



MIC28510 Evaluation Board

75V/4A Hyper Speed Control™ Synchronous DC/DC Buck Regulator

General Description

The MIC28510 DC/DC regulator operates over an input supply range of 4.5V to 75V and provides a regulated output at up to 4A of output current. The output voltage is adjustable down to 0.8V with a typical accuracy of $\pm 1\%$. The switching frequency is adjustable and once adjusted the switching frequency remains fairly constant with changes in input voltage and output load.

The basic parameters of the evaluation board are:

- Input Voltage – 5V to 75V
- Output Voltage – 0.8V to 5V at 4A⁽¹⁾
12V at up to 4A⁽²⁾
- 250kHz Switching Frequency
(Adjustable from 100kHz to 500kHz)

Notes:

1, 2. Refer to thermal de-rating curves shown in Typical Characteristics section.

Datasheets and support documentation can be found on Micrel's web site at: www.micrel.com

Requirements

The MIC28510 evaluation board requires only a single power supply with at least 10A current capability. A linear regulator, which includes a Zener and an NPN transistor, has been installed on the board to provide housekeeping (V_{DD}) for the MIC28510. The output load can either be a passive or an active load.

Precautions

The MIC28510 evaluation board does not have reverse polarity protection. Applying a negative voltage to the PVIN and GND terminals may damage the device. The maximum PVIN of the board is rated at 75V. Exceeding 75V on the PVIN could damage the device.

Getting Started

1. **V_{IN} Supply.** Connect a power supply to the VIN and GND terminals, paying careful attention to the polarity and supply voltage range ($5V < V_{IN} < 75V$). The input current IIN can be monitored with a current meter. Do not apply power until Step 4.
2. **Connect Load and Monitor Output.** Connect a load to the V_{OUT} and GND terminals. The load can be either a passive (resistive) or an active (as in an electronic load) type. A current meter may be placed between the V_{OUT} terminal and load to monitor the output current. Ensure the output voltage is monitored at the V_{OUT} terminal.
3. **Enable Input.** The EN pin has an internal 100k pull-up resistor to VDD, which allows the output to be turned on when VDD exceeds its UVLO threshold. An EN connector is provided on the evaluation board for users to easily access the enable feature. Applying an external logic signal on the EN pin to pull it low or using a jumper to short the EN pin to GND will shut off the output of the MIC28510 evaluation board.
4. **Turn On the Power.** Turn on the VIN supply and verify that the output voltage is regulated to 3.3V.

Ordering Information

Part Number	Description
MIC28510 5V EV	Evaluation Board up to 5V Output
MIC28510 12V EV	Evaluation Board 12V Output

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hbwhelp@micrel.com or (408) 955-1690

Features

Feedback Resistors

The output voltage on the MIC28510 evaluation board, which is preset to 3.3V, is determined by the feedback divider, shown in Equation 1:

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R4}{R_{BOTTOM}} \right) \quad \text{Eq. 1}$$

where $V_{REF} = 0.8V$, and R_{BOTTOM} is one of R5-R12, which corresponds to 0.9V, 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 3.3V, or 5V. Leaving the R_{BOTTOM} open gives a 0.8V output voltage. All other voltages not listed above can be set by modifying R_{BOTTOM} value according to Equation 2:

$$R_{BOTTOM} = \frac{R4 \times V_{REF}}{V_{OUT} - V_{REF}} \quad \text{Eq. 2}$$

Note that the output voltage should not be set to exceed 5V due to the 6.3V voltage rating on the output capacitors.

If higher than 5V output is desired, it is recommended to use the designs shown in the MIC28510 12V/4A output evaluation board schematic, where the output capacitors, L1, R3, and R17 are optimized for 12V output.

SW Node

Test point J11 (V_{SW}) is placed for monitoring the switching waveform, one of the most critical waveforms for the converter.

Current Limit

The MIC28510 has internal FETs, and the current limit is implemented by sensing the R_{DS-ON} of bottom FET. The MIC28510 has a fixed current limit of 6.5A (typical).

Loop Gain Measurement

The resistor, R13, is placed in series with the regulator feedback path. The control loop gain can be measured by connecting an impedance analyzer across the resistor and selecting the resistor value in between 20Ω to 50Ω.

Setting the Switching Frequency

The MIC28510 is an adjustable-frequency, synchronous buck regulator featuring a unique digitally modified adaptive on-time control architecture.

The switching frequency can be adjusted between 100kHz and 500kHz by changing the resistor divider connected network consisting of R18 and R19 from PVIN to PGND.

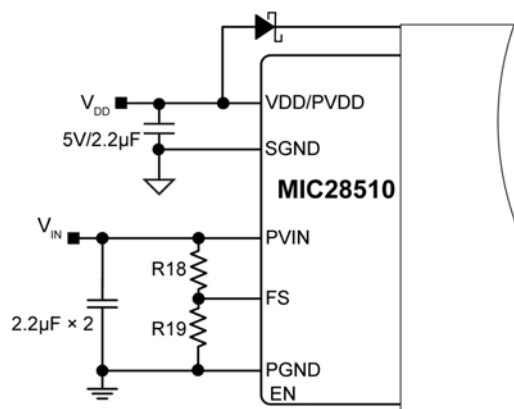


Figure 1. Switching Frequency Adjustment

Equation 3 illustrates the estimated switching frequency:

$$f_{SW_ADJ} = f_O \times \frac{R19}{R18 + R19} \quad \text{Eq. 3}$$

where f_O = Switching Frequency when R18 is 100k and R19 being open, f_O should be typically 450kHz. For more precise setting, it is recommended to use Figure 2:

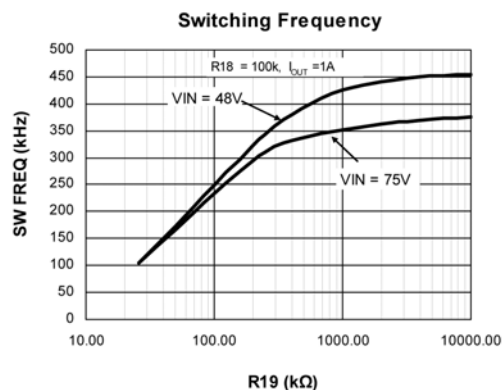
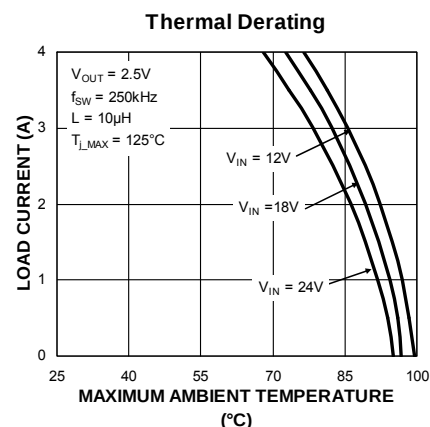
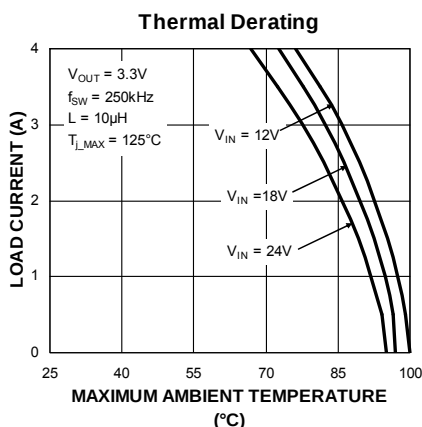
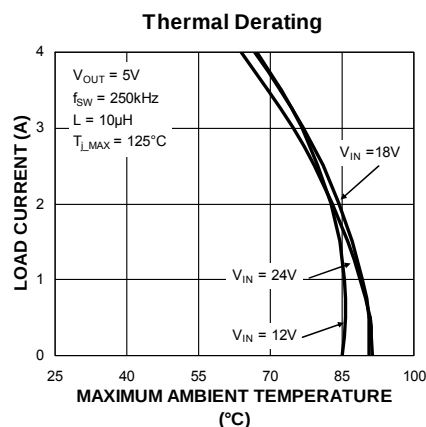
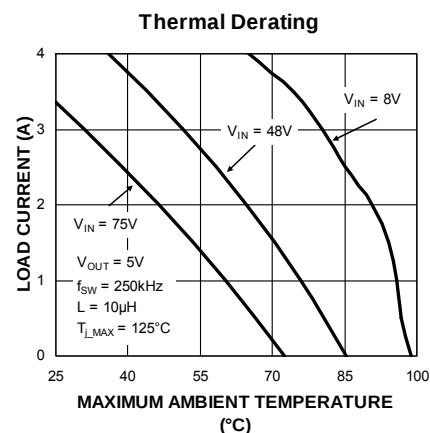
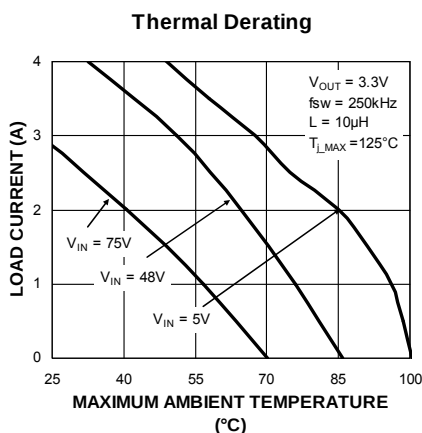
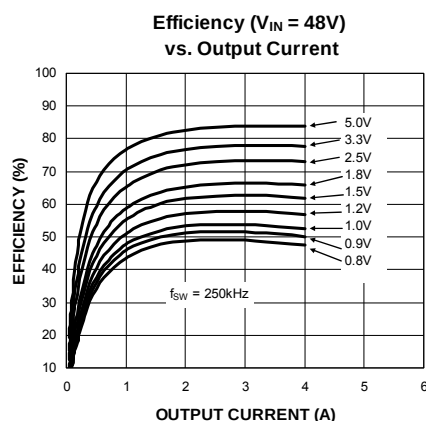


Figure 2. Switching Frequency vs. R19

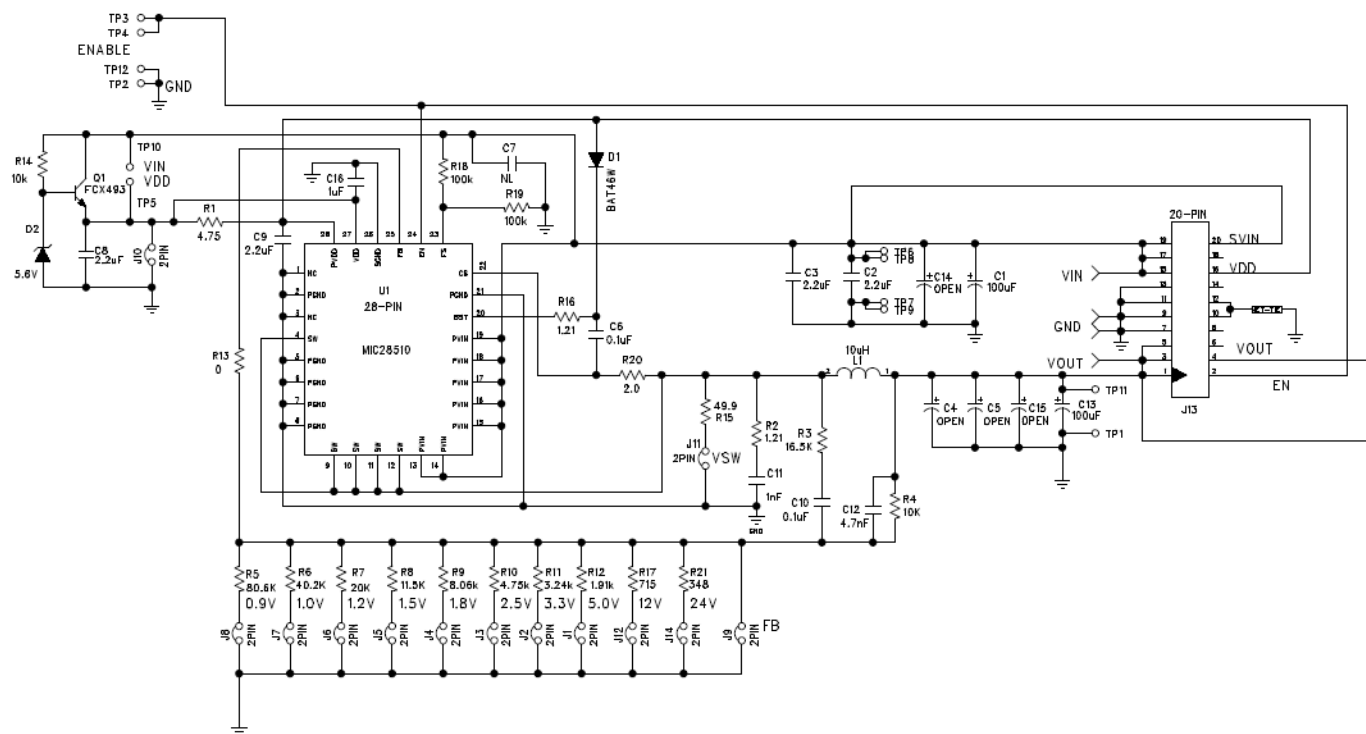
The evaluation board design is optimized for a switching frequency of 250kHz. If the switching frequency is programmed to either lower end or higher end, the design needs optimization.

MIC28510 0.8V to 5V/4A Evaluation Board Typical Characteristics



Die Temperature* : The temperature measurement was taken at the hottest point on the MIC28510 case mounted on a 5 square inch 4 layer, 0.62", FR-4 PCB with 2oz. finish copper weight per layer, see Thermal Measurement section. Actual results will depend upon the size of the PCB, ambient temperature and proximity to other heat emitting components.

MIC28510 0.8V to 5V/4A Output Evaluation Board Schematic



MIC28510 Evaluation Board for 0.8V to 5V/4A Output

Bill of Materials 0.8V to 5V/4A Output

Item	Part Number	Manufacturer	Description	Qty.
C1	EEU-FC2A101B	Panasonic ⁽¹⁾	100µF Aluminum Capacitor, SMD, 100V	1
C2, C3	GRM32ER72A225KA35L	Murata ⁽²⁾	2.2µF Ceramic Capacitor, X7R, Size 1210, 100V	2
	C3225X7R2A225KT5	TDK ⁽³⁾		
C13	GRM32ER60J107ME20L	Murata ⁽²⁾	100µF Ceramic Capacitor, X5R, Size 1210, 6.3V	1
	12106D107MAT2A	AVX ⁽⁴⁾		
C6	06035C104KAT2A	AVX ⁽⁴⁾	0.1µF Ceramic Capacitor, X7R, Size 0603, 50V	1
	GRM188R71H104KA93D	Murata ⁽²⁾		
	C1608X7R1H104K	TDK ⁽³⁾		
C10	GRM188R72A104KA35D	Murata ⁽²⁾	0.1µF Ceramic Capacitor, X7R, Size 0603, 100V	1
	C1608X7S2A104K	TDK ⁽³⁾		
C8, C9	0805ZC225MAT2A	AVX ⁽⁴⁾	2.2µF Ceramic Capacitor, X7R, Size 0805, 10V	2
	GRM21BR71A225KA01L	Murata ⁽²⁾		
	C2012X7R1A225K	TDK ⁽³⁾		
C11	GRM188R72A102KA01D	Murata ⁽²⁾	1nF Ceramic Capacitor, X7R, Size 0603, 100V	1
	C1608X7R2A102K	TDK ⁽³⁾		
	06031C102KAT2A	AVX ⁽⁴⁾		
C12	GRM188R71H472KA01D	Murata ⁽²⁾	4.7nF Ceramic Capacitor, X7R, Size 0603, 50V	1
	C1608X7R2A472K	TDK ⁽³⁾		
	06035C472KAT2A	AVX ⁽⁴⁾		
C16	GRM21BR71A105KA01L	Murata ⁽²⁾	1µF Ceramic Capacitor, X7R, Size 0805, 10V	1
	C2012X7R1A105K	TDK ⁽³⁾		
C4, C5, C7, C14, C15	Open			
D1	BAT46W-TP	MCC ⁽⁵⁾	Small Signal Schottky Diode	1
	BAT46W-7-F	Diodes Inc. ⁽⁶⁾		
D2	MMXZ5232B-TP	MCC ⁽⁵⁾	5.6V Zener Diode	1
	CMDZ5L6	Central Semi ⁽⁷⁾		
L1	DR125-100-R	Cooper Bussmann ⁽⁸⁾	10µH Inductor, 5.35A RMS, 7A Saturation Current	1
Q1	FCX493	Diodes Inc/ZETEX ⁽⁶⁾	100V NPN Transistor	1
R1	CRCW06034R75FKEA	Vishay Dale ⁽⁹⁾	4.75Ω Resistor, Size 0603, 1%	1
R2, R16	CRCW08051R21FKEA	Vishay Dale ⁽⁹⁾	1.21Ω Resistor, Size 0805, 1%	2
R3	CRCW060316K5FKEA	Vishay Dale ⁽⁹⁾	16.5kΩ Resistor, Size 0603, 1%	1
R4	CRCW060310K0FKEA	Vishay Dale ⁽⁹⁾	10kΩ Resistor, Size 0603, 1%	1
R5	CRCW060380K6FKEA	Vishay Dale ⁽⁹⁾	80.6kΩ Resistor, Size 0603, 1%	1
R6	CRCW060340K2FKEA	Vishay Dale ⁽⁹⁾	40.2kΩ Resistor, Size 0603, 1%	1

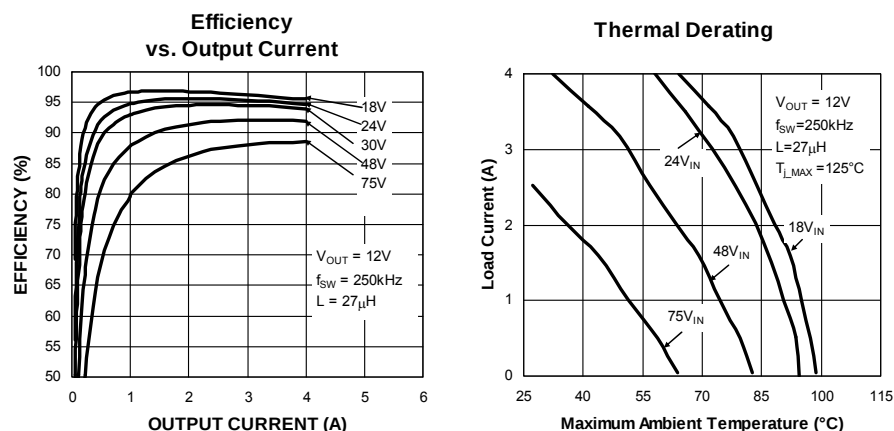
Bill of Materials 0.8V to 5V/4A Output (Continued)

Item	Part Number	Manufacturer	Description	Qty.
R7	CRCW060320K0FKEA	Vishay Dale ⁽⁹⁾	20k Ω Resistor, Size 0603, 1%	1
R8	CRCW060311K5FKEA	Vishay Dale ⁽⁹⁾	11.5k Ω Resistor, Size 0603, 1%	1
R9	CRCW06038K06FKEA	Vishay Dale ⁽⁹⁾	8.06k Ω Resistor, Size 0603, 1%	1
R10	CRCW06034K75FKEA	Vishay Dale ⁽⁹⁾	4.75k Ω Resistor, Size 0603, 1%	1
R11	CRCW06033K24FKEA	Vishay Dale ⁽⁹⁾	3.24k Ω Resistor, Size 0603, 1%	1
R12	CRCW06031K91FKEA	Vishay Dale ⁽⁹⁾	1.91k Ω Resistor, Size 0603, 1%	1
R13	CRCW06030000Z0EAHP	Vishay Dale ⁽⁹⁾	0 Ω Resistor, Size 0603	1
R14	CRCW080510K0JNEA	Vishay Dale ⁽⁹⁾	10k Ω Resistor, Size 0805, 1%	1
R15	CRCW060349R9FKEA	Vishay Dale ⁽⁹⁾	49.9 Ω Resistor, Size 0603, 1%	1
R17 (OPEN)	CRCW0603715RFKEA	Vishay Dale ⁽⁹⁾	715 Ω Resistor, Size 0603, 1%	
R18, R19	CRCW0603100KFKEAHP	Vishay Dale ⁽⁹⁾	100k Ω Resistor, Size 0603, 1%	2
R20	CRCW06032R00FKEA	Vishay Dale ⁽⁹⁾	2 Ω Resistor, Size 0603, 1%	1
R21 (OPEN)	CRCW0603348RFKEA	Vishay Dale ⁽⁹⁾	348 Ω Resistor, Size 0603, 1%	
U1	MIC28510YJL	Micrel, Inc.⁽¹⁰⁾	75V/4A Synchronous Buck DC/DC Regulator	1

Notes:

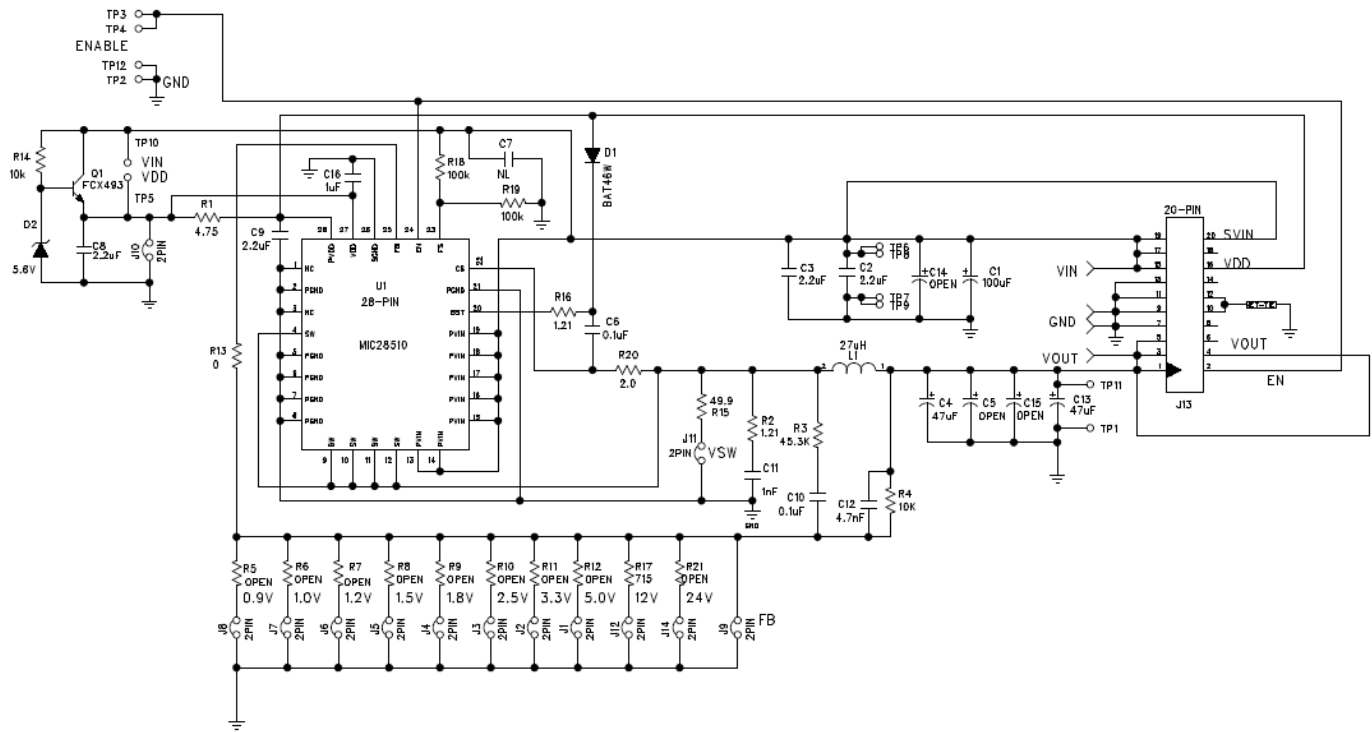
1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. TDK: www.tdk.com.
4. AVX: www.avx.com.
5. MCC: www.mccsemi.com.
6. Diode Inc.: www.diodes.com.
7. Central Semi: www.centra-semi.com.
8. Cooper: www.cooperbussman.com.
9. Vishay: www.vishay.com.
10. Micrel, Inc.: www.micrel.com.

MIC28510 12V/4A Output Evaluation Board Typical Characteristics



Die Temperature* : The temperature measurement was taken at the hottest point on the MIC28510 case mounted on a 5 square inch 4 layer, 0.62", FR-4 PCB with 2oz. finish copper weight per layer, see Thermal Measurement section. Actual results will depend upon the size of the PCB, ambient temperature and proximity to other heat emitting components.

MIC28510 12V/4A Output Evaluation Board Schematic



MIC28510 Evaluation Board for 12V/4A Output

Bill of Materials (12V Up to 4A) Output

Item	Part Number	Manufacturer	Description	Qty.
C1	EEU-FC2A101B	Panasonic ⁽¹⁾	100µF Aluminum Capacitor, SMD, 100V	1
C2, C3	GRM32ER61C476ME15	Murata ⁽²⁾	2.2µF Ceramic Capacitor, X7R, Size 1210, 100V	2
	EMK325BJ476MM-T	Taiyo Yuden ⁽³⁾		
C13, C4	GRM32ER61C476ME15	Murata ⁽²⁾	47µF Ceramic Capacitor, X5R, Size 1210, 16V	2
	EMK325BJ476MM-T	Taiyo Yuden ⁽³⁾		
C6	06035C104KAT2A	AVX ⁽⁴⁾	0.1µF Ceramic Capacitor, X7R, Size 0603, 50V	1
	GRM188R71H104KA93D	Murata ⁽²⁾		
	C1608X7R1H104K	TDK ⁽⁵⁾		
C10	GRM188R72A104KA35D	Murata ⁽²⁾	0.1µF Ceramic Capacitor, X7R, Size 0603, 100V	1
	C1608X7S2A104K	TDK ⁽⁵⁾		
C8, C9	0805ZC225MAT2A	AVX ⁽⁴⁾	2.2µF Ceramic Capacitor, X7R, Size 0805, 10V	2
	GRM21BR71A225KA01L	Murata ⁽²⁾		
	C2012X7R1A225K	TDK ⁽⁵⁾		
C11	GRM188R72A102KA01D	Murata ⁽²⁾	1nF Ceramic Capacitor, X7R, Size 0603, 100V	1
	C1608X7R2A102K	TDK ⁽⁵⁾		
	06031C102KAT2A	AVX ⁽⁴⁾		
C12	GRM188R71H472KA01D	Murata ⁽²⁾	4.7nF Ceramic Capacitor, X7R, Size 0603, 50V	1
	C1608X7R2A472K	TDK ⁽⁵⁾		
	06035C472KAT2A	AVX ⁽⁴⁾		
C16	GRM21BR71A105KA01L	Murata ⁽²⁾	1µF Ceramic Capacitor, X7R, Size 0805, 10V	1
	C2012X7R1A105K	TDK ⁽⁵⁾		
C5, C7, C14, C15	Open			
D1	BAT46W-TP	MCC ⁽⁶⁾	Small Signal Schottky Diode	1
	BAT46W-7-F	Diodes Inc. ⁽⁷⁾		
D2	MMXZ5232B-TP	MCC ⁽⁶⁾	5.6V Zener Diode	1
	CMDZ5L6	Central Semi ⁽⁸⁾		
L1	7447709270	Würth ⁽⁹⁾	27µH Inductor, 5.8A Saturation Current	1
Q1	FCX493	Diodes Inc./ZETEX ⁽⁷⁾	100V NPN Transistor	1
R1	CRCW06034R75FKEA	Vishay Dale ⁽¹⁰⁾	4.75Ω Resistor, Size 0603, 1%	1
R2, R16	CRCW08051R21FKEA	Vishay Dale ⁽¹⁰⁾	1.21Ω Resistor, Size 0805, 1%	2
R3	CRCW060345K3FKEA	Vishay Dale ⁽¹⁰⁾	45.3kΩ Resistor, Size 0603, 1%	1
R4	CRCW060310K0FKEA	Vishay Dale ⁽¹⁰⁾	10kΩ Resistor, Size 0603, 1%	1
R5 (OPEN)	CRCW060380K6FKEA	Vishay Dale ⁽¹⁰⁾	80.6kΩ Resistor, Size 0603, 1%	
R6 (OPEN)	CRCW060340K2FKEA	Vishay Dale ⁽¹⁰⁾	40.2kΩ Resistor, Size 0603, 1%	

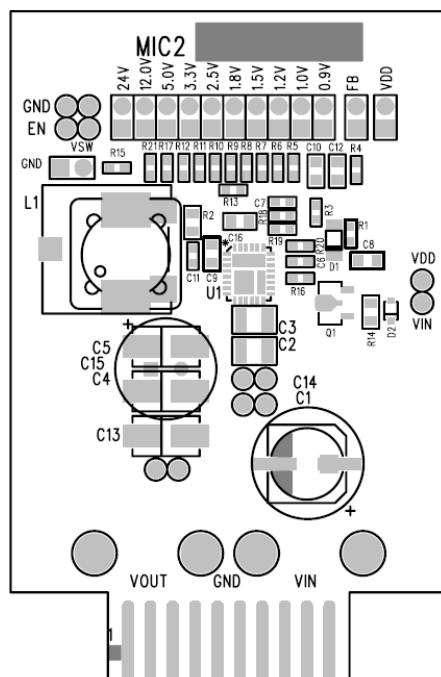
Bill of Materials 12V up-to 4A Output (Continued)

Item	Part Number	Manufacturer	Description	Qty.
R7 (OPEN)	CRCW060320K0FKEA	Vishay Dale ⁽¹⁰⁾	20kΩ Resistor, Size 0603, 1%	1
R8 (OPEN)	CRCW060311K5FKEA	Vishay Dale ⁽¹⁰⁾	11.5kΩ Resistor, Size 0603, 1%	1
R9 (OPEN)	CRCW06038K06FKEA	Vishay Dale ⁽¹⁰⁾	8.06kΩ Resistor, Size 0603, 1%	1
R10 (OPEN)	CRCW06034K75FKEA	Vishay Dale ⁽¹⁰⁾	4.75kΩ Resistor, Size 0603, 1%	1
R11 (OPEN)	CRCW06033K24FKEA	Vishay Dale ⁽¹⁰⁾	3.24kΩ Resistor, Size 0603, 1%	1
R12 (OPEN)	CRCW06031K91FKEA	Vishay Dale ⁽¹⁰⁾	1.91kΩ Resistor, Size 0603, 1%	1
R13	CRCW06030000Z0EAHP	Vishay Dale ⁽¹⁰⁾	0Ω Resistor, Size 0603	1
R14	CRCW080510K0JNEA	Vishay Dale ⁽¹⁰⁾	10kΩ Resistor, Size 0805, 1%	1
R15	CRCW060349R9FKEA	Vishay Dale ⁽¹⁰⁾	49.9Ω Resistor, Size 0603, 1%	1
R17	CRCW0603715RFKEA	Vishay Dale ⁽¹⁰⁾	715Ω Resistor, Size 0603, 1%	1
R18, R19	CRCW0603100KFKEAHP	Vishay Dale ⁽¹⁰⁾	100kΩ Resistor, Size 0603, 1%	2
R20	CRCW06032R00FKEA	Vishay Dale ⁽¹⁰⁾	2Ω Resistor, Size 0603, 1%	1
R21 (OPEN)	CRCW0603348RFKEA	Vishay Dale ⁽¹⁰⁾	348Ω Resistor, Size 0603, 1%	
U1	MIC28510YJL	Micrel, Inc.⁽¹⁰⁾	75V/4A Synchronous Buck DC/DC Regulator	1

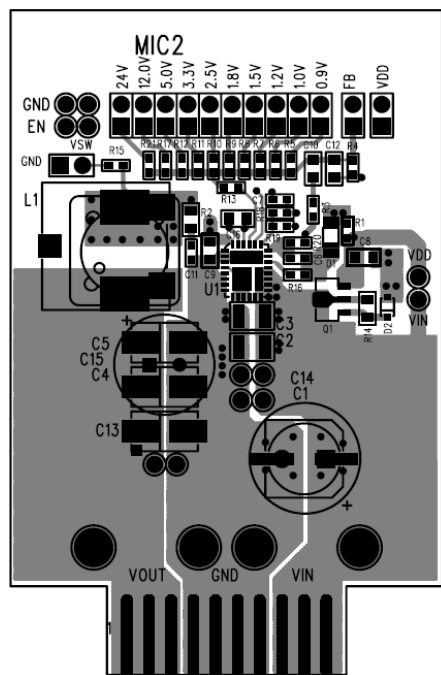
Notes:

1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. Taiyo Yuden: www.taiyo-yuden.com.
4. AVX: www.avx.com.
5. TDK: www.tdk.com.
6. MCC: www.mccsemi.com.
7. Diode Inc.: www.diodes.com.
8. Central Semi: www.centrasemi.com.
9. Würth: www.wurth.com.
10. Vishay Dale: www.vishay.com.
11. Micrel, Inc.: www.micrel.com.

Evaluation Board PCB Layout

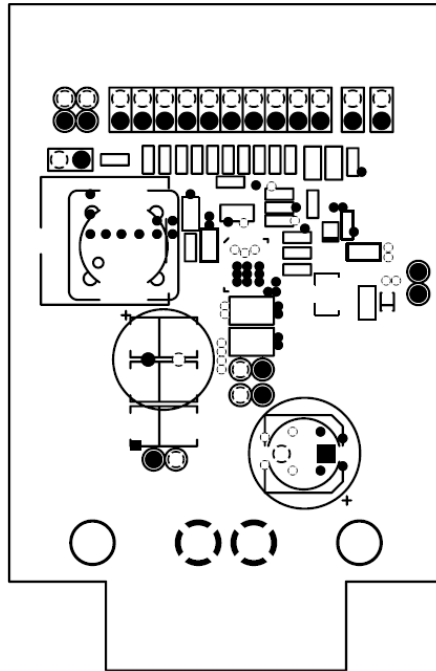


MIC28510 Evaluation Board – Silkscreen Top

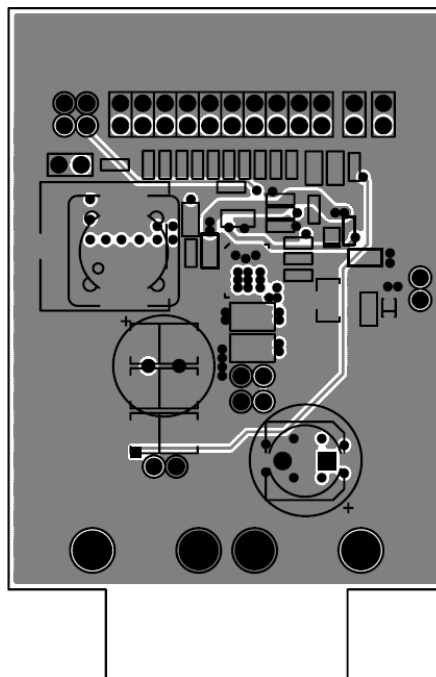


MIC28510 Evaluation Board – Copper Layer 1 (Top)

Evaluation Board PCB Layout (Continued)

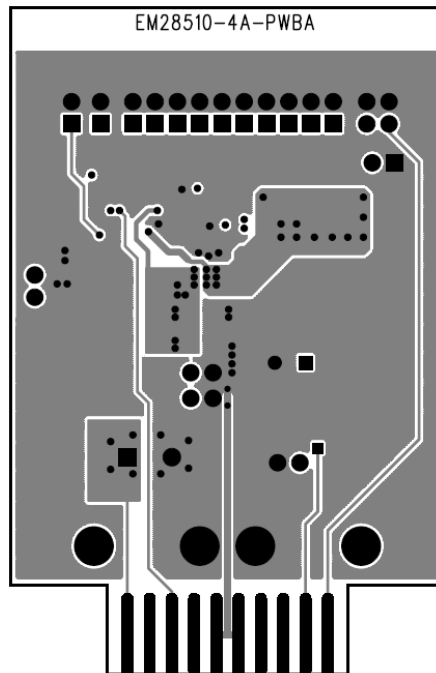


MIC28510 Evaluation Board – Copper Layer 2

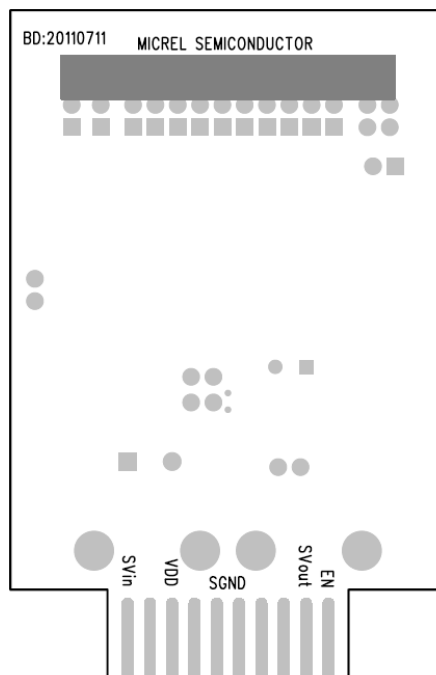


MIC28510 Evaluation Board – Copper Layer 3

Evaluation Board PCB Layout (Continued)



MIC28510 Evaluation Board – Copper Layer 4



MIC28510 Evaluation Board – Silkscreen Bottom

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