MP2492

2A, 55V, 100kHz Step-Down Converter with Programmable Output Current Limit

The Future of Analog IC Technology

DESCRIPTION

The MP2492 is a monolithic step-down switch mode converter with a programmable output current limit. It achieves 2A continuous output current over a wide input supply range with excellent load and line regulation.

The maximum output current can be programmed by sensing current through the inductor DC resistance (DCR) or an accurate sense resistor.

MP2492 achieves low EMI signature with well controlled switching edges.

Fault condition protection includes cycle-by-cycle current limiting, and thermal shutdown.

The MP2492 requires a minimum number of readily available standard external components. The MP2492 is available in QFN10 (3mm x 3mm) and SOIC8E packages.

FEATURES

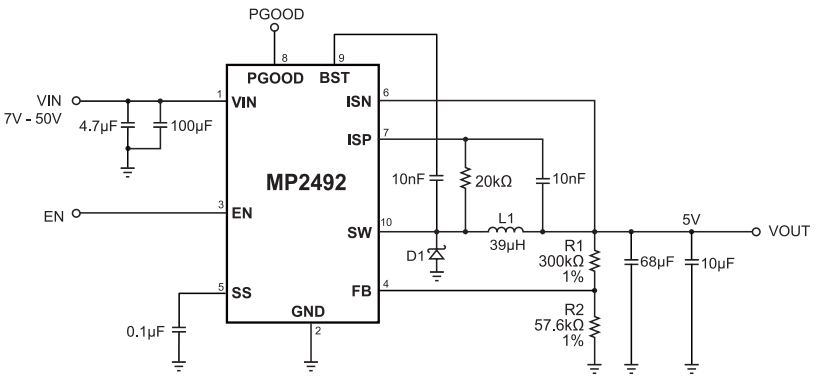
- Wide 4.5V to 55V Operating Input Range
- Programmable up to 2A Output Current
- Output Adjustable from 0.8V to 15V
- Programmable Output Current Limit without power loss
- 0.25Ω Internal Power MOSFET Switch
- Stable with Low ESR Output Ceramic Capacitors
- Fixed 100kHz Frequency
- Low EMI signature
- Thermal Shutdown
- Cycle-by-Cycle Over Current Protection
- Available in QFN10 and SOIC8E Packages

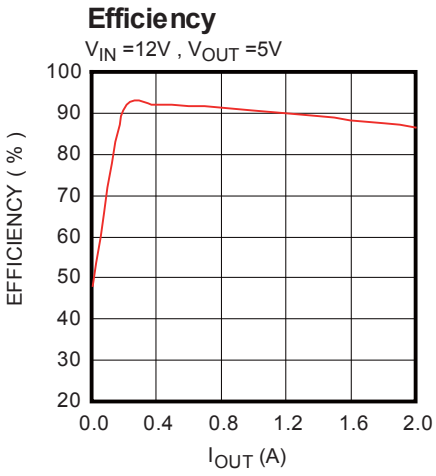
APPLICATIONS

- USB Power Supplies
- Automotive Cigarette Lighter Adapters
- Power Supply for Linear Chargers

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TYPICAL APPLICATION





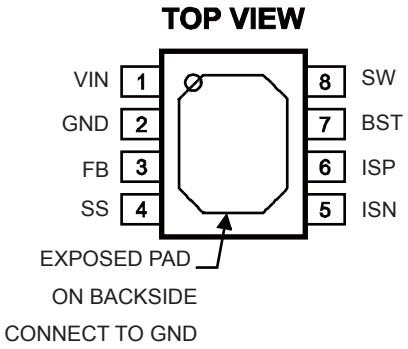
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ORDERING INFORMATION

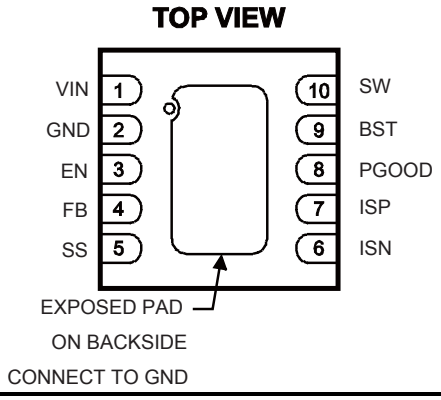
Part Number	Package	Top Marking	Free Air Temperature (T_A)
MP2492DN*	SOIC8E	MP2492DN	–40°C to +85°C
MP2492DQ**	QFN10(3mmx3mm)	3Q	–40°C to +85°C

* For Tape & Reel, add suffix –Z (e.g. MP2492DN–Z).
For RoHS compliant packaging, add suffix –LF (e.g. MP2492DN–LF–Z)
** For Tape & Reel, add suffix –Z (e.g. MP2492DQ–Z).
For RoHS compliant packaging, add suffix –LF (e.g. MP2492DQ–LF–Z)

PACKAGE REFERENCE



SOIC8E



QFN10(3mmx3mm)

ABSOLUTE MAXIMUM RATINGS (1)

Input Voltage V_{IN} 60V
V_{SW} ..... –0.3V to V_{IN} + 0.3V
V_{BST} ..... V_{SW} + 6.5V
V_{ISN}, v_{ISP} 0V to15V
| V_{ISN}, - v_{ISP} | ..... 0 to 0.5V
V_{EN}, ... 0V to15V
All Other Pins ..... –0.3V to +6.5V
Continuous Power Dissipation (T_A = +25°C) (2)
SOIC8E 2.5W
QFN10 (3 x 3 mm) 2.5W
Junction Temperature ..... 150°C
Lead Temperature ..... 260°C
Storage Temperature ..... –50°C to +150°C

Recommended Operating Conditions (3)

Input Voltage V_{IN} ..... 4.5V to 55V
Output Voltage V_{OUT} (V_{IN}>16.5V) ..... 0.8V to 15V
Output Voltage V_{OUT} (V_{IN}<=16.5V) .....
..... 0.8V to (V_{IN}–1.7) V
Operating Junct. Temp. ..... –40°C to +125°C

Thermal Resistance (4)

	θ_{JA}	θ_{JC}
SOIC8E	50	10 .. °C/W
QFN10 (3 x 3 mm)	50	12... °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 JESD51-7, 4-layer PCB.

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ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = +25°C, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Units
Feedback Voltage	V_{FB}	4.5V ≤ V_{IN} ≤ 55V	0.78	0.8	0.82	V
Feedback Bias Current	$I_{BIAS(FB)}$	V_{FB} = 0.8V		10		nA
Switch On Resistance	$R_{DS(ON)}$			0.25		Ω
Switch Leakage(5)		V_{EN} = 0V, V_{SW} = 0V		0.1	10	μA
Current Limit				3.5		A
Oscillator Frequency	f_{SW}	V_{FB} = 0.6V	80	100	120	kHz
Boot-Strap Voltage	V_{BST} - V_{SW}			4.3		V
Minimum On Time	t_{ON}	V_{FB} = 1V		100		ns
SW rising edge	trise	Vin=12V, Vo=5V, Io=2A		50		ns
SW falling edge	tfall	Vin=12V, Vo=5V, Io=2A		50		ns
Under Voltage Lockout Threshold Rising			3.0	3.3	3.6	V
Under Voltage Lockout Threshold Hysteresis				200		mV
Supply Current (Quiescent)		V_{EN} = 2V, V_{FB} = 1V		500	800	μA
Thermal Shutdown				150		°C
Current Sense Voltage	V_{ISP} –V_{ISN}	V_{ISP}, V_{ISN} 0.4–15V	90	100	110	mV
Input Bias Current (ISN, ISP)	$I_{BIAS\ (ISN,ISP)}$	V_{ISP}, V_{ISN} 0.4–15V	–1	–0.5	+1	μA
EN Input Low Voltage (5)					0.4	V
En Input High Voltage (5)			1.8			V
EN Input Bias Current (5)		V_{EN} = 0-6V	-10	-2	10	μA
PGOOD Sink Voltage Dropout		Sink Current 5mA			0.3	V

Note:

4) Guaranteed by design
5) Only available for the MP2490DQ

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PIN FUNCTIONS

QFN10 Pin #	SOIC-8 Pin #	Name	Description
1	1	VIN	Supply Voltage. The MP2492 operates from a +4.5V to +55V unregulated input. C_{IN} is needed to prevent large voltage spikes from appearing at the input. Put C_{IN} as close to the IC as possible. It is the drain of the internal power device and power supply for the whole chip.
2	2	GND Exposed Pad	Ground. This pin is the voltage reference for the regulated output voltage. For this reason care must be taken in its layout. This node should be placed outside of the D1 to C_{IN} ground path to prevent switching current spikes from inducing voltage noise into the part, Exposed Pad must be connected to Ground pin.
3		EN	On/Off Control Input.
4	3	FB	An external resistor divider from the output to GND, tapped to the FB pin sets the output voltage.
5	4	SS	Connect to an external capacitor used for Soft-Start and compensation for current limiting loop.
6	5	ISN	Negative Current Sense Input for load current limiting.
7	6	ISP	Positive Current Sense
8		PGOOD	Power good signal. When FB is less than 90% of 0.8V, PGOOD is low. It is an open-drain output. Use a high value pull-up resistor externally to pull it up to system power supply.
9	7	BST	Bootstrap. This capacitor is needed to drive the power switch's gate above the supply voltage. It is connected between SW and BST pins to form a floating supply across the power switch driver. An on-chip regulator is used to charge up the external boot-strap capacitor. If the on-chip regulator is not strong enough, one optional diode can be connected from IN or OUT to charge the external boot-strap capacitor.
10	8	SW	Switch Output. It is the source of power device.

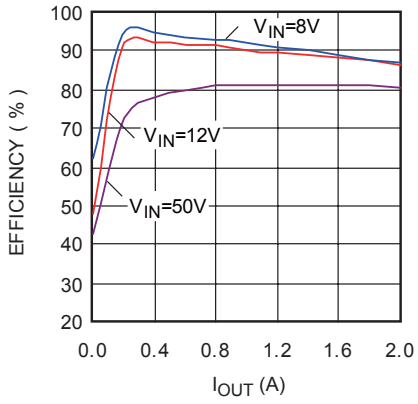
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TYPICAL PERFORMANCE CHARACTERISTICS

C_1=220uF, C_2=2.2uF, C_3=39uF, C_4=22uF, L=39uH, T_A=25ºC，unless otherwise noted.

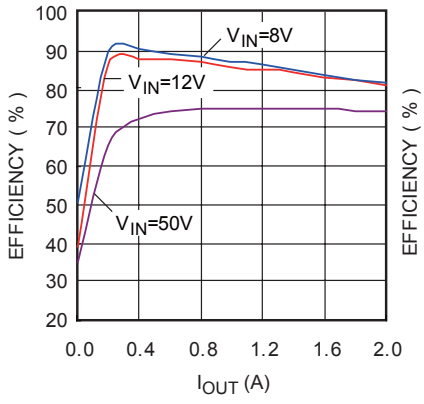
Efficiency vs. Load Current

V_{OUT} =5V



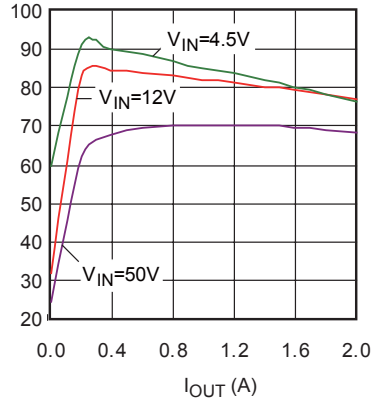
Efficiency vs. Load Current

V_{OUT} =3.3V



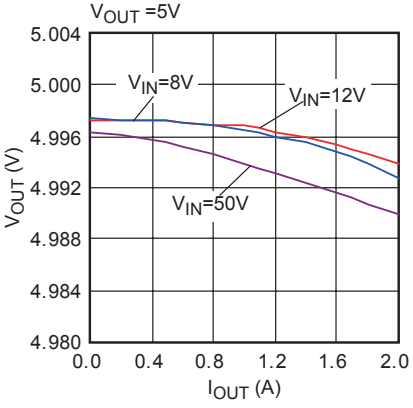
Efficiency vs. Load Current

V_{OUT} =2.5V



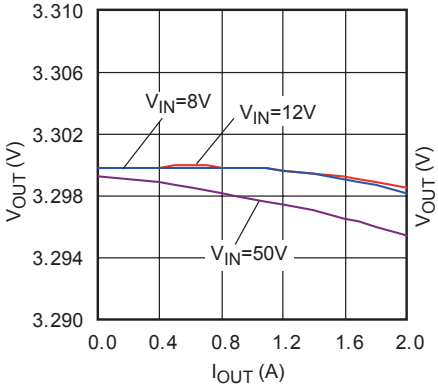
Load Regulation

V_{OUT} =5V



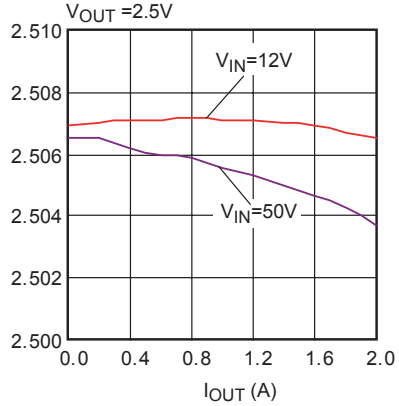
Load Regulation

V_{OUT} =3.3V

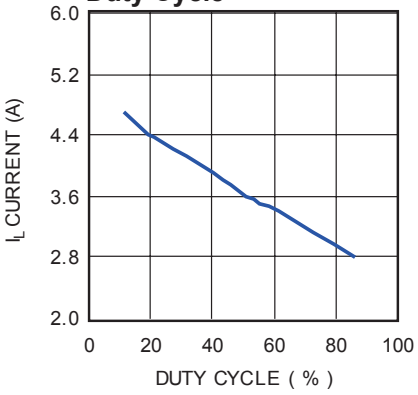


Load Regulation

V_{OUT} =2.5V

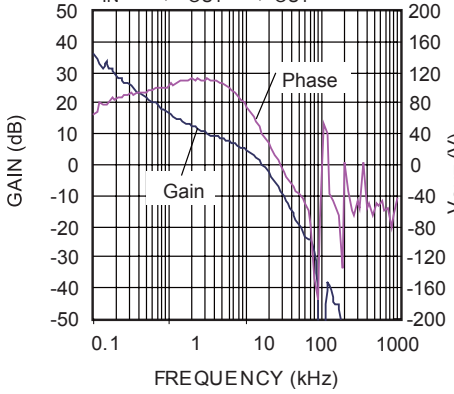


Maximum I_{OUT} vs. Duty Cycle



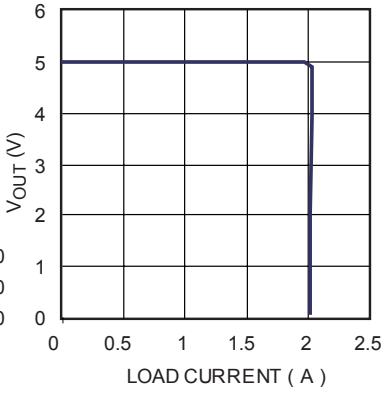
Loop Gain with Phase Margin

V_{IN}=12V, V_{OUT}=5V, I_{OUT}=1.8A



Current regulation

Sense to DCR

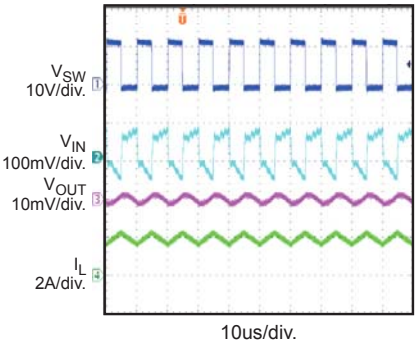


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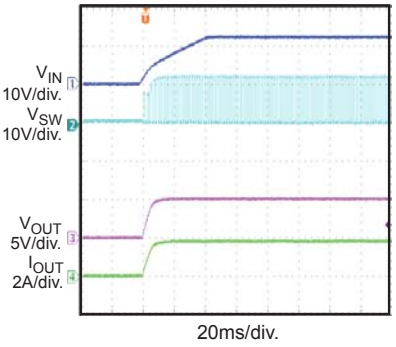
TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

C_1=220uF, C_2=2.2uF, C_3=39uF, C_4=22uF, L=39uH, T_A=25ºC，unless otherwise noted.

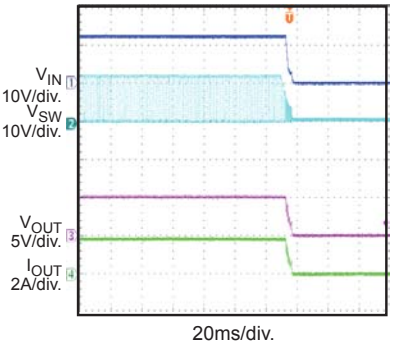
Steady State
V_{IN} = 12V, V_{OUT} =5V, I_{OUT} = 2A
Electrical Load



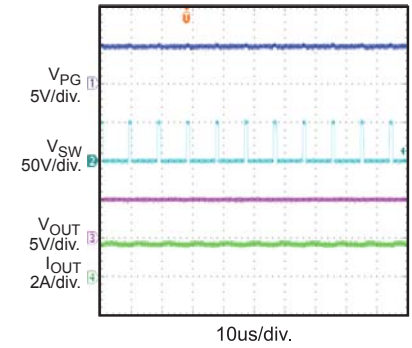
Power Ramp Up
V_{IN} = 12V, V_{OUT} = 5V, I_{OUT} = 2A
Resistor Load



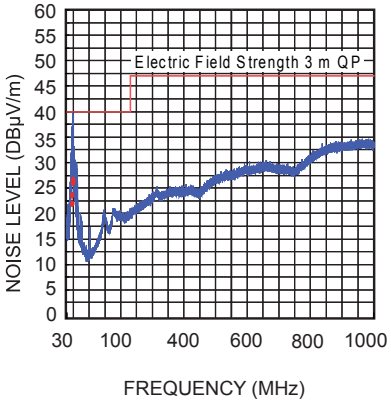
Power Ramp Down
V_{IN} = 12V,V_{OUT} = 5V, I_{OUT} = 2A
Resistor Load



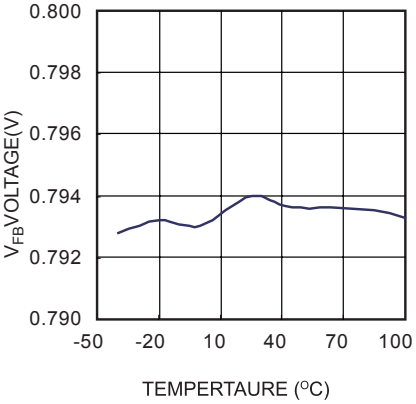
Steady State
V_{IN} = 50V, V_{OUT} = 5V, I_{OUT} = 1.8A
Electrical Load



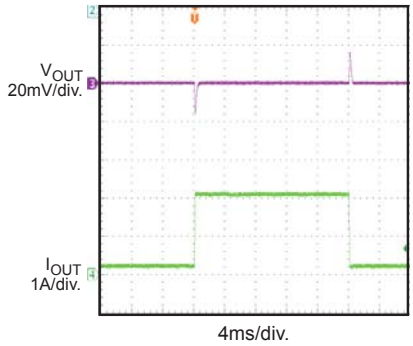
EMI Radiation
V_{IN} = 12V, V_{OUT} =5V, I_{OUT} = 1.5A
Resistor Load



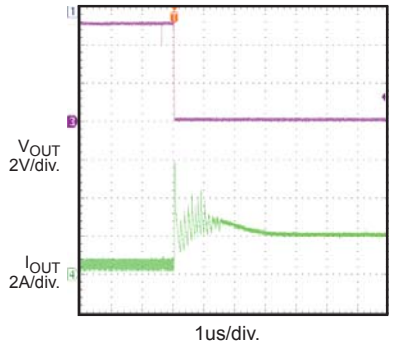
V_{FB} vs. Temperature



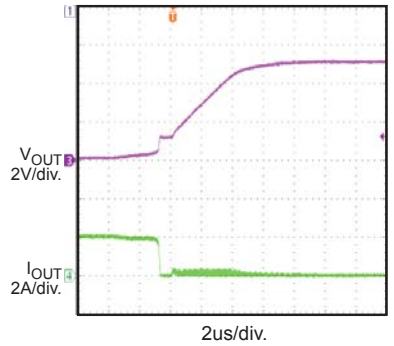
Load Transient Response
V_{IN} = 12V,V_{OUT} = 5V, I_{OUT} = 0.1A to 2A



Short Circuit
V_{IN} = 12V,V_{OUT} = 5V, I_{OUT}=0.5A



Short Circuit Recovery
V_{IN} = 12V,V_{OUT} = 5V



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OPERATION

The MP2492 is a current mode buck regulator. That is, the EA output voltage is proportional to the peak inductor current.

At the beginning of a cycle SW is off, the EA output voltage is higher than the current sense amplifier output and the current comparator's output is low. The rising edge of the 100kHz CLK signal sets the RS Flip-Flop. Its output turns on SW thus connecting the SW pin and inductor to the input supply.

The increasing inductor current is sensed and amplified by the Current Sense Amplifier. Ramp compensation is summed to Current Sense Amplifier output and compared to the Error Amplifier output by the Current Comparator. When the Current Sense Amplifier plus Slope Compensation signal exceeds the EA output voltage, the RS Flip-Flop is reset and the MP2492 reverts to its initial SW off state.

If the Current Sense Amplifier plus Slope Compensation signal does not exceed the COMP voltage, then the falling edge of the CLK resets the Flip-Flop.

The output of the Error Amplifier integrates the voltage difference between the feedback and the 0.8V bandgap reference. The polarity is such that a FB pin voltage lower than 0.8V increases the EA output voltage. Since the EA output voltage is proportional to the peak inductor current, an increase in its voltage increases current delivered to the output. An external Schottky Diode (D1) carries the inductor current when SW is off.

The output current information is sensed via the ISP and ISN pins. The sense voltage is set at 100mV. If V_{SENSE}, the difference of V_{ISP} and V_{ISN}, is less than 100mV, the output voltage of the power supply will be set by the FB pin. If V_{SENSE} reaches 100mV, the current limit loop will pull down on SS and regulate the output at a constant current.

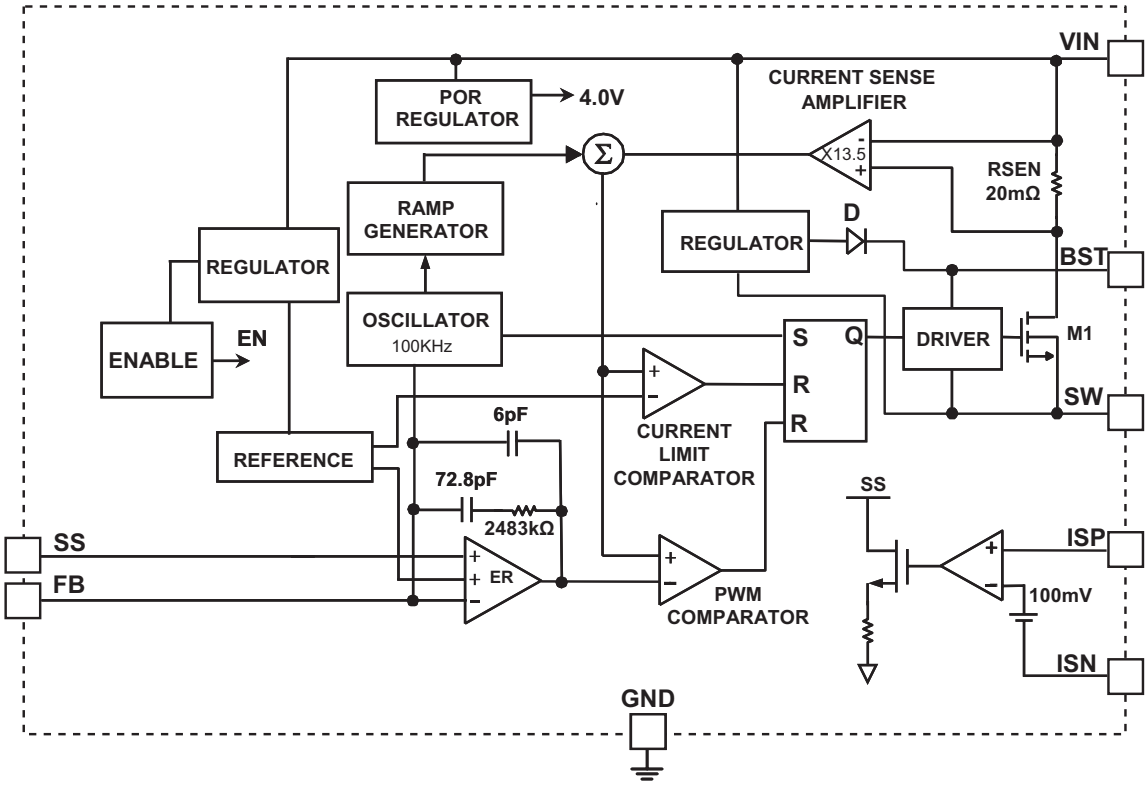


Figure 1—Function Block Diagram

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APPLICATION INFORMATION

Setting the Output Voltage

The external resistor divider is used to set the output voltage (see the schematic on front page). The feedback resistor R1 also sets the feedback loop bandwidth with the internal compensation capacitor (see Figure 1). Choose R1 to be around 300kΩ for optimal transient response. R2 is then given by:

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.8V} - 1}$$

Table 1—Resistor Selection for Common Output Voltages

V_{OUT} (V)	R1 (kΩ)	R2 (kΩ)
1.8	300 (1%)	240 (1%)
2.5	300 (1%)	141.1 (1%)
3.3	300 (1%)	96 (1%)
5	300 (1%)	57.1 (1%)

Selecting the Inductor

A 1μH to 10μH inductor with a DC current rating of at least 25% percent higher than the maximum load current is recommended for most applications. For highest efficiency, the inductor DC resistance should be less than 200mΩ. 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 the inductor ripple current.

Choose inductor current ripple to be approximately 30% of the maximum load current, 2A. The maximum inductor peak current is:

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

Under light load conditions below 100mA, larger inductance is recommended for improved efficiency.

Selecting the Input Capacitor

The input capacitor reduces the surge current drawn from the input and also the switching noise from the device. The input capacitor impedance at the switching frequency should be less than the input source impedance to prevent high frequency switching current from pass 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 4.7μF capacitor is sufficient.

Selecting the Output Capacitor

The output capacitor keeps output voltage small and ensures regulation loop stability. The output capacitor impedance should be low at the switching frequency. Ceramic capacitors with X5R or X7R dielectrics are recommended.

PC Board Layout

The high current paths (GND, IN and SW) should be placed very close to the device with short, direct and wide traces. The input capacitor needs to be as close as possible to the IN and GND pins. The external feedback resistors should be placed next to the FB pin. Keep the switching node SW short and away from the feedback network.

External Bootstrap Diode

It is recommended that an external bootstrap diode be added when the system has a 5V fixed input or the power supply generates a 5V output. This helps improve the efficiency of the regulator. The bootstrap diode can be a low cost one such as IN4148 or BAT54.

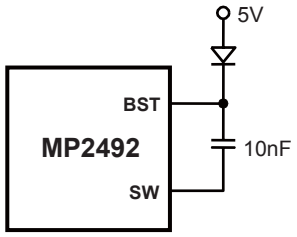


Figure 2—External Bootstrap Diode

This diode is also recommended for high duty cycle operation (when $\frac{V_{OUT}}{V_{IN}}$ >65%) and high output voltage (V_{OUT}>12V) applications.

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Output Current Sensing

The output current can be sensed through the DC resistance (DCR) of the inductor, as shown in Figure 3a.

For more accurate sensing, use a more accurate sense resistor.

In Figure 3a, the output current limit is set as:

$$I_{OUT} = \frac{100mV}{DCR} \times \frac{Rb}{2Ra + Rb}$$

Where DCR is the DC resistance of the inductor winding.

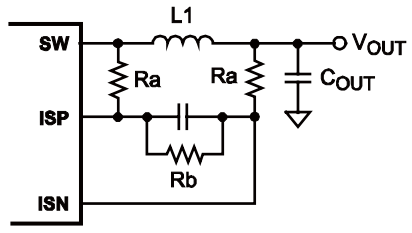
In Figure 3a, it is desirable to keep

$$C_S \times \frac{Ra \times Rb}{Ra + Rb} = \frac{L1}{DCR}$$

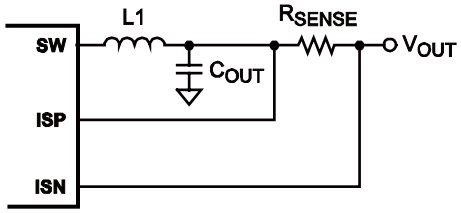
For more accurate sensing, use a more accurate sense resistor.

In Figure 3b, the output current limit is set as:

$$I_{OUT} = \frac{100mV}{R_{SENSE}}$$



(a)



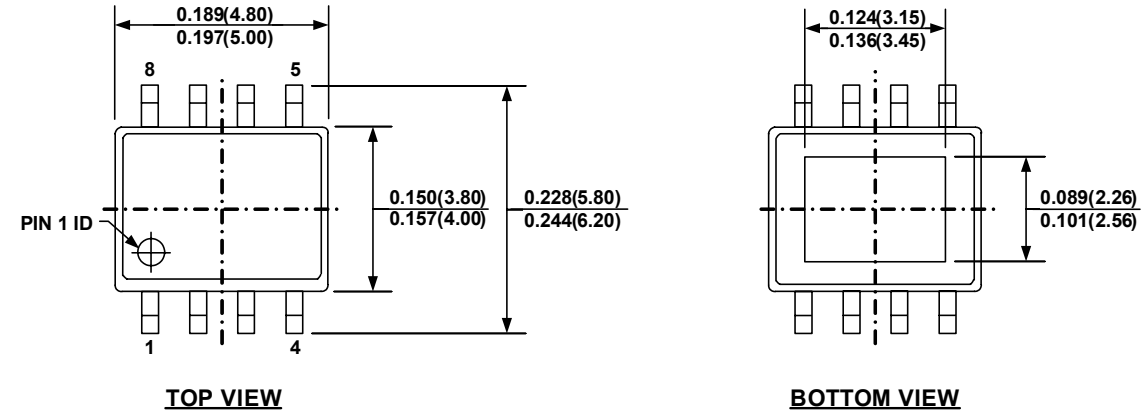
(B)

Figure 3—Current Sensing Methods

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PACKAGE INFORMATION

SOIC8E (EXPOSED PAD)

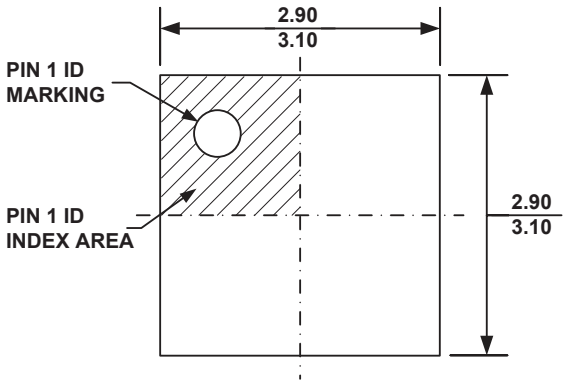


NOTE:

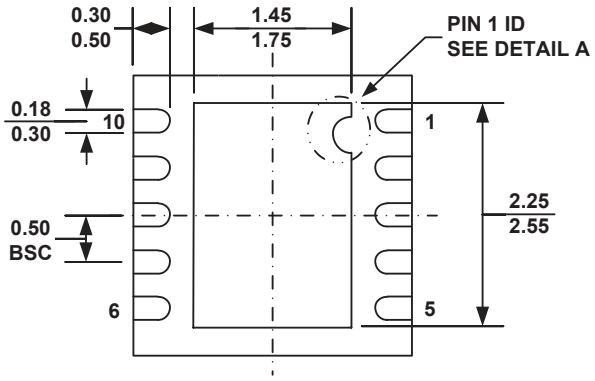
1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
4) LEAD COPLANARITY(BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
5) DRAWING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

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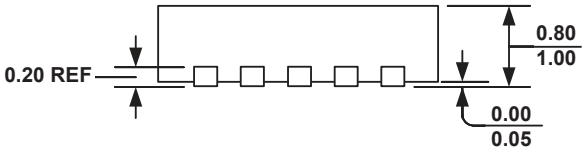
QFN10 (3mm x 3mm)



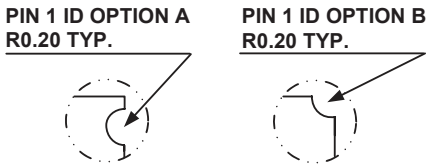
TOP VIEW



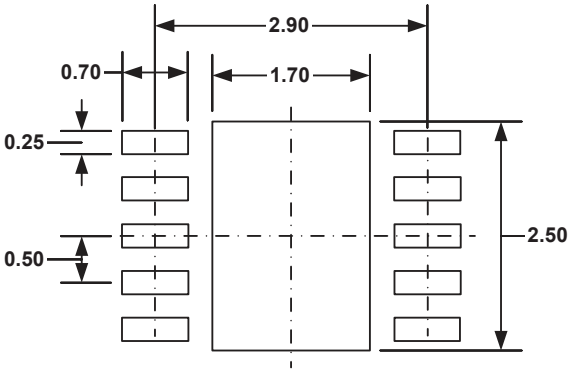
BOTTOM VIEW



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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