MIC29302HWU

High-Current Low-Dropout Regulators

General Description

The MIC29302HWU is a high current, high accuracy, low-dropout voltage regulators. Using Micrel's proprietary Super βeta PNP® process with a PNP pass element, these regulators feature 350mV to 425mV (full load) typical dropout voltages and very low ground current. Designed for high current loads, these devices also find applications in lower current, extremely low dropout-critical systems, where their tiny dropout voltage and ground current values are important attributes.

The MIC29302HWU is fully protected against overcurrent faults, reversed input polarity, reversed lead insertion, over-temperature operation, and positive and negative transient voltage spikes. Five pin fixed voltage versions feature logic level ON/OFF control and an error flag which signals whenever the output falls out of regulation. Flagged states include low input voltage (dropout), output current limit, over-temperature shutdown, and extremely high voltage spikes on the input.

The ENABLE pin may be tied to VIN if it is not required for ON/OFF control. The MIC29302HWU is available in a 5-pin surface mount TO-263 (D^2Pak) package. For applications with input voltage 6V or below, see MIC37xxx LDOs.

Data sheets and support documentation can be found on Micrel's web site at: www.micrel.com.

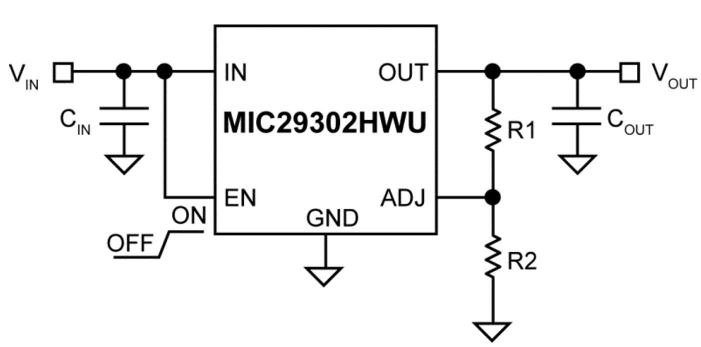
Features

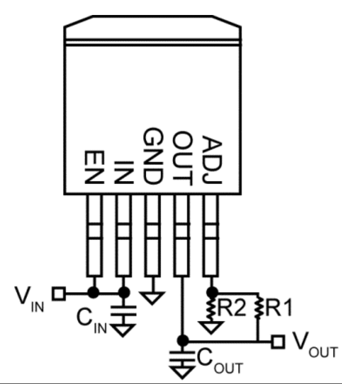
- 3A current capability
- Low-dropout voltage
- Low ground current
- Accurate 1% guaranteed tolerance
- Extremely fast transient response
- Reverse-battery and "Load Dump" protection
- Zero-current shutdown mode
- Error flag signals output out-of-regulation
- Also characterized for smaller loads with industry-leading performance specifications

Applications

- Battery-powered equipment
- High-efficiency "Green" computer systems
- Automotive electronics
- High-efficiency linear power supplies
- High-efficiency post-regulator for switching supply

Typical Application



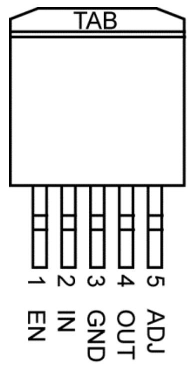


Super βeta PNP is a trademark of Micrel, Inc.

Ordering Information

Part Number	Junction Temp. Range	Voltage	Current	Package
MIC29302HWU	–40° to +125°C	Adjustable	3.0A	5-Pin TO-263

Pin Configuration



5-Pin TO-263 (D^2Pak) Adjustable Voltage
MIC29302HWU

Pin Description

Pin Number	Pin Name
1	EN: Enable, CMOS compatible control input. Logic high = enable, logic low = shutdown.
2	IN: Input power, supplies the current to the output power device
3, TAB	GND: TAB is also connected internally to the IC's ground on D-PAK.
4	OUT: Output, the regulator output voltage
5	ADJ: Adjustable regulator feedback input that connects to the resistor voltage divider that is placed from OUTPUT to GND in order to set the output voltage.

Absolute Maximum Ratings[1]

Input Supply Voltage (V_{IN})[1] .... –20V to +60V
Enable Input Voltage (V_{EN})................................ –0.3V to V_{IN}
Lead Temperature (soldering, 5sec.)......................... 260°C
Power Dissipation .... Internally Limited
Storage Temperature Range .... –65°C to +150°C
ESD Rating.. Note 3

Operating Ratings[2]

Operating Junction Temperature .... –40°C to +125°C
Maximum Operating Input Voltage 26V
Package Thermal Resistance
TO-263 (θ_{JC}).. 2°C/W
TO-263 (θ_{JA})... 26.2°C/W

Electrical Characteristics[4, 13]

$V_{IN} = V_{OUT} + 1V$; $I_{OUT} = 10mA$; $T_J = 25°C$. **Bold** values indicate $–40°C \le T_J \le +125°C$, unless noted.

Parameter	Condition	Min.	Typ.	Max.	Units
Output Voltage	$I_{OUT} = 10mA$	–1		1	%
	$10mA \le I_{OUT} \le I_{FL}$, $(V_{OUT} + 1V) \le V_{IN} \le 26V$ [5]	–2		2	
Line Regulation	$I_{OUT} = 10mA$, $(V_{OUT} + 1V) \le V_{IN} \le 26V$		0.06	0.5	%
Load Regulation	$V_{IN} = V_{OUT} + 1V$, $10mA \le I_{OUT} \le 1.5A$ [5,9]		0.2	1	%
$\frac{\Delta V_O}{\Delta T}$	Output Voltage[9] Temperature Coefficient.		**20**	**100**	ppm/°C
Dropout Voltage ($\Delta V_{OUT} = –1\%$[6])	$I_{OUT} = 100mA$		80	**175**	mV
	$I_{OUT} = 1.5A$		250		
	$I_{OUT} = 3A$		370	**600**	
Ground Current ($V_{IN} = V_{OUT} + 1V$)	$I_{OUT} = 750mA$		8		mA
	$I_{OUT} = 1.5A$,		10	**35**	
	$I_{OUT} = 3A$		37		
Ground Pin Current at Dropout	$V_{IN} = 0.5V$ less than specified V_{OUT} , $I_{OUT} = 10mA$		1.7		mA
Current Limit	$V_{OUT} = 0V$[7]		4.5	**5.0**	A
e_n, Output Noise Voltage (10Hz to 100kHz) $I_L = 100mA$			260		μV (rms)
Ground Current in Shutdown	$V_{EN} = 0.4V$		20		μA
Reference Voltage		1.228 **1.215**	1.240	1.252 **1.265**	V
Reference Voltage	$V_{REF} \le V_{OUT} \le (V_{IN} – 1V)$, $2.3V \le V_{IN} \le 26V$, $10mA < I_L \le 3A$, $T_J \le T_{JMAX}$	**1.203**		**1.277**	V
Adjust Pin Bias Current			40	80 **120**	nA
Reference Voltage Temperature Coefficient	Note 10		20		ppm/°C
Adjust Pin Bias Current Temperature Coefficient			0.1		nA/°C
Input Logic Voltage Low (OFF) High (ON)		**2.4**		**0.8**	V

Electrical Characteristics Continued[4, 13]

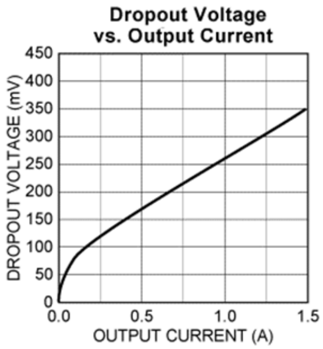
$V_{IN} = V_{OUT} + 1V$; $I_{OUT} = 10mA$; $T_J = 25°C$. **Bold** values indicate –40°C ≤ T_J ≤ +125°C, unless noted.

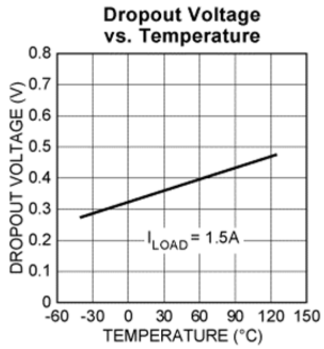
Parameter	Condition	Min.	Typ.	Max.	Units
Enable Pin Input Current	V_{EN} = 26V		100	600 **750**	µA
	V_{EN} = 0.8V		0.8	2 **4**	
Regulator Output Current in Shutdown	Note 12		10	**500**	µA

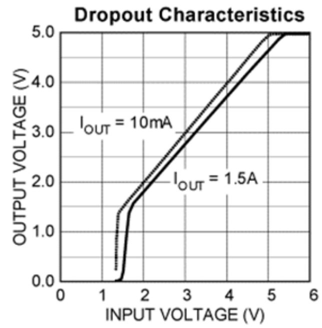
Notes:

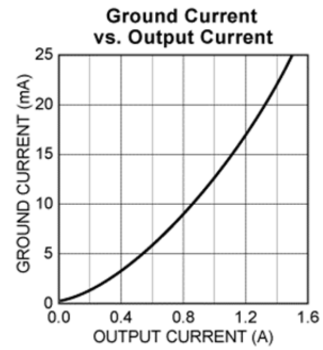
1. Maximum positive supply voltage of 60V must be of limited duration (<100msec) and duty cycle (≤1%). The maximum continuous supply voltage is 26V. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. Devices are ESD sensitive. Handling precautions recommended.
4. Specification for packaged product only.
5. Full load current (I_{FL}) is defined as 3A for the MIC29302H.
6. Dropout voltage is defined as the input-to-output differential when the output voltage drops to 99% of its normal value with V_{OUT} + 1V applied to V_{IN}.
7. $V_{IN} = V_{OUT\ (nominal)} + 1V$. For example, use V_{IN} = 4.3V for a 3.3V regulator or use 6V for a 5V regulator. Employ pulse-testing procedures to pin current.
8. Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the load current plus the ground pin current.
9. Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.
10. Thermal regulation is defined as the change in output voltage at a time T after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 200mA load pulse at VIN = 20V (a 4W pulse) for T = 10ms.
11. Comparator thresholds are expressed in terms of a voltage differential at the Adjust terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = V_{OUT}/V_{REF} = (R1 + R2)/R2. For example, at a programmed output voltage of 5V, the Error output is guaranteed to go low when the output drops by 95mV x 5V/1.240V = 384mV. Thresholds remain constant as a percent of V_{OUT} as V_{OUT} is varied, with the dropout warning occurring at typically 5% below nominal, 7.7% guaranteed.
12. V_{EN} ≤ 0.8V and V_{IN} ≤ 26V, V_{OUT} = 0.
13. When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground

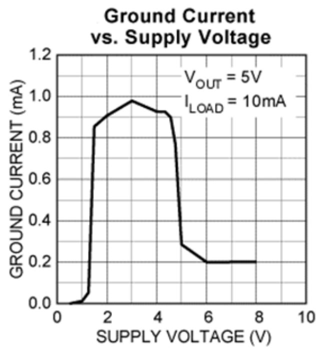
Typical Characteristics

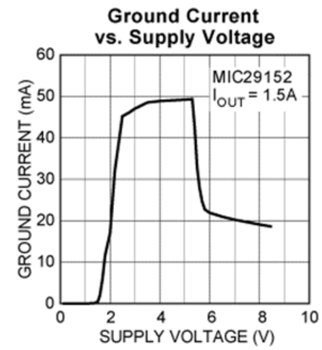


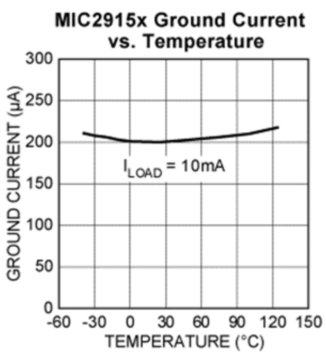


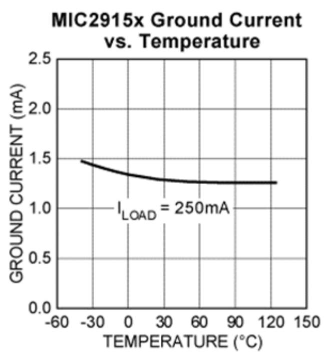


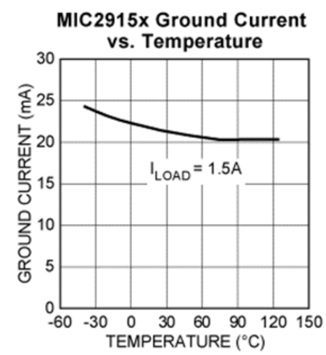


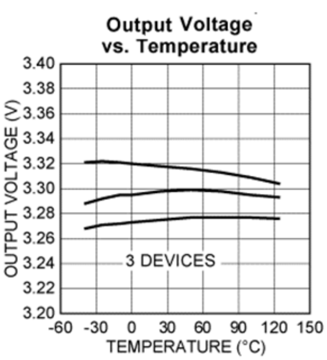


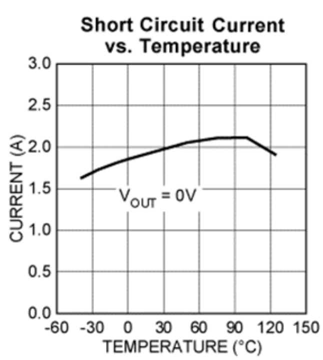


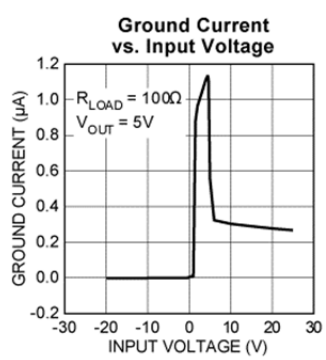




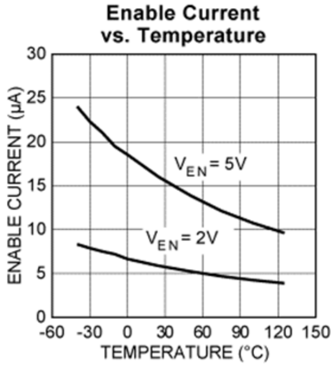


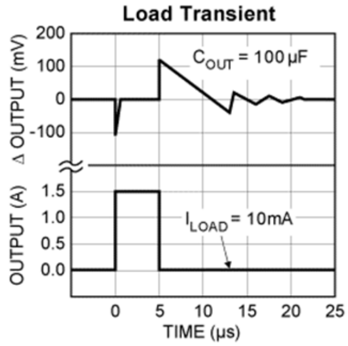


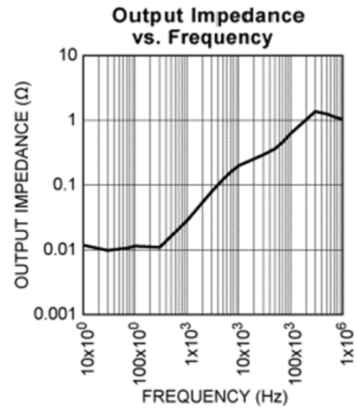


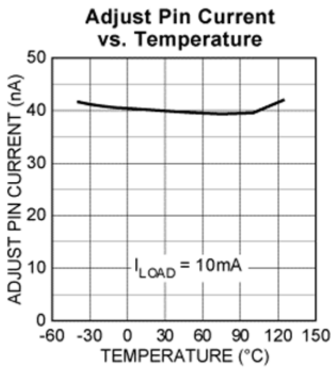


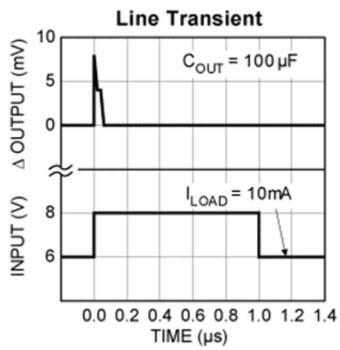
Typical Characteristics (Continued)



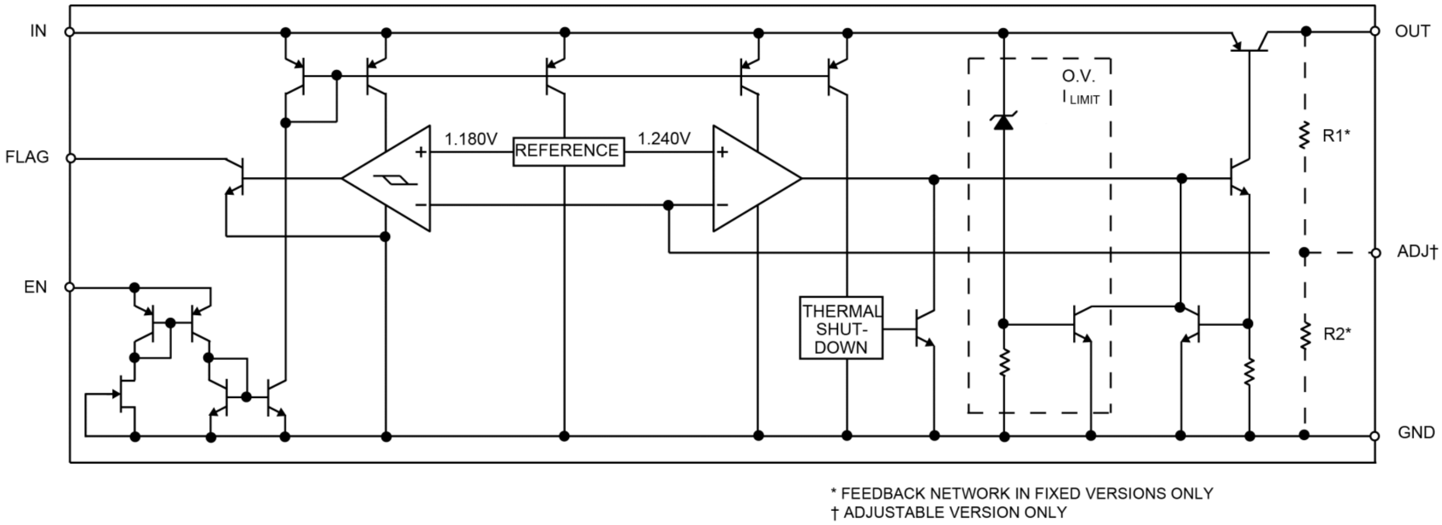








Functional Diagram



Application Information

The MIC29302HWU is a high-performance low-dropout voltage regulator suitable for moderate to high-current voltage regulator applications. The 350mV to 425mV typical dropout voltage at full load makes it especially valuable in battery powered systems and as high efficiency noise filters in “post-regulator” applications. Unlike older NPN-pass transistor designs, where the minimum dropout voltage is limited by the base-emitter voltage drop and collector-emitter saturation voltage, dropout performance of the PNP output of these devices is limited merely by the low V_{CE} saturation voltage.

A trade-off for the low-dropout voltage is a varying base driver requirement. But Micrel’s Super ßeta PNP® process reduces this drive requirement to merely 1% of the load current.

The MIC29302HWU regulator is fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear; output current under overload conditions is constant. Thermal shutdown disables the device when the die temperature exceeds the 125°C maximum safe operating temperature. Line transient protection allows device (and load) survival even when the input voltage spikes between –20V and +60V. When the input voltage exceeds approximately 40V, the over voltage sensor disables the regulator. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow. The MIC29302HWU versions offer a logic level ON/OFF control: when disabled, the devices draw nearly zero current.

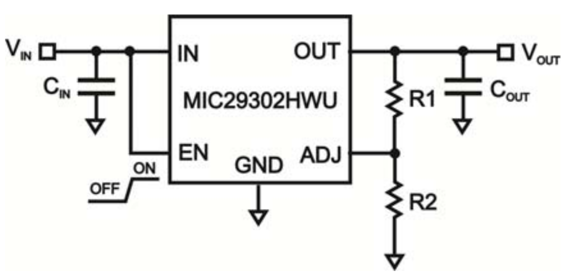


Figure 1. Linear Regulators Require Only Two Capacitors for Operation

Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics. Thermal design requires the following application-specific parameters:

- Maximum ambient temperature, T_A
- Output Current, I_{OUT}
- Output Voltage, V_{OUT}
- Input Voltage, V_{IN}

First, we calculate the power dissipation of the regulator from these numbers and the device parameters from this datasheet.

$$P_D = I_{OUT}\left(1.01\,V_{IN} - V_{OUT}\right) \qquad \text{Eq. 1}$$

where the ground current is approximated by 1% of I_{OUT}. Then the heat sink thermal resistance is determined with

$$\theta_{SA} = \frac{T_{JMAX} - T_A}{P_D} - \left(\theta_{JC} + \theta_{CS}\right) \qquad \text{Eq. 2}$$

:

$$\theta_{SA} = \frac{T_{JMAX} - T_A}{P_D} - \left(\theta_{JC} + \theta_{CS}\right) \qquad \text{Eq. 2}$$

where TJMAX ≤ 125°C and θCS is between 0 and 2°C/W.

For example, given an expected maximum ambient temperature (TA) of 75°C with VIN = 3.3V, VOUT = 2.5V, and IOUT = 1.5A, first calculate the expected PD using Eq. 3:

$$P_D = (3.3V–2.5V)1.5A–(3.3V)(0.016A) = 1.1472W \qquad \text{Eq. 3}$$

Next, calcualte the junction temperature for the expected power dissipation.

$$T_J = (\theta_{JA} \times P_D) + T_A = (56°C/W \times 1.1472W) + 75°C = 139.24°C \qquad \text{Eq. 4}$$

Then determine the maximum power dissipation allowed that would not exceed the IC's maximum junction temperature (125°C) without the useof a heat sink by:

$$P_{D(MAX)} = (T_{J(MAX)} – T_A)/\theta_{JA}$$

$$= (125°C–75°C)/(56°C/W) = 0.893W$$

Eq. 5

Capacitor Requirements

For stability and to minimize output noise, a capacitor on the regulator output is necessary. The value of this capacitor is dependent upon the output current; lower currents allow smaller capacitors. The MIC29302HWU is stable with minimum of 100µF. This capacitor need not be an expensive low ESR type: aluminum electrolytics are adequate. In fact, extremely low ESR capacitors may contribute to instability. Tantalum capacitors are recommended for systems where fast load transient response is important.

Where the regulator is powered from a source with high AC impedance, a 0.1µF capacitor connected between Input and GND is recommended. This capacitor should have good characteristics to above 250kHz.

Minimum Load Current

The MIC29300HWU is specified between finite loads. If the output current below 7mA, leakage currents dominate and the output voltage rises.

Adjustable Regulator Design

The MIC20302HWU allows programming the output voltage anywhere between 1.25V and the 25V. Two resistors are used. The resistor values are calculated by

$$R_1 = R_2 \times \left(\frac{V_{OUT}}{1.240} - 1\right)$$ Eq 6:

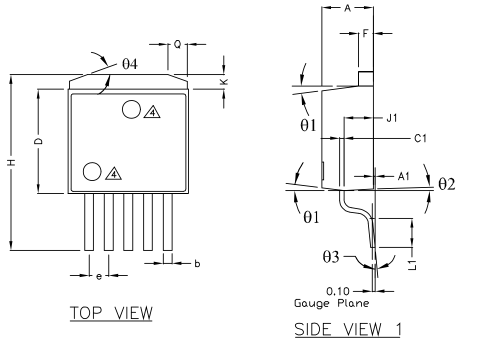
$$R_1 = R_2 \times \left(\frac{V_{OUT}}{1.240} - 1\right)$$ Eq 6.

where V_{OUT} is the desired output voltage. Figure 3 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation (see "Minimum Load Current" sub-section).

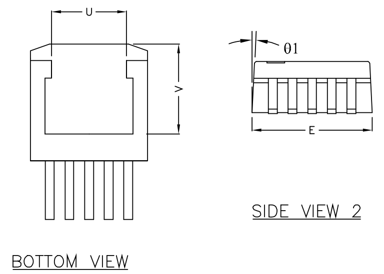
Enable Input

MIC29302HWU features an enable (EN) input that allows ON/OFF control of the device. Special design allows "zero" current drain when the device is disabled—only microamperes of leakage current flows. The EN input has TTL/CMOS compatible thresholds for simple interfacing with logic, or may be directly tied to ≤30V. Enabling the regulator requires approximately 20µA of current.

Package Information(Error! Reference source not found.)



POS	INCH		MM	
	MIN	MAX	MIN	MAX
A	0.170	0.181	4.318	4.597
A1	0.000	0.012	0.000	0.305
b	0.026	0.036	0.660	0.914
C1	0.012	0.023	0.305	0.584
D	0.330	0.361	8.392	9.169
E	0.396	0.420	10.058	10.668
e	0.062	0.072	1.575	1.829
F	0.045	0.055	1.143	1.397
H	0.575	0.625	14.605	15.875
J1	0.080	0.120	2.032	3.048
K	0.045	0.066	1.143	1.676
L1	0.090	0.110	2.286	2.794
θ1	3°	10°	3°	10°
θ2	1°	7°	1°	7°
θ3	0°	8°	0°	8°
θ4	18°	22°	18°	22°
Q	0.055	0.075	1.397	1.905
U	0.256 Ref.		6.502 Ref.	
V	0.305 Ref.		7.747 Ref.	



NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
2. PACKAGE OUTLINE INCLUSIVE OF PLATING THICKNESS.
3. FOOT LENGTH USING GAUGE PLANE METHOD MEASUREMENT 0.010"
4. PACKAGE TOP MARK MAY BE IN TOP CENTER OR LOWER LEFT CORNER
5. ALL DIMENSIONS ARE IN INCHES/MILLIMETERS.

5-Pin TO-263 (U)

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