MIC2238 Evaluation Board

Dual 800mA/800mA 2.5MHz Step-Down Converter with Trickle Mode™ and PGOOD Sequencing

General Description

The Micrel MIC2238 is a dual 800mA output 2.5MHz PWM synchronous step-down switching regulator with Trickle Mode™ and output sequencing using PGOOD (Power Good Output). The MIC2238 is an efficient switching regulator that only draws 28µA of quiescent current and is capable of providing 800mA on both channels with outputs adjustable to 0.8 volt. The MIC2238 is a switching step-down converter that comes in a small package (3mm x 3mm) and can do the job of two switching regulators.

The MIC2238 has two modes of operation. It may be set to Pulse-Width Modulation (PWM) mode to operate at a constant frequency of 2.5MHz or Trickle Mode™ using the FPWM pin. Under light load conditions, from 1mA to 100mA, Trickle Mode™ uses a PFM control scheme and a constant 10µA input to output current to constantly charge the output capacitor. This reduces the amount of switching needed at light loads and ultimately leads to higher efficiency. When the load is more than 100mA, the MIC2238 automatically switches back to PWM mode to ensure high efficiency at higher loads. As a result of setting the MIC2238 to Trickle Mode™, high efficiency is maintained throughout the load range.

Start-up sequencing may be done by MIC2238 via the PGOOD pin. When output voltage 1 is within +6.25% or -8.25% of regulation, the PGOOD pin becomes high through a 5µA current source. An output capacitor may be used at PGOOD to control the slew rate of PGOOD becoming high. When the PGOOD pin is tied to the enable of regulator 2, it will enable regulator 2 once regulator 1 maintains regulation. This ensures that regulator 1 turns on before regulator 2. The delay time between regulator 1 and regulator 2 may be set by the capacitor at the PGOOD pin.

The MIC2238 operates from a 2.5V to 5.5V input and features internal power MOSFETs that can supply up to 800mA of output current on each channel. It can operate with a maximum duty cycle of 100% for use in low-dropout conditions.

Requirements

The MIC2238 evaluation board requires an input power source that is able to deliver greater than 1.8A at 2.5V. The output load can either be an active or passive source.

Getting Started

1. **Connect an external supply to V_{IN} terminal**. Apply desired input voltage to the V_{IN} and ground terminals of the evaluation board, paying careful attention to polarity and supply voltage ($2.5V \le V_{IN} \le 5.5V$). An ammeter may be placed between the input supply and the V_{IN} terminal to the evaluation board. Be sure to monitor the supply voltage at the V_{IN} terminal. The ammeter and/or power lead resistance can reduce the voltage supplied to the input.

2. **Connect loads to the Vo1 and Vo2 output and ground terminals**. The load can be either passive (resistive) or active (electronic load). An ammeter can be placed between the loads and the output terminals. Ensure the output voltages are monitored at Vo1 and Vo2 terminals. Both the default output voltages are set to 1.8V. Output voltage can be adjusted by changing the feedback resistors. (See **Output Voltage**)

3. **Setting Trickle or FPWM mode**. To select Trickle Mode™, use the jumper (JP1) to connect the /FPWM pin to Vin. To select PWM mode, connect the /FPWM pin to ground using the jumper (JP1).

4. **Enable the MIC2238**. Apply a 1.2V or greater voltage source to the enable pins EN1 and EN2.

Ordering Information

Part Number	Description
MIC2238-AAYML EV	Adjustable Output Evaluation Board
MIC2238-521YML EV	Vout1=1.28V, Vout2=1.65V 3x3 MLF® Evaluation Board
MIC2238-G4YML EV	Vout1=1.8V, Vout2=1.2V 3x3 MLF® Evaluation Board
MIC2238-GF9YML EV	Vout1=1.8V, Vout2=1.545V 3x3 MLF® Evaluation Board
MIC2238-GFHYML EV	Vout1=1.8V, Vout2=1.575V 3x3 MLF® Evaluation Board
MIC2238-GSYML EV	Vout1=1.8V, Vout2=3.3V 3x3 MLF® Evaluation Board
MIC2238-GWYML EV	Vout1=1.8V, Vout2=1.6V 3x3 MLF® Evaluation Board
MIC2238-J4YML EV	Vout1=2.5V, Vout2=1.2V 3x3 MLF® Evaluation Board
MIC2238-S4YML EV	Vout1=3.3V, Vout2=1.2V 3x3 MLF® Evaluation Board
MIC2238-SSYML EV	Vout1=3.3V, Vout2=3.3V 3x3 MLF® Evaluation Board

Output Voltage

Both the output voltages, Vo1 and Vo2 on the MIC2238 evaluation board are adjustable. The output voltages are controlled by the feedback resistors (R1, R2 and R3, R4) and can be calculated as follows: R1 and R3 is 549kΩ on the evaluation board.

$$Vo1 = 0.8V \times \left(\frac{R1}{R2} + 1\right)$$

$$Vo2 = 0.8V \times \left(\frac{R3}{R4} + 1\right)$$

Both the outputs on the evaluation board are initially adjusted to 1.8V, but can easily be modified by removing R2 and R4 and replacing it with the value that yields the desired output voltage. (Removing R2 or R4 sets the output voltage of Vo1 and Vo2 to 0.8V, respectively).

$$R2 = \frac{R1}{\left(\frac{Vo1}{0.8V} - 1\right)}$$

$$R4 = \frac{R3}{\left(\frac{Vo2}{0.8V} - 1\right)}$$

PGOOD

The PGOOD is pulled down unless the regulator 1 output voltage is within +6.25% or -8.5% of regulation. After output voltage 1 is in regulation, the PGOOD pin starts to go high with an internal 5µA current source. A delay time could be programmed by tying a capacitor to this pin. Using the circuit in Figure 1, if the NFET is off and the input voltage is at 5 volts, a 390pF external capacitor at the PGOOD pin will cause the PGOOD pin voltage to rise from low to high in around 390µs. The MIC2238 evaluation board has a 390pF capacitor (C3) at the PGOOD pin. The PGOOD capacitor (C3) may be switched to change the time it takes for PGOOD to become high. Connecting the PGOOD pin to Enable 2 will allow the PGOOD pin to control the enabling of output voltage 2. As a result, sequencing the output voltages can be easily done. Refer to Figure 2 to see how voltage sequencing is done.

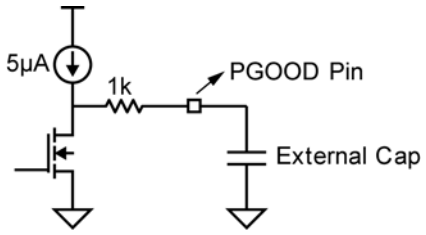


Figure 1. Power Good Circuit

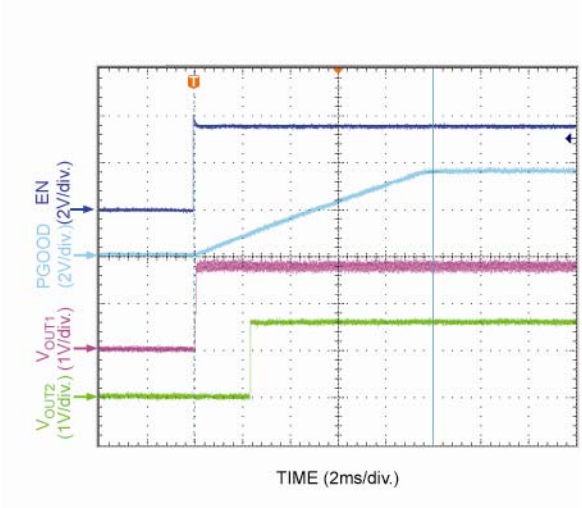


Figure 2. Power Good Sequencing

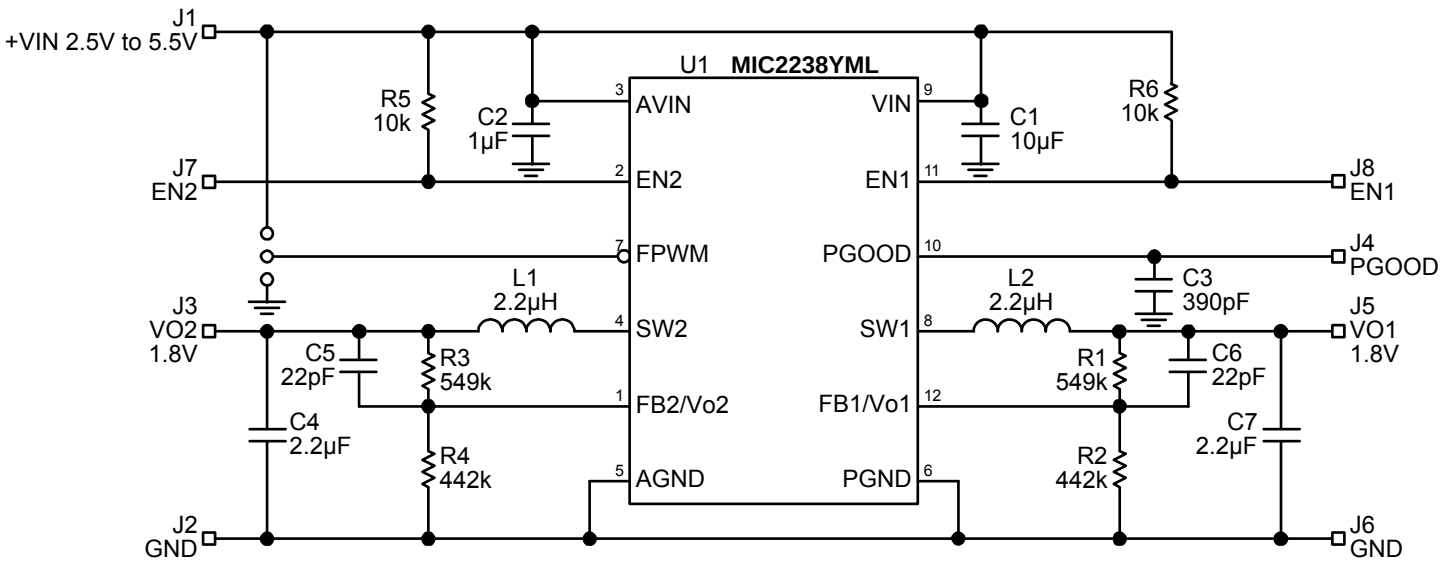
Trickle Mode™ Operation

Trickle Mode™ operation is achieved by clamping the minimum peak current to approximately 150mA. This forces a PFM mode by comparing the output voltage to the internal reference. If the voltage is less than 0.8V, then the MIC2238 turns on the high side until the peak inductor current reaches approximately 150mA. A separate comparator then monitors the output voltage. If the feedback voltage is greater than 0.8V, the high side switch is used as a 10µA current source, never turning completely off. This creates a highly efficient light load mode by increasing the time it takes for the output capacitor to discharge; thereby delaying the amount of switching required and increasing light load efficiency. When the load current is greater than approximately 100mA, the MIC2238 then automatically switches to PWM mode. Jumper JP1 can be used to set MIC2238 to Trickle Mode™ by pulling the /FPWM pin high.

FPWM Operation

The /FPWM stands for Force Pulse-Width Modulation (the back slash before the acronym means this mode is active when pulled low). When the /FPWM pin is pulled low, it will force MIC2238 into PWM mode to switch at a constant frequency of 2.5MHz with synchronous internal MOSFETs throughout the load current. In PWM Mode, the output ripple can be as low as 7mV.

MIC2238 Adjustable Option (1.8V, 1.8V)

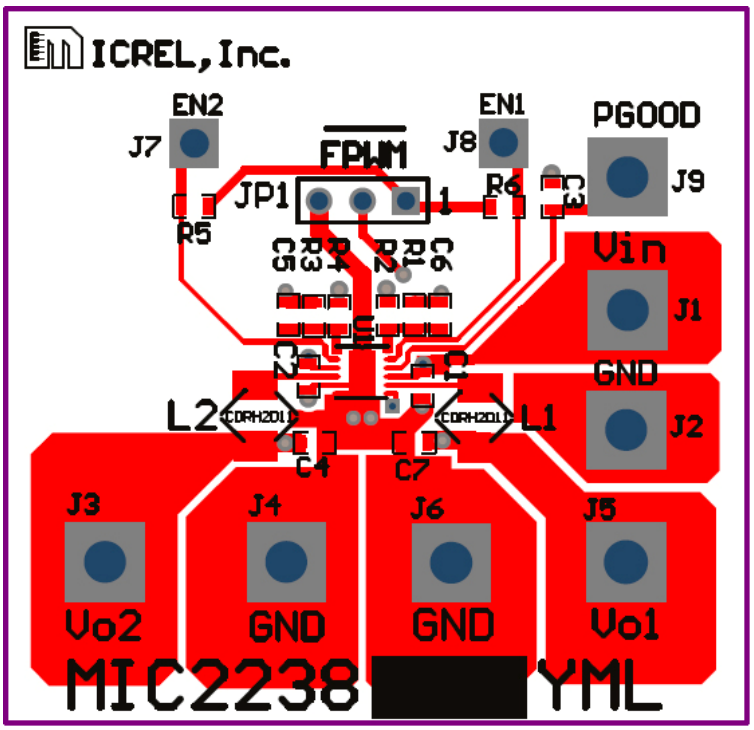


Bill of Materials

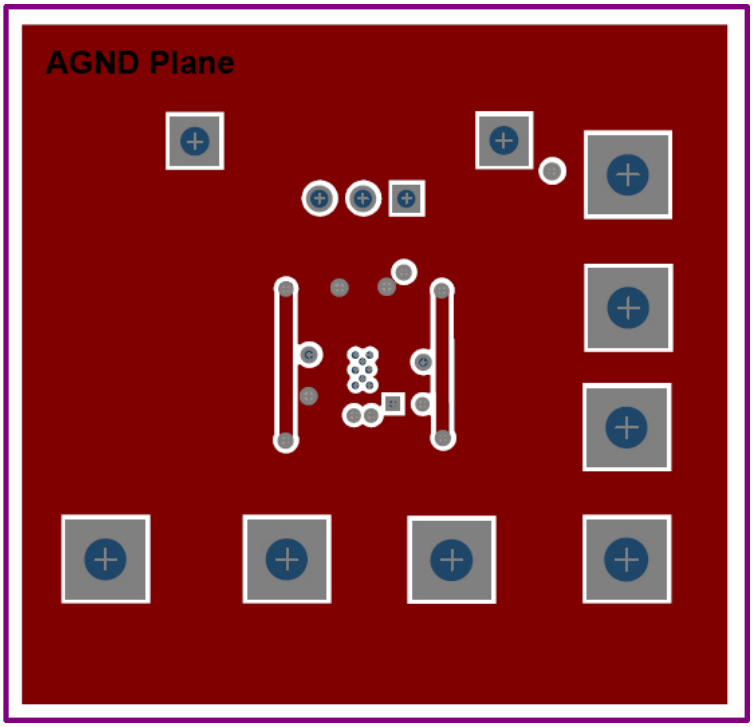
Item	Part Number	Manufacturer	Description	Qty
C1	C1608X5R0J106K	TDK	10µF Ceramic Capacitor, 6.3V, X5R, Size 0603	1
C2	C1005X5R0J105K	TDK	1µF Ceramic Capacitor, 6.3V, X5R, Size 0402	1
C3	C0603Y391KXXA	Vishay	390pF Ceramic Capacitor, 25V, X7R, Size 0603	1
C4, C7	0603ZD225MAT	AVX	2.2µF Ceramic Capacitor, 6.3V, X5R,. Size 0603	2
C5, C6	VJ0603A220KXXAT	Vishay	22pF Ceramic Capacitor, 25V, NPO, Size 0603	2
L1, L2	CDRH2D11/HPNP-2R2NC	Sumida	2.2µH, 1.1A $I_{SAT.}$, 120mΩ, (1.2mm × 3.2mm × 3.2mm)	2
	LQH43CN2R2M03	Murata	2.2µH, 900mA $I_{SAT.}$, 110mΩ, (2.6mm × 3.2mm × 4.5mm)	
	EPL2014-222MLB	Coilcraft	2.2µH, 1.3A $I_{SAT.}$, 120mΩ, (1.4mm x 1.8mm x 2.0mm)	
R2, R4	CRCW06034423FT1	Vishay	442kΩ, 1%, Size 0603	2
R1, R3	CRCW06035493FT1	Vishay	549kΩ, 1%, Size 0603	2
R5, R6	CRCW06031002FT1	Vishay	10kΩ, 1%, Size 0603	2
U1	**MIC2238-AAYML**	**Micrel**	**2.5MHz Dual Phase PWM Buck Regulator**	**1**

1. TDK: www.tdk.com
2. Murata: www.murata.com
3. Sumida: www.sumida.com
4. Coilcraft: www.coilcraft.com
5. Vishay-Dale: www.vishay.com
6. AVX: www.avx.com
7. **Micrel, Inc: www.micrel.com**

Printed Circuit Board Layouts

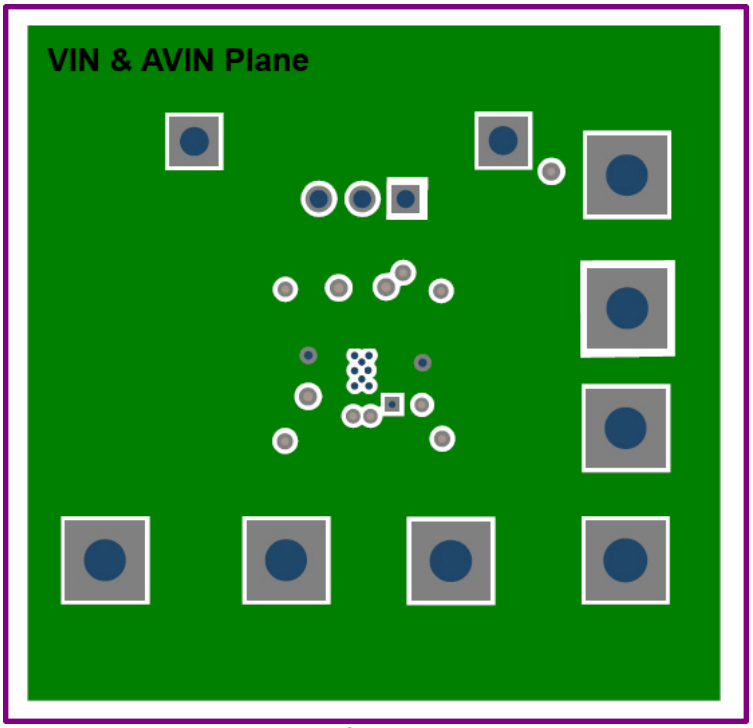


Top Layer

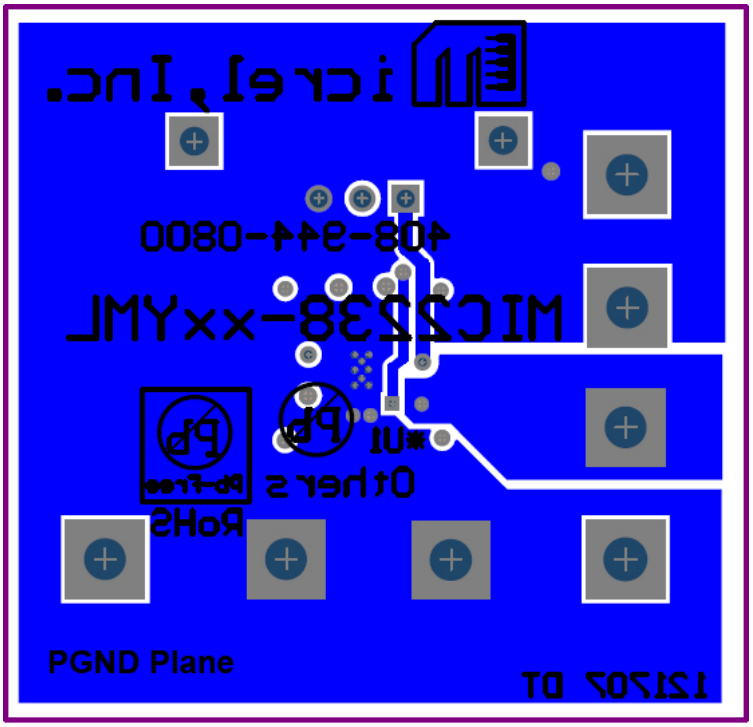


AGND Layer

Printed Circuit Board Layouts



VIN and AVIN Layer



PGND 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