



MIC28500 4A Evaluation Board

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

General Description

The MIC28500 DC/DC regulator operates over an input supply range of 30V 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:

1. Input – 30V to 75V
2. Output – 0.8V to 5V at 4A ⁽¹⁾, 12V at 2A ⁽²⁾
3. 250kHz Switching Frequency (Adjustable 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 MIC28500 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 MIC28500. The output load can either be a passive or an active load.

Precautions

The MIC28500 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 supply to the Vin and GND terminals, paying careful attention to the polarity and the supply range ($30V < V_{IN} < 75V$). Monitor I_{IN} with a current

meter and V_{IN} at Vin and GND terminals with voltmeter. Do not apply power until Step 5.

2. Connect Load and Monitor Output

Connect a load to the Vout 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 Vout terminal and load to monitor the output current. Ensure the output voltage is monitored at the Vout terminal.

3. V_{IN} 30V Limiter Circuit

To prevent overstressing of the internal top FET of the MIC28500, the minimum input voltage at full load should be limited to 30V. This is implemented by using external VIN limiter circuit installed on either EN pin (dash-line block#1) or VDD Pin (dash-line block#2) as shown in the Evaluation board schematic. On the MIC28500 evaluation board the limiter circuit on EN Pin is installed, which shuts off the MIC28500 until the input supply voltage reaches 30V.

4. 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 MIC28500 evaluation board. If in certain application the EN needs to be controlled externally the V_{IN} limiter circuit should be implemented on VDD pin.

5. 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 |
|----------------|----------------------------------|
| MIC28500 4A EV | Evaluation Board up to 5V Output |
| MIC28500 2A EV | Evaluation Board 12V Output |

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

Features

Feedback Resistors

The output voltage on the MIC28500 evaluation board, which is preset to 3.3V, is determined by the feedback divider:

$$V_{\text{OUT}} = V_{\text{REF}} \times \left(1 + \frac{R_4}{R_{\text{BOTTOM}}} \right)$$

where $V_{\text{REF}} = 0.8\text{V}$, and R_{BOTTOM} is one of R5, R6, R7, R8, R9, R10, R11, 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:

$$R_{\text{BOTTOM}} = \frac{R_4 \times V_{\text{REF}}}{V_{\text{OUT}} - V_{\text{REF}}}$$

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 Figure 2, where the output capacitors, L1, R3 and R17 are optimized for 12V/2A output.

SW Node

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

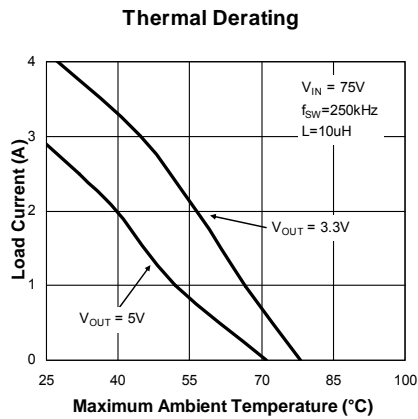
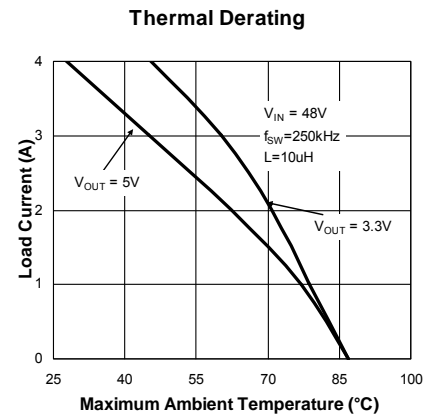
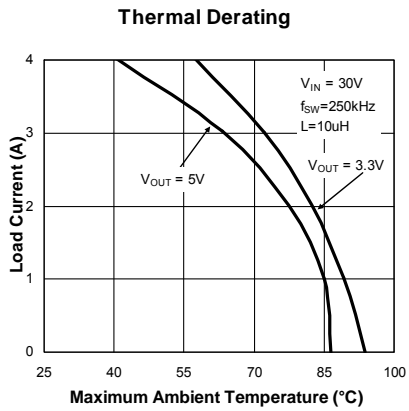
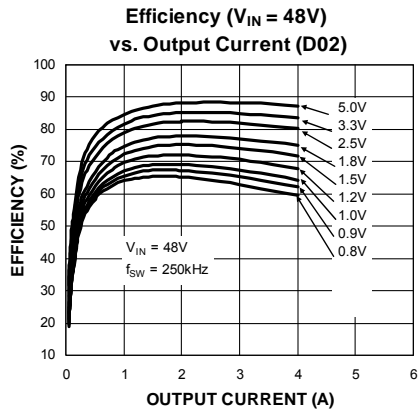
Current Limit

The MIC28500 has internal FETs, and the current limit is implemented by sensing the $R_{\text{DS-ON}}$ of bottom FET. The MIC28500 has a fixed current limit of 7A (TYP).

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.

MIC28500 0.8V to 5V/4A Evaluation Board Typical Characteristics



Die Temperature* : The temperature measurement was taken at the hottest point on the MIC28500 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.

MIC28500 0.8V to 5V/4A Output Evaluation Board Schematic

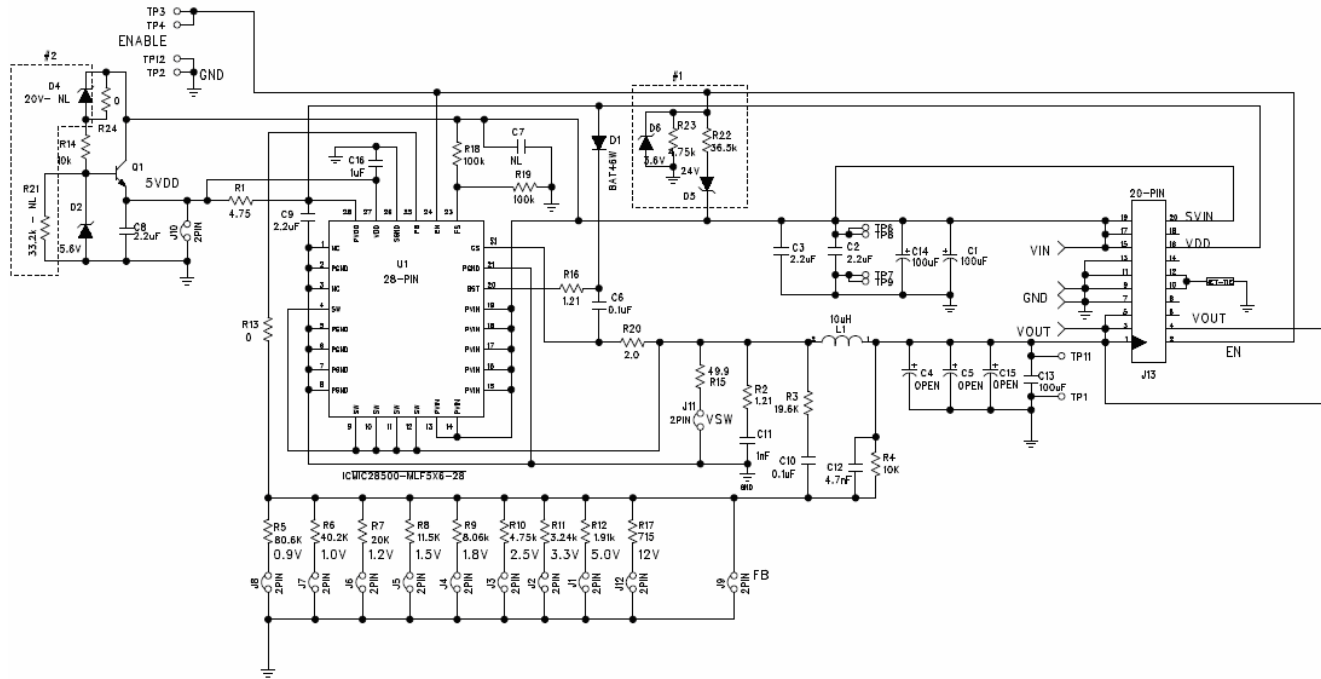


Figure 1. MIC28500 Evaluation board for 0.8V to 5V/4A Output

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 | 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 | 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 | Open | | | |
| 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⁾ | | |
| D5 | CMDZ24L-MIC | Central Semi ⁽⁷⁾ | 24V Zener Diode | 1 |
| D6 | CMDZ3L6-MIC | Central Semi ⁽⁷⁾ | 3.6V Zener Diode | 1 |
| D4 | Open | | | |
| 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 | CRCW060319K6FKEA | Vishay Dale ⁽⁹⁾ | 19.6kΩ 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 |

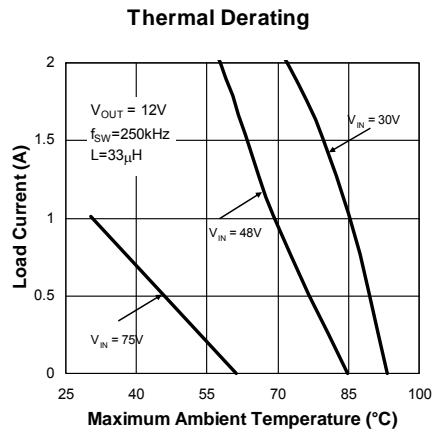
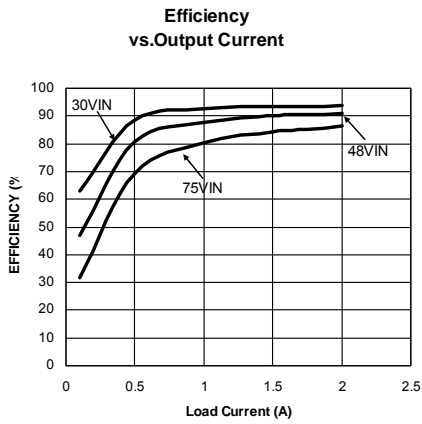
Bill of Materials 0.8V to 5V/4A Output (Continued)

| | | | | |
|------------|--------------------|------------------------------------|--|----------|
| R6 | CRCW060340K2FKEA | Vishay Dale ⁽⁹⁾ | 40.2kΩ Resistor, Size 0603, 1% | 1 |
| R7 | CRCW060320K0FKEA | Vishay Dale ⁽⁹⁾ | 20kΩ Resistor, Size 0603, 1% | 1 |
| R8 | CRCW060311K5FKEA | Vishay Dale ⁽⁹⁾ | 11.5kΩ Resistor, Size 0603, 1% | 1 |
| R9 | CRCW06038K06FKEA | Vishay Dale ⁽⁹⁾ | 8.06kΩ Resistor, Size 0603, 1% | 1 |
| R10, R23 | CRCW06034K75FKEA | Vishay Dale ⁽⁹⁾ | 4.75kΩ Resistor, Size 0603, 1% | 2 |
| R11 | CRCW06033K24FKEA | Vishay Dale ⁽⁹⁾ | 3.24kΩ Resistor, Size 0603, 1% | 1 |
| R12 | CRCW06031K91FKEA | Vishay Dale ⁽⁹⁾ | 1.91kΩ Resistor, Size 0603, 1% | 1 |
| R13, R24 | CRCW06030000Z0EAHP | Vishay Dale ⁽⁹⁾ | 0Ω Resistor, Size 0603 | 2 |
| R14 | CRCW080510K0JNEA | Vishay Dale ⁽⁹⁾ | 10kΩ Resistor, Size 0805, 1% | 1 |
| R15 | CRCW060349R9FKEA | Vishay Dale ⁽⁹⁾ | 49.9Ω Resistor, Size 0603, 1% | 1 |
| R17 (OPEN) | CRCW0603715RFKEA | Vishay Dale ⁽⁹⁾ | 715Ω Resistor, Size 0603, 1% | |
| R18, R19 | CRCW0603100KFKEAHP | Vishay Dale ⁽⁹⁾ | 100kΩ Resistor, Size 0603, 1% | 2 |
| R20 | CRCW06032R00FKEA | Vishay Dale ⁽⁹⁾ | 2Ω Resistor, Size 0603, 1% | 1 |
| R21 (OPEN) | CRCW060333K2FKEA | Vishay Dale ⁽⁹⁾ | 33.2kΩ Resistor, Size 0603, 1% | |
| R22 | CRCW060336K5FKEA | Vishay Dale ⁽⁹⁾ | 36.5kΩ Resistor, Size 0603, 1% | 1 |
| U1 | MIC28500YJL | 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.centalsemi.com.
8. Cooper: www.cooperbussman.com.
9. Vishay: www.vishay.com
10. Micrel, Inc.: www.micrel.com.

MIC28500 12V/2A Output Evaluation Board Typical Characteristics



Die Temperature* : The temperature measurement was taken at the hottest point on the MIC28500 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.

MIC28500 12V/2A Output Evaluation Board Schematic

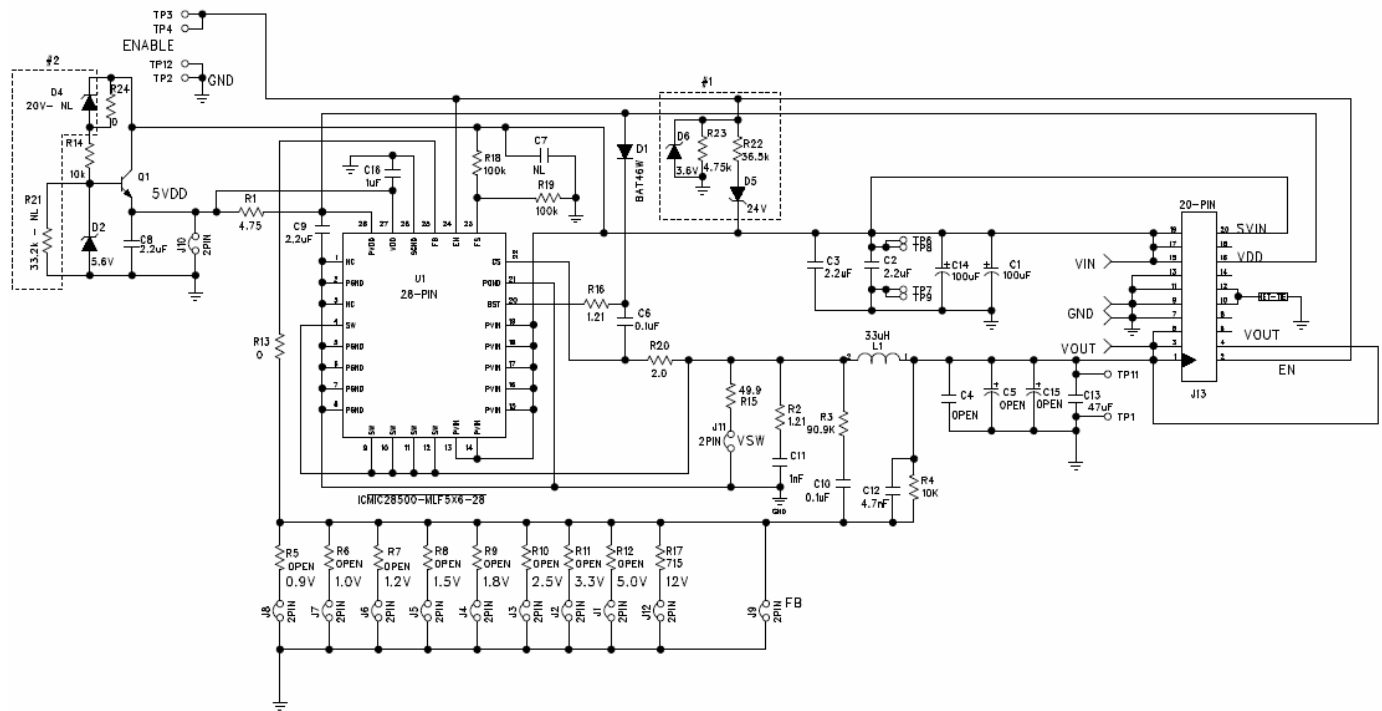


Figure 2. MIC28500 Evaluation board for 12V/2A Output

Bill of Materials 12V/2A 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 | GRM32ER61C476ME15 | Murata ⁽²⁾ | 47µF/16V Ceramic Capacitor, X5R, Size 1210 | 1 |
| | EMK325BJ476MM-T | Taiyo Yuden ⁽⁴⁾ | | |
| C6 | 06035C104KAT2A | AVX ⁽⁵⁾ | 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 ⁽⁵⁾ | 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 ⁽⁵⁾ | | |
| C12 | GRM188R71H472KA01D | Murata ⁽²⁾ | 4.7nF Ceramic Capacitor, X7R, Size 0603, 50V | 1 |
| | C1608X7R2A472K | TDK ⁽³⁾ | | |
| | 06035C472KAT2A | AVX ⁽⁵⁾ | | |
| C16 | GRM21BR71A105KA01L | Murata ⁽²⁾ | 1µF Ceramic Capacitor, X7R, Size 0805, 10V | 1 |
| | C2012X7R1A105K | TDK ⁽³⁾ | | |
| C4, C5, C7 | Open | | | |
| 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⁾ | | |
| D5 | CMDZ24L-MIC | Central Semi ⁽⁸⁾ | 24V Zener Diode | 1 |
| D6 | CMDZ3L6-MIC | Central Semi ⁽⁸⁾ | 3.6V Zener Diode | 1 |
| D4 | Open | | | |
| L1 | DR125-330-R | Cooper Bussmann ⁽⁹⁾ | 33µH Inductor, 3.28A RMS, 3.84A 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 | CRCW060319K6FKEA | Vishay Dale ⁽¹⁰⁾ | 90.9kΩ Resistor, Size 0603, 1% | 1 |
| R4 | CRCW060310K0FKEA | Vishay Dale ⁽¹⁰⁾ | 10kΩ Resistor, Size 0603, 1% | 1 |

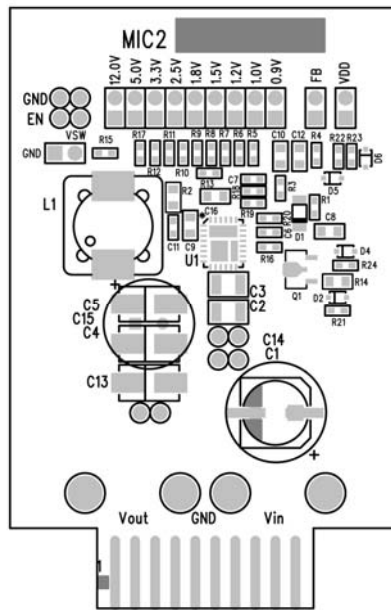
Bill of Materials 12V/2A Output (Continued)

| Item | Part Number | Manufacturer | Description | Qty. |
|------------|--------------------|-------------------------------------|--|----------|
| R5 (Open) | CRCW060380K6FKEA | Vishay Dale ⁽¹⁰⁾ | 80.6kΩ Resistor, Size 0603, 1% | |
| R6 (Open) | CRCW060340K2FKEA | Vishay Dale ⁽¹⁰⁾ | 40.2kΩ Resistor, Size 0603, 1% | |
| R7 (Open) | CRCW060320K0FKEA | Vishay Dale ⁽¹⁰⁾ | 20kΩ Resistor, Size 0603, 1% | |
| R8 (Open) | CRCW060311K5FKEA | Vishay Dale ⁽¹⁰⁾ | 11.5kΩ Resistor, Size 0603, 1% | |
| R9 (Open) | CRCW06038K06FKEA | Vishay Dale ⁽¹⁰⁾ | 8.06kΩ Resistor, Size 0603, 1% | |
| R10 (Open) | CRCW06034K75FKEA | Vishay Dale ⁽¹⁰⁾ | 4.75kΩ Resistor, Size 0603, 1% | |
| R23 | CRCW06034K75FKEA | Vishay Dale ⁽¹⁰⁾ | 4.75kΩ Resistor, Size 0603, 1% | 1 |
| R11 (Open) | CRCW06033K24FKEA | Vishay Dale ⁽¹⁰⁾ | 3.24kΩ Resistor, Size 0603, 1% | |
| R12 (Open) | CRCW06031K91FKEA | Vishay Dale ⁽¹⁰⁾ | 1.91kΩ Resistor, Size 0603, 1% | |
| R13, R24 | CRCW06030000Z0EAHP | Vishay Dale ⁽¹⁰⁾ | 0Ω Resistor, Size 0603 | 2 |
| 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) | CRCW060333K2FKEA | Vishay Dale ⁽¹⁰⁾ | 33.2kΩ Resistor, Size 0603, 1% | |
| R22 | CRCW060336K5FKEA | Vishay Dale ⁽¹⁰⁾ | 36.5kΩ Resistor, Size 0603, 1% | 1 |
| R23 | CRCW06034K75FKEA | Vishay Dale ⁽¹⁰⁾ | 4.75kΩ Resistor, Size 0603, 1% | 1 |
| U1 | MIC28500YJL | Micrel, Inc. ⁽¹¹⁾ | 75V/4A Synchronous Buck DC-DC Regulator | 1 |

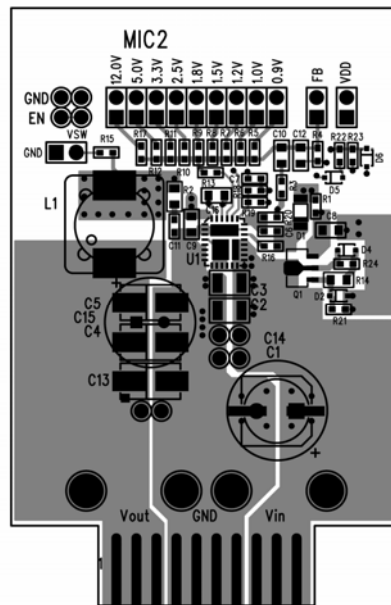
Notes:

1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. TDK: www.tdk.com.
4. Taiyo Yuden: www.t-yuden.com.
5. AVX: www.avx.com.
6. MCC: www.mccsemi.com.
7. Diodes Inc.: www.diodes.com.
8. Central Semi: www.centrasemi.com.
9. Cooper: www.cooperindustries.com.
10. Vishay: www.vishay.com.
11. **Micrel, Inc.:** www.micrel.com.

Evaluation Board PCB Layout

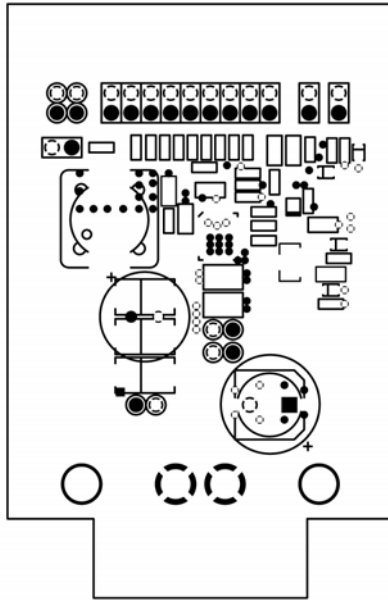


MIC28500 Evaluation Board – Silkscreen Top

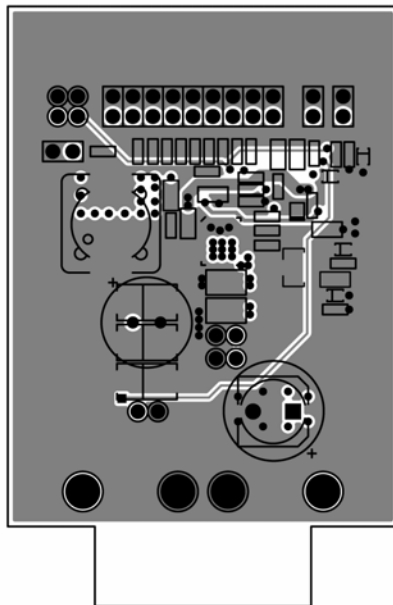


MIC28500 Evaluation Board – Copper Layer 1 (Top)

Evaluation Board PCB Layout (Continued)

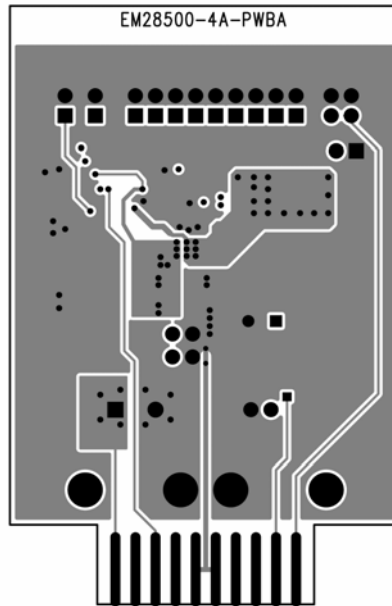


MIC28500 Evaluation Board – Copper Layer 2

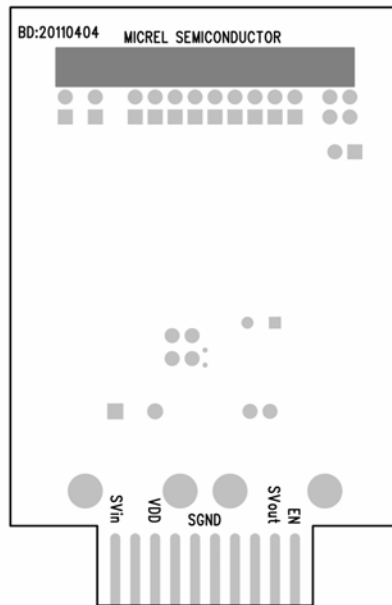


MIC28500 Evaluation Board – Copper Layer 3

Evaluation Board PCB Layout (Continued)



MIC28500 Evaluation Board – Copper Layer 4



MIC28500 Evaluation Board – Silkscreen Bottom

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