DESCRIPTION

The AP62600 is a 6A, synchronous buck converter with a wide input voltage range of 4.5V to 18V. The device fully integrates a 36mΩ high-side power MOSFET and a 14mΩ low-side power MOSFET to provide high-efficiency step-down DC-DC conversion.

The AP62600 device is easily used by minimizing the external component count due to its adoption of Constant On-Time (COT) control to achieve fast transient response, easy loop stabilization, and low output voltage ripple.

The AP62600 design is optimized for Electromagnetic Interference (EMI) reduction. 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.

The device is available in a V-QFN2030-12 (Type A) package.

FEATURES

- VIN: 4.5V to 18V
- Output Voltage (VOUT): 0.6V to 7V
- 6A Continuous Output Current
- 0.6V ± 1% Reference Voltage
- 360µA Quiescent Current
- Selectable Operation Modes
  - Pulse Frequency Modulation (PFM)
  - Ultrasonic Mode (USM)
  - Pulse Width Modulation (PWM)
- Selectable Switching Frequency
  - 400kHz
  - 800kHz
  - 1.2MHz
- Programmable Soft-Start Time
- Proprietary Gate Driver Design for Best EMI Reduction
- Power-Good Indicator
- Precision Enable Threshold to Adjust UVLO
- Protection Circuitry
  - Undervoltage Lockout (UVLO)
  - Cycle-by-Cycle Valley Current Limit
  - Thermal Shutdown

APPLICATIONS

- 5V and 12V Input Distributed Power Bus Supplies
- Television Sets and Monitors
- White Goods and Small Home Appliances
- FPGA, DSP, and ASIC Supplies
- Home Audio
- Network Systems
- Gaming Consoles
- Consumer Electronics
- General Purpose Point of Load

APPLICATIONS

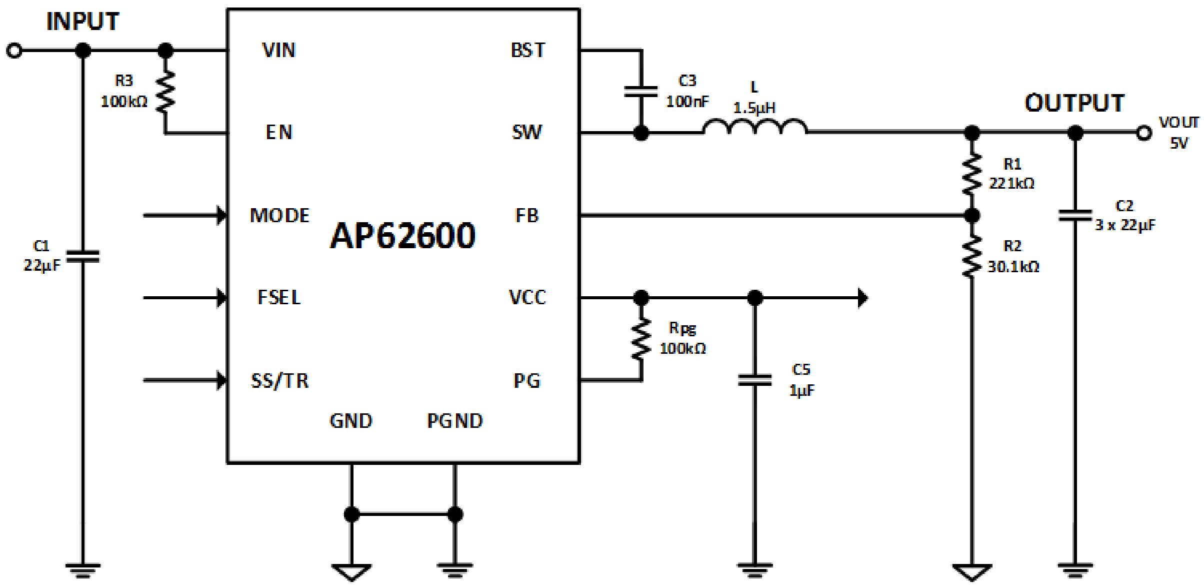

Figure 1. Typical Application Circuit

FUNCTIONAL BLOCK

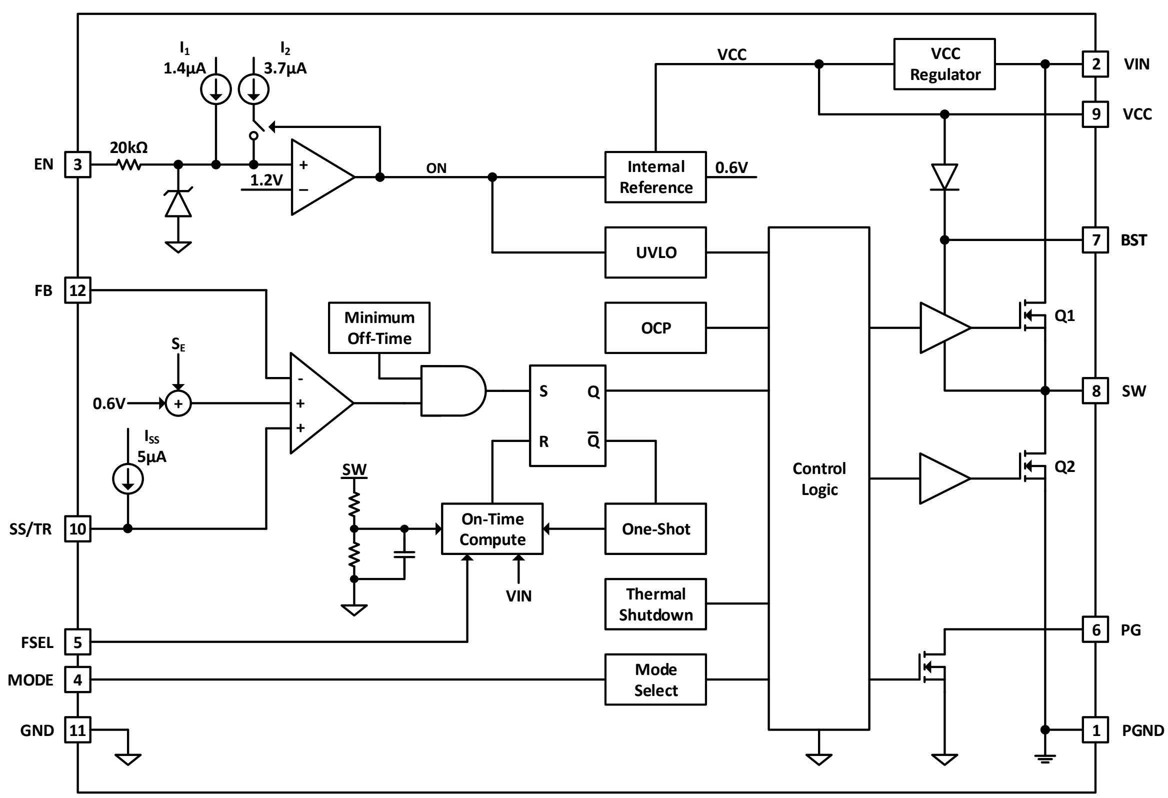

Figure 2. Functional Block Diagram

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Rating	Unit
VIN	Supply Pin Voltage	-0.3 to +20.0 (DC)	V
		-0.3 to 22.0 (400ms)	
VCC	VCC Pin Voltage	-0.3V to +6.0	V
V_{EN}	Enable/UVLO Pin Voltage	-0.3V to +6.0	V
V_{MODE}	MODE Select Pin Voltage	-0.3V to +6.0	V
V_{FSEL}	Frequency Select Pin Voltage	-0.3V to +6.0	V
V_{PG}	Power-Good Pin Voltage	-0.3V to +6.0	V
V_{BST}	Bootstrap Pin Voltage	V_{SW} - 0.3 to V_{SW} + 6.0	V
V_{SW}	Switch Pin Voltage	-1.0 to VIN + 0.3 (DC)	V
		-2.5 to VIN + 2.0 (20ns)	
$V_{SS/TR}$	Soft-Start/Tracking Pin Voltage	-0.3V to +6.0	V
V_{FB}	Feedback Pin Voltage	-0.3V to +6.0	V
T_{ST}	Storage Temperature	-65 to +150	°C
T_J	Junction Temperature	+150	°C
T_L	Lead Temperature	+260	°C
ESD Susceptibility			
HBM	Human Body Mode	±2000	V
CDM	Charge Device Model	±500	V

RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
VIN	Supply Voltage	4.5	18.0	V
VOUT	Output Voltage	0.6	7.0	V
T_A	Operating Ambient Temperature	-40	+85	°C
T_J	Operating Junction Temperature	-40	+125	°C

EVALUATION BOARD

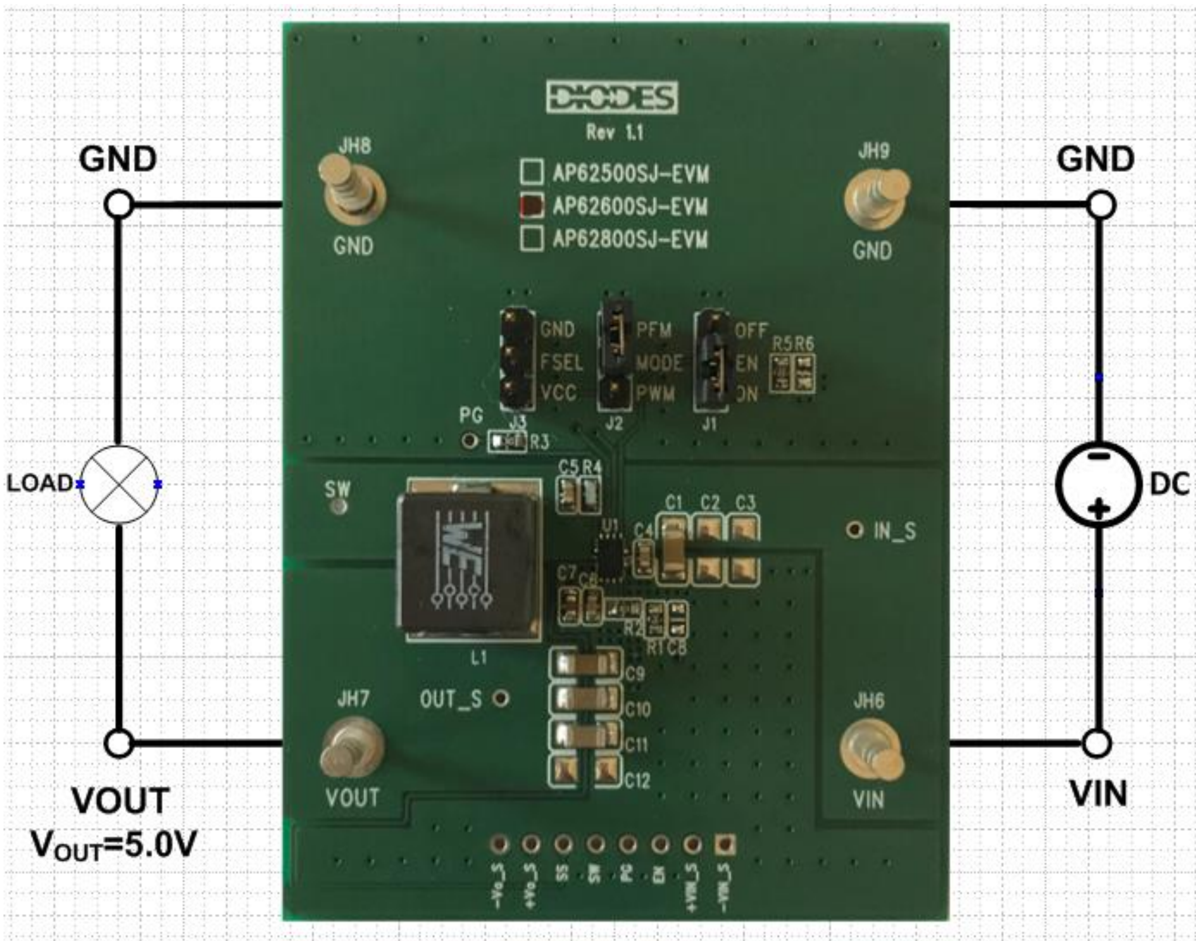

Figure 3. AP62600SJ-EVM

QUICK START GUIDE

The AP62600SJ-EVM has a simple layout and allows access to the appropriate signals through test points. The board is targeted to be used in providing a simple and convenient evaluation environment for the AP62600.

To operate the EVM, set jumpers J1, J2 and J3 to the desired positions per below shown.

- J1 = EN pin input jumper. For Enable, to enable IC, place a jumper at J1 to "ON" position to connect EN pin to V_{IN} through 100KΩ resistor or leave it OPEN. Jump to "OFF" position to disable IC.

- J2 = PFM, PWM or USM mode selection. At J2, connect a jumper to PWM to force the device in Pulse Width Modulation (PWM) operation mode. Connect a jumper to PFM to ground the pin to operate the device in Pulse Frequency Modulation (PFM) operation mode without Ultrasonic Mode (USM). Leave J2 OPEN to float the pin to operate the device in PFM with USM mode.

- J3 = Switching frequency selection. At J3, connect a jumper to GND to set clock frequency to 400kHz. Leave J3 OPEN to float the pin to set clock frequency to 800kHz. Connect a jumper to VCC to set clock frequency to 1.2MHz.

To evaluate the performance of the AP62600SJ-EVM, follow the procedure below:

1. Connect a power supply to the input terminals V_{IN} and GND. Set V_{IN} to 12V.

2. Connect the positive terminal of the electronic load to V_{OUT} and negative terminal to GND.

3. By default, the evaluation board should now power up with a 5.0V output voltage. Frequency is 800kHz.

4. Check for the proper output voltage of 5.0V (±1%) at the output terminals V_{OUT} and GND. Measurement can also be done with a multimeter with the positive and negative leads between V_{OUT} and GND.

5. Set the load to 6A 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.

APPLICATION INFORMATION

Setting the Output Voltage of AP62600

(1) Setting the output voltage

The AP62600 features external programmable output voltage by using a resistor divider network R2 and R1 as shown in the typical application circuit. The output voltage is calculated as below,

$$\mathbf{R1} = \mathbf{R2} \cdot \left(\frac{\mathbf{VOUT}}{\mathbf{0.6V}} - \mathbf{1}\right)$$

First, select a value for R1 according to the value recommended in the table 1. Then, R3 is determined. The output voltage is given by Table 1 for reference. For accurate output voltage, 1% tolerance is required.

Table 1. Resistor selection for output voltage setting

Vo	R2	R1
1.05V	30 KΩ	22.5 KΩ
1.2V	30 KΩ	30 KΩ
1.5V	30 KΩ	45KΩ
1.8V	30 KΩ	60KΩ
2.5V	30 KΩ	95KΩ
3.3V	30 KΩ	135KΩ
5V	30 KΩ	221 KΩ

EXTERNAL COMPONENT SELECTION:

1) Input & output Capacitors
   (1) For lower output ripple, low ESR is required.
   (2) Low leakage current needed, X5R/X7R ceramic recommend, multiple capacitor parallel connection.
   (3) The C1-3 are input capacitors of supply input pin, capacitances is greater than 22uF.
   (4) The C7 is input capacitors of VCC pin, capacitances are greater than 1uF
   (5) The C9-11 are output capacitors, recommended in Table 2.

2) Bootstrap Voltage Regulator

   An external 0.1uF ceramic capacitor is required as bootstrap capacitor between BST and SW pin to work as high side power MOSFET gate driver

3) Soft-start time control capacitor

   . C6 controls the soft-start time of the output voltage. It can be changed for a shorter or slower ramp up of Vout. The capacitor along with an internal ISS of 5µA, sets the soft-start interval of the converter, TSS, according to equation below:

$$C_{SS}\,(nF) = 8.33 * T_{SS}\,(ms)$$

4) Inductor (L)
   (1) Low DCR for good efficiency
   (2) Inductance saturate current must higher than the output current
   (3) The recommended inductance is shown in the table 2 below.

Table 2. Recommended inductors and output capacitor

Frequency	Output Voltage	1.05V	1.2V	1.8V	2.5 V	3.3 V	5.0 V
400KHz	Output Capacitor	88uF	66uF	66uF	66uF	66uF	66uF
	Inductor	3.3uH	3.3uH	3.3uH	3.3uH	4.7uH	4.7uH
	Würth PART	7443330330	7443330330	7443330330	7443330330	7443330470	7443330470
800 KHz	Output Capacitor	44uF	66uF	66uF	66uF	66uF	66uF
	Inductor	1.0uH	1.0uH	1.0uH	1.0uH	1.0uH	1.5 uH
	Würth PART	7443330100	7443330100	7443330100	7443330100	7443330100	7443330150
1.2MHz	Output Capacitor	66uF	66uF	66uF	66uF	66uF	66uF
	Inductor	0.47uH	0.47uH	0.68uH	0.68uH	0.82uH	1.0 uH
	Würth PART	7443330047	7443330047	7443330068	7443330068	7443330082	7443330100

EVALUATION BOARD SCHEMATIC

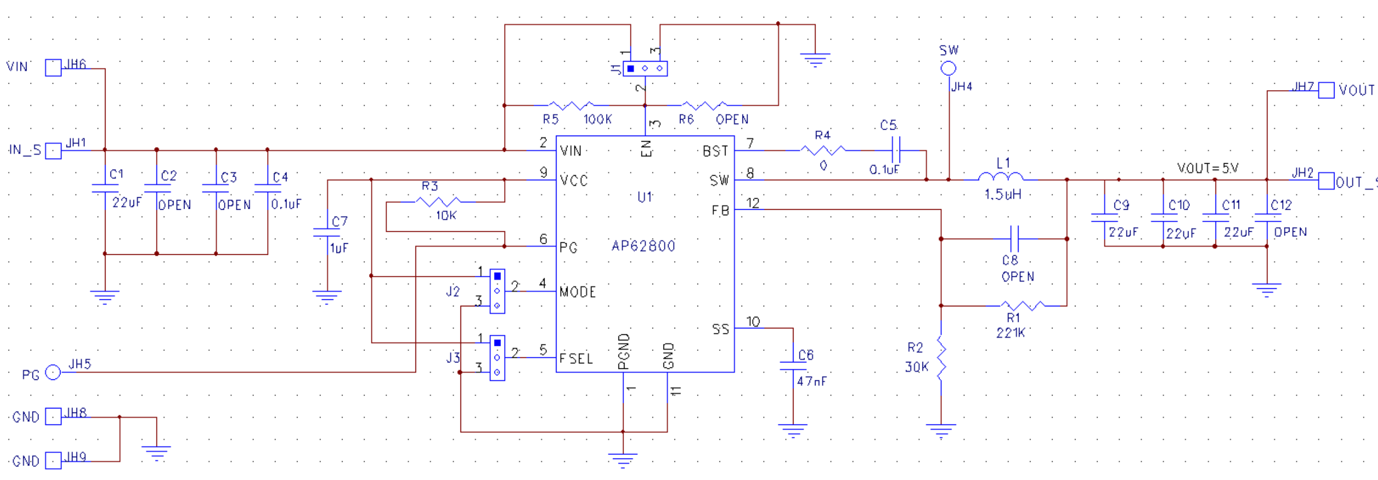

Figure 3. AP2600SJ-EVM Schematic

PCB TOP LAYOUT

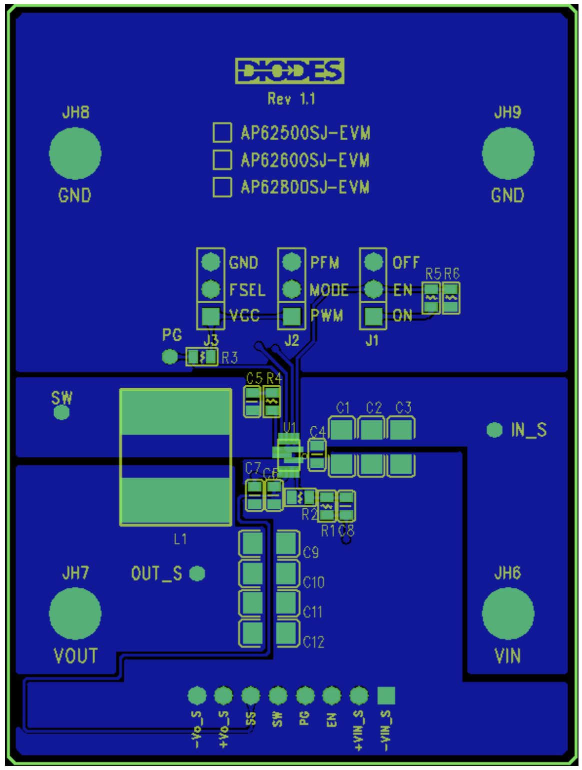

Figure 4. AP62600SJ-EVM – Top Layer

PCB BOTTOM LAYOUT

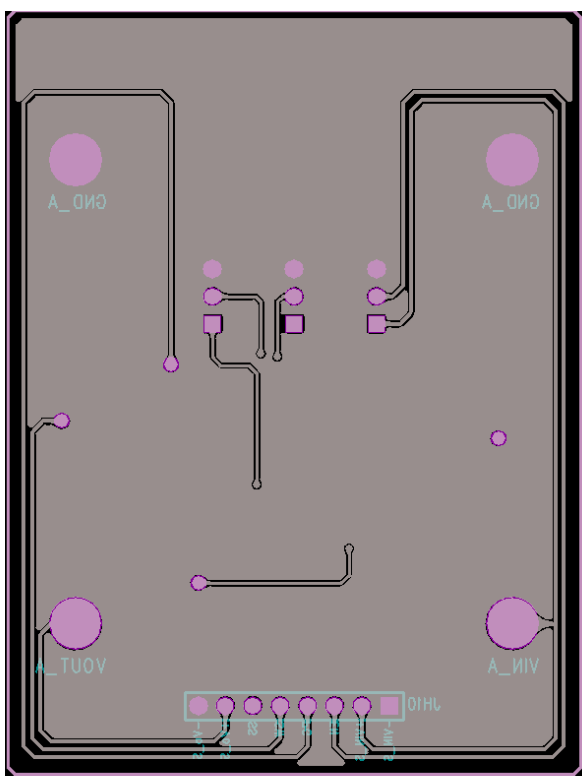

Figure 5. AP62600SJ-EVM – Bottom Layer

BILL OF MATERIALS for AP62600SJ-EVM for V_{OUT}=5V

Ref	Value	Description	Qty	Size	Vendor	Manufacturer PN	PCB Layer
C1, C9, C10, C11	22µF	Ceramic Capacitor, 25V, X6S	4	1206	Samsung	CL31X226KAHN3NE	Top
C4, C5	0.1µF	Ceramic Capacitor, 50V, X7R, 10%	2	0603	Wurth Electronics	885012206095	Top
C6	47nF	Ceramic Capacitor, 50V, X7R, 10%	1	0603	Wurth Electronics	885012206093	Top
C7	1µF	Ceramic Capacitor, 25V, X7R, 10%	1	0603	Wurth Electronics	885012206076	Top
L1	1.5µH	DCR=2.5mΩ, Ir=18A	1	10.9x10x 9.7mm	Wurth Electronics	7443330150	Top
R1	221KΩ	RES SMD 1%	1	0603	Yageo	RC0603FR-07221KL	Top
R2	30KΩ	RES SMD 1%	1	0603	Yageo	RC0603FR-0730KL	Top
R3	10KΩ	RES SMD 1%	1	0603	Yageo	RC0603FR-0710KL	Top
R4	0Ω	RES SMD 1%	1	0603	Vishay	MCT06030Z0000ZP500	Top
R5	100KΩ	RES SMD 1%	1	0603	Yageo	RC0603FR-07100KL	Top
J1, J2, J3		PCB Header, 40 POS	3	1X3	3M	2340-6111TG	Top
JH6, JH7, JH8, JH9	1598	Terminal Turret Triple 0.094" L (Test Points)	4	Through-Hole	Keystone Electronics	1598-2	Top
U1	AP62600	6A Sync DC/DC Converter	1	QFN2030-12	Diodes Inc	AP62600SJ	Top

TYPICAL PERFORMANCE CHARACTERISTICS

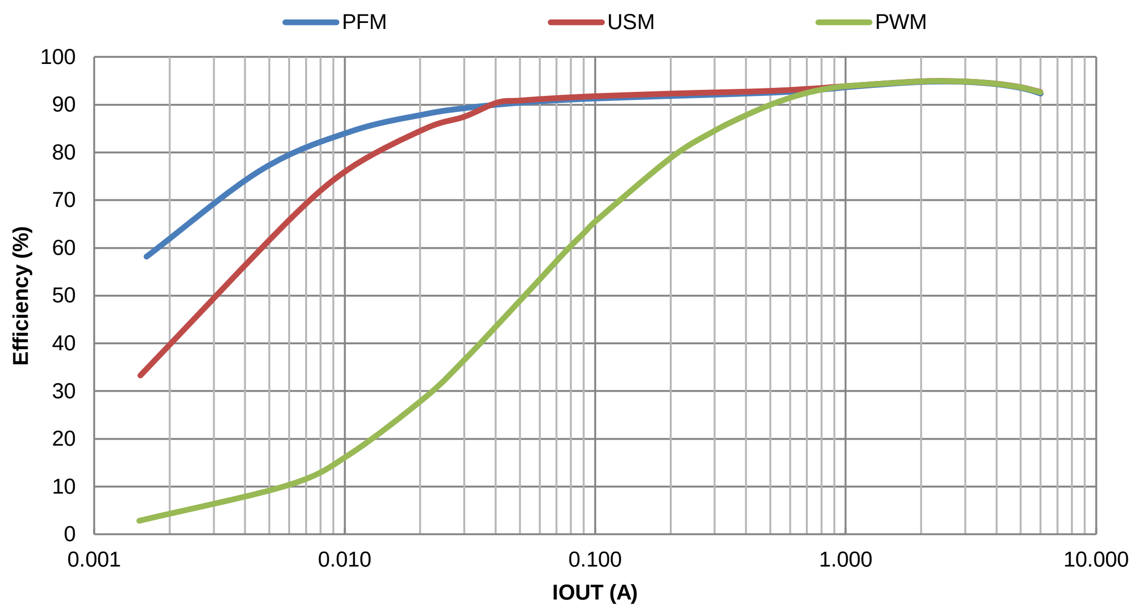

Figure 6. Efficiency vs. Output Current, VIN = 12V, VOUT = 5V, L = 1.5µH, f_{SW} = 800kHz

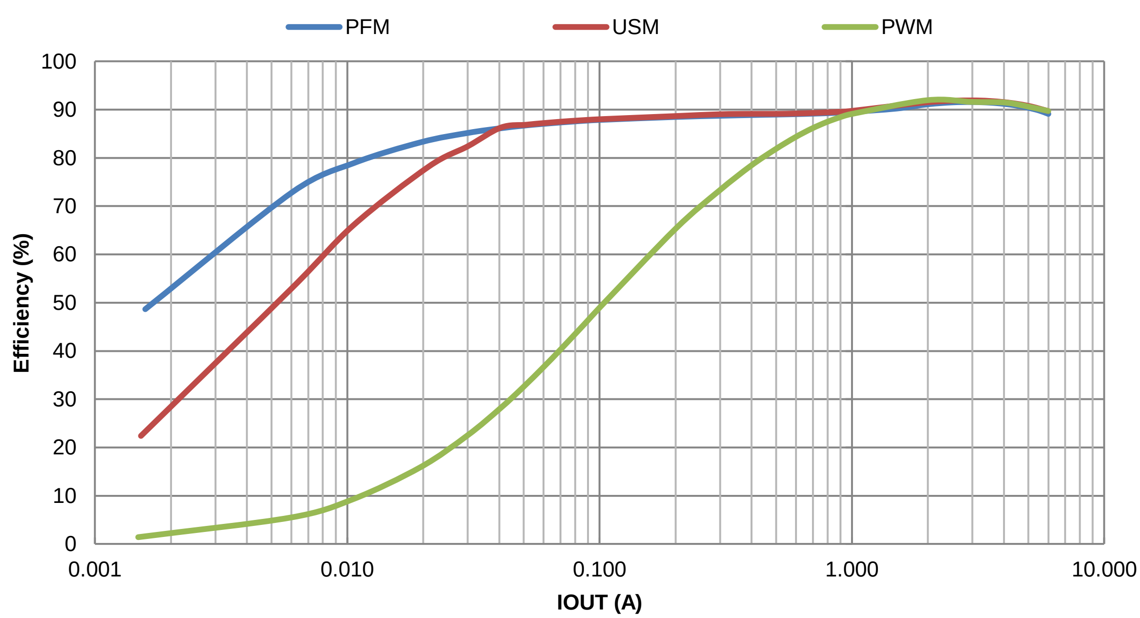

Figure 7. Efficiency vs. Output Current, VIN = 12V, VOUT = 3.3V, L = 1.2µH, f_{SW} = 800kHz

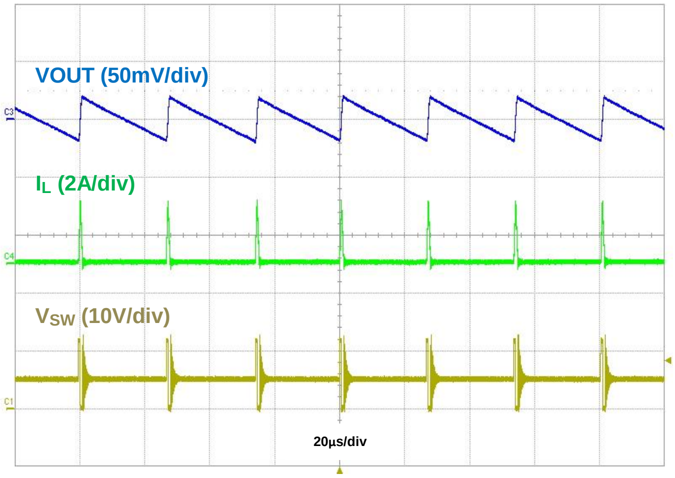

Figure 8. Output Voltage Ripple, IOUT = 50mA
VIN = 12V, VOUT = 5V PFM f_{SW} = 800kHz

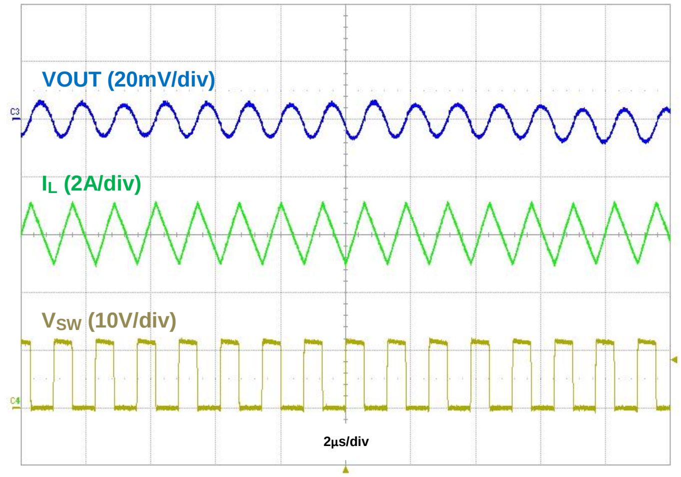

Figure 9. Output Voltage Ripple, IOUT = 6A
VIN = 12V, VOUT = 5V PFM f_{SW} = 800kHz

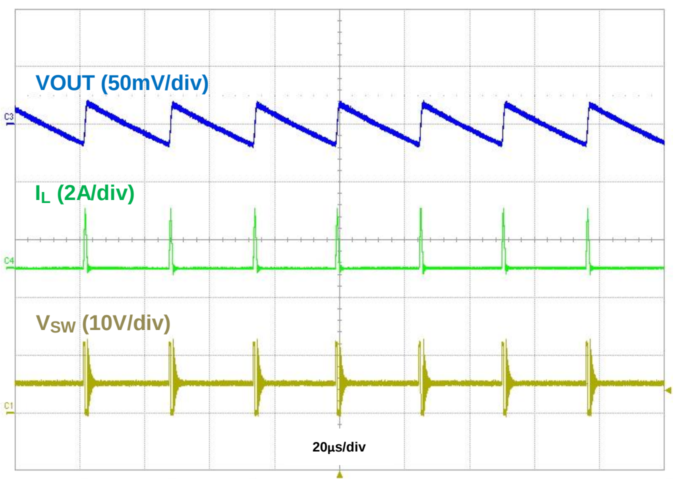

Figure 10. Output Voltage Ripple, IOUT = 50mA
VIN = 12V, VOUT = 5V USM f_{SW} = 800kHz

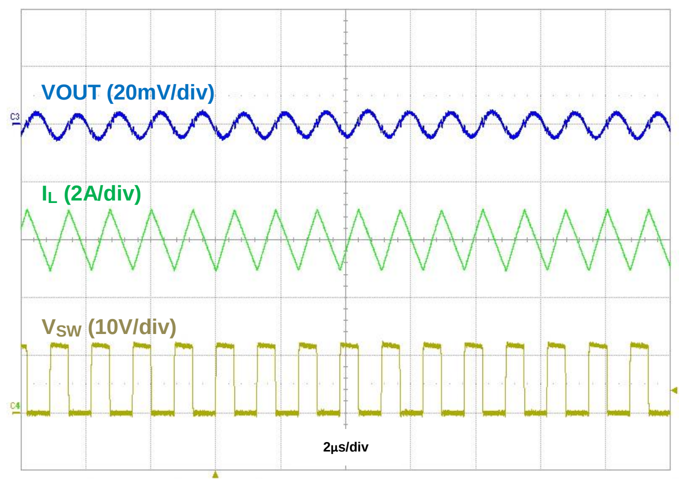

Figure 11. Output Voltage Ripple, IOUT = 6A
VIN = 12V, VOUT = 5V USM f_{SW} = 800kHz

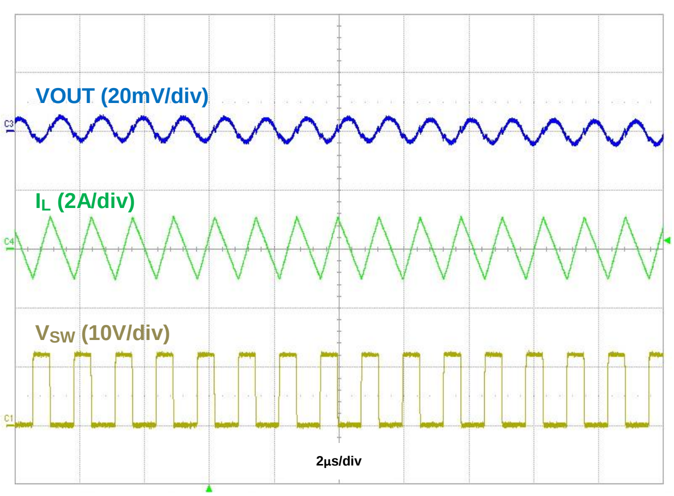

Figure 12. Output Voltage Ripple, IOUT = 50mA
VIN = 12V, VOUT = 5V PWM f_{SW} = 800kHz

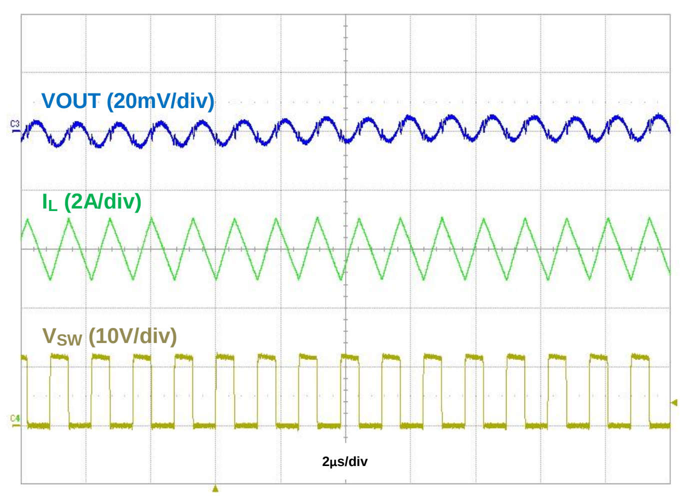

Figure 13. Output Voltage Ripple, IOUT = 6A
VIN = 12V, VOUT = 5V PWM f_{SW} = 800kHz