

## 40V, 5A, Low IQ, Synchronous DC-DC Buck Converter with Internal Compensation

### DESCRIPTION

The AP64502Q is an automotive-compliant, 5A, synchronous buck converter with a wide input voltage range of 3.8V to 40V. The device fully integrates a 45mΩ high-side power MOSFET and a 20mΩ lowside power MOSFET to provide high-efficiency step-down DC-DC conversion.

The AP64502Q device is easily used by minimizing the external component count due to its adoption of peak current mode control along with its integrated loop compensation network.

The AP64502Q 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 AP64502Q 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.

### FEATURES

- AEC-Q100 Qualified with the Following Results
  - Device Temperature Grade 1: -40°C to +125°C TA Range
  - Device HBM ESD Classification Level H2
  - Device CDM ESD Classification Level C5
- VIN: 3.8V to 40V
- 5A Continuous Output Current
- 0.8V  $\pm 1\%$  Reference Voltage
- 25 $\mu$ A Low Quiescent Current (Pulse Frequency Modulation)
- Programmable Switching Frequency: 100kHz to 2.2MHz
- External Clock Synchronization: 100kHz to 2.2MHz
- Programmable Soft-Start Time
- Up to 85% Efficiency at 5mA Light Load
- Proprietary Gate Driver Design for Best EMI Reduction
- Frequency Spread Spectrum (FSS) to Reduce EMI
- 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**
- **Halogen and Antimony Free. "Green" Device**
- **The AP64502Q 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/product-definitions/>

### APPLICATIONS

- Automotive Power Systems
- Automotive Infotainment
- Automotive Instrument Clusters
- Automotive Telematics
- Automotive Lighting Control
- Advanced Driver Assistance Systems

### TYPICAL APPLICATIONS CIRCUIT

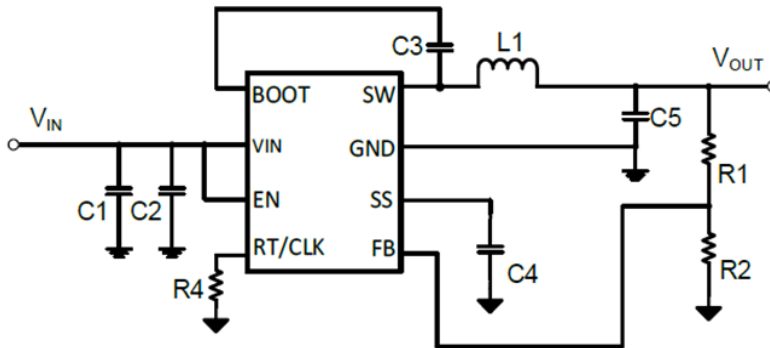


Figure 1. Typical Application Circuit

### ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Rating	Unit
VIN	Supply Pin Voltage	-0.3 to +42.0 (DC)	V
		-0.3 to +45.0 (400ms)	
V <sub>BST</sub>	Bootstrap Pin Voltage	V <sub>SW</sub> - 0.3 to V <sub>SW</sub> + 6.0	V
V <sub>EN</sub>	Enable/UVLO Pin Voltage	-0.3 to +42.0	V
V <sub>SS</sub>	Soft-Start Pin Voltage	-0.3 to +6.0	V
V <sub>FB</sub>	Feedback Voltage	-0.3V to +6.0	V
V <sub>COMP</sub>	Compensation Pin Voltage	-0.3 to +6.0	V
V <sub>SW</sub>	Switch Node Voltage	-0.3 to VIN + 0.3 (DC)	V
		-2.5 to VIN + 2.0 (20ns)	
T <sub>J</sub>	Junction Temperature	+160	°C
T <sub>L</sub>	Lead Temperature	+260	°C

### RECOMMENDED OPERATING CONDITIONS

Symbol	Parameter	Min	Max	Unit
VIN	Supply Voltage	3.8	40	V
VOU	Output Voltage	0.8	39	V
T <sub>A</sub>	Operating Ambient Temperature Range	-40	+125	°C
T <sub>J</sub>	Operating Junction Temperature Range	-40	+150	°C

### EVALUATION BOARD

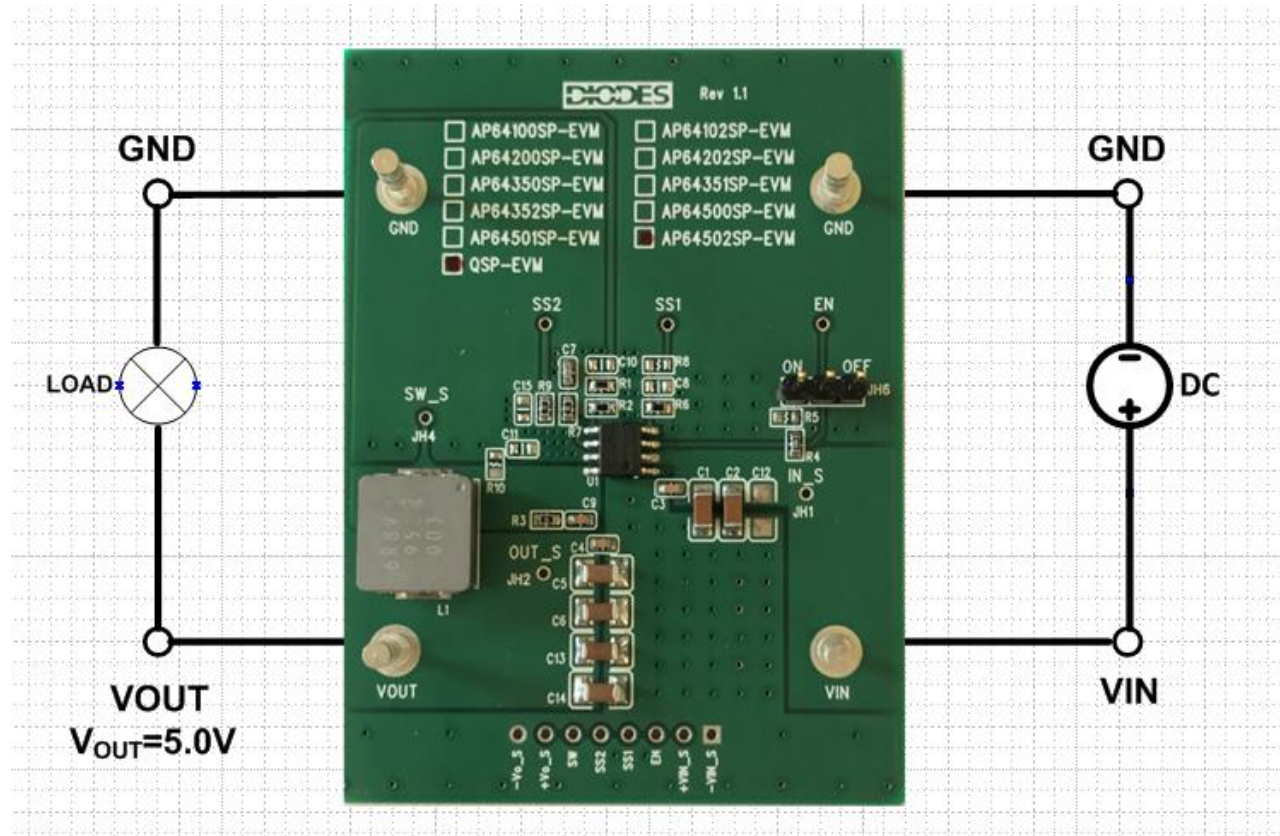


Figure 2. AP64502QSP-EVM

### QUICK START GUIDE

The AP64502QSP-EVM has a simple layout and allows access to the appropriate signals through test points. To evaluate the performance of the AP64502QSP, 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, to enable IC, place a jumper at JH6 to "ON" position to connect EN pin to VIN through 100KΩ resistor or leave it OPEN. Jump to "OFF" position to disable IC.
4. The evaluation board should now power up with a 5.0V output voltage.
5. Check for the proper output voltage of 5.0V ( $\pm 1\%$ ) 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 5A 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	L1	C1, C2	C5, C6, C13
1.2V	4.99KΩ	10KΩ	2.2μH	2x10μF	3x47μF
1.5V	8.66KΩ	10KΩ	3.3μH	2x10μF	3x47μF
1.8V	12.4KΩ	10KΩ	3.3μH	2x10μF	3x47μF
2.5V	21.5KΩ	10KΩ	4.7μH	2x10μF	3x47μF
3.3V	31.6KΩ	10KΩ	5.5μH	2x10μF	4x47μF
5.0V	52.3KΩ	10KΩ	6.8μH	2x10μF	4x47μF
12V	140KΩ	10KΩ	10μH	2x10μF	4x47μF

Table 1. Common Output Voltages

### EVALUATION BOARD SCHEMATIC

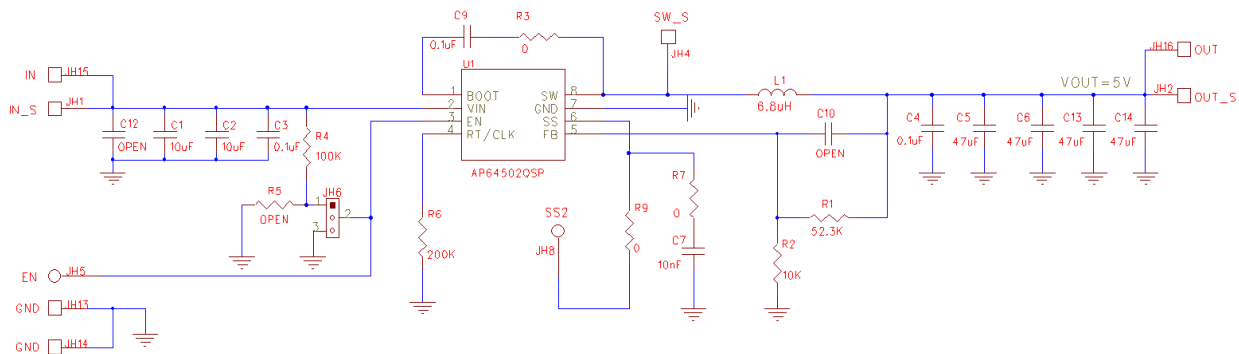


Figure 3. AP64502QSP-EVM Schematic

**PCB TOP LAYOUT**

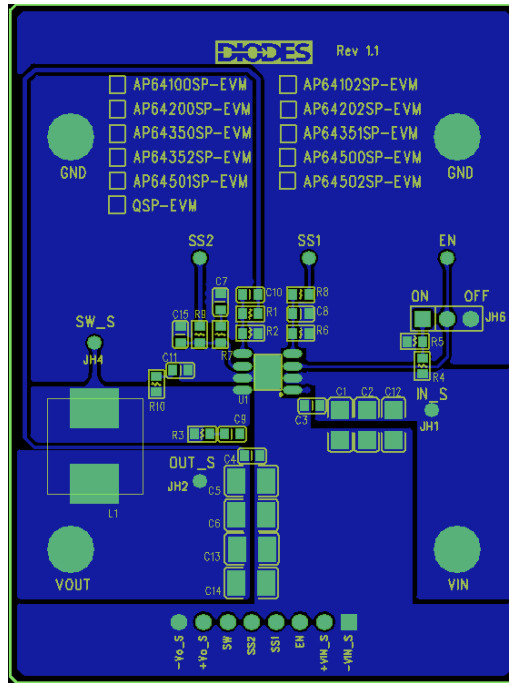


Figure 4. AP64502QSP-EVM – Top Layer

**PCB BOTTOM LAYOUT**

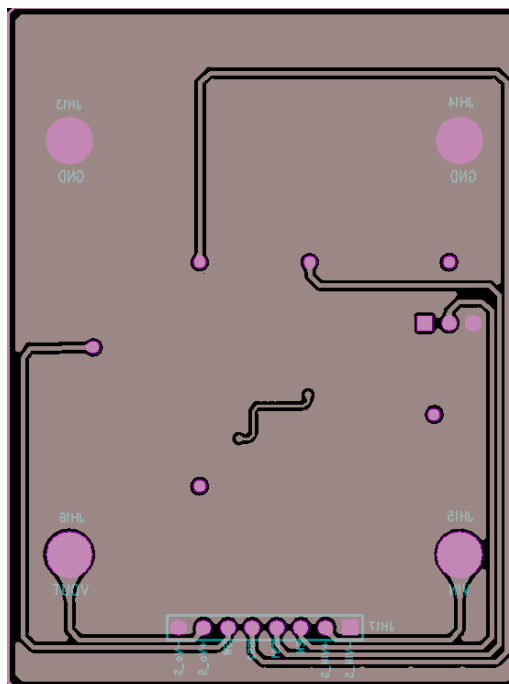
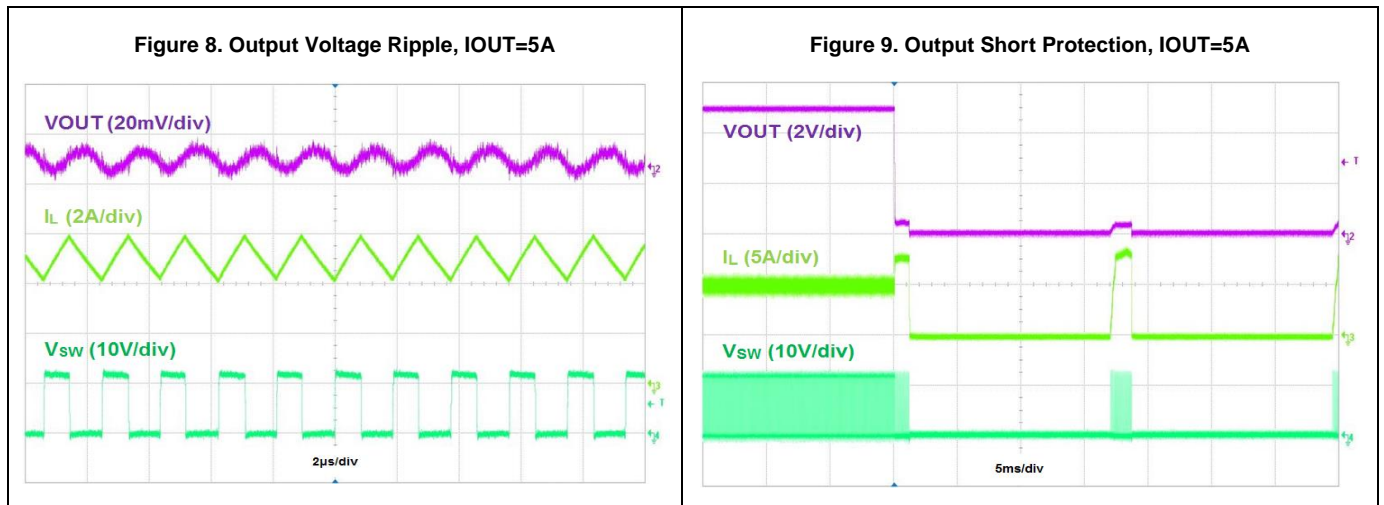
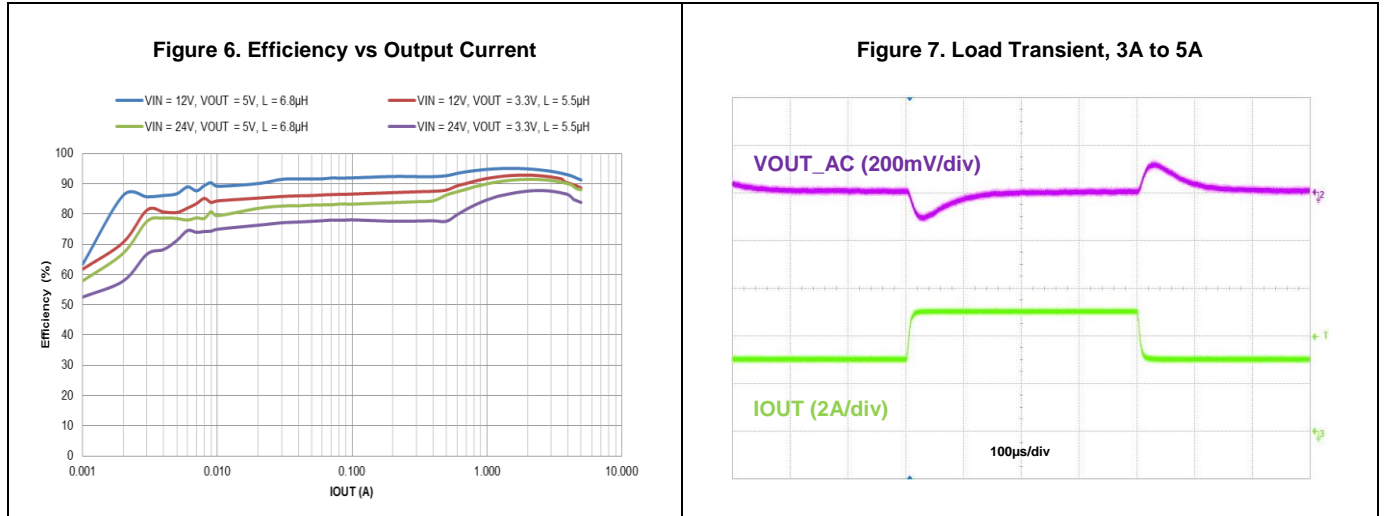


Figure 5. AP64502QSP-EVM – Bottom Layer

### AUTOMOTIVE BILL OF MATERIALS for AP64502QSP-EVM @V<sub>OUT</sub>=5V

Ref	Value	Description	Qty	Size	Vendor Name	Manufacturer PN
C1, C2	10 $\mu$ F	Ceramic Capacitor, 50V	2	1206	TDK	CGA5L1X7R1H106K160AC
C3, C4, C9	0.1 $\mu$ F	Ceramic Capacitor, 50V	3	0603	TDK	CGA3E3X8R1H104K080AB
C5, C6, C13, C14	47 $\mu$ F	Ceramic Capacitor, 10V	4	1210	TDK	CGA6P1X7S1A476M250AC
C7	10nF	Ceramic Capacitor, 50V	1	0603	TDK	CGA3E2NP01H103J080AA
R1	52.3K $\Omega$	SMD Resistor, 1%	1	0603	Panasonic	ERJ-3EKF5232V
R2	10K $\Omega$	SMD Resistor, 1%	1	0603	Panasonic	ERJ-3EKF1002V
R3, R7, R9	0 $\Omega$	RES SMD	3	0603	Panasonic	ERJ-3GEY0R00V
R4	100K $\Omega$	RES SMD	1	0603	Panasonic	ERJ-3RBD104V
R6	200K $\Omega$	RES SMD	1	0603	Panasonic	ERJ-S03F2003V
L1	6.8 $\mu$ H	DCR=20.4m $\Omega$ , Ir=8.9A	1	10.4x10.7x4mm	Panasonic	ETQ-P4M6R8KVC
JH6		PCB Header, 36 POS	1	1X3	Amphenol	78511-136HLF
JH13, JH14, JH15, JH16	1598	Terminal Turret Triple 0.094" L (Test Points)	4	Through-Hole	Keystone Electronics	1598-2
U1	AP64502Q	Sync DC-DC Buck Converter	1	SO-8EP	Diodes Incorporated (Diodes)	AP64502QSP

**TYPICAL PERFORMANCE CHARACTERISTICS**





**40V, 5A, Low IQ, Synchronous DC-DC Buck Converter  
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