MIC2176 15A Evaluation Board

High Input Voltage, Synchronous Buck Controllers Featuring Adaptive On-Time Control

Hyper Speed Control™ Family

General Description

The Micrel MIC2176-1/-2/-3 is a family of constant-frequency, synchronous buck controllers featuring a unique digitally modified adaptive ON-time control architecture. The MIC2176 family operates over an input supply range of 4.5V to 75V. The output voltage is adjustable down to 0.8V with a guaranteed accuracy of ±1% typically, and the device operates at a switching frequency of 100kHz, 200kHz, and 300kHz.

The basic parameters of the evaluation board are:

1. Controller – MIC2176-2, 200kHz
2. Input – 10V to 40V
3. Output – 0.8V to 5V at 15A

Data sheets and other support documents can be found on Micrel's web site at: www.micrel.com.

Requirements

The MIC2176 15A evaluation board requires only a single power supply with adjustable output up to 40V and current limit no less than 20A. A linear regulator, which includes a Zener (D_2) and an NPN transistor (Q_5), has been installed on the board for housekeeping.

Precautions

The MIC2176 15A evaluation board is not allowed to apply a negative voltage to the VIN and GND terminals, since the board does not provide reverse polarity protection. The maximum V_{IN} of the board is rated at 40V, and the maximum load current is rated at 15A.

Getting Started

1. **V_{IN} Supply**

Connect a supply to the VIN and GND terminals, paying careful attention to polarity and supply range (10V < V_{IN} < 40V). Monitor I_{IN} with a current meter and V_{IN} at the VIN and GND terminals with a voltmeter. Don't apply power until step 4.

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 can be placed between the VOUT terminal and the load to monitor the load current. Ensure the output voltage is monitored at the VOUT terminal.

3. **Enable Input**

The EN pin has an internal 100kΩ 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 MIC2176 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 evaluation board.

4. **Turn on the Power**

Turn on the V_{IN} supply and verify that the output voltage is regulated to 3.3V.

Ordering Information

Part Number	Description
MIC2176-2 15A EV	Evaluation Board, up to 5V out
MIC2176-3 12A EV	Evaluation Board, 12V out
MIC2176-3 9A EV	Evaluation Board, 24V out

Features

Feedback Voltage

The output voltage on the MIC2176 evaluation board, which is preset to 3.3V, is determined by the feedback divider:

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

where V_{REF} = 0.8V, and R_{BOTTOM} is one of R5, R10, R12, R11, R9, R8, R7, R6, which corresponds to 0.9V, 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 3.3V, or 5V output voltage.

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:

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

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

If a higher than 5V output is desired, it is recommended to use the designs shown in Figure 2 and Figure 3, where the output capacitors and the values of L1 and R3 are optimized for 12V/12A output and 24V/9A output. These evaluation boards with MIC2176-3YMM are also available per request.

SW Node

Test connector J1 is placed for monitoring the switching waveform, one of the most critical waveforms for the converter.

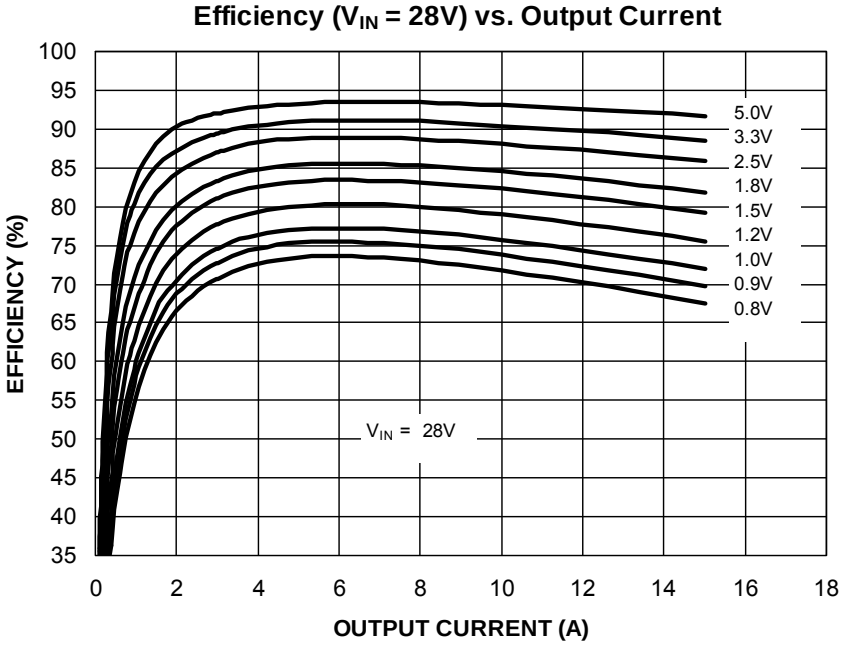
Current Limit

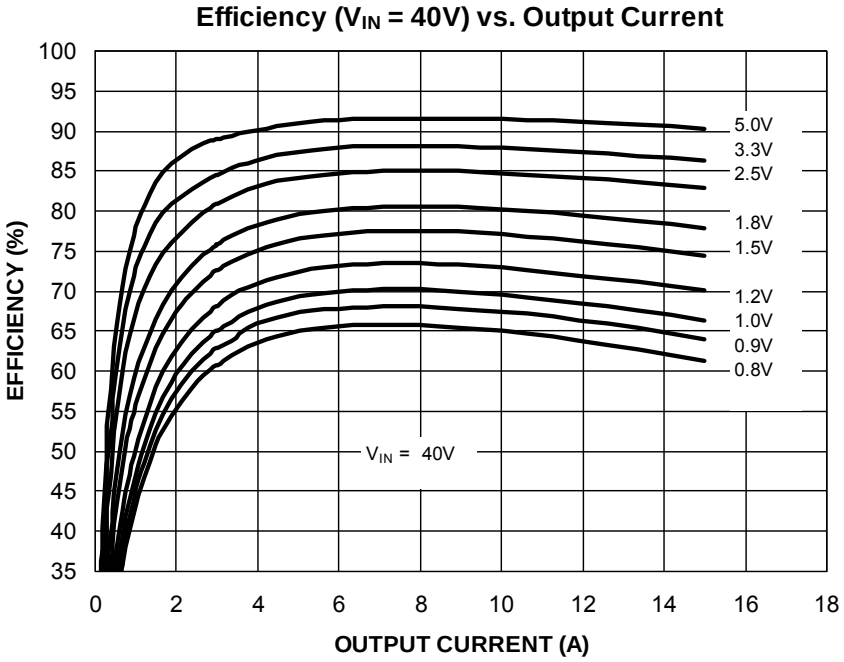
On the evaluation board, two SQD50N06-09L (9 mΩ Rdson) in parallel is used as low-side MOSFET. At 5V gate drive voltage and 125°C operating junction temperature, the total low-side Rdson is about 3.06mΩ (1.6 x 0.5 x 9 mΩ), which results in around 18A over current limit for the 130mV Current Limit Threshold.

Loop Gain Measurement

The resistor, R15, 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.

MIC2176 15A Evaluation Board Efficiency: 28V or 40V Input, 0.8V/15A to 5V/15A Output





Evaluation Board Schematic: 10V to 40V Input, 0.8V/15A to 5V/15A Output

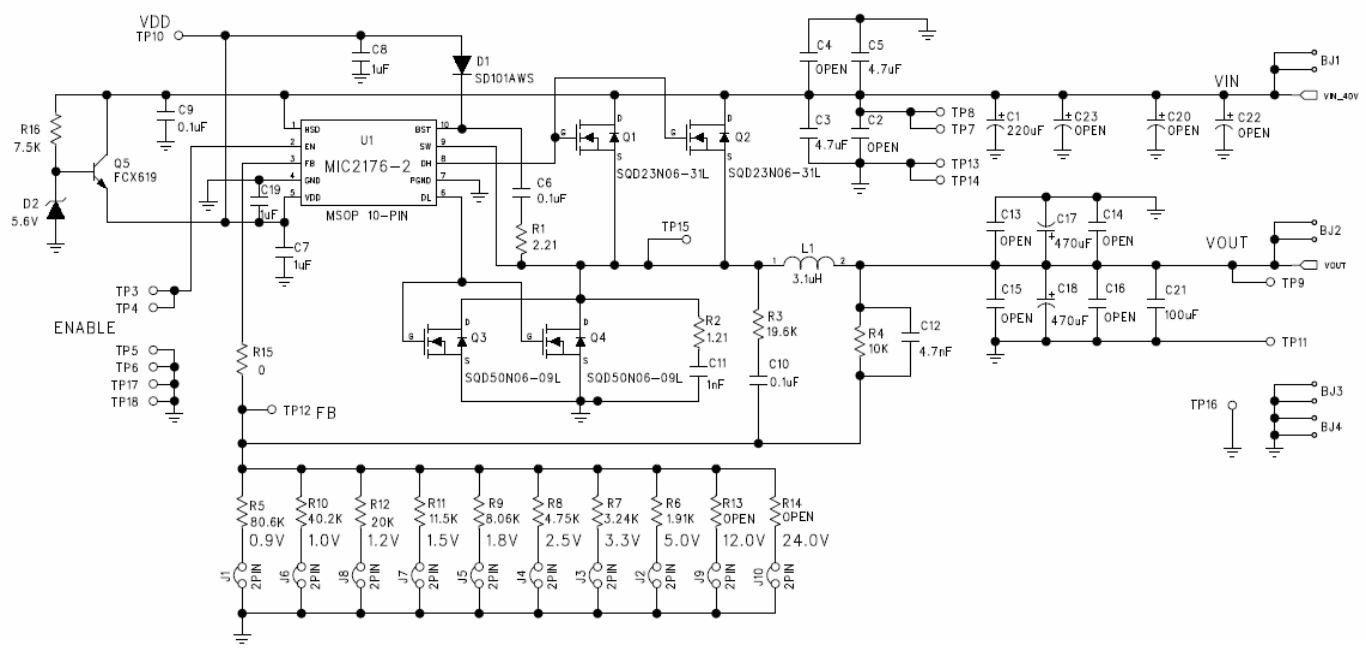


Figure 1. Schematic of MIC2176 Evaluation Board for 0.8V/15A to 5V/15A Output (R15 is for testing purpose)

Bill of Materials: 10V to 40V Input, 0.8V/15A to 5V/15A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUFC1J221S	Panasonic[1]	220µF/63V, Aluminum Capacitor	1
C2, C4, C13, C14, C15, C16, C20, C22, C23	Open			
C3, C5	GRM31CR71H475KA12	Murata[2]	4.7µF/50V Ceramic Capacitor, X7R, Size 1210	2
	12105C475KZ2A	AVX[3]		
	C3225X7R1H475K	TDK[4]		
C6, C9, C10	GRM188R71H104KA93D	Murata[2]	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C7, C8, C19	GRM188R70J105KA01D	Murata[2]	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	3
C11	GRM188R71H102KA01D	Murata[2]	1nF/50V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata[2]	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C17, C18	6SEPC470M	Sanyo[5]	470µF/6.3V OSCON Capacitor	2
C21	GRM32ER60J107ME20L	Murata[2]	100µF/6.3V Ceramic Capacitor, X5R, Size 1210	1
	12106D107MAT2A	AVX[3]		
	C3225X5ROJ107M	TDK[4]		

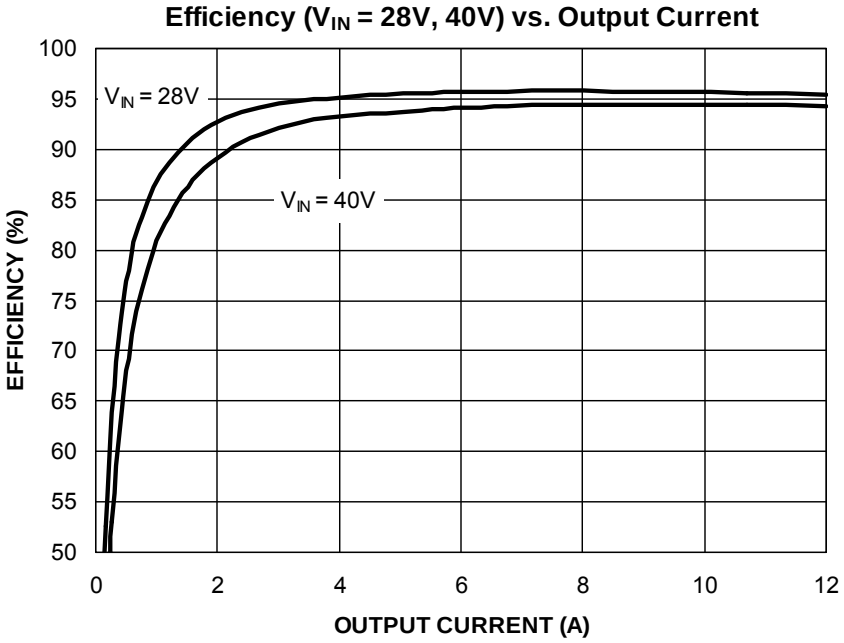
Bill of Materials: 10V to 40V Input, 0.8V/15A to 5V/15A Output (Continued)

D1	SOD101AWS	MCC[6]	60V, 200mA, Schottky Diode, SOD323	1
		Diodes Inc.[7]		
D2	MMXZ5232B-TP	MCC[6]	5.6V, 200mA, Zener Diode, SOD323	1
	CMDZ5L6	Central Semi[8]		
L1	CDEP147NP-3R1MC-125	Sumida[9]	3.1µH Inductor, 17.5A Saturation Current	1
Q1, Q2	SQD23N06-31L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q3, Q4	SQD50N06-09L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q5	FCX619	ZETEX[7]	50V NPN Transistor, SOT89	1
R1	CRCW06032R21FKEA	Vishay Dale[10]	2.21Ω Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060319K6FKEA	Vishay Dale	19.6kΩ Resistor, Size 0603, 1%	1
R4	CRCW060310K0FKEA	Vishay Dale	10kΩ Resistor, Size 0603, 1%	1
R5	CRCW060380K6FKEA	Vishay Dale	80.6kΩ Resistor, Size 0603, 1%	1
R6	CRCW06031K91FKEA	Vishay Dale	1.91kΩ Resistor, Size 0603, 1%	1
R7	CRCW06033K24FKEA	Vishay Dale	3.24kΩ Resistor, Size 0603, 1%	1
R8	CRCW06034K75FKEA	Vishay Dale	4.75kΩ Resistor, Size 0603, 1%	1
R9	CRCW06038K06FKEA	Vishay Dale	8.06kΩ Resistor, Size 0603, 1%	1
R10	CRCW060340K2FKEA	Vishay Dale	40.2kΩ Resistor, Size 0603, 1%	1
R11	CRCW060311K5FKEA	Vishay Dale	11.5kΩ Resistor, Size 0603, 1%	1
R12	CRCW060320K0FKEA	Vishay Dale	20kΩ Resistor, Size 0603, 1%	1
R13 (Open)	CRCW0603715R0FKEA	Vishay Dale	715Ω Resistor, Size 0603, 1%	1
R14 (Open)	CRCW0603345R0FKEA	Vishay Dale	345Ω Resistor, Size 0603, 1%	1
R15	CRCW06030000FKEA	Vishay Dale	0Ω Resistor, Size 0603	1
R16	CRCW08057K5FKEA	Vishay Dale	7.5kΩ Resistor, Size 0805, 1%	1
U1	**MIC2176-2YMM**	**Micrel. Inc.[11]**	**75V Synchronous Buck DC-DC Controller**	**1**

Notes:

1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. AVX: www.avx.com.
4. TDK: www.tdk.com.
5. Sanyo: www.sanyo.com.
6. MCC: www.mccsemi.com.
7. Diodes Inc.: www.diodes.com.
8. Central Semi: www.centralsemi.com.
9. Sumida: www.sumida.com.
10. Vishay: www.vishay.com.
11. **Micrel, Inc.: www.micrel.com.**

MIC2176 15A Evaluation Board Efficiency: 28V or 40V Input, 12V/12A Output



Evaluation Board Schematic: 17V to 40V Input, 12V/12A Output

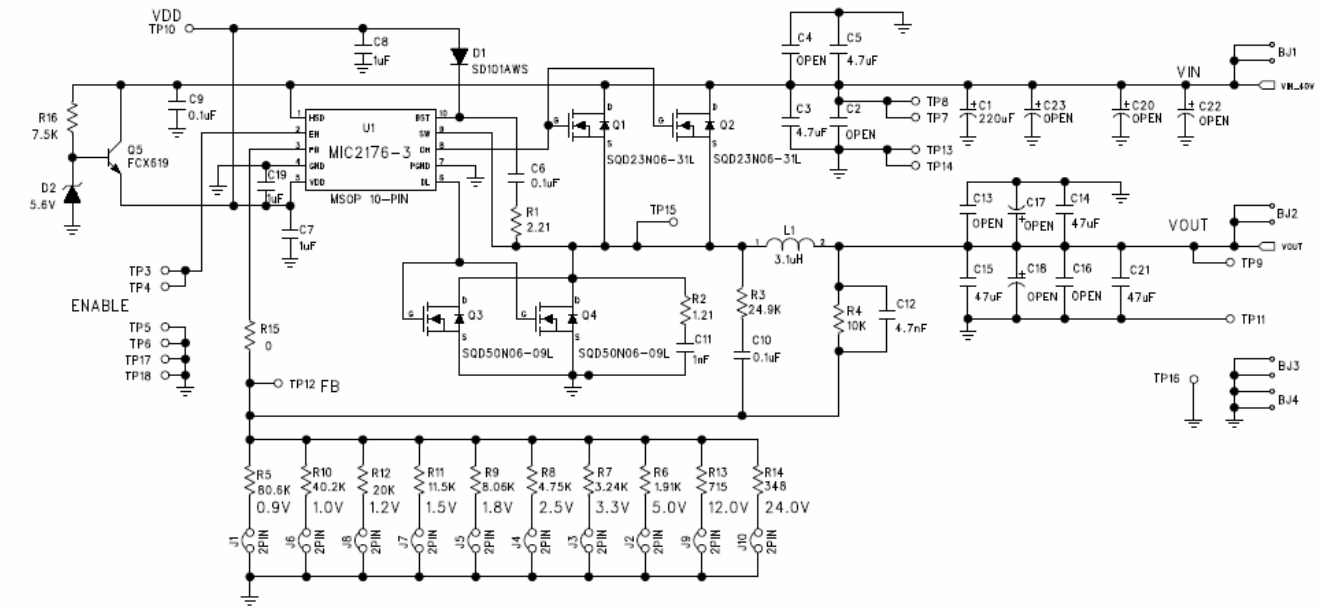


Figure 2. Schematic of MIC2176 Evaluation Board for 12V/12A Output (R15 is for testing purpose)

Bill of Materials: 17V to 40V Input, 12V/12A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUFC1J221S	Panasonic[1]	220µF/63V, Aluminum Capacitor	1
C2, C4, C13, C16, C17, C18, C20, C22, C23	Open			
C3, C5	GRM31CR71H475KA12	Murata[2]	4.7µF/50V Ceramic Capacitor, X7R, Size 1210	2
	12105C475KZ2A	AVX[3]		
	C3225X7R1H475K	TDK[4]		
C6, C9, C10	GRM188R71H104KA93D	Murata[2]	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C7, C8, C19	GRM188R70J105KA01D	Murata[2]	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	3
C11	GRM188R71H102KA01D	Murata[2]	1nF/50V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata[2]	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C14, C15, C21	GRM32ER61C476ME15	Murata[2]	47µF/16V Ceramic Capacitor, X5R, Size 1210	3
	EMK325BJ476MM-T	Taiyo Yuden[5]		
D1	SOD101AWS	MCC[6]	60V, 200mA, Schottky Diode, SOD323	1
		Diodes Inc.[7]		

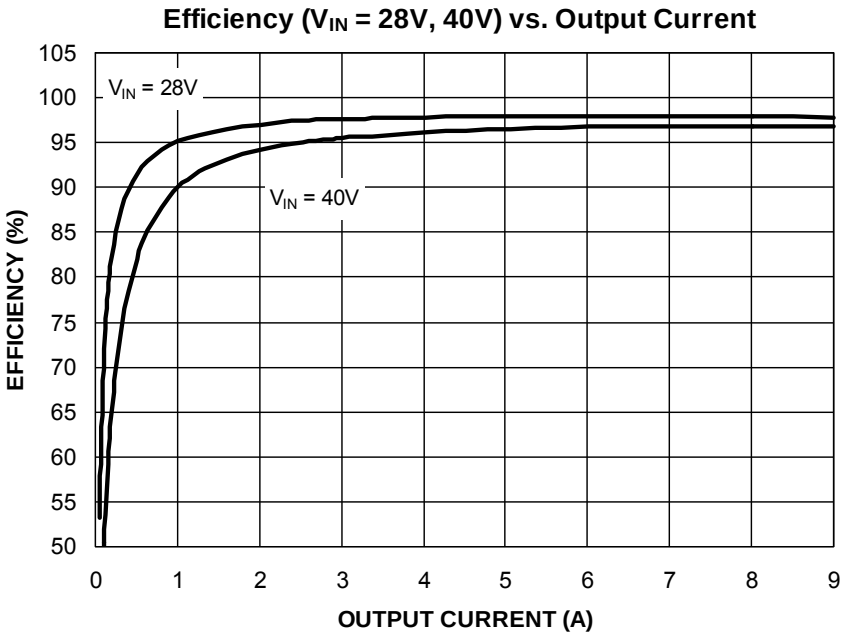
Bill of Materials: 17V to 40V Input, 12V/12A Output (Continued)

D2	MMXZ5232B-TP	MCC[6]	5.6V, 200mA, Zener Diode, SOD323	1
	CMDZ5L6	Central Semi[8]		
L1	CDEP147NP-3R1MC-125	Sumida[9]	3.1µH Inductor, 17.5A Saturation Current	1
Q1, Q2	SQD23N06-31L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q3, Q4	SQD50N06-09L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q5	FCX619	ZETEX[7]	50V NPN Transistor, SOT89	1
R1	CRCW06032R21FKEA	Vishay Dale[10]	2.21Ω Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060324K9FKEA	Vishay Dale	24.9kΩ Resistor, Size 0603, 1%	1
R4	CRCW060310K0FKEA	Vishay Dale	10kΩ Resistor, Size 0603, 1%	1
R5	CRCW060380K6FKEA	Vishay Dale	80.6kΩ Resistor, Size 0603, 1%	1
R6	CRCW06031K91FKEA	Vishay Dale	1.91kΩ Resistor, Size 0603, 1%	1
R7	CRCW06033K24FKEA	Vishay Dale	3.24kΩ Resistor, Size 0603, 1%	1
R8	CRCW06034K75FKEA	Vishay Dale	4.75kΩ Resistor, Size 0603, 1%	1
R9	CRCW06038K06FKEA	Vishay Dale	8.06kΩ Resistor, Size 0603, 1%	1
R10	CRCW060340K2FKEA	Vishay Dale	40.2kΩ Resistor, Size 0603, 1%	1
R11	CRCW060311K5FKEA	Vishay Dale	11.5kΩ Resistor, Size 0603, 1%	1
R12	CRCW060320K0FKEA	Vishay Dale	20kΩ Resistor, Size 0603, 1%	1
R13	CRCW0603715R0FKEA	Vishay Dale	715Ω Resistor, Size 0603, 1%	1
R14 (Open)	CRCW0603345R0FKEA	Vishay Dale	345Ω Resistor, Size 0603, 1%	1
R15	CRCW06030000FKEA	Vishay Dale	0Ω Resistor, Size 0603	1
R16	CRCW08057K5FKEA	Vishay Dale	7.5kΩ Resistor, Size 0805, 1%	1
U1	**MIC2176-3YMM**	**Micrel. Inc.[11]**	**75V Synchronous Buck DC-DC Controller**	**1**

Notes:

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

MIC2176 15A Evaluation Board Efficiency: 28V or 40V Input, 24V/9A Output



Evaluation Board Schematic: 28V to 40V Input, 24V/9A Output

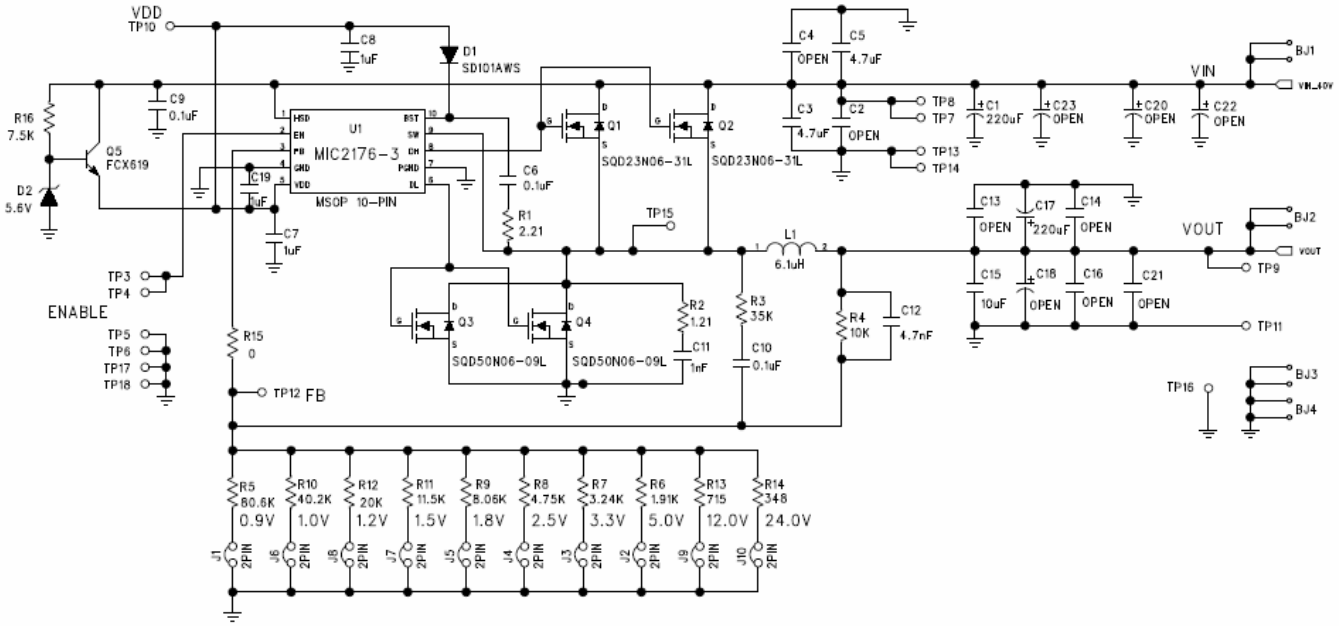


Figure 3. Schematic of MIC2176 Evaluation Board for 24V/9A Output (R15 is for testing purpose)

Bill of Materials: 28V to 40V Input, 24V/9A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUFC1J221S	Panasonic[1]	220µF/63V, Aluminum Capacitor	1
C2, C4, C13, C14, C16, C18, C20, C21, C22, C23	Open			
C3, C5	GRM31CR71H475KA12	Murata[2]	4.7µF/50V Ceramic Capacitor, X7R, Size 1210	2
	12105C475KZ2A	AVX[3]		
	C3225X7R1H475K	TDK[4]		
C6, C9, C10	GRM188R71H104KA93D	Murata[2]	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C7, C8, C19	GRM188R70J105KA01D	Murata[2]	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	3
C11	GRM188R71H102KA01D	Murata[2]	1nF/50V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata[2]	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C15	GRM32ER67YA106KA12	Murata[2]	10µF/35V Ceramic Capacitor, X7R, Size 1210	1
	GMK325BJ106KN-T	Taiyo Yuden[5]		
	C3225X7S1H106M	TDK[4]		
C17	EEE-FP1V221AP	Panasonic[1]	220µF/35V, Aluminum Capacitor	1

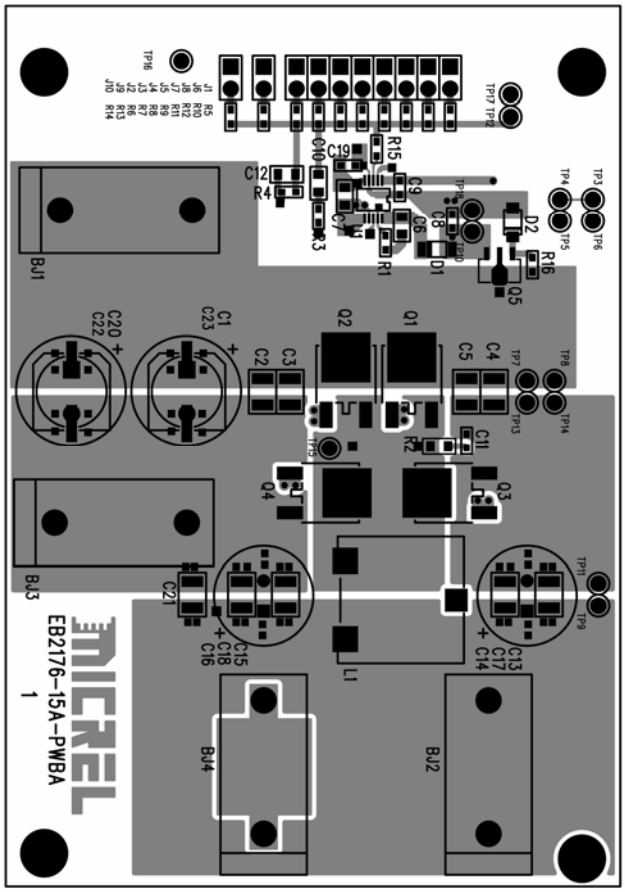
Bill of Materials: 28V to 40V Input, 24V/9A Output (Continued)

D1	SOD101AWS	MCC[6]	60V, 200mA, Schottky Diode, SOD323	1
		Diodes Inc.[7]		
D2	MMXZ5232B-TP	MCC[6]	5.6V, 200mA, Zener Diode, SOD323	1
	CMDZ5L6	Central Semi[8]		
L1	CDEP147NP-6R1MC-125	Sumida[9]	6.1µH Inductor, 12.5A Saturation Current	1
Q1, Q2	SQD23N06-31L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q3, Q4	SQD50N06-09L	Vishay[10]	60V, MOSFET, N-CH, TO-252	2
Q5	FCX619	ZETEX[7]	50V NPN Transistor, SOT89	1
R1	CRCW06032R21FKEA	Vishay Dale[10]	2.21Ω Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060335K0FKEA	Vishay Dale	35kΩ Resistor, Size 0603, 1%	1
R4	CRCW060310K0FKEA	Vishay Dale	10kΩ Resistor, Size 0603, 1%	1
R5	CRCW060380K6FKEA	Vishay Dale	80.6kΩ Resistor, Size 0603, 1%	1
R6	CRCW06031K91FKEA	Vishay Dale	1.91kΩ Resistor, Size 0603, 1%	1
R7	CRCW06033K24FKEA	Vishay Dale	3.24kΩ Resistor, Size 0603, 1%	1
R8	CRCW06034K75FKEA	Vishay Dale	4.75kΩ Resistor, Size 0603, 1%	1
R9	CRCW06038K06FKEA	Vishay Dale	8.06kΩ Resistor, Size 0603, 1%	1
R10	CRCW060340K2FKEA	Vishay Dale	40.2kΩ Resistor, Size 0603, 1%	1
R11	CRCW060311K5FKEA	Vishay Dale	11.5kΩ Resistor, Size 0603, 1%	1
R12	CRCW060320K0FKEA	Vishay Dale	20kΩ Resistor, Size 0603, 1%	1
R13 (Open)	CRCW0603715R0FKEA	Vishay Dale	715Ω Resistor, Size 0603, 1%	1
R14	CRCW0603345R0FKEA	Vishay Dale	345Ω Resistor, Size 0603, 1%	1
R15	CRCW06030000FKEA	Vishay Dale	0Ω Resistor, Size 0603	1
R16	CRCW08057K5FKEA	Vishay Dale	7.5kΩ Resistor, Size 0805, 1%	1
U1	**MIC2176-3YMM**	**Micrel. Inc.[11]**	**75V Synchronous Buck DC-DC Controller**	**1**

Notes:

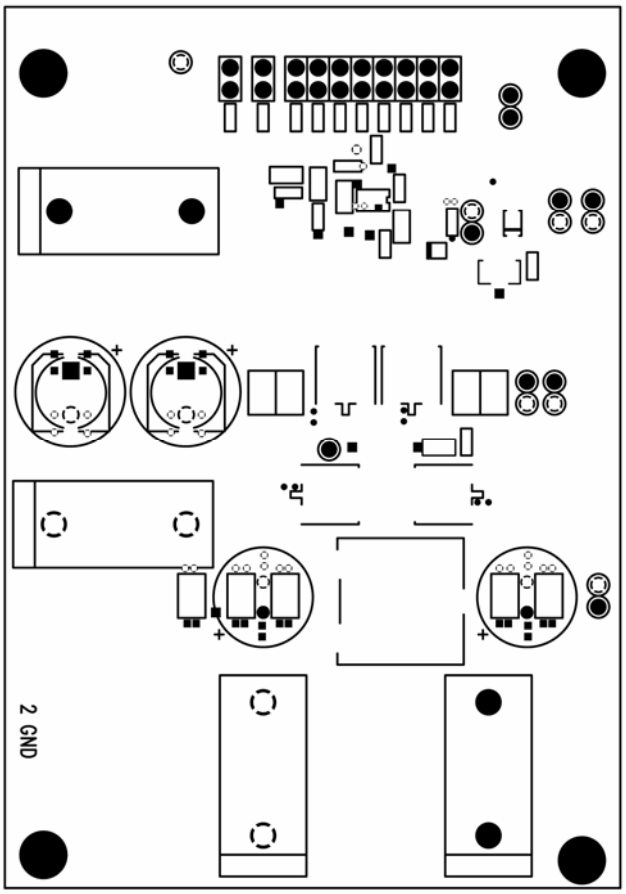
1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. AVX: www.avx.com.
4. TDK: www.tdk.com.
5. Taiyo Yuden: www.t-yuden.com.
6. MCC: www.mccsemi.com.
7. Diodes Inc.: www.diodes.com.
8. Central Semi: www.centralsemi.com.
9. Sumida: www.sumida.com.
10. Vishay: www.vishay.com.
11. **Micrel, Inc.: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

Evaluation Board PCB Layout



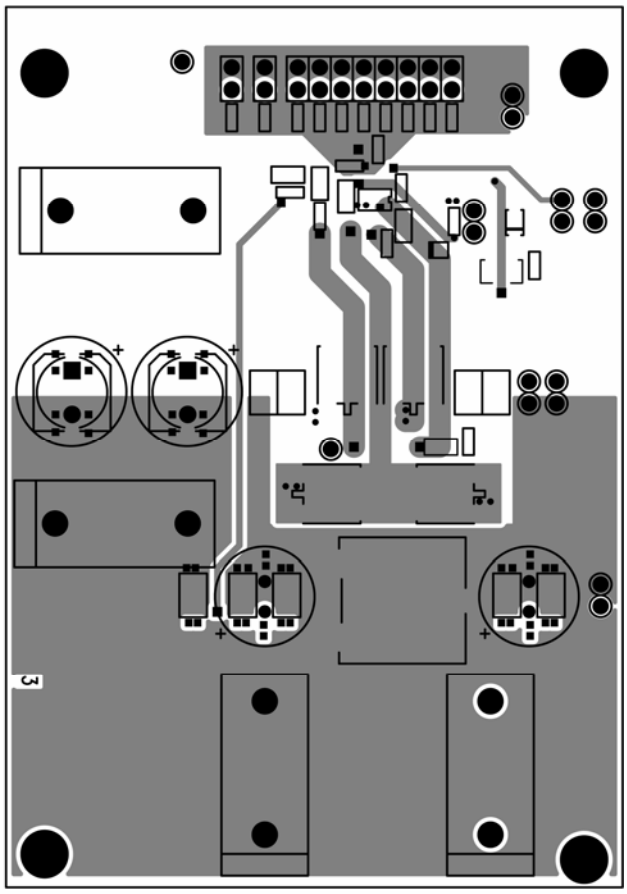
MIC2176 Evaluation Board Top Layer

Evaluation Board PCB Layout (Continued)



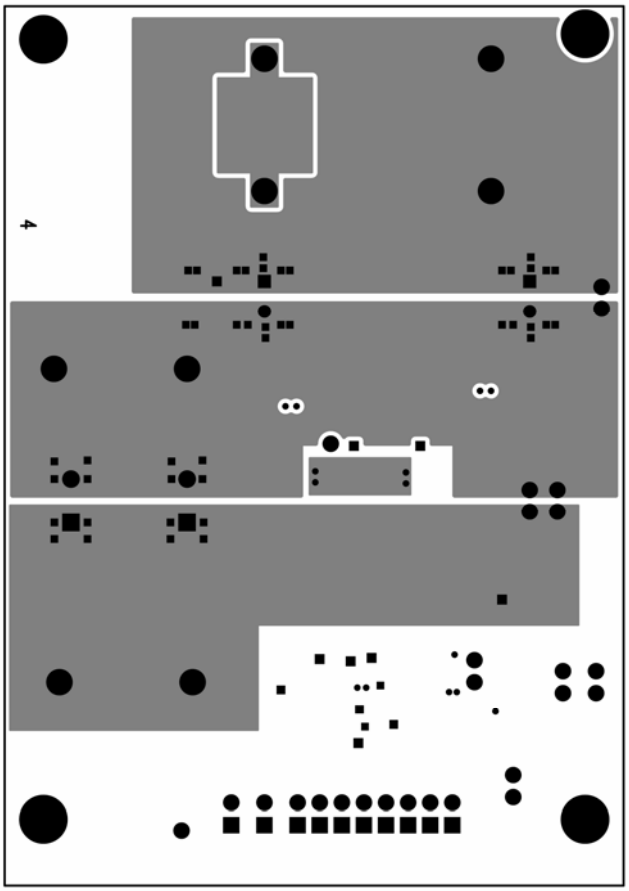
MIC2176 Evaluation Board Mid-Layer 1 (Ground Plane)

Evaluation Board PCB Layout (Continued)



MIC2176 Evaluation Board Mid-Layer 2

Evaluation Board PCB Layout (Continued)



MIC2176 Evaluation Board Bottom Layer

MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA
TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB http://www.micrel.com