



# MIC23031 Evaluation Board

## 4MHz PWM 400mA Buck Regulator with HyperLight Load™

### General Description

The MIC23031 is a 400mA 4MHz switching regulator featuring HyperLight Load™ mode. The MIC23031 is highly efficient throughout the entire output current range, drawing just 21µA of quiescent current in operation. The tiny 1.6mm × 1.6mm MLF® package in combination with the 4MHz switching frequency enables a compact sub-1mm height solution with only three external components. The MIC23031 provides accurate output voltage regulation under the most demanding conditions responding extremely quickly to a load transient with exceptionally small output voltage ripple.

Factoring in the output current, the internal circuitry of the MIC23031 automatically selects between two modes of operation for optimum efficiency. Under light load conditions, the MIC23031 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 MIC23031 attains up to 88% 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 93% efficiency at higher loads. The two modes of operation ensure the highest efficiency across the entire load range.

The MIC23031 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 MIC23031 is available in fixed or adjustable versions supporting an output voltage as low as 0.7V.

Datasheets and support documentation can be found on Micrel's web site at [www.micrel.com](http://www.micrel.com).

### Requirements

The MIC23031 evaluation board requires an input power source that is able to deliver greater than 500mA at 2.7V to the MIC23031. The output load can either be an active (electronic) or passive (resistive) load.

### Getting Started

1. **Connect an external supply to the V<sub>IN</sub> (J1) terminal.** Apply the desired input voltage to V<sub>IN</sub> (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<sub>IN</sub> (J1) terminal. Be sure to monitor the supply voltage at the V<sub>IN</sub> (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<sub>OUT</sub> (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<sub>OUT</sub> (J3) terminal.
3. **Enable the MIC23031.** The MIC23031 evaluation board has a pull-up resistor to V<sub>IN</sub>. 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 (EN). 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 EN pin must be either pulled high or low for proper operation. Removing the pull-up regulator to operate in an indeterminable state.

### Output Voltage

The MIC23031 evaluation board is available with the output voltage options listed in the Ordering Information table.

### Ordering Information

Part Number	Description
MIC23031-AYMT EV	Adjustable-Output Evaluation Board
MIC23031-CYMT EV	1.0V Fixed-Output Evaluation Board
MIC23031-4YMT EV	1.2V Fixed-Output Evaluation Board
MIC23031-FYMT EV	1.5V Fixed-Output Evaluation Board
MIC23031-GYMT EV	1.8V Fixed-Output Evaluation Board

**Note:** Other voltage options available upon request.

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**Output Voltage (Adjustable Option Only)**

The output voltage of the MIC23031-AYMT regulator is determined by feedback resistors R1 and R2 whose values are calculated in Equation 1:

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

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.

$$R1 = \left( \frac{V_{OUT}}{0.62V} - 1 \right) \times R2 \tag{Eq. 2}$$

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

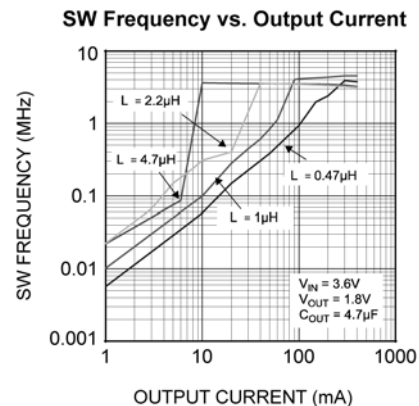
**HyperLight Load™ Mode**

MIC23031 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 current is sourced from ground. In discontinuous mode, the MIC23031 works in PFM to regulate the output. As the output current increases, the off-time decreases, therefore more energy is delivered to the output. This switching scheme improves the efficiency of the MIC23031 during light load currents by activating the power FETs only as needed. As the load current increases, the MIC23031 goes into continuous conduction mode (CCM) and switches at a

frequency centered at 4MHz. Equation 3 calculates the load where the MIC23031 goes into continuous conduction mode:

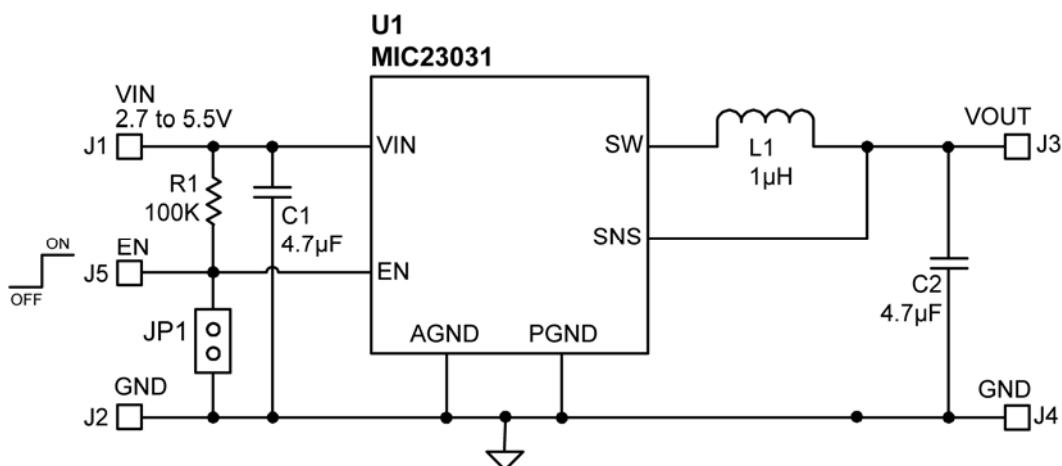
$$I_{LOAD} > \left( \frac{(V_{IN} - V_{OUT}) \times D}{2L \times f} \right) \tag{Eq. 3}$$

As shown in Equation 3, the load at which the MIC23031 transitions from HyperLight Load™ mode to PWM mode is a function of the input voltage (V<sub>IN</sub>), output voltage (V<sub>OUT</sub>), duty cycle (D), inductance (L), and frequency (f) (see Figure 1). Suitable inductors for the MIC23031 range from 0.47μH to 4.7μH. 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 4.7μH inductor is selected in a 3.6V<sub>IN</sub> to 1.8V<sub>OUT</sub> application, the MIC23031 will transition into PWM mode at a load of approximately 5mA. If, under the same conditions, a 1μH inductor is chosen, the MIC23031 will transition into PWM mode at approximately 70mA.



**Figure 1. MIC23031 SW Frequency vs. Output Current**

## MIC23031 Typical Application Circuit (Fixed)



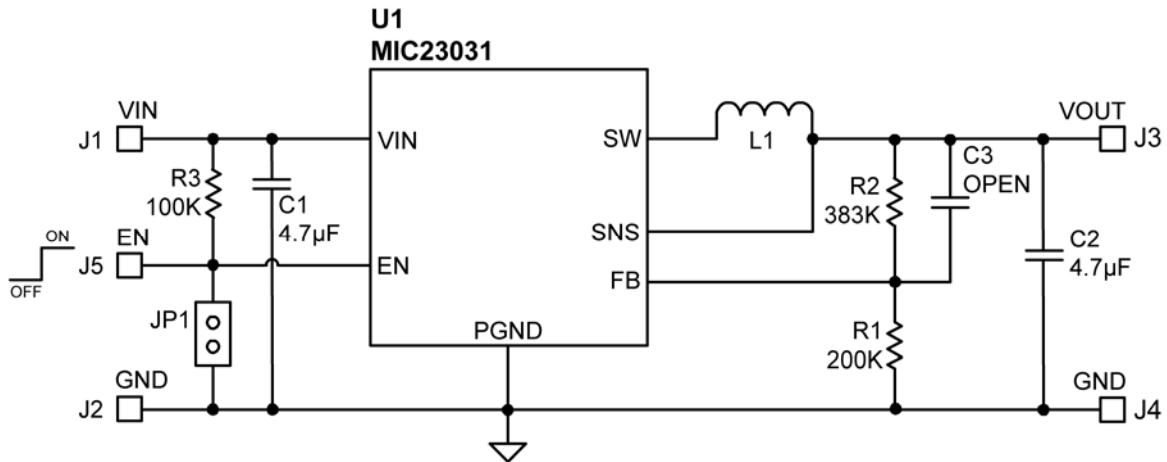
### Bill of Materials

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	LQM21PN1R0MC0D	Murata <sup>(3)</sup>	1μH, 0.8A, 190mΩ, L2mm × W1.25mm × H0.5mm	1
	LQH32CN1R0M33	Murata <sup>(3)</sup>	1μH, 1A, 60mΩ, L3.2mm × W2.5mm × H2.0mm	
	LQM31PN1R0M00	Murata <sup>(3)</sup>	1μH, 1.2A, 120mΩ, L3.2mm × W1.6mm × H0.85mm	
	LQM31PNR47M00	Murata <sup>(3)</sup>	0.47μH, 1.4A, 80mΩ, L3.2mm × W1.8mm × H0.85mm	
	GLF251812T1R0M	TDK <sup>(1)</sup>	1μH, 0.8A, 100mΩ, L2.5mm × W1.8mm × H1.2mm	
	MIPF2520D1R5	FDK <sup>(4)</sup>	1.5μH, 1.5A, 70mΩ, L2.5mm × W2mm × H1mm	
	EPL2010-102	Coilcraft <sup>(5)</sup>	1μH, 1A, 86mΩ, L2mm × W1.8mm × H1mm	
U1	MIC23031-xYMT	Micrel, Inc. <sup>(6)</sup>	4MHz 400mA Fixed-Output Buck Regulator with HyperLight Load™ Mode	1

#### Notes:

1. TDK: [www.onsemiconductor.com](http://www.onsemiconductor.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).

### MIC23031 Typical Application Circuit (Adjustable 1.8V)



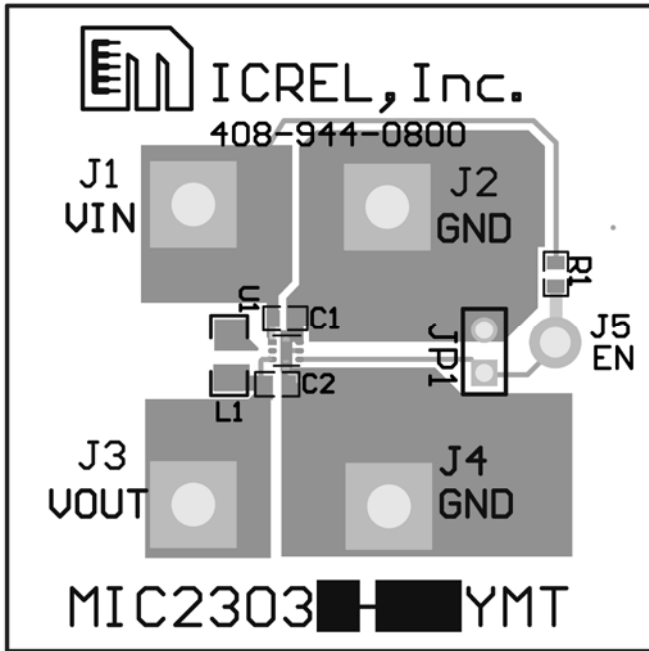
### Bill of Materials

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	LQM21PN1R0MC0D	Murata <sup>(3)</sup>	1μH, 0.8A, 190mΩ, L2mm × W1.25mm × H0.5mm	1
	LQH32CN1R0M33	Murata <sup>(3)</sup>	1μH, 1A, 60mΩ, L3.2mm × W2.5mm × H2.0mm	
	LQM31PN1R0M00	Murata <sup>(3)</sup>	1μH, 1.2A, 120mΩ, L3.2mm × W1.6mm × H0.85mm	
	LQM31PNR47M00	Murata <sup>(3)</sup>	0.47μH, 1.4A, 80mΩ, L3.2mm × W1.8mm × H0.85mm	
	GLF251812T1R0M	TDK <sup>(1)</sup>	1μH, 0.8A, 100mΩ, L2.5mm × W1.8mm × H1.2mm	
	MIPF2520D1R5	FDK <sup>(4)</sup>	1.5μH, 1.5A, 70mΩ, L2.5mm × W2mm × H1mm	
	EPL2010-102	Coilcraft <sup>(5)</sup>	1μH, 1A, 86mΩ, L2mm × W1.8mm × H1mm	
U1	MIC23031-AYMT	Micrel, Inc. <sup>(6)</sup>	4MHz 400mA Fixed-Output Buck Regulator with HyperLight Load™ Mode	1

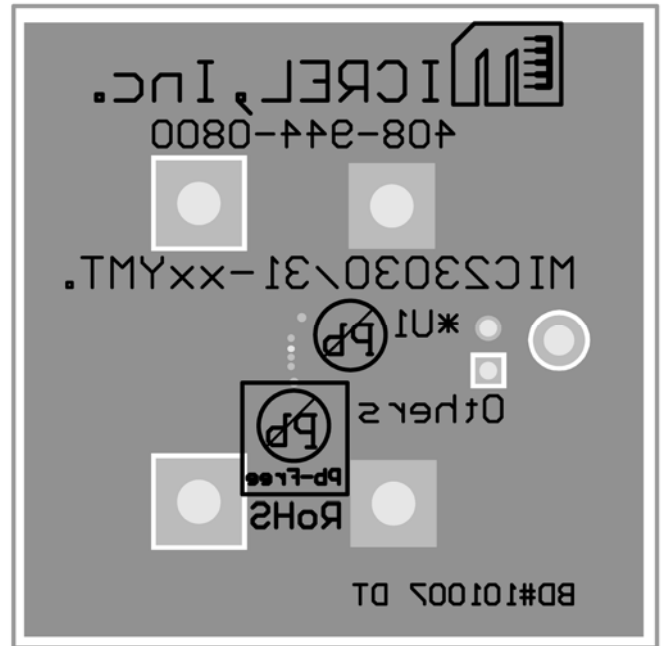
**Notes:**

1. TDK: [www.onsemiconductor.com](http://www.onsemiconductor.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).

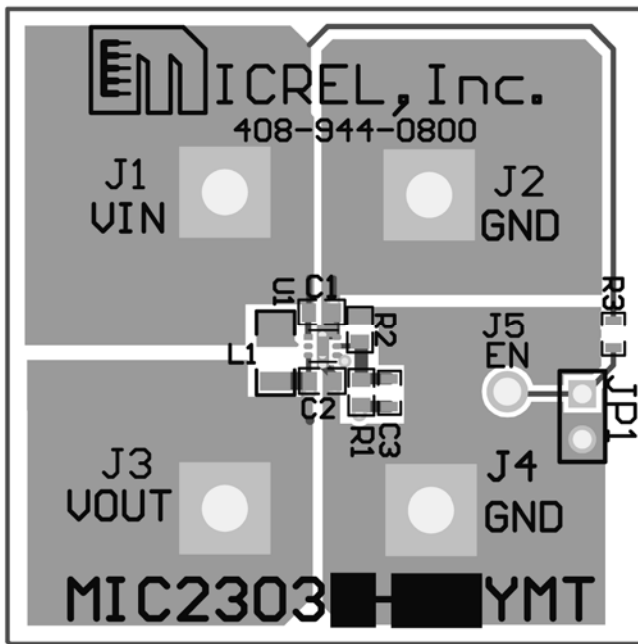
### PCB Layout Recommendations



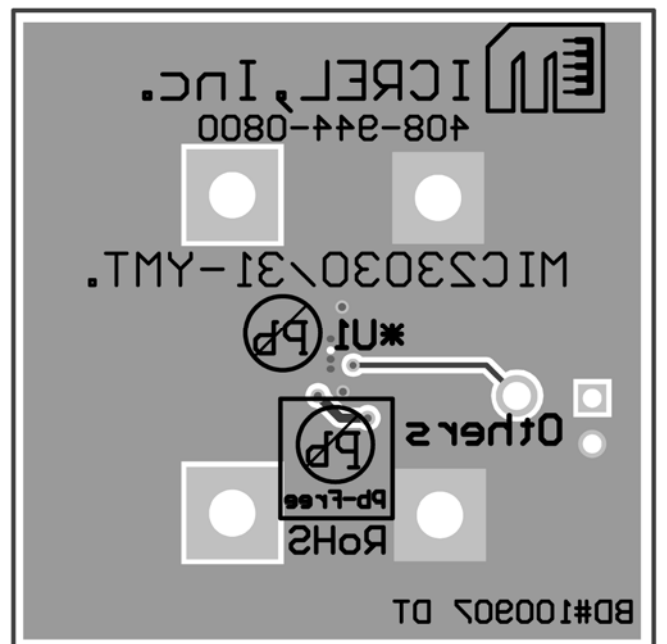
Fixed Top Layer



Fixed Bottom Layer

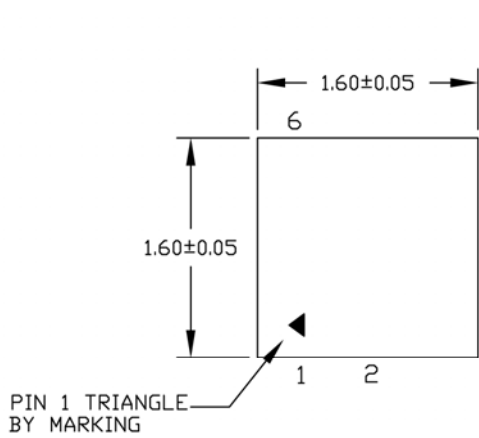


Adjustable Top Layer

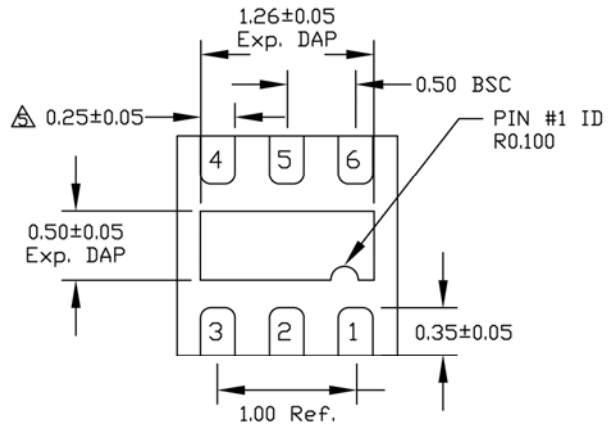


Adjustable Bottom Layer

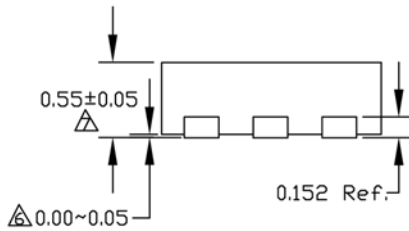
**Bill of Materials**



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.

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