



# MIC23030 Evaluation Board

## 8MHz PWM 400mA Buck Regulator

### with HyperLight Load™

## General Description

The MIC23030 is a 400mA 8MHz switching regulator featuring HyperLight Load™ mode. The MIC23030 is highly efficient throughout the entire output current range, drawing just 21µA of quiescent current in operation. The tiny 1.6 x 1.6mm MLF® package, in combination with the 8MHz switching frequency, enables a compact sub-1mm height solution with only three external components. The MIC23030 provides accurate output voltage regulation under the most demanding conditions and responds extremely quickly to a load transient with exceptionally small output voltage ripple.

Factoring in the output current, the internal circuitry of the MIC23030 automatically selects between two modes of operation for optimum efficiency. Under light load conditions, the MIC23030 goes into HyperLight Load™ mode. HyperLight Load™ uses a Pulse-Frequency Modulation (PFM) control scheme that controls the off time at light load. This proprietary architecture reduces the amount of switching needed at light loads, thereby increasing operating efficiency. The MIC23030 attains up to 83% efficiency at 1mA output load. As the load current increases beyond approximately 100mA, the device operates using the Pulse-Width Modulation (PWM) method for up to 91% efficiency at higher loads. The two modes of operation ensure the highest efficiency across the entire load range.

The MIC23030 operates from an input voltage range of 2.7V to 5.5V and features internal power MOSFETs that deliver up to 400mA of output current. This step-down regulator provides an output voltage accuracy of +/-2.5% across the junction temperature range of -40°C to +125°C. The MIC23030 is available in fixed or adjustable versions supporting an output voltage as low as 0.7V.

## Requirements

The MIC23030 evaluation board requires an input power source that is able to deliver greater than 500mA at 2.7V to the MIC23030. The output load can either be an active (electronic) or passive (resistive) load.

## Getting Started

1. **Connect an external supply to the  $V_{IN}$  (J1) terminal.** Apply the desired input voltage to  $V_{IN}$  (J1) and ground (J2) terminals of the evaluation board, paying careful attention to polarity and supply voltage ( $2.7V \leq V_{IN} \leq 5.5V$ ). An ammeter may be placed between the input supply and the  $V_{IN}$  (J1) terminal. Be sure to monitor the supply voltage at the  $V_{IN}$  (J1) terminal, since the ammeter and/or power lead resistance can reduce the voltage supplied to the device.
2. **Connect a load to the  $V_{OUT}$  (J3) and ground terminal (J4).** The load can be either passive (resistive) or active (electronic load). An ammeter may be placed between the load and the output terminal. Ensure the output voltage is monitored at the  $V_{OUT}$  (J3) terminal.
3. **Enable the MIC23030.** The MIC23030 evaluation board has a pull-up resistor to  $V_{IN}$ . To disable the device, apply a voltage below 0.5V to the EN (J5) terminal or place a jumper on JP1 to ground the enable. In the absence of the pull-up resistor, the device is enabled by applying a voltage greater than 1.2V to the EN (J5) terminal. The enable pin must be either pulled high or low for proper operation. Removing the pull-up resistor and leaving the pin floating will cause the regulator to operate in an indeterminable state.

## Output Voltage

The MIC23030 evaluation board is available with the following output voltage options listed below:

## Ordering Information

Part Number	Description
MIC23030-AYMT EV	Adjustable Output Evaluation Board
MIC23030-CYMT EV	1.0V Fixed Output Evaluation Board
MIC23030-4YMT EV	1.2V Fixed Output Evaluation Board
MIC23030-FYMT EV	1.5V Fixed Output Evaluation Board
MIC23030-GYMT EV	1.8V Fixed Output Evaluation Board

Note: Other voltage options available on request

HyperLight Load is a trademark of Micrel, Inc. MLF is a registered trademark of Amkor Technology.

Micrel Inc. • 2180 Fortune Drive • San Jose, CA 95131 • USA • tel +1 (408) 944-0800 • fax + 1 (408) 474-1000 • <http://www.micrel.com>

### Output Voltage (Adjustable Option Only)

The output voltage of the MIC23030-AYMT regulator is determined by feedback resistors R1 and R2 whose values are calculated as follows:

$$V_{OUT} = 0.62V \times \left( \frac{R1}{R2} + 1 \right)$$

The output on the evaluation board is by default set to 1.8V (R1=383kΩ, R2=200kΩ), but can easily be modified by removing R1 and replacing it with the value that yields the desired output voltage.

$$R1 = \left( \frac{V_{OUT}}{0.62V} - 1 \right) \times R2$$

For optimum transient response performance, R2 should be in the range of 180kΩ to 220kΩ.

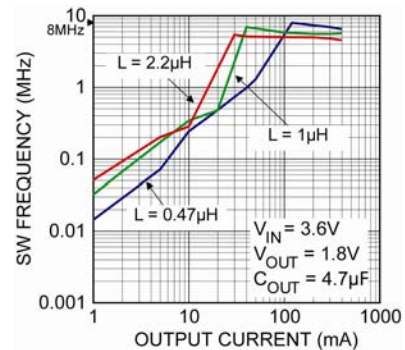
### HyperLight Load™ Mode

MIC23030 uses a patented minimum on and off time control loop at light loads. When the output voltage falls below the lower regulation threshold, the error comparator begins a switching cycle that turns the PMOS on and keeps it on for the duration of the minimum-on-time. This increases the output voltage. Once the output voltage rises to the higher regulation threshold, the error comparator turns the PMOS off for a minimum off time until the output drops down to the lower threshold. The NMOS acts as an ideal rectifier that conducts when the PMOS is off. Using a NMOS switch instead of a diode, reduces power dissipation as the current is sourced from ground. In discontinuous mode, the MIC23030 works in pulse frequency modulation (PFM) to regulate the output. As the output current increases, the off-time decreases, more energy is delivered to the output. This switching scheme improves the efficiency of MIC23030 during light load currents by activating the power FETs only as needed. As the load current increases, the MIC23030 goes into

continuous conduction mode (CCM) and switches at a frequency centered at 8MHz. The equation to calculate the load where the MIC23030 goes into continuous conduction mode is approximated by the following formula:

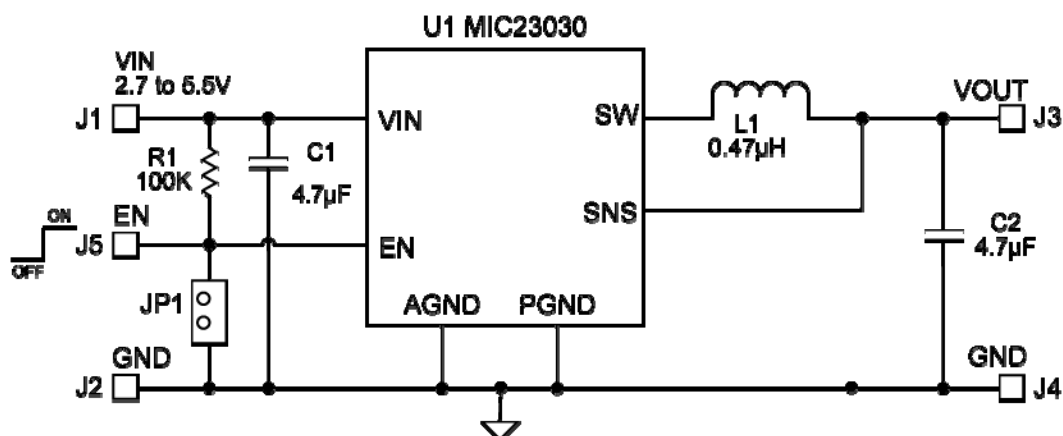
$$I_{LOAD} > \left( \frac{(V_{IN} - V_{OUT}) \times D}{2L \times f} \right)$$

As shown in the previous equation, the load at which MIC23030 transitions from HyperLight Load™ mode to PWM mode is a function of the input voltage ( $V_{IN}$ ), output voltage ( $V_{OUT}$ ), duty cycle ( $D$ ), inductance ( $L$ ) and frequency ( $f$ ). This is illustrated in the graph below. Suitable inductors for the MIC23030 range from 0.47μH to 2.2μH. The device may be tailored to enter HyperLight Load™ mode or PWM mode at a specific load current by selecting the appropriate inductor. For example, if a 2.2μH inductor is selected in a 3.6V $V_{IN}$  to 1.8V $V_{OUT}$  application, the MIC23030 will transition into PWM mode at a load of approximately 30mA. If under the same condition a 0.47μH inductor is chosen, the MIC23030 will transition into PWM mode at approximately 120mA.



**SW Frequency vs. Inductance**

### MIC23030 Typical Application Circuit (Fixed)



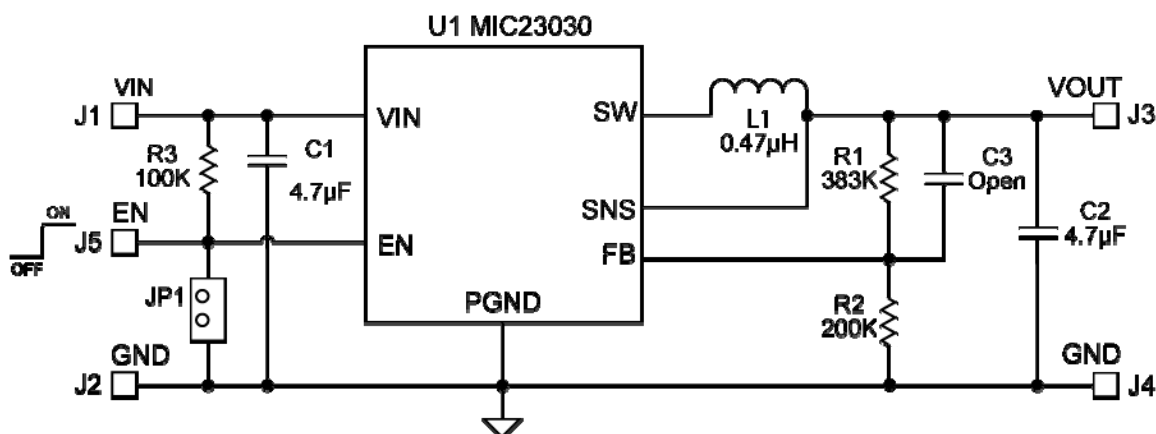
### Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1, C2	C1608X5R0J475K	TDK <sup>(1)</sup>	4.7µF Ceramic Capacitor, 6.3V, X5R, Size 0603	2
R1	CRCW06031003FT1	Vishay <sup>(2)</sup>	100kΩ, 1%, Size 0603	1
L1	LQM21PNR47M00	Murata <sup>(3)</sup>	0.47µH, 0.9A, 90mΩ, L2mm x W1.25mm x H0.5mm	1
	LQH32CNR47M33	Murata <sup>(3)</sup>	0.47µH, 1.1A, 42mΩ, L3.2mm x W2.5mm x H2.0mm	
	LQM31PNR47M00	Murata <sup>(3)</sup>	0.47µH, 1.4A, 80mΩ, L3.2mm x W1.6mm x H0.85mm	
	GLF251812T1R0M	TDK <sup>(1)</sup>	1µH, 0.8A, 100mΩ, L2.5mm x W1.8mm x H1.35mm	
	MIPF2520D1R5	FDK <sup>(4)</sup>	1.5µH, 1.5A, 70mΩ, L2.5mm x W2mm x H1.0mm	
	EPL2010-471	Coilcraft <sup>(5)</sup>	0.47µH, 1.6A, 40mΩ, L2.0mm x W1.8mm x H1.0mm	
U1	MIC23030-xYMT	Micrel, Inc. <sup>(6)</sup>	8MHz 400mA Buck Regulator with HyperLight Load™ Mode	1

**Notes:**

1. TDK: [www.tdk.com](http://www.tdk.com)
2. Vishay: [www.vishay.com](http://www.vishay.com)
3. Murata: [www.murata.com](http://www.murata.com)
4. FDK: [www.fdk.co.jp](http://www.fdk.co.jp)
5. Coilcraft: [www.coilcraft.com](http://www.coilcraft.com)
6. Micrel, Inc.: [www.micrel.com](http://www.micrel.com)

### MIC23030 Typical Application Circuit (Adjustable 1.8V)



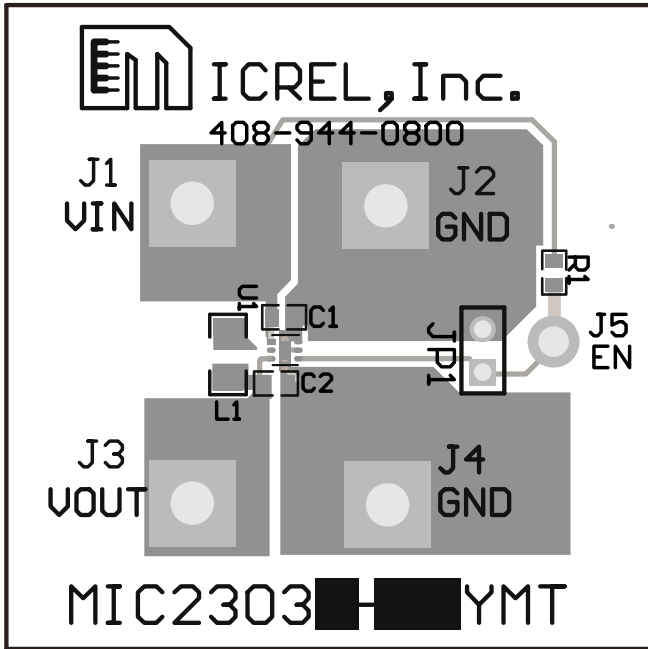
### Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1, C2	C1608X5R0J475K	TDK <sup>(1)</sup>	4.7μF Ceramic Capacitor, 6.3V, X5R, Size 0603	2
C3				OPEN
R1	CRCW06033833FT1	Vishay <sup>(2)</sup>	383kΩ, 1%, Size 0603	1
R2	CRCW06032003FT1	Vishay <sup>(2)</sup>	200kΩ, 1%, Size 0603	1
R3	CRCW06031003FT1	Vishay <sup>(2)</sup>	100kΩ, 1%, Size 0603	1
L1	LQM21PNR47M00	Murata <sup>(3)</sup>	0.47μH, 0.9A, 90mΩ, L2mm x W1.25mm x H0.5mm	1
	LQH32CNR47M33	Murata <sup>(3)</sup>	0.47μH, 1.1A, 42mΩ, L3.2mm x W2.5mm x H2.0mm	
	LQM31PNR47M00	Murata <sup>(3)</sup>	0.47μH, 1.4A, 80mΩ, L3.2mm x W1.6mm x H0.85mm	
	GLF251812T1R0M	TDK <sup>(1)</sup>	1μH, 0.8A, 100mΩ, L2.5mm x W1.8mm x H1.35mm	
	MIPF2520D1R5	FDK <sup>(4)</sup>	1.5μH, 1.5A, 70mΩ, L2.5mm x W2mm x H1.0mm	
	EPL2010-471	Coilcraft <sup>(5)</sup>	0.47μH, 1.6A, 40mΩ, L2.0mm x W1.8mm x H1.0mm	
U1	MIC23030-AYMT	Micrel, Inc. <sup>(6)</sup>	8MHz 400mA Buck Regulator with HyperLight Load™ Mode	1

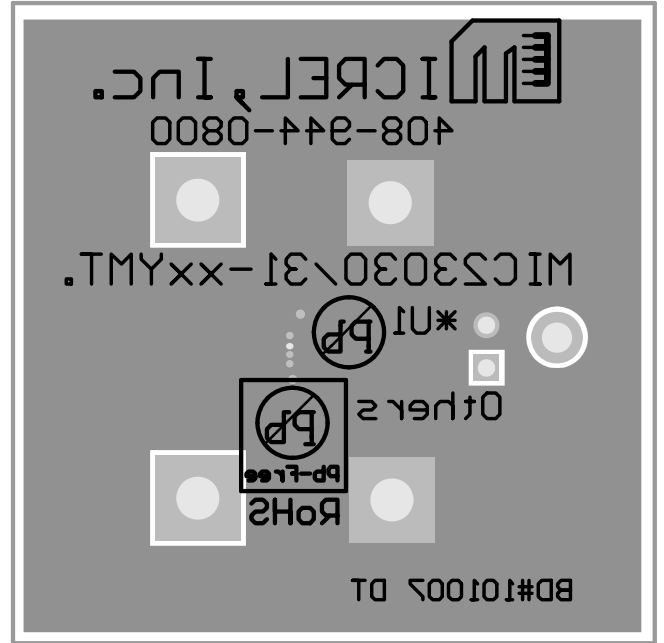
**Notes:**

1. TDK: [www.tdk.com](http://www.tdk.com)
2. Vishay: [www.vishay.com](http://www.vishay.com)
3. Murata: [www.murata.com](http://www.murata.com)
4. FDK: [www.fdk.co.jp](http://www.fdk.co.jp)
5. Coilcraft: [www.coilcraft.com](http://www.coilcraft.com)
6. Micrel, Inc.: [www.micrel.com](http://www.micrel.com)

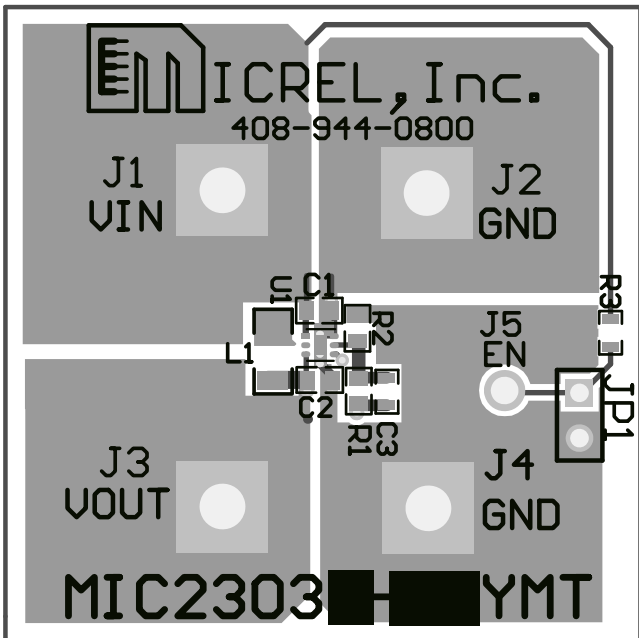
### PCB Layout Recommendations



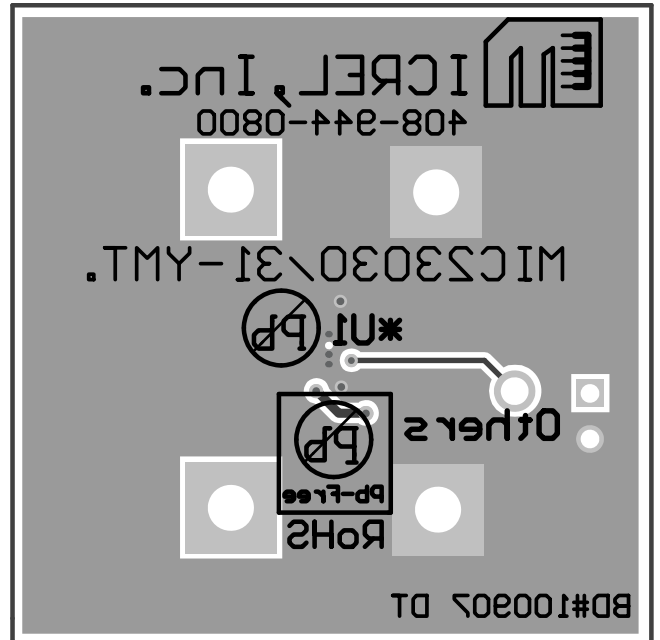
Fixed Top Layer



Fixed Bottom Layer

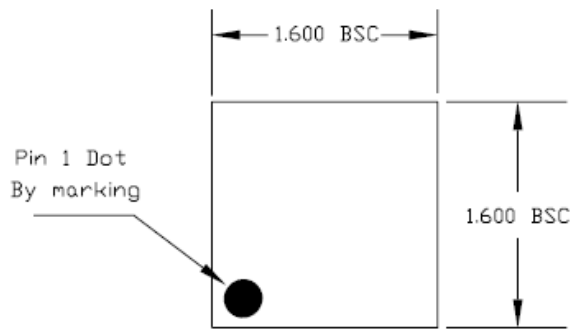


Adjustable Top Layer

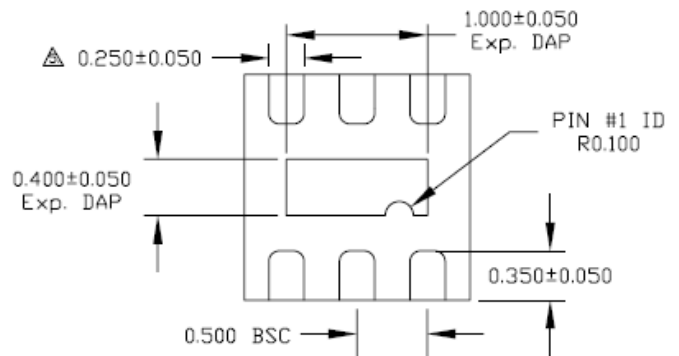


Adjustable Bottom Layer

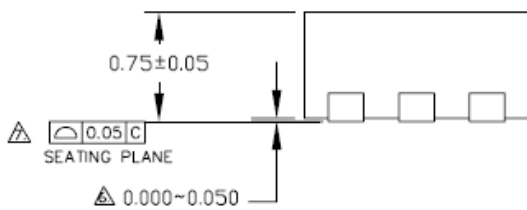
## Package Information



TOP VIEW



BOTTOM VIEW



SIDE VIEW

**NOTE:**

1. ALL DIMENSIONS ARE IN MILLIMETERS.
  2. MAX. PACKAGE WARPAGE IS 0.05 mm.
  3. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.
  4. PIN #1 ID ON TOP WILL BE LASER/INK MARKED.
- ⚠ DIMENSION APPLIES TO METALIZED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25 mm FROM TERMINAL TIP.  
 APPLIED ONLY FOR TERMINALS.
- ⚠ APPLIED FOR EXPOSED PAD AND TERMINALS.

**6-pin 1.6mm x 1.6mm Thin MLF<sup>®</sup> (MT)**

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