

1.2 MHz PWM Boost Converter with OVP

Features

- 2.8V to 6.5V Input Voltage
- 350 mA Switch Current
- Output Voltage up to 35V
- 1.2 MHz PWM Operation
- 1.265V Feedback Voltage
- Programmable Overvoltage Protection (OVP)
- <1% Line Regulation
- <1 μ A Shutdown Current
- Overtemperature Protection
- Undervoltage Lock Out (UVLO)
- Low Profile Thin SOT-23-6 Package
- -40°C to $+125^{\circ}\text{C}$ Junction Temperature Range

Applications

- Bias Supply Applications:
 - Tuner Varactor Bias
 - High Voltage Bias Supplies
 - Avalanche Photo Diode
 - High Voltage Display Bias
- DSL/Broadband Applications
- Constant Current Power Supplies

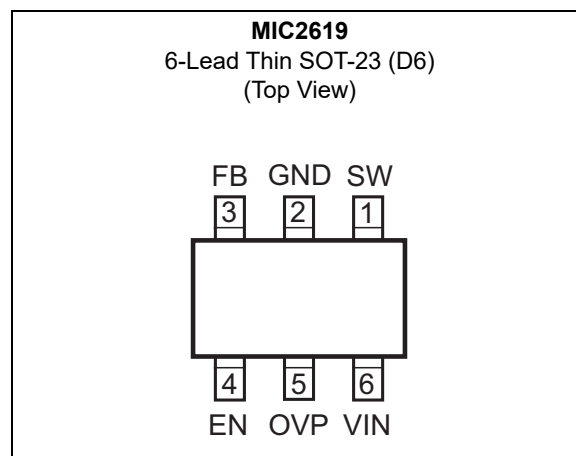
General Description

The MIC2619 is a 1.2 MHz pulse width modulated (PWM) step-up switching regulator that is optimized for low power, high output voltage applications. With a maximum output voltage of 35V and a switch current of over 350 mA, the MIC2619 can easily supply most high voltage bias applications, such as TV tuners.

The MIC2619 implements a constant frequency 1.2 MHz PWM current-mode control scheme. The high frequency PWM operation saves board space by reducing external component sizes. The additional benefit of the constant frequency PWM control scheme, as opposed to variable frequency control schemes, is lower output noise and smaller input ripple injected back to the battery source. The MIC2619 has programmable overvoltage protection to ensure output protection in case of fault condition.

The MIC2619 is available in a low profile Thin SOT-23 6-lead package. The MIC2619 has a junction temperature range of -40°C to $+125^{\circ}\text{C}$.

Package Type



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN})	+7V
Switch Voltage (V_{SW})	–0.3V to +40V
Enable Pin Voltage (V_{EN})	–0.3V to V_{IN}
Feedback Voltage (V_{FB} , V_{OVP})	+6V
ESD Rating (Note 1)	2 kV

Operating Ratings ‡

Supply Voltage (V_{IN})	+2.8V to +6.5V
Output Voltage (V_{OUT})	V_{IN} to +35V

† **Notice:** Stresses above those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

‡ **Notice:** The device is not guaranteed to function outside its operating ratings.

Note 1: Devices are inherently ESD sensitive. Handling precautions required. Human body model: 1.5 k Ω in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: $T_A = +25^\circ\text{C}$, $V_{IN} = V_{EN} = 3.6\text{V}$, $V_{OUT} = 10\text{V}$, $I_{OUT} = 10\text{ mA}$, unless otherwise noted.

Bold values valid for $-40^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$. (Note 1)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Voltage Range	V_{IN}	2.8	—	6.5	V	—
Undervoltage Lockout	UVLO	1.8	2.1	2.4	V	—
Quiescent Current	I_Q	—	2.1	5	mA	$V_{FB} > 1.265\text{V}$, (not switching)
Shutdown Current	I_{SD}	—	0.04	1	μA	$V_{EN} = 0\text{V}$
Feedback Voltage	V_{FB}	1.227	1.265	1.303	V	—
Feedback Input Current	I_{FB}	—	–450	—	nA	$V_{FB} > 1.265\text{V}$
Line Regulation		—	0.2	1	%	$2.8\text{V} \leq V_{IN} \leq 6.5\text{V}$
Load Regulation		—	0.3	—	%	$5\text{ mA} \leq I_{OUT} \leq 20\text{ mA}$
Maximum Duty Cycle	—	85	90	—	%	—
Switch Current Limit	I_{SW}	350	—	—	mA	$V_{IN} = 3.6\text{V}$ (Note 2)
Switch Saturation Voltage	V_{SW}	—	400	—	mV	$V_{IN} = 3.6\text{V}$, $I_{SW} = 300\text{ mA}$
Switch Leakage Current		—	0.01	1	μA	$V_{EN} = 0\text{V}$, $V_{SW} = 10\text{V}$
Enable Threshold		1.5	—	—	V	Turn On
		—	—	0.4		Turn Off
Enable Pin Current	I_{EN}	—	14	40	μA	$V_{EN} = 6.5\text{V}$
Oscillator Frequency	f_O	—	1.2	—	MHz	—
Overvoltage Protection	V_{OVP}	1.202	1.265	1.328	V	—
OVP Input Current	I_{OVP}	—	–200	—	nA	$V_{OVP} = 1.265\text{V}$
Overtemperature Threshold Shutdown		—	150	—	$^\circ\text{C}$	—
		—	10	—	$^\circ\text{C}$	Hysteresis

Note 1: Specification for packaged product only.

2: Ensured by design.

MIC2619

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	-40	—	+125	°C	—
Ambient Storage Temperature Range	T_S	-65	—	+150	°C	Soldering, 5 sec.
Package Thermal Resistance						
Thermal Resistance, TSOT 6-Ld	θ_{JA}	—	177	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A , T_J , θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

2.0 TYPICAL PERFORMANCE CURVES

Note: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

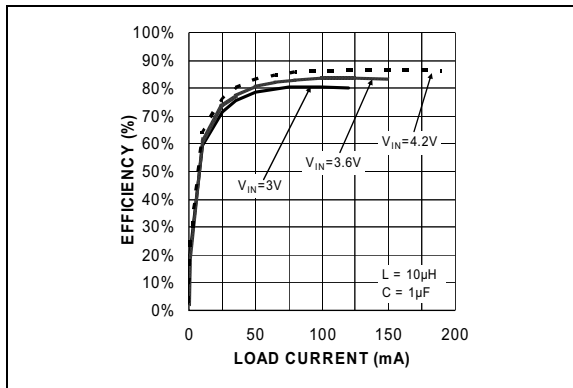


FIGURE 2-1: Efficiency $V_{OUT} = 5V$.

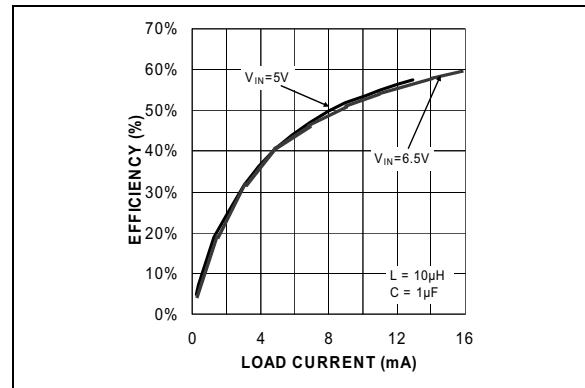


FIGURE 2-4: Efficiency $V_{OUT} = 35V$.

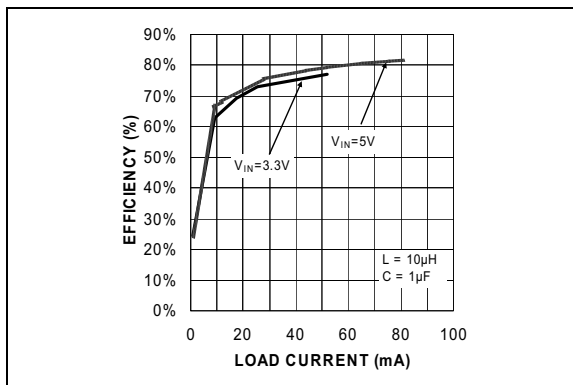


FIGURE 2-2: Efficiency $V_{OUT} = 10V$.

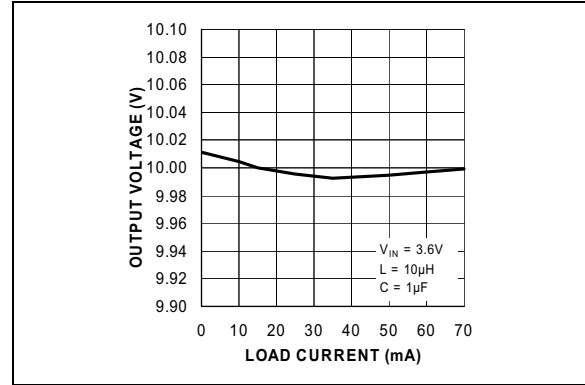


FIGURE 2-5: Load Regulation ($V_{OUT} = 10V$).

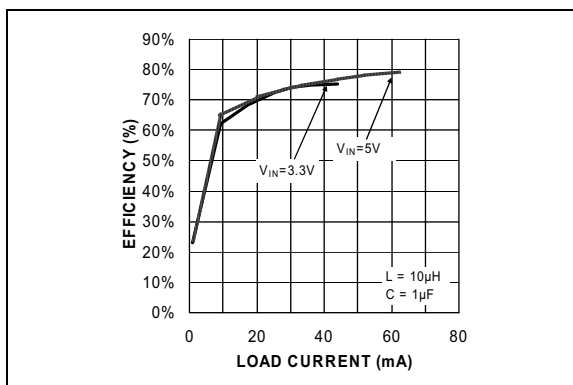


FIGURE 2-3: Efficiency $V_{OUT} = 12V$.

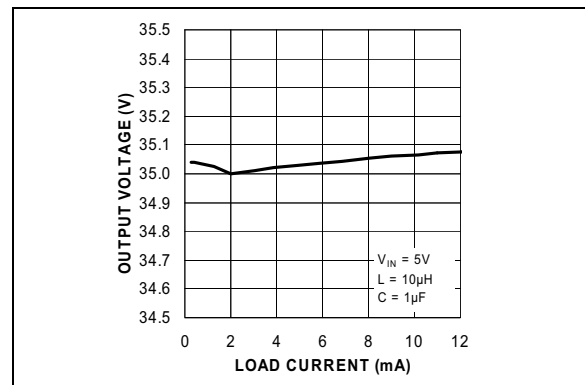


FIGURE 2-6: Load Regulation ($V_{OUT} = 35V$).

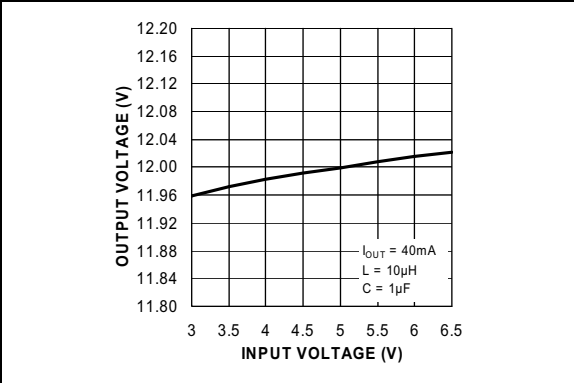


FIGURE 2-7: Line Regulation ($V_{OUT} = 12V$).

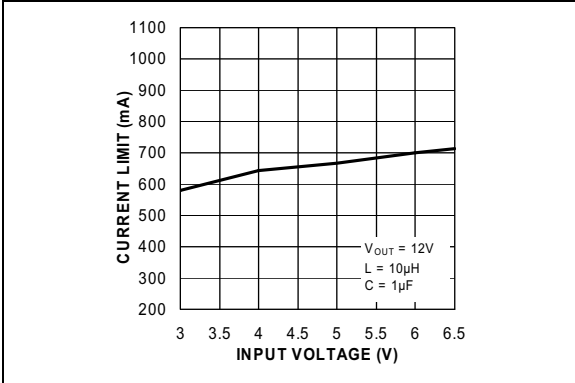


FIGURE 2-10: Switch Current Limit vs. Input Voltage.

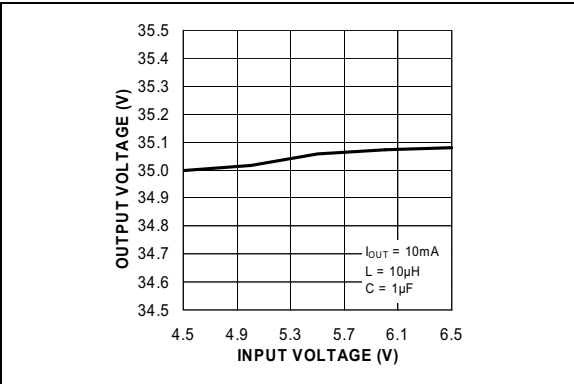


FIGURE 2-8: Line Regulation ($V_{OUT} = 35V$).

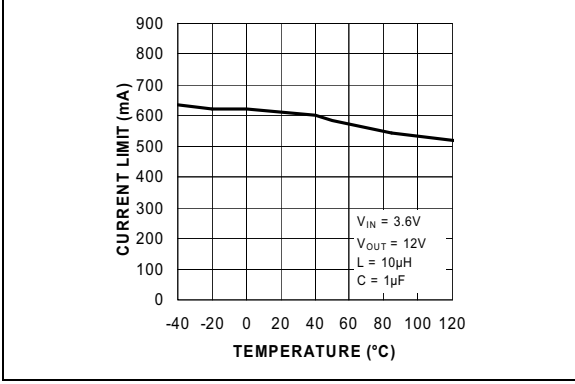


FIGURE 2-11: Switch Current Limit vs. Temperature.

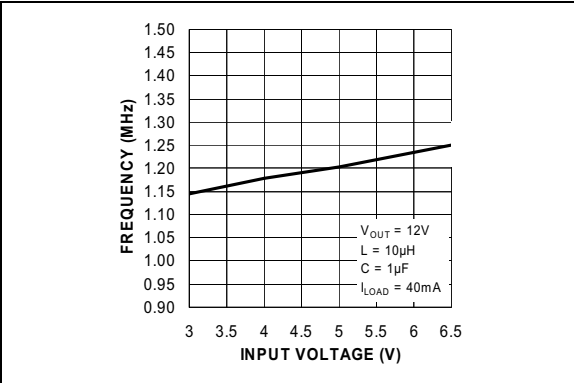


FIGURE 2-9: Frequency vs. Input Voltage.

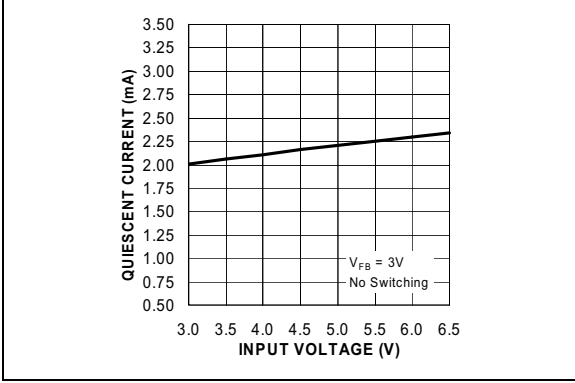


FIGURE 2-12: Quiescent Current vs. Input Voltage.

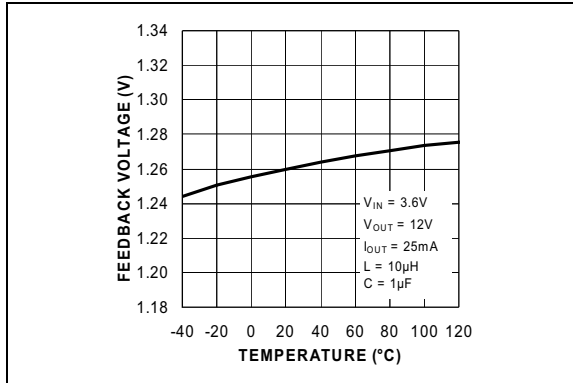


FIGURE 2-13: Feedback Voltage vs. Temperature.

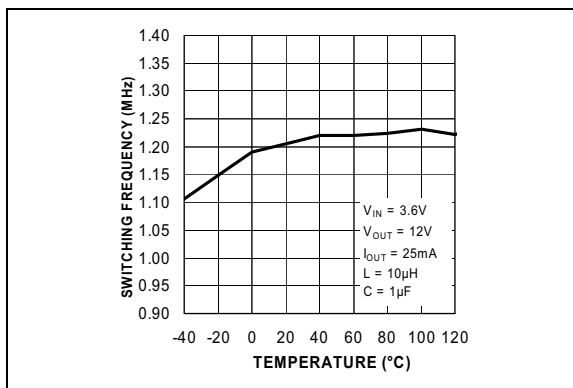


FIGURE 2-14: Switching Frequency vs. Temperature.

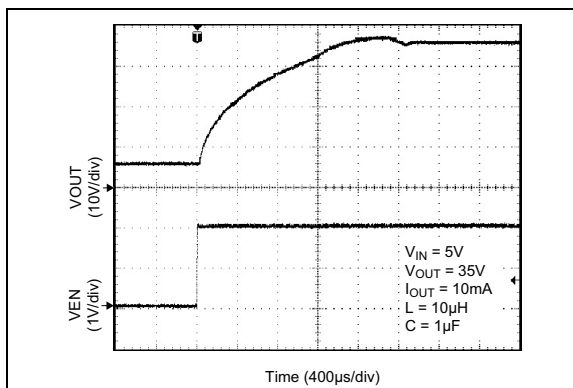


FIGURE 2-15: Enable Turn-On.

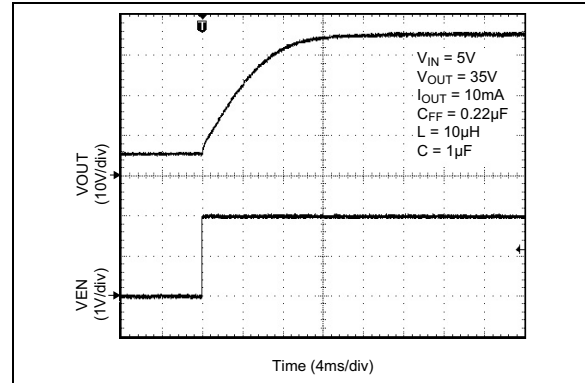


FIGURE 2-16: Enable Turn-On with Soft-Start.

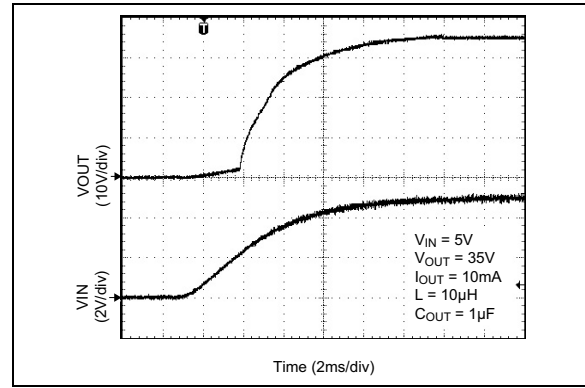


FIGURE 2-17: Input Turn-On.

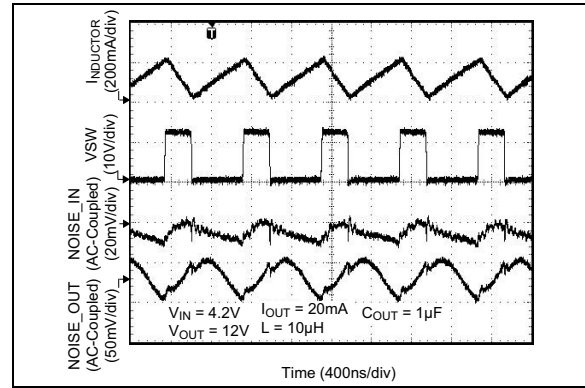


FIGURE 2-18: Switching Waveform – Continuous.

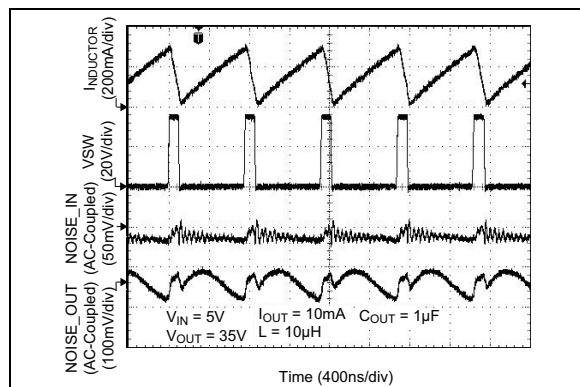


FIGURE 2-19: Switching Waveform – Continuous.

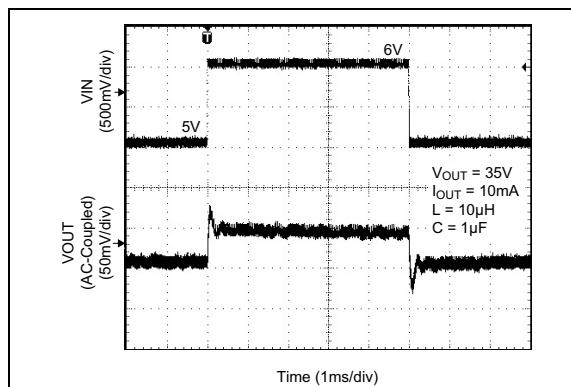


FIGURE 2-22: Line Transient, $V_{OUT} = 35V$.

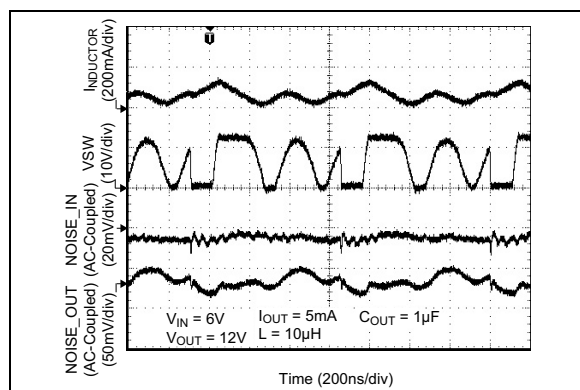


FIGURE 2-20: Switching Waveform – Discontinuous.

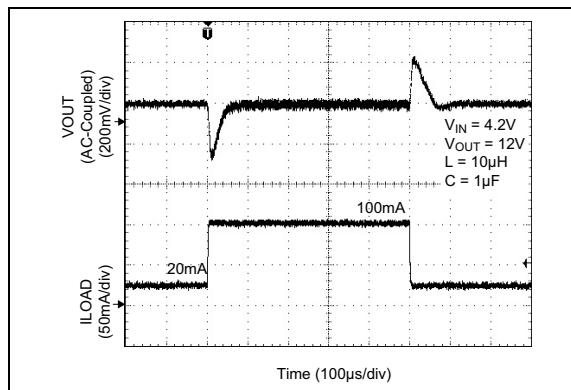


FIGURE 2-23: Load Transient, $V_{OUT} = 12V$.

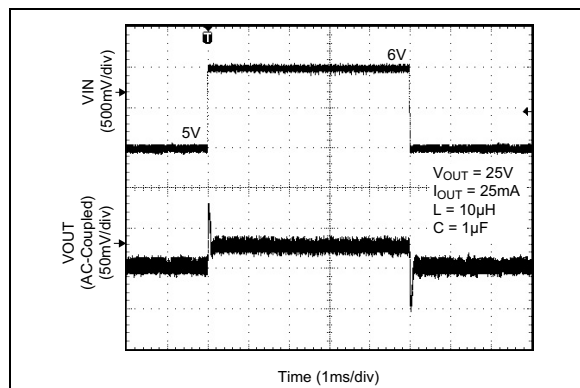


FIGURE 2-21: Line Transient, $V_{OUT} = 25V$.

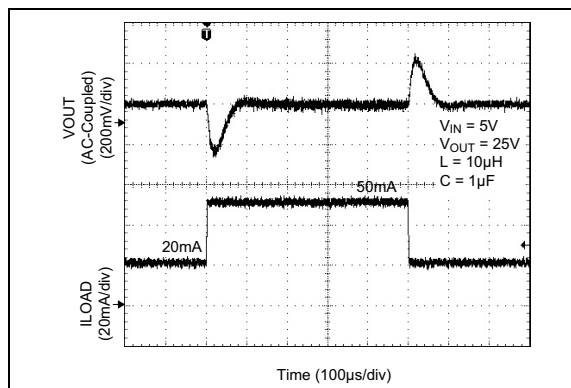


FIGURE 2-24: Load Transient, $V_{OUT} = 25V$.

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in [Table 3-1](#).

TABLE 3-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	SW	Switch Node (Input): Internal power bipolar collector.
2	GND	Ground.
3	FB	Feedback (Input): Output voltage sense node. Connect external resistor network to set output voltage. Nominal feedback voltage is 1.265V.
4	EN	Enable (Input): Logic high enables regulator. Logic low shuts down regulator. Do not leave floating.
5	OVP	Overvoltage Protection (Input): Programmable to 35V; adjustable through resistor divider network.
6	VIN	Supply (Input): 2.8V to 6.5V for internal circuitry. Requires a minimum 1.0 μ F ceramic capacitor.

4.0 FUNCTIONAL DESCRIPTION

The MIC2619 is a constant frequency, PWM current mode boost regulator. It is composed of an oscillator, slope compensation ramp generator, current amplifier, g_m error amplifier, PWM generator, and bipolar output transistor. The oscillator generates a 1.2 MHz clock that triggers the PWM generator to turn on the output transistor and resets the slope compensation ramp generator. The current amplifier is used to measure switch current by amplifying the voltage signal from the internal sense resistor. The output of the current amplifier is summed with the output of the slope compensation ramp generator. This summed current-loop signal is then fed to one of the inputs of the PWM generator.

The g_m error amplifier measures the feedback voltage through the external feedback resistors and amplifies the error between the detected signal and the 1.265V reference voltage. The output of the g_m error amplifier provides the voltage-loop signal that is fed to the other input of the PWM generator. When the current-loop signal exceeds the voltage loop signal, the PWM generator turns off the bipolar output transistor. The next clock period initiates the next switching cycle, maintaining the constant frequency current-mode PWM control.

4.1 VIN

VIN provides power to the control and reference circuitry as well as the switch mode regulator MOSFETs. Due to the high speed switching, a 1 μ F capacitor is recommended as close as possible to the VIN and GND pin.

4.2 EN

The enable pin provides a logic level control of the output. In the off state, supply current of the device is greatly reduced (typically <0.1 μ A). Also, in the off state, the output drive is placed in a “tri-stated” condition, where the bipolar output transistor is in an “off” state or non-conducting state.

4.3 OVP

The OVP pin provides overvoltage protection on the output of the MIC2619. When the OVP circuit is tripped, the output voltage remains at the set OVP voltage. Because the OVP circuit operates at a lower frequency than the feedback circuit, output ripple will be higher while in an OVP state. OVP requires a resistor divider network to the output and GND to set the OVP voltage. If the output voltage overshoots the set OVP voltage, then the MIC2619 OVP circuit will shut off the switch; saving itself and other sensitive circuitry downstream. The accuracy of the OVP pin is $\pm 5\%$ and therefore

should be set above the output voltage to ensure noise or other variations will not cause a false triggering of the OVP circuit.

4.4 FB

The feedback pin provides the control path to control the output. FB requires a resistor divider network to the output and GND to set the output voltage.

4.5 SW

The switching pin connects directly to one end of the inductor to VIN and the anode of the Schottky diode to the output. Due to the high switching speed and high voltage associated with this pin, the switch node should be routed away from sensitive nodes.

4.6 GND

The ground pin is the ground path for high current PWM mode. The current loop for the power ground should be kept as small as possible.

5.0 APPLICATIONS INFORMATION

5.1 DC-to-DC PWM Boost Conversion

The MIC2619 is a constant-frequency boost converter. It can convert a low DC input voltage to a higher DC output voltage. Figure 5-1 shows a typical circuit. Boost regulation is achieved by turning on an internal switch, which draws current through the inductor. When the switch turns off, the inductor's magnetic field collapses. This causes the current to be discharged into the output capacitor through an external Schottky diode (D1). The Electrical Characteristics show Input Voltage ripple, Output Voltage ripple, SW Voltage, and Inductor Current for 10 mA load current. Regulation is achieved by modulating the pulse width i.e., pulse-width modulation (PWM).

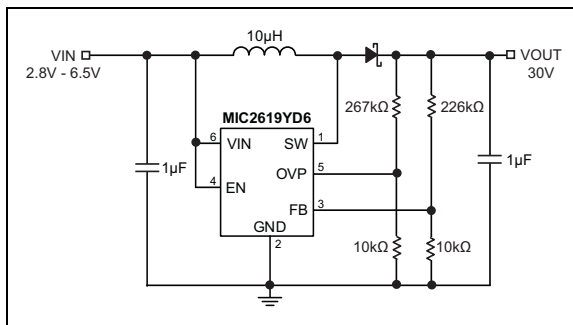


FIGURE 5-1: Typical Application Circuit.

5.2 Duty Cycle Considerations

Duty cycle refers to the switch on-to-off time ratio and can be calculated as follows for a boost regulator:

EQUATION 5-1:

$$D = 1 - \frac{V_{IN}}{V_{OUT}}$$

However, at light loads, the inductor will completely discharge before the end of a switching cycle. The current in the inductor reaches 0A before the end of the switching cycle. This is known as discontinuous conduction mode (DCM). DCM occurs when:

EQUATION 5-2:

$$I_{OUT} < \frac{V_{IN}}{V_{OUT}} \times \frac{I_{PEAK}}{2}$$

Where:

$$I_{PEAK} = \frac{(V_{OUT} - V_{IN})}{L \times f} \times \left(\frac{V_{IN}}{V_{OUT}} \right)$$

In DCM, the duty cycle is smaller than in continuous conduction mode. In DCM, the duty cycle is given by:

EQUATION 5-3:

$$D = \frac{f \times \sqrt{2 \times L \times I_{OUT} \times (V_{OUT} - V_{IN})}}{V_{IN}}$$

The duty cycle required for voltage conversion should be less than the maximum duty cycle of 85%. Also, in light load conditions where the input voltage is close to the output voltage, the minimum duty cycle can cause pulse skipping. This is due to the energy stored in the inductor causing the output to slightly overshoot the regulated output voltage. During the next cycle, the error amplifier detects the output as being high and skips the following pulse. This effect can be reduced by increasing the minimum load or by increasing the inductor value. Increasing the inductor value also reduces the peak current.

5.3 Input Capacitors

A 1 µF ceramic capacitor is recommended on the VIN pin for bypassing. Increasing input capacitance will improve performance and provide greater noise immunity. The input capacitor should be as close as possible to the inductor and the MIC2619, with short traces for good noise performance.

X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore not recommended. Also, tantalum and electrolytic capacitors alone are not recommended because of their reduced RMS current handling, reliability, and ESR increases.

5.4 Output Capacitors

Output capacitor selection is also a trade-off between performance, size, and cost. The minimum recommended output capacitor is 1 µF. Increasing output capacitance will lead to an improved transient response but also an increase in size and cost. X5R or X7R dielectrics are recommended for the output capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore not recommended.

5.5 Inductor

Inductor selection will be determined by the following (not necessarily in order of importance)

- Inductance
- Rated current value
- Size requirements
- DC resistance (DCR)

The MIC2619 was designed for use with a 10 μ H inductor. Proper selection should ensure the inductor can handle the maximum average and peak currents required by the load. Maximum current ratings of the inductor are generally given in two methods; permissible DC current and saturation current. Permissible DC current can be rated either for a 40°C temperature rise or a 10% to 20% loss in inductance. Ensure the inductor selected can handle the maximum operating current. When saturation current is specified, make sure that there is enough margin so that the peak current will not saturate the inductor. Peak current can be calculated as follows:

EQUATION 5-4:

$$I_{PEAK} = \left[I_{OUT} + V_{OUT} \times \left(\frac{1 - V_{OUT} \times V_{IN}}{2 \times f \times L} \right) \right]$$

As shown by Equation 5-4, the peak inductor current is inversely proportional to the switching frequency and the inductance; the lower the switching frequency or the inductance the higher the peak current. As input voltage increases, the peak current also increases.

The size of the inductor depends on the requirements of the application.

DC resistance (DCR) is also important. While DCR is inversely proportional to size, DCR can represent a significant efficiency loss.

To maintain stability, increasing inductor size will have to be met with an increase in output capacitance. This is due to the unavoidable “right half plane zero” (RHPZ) effect for the continuous current boost converter topology. The frequency at which the right half plane zero occurs can be calculated as follows:

EQUATION 5-5:

$$f = \frac{V_{IN}^2}{V_{OUT} \times L \times I_{OUT} \times 2\pi}$$

The right half plane zero has the undesirable effect of increasing gain, while decreasing phase. This requires that the loop gain is rolled off before this has significant effect on the total loop response. This can be accomplished by either reducing inductance (increasing RHPZ frequency) or increasing the output capacitor value (decreasing loop gain).

5.6 Diode Selection

The MIC2619 requires an external diode for operation. A Schottky diode is recommended for most applications due to their lower forward voltage drop and reverse recovery time. Ensure the diode selected can deliver the peak inductor current and the maximum reverse voltage is rated greater than the output voltage.

5.7 Soft-Start

Feed-forward capacitors can be used to provide soft-start for the MIC2619. Figure 5-2 shows a typical circuit for soft-start applications. Typically, a 0.22 nF feed-forward capacitor will yield 5 ms in rise time.

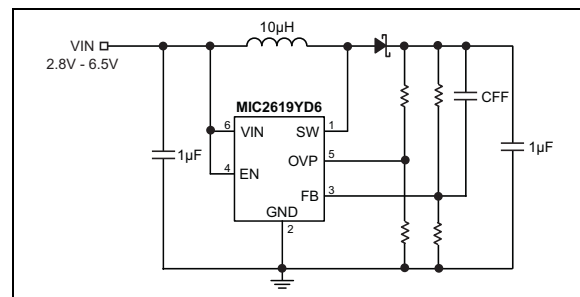


FIGURE 5-2: Soft-Start Circuit.

5.8 Feedback Resistors

The MIC2619 utilizes a feedback pin to compare the output to an internal reference. The output voltage is adjusted by selecting the appropriate feedback resistor network values. Using the evaluation board schematic as a reference, the desired output voltage can be calculated as follows:

EQUATION 5-6:

$$V_{OUT} = V_{REF} \times \left(\frac{R4}{R5} + 1 \right)$$

Where:

$$V_{REF} = 1.265V$$

Overvoltage protection uses the same equation as the feedback pin.

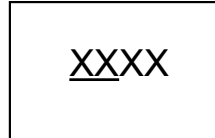
EQUATION 5-7:

$$V_{OVP} = V_{REF} \times \left(\frac{R1}{R2} + 1 \right)$$

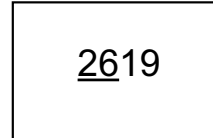
6.0 PACKAGING INFORMATION

6.1 Package Marking Information

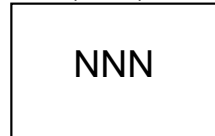
6-Lead Thin SOT-23*
(Front)



Example



6-Lead Thin SOT-23*
(Back)



Example



Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC [®] designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.
	•, ▲, ▼	Pin one index is identified by a dot, delta up, or delta down (triangle mark).
Note:	In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.	
	Underbar (¯) and/or Overbar (¯) symbol may not be to scale.	

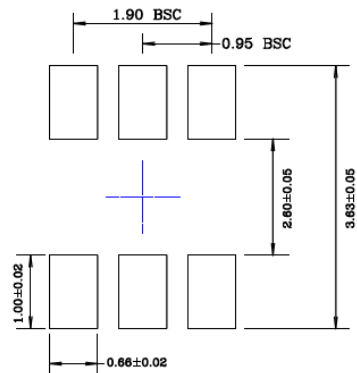
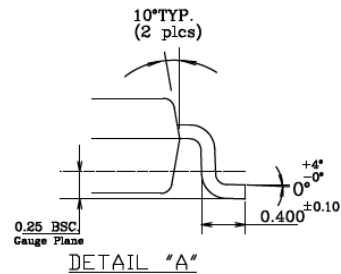
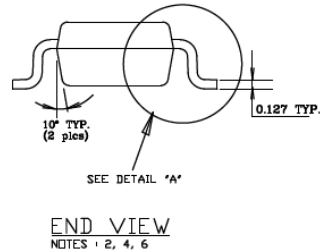
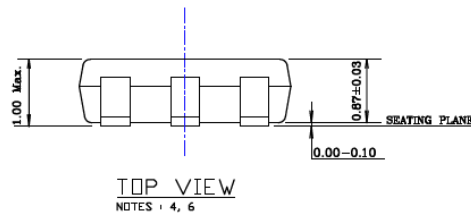
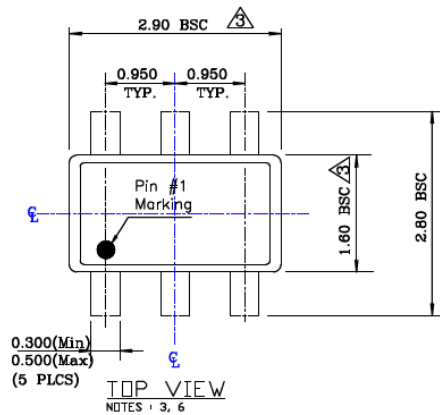
Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
 6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
 2 Characters = NN; 1 Character = N

6-Lead Thin SOT-23 Package Outline and Recommended Land Pattern

TITLE

6 LEAD TSOT PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	TSOT-6LD-PL-1	UNIT	MM
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NOTE:

1. Dimensions and tolerances are as per ANSI Y14.5M, 1994.
2. Die is facing up for mold. Die is facing down for trim/form, ie. reverse trim/form.
3. Dimensions are exclusive of mold flash and gate burr.
4. The footlength measuring is based on the gauge plane method.
5. All specification comply to Jedec Spec M0193 Issue C.
6. All dimensions are in millimeters.

Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>.

APPENDIX A: REVISION HISTORY

Revision A (May 2022)

- Converted Micrel document MIC2619 to Microchip data sheet DS20006545A.
- Minor text changes throughout.
- Removed the Evaluation Board Schematic and Recommended Layout sections as those appear in the MIC2619 User's Guide.

MIC2619

NOTES:

PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

<u>PART No.</u>	<u>X</u>	<u>X</u>	<u>-XX</u>
Device	Junction Temperature Range	Package	Media Type
Device: MIC2619: 1.2 MHz PWM Boost Converter with OVP Junction Temperature Range: Y = -40°C to +125°C Package: D6 = 6-Lead Thin SOT-23 Media Type: TR = 3,000/Reel			
Examples: a) MIC2619YD6-TR: 1.2 MHz PWM Boost Converter with OVP, -40°C to +125°C Temperature Range, 6-Lead TSOT-23, 3,000/Reel Note 1: Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.			

MIC2619

NOTES:

Note the following details of the code protection feature on Microchip products:

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