MIC2176 10A 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 – 8V to 75V
3. Output – 0.8V to 5V at 10A

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

Requirements

The MIC2176 evaluation board requires only a single power supply with adjustable output up to 75V and current limit no less than 10A. 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 10A 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 75V, and the maximum load current is rated at 10A up to 50V input, or 6A up to 75V input. Due to thermal constraint, the load current must be degraded from 10A for any input higher than 50V.

Getting Started

1. **V_{IN} Supply**

Connect a supply to the VIN and GND terminals, paying careful attention to polarity and supply range (8V < V_{IN} < 75V). 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 VIN supply and verify that the output voltage is regulated to 3.3V.

Ordering Information

Part Number	Description
MIC2176-2 10A EV	Evaluation Board, up to 5V out
MIC2176-2 8A EV	Evaluation Board, 12V out
MIC2176-2 6A EV	Evaluation Board, 24V out

Features

Feedback Resistors

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

$$V_{OUT} = V_{REF} \times (1 + \frac{R_1}{R_{BOTTOM}})$$

where V_{REF} = 0.8V, and R_{BOTTOM} is one of R4, R5, R6, R7, R8, R9, R10, R11, 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:

$$R_{BOTTOM} = \frac{R_1 \times V_{REF}}{V_{OUT} - V_{REF}}$$

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 voltage 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/8A output and 24V/6A output. These evaluation boards 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.

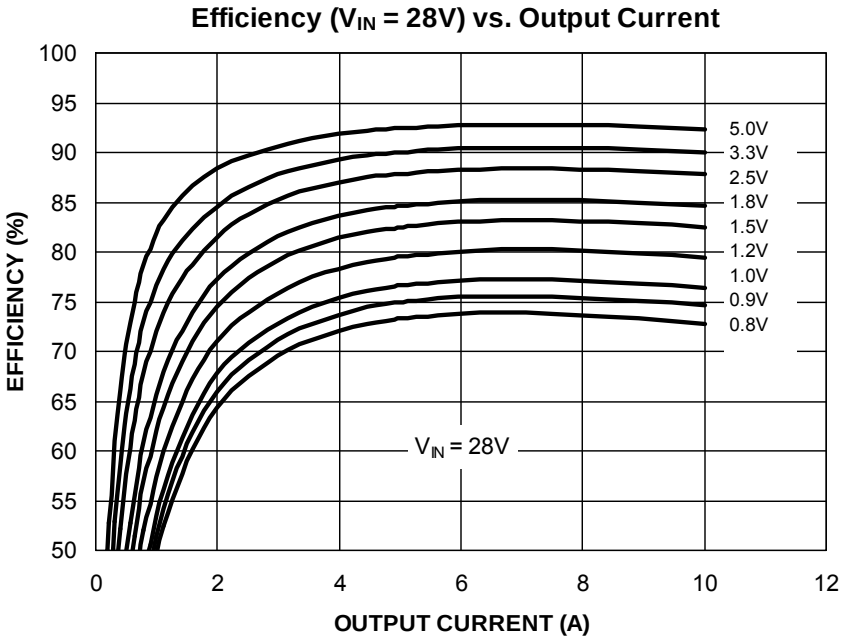
Current Limit

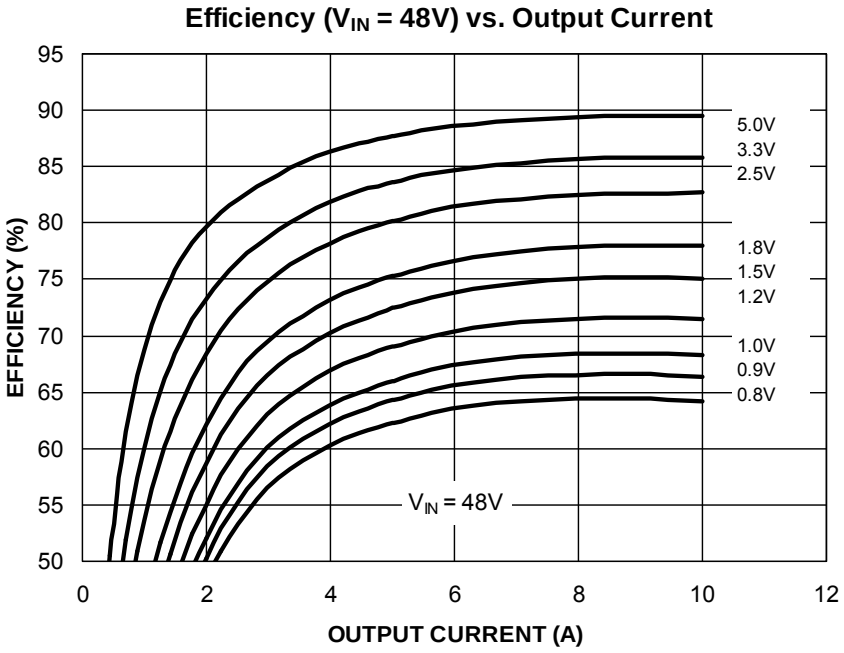
On the evaluation board, two SIR882DP (10 mΩ Rdson) in parallel is used as low-side MOSFET. At 5V gate drive voltage and 125°C operating junction temperature, the total low-side Rdson is about 3.06mΩ (1.75 x 0.5 x 10 mΩ), which results in around 15A over current limit for the 130mV Current Limit Threshold.

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.

MIC2176 10A Evaluation Board Efficiency: 28V or 48V Input, 0.8V/10A to 5V/10A Output





Evaluation Board Schematic: 8V to 50V Input, 0.8V/10A to 5V/10A Output

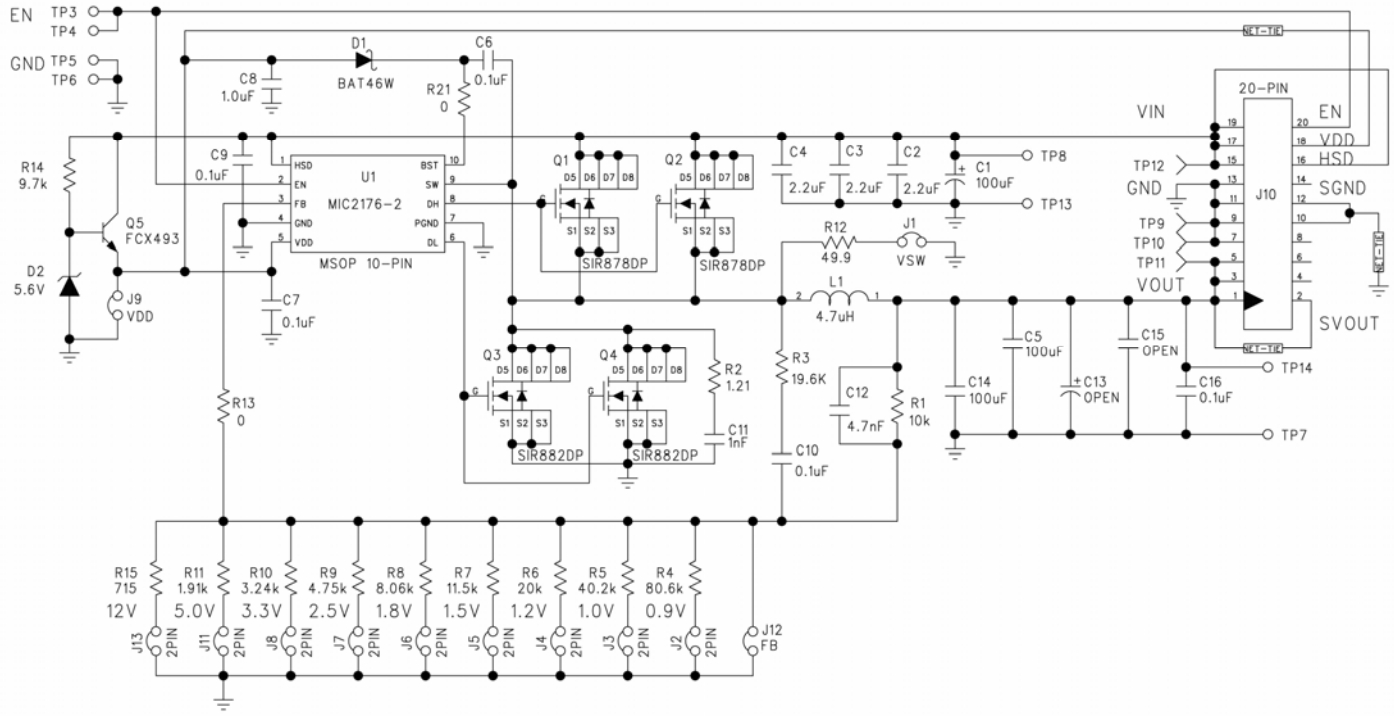


Figure 1. Schematic of MIC2176 Evaluation Board for 0.8V/10A to 5V/10A Output (J1, J9, J12, R12, and R13 are for testing purposes)

Bill of Materials: 8V to 50V Input, 0.8V/10A to 5V/10A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUF2A101	Panasonic(1)	100µF/100V, Aluminum Capacitor	1
C2, C3, C4	GRM32ER72A225K	Murata(2)	2.2µF/100V Ceramic Capacitor, X7R, Size 1210	3
C5, C14, C15	GRM32ER60J107ME20	Murata(2)	100µF/6.3V Ceramic Capacitor, X7R, Size 1210	3
C6, C7, C16	GRM188R71H104KA94L	Murata(2)	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C8	GRM188R70J105KA01D	Murata(2)	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	1
C9, C10	GRM188R72A104KA35D	Murata(2)	0.1µF/100V Ceramic Capacitor, X7R, Size 0603	2
C11	GRM188R72A102KA01D	Murata(2)	1nF/100V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata(2)	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C13	6SEPC470M	Sanyo(3)	470µF/6.3V OSCON Capacitor	1
D1	BAT46W	Diodes, Inc.(4)	100V Small Signal Schottky Diode, SOD123	1

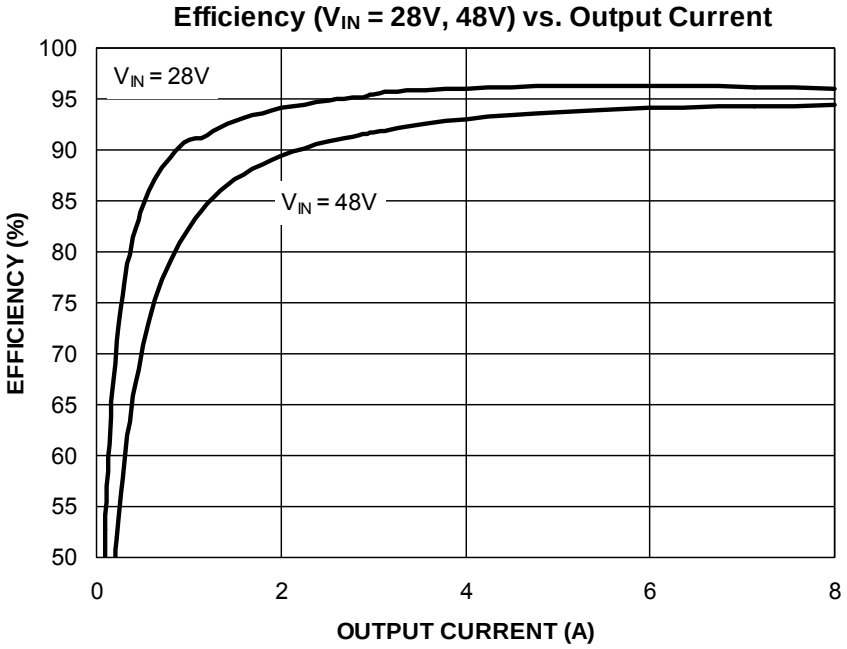
Bill of Materials: 8V to 50V Input, 0.8V/10A to 5V/10A Output (Continued)

D2	CMDZ5L6	Central Semi[5]	5.6V, 200mA, Zener Diode, SOD323	1
L1	CDEP147NP-4R7MC-95	Sumida[6]	4.7µH Inductor, 15A Saturation Current	1
Q1, Q2	SIR878DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC265N10LSF	Infineon[8]		
Q3, Q4	SIR882DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC060N10NS3	Infineon[8]		
Q5	FCX493	ZETEX[4]	100V NPN Transistor, SOT89	1
R1	CRCW060310K0FKEA	Vishay Dale[7]	10kΩ Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale[7]	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060319K6FKEA	Vishay Dale[7]	19.6kΩ Resistor, Size 0603, 1%	1
R4	CRCW060380K6FKEA	Vishay Dale[7]	80.6kΩ Resistor, Size 0603, 1%	1
R5	CRCW060340K2FKEA	Vishay Dale[7]	40.2kΩ Resistor, Size 0603, 1%	1
R6	CRCW060320K0FKEA	Vishay Dale[7]	20kΩ Resistor, Size 0603, 1%	1
R7	CRCW060311K5FKEA	Vishay Dale[7]	11.5kΩ Resistor, Size 0603, 1%	1
R8	CRCW06038K06FKEA	Vishay Dale[7]	8.06kΩ Resistor, Size 0603, 1%	1
R9	CRCW06034K75FKEA	Vishay Dale[7]	4.75kΩ Resistor, Size 0603, 1%	1
R10	CRCW06033K24FKEA	Vishay Dale[7]	3.24kΩ Resistor, Size 0603, 1%	1
R11	CRCW06031K91FKEA	Vishay Dale[7]	1.91kΩ Resistor, Size 0603, 1%	1
R12	CRCW060349K24FKEA	Vishay Dale[7]	49.9Ω Resistor, Size 0603, 1%	1
R13, R21	CRCW06030000FKEA	Vishay Dale[7]	0Ω Resistor, Size 0603	2
R14	CRCW08059K7FKEA	Vishay Dale[7]	9.7kΩ Resistor, Size 0805, 5%	1
R15	CRCW0603715R0FKEA	Vishay Dale[7]	715Ω Resistor, Size 0603, 1%	1
U1	**MIC2176-2YMM**	**Micrel. Inc.[9]**	**75V Synchronous Buck DC-DC Controller**	**1**

Notes:

1. Panasonic: www.panasonic.com.
2. Murata: www.murata.com.
3. Sanyo: www.sanyo.com.
4. Diodes Inc.: www.diodes.com.
5. Central Semi: www.centralsemi.com.
6. Sumida: www.sumida.com.
7. Vishay: www.vishay.com.
8. Infineon: www.infineon.com.
9. **Micrel, Inc.: www.micrel.com.**

MIC2176 10A Evaluation Board Efficiency: 28V or 48V Input, 12V/8A Output



Evaluation Board Schematic: 17V to 50V Input, 12V/8A Output

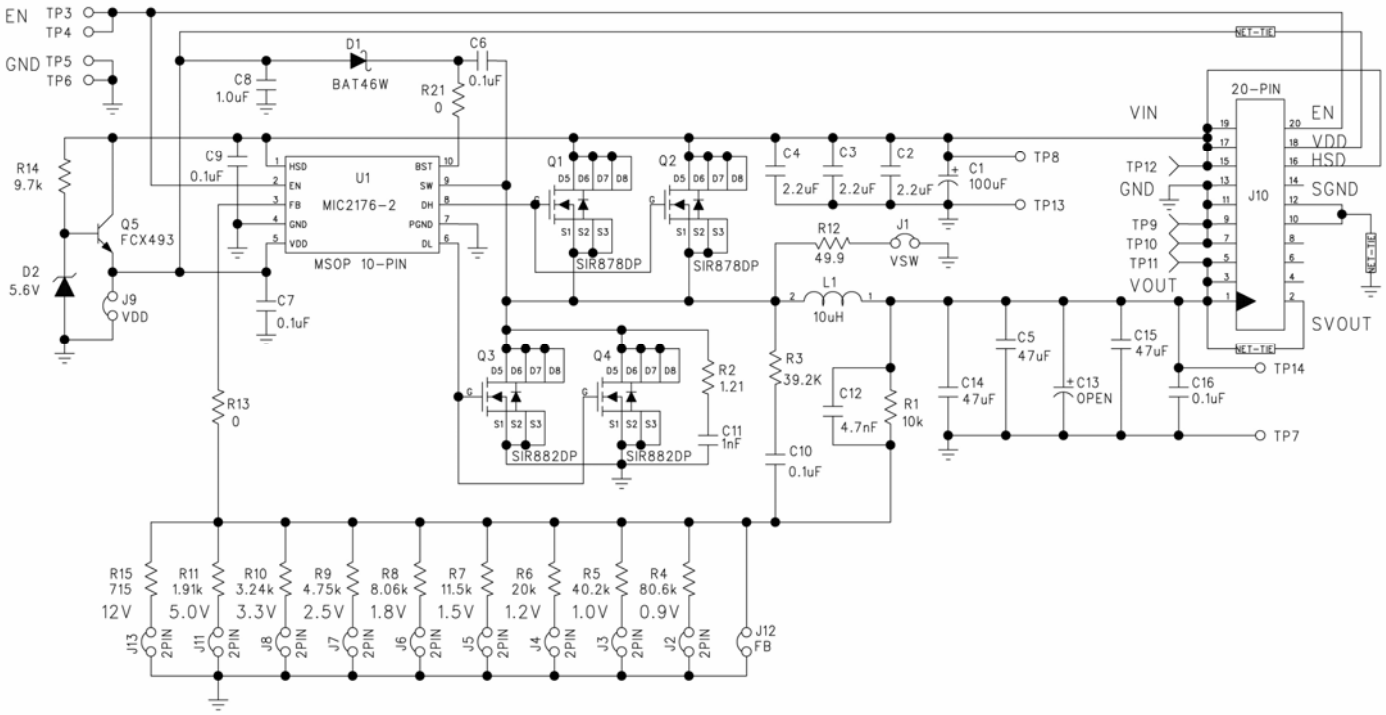


Figure 2. Schematic of MIC2176 8A Evaluation Board for 12V/8A Output (J1, J9, J12, R12, and R13 are for testing purposes)

Bill of Materials: 17V to 50V Input, 12V/8A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUF2A101	Panasonic(1)	100µF/100V, Aluminum Capacitor	1
C2, C3, C4	GRM32ER72A225K	Murata(2)	2.2µF/100V Ceramic Capacitor, X7R, Size 1210	3
C5, C14, C15	GRM32ER61C476ME15	Murata(2)	47µF/16V Ceramic Capacitor, X5R, Size 1210	3
C6, C7, C16	GRM188R71H104KA94L	Murata(2)	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C8	GRM188R70J105KA01D	Murata(2)	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	1
C9, C10	GRM188R72A104KA35D	Murata(2)	0.1µF/100V Ceramic Capacitor, X7R, Size 0603	2
C11	GRM188R72A102KA01D	Murata(2)	1nF/100V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata(2)	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C13	16SEPC270M	Sanyo(3)	270µF/16V OSCON Capacitor	1
D1	BAT46W	Diodes, Inc.(4)	100V Small Signal Schottky Diode, SOD123	1
D2	CMDZ5L6	Central Semi(5)	5.6V, 200mA, Zener Diode, SOD323	1
L1	CDEP147NP-100MC-95	Sumida(6)	10µH Inductor, 10A Saturation Current	1

Bill of Materials: 17V to 50V Input, 12V/8A Output (Continued)

Q1, Q2	SIR878DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC265N10LSF	Infineon[8]		
Q3, Q4	SIR882DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC060N10NS3	Infineon[8]		
Q5	FCX493	ZETEX[4]	100V NPN Transistor, SOT89	1
R1	CRCW060310K0FKEA	Vishay Dale[7]	10kΩ Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale[7]	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060339K2FKEA	Vishay Dale[7]	39.2kΩ Resistor, Size 0603, 1%	1
R4	CRCW060380K6FKEA	Vishay Dale[7]	80.6kΩ Resistor, Size 0603, 1%	1
R5	CRCW060340K2FKEA	Vishay Dale[7]	40.2kΩ Resistor, Size 0603, 1%	1
R6	CRCW060320K0FKEA	Vishay Dale[7]	20kΩ Resistor, Size 0603, 1%	1
R7	CRCW060311K5FKEA	Vishay Dale[7]	11.5kΩ Resistor, Size 0603, 1%	1
R8	CRCW06038K06FKEA	Vishay Dale[7]	8.06kΩ Resistor, Size 0603, 1%	1
R9	CRCW06034K75FKEA	Vishay Dale[7]	4.75kΩ Resistor, Size 0603, 1%	1
R10	CRCW06033K24FKEA	Vishay Dale[7]	3.24kΩ Resistor, Size 0603, 1%	1
R11	CRCW06031K91FKEA	Vishay Dale[7]	1.91kΩ Resistor, Size 0603, 1%	1
R12	CRCW060349K24FKEA	Vishay Dale[7]	49.9Ω Resistor, Size 0603, 1%	1
R13, R21	CRCW06030000FKEA	Vishay Dale[7]	0Ω Resistor, Size 0603	2
R14	CRCW08059K7FKEA	Vishay Dale[7]	9.7kΩ Resistor, Size 0805, 5%	1
R15	CRCW0603715R0FKEA	Vishay Dale[7]	715Ω Resistor, Size 0603, 1%	1
U1	**MIC2176-2YMM**	**Micrel. Inc.[9]**	**75V Synchronous Buck DC-DC Controller**	**1**

Notes:

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5. Central Semi: www.centralsemi.com.
6. Sumida: www.sumida.com.
7. Vishay: www.vishay.com
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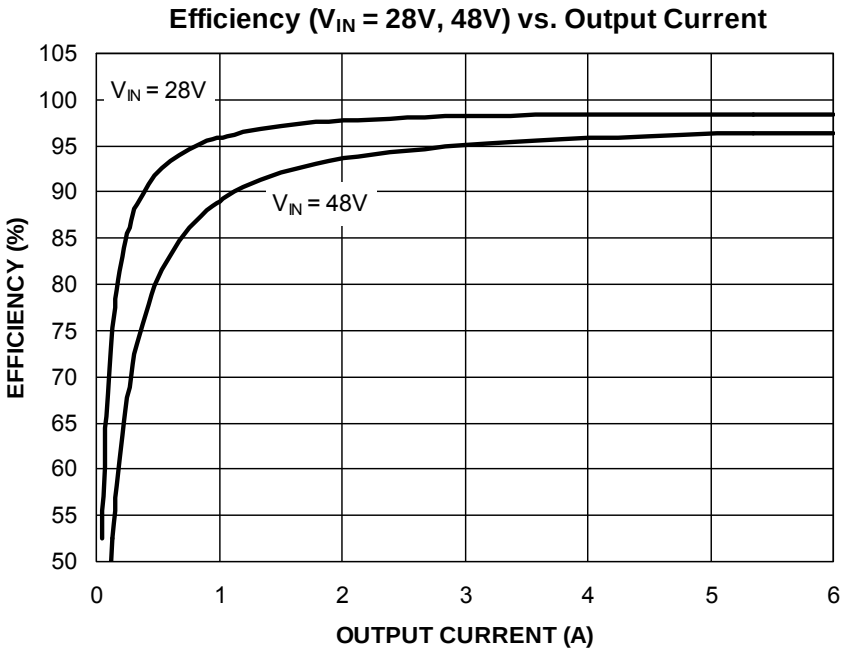
MIC2176 10A Evaluation Board Efficiency: 28V or 48V Input, 24V/6A Output



Evaluation Board Schematic: 28V to 50V Input, 24V/6A Output

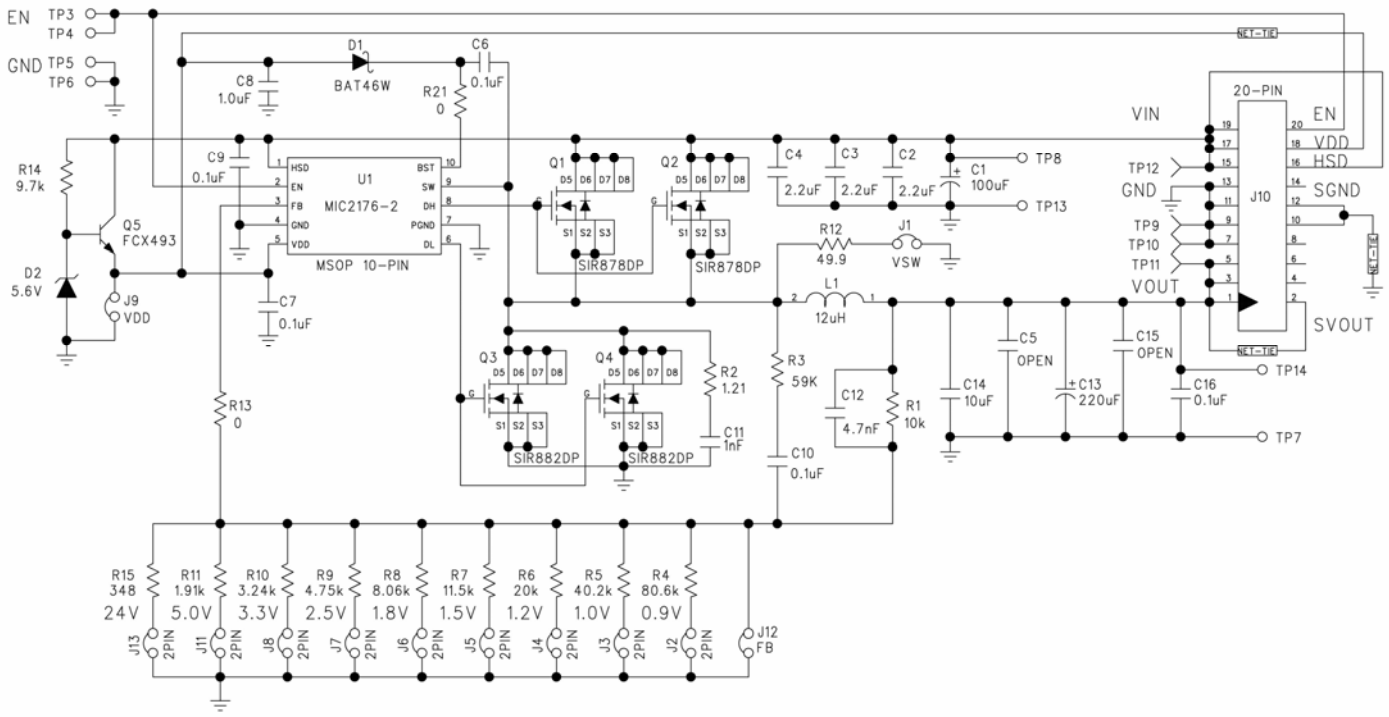


Figure 3. Schematic of MIC2176 Evaluation Board for 24V/6A Output
(J1, J9, J12, R12, and R13 are for testing purposes)

Bill of Materials: 28V to 50V Input, 24V/6A Output

Item	Part Number	Manufacturer	Description	Qty
C1	EEUF2A101	Panasonic(1)	100µF/100V, Aluminum Capacitor	1
C2, C3, C4	GRM32ER72A225K	Murata(2)	2.2µF/100V Ceramic Capacitor, X7R, Size 1210	3
C5, C14, C15	GRM32ER67YA106KA12	Murata(2)	10µF/35V Ceramic Capacitor, X7R, Size 1210	3
C6, C7, C16	GRM188R71H104KA94L	Murata(2)	0.1µF/50V Ceramic Capacitor, X7R, Size 0603	3
C8	GRM188R70J105KA01D	Murata(2)	1µF/6.3V Ceramic Capacitor, X7R, Size 0603	1
C9, C10	GRM188R72A104KA35D	Murata(2)	0.1µF/100V Ceramic Capacitor, X7R, Size 0603	2
C11	GRM188R72A102KA01D	Murata(2)	1nF/100V Cermiac Capacitor, X7R, Size 0603	1
C12	GRM188R71H472KA01D	Murata(2)	4.7nF/50V Ceramic Capacitor, X7R, Size 0603	1
C13	EEE-FP1V221AP	Panasonic(1)	220µF/35V, Aluminum Capacitor	1
D1	BAT46W	Diodes, Inc.(4)	100V Small Signal Schottky Diode, SOD123	1
D2	CMDZ5L6	Central Semi(5)	5.6V, 200mA, Zener Diode, SOD323	1
L1	CDEP147NP-120MC-125	Sumida(6)	12µH Inductor, 8.2A Saturation Current	1

Bill of Materials: 28V to 50V Input, 24V/6A Output (Continued)

Q1, Q2	SIR878DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC265N10LSF	Infineon[8]		
Q3, Q4	SIR882DP	Vishay[7]	100V, MOSFET, N-CH, Power SO-8	2
	BSC060N10NS3	Infineon[8]		
Q5	FCX493	ZETEX[4]	100V NPN Transistor, SOT89	1
R1	CRCW060310K0FKEA	Vishay Dale[7]	10kΩ Resistor, Size 0603, 1%	1
R2	CRCW08051R21FKEA	Vishay Dale[7]	1.21Ω Resistor, Size 0805, 5%	1
R3	CRCW060359K0FKEA	Vishay Dale[7]	59kΩ Resistor, Size 0603, 1%	1
R4	CRCW060380K6FKEA	Vishay Dale[7]	80.6kΩ Resistor, Size 0603, 1%	1
R5	CRCW060340K2FKEA	Vishay Dale[7]	40.2kΩ Resistor, Size 0603, 1%	1
R6	CRCW060320K0FKEA	Vishay Dale[7]	20kΩ Resistor, Size 0603, 1%	1
R7	CRCW060311K5FKEA	Vishay Dale[7]	11.5kΩ Resistor, Size 0603, 1%	1
R8	CRCW06038K06FKEA	Vishay Dale[7]	8.06kΩ Resistor, Size 0603, 1%	1
R9	CRCW06034K75FKEA	Vishay Dale[7]	4.75kΩ Resistor, Size 0603, 1%	1
R10	CRCW06033K24FKEA	Vishay Dale[7]	3.24kΩ Resistor, Size 0603, 1%	1
R11	CRCW06031K91FKEA	Vishay Dale[7]	1.91kΩ Resistor, Size 0603, 1%	1
R12	CRCW060349K24FKEA	Vishay Dale[7]	49.9Ω Resistor, Size 0603, 1%	1
R13, R21	CRCW06030000FKEA	Vishay Dale[7]	0Ω Resistor, Size 0603	2
R14	CRCW08059K7FKEA	Vishay Dale[7]	9.7kΩ Resistor, Size 0805, 5%	1
R15	CRCW0603348R0FKEA	Vishay Dale[7]	348Ω Resistor, Size 0603, 1%	1
U1	**MIC2176-2YMM**	**Micrel. Inc.[9]**	**75V Synchronous Buck DC-DC Controller**	**1**

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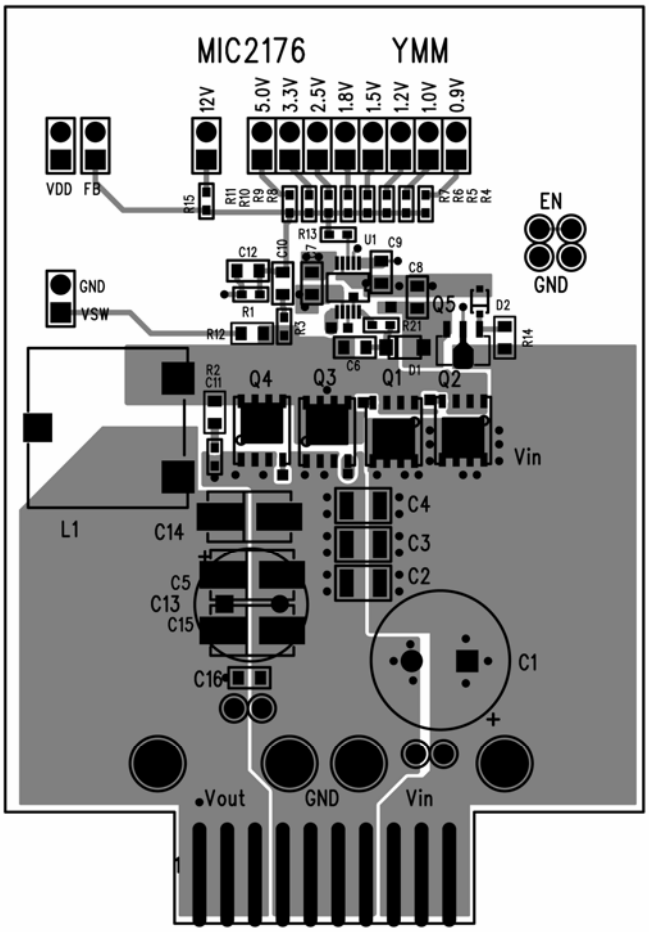
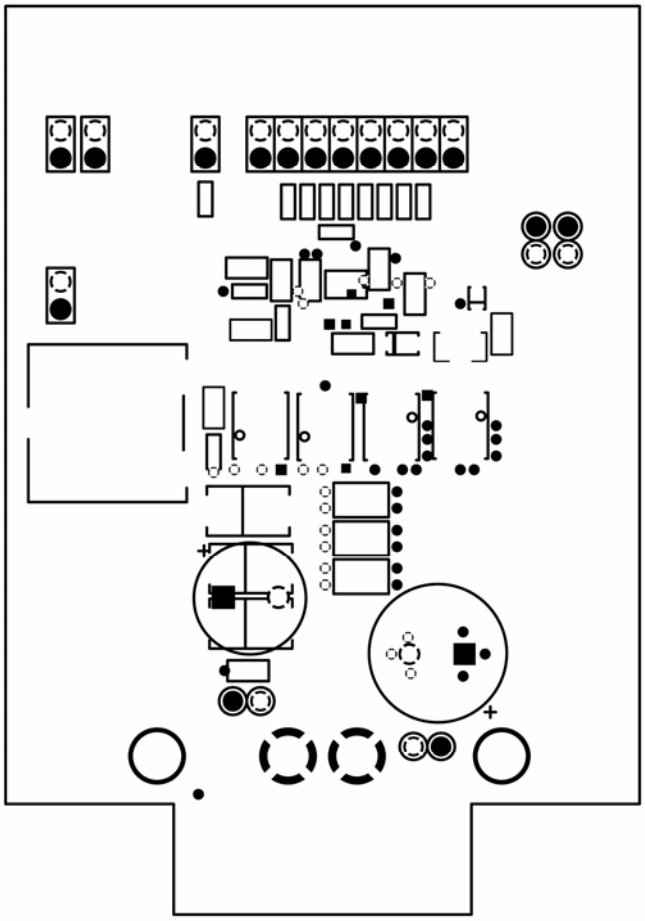
Evaluation Board PCB Layout



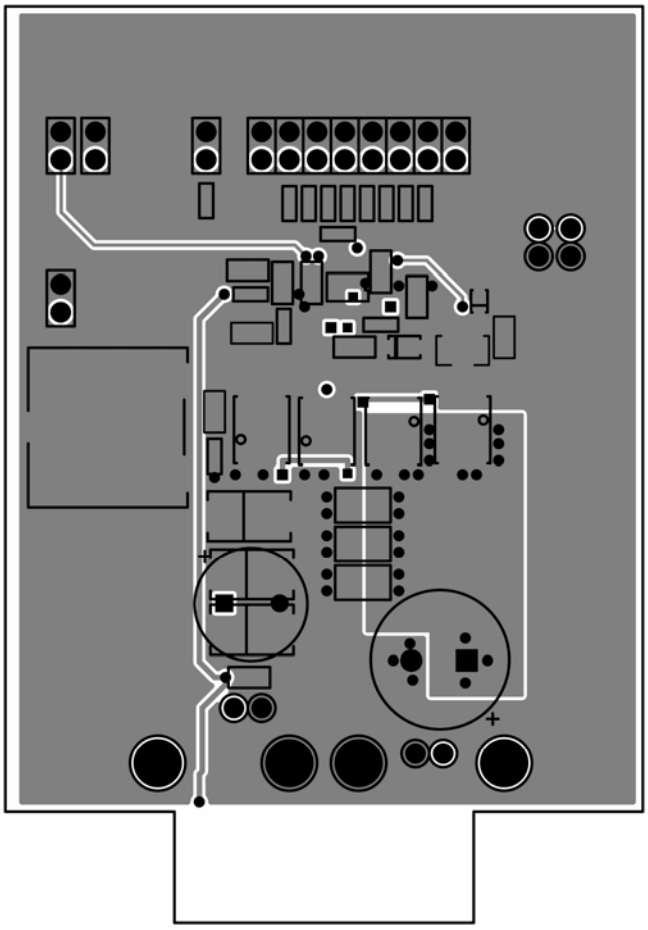
MIC2176 Evaluation Board Top Layer

Evaluation Board PCB Layout (Continued)



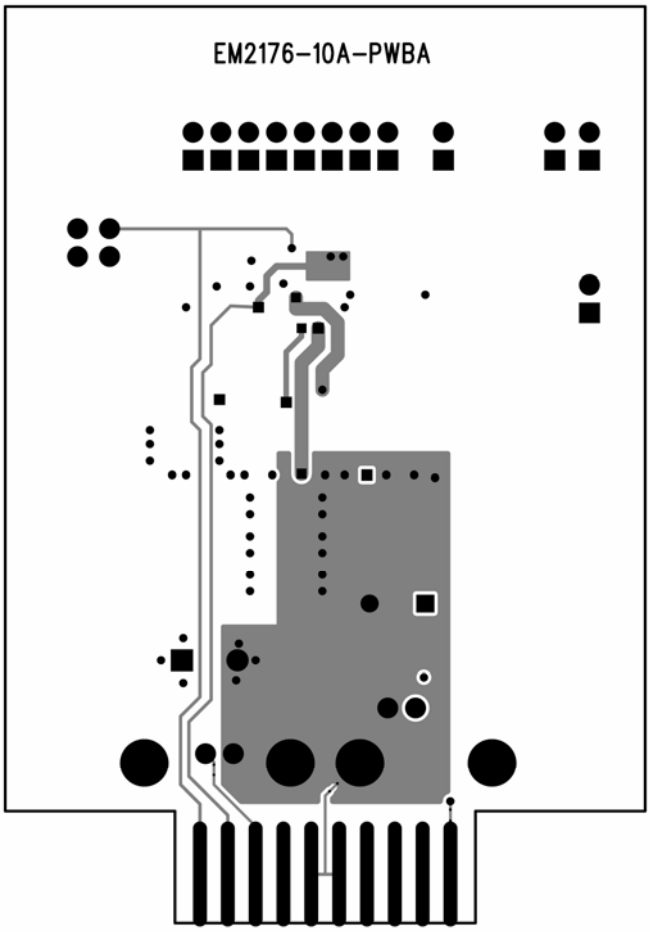
MIC2176 Evaluation Board Mid-Layer 1 (Ground Plane)

Evaluation Board PCB Layout (Continued)



MIC2176 Evaluation Board Mid-Layer 2

Evaluation Board PCB Layout (Continued)



MIC2176 Evaluation Board Bottom Layer

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