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## 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load<sup>®</sup>

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### Features

- Internal Inductor
  - Simplifies Design to Two External Capacitors
- Input Voltage: 2.7V to 5.5V
- Output Voltage Accuracy of  $\pm 2.5\%$  over Temperature
- 400 mA Output Current
- Efficiency up to 78% at 1 mA
- 21  $\mu$ A Typical Quiescent Current
- Up to 8 MHz PWM Operation in Continuous Mode
- Ultra-Fast Transient Response
- Low Voltage Output Ripple
  - 30 mV<sub>PP</sub> Ripple in HyperLight Load<sup>®</sup> Mode
  - 7 mV Output Voltage Ripple in Full PWM Mode
- Fully Integrated MOSFET Switches
- 0.01  $\mu$ A Shutdown Current
- Thermal Shutdown and Current-Limit Protection
- Fixed and Adjustable Output Voltage Options Available (0.7V to 3.6V)
- 2.5 mm x 2.0 mm 10-Lead HJDFN Package
- $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$  Junction Temperature Range

### Applications

- Mobile Handsets
- Portable Media/MP3 Players
- Portable Navigation Devices (GPS)
- WiFi/WiMax/WiBro Modules
- Digital Cameras
- Wireless LAN Cards
- USB-Powered Devices
- Portable Applications

### General Description

The MIC33030 is a high-efficiency, 8 MHz, 400 mA synchronous buck regulator with an internal inductor and HyperLight Load<sup>®</sup> mode. HyperLight Load<sup>®</sup> provides very high efficiency at light loads and ultra-fast transient response that is perfectly suited for supplying processor core voltages. An additional benefit of this proprietary architecture is the very low output ripple voltage throughout the entire load range with the use of small output capacitors. The tiny 2.5 mm x 2.0 mm HJDFN package saves precious board space and requires only two external capacitors.

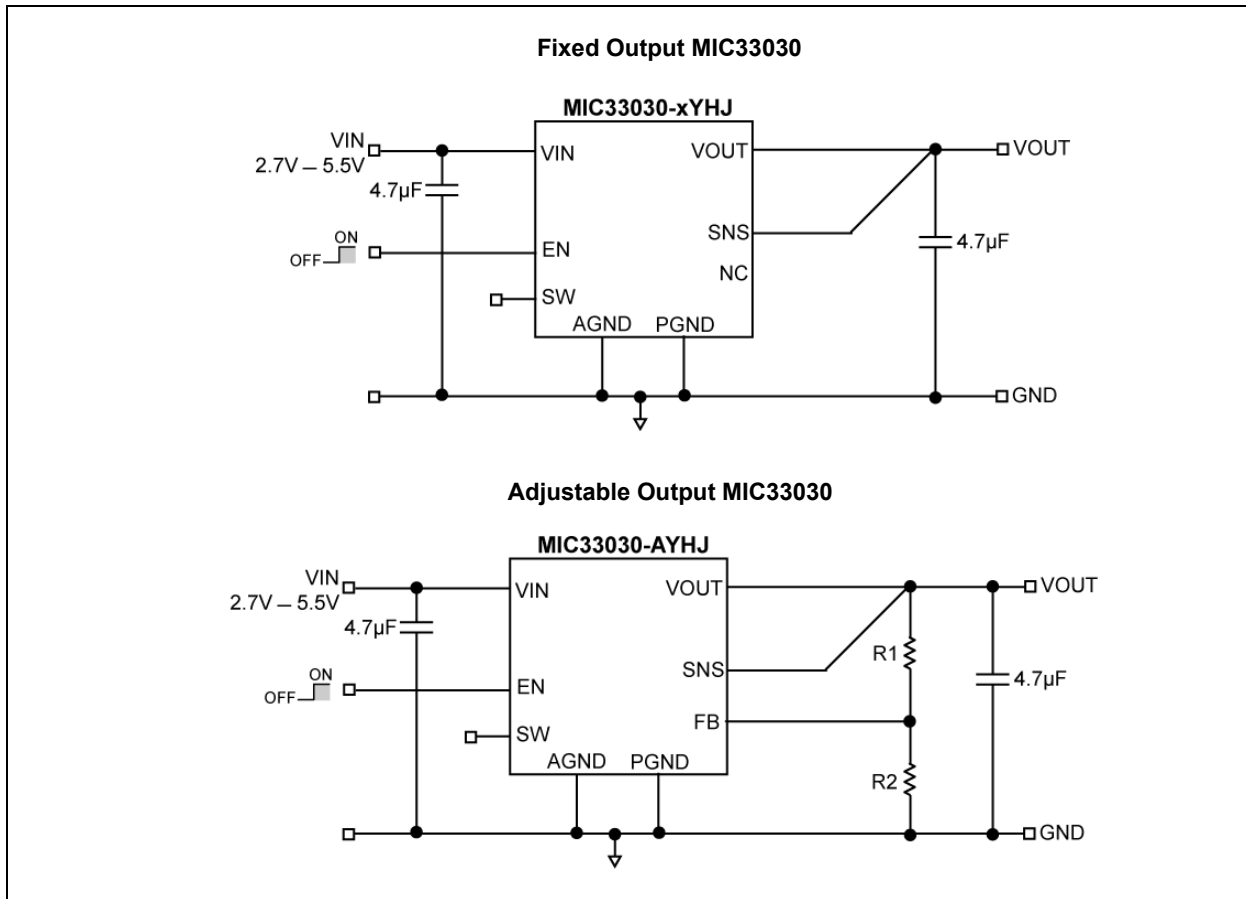
The MIC33030 is designed for use with tiny output capacitors as small as 2.2  $\mu$ F. This gives the MIC33030 the ease of use of an LDO with the efficiency of a HyperLight Load<sup>®</sup> DC converter.

The MIC33030 achieves efficiency in HyperLight Load<sup>®</sup> mode as high as 78% at 1 mA, with a very low quiescent current of 21  $\mu$ A. At higher loads, the MIC33030 provides a constant switching frequency up to 8 MHz.

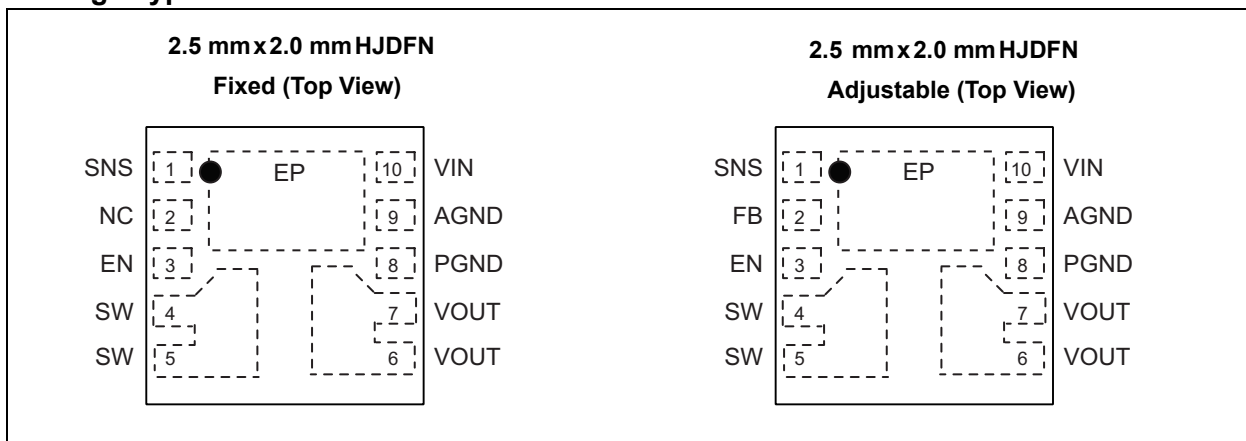
The MIC33030 is available in a 10-pin 2.5 mm x 2.0 mm HJDFN package with an operating junction temperature range of  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ .

# MIC33030

## Typical Application Circuits

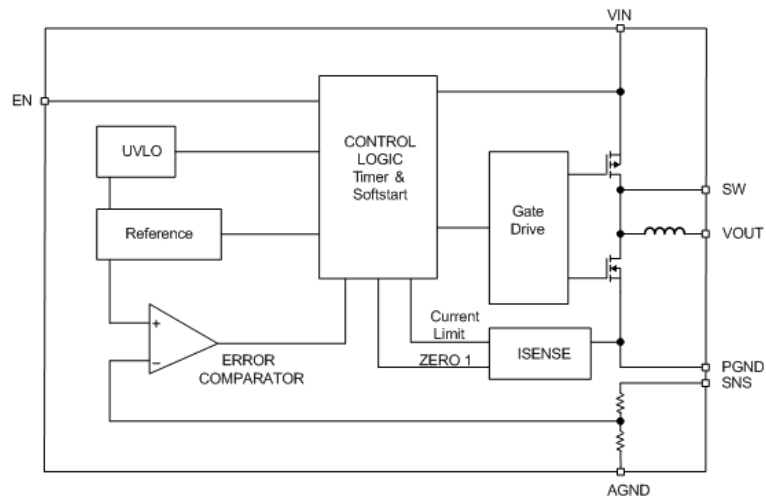


## Package Types

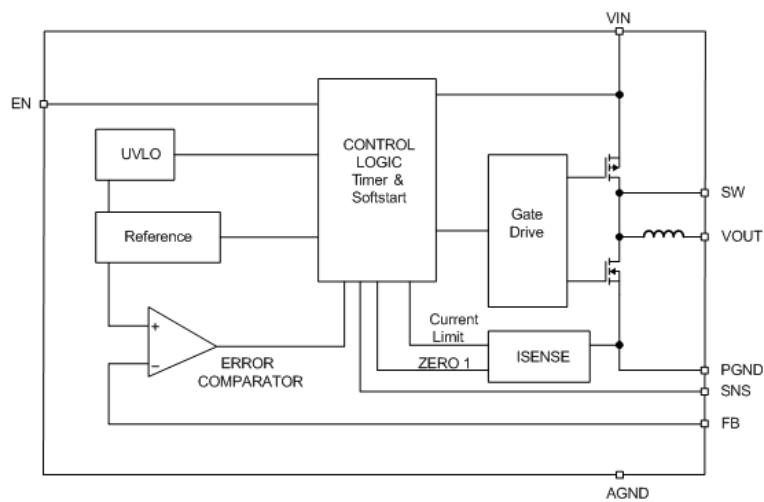


## Functional Block Diagrams

**Simplified MIC33030 Fixed Functional Block Diagram**



**Simplified MIC33030 Adjustable Functional Block Diagram**



# MIC33030

## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Supply Voltage ( $V_{IN}$ ).....	-0.3V to +6V
Sense ( $V_{SNS}$ ).....	-0.3V to +6V
Output Switch Voltage.....	-0.3V to +6V
Enable Input Voltage ( $V_{EN}$ ).....	-0.3V to $V_{IN}$
ESD Rating (Note 1).....	ESD Sensitive

### Operating Ratings ‡

Supply Voltage ( $V_{IN}$ ).....	+2.7V to +5.5V
Enable Input Voltage ( $V_{EN}$ ).....	0V to $V_{IN}$
Output Voltage ( $V_{OUT}$ ).....	+0.7V to +3.6V

† **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. Specifications are for packaged product only.

‡ **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 k $\Omega$  in series with 100 pF.

**TABLE 1-1: ELECTRICAL CHARACTERISTICS**

**Electrical Characteristics:**  $T_A = 25^\circ\text{C}$ ,  $V_{IN} = V_{EN} = 3.6\text{V}$ ;  $C_{OUT} = 4.7\mu\text{F}$ ; **Bold** values indicate  $-40^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$ ; unless otherwise specified. Specification for packaged product only.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Supply Voltage Range	—	<b>2.7</b>	—	<b>5.5</b>	V	—
Undervoltage Lockout Threshold	—	<b>2.45</b>	2.55	<b>2.65</b>	V	Turn-On
Under-Voltage Lockout Hysteresis	—	—	100	—	mV	—
Quiescent Current	—	—	21	35	$\mu\text{A}$	$I_{OUT} = 0\text{ mA}$ , $SNS > 1.2 * V_{OUT(NOM)}$
Shutdown Current	—	—	0.01	<b>4</b>	$\mu\text{A}$	$V_{EN} = 0\text{V}$ ; $V_{IN} = 5.5\text{V}$
Output Voltage Accuracy	—	<b>-2.5</b>	—	<b>+2.5</b>	%	$V_{IN} = 3.6\text{V}$ ; $I_{LOAD} = 20\text{ mA}$
Feedback Voltage	—	—	0.62	—	V	Adjustable Option Only
Current-Limit	—	<b>0.41</b>	0.7	<b>1</b>	A	$SNS = 0.9 * V_{OUT(NOM)}$
Output Voltage Line Regulation	—	—	0.5	—	%/V	$V_{IN} = 3.0\text{V}$ to $5.5\text{V}$ , $V_{OUT} = 1.2\text{V}$ , $I_{LOAD} = 20\text{ mA}$ ,
Output Voltage Load Regulation	—	—	0.7	—	%	$20\text{ mA} < I_{LOAD} < 400\text{ mA}$ , $V_{OUT} = 1.2\text{V}$ , $V_{IN} = 3.6\text{V}$
PWM Switch On-Resistance	—	—	0.65	—	$\Omega$	$I_{SW} = 100\text{ mA PMOS}$
	—	—	0.8	—		$I_{SW} = -100\text{ mA NMOS}$
Maximum Frequency	—	—	8	—	MHz	$I_{OUT} = 120\text{ mA}$
Soft Start Time	—	—	100	—	$\mu\text{s}$	$V_{OUT} = 90\%$
Enable Threshold	—	<b>0.5</b>	0.9	<b>1.2</b>	V	—
Enable Hysteresis	—	—	35	—	mV	—
Enable Input Current	—	—	0.1	<b>2</b>	$\mu\text{A}$	—
Over Temperature Shutdown	—	—	160	—	$^\circ\text{C}$	—
Over Temperature Shutdown Hysteresis	—	—	20	—	$^\circ\text{C}$	—

## TEMPERATURE SPECIFICATIONS (Note 1)

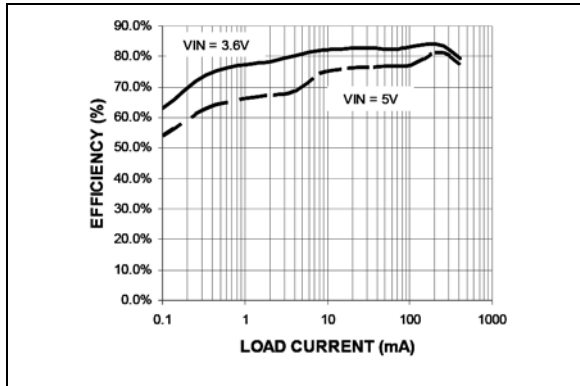
Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
<b>Temperature Ranges</b>						
Junction Operating Temperature Range	$T_J$	-40	—	+125	°C	—
Storage Temperature Range	$T_S$	-65	—	+150	°C	—
<b>Package Thermal Resistances</b>						
Thermal Resistance HJDFN 2.5 mm x 2.0 mm	$\theta_{JA}$	—	76	—	°C/W	—
Thermal Resistance HJDFN 2.5 mm x 2.0 mm	$\theta_{JC}$	—	45	—	°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.,  $T_A$ ,  $T_J$ ,  $\theta_{JA}$ ). 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.

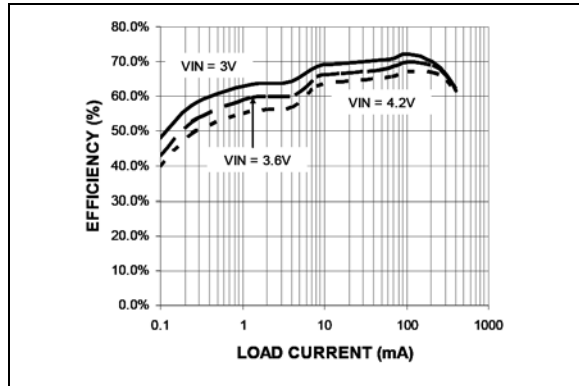
# MIC33030

## 2.0 TYPICAL PERFORMANCE CURVES

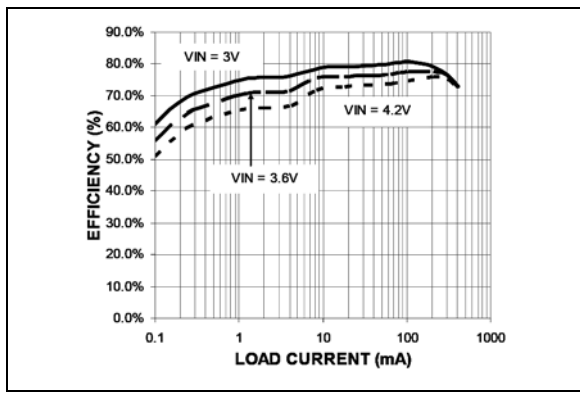
**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be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



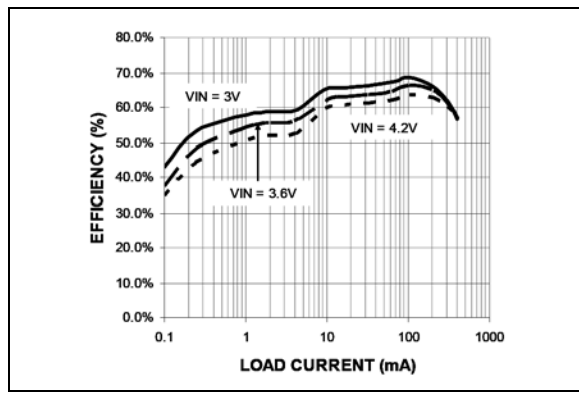
**FIGURE 2-1:** Efficiency vs. Load ( $V_{OUT} = 2.5V$ ).



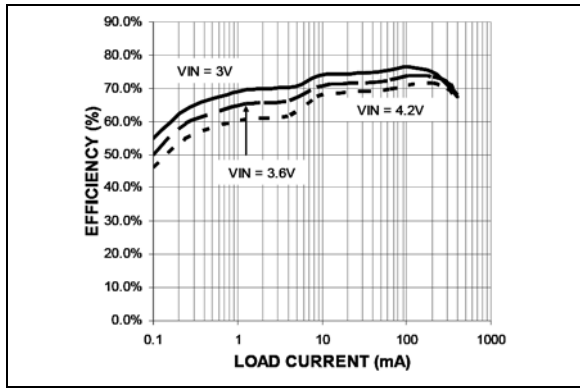
**FIGURE 2-4:** Efficiency vs. Load ( $V_{OUT} = 1.2V$ ).



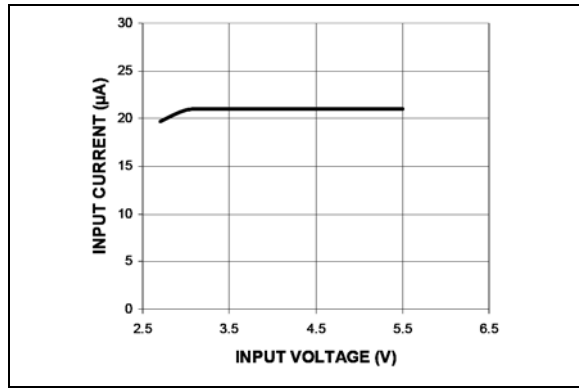
**FIGURE 2-2:** Efficiency vs. Load ( $V_{OUT} = 1.8V$ ).



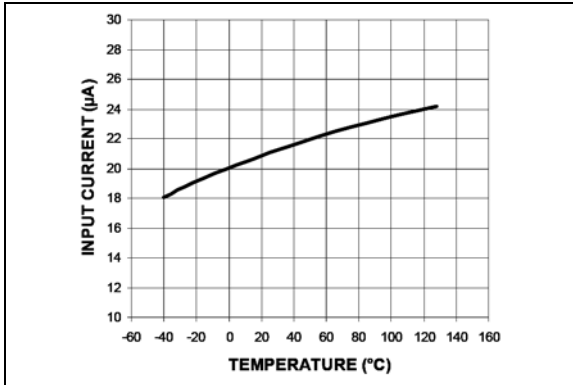
**FIGURE 2-5:** Efficiency vs. Load ( $V_{OUT} = 1V$ ).



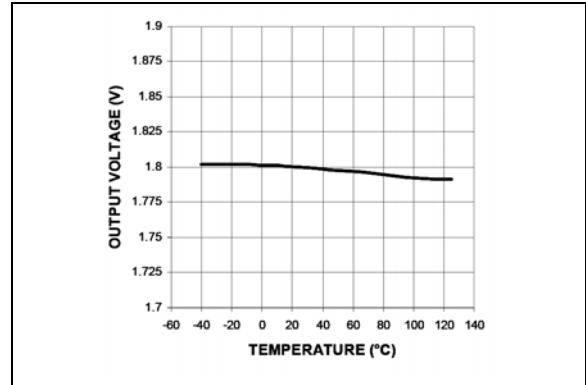
**FIGURE 2-3:** Efficiency vs. Load ( $V_{OUT} = 1.5V$ ).



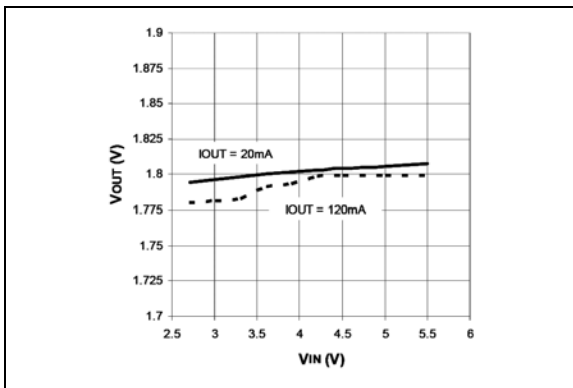
**FIGURE 2-6:** Quiescent Current vs. Input Voltage (Not Switching).



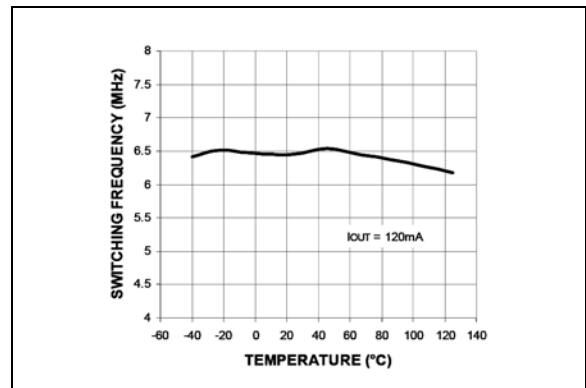
**FIGURE 2-7:** Quiescent Current vs. Temperature (Not Switching).



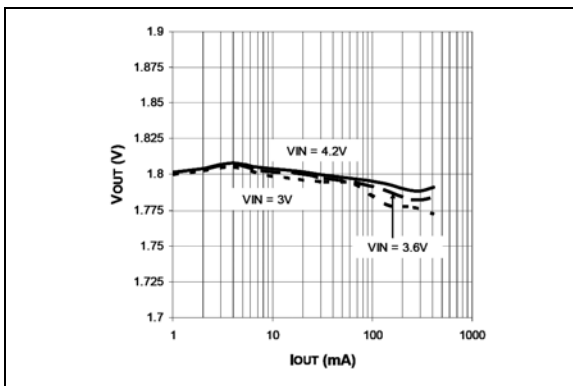
**FIGURE 2-10:** Output Voltage vs. Temperature.



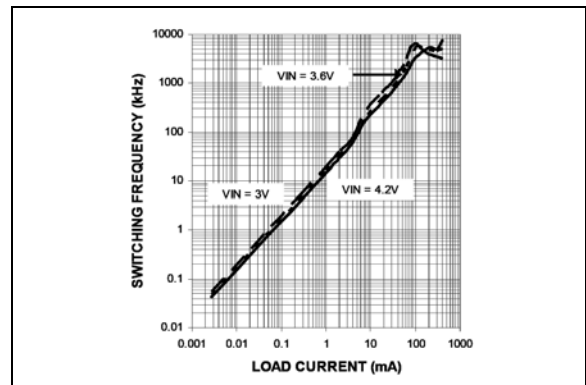
**FIGURE 2-8:** Output Voltage vs. Input Voltage.



**FIGURE 2-11:** Switching Frequency vs. Temperature.

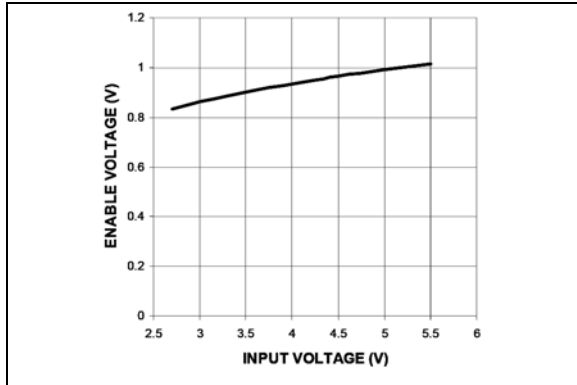


**FIGURE 2-9:** Output Voltage vs. Output Current.

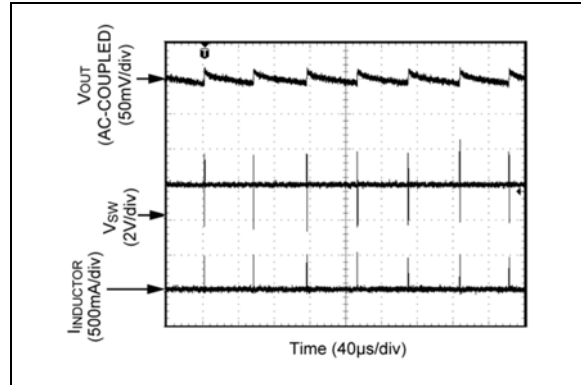


**FIGURE 2-12:** Switching Frequency vs. Load Current.

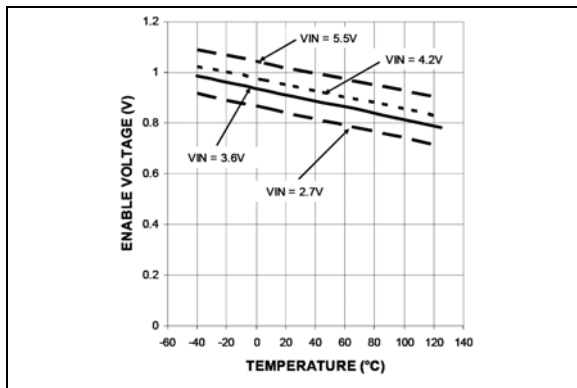
# MIC33030



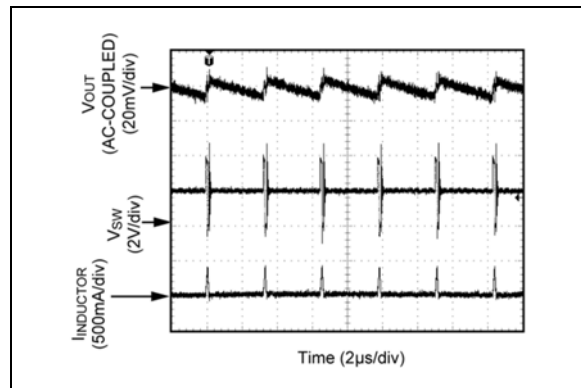
**FIGURE 2-13:** Enable (ON) Voltage vs. Input Voltage.



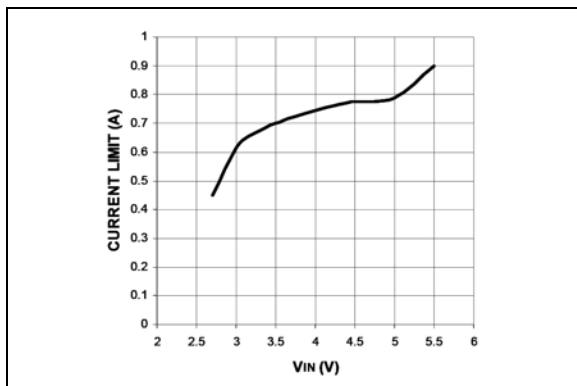
**FIGURE 2-16:** Switching Waveform - Discontinuous Mode  $I_{OUT} = 1 \text{ mA}$ .



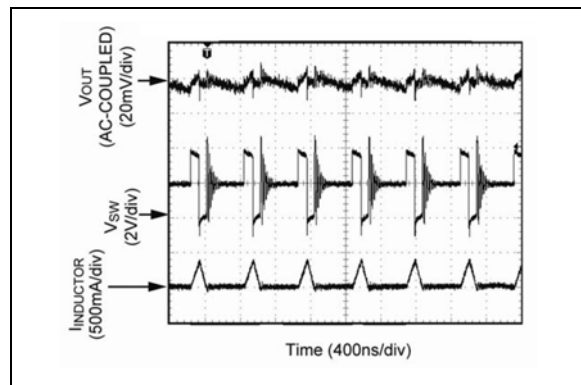
**FIGURE 2-14:** Enable Voltage vs. Temperature.



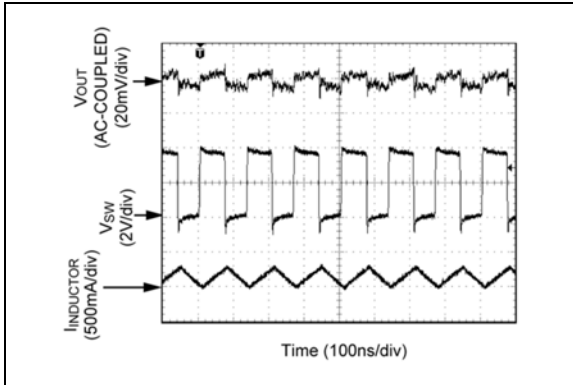
**FIGURE 2-17:** Switching Waveform - Discontinuous Mode  $I_{OUT} = 10 \text{ mA}$ .



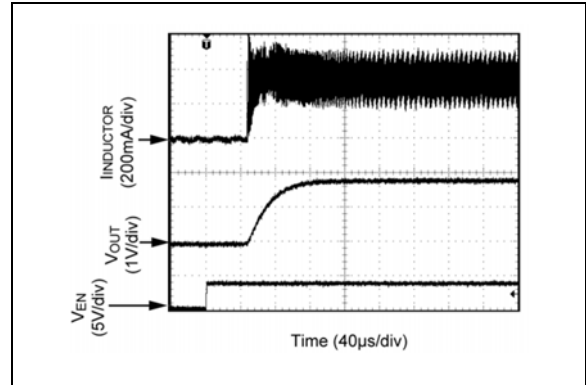
**FIGURE 2-15:** Current-Limit vs. Input Voltage.



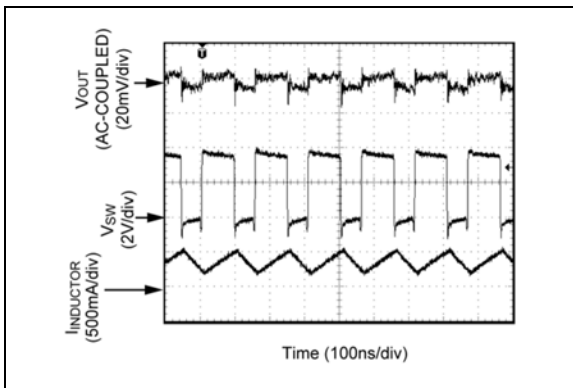
**FIGURE 2-18:** Switching Waveform - Discontinuous Mode  $I_{OUT} = 50 \text{ mA}$ .



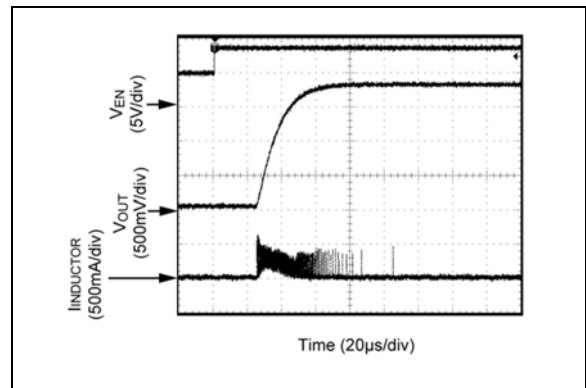
**FIGURE 2-19:** Switching Waveform - Continuous Mode  $I_{OUT} = 120\text{ mA}$ .



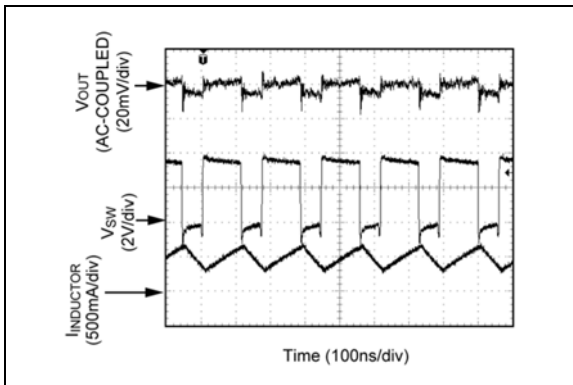
**FIGURE 2-22:** Start Up ( $I_{OUT} = 350\text{ mA}$ ).



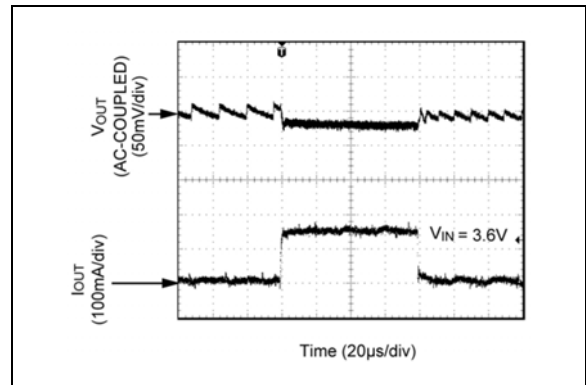
**FIGURE 2-20:** Switching Waveform - Continuous Mode  $I_{OUT} = 300\text{ mA}$ .



**FIGURE 2-23:** Start Up ( $I_{OUT} = 1\text{ mA}$ ).

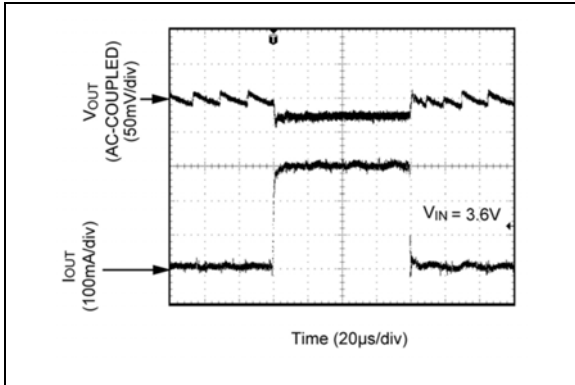


**FIGURE 2-21:** Switching Waveform - Continuous Mode  $I_{OUT} = 400\text{ mA}$ .

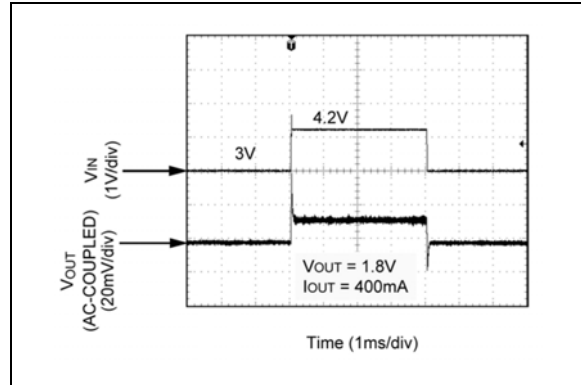


**FIGURE 2-24:** Load Transient  $0\text{ mA}$  to  $150\text{ mA}$ .

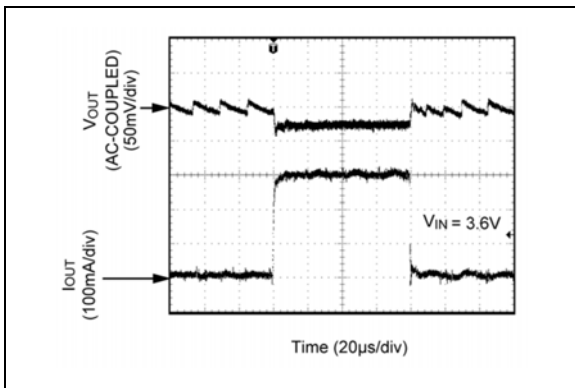
# MIC33030



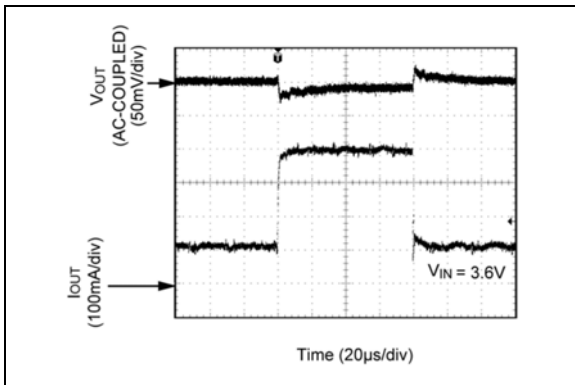
**FIGURE 2-25:** Load Transient 0 mA to 300 mA.



**FIGURE 2-28:** Line Transient (3V to 4.2V).



**FIGURE 2-26:** Load Transient (0 mA to 400 mA).



**FIGURE 2-27:** Load Transient (100 mA to 400 mA).

## 3.0 PIN DESCRIPTIONS

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

**TABLE 3-1: PIN FUNCTION TABLE**

Pin Number MIC33030 (Fixed Option)	Pin Number MIC33030 (ADJ Option)	Pin Name	Description
1	1	SNS	Sense: Connect to $V_{OUT}$ as close to output capacitor as possible to sense output voltage.
2	—	NC	Not internally connected.
—	2	FB	Feedback: Connect resistor divider at this node to set output voltage. Resistors should be selected based on a nominal $V_{FB} = 0.62V$ .
3	3	EN	Enable: Logic high enables operation of the regulator. Logic low will shut down the device. Do not leave floating.
4, 5	4, 5	SW	Switch: Internal power MOSFET output switches.
6, 7	6, 7	VOUT	Output Voltage: The output of the regulator. Connect to SNS pin. For adjustable option, connect to feedback resistor network.
8	8	PGND	Power Ground.
9	9	AGND	Analog Ground.
10	10	VIN	Input Voltage: Connect a capacitor to ground to decouple the noise.
ePAD	ePAD	HS PAD	Connect to PGND or AGND.

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## 4.0 FUNCTIONAL DESCRIPTION

### 4.1 VIN

The input supply ( $V_{IN}$ ) provides power to the internal MOSFETs for the switch mode regulator along with the internal control circuitry. The  $V_{IN}$  operating range is 2.7V to 5.5V, so an input capacitor with a minimum voltage rating of 6.3V is recommended. Due to the high switching speed, a minimum 2.2  $\mu\text{F}$  bypass capacitor placed close to  $V_{IN}$  and the power ground (PGND) pin is required.

### 4.2 EN

A logic high signal on the enable pin activates the output voltage of the device. A logic low signal on the enable pin deactivates the output and reduces supply current to 0.01  $\mu\text{A}$ . The MIC33030 features built in soft-start circuitry that reduces in-rush current and prevents the output voltage from overshooting at start up. Do not leave the enable pin floating.

### 4.3 SW

The switch (SW) connects directly to one end of the internal inductor and provides the current path during switching cycles. The other end of the inductor is connected to the load, SNS pin and output capacitor. Because the MIC33030 has an internal inductor, this pin is not routed in most applications.

### 4.4 VOUT

The output pin ( $V_{OUT}$ ) is the output voltage pin following the internal inductor. Connect a minimum of 2.2  $\mu\text{F}$  output filter capacitor to this pin.

### 4.5 SNS

The sense (SNS) pin is connected to the output of the device to provide feedback to the control circuitry. The SNS connection should be placed close to the output capacitor.

### 4.6 AGND

The analog ground (AGND) is the ground path for the biasing and control circuitry. The current loop for the signal ground should be separate from the power ground (PGND) loop.

## 4.7 FB (Adjustable Output Only)

The feedback pin (FB) allows the regulated output voltage to be set by applying an external resistor network. The internal reference voltage is 0.62V and the recommended value of R2 is 200 k $\Omega$ . The output voltage is calculated from the equation below:

### EQUATION 4-1:

$$V_{OUT} = 0.62V \left( \frac{R1}{200k\Omega} + 1 \right)$$

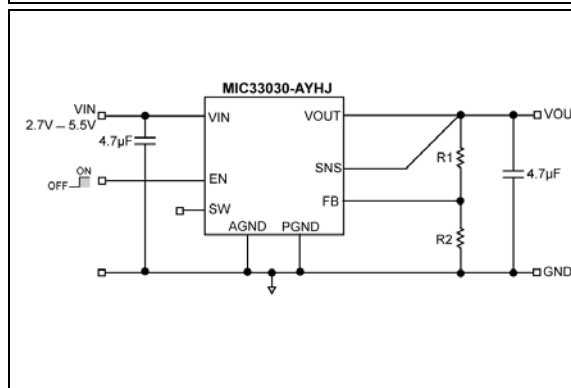


FIGURE 4-1: MIC33030-AYHJ Schematic.

## 4.8 PGND

The power ground pin is the ground path for the high current in PWM mode. The current loop for the power ground should be as small as possible and separate from the analog ground (AGND) loop as applicable.

## 5.0 APPLICATION INFORMATION

The MIC33030 is a high-performance DC/DC step down regulator that offers a small solution size. Supporting an output current up to 400 mA inside a tiny 2.5 mm x 2.0 mm HJDFN package and requiring only two external components, the MIC33030 meets today's miniature portable electronic device needs. Using the HyperLight Load<sup>®</sup> switching scheme, the MIC33030 is able to maintain high efficiency throughout the entire load range while providing ultra-fast load transient response. The following sections provide additional device application information.

### 5.1 Input Capacitor

A 2.2  $\mu$ F ceramic capacitor or greater should be placed close to the VIN pin and PGND pin for bypassing. A TDK C1608X5R0J475K, size 0603, 4.7  $\mu$ F ceramic capacitor is recommended based upon performance, size and cost. A X5R or X7R temperature rating is recommended for the input capacitor. Y5V temperature rating capacitors, aside from losing most of their capacitance over temperature, can also become resistive at high frequencies. This reduces their ability to filter out high frequency noise.

### 5.2 Output Capacitor

The MIC33030 is designed for use with a 2.2  $\mu$ F or greater ceramic output capacitor. Increasing the output capacitance will lower output ripple and improve load transient response but could increase solution size or cost. A low equivalent series resistance (ESR) ceramic output capacitor such as the TDK C1608X5R0J475K, size 0603, 4.7  $\mu$ F ceramic capacitor is recommended based upon performance, size and cost. Both the X7R or X5R temperature rating capacitors are recommended. The Y5V and Z5U temperature rating capacitors are not recommended due to their wide variation in capacitance over temperature and increased resistance at high frequencies.

### 5.3 Compensation

The MIC33030 is designed to be stable with a minimum of 2.2  $\mu$ F ceramic (X5R) output capacitor.

### 5.4 Duty Cycle

The typical maximum duty cycle of the MIC33030 is 90%.

## 5.5 Efficiency Considerations

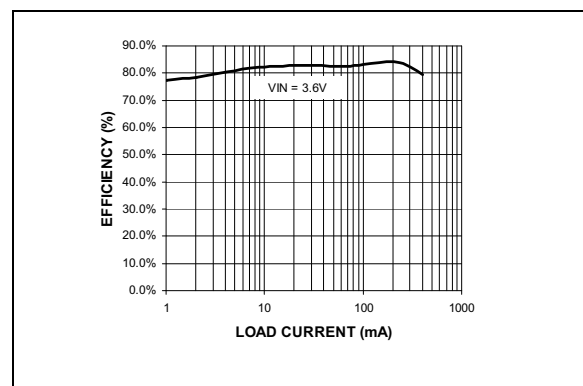
Efficiency is defined as the amount of useful output power, divided by the amount of power supplied.

### EQUATION 5-1:

$$\eta = \left( \frac{V_{OUT} \times I_{OUT}}{V_{IN} \times I_{IN}} \right) \times 100$$

Maintaining high efficiency serves two purposes. It reduces power dissipation in the power supply, reducing the need for heat sinks and thermal design considerations and it reduces consumption of current for battery powered applications. Reduced current draw from a battery increases the devices operating time which is critical in hand held devices.

There are two types of losses in switching converters; DC losses and switching losses. DC losses are simply the power dissipation of  $I^2R$ . Power is dissipated in the high-side switch during the on cycle. Power loss is equal to the high-side MOSFET  $R_{DS(ON)}$  multiplied by the switch current squared. During the off cycle, the low-side N-channel MOSFET conducts, also dissipating power. Device operating current also reduces efficiency. The product of the quiescent (operating) current and the supply voltage represents another DC loss. The current required driving the gates on and off at a constant 8 MHz frequency and the switching transitions make up the switching losses.



**FIGURE 5-1:** Efficiency under Load.

Figure 5-1 shows an efficiency curve. From no load to 100 mA, efficiency losses are dominated by quiescent current losses, gate drive and transition losses. By using the HyperLight Load<sup>®</sup> mode, the MIC33030 is able to maintain high efficiency at low output currents.

Over 100 mA, efficiency loss is dominated by MOSFET  $R_{DS(ON)}$  and inductor losses. Higher input supply voltages will increase the gate to source threshold on the internal MOSFETs, thereby reducing the internal

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$R_{DS(ON)}$ . This improves efficiency by reducing DC losses in the device. All but the inductor losses are inherent to the device. In which case, inductor selection becomes increasingly critical in efficiency calculations. As the inductors are reduced in size, the DC resistance (DCR) can become quite significant.

The DCR losses can be calculated by using [Equation 5-2](#):

## EQUATION 5-2:

$$P_{DCR} = I_{OUT}^2 \times DCR$$

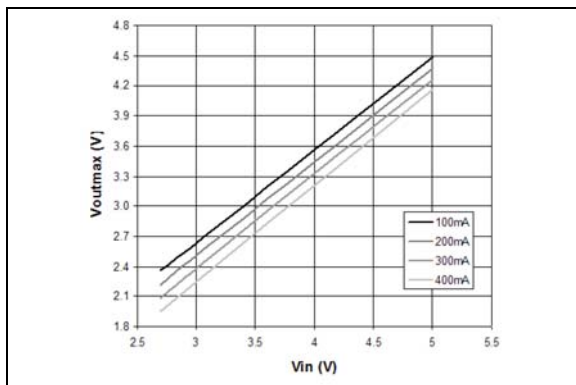
From that, the loss in efficiency due to inductor resistance can be calculated by using [Equation 5-3](#):

## EQUATION 5-3:

$$EfficiencyLoss = \left[ 1 - \left( \frac{V_{OUT} \times I_{OUT}}{V_{OUT} \times I_{OUT} + P_{DCR}} \right) \right] \times 100$$

Efficiency loss due to DCR is minimal at light loads and gains significance as the load is increased. Inductor selection becomes a trade-off between efficiency and size in this case.

The effect of MOSFET voltage drops and DCR losses in conjunction with the maximum duty cycle combine to limit maximum output voltage for a given input voltage. [Figure 5-2](#) shows this relationship based on the typical resistive losses in the MIC33030:



**FIGURE 5-2:**  $V_{OUT(MAX)}$  vs.  $V_{IN}$

## 5.6 HyperLight Load® Mode

MIC33030 uses a minimum on-time and off-time proprietary control loop. When the output voltage falls below the regulation threshold, the error comparator begins a switching cycle that turns the PMOS on and keeps it on for the duration of the minimum-on-time. This increases the output voltage. If the output voltage is over the regulation threshold, then the error comparator turns the PMOS off for a minimum off-time until the output drops below the threshold. The NMOS acts as an ideal rectifier that conducts when the PMOS is off. Using a NMOS switch instead of a diode allows for lower voltage drop across the switching device when it is on. The asynchronous switching combination between the PMOS and the NMOS allows the control loop to work in discontinuous mode for light load operations. In discontinuous mode, the MIC33030 works in pulse frequency modulation (PFM) to regulate the output. As the output current increases, the off-time decreases, thus provides more energy to the output. This switching scheme improves the efficiency of MIC33030 during light load currents by only switching when it is needed. As the load current increases, the MIC33030 goes into continuous conduction mode (CCM) and switches at a frequency centered at 8 MHz. The equation to calculate the load when the MIC33030 goes into continuous conduction mode may be approximated by the following [Equation 5-4](#):

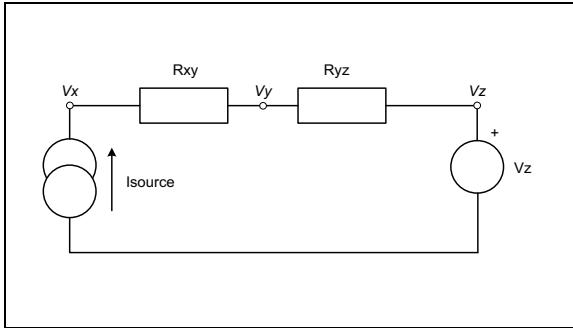
## EQUATION 5-4:

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

The load at which MIC33030 transitions from HyperLight Load® mode to PWM mode is a function of the input voltage ( $V_{IN}$ ), output voltage ( $V_{OUT}$ ), duty cycle ( $D$ ), inductance ( $L$ ), and frequency ( $f$ ). Because the inductance of MIC33030 is 0.36  $\mu$ H, the device will enter HyperLight Load® mode or PWM mode at approximately 150 mA.

## 5.7 Power Dissipation Considerations

As with all power devices, the ultimate current rating of the output is limited by the thermal properties of the package and the PCB it is mounted on. There is a simple, ohms law type relationship between thermal resistance, power dissipation, and temperature which are analogous to an electrical circuit:



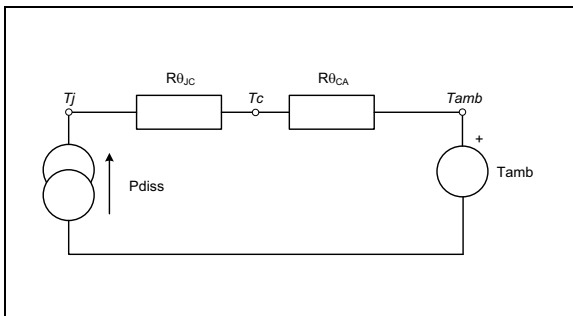
**FIGURE 5-3:**

From this simple circuit  $V_x$  can be calculated if  $I_{SOURCE}$ ,  $V_z$  and the resistor values,  $R_{xy}$  and  $R_{yz}$  are known, using the [Equation 5-5](#):

**EQUATION 5-5:**

$$V_x = I_{SOURCE} \times (R_{XY} + R_{YZ}) + V_z$$

Thermal circuits can be considered using these same rules and can be drawn similarly replacing current sources with power dissipation (in Watts), resistance with thermal resistance (in °C/W) and voltage sources with temperature (in °C):



**FIGURE 5-4:**

Now replacing the variables in the equation for  $V_x$ , we can find the junction temperature ( $T_J$ ) from power dissipation, ambient temperature and the known thermal resistance of the PCB ( $R_{\theta_{CA}}$ ) and the package ( $R_{\theta_{JC}}$ ):

**EQUATION 5-6:**

$$T_J = P_{DISS} \times (R_{\theta_{JC}} + R_{\theta_{CA}}) + T_{AMB}$$

As can be seen in [Figure 5-4](#), total thermal resistance  $R_{\theta_{JA}} = R_{\theta_{JC}} + R_{\theta_{CA}}$ . This can also be calculated using [Equation 5-6](#):

**EQUATION 5-7:**

$$T_J = P_{DISS} \times (R_{\theta_{JA}}) + T_{AMB}$$

Since effectively all of the power loss in the converter is dissipated within the MIC33030 package,  $P_{DISS}$  can be calculated by using [Equation 5-8](#):

**EQUATION 5-8:**

$$P_{DISS} = P_{OUT} \times \left( \frac{1}{\eta} - 1 \right)$$

Where:

$\eta =$  Efficiency taken from Efficiency Curves

$R_{\theta_{JC}}$  and  $R_{\theta_{JA}}$  are found in the operating ratings section of the data sheet.

**EXAMPLE:**

A MIC33030 is intended to drive a 300 mA load at 1.8V and is placed on a printed circuit board which has a ground plane area of at least 25 mm square. The voltage source is a Li-ion battery with a lower operating threshold of 3V and the ambient temperature of the assembly can be up to 50°C.

Summary of variables:

- $I_{OUT} = 0.3A$
- $V_{OUT} = 1.8V$
- $V_{IN} = 3V$  to  $4.2V$
- $T_{AMB} = 50^\circ C$
- $R_{\theta_{JA}} = 76^\circ C/W$

$\eta @ 300\text{ mA} = 75\%$  (worst case with  $V_{IN} = 4.2V$ ) See [Section 2.0, Typical Performance Curves](#).

# MIC33030

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## EQUATION 5-9:

$$P_{DISS} = 1.8 \times 0.3 \times \left( \frac{1}{0.75} - 1 \right) = 0.18 W$$

The worst case switch and inductor resistance will increase at higher temperatures, so a margin of 20% can be added to account for this:

## EQUATION 5-10:

$$P_{DISS} = 0.18 \times 1.2 = 0.216 W$$

Therefore:

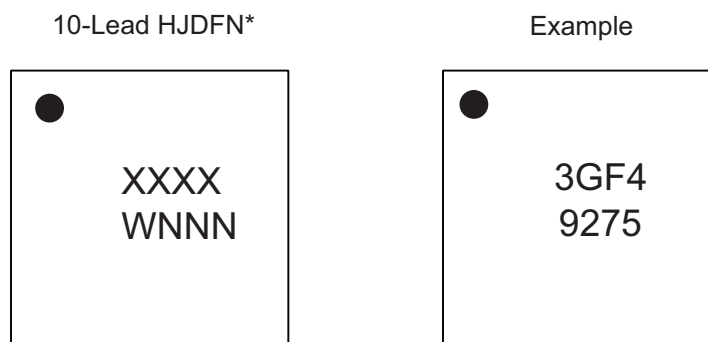
$$T_J = 0.216 W \times (76^\circ C/W) + 50^\circ C$$

$$T_J = 66^\circ C$$

This is well below the maximum 125°C.

## 6.0 PACKAGING INFORMATION

### 6.1 Package Marking Information



**TABLE 6-1: MIC33030 PACKAGE MARKING CODES**

Part Number	Output Voltage	Marking Code
MIC33030-AYHJ	ADJ	3GFA
MIC33030-JYHJ	2.5V	3GFJ
MIC33030-GYHJ	1.8V	3GFG
MIC33030-4YHJ	1.2V	3GF4

<p><b>Legend:</b> 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).</p>
<p><b>Note:</b> 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.</p>

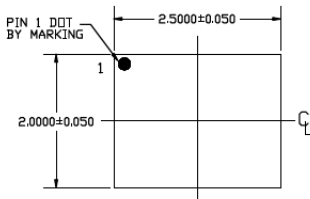
# MIC33030

## 10-Lead HJDFN 2.5 mm x 2.0 mm Package Outline and Recommended Land Pattern

**TITLE**

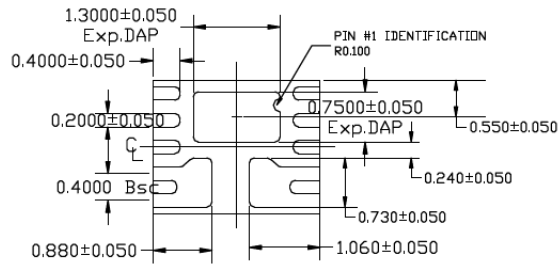
10 LEAD HJDFN 2.5 x 2.0 mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	HJDFN2520-10LD-PL-1	UNIT	MM
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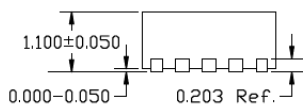
TOP VIEW

NOTE: 1, 2, 3



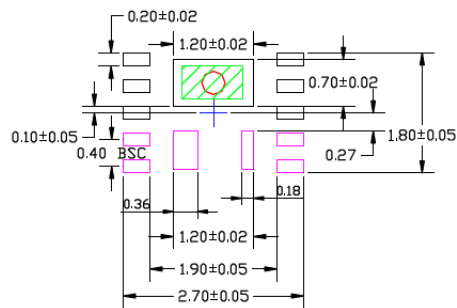
BOTTOM VIEW

NOTE: 1, 2



SIDE VIEW

NOTE: 1, 2



RECOMMENDED LAND PATTERN

NOTE: 4, 5, 6

**NOTE:**

1. MAX PACKAGE WARPAGE IS 0.05MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. GREEN RECTANGLE (SHADED AREA) REPRESENTS STENCIL OPENING ON EXPOSED AREA. SIZE IS 0.90X0.50 MM
5. RED CIRCLE REPRESENTS THERMAL VIAS & SHOULD BE CONNECTED TO GND FOR MAX PERFORMANCE. 0.30 - 0.35 MM RECOMMENDED DIAMETER
6. PURPLE PADS ARE OF A DIFFERENT POTENTIAL, DO NOT CONNECT TO GND

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 2018)

- Converted Micrel document MIC33030 to Microchip data sheet DS20006026A.
- Minor text changes throughout.

# MIC33030

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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>X</u>	<u>-XX</u>
Device	Output Voltage	Junction Temperature Range	Package Option	Media Type
<p><b>Device:</b> MIC33030: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®</p> <p><b>Output Voltage:</b>            4 = 1.2V            G* = 1.8V            J = 2.5V            A = Adjustable</p> <p><b>Junction Temperature Range:</b> Y = -40°C to +125°C</p> <p><b>Package:</b> HJ = 10-Lead 2.5 mm x 2.0 mm x 1.15 mm HJDFN</p> <p><b>Media Type:</b> T5 = 500/Reel            TR = 5000/Reel</p> <p><b>Note:</b> Other voltages available. Contact Factory for details.</p>				
<p><b>Examples:</b></p> <p>a) MIC33030-4YHJ-T5: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®, 1.2V Fixed Output Voltage, -40°C to +125°C Junction Temperature Range, Pb-Free, RoHS Compliant, 10-Lead HJDFN Package, 500/Reel</p> <p>b) MIC33030-GYHJ-TR: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®, 1.8V Fixed Output Voltage, -40°C to +125°C Junction Temperature Range, Pb-Free, RoHS Compliant, 10-Lead HJDFN Package, 5000/Reel</p> <p>c) MIC33030-JYHJ-T5: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®, 2.5V Fixed Output Voltage, -40°C to +125°C Junction Temperature Range, Pb-Free, RoHS Compliant, 10-Lead HJDFN Package, 500/Reel</p> <p>d) MIC33030-AYHJ-TR: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®, Adjustable Output Voltage, -40°C to +125°C Junction Temperature Range, Pb-Free, RoHS Compliant, 10-Lead HJDFN Package, 5000/Reel</p> <p>d) MIC33030-4YHJ-TR: 8 MHz 400 mA Internal Inductor Buck Regulator with HyperLight Load®, 1.2V Fixed Output Voltage, -40°C to +125°C Junction Temperature Range, 10-Lead HJDFN Package, 5000/Reel</p> <p><b>Note 1:</b> 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.</p>				



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