MP2117

1.25MHz, 2.2A Synchronous Step-Down Switcher

The Future of Analog IC Technology

DESCRIPTION

The MP2117 is an internally compensated 2.2A synchronous step-down switcher. The operating frequency is internally set at 1.25MHz. MP2117 is ideal for powering portable equipment that runs from a single cell Lithium-Ion (Li+) Battery. The MP2117 can provide up to 2.2A continuous load current from a 2.5V to 6V input voltage. The output voltage can be regulated as low as 0.6V. 100% duty cycle provides low dropout operation that extends operating time in battery-operated systems.

The MP2117 features an integrated high-side switch and synchronous rectifier for high efficiency. With peak current mode control and internal compensation, the MP2117 can be stabilized with ceramic capacitors and small inductors. Fault condition protection includes cycle-by-cycle current limiting and thermal shutdown.

MP2117 is available in the small 10-pin 3mmx3mm QFN and SOIC-8 packages.

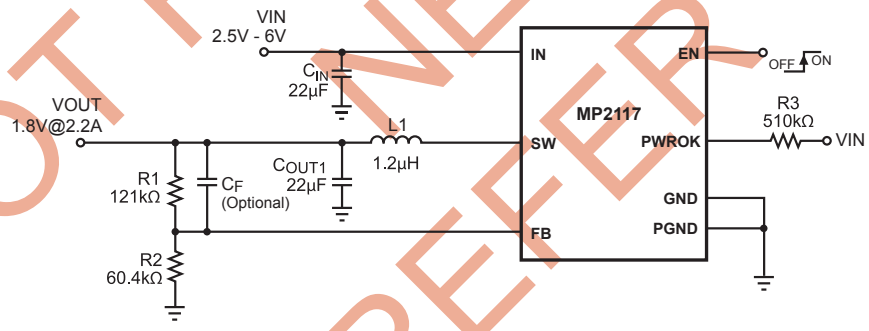
FEATURES

- 2.2A Output Current
- 2.5V to 6V Input Range V_{IN}
- Internal Power MOSFET Switches
- Low Dropout Operation: 100% Duty Cycle
- Up to 90% Efficiency
- Stable with Ceramic Output Capacitors
- 1μA Shutdown Current
- 1.25MHz Switching Frequency
- Thermal Shutdown
- Cycle-by-Cycle Over Current Protection
- Output Short Circuit Protection
- Internal Soft-start
- Power On Reset Output
- Available in 10-Pin QFN (3mmx3mm) and 8-pin SOIC Packages

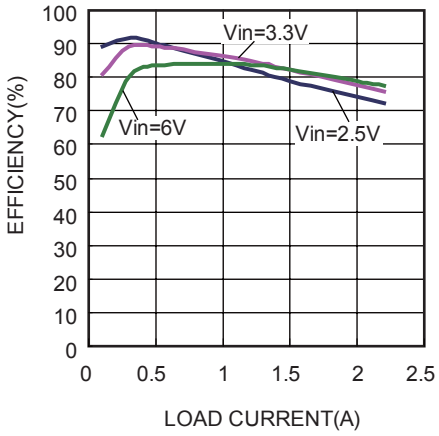
APPLICATIONS

- DVD+/-RW Drives
- LCD TV
- PDAs
- Portable Instruments

TYPICAL APPLICATION



Efficiency vs. Load Current



ORDERING INFORMATION

Part Number*	Package	Top Marking	Temperature
MP2117DQ	QFN10 (3mmx3mm)	S4	–40°C to +85°C
Part Number**	**Package**	**Top Marking**	**Temperature**
MP2117DN	SOIC8E	MP2117DN	–40°C to +85°C

*For Tape & Reel, add suffix –Z (eg. MP2117DQ–Z): For RoHS compliant packaging, add suffix –LF (eg. MP2117DQ–LF–Z). CONTACT FACTORY

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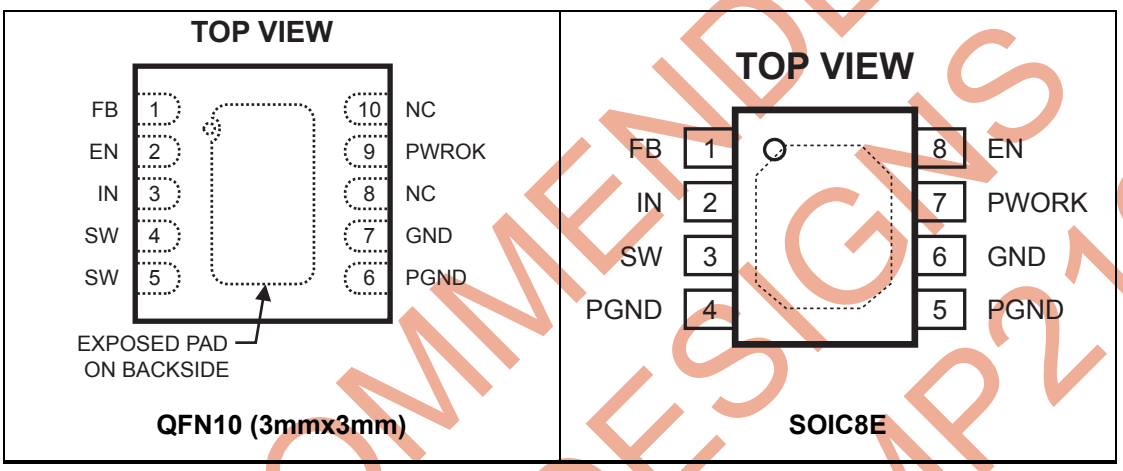
PACKAGE REFERENCE



ABSOLUTE MAXIMUM RATINGS (1)

IN to GND .....–0.3V to + 6.5V
SW to GND .....–0.3V to V_{IN} + 0.3V
.....(V_{SW} >-2.5V, Transient <50ns ; V_{SW}<+8.5V, Transient <50ns)
PWROK to GND .....–0.3V to +6.5V
FB, EN to GND .....–0.3V to +6.5V
Operating Temperature..... –40°C to +85°C
Continuous Power Dissipation (T_A = +25°C) (2)
SOIC8E..... 2.5W
QFN10 (3mm x 3mm) 2.5W
Junction Temperature .....150°C
Lead Temperature .....260°C
Storage Temperature ..... –65°C to +150°C

Recommended Operating Conditions (3)

Supply Voltage V_{IN} .....2.5V to 6V
Output Voltage V_{OUT}.....0.6V to 6V
Operating Temperature..... –40°C to +85°C

Thermal Resistance (4)

	θ_{JA}	θ_{JC}	
QFN10 (3mm x 3mm)	50	12	°C/W
SOIC8E	50	10	°C/W

Notes:

1) Exceeding these ratings may damage the device.
2) The maximum allowable power dissipation is a function of the maximum junction temperature T_J (MAX), the junction-to-ambient thermal resistance θ_{JA}, and the ambient temperature T_A. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P_D (MAX) = (T_J (MAX)-T_A)/θ_{JA}. Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
3) The device is not guaranteed to function outside of its operating conditions.
4) Measured on JESD5 1-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS (5)

V_{IN} = V_{EN} = 3.6V, T_A = +25°C, unless otherwise noted.

Parameters	Condition	Min	Typ	Max	Units
No Load Supply Current	V_{IN} = 3.6V, V_{EN}=3.6V V_{FB} = 0.65V		350	500	μA
Shutdown Current	V_{EN} = 0V, V_{IN} = 6V		0.01	1	μA
Thermal Shutdown Trip Threshold	Hysteresis = 20°C		150		°C
PWROK Upper Trip Threshold	FB with respect to the Nominal Value		10		%
PWROK Lower Trip Threshold	FB with respect to the Nominal Value		–10		%
PWROK Output Lower Voltage	I_{SINK} = 5mA			0.3	V
PWROK Deglitch Timer			50		μs
EN Trip Threshold	–40°C ≤ T_A ≤ +85°C	0.3		1.5	V
EN Pull Down Resistor			1		MΩ
IN Under Voltage Lockout Threshold	Rising Edge, Hysteresis=0.3V	1.8	2.2		V
Regulated FB Voltage	T_A = +25°C	0.584	0.596	0.608	V
	–40°C ≤ T_A ≤ +85°C	0.578	0.596	0.614	
FB Input Bias Current	V_{FB} = 0.62V	–50		+50	nA
SW PFET On Resistance	I_{SW} = 100mA		0.20		Ω
SW NFET On Resistance	I_{SW} = –100mA		0.15		Ω
SW Leakage Current	V_{EN} = 0V, V_{IN} = 6V V_{SW} = 0V or 6V	–5		+5	μA
SW PFET Peak Current Limit	Duty Cycle = 100%, Current Pulse Width < 1ms		3.3		A
Oscillator Frequency		1.00	1.25	1.50	MHz

Notes:

5) Production test at +25°C. Specifications over the temperature range are guaranteed by design and characterization.

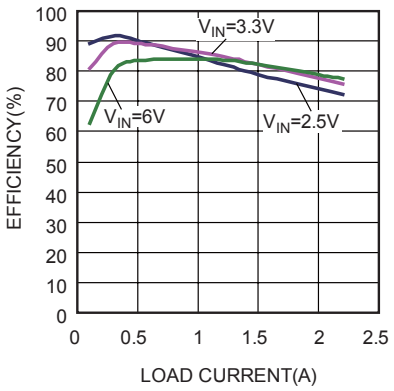
PIN FUNCTIONS

QFN Pin #	SOIC Pin #	Name	Description
1	1	FB	Feedback Input for the switcher output VOUT.
2	8	EN	Enable Input for the switcher.
3	2	IN	Input Supply Pin.
4, 5	3	SW	Switcher switch node.
6	4, 5	PGND	Low Side Synchronous Rectifier Switch Power Ground.
7	6	GND	Chip Analog Ground. Connect the Exposed Pad to GND.
9	7	PWROK	Power On Reset Open Drain Output. HIGH output indicates that the output is within ±10% of the regulation value. LOW output indicates that the output is out of ±10% window. PWROK is pulled down in shutdown. The PWROK window comparators have 50us deglitch timer to avoid false trigger during load transient.
8, 10	-	N/C	No Connection.

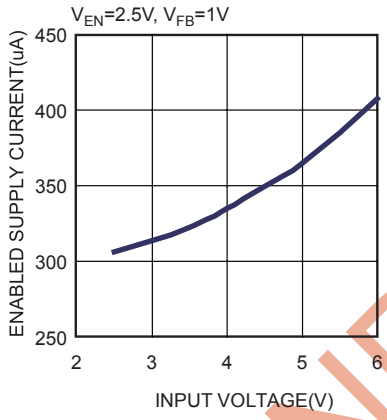
TYPICAL PERFORMANCE CHARACTERISTICS

V_{IN} = 5V, V_{OUT} = 1.8V, L=1.2uH, T_A = +25ºC, unless otherwise noted.

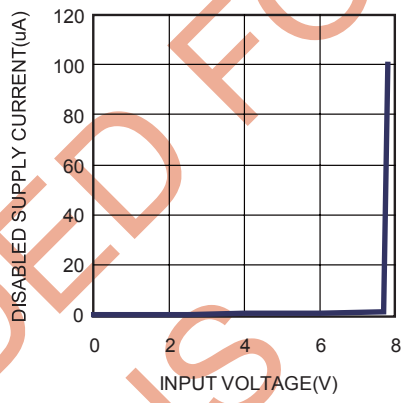
Efficiency vs. Load Current



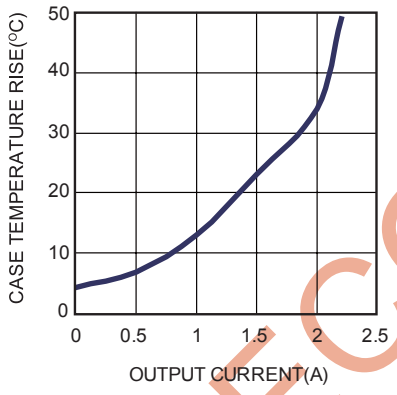
Enabled Supply Current vs. Input Voltage



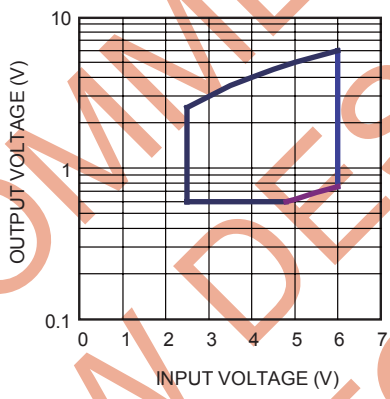
Disabled Supply Current vs. Input Voltage



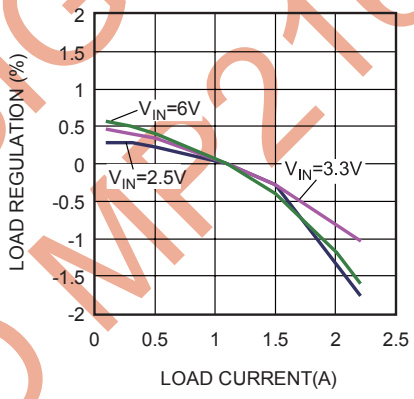
Case Temperature Rise vs. Output Current



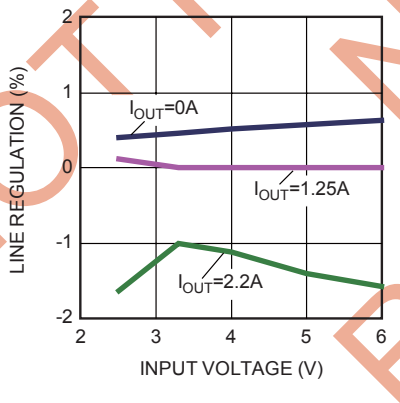
Operating Range



Load Regulation



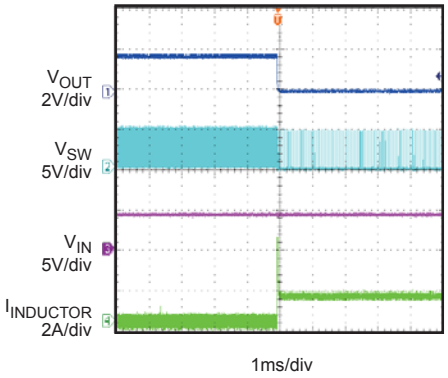
Line Regulation



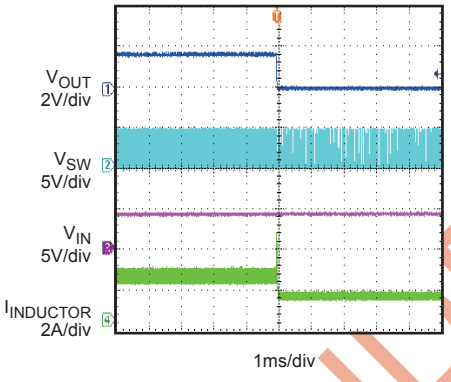
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 5V, V_{OUT} = 1.8V, L=1.2uH, T_A = +25ºC, unless otherwise noted.

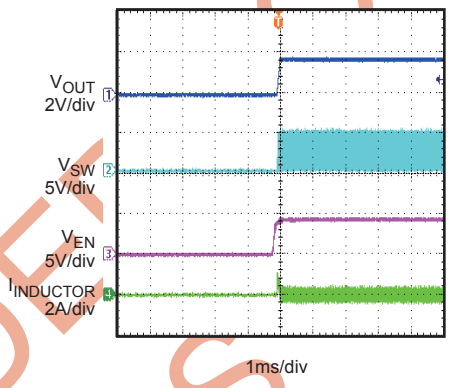
Output Short Entry
I_O=0A



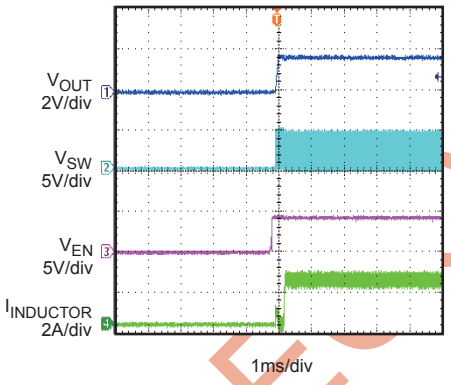
Output Short Entry
I_O=2.2A



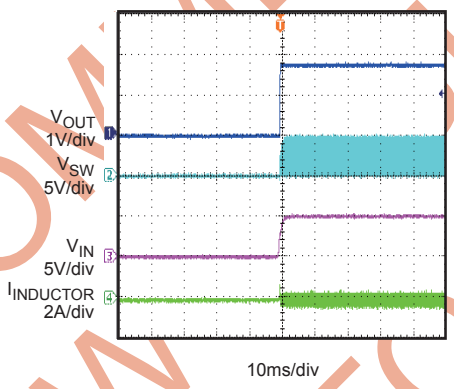
Enable Startup
I_O=0A



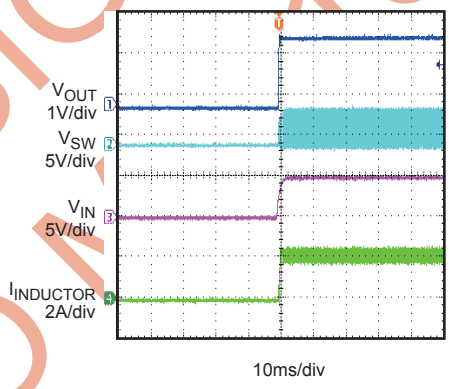
Enable Startup
I_O=2.2A



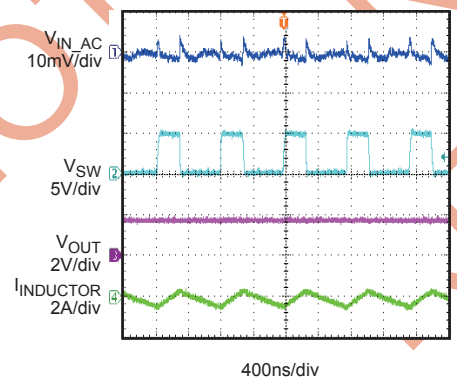
Power Up
I_O=0A



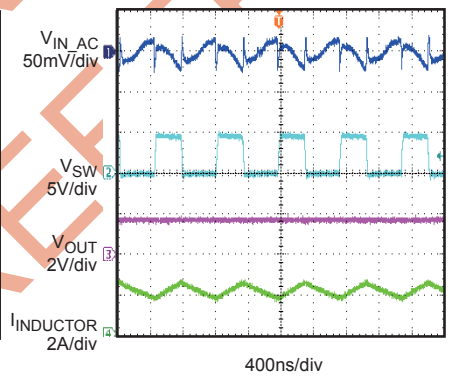
Power Up
I_O=2.2A



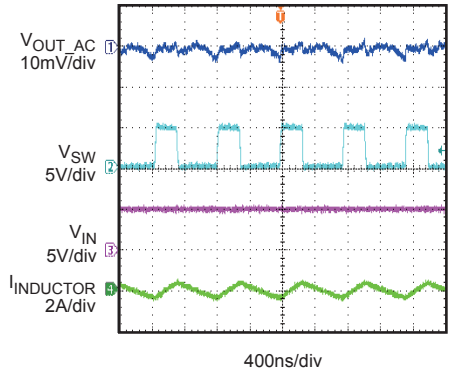
Input Ripple Voltage
I_O=0A



Input Ripple Voltage
I_O=2.2A



Output Ripple Voltage
I_O=0A

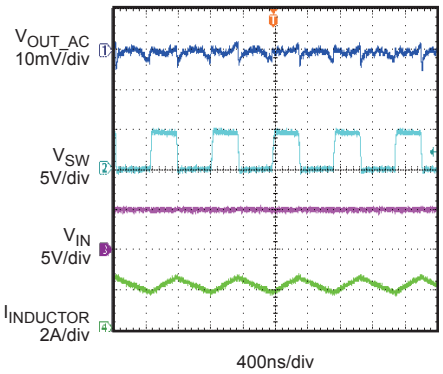


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

V_{IN} = 5V, V_{OUT} = 1.8V, L=1.2uH, T_A = +25ºC, unless otherwise noted.

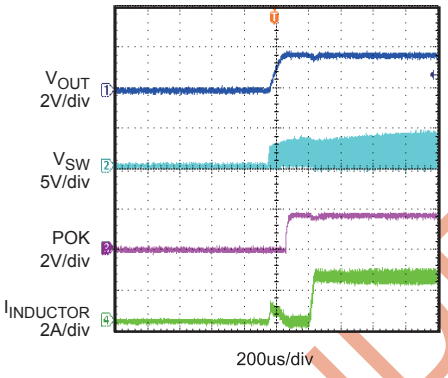
Output Ripple Voltage

I_O=2.2A



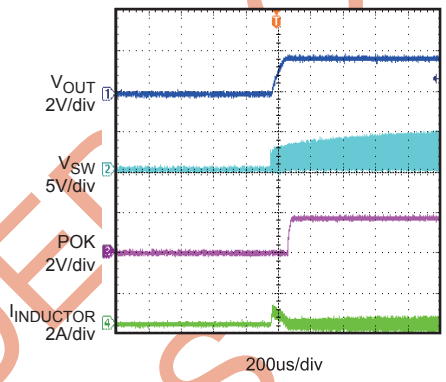
Power OK Response

I_O=2.2A



Power OK Response

I_O=0A



OPERATION

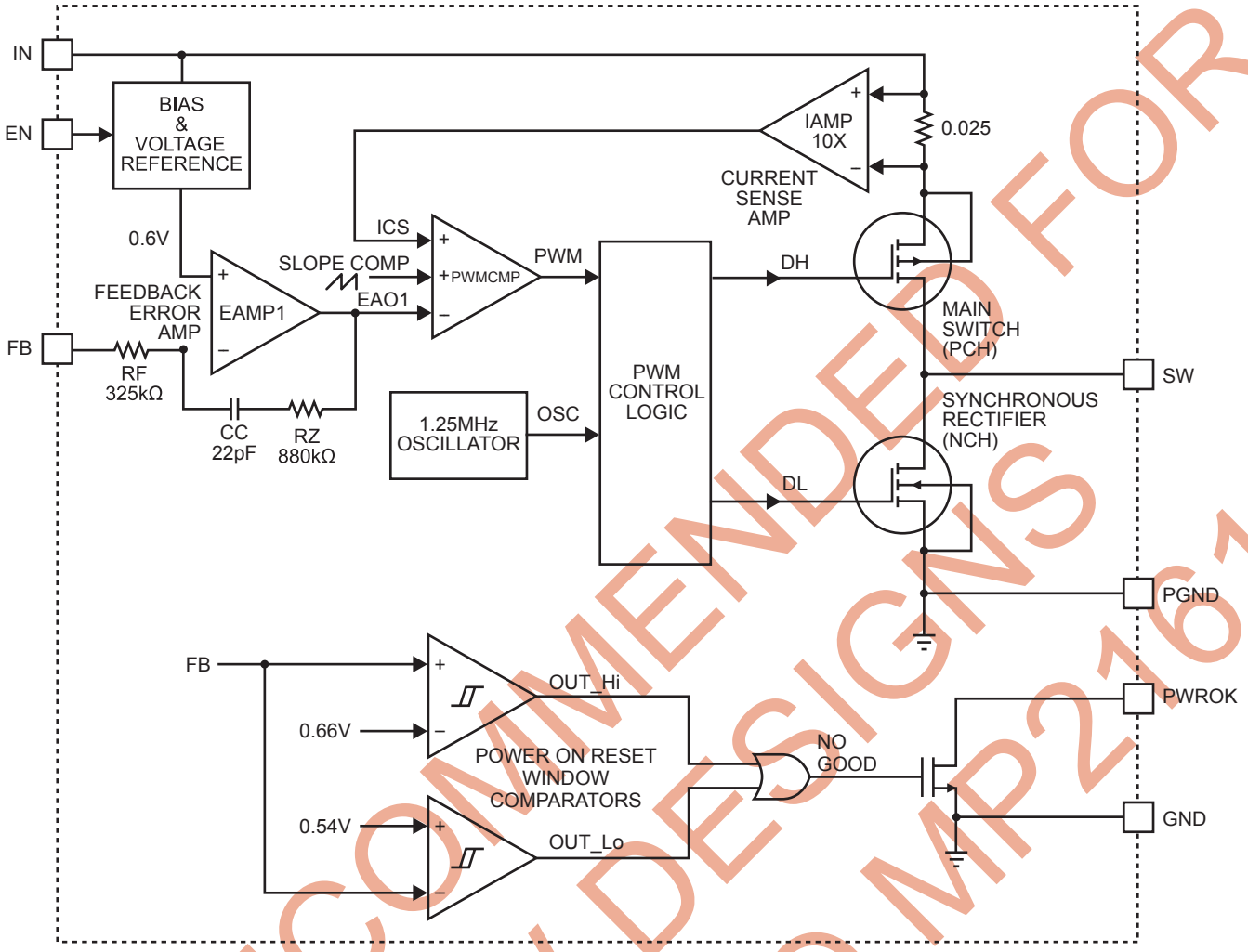


Figure 1—Functional Block Diagram

The MP2117 is a 1.25MHz fixed frequency current mode synchronous step-down switcher. The MP2117 is optimized for low voltage, Li-Ion battery powered applications where high efficiency and small size are critical. The MP2117 can provide up to 2.2A continuous load current from a 2.5V to 6V input voltage.

The MP2117 uses an external resistor divider to set the switcher output voltage from 0.6V to 6V.

2.2A Step-Down Switcher

The switcher integrates both a main switch and a synchronous rectifier, which provides high efficiency and eliminates an external Schottky diode.

The duty cycle D of a step-down switcher is defined as:

$$D = T_{ON} \times f_{OSC} \times 100\% \approx \frac{V_{OUT}}{V_{IN}} \times 100\%$$

Where T_{ON} is the main switch on time and f_{OSC} is the oscillator frequency (1.25MHz).

Current Mode PWM Control

Slope compensated current mode PWM control provides stable switching and cycle-by-cycle current limiting for superior load and line response in addition to protection of the internal main switch and synchronous rectifier. The MP2117 switches at a constant frequency (1.25MHz) and regulates the output voltage. During each cycle the PWM comparator

modulates the power transferred to the load by changing the inductor peak current based on the feedback error voltage. During normal operation, the main switch is turned on for a certain time to ramp the inductor current at each rising edge of the internal oscillator, and switched off when the peak inductor current is above the error voltage. When the main switch is off, the synchronous rectifier will be turned on immediately and stay on until the next cycle starts.

Dropout Operation

The MP2117 allows the main switch to remain on for more than one switching cycle and increases the duty cycle while the input voltage is dropping close to the output voltage. When the duty cycle reaches 100%, the main switch is held on continuously to deliver current to the output up to the PFET current limit. The output voltage then becomes the input voltage minus the voltage drop across the main switch and the inductor.

Short Circuit Protection

When the output is shorted to ground, the oscillator frequency is reduced to prevent the inductor current from increasing beyond the PFET current limit. The PFET current limit is also reduced to lower the short circuit current. The frequency and current limit will return to the normal values once the short circuit condition is removed and the feedback voltage reaches 0.6V.

Maximum Load Current

The MP2117 can operate down to 2.5V input voltage; however the maximum load current decreases at lower input due to a large IR drop on the main switch and synchronous rectifier. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%. Conversely, the current limit increases as the duty cycle decreases.

Power OK

The MP2117 provides an open-drain PWROK output that goes high after the output reaches regulation during startup. PWROK goes low after the output goes out of regulation by ±10% or when device enters shutdown. There is 50μsec deglitch timer built in to avoid PWROK false triggered during load transient.

Enable Control

MP2117 has a dedicated Enable control pin. By pulling it to high or low, the IC can be enabled and disabled by EN. Tie EN to VIN by proper voltage divider for automatic start up as Figure 2 shows. And make sure that:

$$\text{Max. EN Threshold} < V_{IN} \times \frac{R_{EN2}}{(R_{EN1} + R_{EN2})} < 6V$$

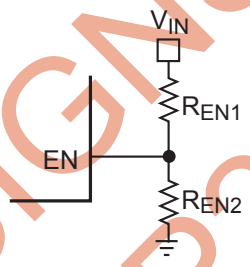


Figure 2

APPLICATION INFORMATION

Output Voltage Setting

The external resistor divider sets the output voltage. It is optional to speed loop response by adding a small feedforward capacitor C_F parallel with R1. Choose R1*C_F time constant around 3usec.

Choose R2 value between 1kΩ and 100kΩ. R1 is then given by:

$$R1 = R2 \times (\frac{V_{OUT}}{0.6V} - 1)$$

Table 1—Resistor Selection vs. Output Voltage Setting

V_{OUT}	R1	R2
1.2V	60.4kΩ	60.4kΩ
1.5V	90.9kΩ	60.4kΩ
1.8V	121kΩ	60.4kΩ
2.5V	191kΩ	60.4kΩ)
3.3V	274KΩ	60.4kΩ

Inductor Selection

A 1μH to 10μH inductor with DC current rating at least 25% higher than the maximum load current is recommended for most applications. For best efficiency, the inductor DC resistance should be <100mΩ. See Table 2 for recommended inductors and manufacturers. For most designs, the inductance value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductor ripple current. Choose inductor ripple current approximately 30% of the maximum load current, 2.2A.

The maximum inductor peak current is:

$$I_{L(MAX)} = I_{LOAD(MAX)} + \frac{\Delta I_L}{2}$$

Table 2—Suggested Surface Mount Inductors

Manufacturer	Part Number	Inductance (μH)	Max DCR (mΩ)	Saturation Current (A)
Wurth	7447745012	1.2	17	4.6
Toko	D62LCB-#A918CY-1R0M	1.0	17	3.7

Switcher Input Capacitor C_{IN1} Selection

The input capacitor reduces the surge current drawn from the input and switching noise from the device. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. For most applications, a 10μF~22μF capacitor is sufficient.

Switcher Output Capacitor C_{OUT1} Selection

The output capacitor keeps output voltage ripple small and ensures regulation loop stable. The output capacitor impedance should be low at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended. For most applications, a 22μF~47μF capacitor is sufficient.

The output ripple ΔV_{OUT} is approximately:

$$\Delta V_{OUT} \le \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times f_{OSC} \times L} \times \left(ESR \frac{1}{8 \times f_{OSC} \times C_{OUT}} \right)$$

Thermal Dissipation

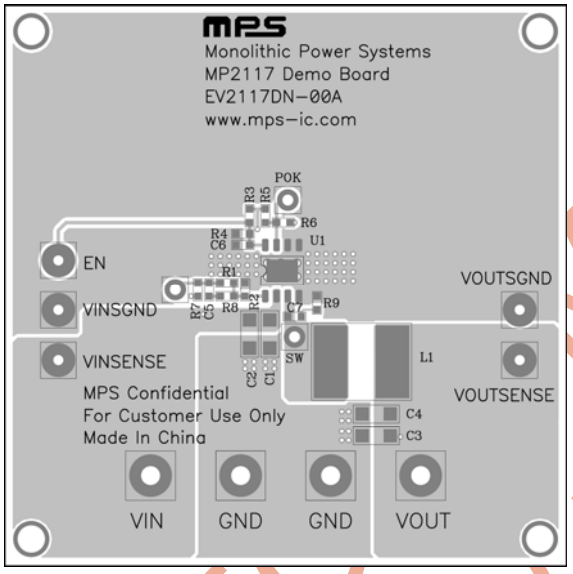
Power dissipation should be considered when MP2117 provide maximum 2.2A output current to the loads at high ambient temperature. If the junction temperature rises above 150°C, the MP2117 will be shut down.

The junction-to-ambient thermal resistance of the 10-pin QFN or 8-pin SOIC $R_{\Theta JA}$ is 50°C/W. The maximum power dissipation is about 1.6W when the MP2117 is operating in a 70°C ambient temperature environment.

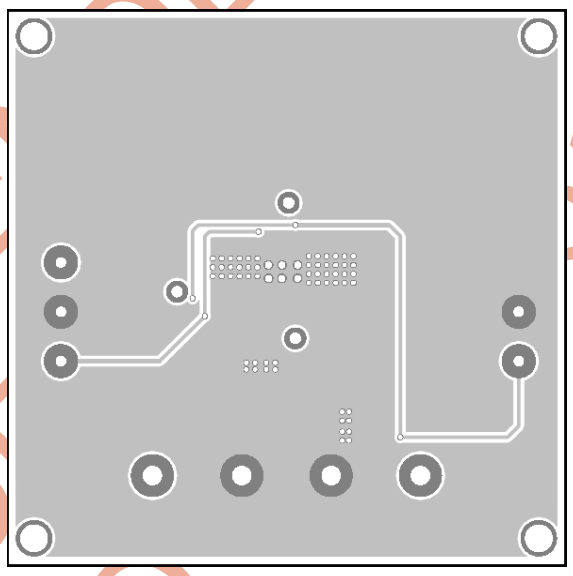
$$PD_{MAX} = \frac{150^{o}C - 70^{o}C}{50^{o}C/W} = 1.6W$$

PCB Layout

The high current paths (GND, IN, OUT and SW) should be placed very close to the device with short, direct and wide traces. Input capacitors should be placed as close as possible to the respective IN and PGND pins. The external feedback resistors should be placed next to the FB pins. Keep the switching nodes SW short and away from the feedback network. An external diode (i.e. B130) can be added between SW and GND to reduce switching noise and to improve the load regulation. The reference layout and its schematic are shown below:



Top Layer



Bottom Layer

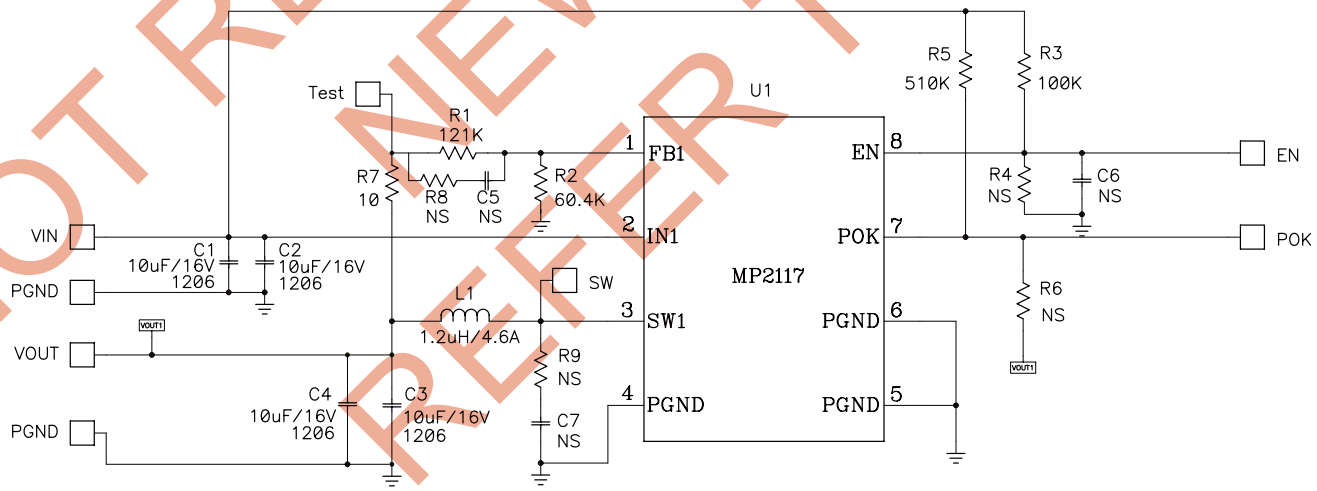
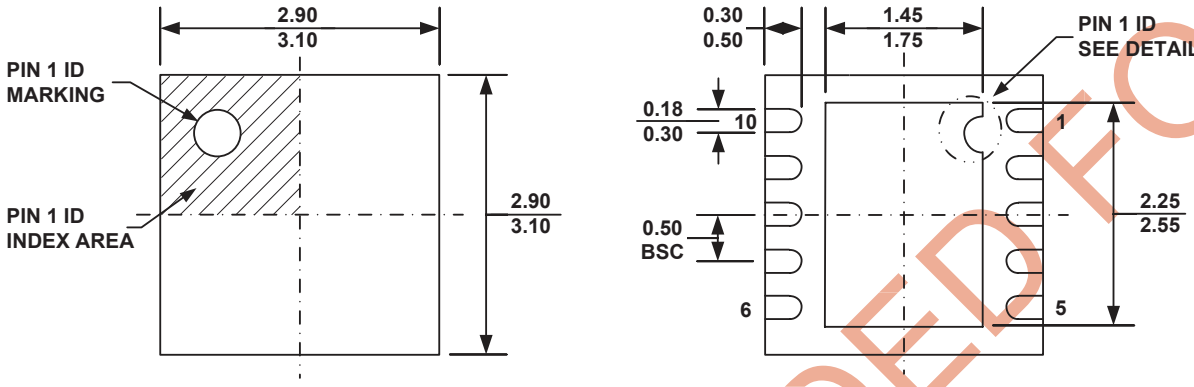


Figure 3

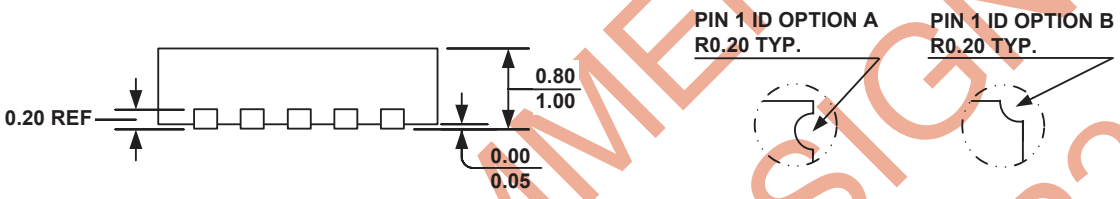
PACKAGE INFORMATION

QFN10 (3X3)



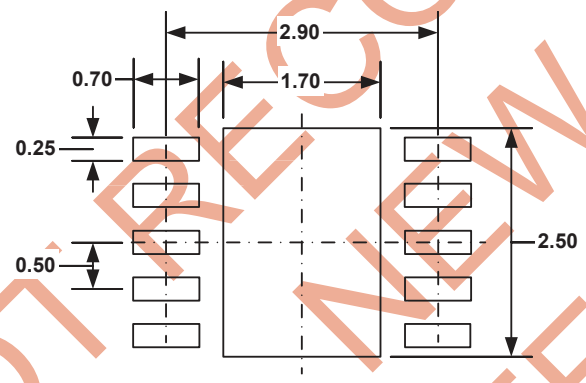
TOP VIEW

BOTTOM VIEW



SIDE VIEW

DETAIL A



RECOMMENDED LAND PATTERN

NOTE:

1) ALL DIMENSIONS ARE IN MILLIMETERS.
2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETER MAX.
4) DRAWING CONFORMS TO JEDEC MO-229, VARIATION VEED-5.
5) DRAWING IS NOT TO SCALE.

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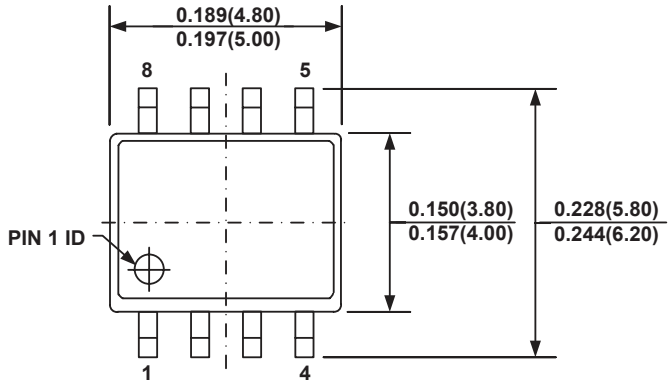
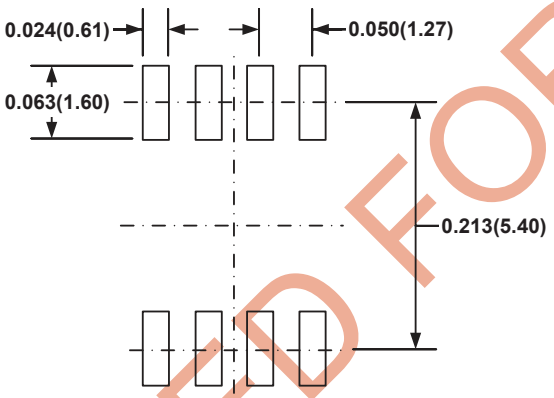
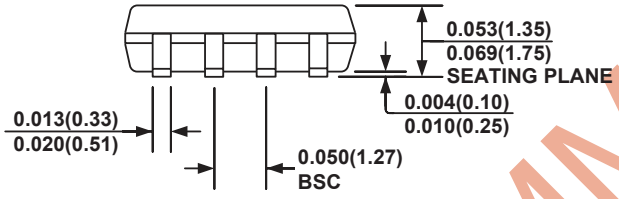


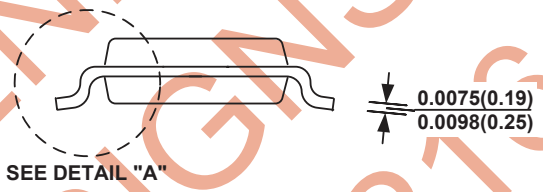
TOP VIEW



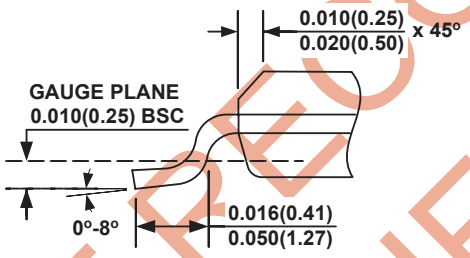
RECOMMENDED LAND PATTERN



FRONT VIEW



SIDE VIEW



DETAIL "A"

NOTE:

1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) DRAWING CONFORMS TO JEDEC MS-012, VARIATION AA.
6) DRAWING IS NOT TO SCALE.