AP64350QSP EVB User Guide

## DESCRIPTION

The AP64350Q is an automotive-compliant, 3.5 A , synchronous buck converter with a wide input voltage range of 3.8 V to 40 V . The device fully integrates a $75 \mathrm{~m} \Omega$ high-side power MOSFET and a $45 \mathrm{~m} \Omega$ lowside power MOSFET to provide high-efficiency step-down DC-DC conversion.

The AP64350Q device is easily used by minimizing the external component count due to its adoption of peak current mode control.

The AP64350Q design is optimized for Electromagnetic Interference (EMI) reduction.

## FEATURES

- AEC-Q100 Qualified with the Following Results
- Device Temperature Grade 1: $-40^{\circ} \mathrm{C}$ to $+125^{\circ} \mathrm{C}$ TA Range
- Device HBM ESD Classification Level H2
- Device CDM ESD Classification Level C5
- VIN: 3.8 V to 40 V
- 3.5A Continuous Output Current
- $0.8 \mathrm{~V} \pm 1 \%$ Reference Voltage
- $22 \mu \mathrm{~A}$ Low Quiescent Current (Pulse Frequency Modulation)
- Programmable Switching Frequency: 100 kHz to 2.2 MHz
- External Clock Synchronization: 100 kHz to 2.2 MHz
- Up to 85\% Efficiency at 5mA Light Load
- Proprietary Gate Driver Design for Best EMI Reduction
- Frequency Spread Spectrum (FSS) to Reduce EMI

The device has a proprietary gate driver scheme to resist switching node ringing without sacrificing MOSFET turn-on and turn-off times, which reduces high-frequency radiated EMI noise caused by MOSFET switching. AP64350Q also features Frequency Spread Spectrum (FSS) with a switching frequency jitter of $\pm 6 \%$, which reduces EMI by not allowing emitted energy to stay in any one frequency for a significant period of time.

The device is available in an SO-8EP package.

- Low-Dropout (LDO) Mode
- Precision Enable Threshold to Adjust UVLO
- Protection Circuitry
- Undervoltage Lockout (UVLO)
- Output Overvoltage Protection (OVP)
- Cycle-by-Cycle Peak Current Limit
- Thermal Shutdown
- Totally Lead-Free \& Fully RoHS Compliant (Notes $1 \& 2$ )
- Halogen and Antimony Free. "Green" Device (Note 3)
- The AP64350Q is suitable for automotive applications requiring specific change control; this part is AEC-Q100 qualified, PPAP capable, and manufactured in IATF 16949 certified facilities.
https://www.diodes.com/quality/produ ct-definitions/

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## APPLICATIONS

- 12V Automotive Power Systems
- Automotive Infotainment
- Automotive Instrument Clusters
- Automotive Telematics
- Advanced Driver Assistance Systems


## TYPICAL APPLICATIONS CIRCUIT



Figure 1. Typical Application Circuit

## ABSOLUTE MAXIMUM RATINGS

| Symbol | Parameter | Rating | Unit |
| :---: | :---: | :---: | :---: |
| VIN | Supply Pin Voltage | -0.3 to $+42.0(\mathrm{DC})$ | V |
|  |  | -0.3 to $+45.0(400 \mathrm{~ms})$ |  |
| $\mathrm{V}_{\mathrm{BST}}$ | Bootstrap Pin Voltage | $\mathrm{V}_{\mathrm{SW}}-0.3$ to $\mathrm{V}_{\mathrm{SW}}+6.0$ | V |
| $\mathrm{~V}_{\mathrm{EN}}$ | Enable/UVLO Pin Voltage | -0.3 to +42.0 | V |
| $\mathrm{~V}_{\text {RT/CLK }}$ | RT/CLK Pin Voltage | -0.3 to +6.0 | V |
| $\mathrm{~V}_{\text {FB }}$ | Feedback Voltage | -0.3 V to +6.0 | V |
| $\mathrm{~V}_{\text {ComP }}$ | Compensation Pin Voltage | -0.3 to +6.0 | V |
| $\mathrm{~V}_{\mathrm{SW}}$ | Switch Node Voltage | -0.3 to VIN $+0.3(\mathrm{DC})$ | V |
|  | $\mathrm{T}_{J}$ | -2.5 to VIN $+2.0(20 \mathrm{~ns})$ |  |
| $\mathrm{T}_{\mathrm{L}}$ | Junction Temperature | +160 | ${ }^{\circ} \mathrm{C}$ |

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RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | Min | Max | Unit |
| :---: | :---: | :---: | :---: | :---: |
| VIN | Supply Voltage | 3.8 | 40 | V |
| VOUT | Output Voltage | 0.8 | 39 | V |
| $\mathrm{~T}_{\mathrm{A}}$ | Operating Ambient Temperature <br> Range | -40 | +125 | ${ }^{\circ} \mathrm{C}$ |
| $\mathrm{T}_{J}$ | Operating Junction Temperature <br> Range | -40 | +150 | ${ }^{\circ} \mathrm{C}$ |

## EVALUATION BOARD



Figure 2. AP64350QSP-EVM

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## QUICK START GUIDE

The AP64350QSP-EVM has a simple layout and allows access to the appropriate signals through test points. To evaluate the performance of the AP64350QSP, follow the procedure below:

1. Connect a power supply to the input terminals VIN and GND. Set VIN to 12V.
2. Connect the positive terminal of the electronic load to VOUT and negative terminal to GND.
3. For Enable, place a jumper at JH6 to "ON" position to connect EN pin to VIN through $100 \mathrm{~K} \Omega$ resistor to enable IC. Jump to "OFF" position to disable IC.
4. The evaluation board should now power up with a 5.0 V output voltage.
5. Check for the proper output voltage of $5.0 \mathrm{~V}( \pm 1 \%)$ at the output terminals VOUT and GND. Measurement can also be done with a multimeter with the positive and negative leads between VOUT and GND.
6. Set the load to 3.5 A through the electronic load. Check for the stable operation of the SW signal on the oscilloscope. Measure the switching frequency.

## MEASUREMENT/PERFORMANCE GUIDELINES:

1) When measuring the output voltage ripple, maintain the shortest possible ground lengths on the oscilloscope probe. Long ground leads can erroneously inject high frequency noise into the measured ripple.
2) For efficiency measurements, connect an ammeter in series with the input supply to measure the input current. Connect an electronic load to the output for output current.

## SETTING OUTPUT VOLTAGE:

Table 1 shows a list of recommended component selections for common output voltages.

| VOUT | R1 | R2 | $\mathbf{L 1}$ | $\mathbf{R 7}$ | $\mathbf{C 7}$ | $\mathbf{C 1}, \mathbf{C 2}$ | $\mathbf{C 5}, \mathbf{C} 6$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1.2 V | $4.99 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $3.3 \mu \mathrm{H}$ | $3.32 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 1.5 V | $8.66 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $3.3 \mu \mathrm{H}$ | $4.22 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 1.8 V | $12.4 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $3.3 \mu \mathrm{H}$ | $4.99 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 2.5 V | $21.5 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $4.7 \mu \mathrm{H}$ | $6.98 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 3.3 V | $31.6 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $4.7 \mu \mathrm{H}$ | $9.31 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 5.0 V | $52.3 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $6.8 \mu \mathrm{H}$ | $14 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |
| 12 V | $140 \mathrm{~K} \Omega$ | $10 \mathrm{~K} \Omega$ | $10 \mu \mathrm{H}$ | $33.2 \mathrm{~K} \Omega$ | 3.3 nF | $2 \times 10 \mu \mathrm{~F}$ | $2 \times 22 \mu \mathrm{~F}$ |

Table 1. Common Output Voltages

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## EVALUATION BOARD SCHEMATIC



Figure 3. AP64350QSP-EVM Schematic

## PCB TOP LAYOUT



Figure 4. AP64350QSP-EVM - Top Layer

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## PCB BOTTOM LAYOUT



Figure 5. AP64350QSP-EVM - Bottom Layer

## AUTOMOTIVE BILL OF MATERIALS for AP64350QSP-EVM @Vout=5V

| Ref | Value | Description | Qty | Size | Vendor <br> Name | Manufacturer PN |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| C1, <br> C2 | $10 \mu \mathrm{~F}$ | Ceramic <br> Capacitor, 50V | 2 | 1206 | TDK | CGA5L1X7R1H106K160 <br> AC |
| C3, <br> C4, <br> C9 | $0.1 \mu \mathrm{~F}$ | Ceramic <br> Capacitor, 50 V | 3 | 0603 | TDK | CGA3E3X8R1H104K08 <br> 0AB |
| C5, | $22 \mu \mathrm{~F}$ | Ceramic <br> Capacitor, 16 V | 2 | 1210 | TDK | CGA6P1X8L1C226M25 <br> OAC |
| C7 | 3.3 nF | Ceramic <br> Capacitor, 50 V | 1 | 0603 | TDK | CGA3E2NP01H332J080 <br> AA |
| R1 | $52.3 \mathrm{~K} \Omega$ | SMD Resistor, $1 \%$ | 1 | 0603 | Panasonic | ERJ-3EKF5232V |
| R2 | $10 \mathrm{~K} \Omega$ | SMD Resistor, $1 \%$ | 1 | 0603 | Panasonic | ERJ-3EKF1002V |
| R3 | $0 \Omega$ | SMD Resistor, $1 \%$ | 1 | 0603 | Panasonic | ERJ-3GEY0R00V |
| R4 | $100 \mathrm{~K} \Omega$ | SMD Resistor, $1 \%$ | 1 | 0603 | Panasonic | ERJ-3EKF1003V |
| R6 | $200 \mathrm{~K} \Omega$ | SMD Resistor, $1 \%$ | 1 | 0603 | Panasonic | ERJ-S03F2003V |
| R7 | $14 \mathrm{~K} \Omega$ | RES SMD | 1 | 0603 | Panasonic | ERJ-3EKF1402V |

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| L1 | $6.8 \mu \mathrm{H}$ | DCR=18.5m, <br> Ir=8.9A | 1 | $10.0 \times 10.7 x$ <br> 4 mm | Panasonic | ETQP4M6R8KVC |
| :--- | :--- | :--- | :--- | :--- | :--- | :--- |
| JH6 |  | PCB Header, 36 <br> POS | 1 | 1 X3 | Amphenol | $78511-136 \mathrm{HLF}$ |
| JH1 <br> 3, |  | Terminal Turret <br> JH1 <br> 4, <br> JH1 | 1598 | Thest 0.094" L | 4 | Through- <br> (Tole |
| JH1 <br> 6 |  | Keystone <br> Electronics | $1598-2$ |  |  |  |
| U1 | AP64350Q | Sync DC-DC Buck <br> Converter | 1 | SO-8EP | Diodes <br> Incorporated <br> (Diodes) | AP64350QSP |

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## TYPICAL PERFORMANCE CHARACTERISTICS

Figure 6. Efficiency vs Output Current


Figure 7. Load Transient 2A to 3.5A


Figure 8. Output Voltage Ripple, IOUT=3.5A


Figure 9. Output Short Protection, IOUT=3.5A


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