	1	Active Low	2.1A	1.5A
AP2191A	1	Active High	2.1A	1.5A

Pin Descriptions

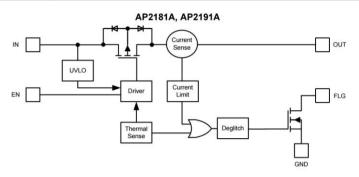
Pin		Pin N	lumber		Function
Name	SO-8	MSOP-8EP	SOT25	U-DFN2018-6	Function
GND	1	1	2	1	Ground
IN	2, 3	2, 3	5	2	Voltage Input Pin (all IN pins must be tied together externally)
EN	4	4	4	3 Enable input, active low (AP2181A) or active high (AP2191A)	
FLG	5	5	3	Over-current and over-temperature fault report; open-drain flag is active low what triggered	
OUT	6, 7	6, 7	1	5, 6 Voltage Output Pin (all OUT pins must be tied together externally)	
NC	8	8	N/A	N/A	No internal connection; recommend tie to OUT pins
Exposed Tab	_	Exposed Tab	-	Exposed Tab	Exposed Pad It should be connected to GND and thermal mass for enhanced thermal impedance. It should not be used as electrical ground conduction path.

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AP2181A/AP2191A

Functional Block Diagram



Absolute Maximum Ratings (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Ratings	Unit
ESD HBM	Human Body Model ESD Protection	4	kV
ESD MM	Machine Model ESD Protection for MSOP-8EP, SOT25 Packages	400	V
ESD MM	Machine Model ESD Protection for U-DFN2018-6, SO-8 Packages	300	V
VIN	Input Voltage	6.5	V
V _{OUT}	Output Voltage	V _{IN} +0.3	V
V _{EN} , V _{FLG}	Enable Voltage	6.5	V
I _{LOAD} Maximum Continuous Load Current		Internal Limited	A
T _{J(MAX)} Maximum Junction Temperature		+150	°C
T _{ST}	Storage Temperature Range (Note 4)	-65 to +150	°C

Caution: Stresses greater than the 'Absolute Maximum Ratings' specified above, may cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Semiconductor devices are ESD sensitive and may be damaged by exposure to ESD events. Suitable ESD precautions should be taken when handling and transporting these devices.

Note: 4. UL Recognized Rating from -30°C to +70°C (Diodes Incorporated qualified T_{ST} from -65°C to +150°C).

Recommended Operating Conditions (@TA = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
VIN	Input Voltage	2.7	5.5	V
lout	Output Current	0	1.5	Α
TA	Operating Ambient Temperature	-40	+85	°C
V _{IH}	High-Level Input Voltage on EN or EN	2.0	V _{IN}	V
VIL	Low-Level Input Voltage on EN or EN	0	0.8	V

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AP2181A/AP2191A

$\begin{tabular}{ll} \textbf{Electrical Characteristics} & \textbf{(@TA = +25^{\circ}C, V_{IN} = 5V, unless otherwise specified.)} \end{tabular}$

Symbol	Parameter		Test Conditions			Тур	Max	Unit
Vuvlo	Input UVLO	$R_{LOAD} = 1k\Omega$			1.6	1.9	2.5	V
I _{SHDN}	Input Shutdown Current	Disabled, I _{OUT}	r = 0		_	0.5	1	Α
IQ	Input Quiescent Current	Enabled, I _{OUT}	= 0		-	45	70	μΑ
I _{LEAK}	Input Leakage Current	Disabled, OU	T grounded			-	1	μA
I _{REV}	Reverse Leakage Current	Disabled, V _{IN}	= 0V, V _{OUT} = 5\	/, I _{REV} at V _{IN}	_	1	_	μA
			T = 125°C	SOT25, MSOP-8EP, SO-8	_	95	115	
		$V_{IN} = 5V$, $I_{OUT} = 1.5A$	$T_A = +25^{\circ}C$	U-DFN2018-6	_	90	110]
R _{DS(ON)}	Switch On-Resistance	10UT = 1.5A	-40°C ≤ T _A ≤	+85°C		_	140	mΩ
		$V_{IN} = 3.3V$	T _A = +25°C		_	120	140	
		I _{OUT} = 1.5A	-40°C ≤ T _A ≤	+85°C	_	_	170	1
ISHORT	Short-Circuit Current Limit	Enabled into s	short circuit, C _L	= 100µF	_	2.0	-	Α
ILIMIT	Over-Load Current Limit	V _{IN} = 5V, V _{OU}	T = 4.5V, C _L = 1	20μF, -40°C ≤ T _A ≤ +85°C	1.6	2.1	2.6	Α
I _{Trig}	Current Limiting Trigger Threshold	Output Currer	Output Current Slew Rate (<100A/s), C _L = 100µF			2.6		Α
VIL	EN Input Logic Low Voltage	V _{IN} = 2.7V to 5.5V			-	0.8	V	
VIH	EN Input Logic High Voltage	V _{IN} = 2.7V to 5.5V		2	_	-	V	
ISINK	EN Input Leakage	V _{EN} = 5V			1	1	μA	
t _{D(ON)}	Output Turn-On Delay Time	C _L = 1µF, R _{LO}	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$		_	0.05	_	ms
t _R	Output Turn-On Rise Time	C _L = 1µF, R _{LO}	$C_L = 1\mu F$, $R_{LOAD} = 10\Omega$			0.6	1.5	ms
tD(OFF)	Output Turn-Off Delay Time	C _L = 1µF, R _{LC}	_{OAD} = 10Ω		77-0	0.01		ms
t _F	Output Turn-Off Fall Time	C _L = 1µF, R _{LO}	_{OAD} = 10Ω			0.05	0.1	ms
R _{FLG}	FLG Output FET On-Resistance	I _{FLG} = 10mA,	C _L = 100µF			20	40	Ω
t BLANK	FLG Blanking Time	C _{IN} = 10µF, C _L = 100µF		4	7	15	ms	
T _{SHDN}	Thermal Shutdown Threshold	Enabled, $R_{LOAD} = 1k\Omega$		4-0	+140		°C	
T _{HYS}	Thermal Shutdown Hysteresis	_		_	+25	_	°C	
		SO-8 (Note 5)		_	110	_	°C/W	
	Thermal Resistance Junction-to-	MSOP-8EP (N	MSOP-8EP (Note 6)		_	60	_	°CM
$AL\theta$	Ambient	SOT25 (Note	SOT25 (Note 7)			157	_	°CM
		U-DFN2018-6	U-DFN2018-6 (Note 8)			70	_	°C/W

Notes

^{5.} Test condition for SO-8: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.

6. Test condition for MSOP-8EP: Device mounted on 2" x 2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

7. Test condition for SOT25: Device mounted on FR-4, 2oz copper, with minimum recommended pad layout.

8. Test condition for U-DFN2018-6: Device mounted on FR-4 2-layer board, 2oz copper, with minimum recommended pad on top layer and 3 vias to bottom layer 1.0"x1.4" ground plane.

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AP2181A/AP2191A

Typical Performance Characteristics

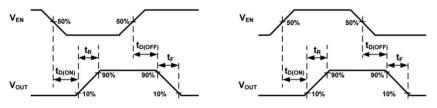
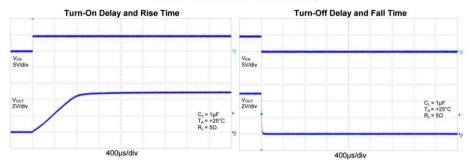
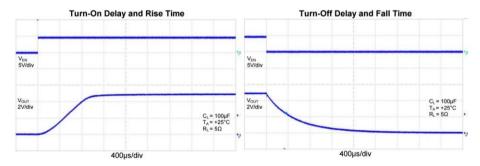


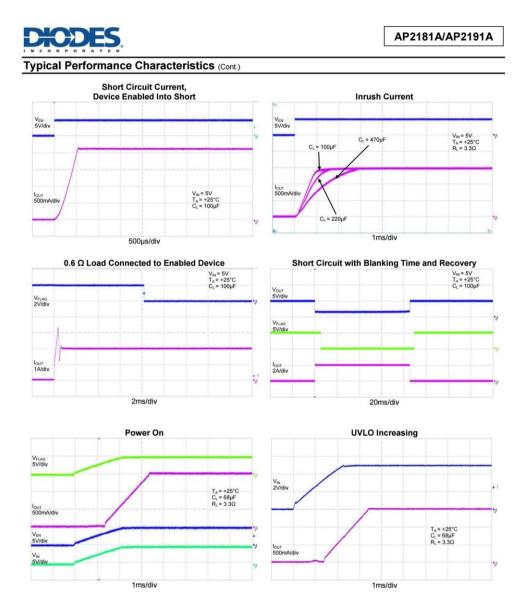
Figure 1. Voltage Waveforms: AP2181A (Left), AP2191A (Right)

All Enable Plots are for AP2191A Active High





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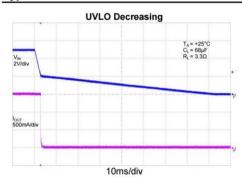


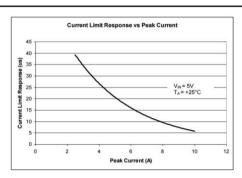
Manuals ID 06-12

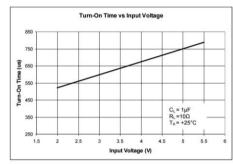


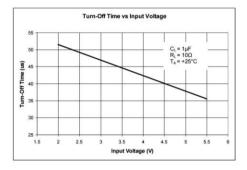
AP2181A/AP2191A

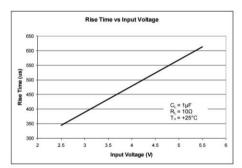
Typical Performance Characteristics (Cont.)

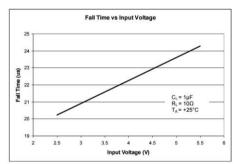










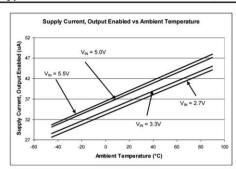


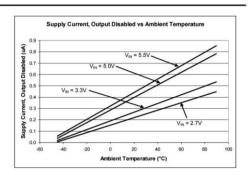
Manuals ID 06-12

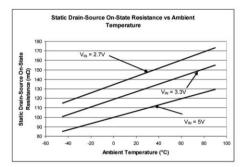


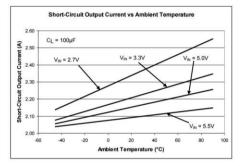
AP2181A/AP2191A

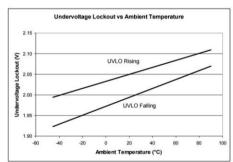
Typical Performance Characteristics (Cont.)

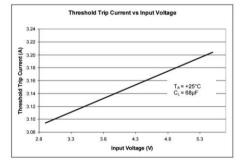












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AP2181A/AP2191A

Application Information

Power Supply Considerations

A 0.01µF to 0.1µF X7R or X5R ceramic bypass capacitor between IN and GND, close to the device, is recommended. Placing a high-value electrolytic capacitor on the input (10µF minimum) and output pin(s) is recommended when the output load is heavy. This precaution reduces power-supply transients that may cause ringing on the input. Additionally, bypassing the output with a 0.01µF to 0.1µF ceramic capacitor improves the immunity of the device to short-circuit transients.

Over-Current and Short Circuit Protection

An internal sensing FET is employed to check for over-current conditions. Unlike current-sense resistors, sense FETs do not increase the series resistance of the current path. When an overcurrent condition is detected, the device maintains a constant output current and reduces the output voltage accordingly. Complete shutdown occurs only if the fault stays long enough to activate thermal limiting.

Three possible overload conditions can occur. In the first condition, the output has been shorted to GND before the device is enabled or before V_{IN} has been applied. The AP2181A/AP2191A senses the short circuit and immediately clamps output current to a certain safe level namely I_{LIMIT} .

In the second condition, an output short or an overload occurs while the device is enabled. At the instance the overload occurs, higher current may flow for a very short period of time before the current limit function can react. After the current limit function has tripped (reached the overcurrent trip threshold), the device switches into current limiting mode and the current is clamped at I_{LIMIT}.

In the third condition, the load has been gradually increased beyond the recommended operating current. The current is permitted to rise until the current-limit threshold (I_{TRIG}) is reached or until the thermal limit of the device is exceeded. The AP2181A/AP2191A is capable of delivering current up to the current-limit threshold without damaging the device. Once the threshold has been reached, the device switches into its current limiting mode and is set at I_{LIMIT}.

Note that when the output has been shorted to GND at extremely low temperature (< -30°C), a minimum 120µF electrolytic capacitor on the output pin is recommended. A correct capacitor type with capacitor voltage rating and temperature characteristics must be properly chosen so that capacitance value does not drop too low at the extremely low temperature operation. A recommended capacitor should have temperature characteristics of less than 10% variation of capacitance change when operated at extremely low temp. Our recommended aluminum electrolytic capacitor type is Panasonic FC series.

FLG Response

When an over-current or over-temperature shutdown condition is encountered, the FLG open-drain output goes active low after a nominal 7ms deglitch timeout. The FLG output remains low until both over-current and over-temperature conditions are removed. Connecting a heavy capacitive load to the output of the device can cause a momentary over-current condition, which does not trigger the FLG due to the 7ms deglitch timeout. The AP2181A/AP2191A is designed to eliminate false over-current reporting without the need of external components to remove unwanted pulses.

Power Dissipation and Junction Temperature

The low on-resistance of the internal MOSFET allows the small surface-mount packages to pass large current. Using the maximum operating ambient temperature (T_A) and $R_{DS(ON)}$, the power dissipation can be calculated by:

P_D = R_{DS(ON)}× I

Finally, calculate the junction temperature:

T_J = P_D x R₀JA + T_A

Where

 T_A = Ambient temperature °C $R_{\theta JA}$ = Thermal resistance P_D = Total power dissipation

Thermal Protection

Thermal protection prevents the IC from damage when heavy-overload or short-circuit faults are present for extended periods of time. The AP2181A/AP2191A implements a thermal sensing to monitor the operating junction temperature of the power distribution switch. Once the die temperature rises to approximately +140°C due to excessive power dissipation in an over-current or short-circuit condition the internal thermal sense circuitry turns the power switch from damage. Hysteresis is built into the thermal sense circuit allowing the device to cool down approximately +25°C before the switch turns back on. The switch continues to cycle in this manner until the load fault or input power is removed. The FLG open-drain output is asserted when an over-temperature shutdown or over-current occurs with 7ms deglitch.

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AP2181A/AP2191A

Application Information (Cont.)

Undervoltage Lockout (UVLO)

Undervoltage Lockout (UVLO) function keeps the internal power switch from being turned on until the power supply has reached at least 1.9V, even if the switch is enabled. Whenever the input voltage falls below approximately 1.9V, the power switch is quickly turned off. This facilitates the design of hot-insertion systems where it is not possible to turn off the power switch before input power is removed.

Host/Self-Powered HUBs

Hosts and Self-Powered HUBs (SPH) have a local power supply that powers the embedded functions and the downstream ports (see Figure 2). This power supply must provide from 5.25V to 4.75V to the board side of the downstream connection under both full-load and no-load conditions. Hosts and SPHs are required to have current-limit protection and must report over-current conditions to the USB controller. Typical SPHs are desktop PCs, monitors, printers, and stand-alone hubs.

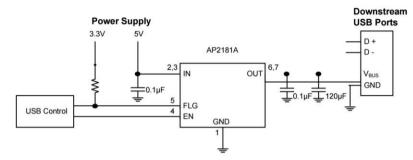


Figure 2. Typical One-Port USB Host / Self-Powered Hub

Generic Hot-Plug Applications

In many applications it may be necessary to remove modules or PC boards while the main unit is still operating. These are considered hot-plug applications. Such implementations require the control of current surges seen by the main power supply and the card being inserted. The most effective way to control these surges is to limit and slowly ramp the current and voltage being applied to the card, similar to the way in which a power supply normally turns on. Due to the controlled rise and fall time of the AP2181A/AP2191A, these devices can be used to provide a softer start-up to devices being hot-plugged into a powered system. The UVLO feature of the AP2181A/AP2191A also ensures that the switch is off after the card has been removed, and that the switch is off during the next insertion.

By placing the AP2181A/AP2191A between the VCC input and the rest of the circuitry, the input power reaches these devices first after insertion. The typical rise time of the switch is approximately 1ms, providing a slow voltage ramp at the output of the device. This implementation controls system surge current and provides a hot-plugging mechanism for any device.

Dual-Purpose Port Applications

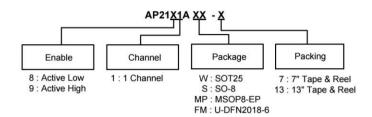
AP2181A/AP2191A is suitable for use in dual-purpose port applications in which a single port is used for data communication between the host and peripheral devices while simultaneously maintaining a charge to the battery of the peripheral device. An example of this is a shared HDMI/MHL (Mobille High-Definition Link) port that allows streaming video between an HDTV or set-top box and a smartphone or tablet while maintaining a charge to the smartphone or tablet battery. In such dual-purpose port applications, it is important to insure V_{IN} of the AP2181A/AP2191A is ramped to its operating voltage prior to enabling the output.

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AP2181A/AP2191A

Ordering Information



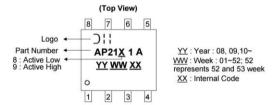
Part Number	Package	Deekens Code	7"/13" Tape	Status	
Part Number	(Note 10)	Package Code	Quantity	Part Number Suffix	(Note 9)
AP2181AW-7	SOT25	W	3000	-7	In Production
AP2181AS-13	SO-8	S	2500	-13	In Production
AP2181AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2181AFM-7	U-DFN2018-6	FM	3000	-7	In Production
AP2191AW-7	SOT25	W	3000	-7	In Production
AP2191AS-13	SO-8	S	2500	-13	In Production
AP2191AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2191AFM-7	U-DFN2018-6	FM	3000	-7	End of Life

otes: 9. AP2191AFM-7 is End of Life (EOL) and recommended alternative is AP2181AFM-7.

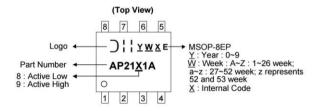
10. For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/.

Marking Information

(1) SO-8



(2) MSOP-8EP



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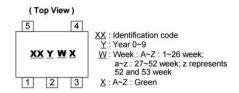
Manuals ID 06-12



AP2181A/AP2191A

Marking Information (Cont.)

(3) SOT25



Device	Package Type	Identification Code	
AP2181AW	SOT25	VX	
AP2191AW	SOT25	VY	

(4) U-DFN2018-6





XX : Identification Code
Y: Year : 0~9
W: Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Green

Device	Device Package Type	
AP2181AFM	U-DFN2018-6	ZX
AP2191AFM	U-DFN2018-6	ZY

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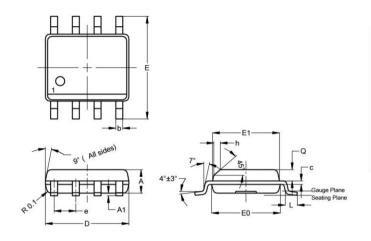


AP2181A/AP2191A

Package Outline Dimensions

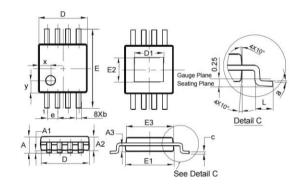
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



SO-8					
Dim	Min	Max	Тур		
Α	1.40	1.50	1.45		
A1	0.10	0.20	0.15		
b	0.30	0.50	0.40		
С	0.15	0.25	0.20		
D	4.85	4.95	4.90		
E	5.90	6.10	6.00		
E1	3.80	3.90	3.85		
E0	3.85	3.95	3.90		
е			1.27		
h	72		0.35		
L	0.62	0.82	0.72		
Q	0.60	0.70	0.65		
All	Dimens	ions in	mm		

(2) Package Type: MSOP-8EP



MSOP-8EP						
Dim	Min	Max	Тур			
Α	-	1.10	-			
A1	0.05	0.15	0.10			
A2	0.75	0.95	0.86			
A3	0.29	0.49	0.39			
b	0.22	0.38	0.30			
С	0.08	0.23	0.15			
D	2.90	3.10	3.00			
D1	1.60	2.00	1.80			
E	4.70	5.10	4.90			
E1	2.90	3.10	3.00			
E2	1.30	1.70	1.50			
E3	2.85	3.05	2.95			
е	-	-	0.65			
L	0.40	0.80	0.60			
а	0°	8°	4°			
X	-	-	0.750			
у	-	-	0.750			
All D						

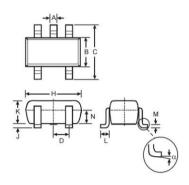
Manuals ID 06-12



AP2181A/AP2191A

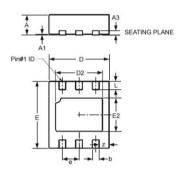
Please see http://www.diodes.com/package-outlines.html for the latest version.

(3) Package Type: SOT25



SOT25					
Dim	Min	Max	Тур		
Α	0.35	0.50	0.38		
В	1.50	1.70	1.60		
С	2.70	3.00	2.80		
D	_	-	0.95		
Н	1 2.90 3.10		3.00		
J	0.013	0.10	0.05		
K	1.00	1.30	1.10		
L	0.35	0.55	0.40		
М	0.10	0.20	0.15		
N	0.70	0.80	0.75		
α	0°	8°	1		
All C	imensi	ons in	mm		

(4) Package Type: U-DFN2018-6



U-DFN2018-6						
Dim	Min	Max	Тур			
Α	0.545	0.605	0.575			
A1	0	0.05	0.02			
A3	_	_	0.13			
b	0.15	0.25	0.20			
D	1.750	1.875	1.80			
D2	1.30	1.50	1.40			
е	_	_	0.50			
Е	1.95	2.075	2.00			
E2	0.90	1.10	1.00			
L 0.20		0.30	0.25			
z — — 0.30						
All D	imens	ions ir	mm n			

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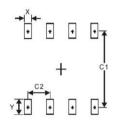


AP2181A/AP2191A

Suggested Pad Layout

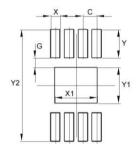
Please see http://www.diodes.com/package-outlines.html for the latest version.

(1) Package Type: SO-8



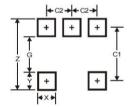
Dimensions	Value (in mm)	
Х	0.60	
Y	1.55	
C1	5.4	
C2	1.27	

(2) Package Type: MSOP-8EP



Dimensions	Value (in mm)
С	0.650
G	0.450
Х	0.450
X1	2.000
Υ	1.350
Y1	1.700
Y2	5.300

(3) Package Type: SOT25



Dimensions	Value (in mm)
Z	3.20
G	1.60
х	0.55
Y	0.80
C1	2.40
C2	0.95

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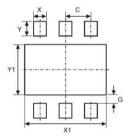


AP2181A/AP2191A

Suggested Pad Layout (Cont.)

Please see http://www.diodes.com/package-outlines.html for the latest version.

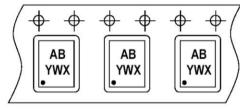
(4) Package Type: U-DFN2018-6

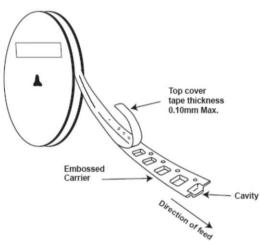


Dimensions	Value (in mm)
С	0.50
G	0.20
Х	0.25
X1	1.60
Y	0.35
Y1	1.20

Taping Orientation

For U-DFN2018-6





Note: 11. The taping orientation of the other package type can be found on our website at http://www.diodes.com/datasheets/ap02007.pdf.

Manuals ID 06-12



AP2181A/AP2191A

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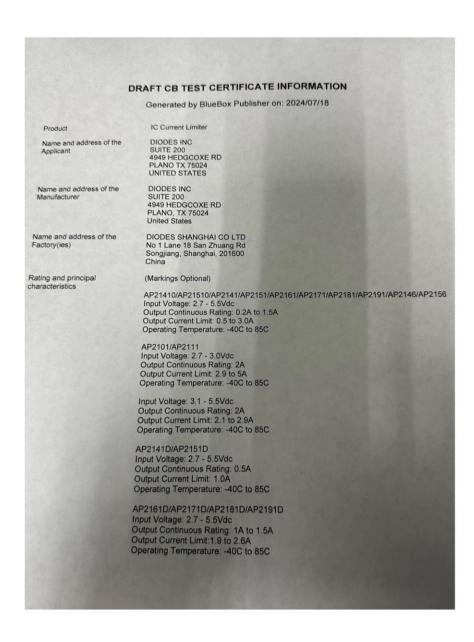
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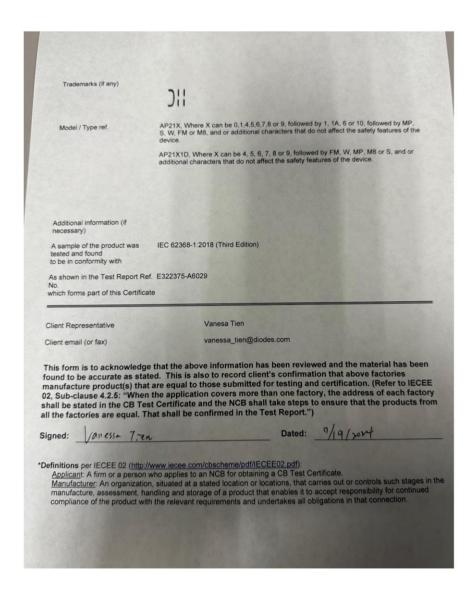
Miscellaneous ID 07-01



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Enclosures

Miscellaneous ID 07-01

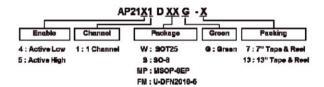


Miscellaneous ID 07-04



AP2141D/ AP2151D

Ordering Information

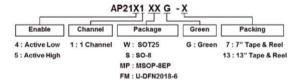


D Mb		Destroine	7"/13" Tap	pe and Reel
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1DSG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1DMPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1DWG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1DFMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Note: 9. For packaging details, go to our website at http://www.diodes.com/products/packages.html.



AP2141/ AP2151



Part Number	Deeless Code	Dealersian (Nata 40)	7" / 13" Ta	pe and Reel
	Package Code	Packaging (Note 10)	Quantity	Part Number Suffix
AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1FMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

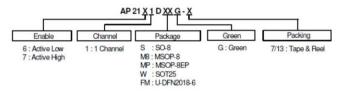
Note: 10. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

Miscellaneous ID 07-04



AP2161D/AP2171D

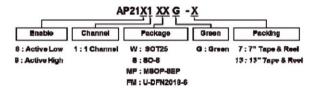
Ordering Information



Part Number	Bastone Ondo	Deskasins	7"/13" Tap	e and Reel
	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1DSG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1DM8G-13	M8	MSOP-8	2,500/Tape & Reel	-13
AP21X1DMPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1DWG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1DFMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7



AP2181/ AP2191



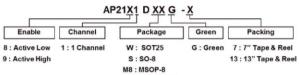
	David March 1	Dealers Onde	Bastonia a	7"/13" Tap	e and Reel
	Part Number	Package Code	Packaging	Quantity	Part Number Suffix
Г	AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7
	AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13
	AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
	AP21X1FMG-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

Miscellaneous ID 07-04



AP2181D/AP2191D

Ordering Information



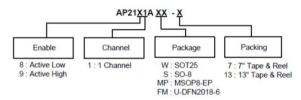
MP : MSOP-8EP FM : U-DFN2018-6

Part Number	Package (Note 9)	Package Code	7"/13" Tape and Reel Quantity	Status (Note 8)
AP2181DWG-7	SOT25	S	3000	In Production
AP2181DSG-13	SO-8	SN	2500	In Production
AP2181DMPG-13	MSOP-8EP	MP	2500	In Production
AP2181DFMG-7	U-DFN2018-6	FM	3000	In Production
AP2191DWG-7	SOT25	S	3000	In Production
AP2191DSG-13	SO-8	SN	2500	In Production
AP2191DM8G-13	MSOP-8	M8	2500	In Production
AP2191DMPG-13	MSOP-8EP	MP	2500	In Production
AP2191DFMG-7	U-DFN2018-6	FM	3000	In Production

AP2181DM8G-13 is End of Life (EOL) and recommended alternative is AP2181DMPG-13 or AP2191DM8G-13.
 For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/



AP2181A/AP2191A



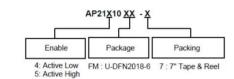
Part Number	Package (Note 10)	D	7"/13" T	Status	
		Package Code	Quantity	Part Number Suffix	(Note 9)
AP2181AW-7	SOT25	W	3000	-7	In Production
AP2181AS-13	SO-8	S	2500	-13	In Production
AP2181AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2181AFM-7	U-DFN2018-6	FM	3000	-7	In Production
AP2191AW-7	SOT25	W	3000	-7	In Production
AP2191AS-13	SO-8	S	2500	-13	In Production
AP2191AMP-13	MSOP-8EP	MP	2500	-13	In Production
AP2191AFM-7	U-DFN2018-6	FM	3000	-7	End of Life

lotes: 9. AP2191AFM-7 is End of Life (EOL) and recommended alternative is AP2181AFM-7.

10. For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/

Miscellaneous ID 07-04

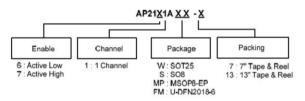




D	Package Code	Packaging	7" Tape	and Reel
Part Number			Quantity	Part Number Suffix
AP21410FM-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7
AP21510FM-7	FM	U-DFN2018-6	3.000/Tape & Reel	-7

Note: 7. For packaging details, go to our website at http://www.diodes.com/products/packages.html.

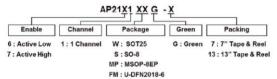




Dest Number	Backson Code	Deckening	7"/13" Tape and Reel	
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1AW-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1AS-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1AMP-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1AFM-7	FM	U-DFN2018-6	3,000/Tape & Reel	-7

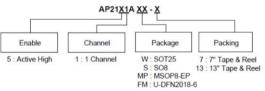
Miscellaneous ID 07-04





Part Number	Darkers Code	Bushaulan	7"/13" Tape and Reel	
Part Number	Package Code	Packaging	Quantity	Part Number Suffix
AP21X1WG-7	W	SOT25	3,000/Tape & Reel	-7
AP21X1SG-13	S	SO-8	2,500/Tape & Reel	-13
AP21X1MPG-13	MP	MSOP-8EP	2,500/Tape & Reel	-13
AP21X1FMG-7	FM	U-DFN2018-6	3.000/Tape & Reel	-7

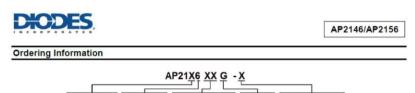




Part Number	Package (Note 11)	Package Code	7"/13" Tape and Reel Quantity	Status (Note 10)
AP2151AW-7	SOT25	W	3000	In Production
AP2151AS-13	SO-8	S	2500	In Production
AP2151AMP-13	MSOP-8EP	MP	2500	In Production
AP2151AFM-7	U-DFN2018-6	FM	3000	In Production

All variants of AP2141A are End of Life and recommended alternatives are AP2141.
 For packaging details, go to our website at: https://www.diodes.com/design/support/packaging/diodes-packaging/

Miscellaneous ID 07-04

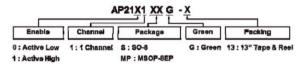


4 : Active Low	6: 2 Channel	S:SO-8	G: Green	13:13" Tape & Ree
5 : Active High		MP: MSOP-8EP		

Part Number	Dankana Code	Deckering	13" Tap	e and Reel
Part Number	Package Code	Packaging -	Quantity	Part Number Suffix
AP21X6SG-13	S	SO-8	2500/Tape & Reel	-13
AP21X6MPG-13	MP	MSOP-8EP	2500/Tape & Reel	-13



AP2101/AP2111



	Part Number	Package Code	Packaging	13" Tape and Reel	
	Part Number			Quantity	Part Number Suffix
0	AP21X1SG-13	S	SO-8	2500/Tape & Reel	-13
0	AP21X1MPG-13	MP	MSOP-8EP	2500/Tape & Reel	-13

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Enclosures

Miscellaneous ID 07-05

Annex G.9 – IC Current Limiter Testing Results	Passilt (State Pass on Fail)
Condition Description	Result [State Pass or Fail]
10,000 Cycles of Enable pin with the output delivering Nominal Current at 25C	Pass
50 Cycles of Enable pin with the output delivering Nominal Current at 85C	Pass
50 Cycles of Enable pin with the output delivering Nominal Current at -40C	Pass
50 Cycles of Power pin with the output delivering Nominal Current at 85C	Pass
50 Cycles of Power pin with the output delivering Nominal Current at -40C	Pass
50 Cycles of Power pin with the output delivering Short Circuit Current at 85C	Pass
50 Cycles of Enable pin with the output delivering 150% Nominal Current at 25C	Pass
50 Cycles of Power pin with the output delivering 150% Nominal Current at 25C	Pass