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MIC2290

0.75A Switch PWM Boost Regulator with Internal Schottky Diode and Undervoltage Lockout

Features

- Internal Schottky Diode
- 2.5V to 10V Input Voltage
- Output Voltage Adjustable to 34V
- 750 mA Switch Current
- 1.2MHz PWM Operation
- Stable with Ceramic Capacitors
- <1% Line and Load Regulation
- Low Output Voltage Ripple
- <1 µA Shutdown Current
- Undervoltage Lockout
- Output Overvoltage Protection
- Overtemperature Protection
- 2 mm x 2 mm 8-pin DFN Package
- –40°C to +125°C Junction Temperature Range

Applications

- Organic EL Power Supply
- TFT LCD Bias Supply
- 12V DSL Power Supply
- CCD Bias Supply
- SEPIC Converters

General Description

The MIC2290 is a 1.2 MHz, PWM, boost-switching regulator housed in the small 2 mm x 2 mm 8-pin DFN package. The MIC2290 features an internal Schottky diode that reduces circuit board area and total solution cost. High power density is achieved with the MIC2290's internal 34V/0.5A switch, allowing it to power large loads in a tiny footprint.

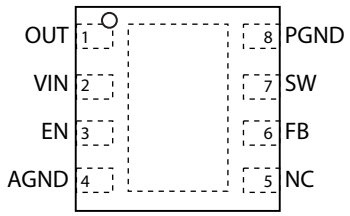
The MIC2290 implements a constant frequency 1.2 MHz PWM control scheme. The high frequency operation saves board space by reducing external component sizes. The fixed frequency PWM topology also reduces switching noise and ripple to the input power source.

The MIC2290's wide 2.5V to 10V input voltage allows direct operation from 3- to 4-cell NiCad/NiMH/Alkaline batteries, 1-and 2-cell Li-Ion batteries, as well as fixed 3.3V and 5V systems.

The MIC2290 is available in a low-profile 2 mm x 2 mm 8-pin DFN leadless package and operates from a junction temperature range of –40°C to +125°C.

Package Type

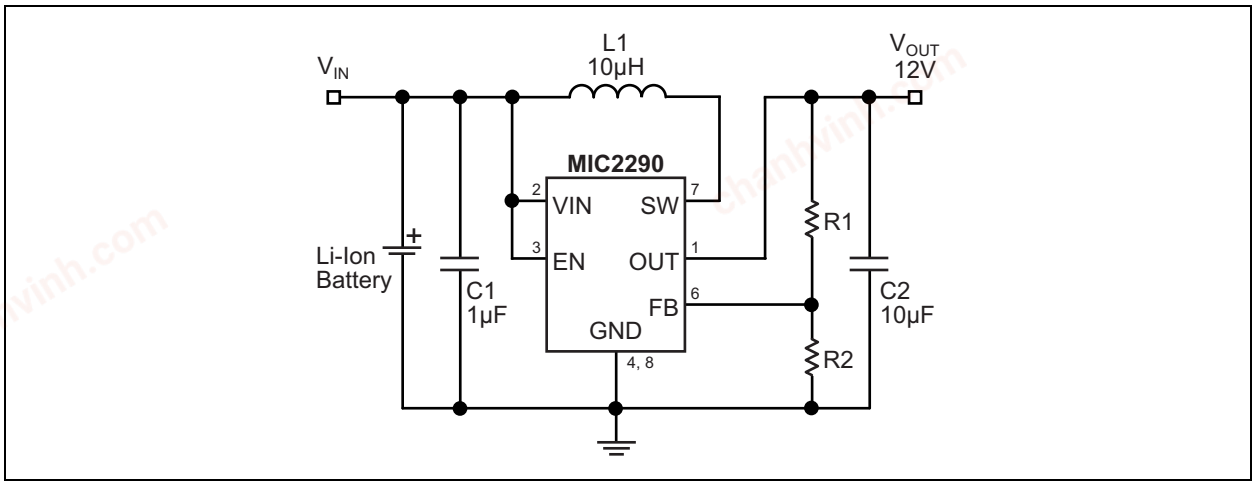
MIC2290
DFN-8 (ML)
(Top View)



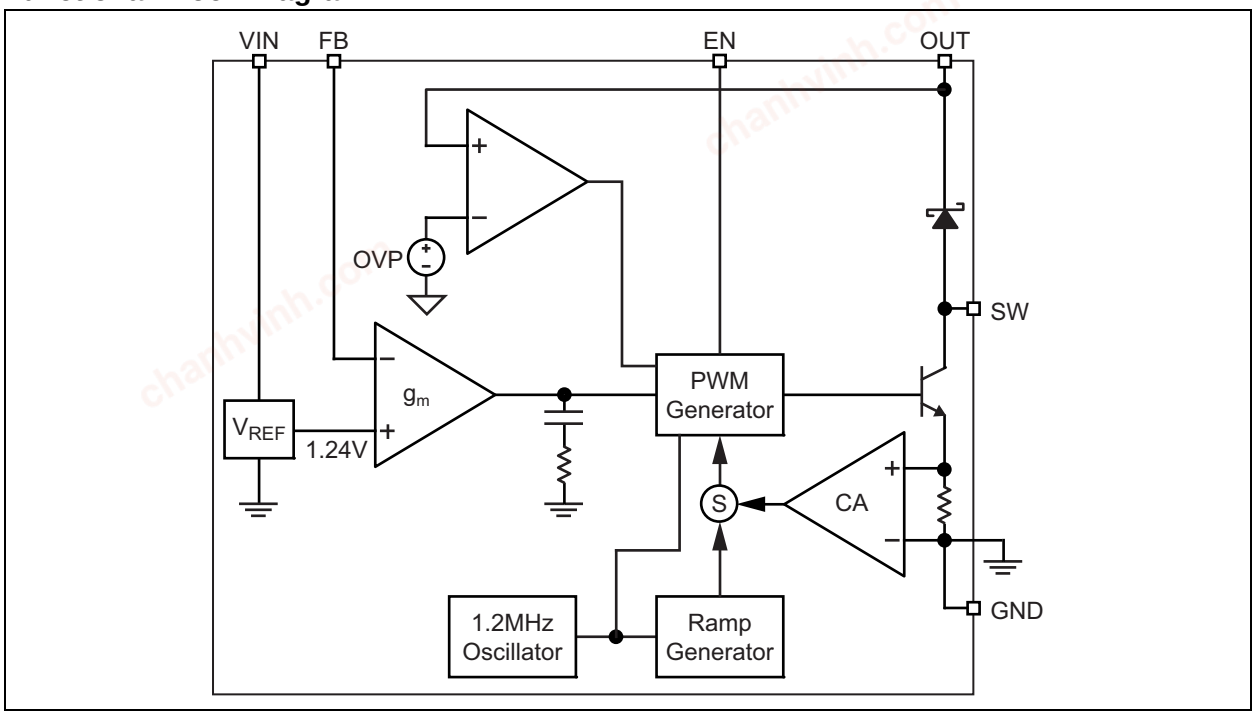
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Typical Application Circuit



Functional Block Diagram



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}) ..... +12V
Switch Voltage (V_{SW}) ..... –0.3V to +34V
Enable Pin Voltage (V_{EN}) ..... –0.3V to V_{IN}
FB Voltage (V_{FB}) ..... +6V
Switch Current (I_{SW}) 2A
ESD Rating (Note 1) ..... 2 kV

Operating Ratings ††

Supply Voltage (V_{IN}) ..... +2.5V to +10V

† **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 ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: T_A = +25°C, V_{IN} = V_{EN} = 3.6V, V_{OUT} = 15V, I_{OUT} = 40 mA, unless otherwise noted.
Bold values indicate –40°C ≤ T_J ≤ ±125°C. Note 1

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Supply Voltage Range	V_{IN}	**2.5**	—	**10**	V	—
Undervoltage Lockout	V_{UVLO}	1.8	2.1	2.4	V	—
Quiescent Current	I_{VIN}	—	2.5	5	mA	V_{FB} = 2V, not switching
Shutdown Current	I_{SD}	—	0.2	**1**	µA	VEN = 0V, Note 2
Feedback Voltage	V_{FB}	1.227	1.24	1.252	V	±1%
		1.215	—	**1.265**		±2% (overtemperature)
Feedback Input Current	I_{FB}	—	–450	—	nA	V_{FB} = 1.24V
Line Regulation	—	—	0.1	**1**	%	3V ≤ V_{IN} ≤ 5V
Load Regulation	—	—	0.2	—		5 mA ≤ I_{OUT} ≤ 20 mA
Maximum Duty Cycle	D_{MAX}	**85**	90	—	%	—
Switch Current Limit	I_{SW}	—	0.75	—	A	—
Switch Saturation Voltage	V_{SW}	—	450	—	mV	I_{SW} = 0.5A
Switch Leakage Current	I_{SW}	—	0.01	**5**	µA	V_{EN} = 0V, V_{SW} = 10V
Enable Threshold	V_{EN}	**1.5**	—	—	V	Turn on.
		—	—	**0.4**		Turn off.
Enable Pin Current	I_{EN}	—	20	40	µA	V_{EN} = 10V
Oscillator Frequency	f_{SW}	1.05	1.2	1.35	MHz	—
Schottky Forward Drop	V_D	—	0.8	1	V	I_D = 150 mA
Schottky Leakage Current	I_{RD}	—	—	**4**	µA	V_R = 30V

Note 1: Specification for packaged product only.
2: I_{SD} = I_{VIN}.

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ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: T_A = +25°C, V_{IN} = V_{EN} = 3.6V, V_{OUT} = 15V, I_{OUT} = 40 mA, unless otherwise noted.
Bold values indicate –40°C ≤ T_J ≤ ±125°C. Note 1

Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Overvoltage Protection	V_{OVP}	30	32	34	V	Nominal voltage
Overtemperature Threshold Shutdown	T_J	—	150	—	°C	Hysteresis
		—	10	—		—

Note 1: Specification for packaged product only.
2: I_{SD} = I_{VIN}.

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TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+150	°C	—
Ambient Operating Temperature Range	T_J	–40	—	+125	°C	—
Package Thermal Resistances						
Thermal Resistance, 2x2 DFN 8-Ld	θ_{JA}	—	93	—	°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.

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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.

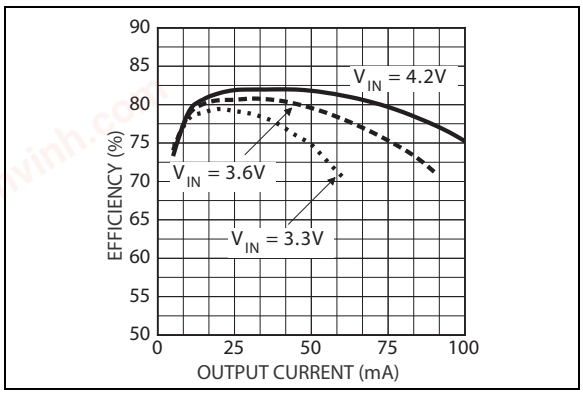


FIGURE 2-1: *Efficiency at V_{OUT} = 12V.*

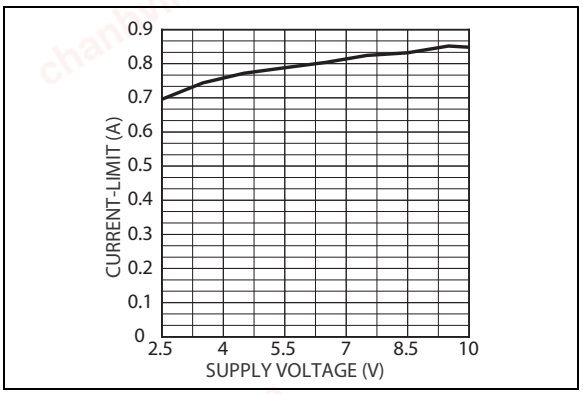


FIGURE 2-4: *Current-Limit vs. Supply Voltage.*

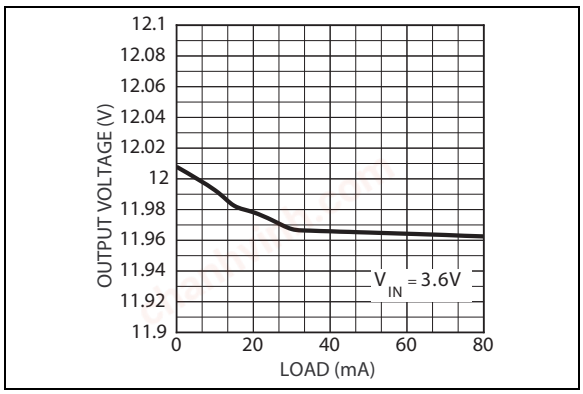


FIGURE 2-2: *Load Regulation.*

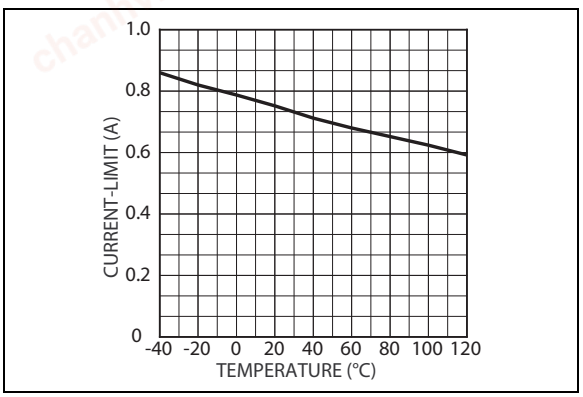


FIGURE 2-5: *Current-Limit vs. Temperature.*

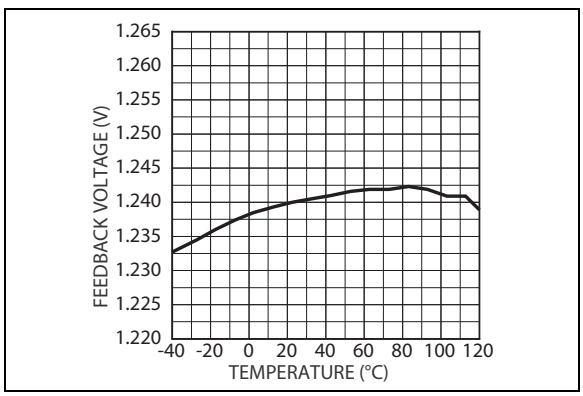


FIGURE 2-3: *Feedback Voltage vs. Temperature.*

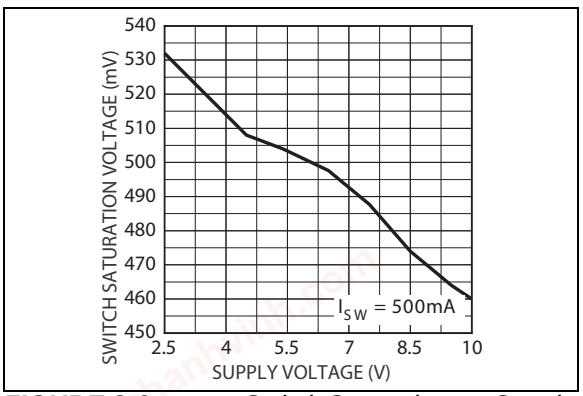


FIGURE 2-6: *Switch Saturation vs. Supply Voltage.*

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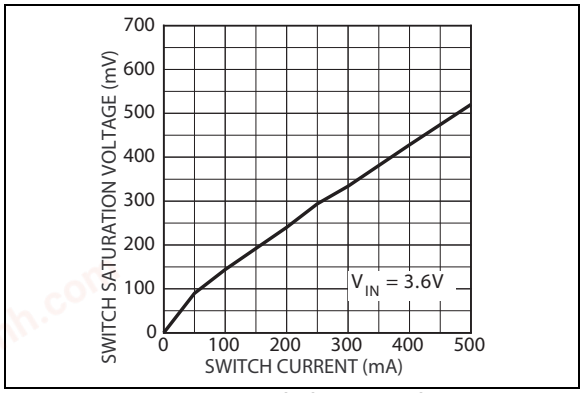


FIGURE 2-7: *Switch Saturation vs. Current.*

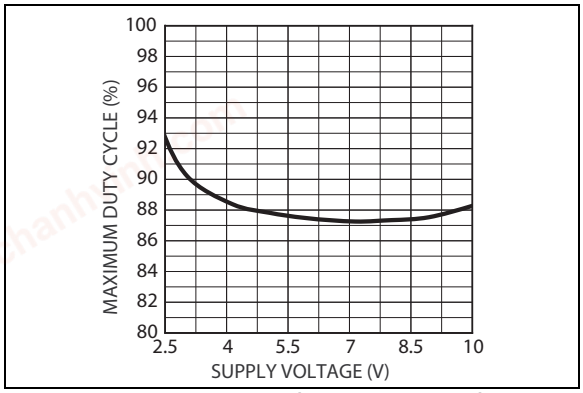


FIGURE 2-10: *Maximum Duty Cycle vs. Supply Voltage.*

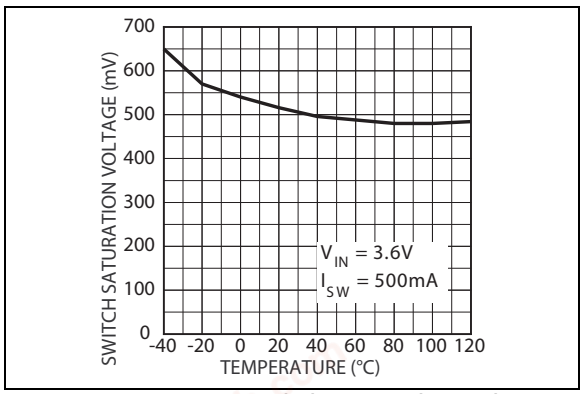


FIGURE 2-8: *Switch Saturation Voltage vs. Temperature.*

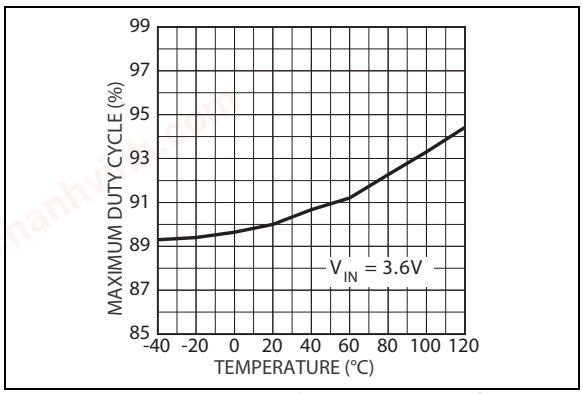


FIGURE 2-11: *Maximum Duty Cycle vs. Temperature.*

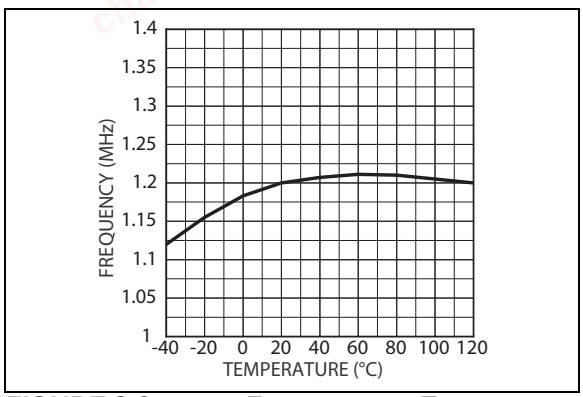


FIGURE 2-9: *Frequency vs. Temperature.*

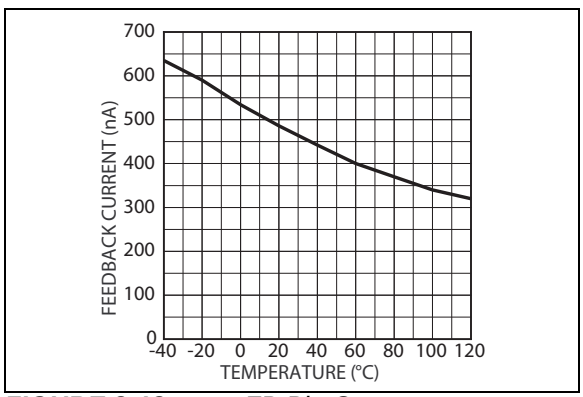


FIGURE 2-12: *FB Pin Current vs. Temperature.*

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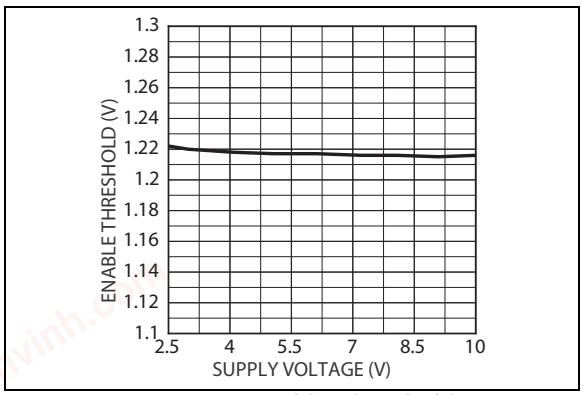


FIGURE 2-13: *Enable Threshold vs. Supply Voltage.*

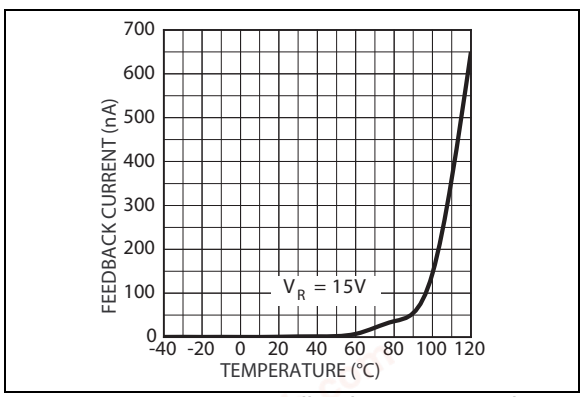


FIGURE 2-14: *Feedback Current Leakage vs. Temperature.*

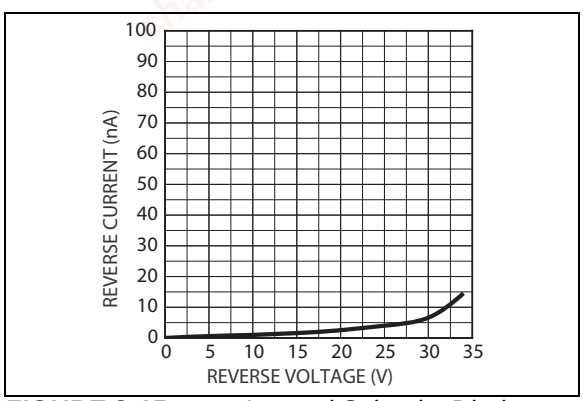


FIGURE 2-15: *Internal Schottky Diode Reverse Leakage vs. Reverse Voltage.*

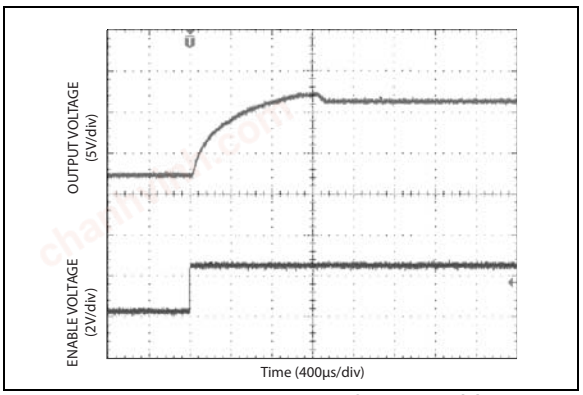


FIGURE 2-16: *Start-Up from Enable.*

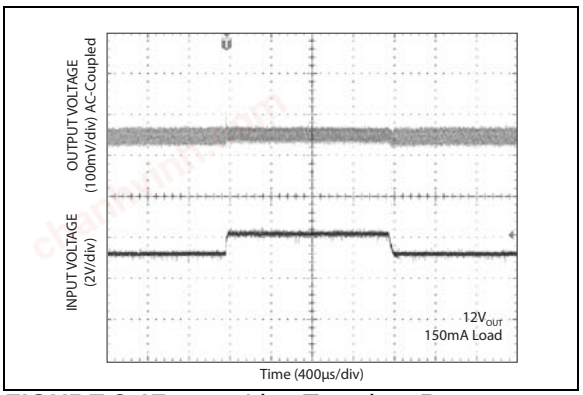


FIGURE 2-17: *Line Transient Response.*

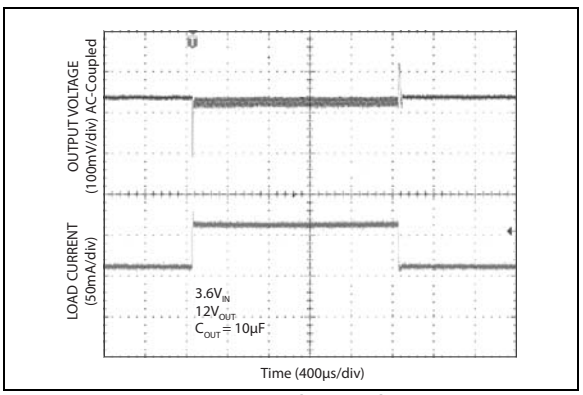


FIGURE 2-18: *Load Transient Response.*

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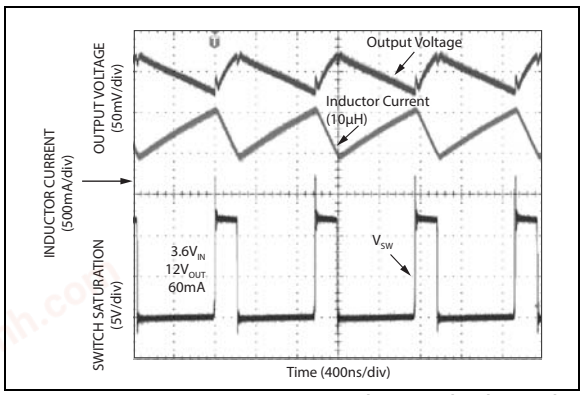


FIGURE 2-19: *Output Voltage Ripple and Switching Waveforms.*

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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	OUT	Output pin (Output): Output voltage. Connect to FB resistor divider. This pin has an internal 34V output overvoltage clamp. See Functional Block Diagram and the Applications section for more information.
2	VIN	Supply (Input): 2.5V to 10V input voltage.
3	EN	Enable (Input): Logic-high enables regulator. Logic-low shuts down regulator. Do not leave floating.
4	AGND	Analog ground.
5	NC	No connect (no internal connection to die).
6	FB	Feedback (Input): Output voltage sense node. Connect feedback resistor network to this pin.
7	SW	Switch node (Input): Internal power Bipolar collector.
8	PGND	Power ground.
EP	GND	Ground (Return): Exposed backside pad.

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4.0 FUNCTIONAL DESCRIPTION

The MIC2290 is a constant-frequency, PWM current-mode boost regulator (see the Functional Block Diagram). The MIC2290 is composed of an oscillator, slope compensation ramp generator, current amplifier, g_m error amplifier, PWM generator, and a 0.5A bipolar output transistor. The oscillator generates a 1.2 MHz clock. The clock's two functions are to trigger the PWM generator that turns on the output transistor and to reset the slope compensation ramp generator. The current amplifier is used to measure the 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 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 1.24V 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.

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5.0 APPLICATION INFORMATION

5.1 DC-to-DC PWM Boost Conversion

The MIC2290 is a constant frequency boost converter. It operates by taking a DC input voltage and regulating a higher DC output voltage. Figure 5-1 shows a typical circuit. Boost regulation is achieved by turning on an internal switch that draws current through the inductor (L1). When the switch turns off, the inductor's magnetic field collapses, causing the current to be discharged into the output capacitor through an internal Schottky diode (D1). Voltage regulation is achieved through pulse-width modulation (PWM).

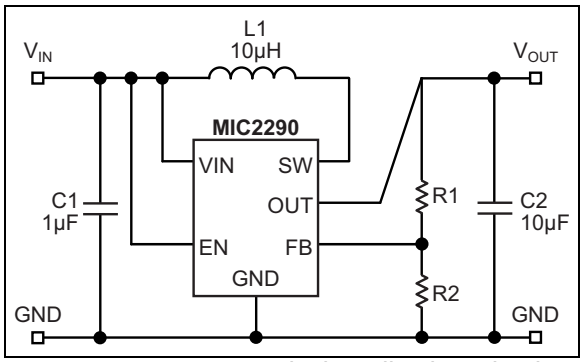


FIGURE 5-1: *Typical Application Circuit.*

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:

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

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 overshoot slightly over 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 reduces peak current, which in turn reduces energy transfer in each cycle.

5.3 Overvoltage Protection

For the DFN package option, there is an overvoltage protection function. If the feedback resistors are disconnected from the circuit or the feedback pin is shorted to ground, the feedback pin will fall to ground potential. This will cause the MIC2290 to switch at full duty cycle in an attempt to maintain the feedback voltage. As a result, the output voltage will climb out of control. This may cause the switch node voltage to exceed its maximum voltage rating, possibly damaging the IC and the external components. To ensure the highest level of protection, the MIC2290 OVP pin will shut the switch off when an overvoltage condition is detected, saving the regulator and other sensitive circuitry downstream.

5.4 Component Selection

5.4.1 INDUCTOR

Inductor selection is a balance between efficiency, stability, cost, size, and rated current. For most applications, 10 µH is the recommended inductor value; it is usually a good balance between these considerations.

Large inductance values reduce the peak-to-peak ripple current, which affects efficiency. This has an effect of reducing both the DC losses and the transition losses. There is also a secondary effect of an inductor's DC resistance (DCR). The DCR of an inductor will be higher for more inductance in the same package size. This is due to the longer windings required for an increase in inductance. Because the majority of input current (minus the MIC2290 operating current) is passed through the inductor, higher DCR inductors will reduce efficiency.

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

EQUATION 5-2:

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

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).

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5.4.2 OUTPUT CAPACITOR

Output capacitor selection is also a trade-off between performance, size, and cost. Increasing output capacitance will lead to an improved transient response, but also an increase in size and cost. X5R or X7R dielectric ceramic capacitors are recommended for designs with the MIC2290. Y5V values may be used, but to compensate their drift over temperature, more capacitance is required. The following table shows the recommended ceramic (X5R) output capacitor value vs. output voltage.

TABLE 5-1: OUTPUT CAPACITOR SELECTION

Output Voltage	Recommended Output Capacitance
<6V	22 µF
<16V	10 µF
<34V	4.7 µF

5.4.3 INPUT CAPACITOR

A minimum 1 µF ceramic capacitor is recommended for designing with the MIC2290. Increasing input capacitance will improve performance and greater noise immunity on the source. The input capacitor should be as close as possible to the inductor and the MIC2290, with short traces for good noise performance.

5.4.4 FEEDBACK RESISTORS

The MIC2290 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. The R2 resistor value must be less than or equal to 5 kΩ (R2 ≤ 5 kΩ). The desired output voltage can be calculated as follows:

EQUATION 5-3:

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

Where:

V_{REF} = 1.24V

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6.0 APPLICATION CIRCUITS

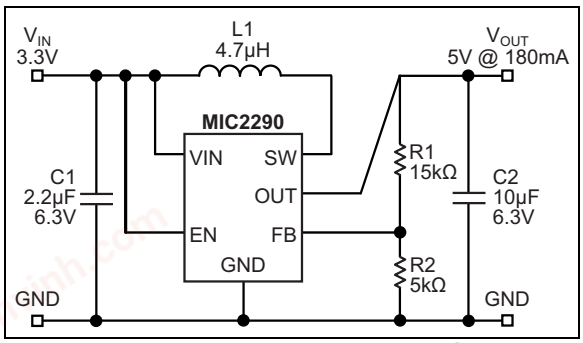


FIGURE 6-1: *$3.3V_{IN}$ to $5V_{OUT}$ @ 180 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0805 X5R Cer. Cap.	08056D475MAT	AVX
C2	10 µF, 6.3V, 0805 X5R Cer. Cap.	08056D106MAT	AVX
L1	4.7 µH, 450 mA Inductor	LQH32CN4R7N11	Murata

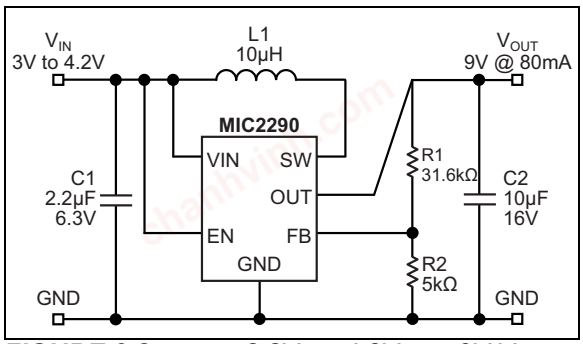


FIGURE 6-2: *$3.3V_{IN}$ - $4.2V_{IN}$ to 9V V_{OUT} @ 80 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	10 µF, 16V, 1206 X5R Cer. Cap.	1206YD106MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

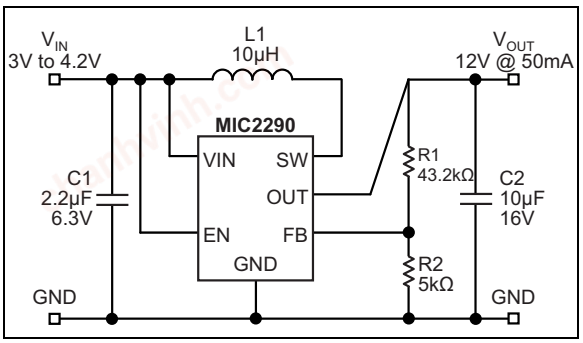


FIGURE 6-3: *$3.3V_{IN}$ - $4.2V_{IN}$ to 12V V_{OUT} @ 50 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	10 µF, 16V, 1206 X5R Cer. Cap.	1206YD106MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

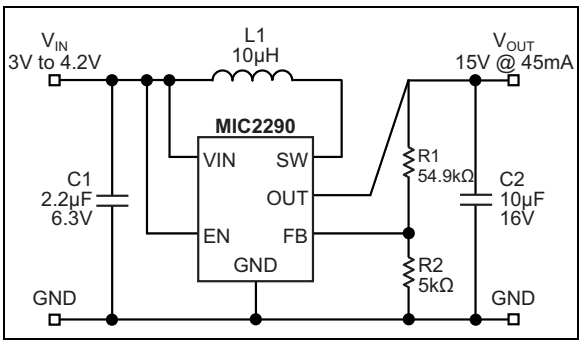


FIGURE 6-4: *$3.3V_{IN}$ - $4.2V_{IN}$ to 15V V_{OUT} @ 45 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	10 µF, 16V, 1206 X5R Cer. Cap.	1206YD106MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

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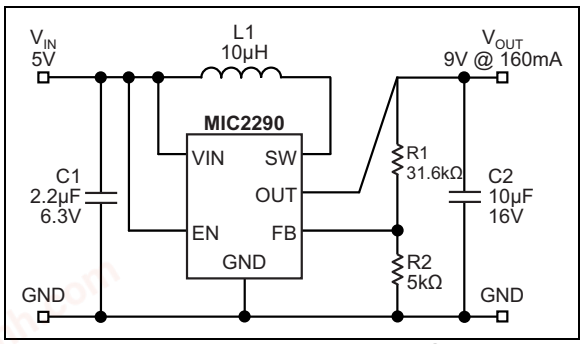


FIGURE 6-5: *$5V_{IN}$ to $9V_{OUT}$ @160 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	10 µF, 16V, 1206 X5R Cer. Cap.	1206YD106MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

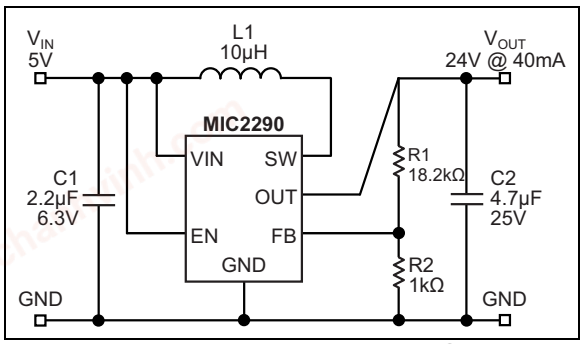


FIGURE 6-7: *$5V_{IN}$ to $24V_{OUT}$ @ 40 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	4.7 µF, 25V, 1206 X5R Cer. Cap.	12063D475MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

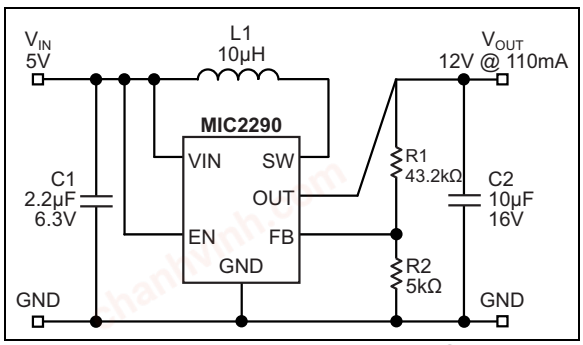


FIGURE 6-6: *$5V_{IN}$ to $12V_{OUT}$ @ 110 mA.*

Ref	Description	Part Number	Vendor
C1	2.2 µF, 6.3V, 0603 X5R Cer. Cap.	06036D225MAT	AVX
C2	10 µF, 16V, 1206 X5R Cer. Cap.	1206YD106MAT	AVX
L1	10 µH, 450 mA Inductor	LQH32CN100K11	Murata

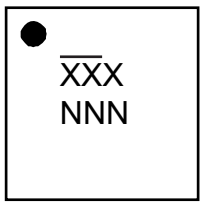
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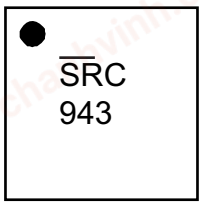
7.0 PACKAGING INFORMATION

7.1 Package Marking Information

8-Lead DFN*



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.	

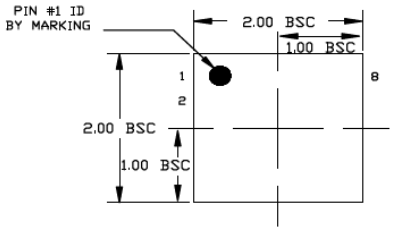
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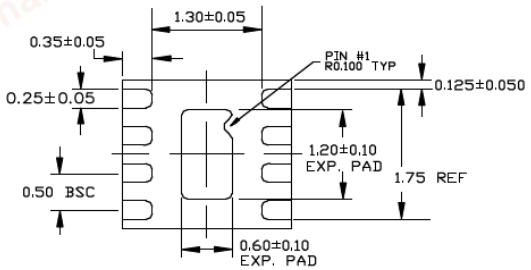
8-Lead DFN 2 mm x 2 mm Package Outline & Recommended Land Pattern

TITLE
8 LEAD DFN 2x2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

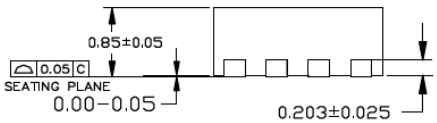
DRAWING #	DFN22-8LD-PL-1	UNIT	MM



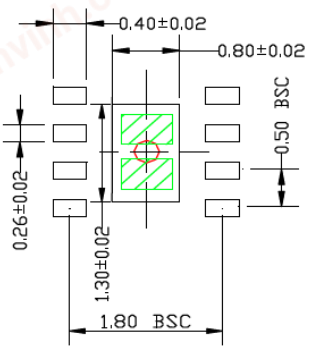
TOP VIEW
NOTE: 1, 2, 3



BOTTOM VIEW
NOTE: 1, 2, 3



END VIEW
NOTE: 1, 2, 3



RECOMMENDED LAND PATTERN
NOTE: 4, 5

NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. RED CIRCLE IN LAND PATTERN INDICATE THERMAL VIA. SIZE SHOULD BE 0.30-0.35MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) INDICATE SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.60x0.40 MM IN SIZE, 0.20 MM SPACING.

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

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NOTES:

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APPENDIX A: REVISION HISTORY

Revision A (June 2018)

- Converted Micrel document MIC2290 to Microchip data sheet template DS20006038A.
- Minor grammatical text changes throughout.
- Title of the data sheet updated.
- Switch Current value updated in Features.
- Figure captions for Figure 2-14, Figure 2-15, and Figure 2-16 updated.
- Capacitor C1 value in Figure 5-1 updated.

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PRODUCT IDENTIFICATION SYSTEM

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

Device	X	XX	-XX
Part No.	Junction Temp. Range	Package	Media Type

Device:	MIC2290:	2 mm x 2 mm PWM Boost Regulator with Internal Schottky Diode	
Junction Temperature Range:	Y	=	–40°C to +125°C, RoHS-Compliant
Package:	ML	=	8-Lead 2 mm x 2 mm DFN
Media Type:	TR	=	5,000/Reel

Examples:

a) MIC2290YML-TR: MIC2290, –40°C to +125°C Temperature Range, 8-Lead 2 mm x 2 mm DFN, 5,000/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.

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NOTES:

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