



The Future of Analog IC Technology®

# MP2269

3.3V - 30V, 1A, 12µA I<sub>Q</sub>,  
Synchronous, Step-Down Converter  
with External Soft Start and Power Good  
in 2x3mm QFN Package

## DESCRIPTION

The MP2269 is a frequency-programmable (350kHz to 2.5MHz), synchronous, step-down, switching regulator with integrated, internal, high-side and low-side power MOSFETs. The MP2269 provides 1A of highly efficient output current with current-mode control for fast loop response.

The wide 3.3V to 30V input range accommodates a variety of step-down applications. A 1µA shutdown mode quiescent current allows the MP2269 to be used in battery-powered applications.

High power conversion efficiency over a wide load range is achieved by scaling down the switching frequency at light-load condition to reduce switching and gate driving losses.

An open-drain power good signal indicates the output signal. Frequency foldback helps prevent inductor current runaway during start-up. Thermal shutdown provides reliable and fault-tolerant operation. High duty cycle and low drop-out mode are provided for battery-powered systems.

The MP2269 is available in a QFN-15 (2mmx3mm) package.

## FEATURES

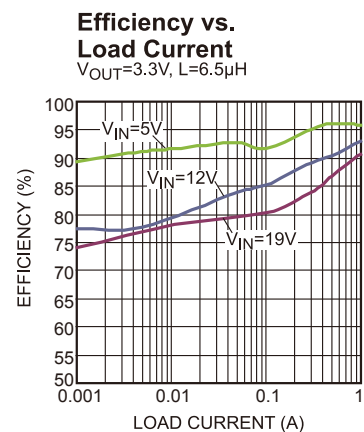
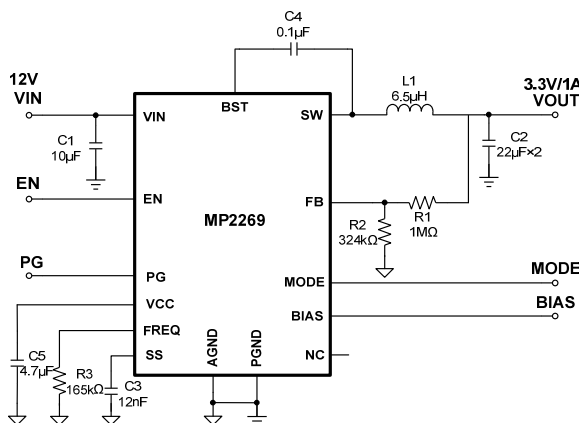
- Wide 3.3V to 30V Operating Voltage Range
- 1A Continuous Output Current
- 1µA Low Shutdown Supply Current
- 12µA Sleep Mode Quiescent Current
- 180mΩ/80mΩ High-Side/Low-Side R<sub>DS(ON)</sub> for Internal Power MOSFETs
- 350kHz to 2.5MHz Programmable Switching Frequency
- Power Good Output
- External Soft Start
- 80ns Minimum On Time
- Selectable Forced PWM Mode and Auto PFM/PWM Mode
- Low Dropout Mode
- Hiccup Over-Current Protection (OCP)
- Available in a QFN-15 (2mmx3mm) Package

## APPLICATIONS

- Battery-Powered Systems
- Smart Homes
- Wide Input Range Power Supplies
- Standby Power Supplies

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## TYPICAL APPLICATION



### ORDERING INFORMATION

| Part Number* | Package          | Top Marking |
|--------------|------------------|-------------|
| MP2269GD     | QFN-15 (2mmx3mm) | See Below   |

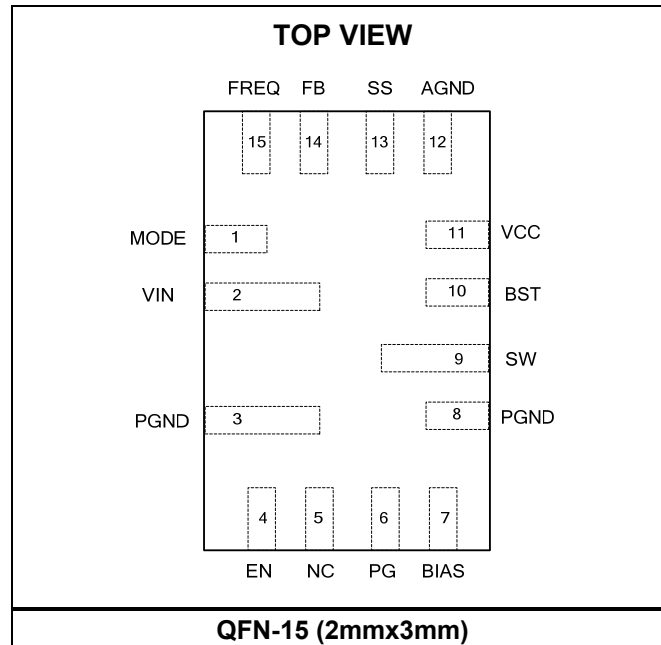
\* For Tape & Reel, add suffix -Z (e.g. MP2269GD-Z)

### TOP MARKING

\_\_\_\_\_  
**AUH**  
**YWW**  
**LLL**

AUH: Product code of MP2269GD  
 Y: Year code  
 WW: Week code  
 LLL: Lot number

### PACKAGE REFERENCE



**ABSOLUTE MAXIMUM RATINGS (1)**

|   |                                       |
|---|---------------------------------------|
| Supply voltage (VIN).....                                       | -0.3V to 40V                          |
| Switch voltage (V <sub>SW</sub> ) .....                         | -0.3V to V <sub>IN (MAX)</sub> + 0.3V |
| BST voltage (V <sub>BST</sub> ) .....                           | V <sub>SW (MAX)</sub> + 6.5V          |
| EN voltage (V <sub>EN</sub> ) .....                             | -0.3V to 40V                          |
| PG voltage .....  | -0.3V to 32V                          |
| BIAS voltage .....  | -0.3V to 20V                          |
| All other pins .....  | -0.3V to 6V                           |
| <b>Continuous power dissipation (T<sub>A</sub> = +25°C) (2)</b> |                                       |
| QFN-15 (2mmx3mm).....   | 1.7W                                  |
| Operating junction temperature .....                            | 150°C                                 |
| Lead temperature.....   | 260°C                                 |
| Storage temperature .....                                       | -65°C to 150°C                        |

**Recommended Operating Conditions (3)**

|  |                 |
|--|-----------------|
| Supply voltage (VIN).....                      | 3.3V to 30V     |
| Operating junction temp (T <sub>J</sub> )..... | -40°C to +125°C |

|                               |                       |                       |
|-------------------------------|-----------------------|-----------------------|
| <b>Thermal Resistance (4)</b> | <b>θ<sub>JA</sub></b> | <b>θ<sub>JC</sub></b> |
| QFN-15 (2mmx3mm).....         | 70 .....              | 15 ... °C/W           |

**NOTES:**

- 1) Absolute maximum ratings are rated under room temperature unless otherwise noted. Exceeding these ratings may damage the device.
- 2) The maximum allowable power dissipation is a function of the maximum junction temperature T<sub>J(MAX)</sub>, the junction-to-ambient thermal resistance θ<sub>JA</sub>, and the ambient temperature T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D(MAX)</sub>=(T<sub>J(MAX)</sub>-T<sub>A</sub>)/ θ<sub>JA</sub>. Exceeding the maximum allowable power dissipation produces an excessive die temperature, causing the regulator to 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.

## ELECTRICAL CHARACTERISTICS

VIN = 12V, VEN = 2V, TJ = -40°C to +125°C <sup>(5)</sup>, typical values are at TJ = +25°C, unless otherwise noted.

| Parameter                                      | Symbol                           | Condition                              | Min   | Typ  | Max   | Units |
|--|----------------------------------|--|-------|------|-------|-------|
| VIN under-voltage lockout threshold rising     | INUV <sub>Vth</sub>              |  | 2.5   | 2.8  | 3.2   | V     |
| VIN under-voltage lockout threshold hysteresis | INUV <sub>HYS</sub>              |  |       | 150  |       | mV    |
| VIN quiescent current                          | I <sub>Q</sub>                   | FB = 0.85V, no load, sleep mode        |       | 12   |       | μA    |
| VIN shutdown current                           | I <sub>SHDN</sub>                | EN = 0V                                |       | 1    | 5     | μA    |
| FB voltage                                     | V <sub>FB</sub>                  | T <sub>J</sub> = -40°C to +125°C       | 784   | 800  | 816   | mV    |
|  |                                  | T <sub>J</sub> = 25°C                  | 792   | 800  | 808   | mV    |
| Switching frequency                            | F <sub>SW</sub>                  | R <sub>FREQ</sub> = 164kΩ              | 425   | 500  | 575   | kHz   |
|  |                                  | R <sub>FREQ</sub> = 82kΩ               | 850   | 1000 | 1150  | kHz   |
|  |                                  | R <sub>FREQ</sub> = 27kΩ               | 2250  | 2500 | 2750  | kHz   |
| Minimum on time <sup>(6)</sup>                 | T <sub>ON_MIN</sub>              |  |       | 80   |       | ns    |
| Switch current limit                           | I <sub>LIMIT_HS</sub>            | Duty cycle = 40%                       |       | 2.5  |       | A     |
| Valley current limit                           | I <sub>LIMIT_LS</sub>            | V <sub>OUT</sub> = 3.3V, L = 6.5μH     |       | 1.35 |       | A     |
| ZCD current                                    | I <sub>ZCD</sub>                 |  |       | 50   |       | mA    |
| LS reverse current limit                       | I <sub>LIMIT_REVERSE</sub>       |  |       | 1.5  |       | A     |
| Switch leakage current                         | I <sub>SW_LKG</sub>              |  |       | 0.01 | 1     | μA    |
| HS switch on resistance                        | R <sub>ON_HS</sub>               | V <sub>BST</sub> -V <sub>SW</sub> = 5V |       | 180  |       | mΩ    |
| LS switch on resistance                        | R <sub>ON_LS</sub>               |  |       | 80   |       | mΩ    |
| Soft-start current                             | I <sub>SS</sub>                  | V <sub>SS</sub> = 0.8V                 | 5     | 10   | 15    | μA    |
| EN rising threshold voltage                    | V <sub>EN_RISING</sub>           |  | 0.9   | 1.05 | 1.2   | V     |
| EN hysteresis voltage                          | V <sub>EN_HYS</sub>              |  |       | 110  |       | mV    |
| PG OV rising (V <sub>FB</sub> /0.8V)           | PG <sub>Vth_OV_Rising</sub>      |  | 105   | 110  | 115   | %     |
| PG OV falling (V <sub>FB</sub> /0.8V)          | PG <sub>Vth_OV_Falling</sub>     |  | 113.5 | 118  | 123.5 | %     |
| PG UV rising (V <sub>FB</sub> /0.8V)           | PG <sub>Vth_UV_Rising</sub>      |  | 85    | 90   | 95    | %     |
| PG UV falling (V <sub>FB</sub> /0.8V)          | PG <sub>Vth_UV_Falling</sub>     |  | 79    | 84   | 89    | %     |
| PG output voltage low                          | V <sub>PG_LOW</sub>              | I <sub>SINK</sub> = 2mA                |       | 0.2  | 0.4   | V     |
| PG deglitch timer rising                       | T <sub>PG_DEGLITCH_Rising</sub>  |  |       | 34   |       | μs    |
| PG deglitch timer falling                      | T <sub>PG_DEGLITCH_Falling</sub> |  |       | 57   |       | μs    |
| Thermal shutdown <sup>(6)</sup>                | T <sub>SD</sub>                  |  |       | 170  |       | °C    |
| Thermal shutdown hysteresis <sup>(6)</sup>     | T <sub>SD_HYS</sub>              |  |       | 20   |       | °C    |

**NOTE:**

5) Not tested in production. Guaranteed by over-temperature correlation.

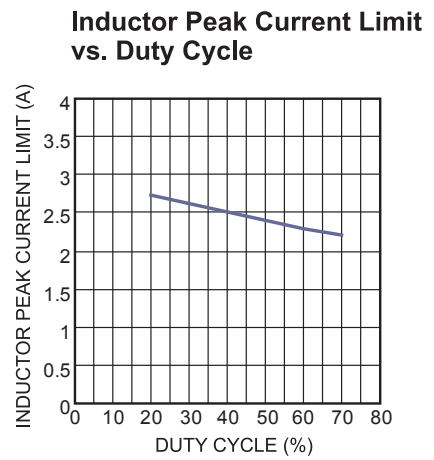
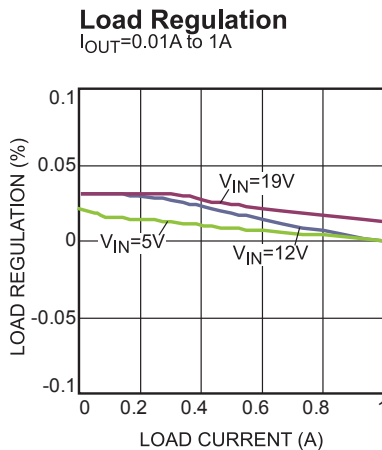
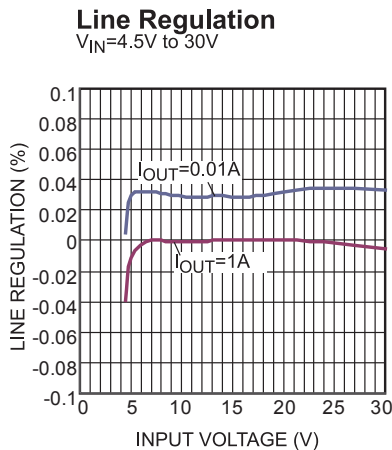
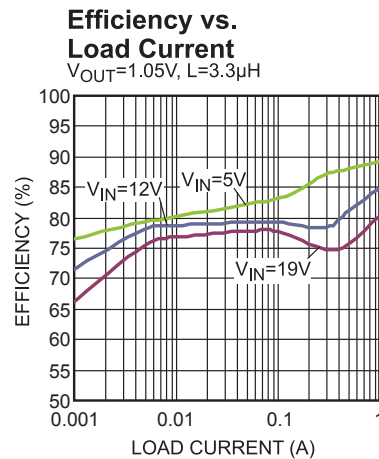
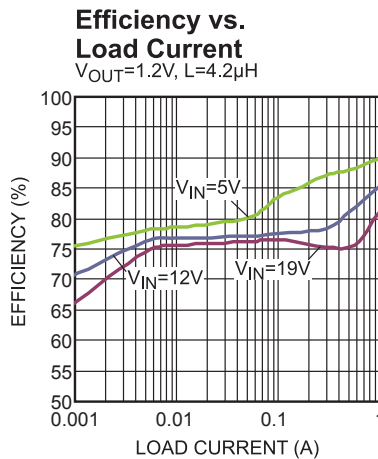
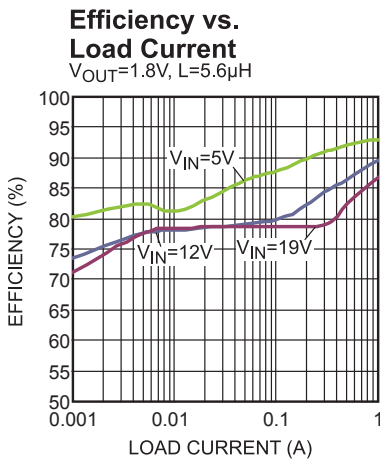
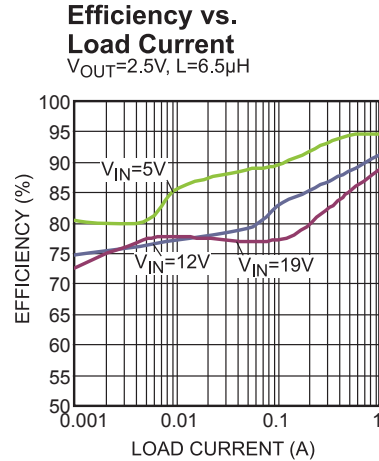
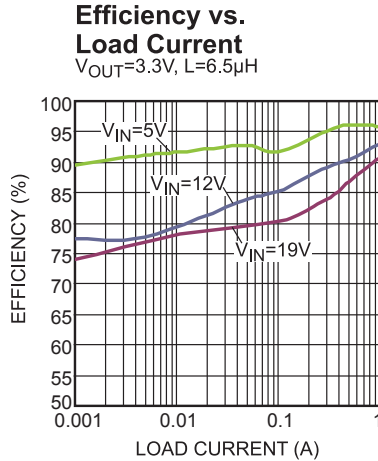
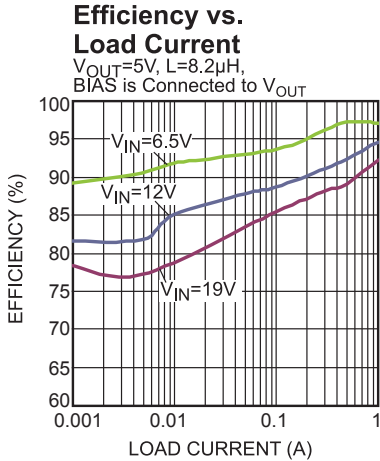
6) Guaranteed by characterization test.

## PIN FUNCTIONS

| Pin #<br>QFN-15<br>(2mmx3mm) | Name | Description   |
|------------------------------|------|---|
| 1                            | MODE | <b>Mode selection.</b> Pull MODE low or float MODE to set auto PFM/PWM mode; pull MODE high to set forced PWM mode. MODE is pulled down internally. Select MODE before the part starts up.  |
| 2                            | VIN  | <b>Input supply.</b> VIN supplies power to all the internal control circuitries and the power switch connected to SW. A decoupling capacitor to ground must be placed close to VIN to minimize switching spikes.  |
| 3, 8                         | PGND | <b>Power ground.</b>  |
| 4                            | EN   | <b>Enable.</b> Pull EN below the specified threshold to shut down the MP2269. Pull EN up above the specified threshold to enable the MP2269.  |
| 5                            | NC   | <b>No connection.</b> Leave NC floating.  |
| 6                            | PG   | <b>Power good output.</b> The output of PG is an open drain.  |
| 7                            | BIAS | <b>Bias input.</b> BIAS must be connected to GND if the bias function is not being used.  |
| 9                            | SW   | <b>Switch node.</b> SW is the output of the internal power switch.  |
| 10                           | BST  | <b>Bootstrap.</b> BST is the positive power supply for the high-side MOSFET driver connected to SW. Connect a bypass capacitor between BST and SW.  |
| 11                           | VCC  | <b>Internal LDO output.</b> VCC supplies power to the internal control circuit and gate drivers. A decoupling capacitor to ground is required close to VCC.   |
| 12                           | AGND | <b>Analog ground.</b>   |
| 13                           | SS   | <b>Soft-start input.</b> Place a capacitor from SS to GND to set the soft-start period. The MP2269 sources 10 $\mu$ A from SS to the soft-start capacitor during start-up. As the SS voltage rises, the feedback threshold voltage increases to limit inrush current during start-up. |
| 14                           | FB   | <b>Feedback input.</b> Connect FB to the center point of the external resistor divider. The feedback threshold voltage is 0.8V.   |
| 15                           | FREQ | <b>Switching frequency set.</b> Connect a resistor from FREQ to ground to set the switching frequency.  |

## TYPICAL PERFORMANCE CHARACTERISTICS

Performance waveforms are tested on the evaluation board of the Design Example section.  
 $V_{IN} = 12V$ ,  $V_{OUT} = 3.3V$ ,  $L = 6.5\mu H$ ,  $F_{SW} = 500kHz$ ,  $C_{SS} = 12nF$ ,  $T_A = 25^\circ C$ , BIAS is connected to GND, unless otherwise noted.

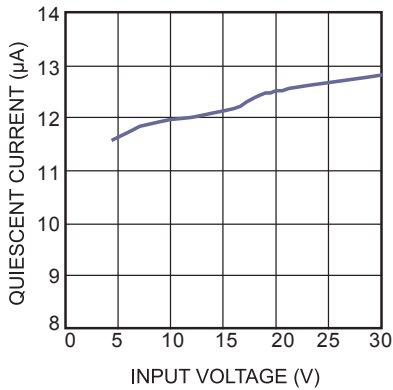


**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

Performance waveforms are tested on the evaluation board of the Design Example section.  
**V<sub>IN</sub> = 12V, V<sub>OUT</sub> = 3.3V, L = 6.5μH, F<sub>SW</sub> = 500kHz, C<sub>SS</sub> = 12nF, T<sub>A</sub> = 25°C, BIAS is connected to GND, unless otherwise noted.**

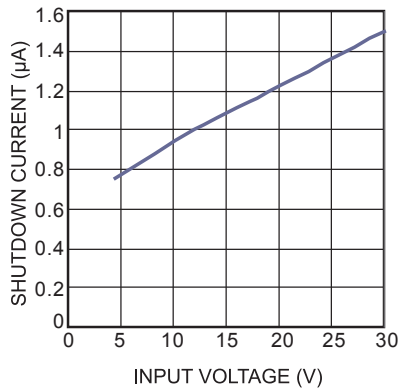
**Quiescent Current vs. Input Voltage**

V<sub>IN</sub>=4.5V to 30V, V<sub>EN</sub>=2V, V<sub>FB</sub>=0.85V



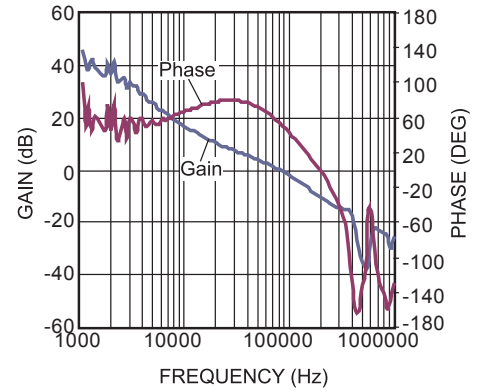
**Shutdown Current vs. Input Voltage**

V<sub>IN</sub>=4.5V to 30V, V<sub>EN</sub>=0V



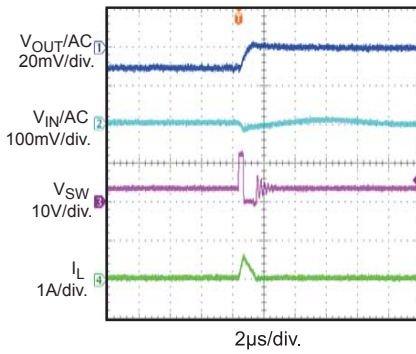
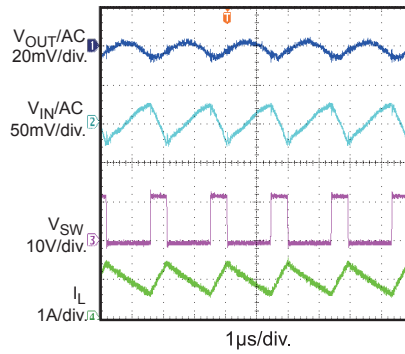
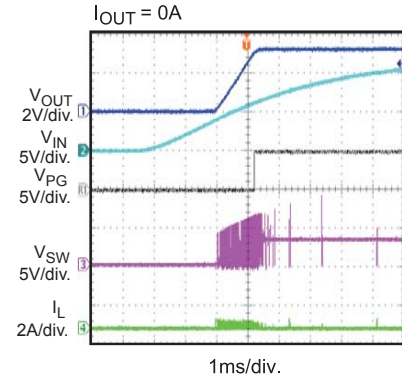
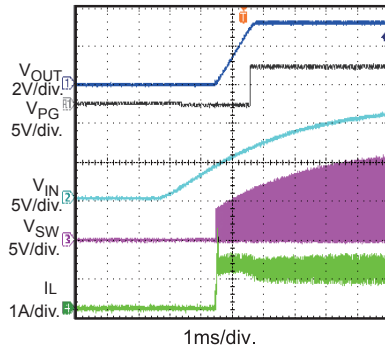
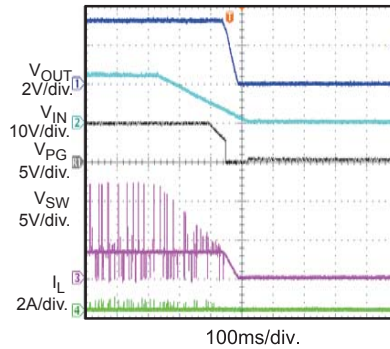
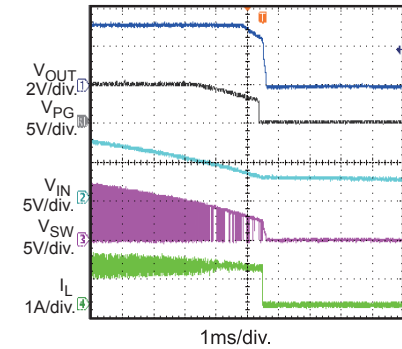
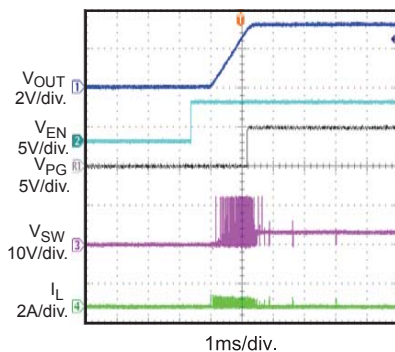
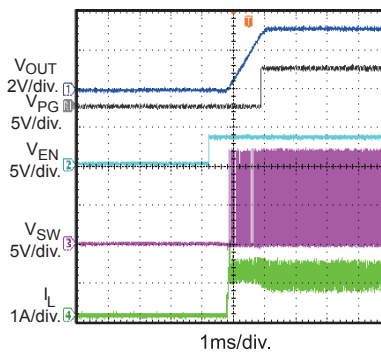
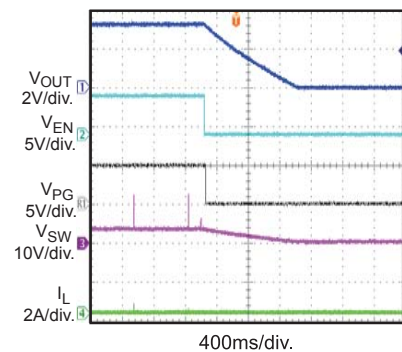
**Bode Plot**

I<sub>OUT</sub>=1A



**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

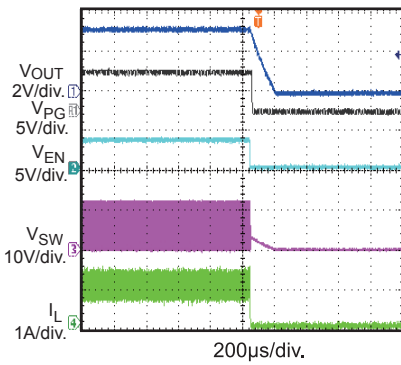
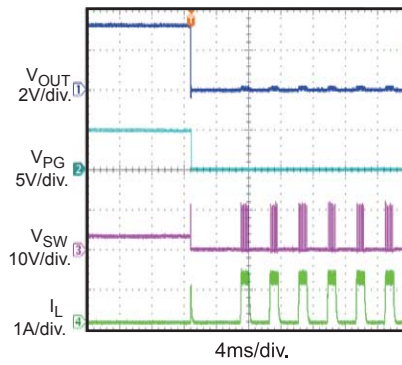
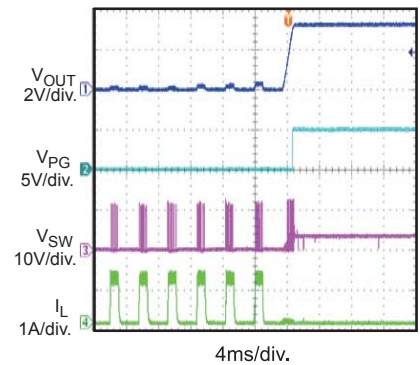
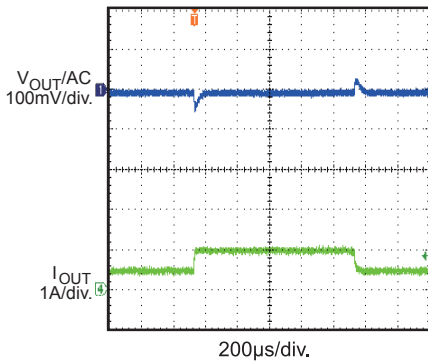
Performance waveforms are tested on the evaluation board of the Design Example section.  
 $V_{IN} = 12V$ ,  $V_{OUT} = 3.3V$ ,  $L = 6.5\mu H$ ,  $F_{SW} = 500kHz$ ,  $C_{SS} = 12nF$ ,  $T_A = 25^\circ C$ , BIAS is connected to GND, unless otherwise noted.

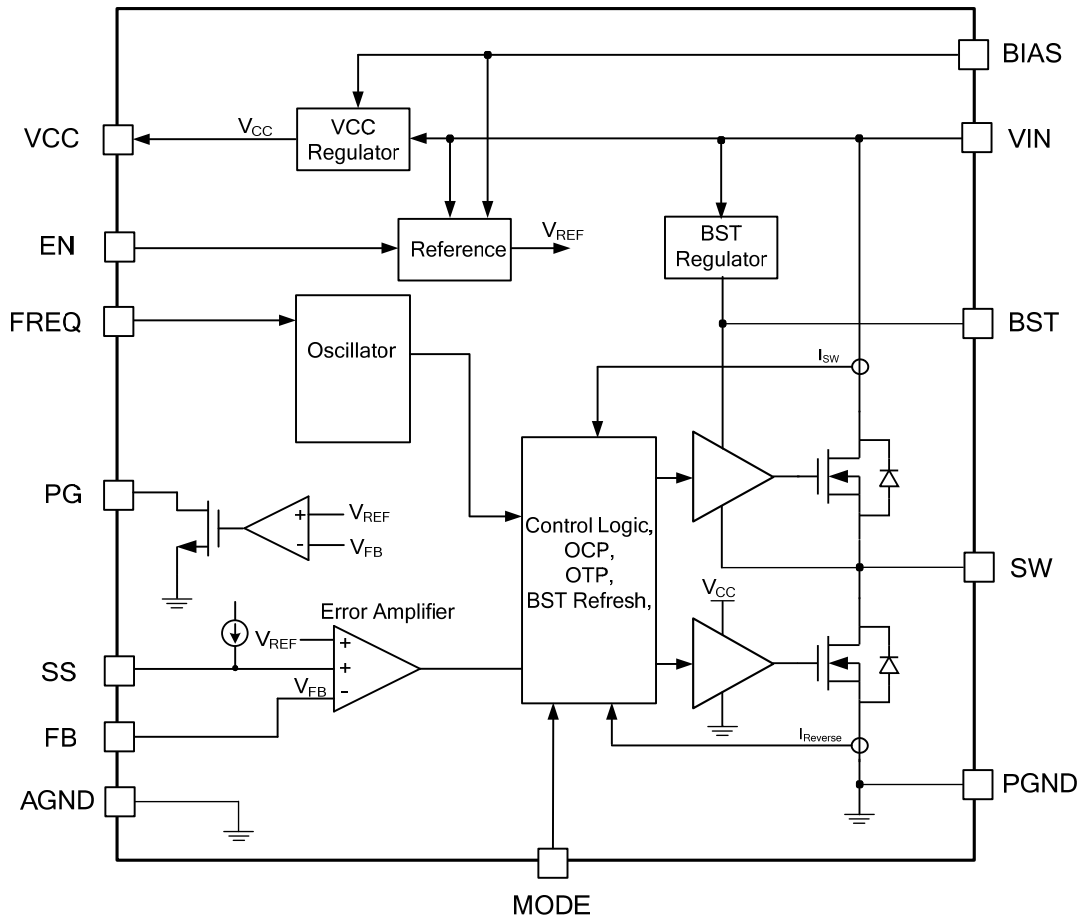
**Input/Output Ripple**  
 $I_{OUT} = 0A$ 

**Input/Output Ripple**  
 $I_{OUT} = 1A$ 

**Start-Up through Input Voltage**  
 $I_{OUT} = 0A$ 

**Start-Up through Input Voltage**  
 $I_{OUT} = 1A$ 

**Shutdown through Input Voltage**  
 $I_{OUT} = 0A$ 

**Shutdown through Input Voltage**  
 $I_{OUT} = 1A$ 

**Start-Up through EN**  
 $I_{OUT} = 0A$ 

**Start-Up through EN**  
 $I_{OUT} = 1A$ 

**Shutdown through EN**  
 $I_{OUT} = 0A$ 




**TYPICAL PERFORMANCE CHARACTERISTICS (continued)**

Performance waveforms are tested on the evaluation board of the Design Example section.  
**VIN = 12V, VOUT = 3.3V, L = 6.5μH, FSW = 500kHz, CSS = 12nF, TA = 25°C, BIAS is connected to GND, unless otherwise noted.**

**Shutdown through EN**
 $I_{OUT} = 1A$ 

**Short-Circuit Protection Entry**

**Short-Circuit Protection Recovery**

**Load Transient Response**
 $I_{OUT} = 0.5A \text{ to } 1A$ 


**BLOCK DIAGRAM**

**Figure 1: Functional Block Diagram**

## OPERATION

The MP2269 is a synchronous, step-down, switching regulator with integrated, internal, high-side and low-side power MOSFETs. It provides 1A of highly efficient output current with current-mode control. The MP2269 features a wide input voltage range, programmable 350kHz to 2.5MHz switching frequency, external soft start, and current limit. Its very low operational quiescent current makes it suitable for battery-powered applications.

### PWM Control

At moderate-to-high output currents, the MP2269 operates in a fixed-frequency, peak-current-control mode to regulate the output voltage. A PWM cycle is initiated by the internal clock. At the rising edge of the clock, the high-side power MOSFET (HS-FET) is turned on and remains on until its current reaches the value set by the COMP voltage ( $V_{COMP}$ ). When the high-side power switch is off, the low-side MOSFET (LS-FET) is turned on and remains on until the next cycle begins. If the current in the HS-FET does not reach the COMP-set current value in one PWM period, the HS-FET remains on, saving a turn-off operation.

### Advanced Asynchronous Mode (AAM)

The MP2269 employs advanced asynchronous mode (AAM) functionality to optimize efficiency during light-load or no-load conditions. AAM mode is selectable. Enable AAM by connecting MODE to a low level or floating MODE; disable AAM by connecting MODE to a high level.

If AAM is enabled, the MP2269 first enters non-synchronous operation for as long as the inductor current approaches zero at light load. If the load is further decreased or is at no load,  $V_{COMP}$  is below  $V_{AAM}$ , and the MP2269 enters AAM or sleep mode, which consumes very low quiescent current and improves light-load efficiency further.

In AAM, the internal clock is reset whenever  $V_{COMP}$  crosses over  $V_{AAM}$ , and the crossover time is taken as the benchmark for the next clock. When the load increases, and the DC value of  $V_{COMP}$  is higher than  $V_{AAM}$ , the

operation mode is DCM or CCM, which have a constant switching frequency.

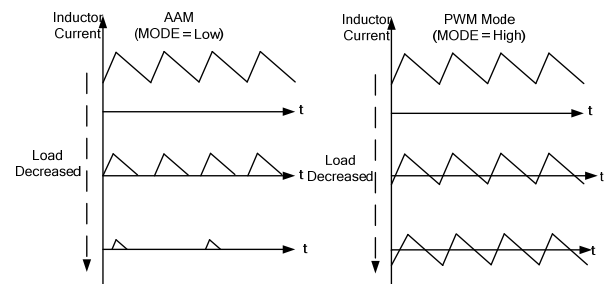


Figure 2: AAM and PWM Mode

The MP2269 has a mode selection function (see Figure 2). Pull MODE low or float MODE to set auto PFM/PWM mode. Pull MODE high to set forced PWM mode. MODE is pulled down internally. Select MODE before the part starts up.

### Error Amplifier (EA)

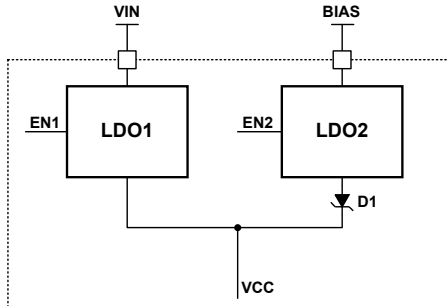
The error amplifier (EA) compares the FB voltage with the internal reference (typically 0.8V) and outputs a current proportional to the difference between the two. This output current is used to charge the internal compensation network to form  $V_{COMP}$ , which is used to control the power MOSFET current.

### BIAS and VCC Regulator

Most of the internal circuitry is powered by the internal regulator. The MP2269 has two internal regulators (see Figure 3). The regulator LDO1 takes the VIN input and operates in the full VIN range. When VIN is greater than 5V, the output of the regulator is in full regulation, and VCC is 5V. When VIN is lower than 5V, the output degrades.

Another regulator, LDO2, is powered by BIAS. Connect BIAS to an external power source, and keep the BIAS voltage higher than 4.8V. VCC and the internal circuit are then powered by BIAS. When  $V_{BIAS}$  is greater than 5V, the output of the regulator is in full regulation, and VCC is 5V. When  $V_{BIAS}$  is lower than 5V, the output degrades. LDO2 is enabled when  $V_{BIAS} > 4.8V$ . Once LDO2 is enabled, LDO1 is disabled. For a 5V output application, BIAS is recommended to be connected to  $V_{OUT}$  for improved efficiency. The diode (D1) between BIAS and the internal circuit is used for reverse blocking. Since LDO1

has no reverse block function,  $V_{BIAS}$  must be less than  $V_{IN}$ . Connect BIAS to GND if BIAS is not used.



**Figure 3: VCC Regulator**

### Bootstrap Charging

The bootstrap capacitor is charged and regulated to about 5V by the dedicated internal bootstrap regulator. When the voltage between the BST and SW nodes is lower than its regulation, a PMOS connected from VCC to BST is turned on. The charging current path is from VCC to BST to SW. When the HS-FET is on,  $V_{IN}$  is about equal to SW, so the bootstrap capacitor cannot be charged.

At higher duty cycle operation conditions, the time period available to the bootstrap charging is less, so the bootstrap capacitor may not be charged sufficiently. If the internal circuit does not have sufficient voltage or time to charge the bootstrap capacitor, extra external circuitry can be used to ensure that the bootstrap voltage is in the normal operation region.

### Low-Dropout Operation

To improve dropout, the MP2269 is designed to operate at almost 100% duty cycle as long as the BST to SW voltage is greater than 2.5V. When the voltage from BST to SW drops below 2.5V, the HS-FET is turned off using an under-voltage lockout (UVLO) circuit that allows the LS-FET to conduct and refresh the charge on the BST capacitor. In DCM or PSM, the LS-FET is forced on to refresh the BST voltage.

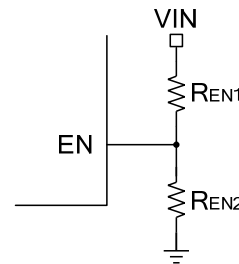
Since the supply current sourced from the BST capacitor is low, the HS-FET can remain on for more switching cycles than are required to refresh the capacitor, making the effective duty cycle of the switching regulator high.

The effective duty cycle during the dropout of the regulator is mainly influenced by the voltage drops across the power MOSFET, inductor resistance, low-side diode, and printed circuit board resistance.

### Enable (EN) Control

EN is a digital control pin that turns the regulator on and off. EN can be enabled by an external logic H/L signal. When EN is pulled below the threshold voltage, the chip is put into the lowest shutdown current mode. Forcing EN above the EN threshold voltage turns on the part.

For the programmable  $V_{IN}$  under-voltage lockout (UVLO), with a high-enough  $V_{IN}$ , the chip can be enabled and disabled by EN (see Figure 4). This circuit can generate a programmable  $V_{IN}$  UVLO and hysteresis.



**Figure 4: Enable Divider Circuit**

### Frequency Programmable

The MP2269 oscillating frequency is programmed by an external resistor ( $R_{freq}$ ) from FREQ to ground.

The approximate value of  $R_{freq}$  can be calculated with Equation (1):

$$R_{freq} (\text{k}\Omega) = \frac{86500}{f_s (\text{kHz})} - 6.5 \quad (1)$$

### Soft Start (SS)

Soft start (SS) is implemented to prevent the converter output voltage from overshooting during start-up. When the soft-start period begins, an internal current source begins charging the external soft-start capacitor. After the soft-start voltage (SS) charges higher than the internal offset voltage (typically 600mV),  $V_{OUT}$  starts up. When  $(SS - V_{offest})/1.125$  is lower than the internal reference (REF), the error amplifier uses  $(SS - V_{offest})/1.125$  as the

reference. When  $(SS - V_{\text{offest}})/1.125$  is higher than REF, REF regains control.  $C_{\text{SS}}$  can be calculated with Equation (2):

$$C_{\text{SS}}(\text{nF}) = \frac{T_{\text{SS}}(\text{ms}) \times I_{\text{SS}}(\mu\text{A})}{1.125 \times V_{\text{ref}}(\text{V})} \quad (2)$$

The minimum  $T_{\text{SS}}$  is 800 $\mu\text{s}$ , typically.

### Pre-Bias Start-Up

The MP2269 has been designed for monotonic start-up into pre-biased loads. If the output is pre-biased to a certain voltage during start-up, the BST voltage is refreshed and charged. The voltage on the soft-start capacitor is charged as well. If the BST voltage exceeds its rising threshold voltage, and the soft-start capacitor voltage exceeds  $1.125 \times V_{\text{FB}} + V_{\text{offest}}$ , the part begins working normally.

### Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from running away thermally. When the silicon die temperature is higher than its upper threshold, the power MOSFETs are shut down. When the temperature is lower than its lower threshold, thermal shutdown is removed, and the chip is enabled again.

### Current Comparator and Current Limit

The power MOSFET current is accurately sensed via a current sense MOSFET. The current is then fed to the high-speed current comparator for current-mode control purposes. The current comparator uses this sensed current as one of its inputs. When the HS-FET is turned on, the comparator is first blanked until the end of the turn-on transition to avoid noise. Then, the comparator compares the power switch current with  $V_{\text{COMP}}$ .

When the sensed current is higher than  $V_{\text{COMP}}$ , the comparator outputs low to turn off the HS-FET.

The maximum current of the internal power MOSFET is limited cycle-by-cycle internally.

### Hiccup Protection

When the output is shorted to ground, causing the output voltage to drop below 70% of its nominal output, the IC shuts down momentarily and begins discharging the soft-start capacitor. The IC restarts with a full soft start when the

soft-start capacitor is fully discharged. This hiccup process is repeated until the fault is removed.

### Start-Up and Shutdown

If both VIN and EN are higher than their respective thresholds, the chip starts up. The reference block starts first, generating a stable reference voltage and current, and then the internal regulator is enabled. The regulator provides a stable supply for the rest of the circuitries.

While the internal supply rail starts up, an internal timer holds the power MOSFET off for about 50 $\mu\text{s}$  to blank the start-up glitches. When the soft-start block is enabled, it first holds its SS output low to ensure that the rest of the circuitries are ready and then ramps up slowly.

Three events can shut down the chip: EN low, VIN low, and thermal shutdown. In the shutdown procedure, the signaling path is blocked first to avoid any fault triggering.  $V_{\text{COMP}}$  and the internal supply rail are then pulled down. The floating driver is not subject to this shutdown command, but its charging path is disabled.

### Power Good (PG) Output

The MP2269 has an open-drain pin as the power good indicator (PG). PG can indicate under-voltage (UV) and over-voltage (OV). Pull PG up to VCC through a 100k $\Omega$  resistor. At the UV condition, when  $V_{\text{FB}}$  exceeds 90% of  $V_{\text{REF}}$ , PG goes high. If  $V_{\text{FB}}$  goes below 84% of  $V_{\text{REF}}$ , an internal MOSFET pulls PG down to ground. At the OV condition, when  $V_{\text{FB}}$  exceeds 118% of  $V_{\text{REF}}$ , PG goes low. If  $V_{\text{FB}}$  goes below 110% of  $V_{\text{REF}}$ , PG goes high.

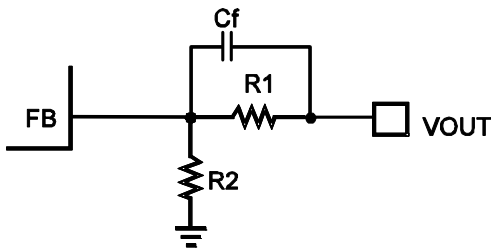
## APPLICATION INFORMATION

### Setting the Output

The external resistor divider is used to set the output voltage (see Typical Application on page 1). Choose R1 by referring to Table 1. R2 can then be calculated with Equation (3):

$$R2 = \frac{R1}{\frac{V_{OUT}}{0.8V} - 1} \quad (3)$$

The feedback network is highly recommended (see Figure 5).



**Figure 5: Feedback Network**

Table 1 lists the recommended feedback network parameters for common output voltages.

**Table 1: Recommended Parameters for Common Output Voltages<sup>(7)</sup>**

| V <sub>OUT</sub> (V) | R1 (kΩ) | R2 (kΩ) | C <sub>f</sub> (pF) |
|----------------------|---------|---------|---------------------|
| 1.05                 | 470     | 1500    | 5.6                 |
| 1.2                  | 750     | 1500    | 5.6                 |
| 1.8                  | 1000    | 806     | 5.6                 |
| 2.5                  | 1000    | 470     | 5.6                 |
| 3.3                  | 1000    | 324     | 5.6                 |
| 5                    | 1000    | 191     | 5.6                 |

#### NOTES:

7) The recommended parameters are based on a 500kHz switching frequency. A different input voltage, output inductor value, and output capacitor value may affect the selection of R1, R2, and C<sub>f</sub>. For additional component parameters, please refer to the Typical Application Circuits on pages 17 and 18.

### Selecting the Inductor

For most applications, use a 1μH to 22μH inductor with a DC current rating at least 25% higher than the maximum load current. For highest efficiency, use an inductor with a DC resistance less than 15mΩ.

For most designs, the inductance value can be derived from Equation (4):

$$L_1 = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{OSC}} \quad (4)$$

Where ΔI<sub>L</sub> is the inductor ripple current.

Choose the inductor ripple current at approximately 30% of the maximum load current. The maximum inductor peak current is calculated with Equation (5):

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2} \quad (5)$$

### Selecting the Input Capacitor

The input current to the step-down converter is discontinuous and therefore requires a capacitor to supply AC current while maintaining the DC input voltage. Use low ESR capacitors for the best performance. Ceramic capacitors with X5R or X7R dielectrics are recommended because of their low ESR and small temperature coefficients. For most applications, use one 10μF capacitor.

Since C1 absorbs the input switching current, it requires an adequate ripple current rating. The RMS current in the input capacitor can be estimated with Equation (6):

$$I_{C1} = I_{LOAD} \times \sqrt{\frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)} \quad (6)$$

The worst-case condition occurs at V<sub>IN</sub> = 2V<sub>OUT</sub>, shown in Equation (7):

$$I_{C1} = \frac{I_{LOAD}}{2} \quad (7)$$

For simplification, choose an input capacitor with an RMS current rating greater than half of the maximum load current.

The input capacitor can be electrolytic, tantalum, or ceramic. When using electrolytic or tantalum capacitors, a small, high-quality ceramic capacitor (e.g.: 0.1μF) should be placed as close to the IC as possible. When using ceramic capacitors, ensure that they have enough capacitance to provide a sufficient charge to prevent excessive voltage ripple at the input.



The input voltage ripple caused by the capacitance can be estimated with Equation (8):

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_s \times C1} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (8)$$

### Selecting the Output Capacitor

The output capacitor (C2) maintains the DC output voltage. Use ceramic, tantalum, or low ESR electrolytic capacitors. For best results, use low ESR capacitors to keep the output voltage ripple low. The output voltage ripple can be estimated with Equation (9):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_s \times C2}\right) \quad (9)$$

Where  $L_1$  is the inductor value, and  $R_{ESR}$  is the equivalent series resistance (ESR) value of the output capacitor.

For ceramic capacitors, the capacitance dominates the impedance at the switching frequency, and the capacitance causes the majority of the output voltage ripple. For simplification, the output voltage ripple can be estimated with Equation (10):

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_s^2 \times L_1 \times C2} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \quad (10)$$

For tantalum or electrolytic capacitors, the ESR dominates the impedance at the switching frequency. For simplification, the output ripple can be approximated with Equation (11):

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_s \times L_1} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR} \quad (11)$$

The characteristics of the output capacitor affect the stability of the regulation system. The MP2269 can be optimized for a wide range of capacitance and ESR values.

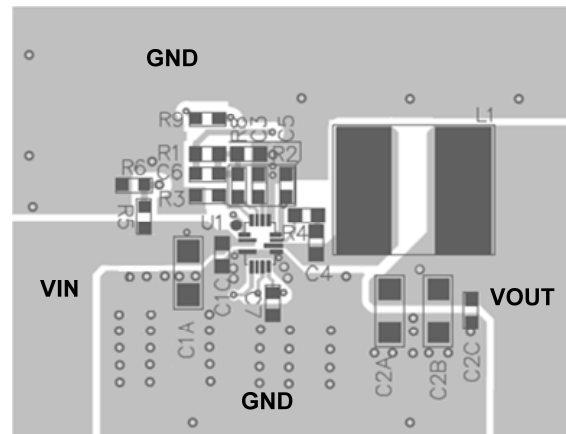
### PCB Layout Guidelines <sup>(8)</sup>

Efficient PCB layout is critical for stable operation. For best results, refer to Figure 6 and follow the guidelines below.

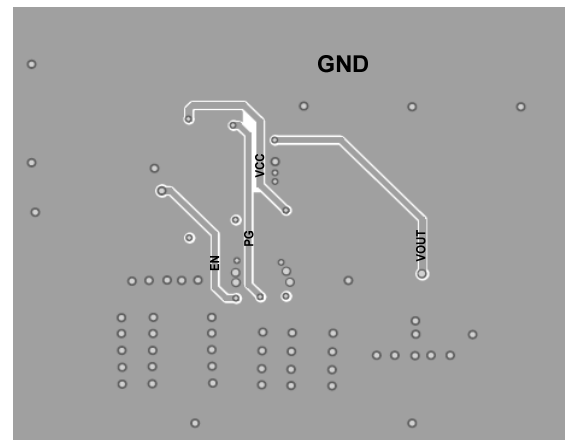
1. Keep the connection of the input ground and GND as short and wide as possible.
2. Keep the connection of the input capacitor and VIN as short and wide as possible.
3. Ensure all feedback connections are short and direct.
4. Place the feedback resistors and compensation components as close to the chip as possible.
5. Route SW away from sensitive analog areas such as FB.

#### NOTES:

- 8) The recommended layout is based on the Typical Application circuit on page 17 and page 18.



**Top Layer**



**Bottom Layer**

**Figure 6: Sample PCB Layout**

### Design Example

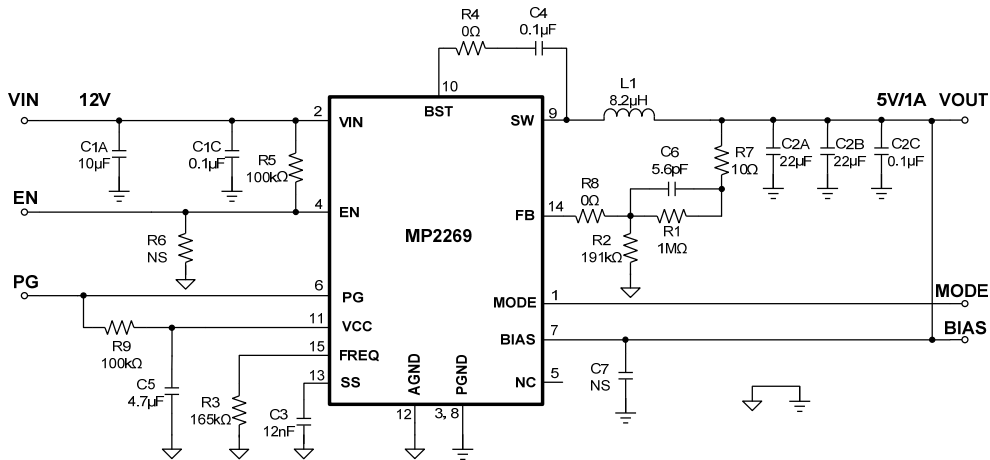
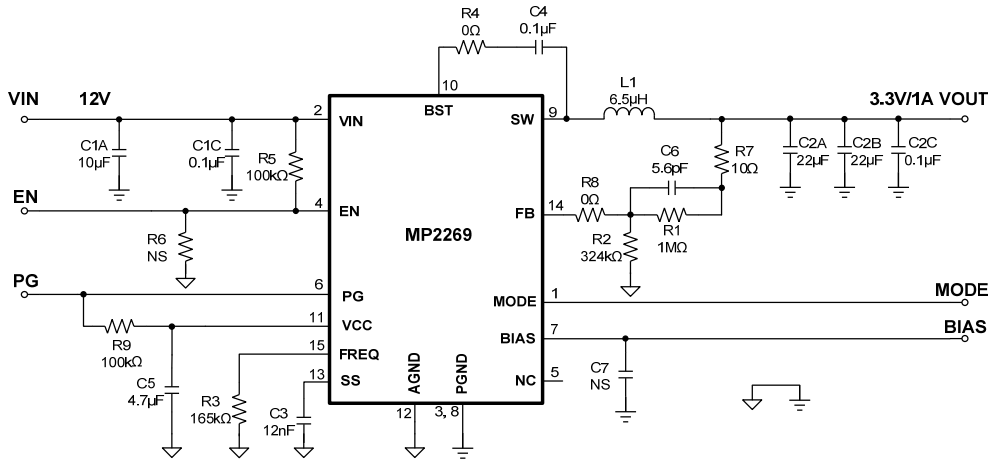
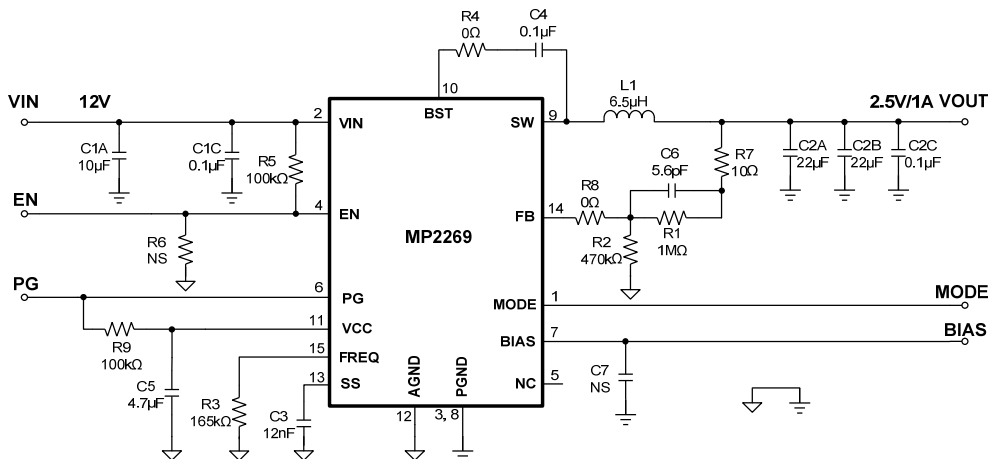
Table 2 shows a design example following the application guidelines for the specifications below.

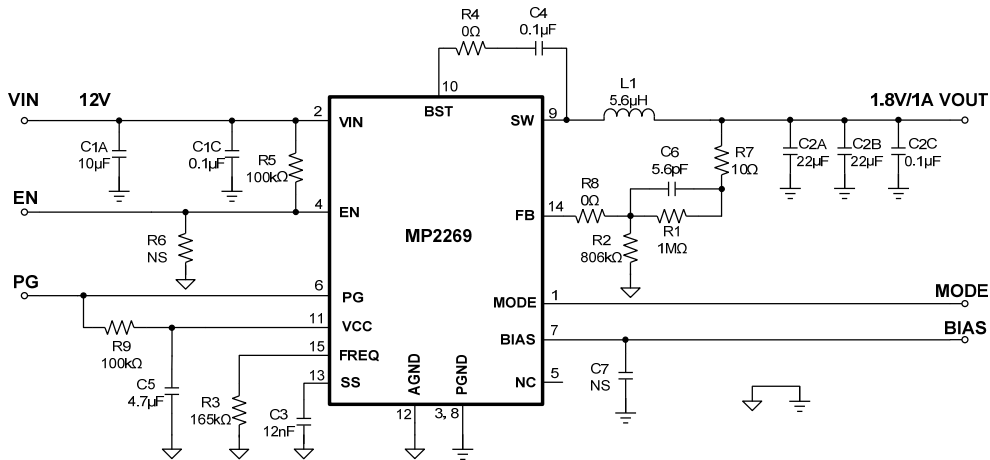
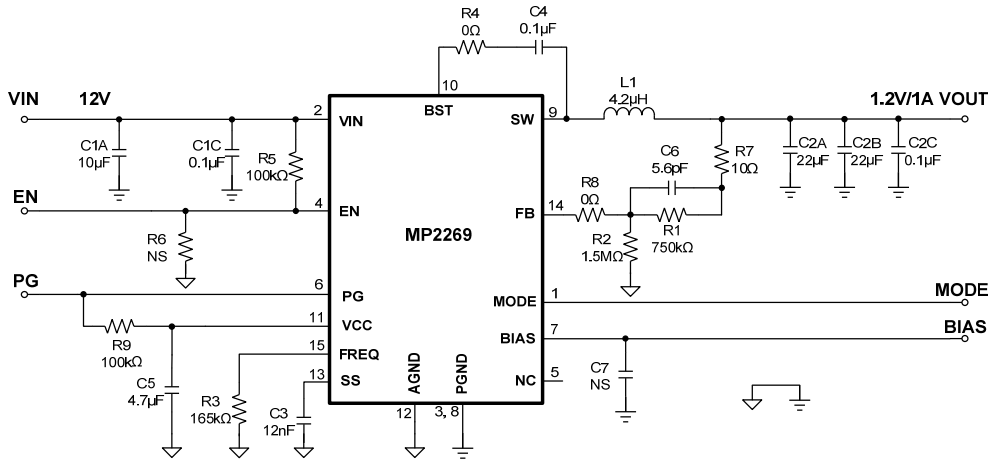
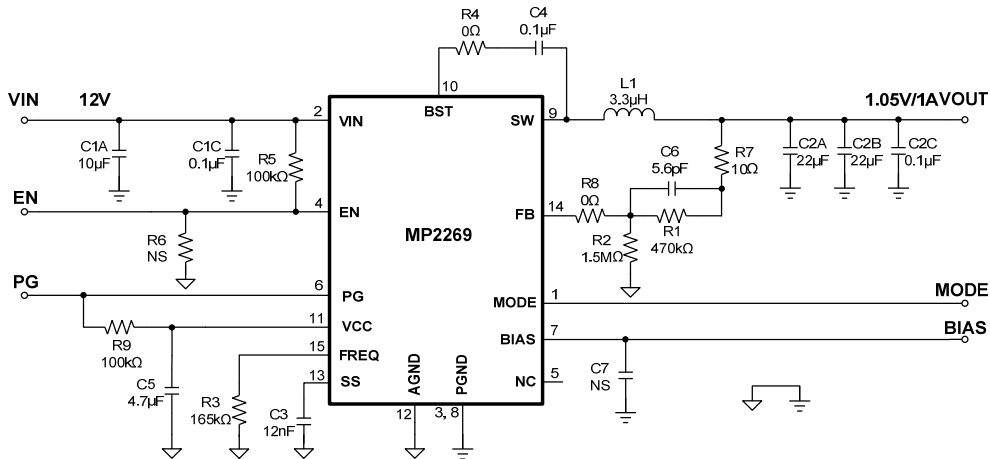
**Table 2: Design Example**

|                        |      |
|------------------------|------|
| <b>V<sub>IN</sub></b>  | 12V  |
| <b>V<sub>OUT</sub></b> | 3.3V |
| <b>I<sub>OUT</sub></b> | 1A   |

The detailed application schematic is shown in Figure 7 through Figure 12. The typical performance and circuit waveforms are shown in the Typical Performance Characteristics section. For additional device applications, please refer to the related evaluation board datasheet.



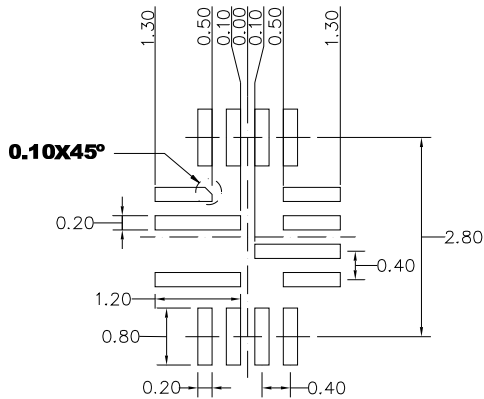
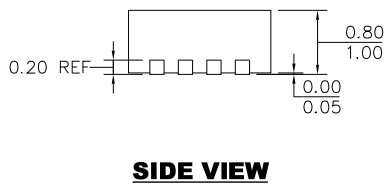
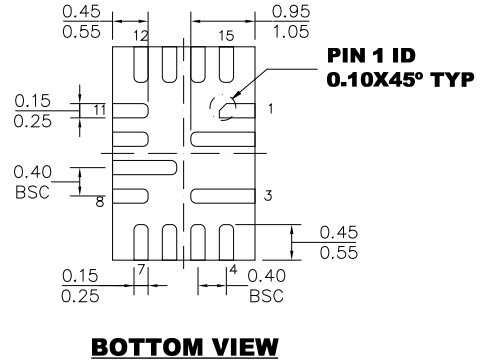
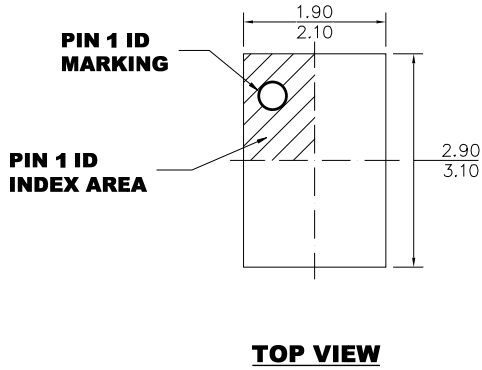
**TYPICAL APPLICATION CIRCUITS (9)**

**Figure 7: VIN = 12V, VOUT = 5V**

**Figure 8: VIN = 12V, VOUT = 3.3V**

**Figure 9: VIN = 12V, VOUT = 2.5V**

**TYPICAL APPLICATION CIRCUITS (continued)**

**Figure 10: VIN = 12V, V<sub>OUT</sub> = 1.8V**

**Figure 11: VIN = 12V, V<sub>OUT</sub> = 1.2V**

**Figure 12: VIN = 12V, V<sub>OUT</sub> = 1.05V**
**NOTE:**

9) To use the BIAS function, connect BIAS to a power source higher than 4.8V. If the BIAS function is not used, connect BIAS to GND.

PACKAGE INFORMATION

QFN-15 (2mmx3mm)



**NOTE:**

- 1) ALL DIMENSIONS ARE IN MILLIMETERS.
- 2) EXPOSED PADDLE SIZE DOES NOT INCLUDE MOLD FLASH.
- 3) LEAD COPLANARITY SHALL BE 0.10 MILLIMETERS MAX.
- 4) JEDEC REFERENCE IS MO-220.
- 5) DRAWING IS NOT TO SCALE.

**RECOMMENDED LAND PATTERN**

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