

General Description

The SP29150/29300/29500 are high current, high accuracy, low-dropout voltage regulators. Using Micrel's proprietary Super β PNP™ process with a PNP pass element, these regulators feature 300mV to 370mV (full load) 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 SP29150/29300/29500 are fully protected against over current faults, reversed input polarity, reversed lead in sertion, over temperature operation, and positive and nega-tive 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.

On the SP29xx1 and SP29xx2, the ENABLE pin may be tied to VIN if it is not required for ON/OFF control. The SP29150/29300/29500 are available in 3- and 5-pin TO-220and surface mount TO-263 packages.

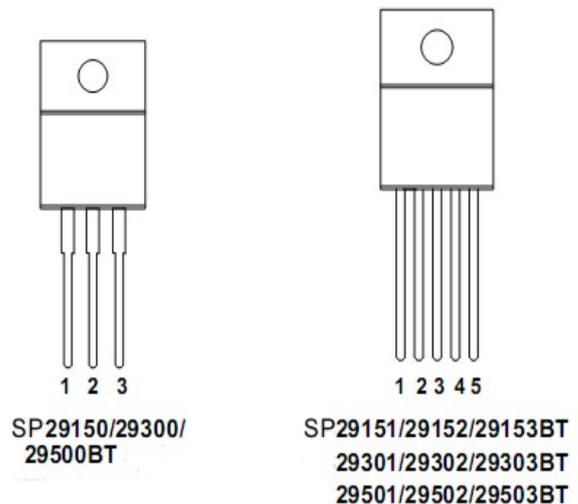
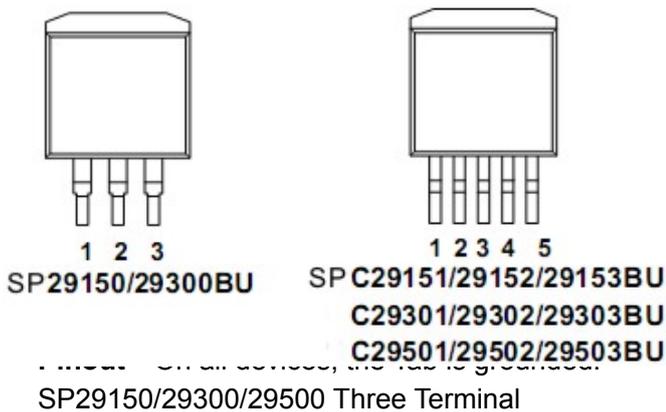
Features

- ◆ High Current Capability
- ◆ MIC29300/29301/29302/29303.....3A
- ◆ MIC29500/29501/29502/29503.....5A
- ◆ MIC29750/29751/29752.....7.5A
- ◆ Low-Dropout Voltage.....350mV at Full Load
- ◆ Low Ground Current
- ◆ Accurate 1% Guaranteed Tolerance
- ◆ Extremely Fast Transient Response
- ◆ Reverse-battery and “Load Dump” Protection
- ◆ (5-Pin versions)
- ◆ Error Flag Signals Output Out-of-Regulation (5-Pin versions)
- ◆ Also Characterized For Smaller Loads With Industry Leading Performance Specifications
- ◆ Fixed Voltage and Adjustable Versions

Applications

- ◆ Battery Powered Equipment
- ◆ High-Efficiency “Green” Computer Systems
- ◆ Automotive Electronics
- ◆ High-Efficiency Linear Power Supplies
- ◆ High-Efficiency Post-Regulator For Switching Supply

Pin Configuration



Devices:

Pin 1 = Input, 2 = Ground, 3 = Output

SP29151/29301/29501 Five Terminal

Fixed Voltage Devices:

Pin 1 = Enable, 2 = Input, 3 = Ground, 4 = Output, 5 = Flag

SP29152/29302/29502/29752 Adjustable with ON/OFF Control

Pin 1 = Enable, 2 = Input, 3 = Ground, 4 = Output, 5 = Adjust

SP29153/29303/29503 Adjustable with Flag

Pin 1 = Flag, 2 = Input, 3 = Ground, 4 = Output, 5 = Adjust

Ordering Information

Part Number	Temp. Range	Volts	Current	Package
SP29150-3.3BT	- 40 to +125°C	3.3V	1.5A	TO-220/TO-263
SP29150-4.2BT	- 40 to +125°C	4.2V	1.5A	TO-220/TO-263
SP29150-5.0BT	- 40 to +125°C	5.0V	1.5A	TO-220/TO-263
SP29150-12BT	- 40 to +125°C	12V	1.5A	TO-220/TO-263
SP29300-3.3BT	- 40 to +125°C	3.3V	3A	TO-220/TO-263
SP29300-4.2BT	- 40 to +125°C	4.2V	3A	TO-220/TO-263
SP29300-5.0BT	- 40 to +125°C	5.0V	3A	TO-220/TO-263
SP29300-12BT	- 40 to +125°C	12V	3A	TO-220/TO-263
SP29500-3.3BT	- 40 to +125°C	3.3V	5A	TO-220/TO-263
SP29500-4.2BT	- 40 to +125°C	4.2V	5A	TO-220/TO-263
SP29500-5.0BT	- 40 to +125°C	5.0V	5A	TO-220/TO-263
SP29500-12BT	- 40 to +125°C	12V	5A	TO-220/TO-263

Absolute Maximum Ratings

Power Dissipation.....Internally Limited

Lead Temperature (Soldering, 5 seconds).....260°C

Storage Temperature Range.....-65°C to +150°C

Input Supply Voltage (Note 1).....-20V to +60V

Operating Ratings

Operating Junction Temperature.....-40°C to +125°C

Maximum Operating Input Voltage.....26V

TO-220 θ_{JC}2°C/W

TO-263 θ_{JC}2°C/W

Electrical Characteristics

All measurements at TJ = 25°C unless otherwise noted. Bold values are guaranteed across the

operating temperature range.

Adjustable versions are programmed to 5.0V.

Parameter	condition	Min	Typ	Max	Units
Output Voltage	IO = 10mA	-1		1	%
	10mA ≤ IO ≤ IFL, (VOUT + 1V) ≤ VIN ≤ 26V (Note 2)	-2		2	%
Line Regulation	IO = 10mA, (VOUT + 1V) ≤ VIN ≤ 26V		0.06	0.5	%
Load Regulation	VIN = VOUT + 5V, 10mA ≤ IO ≤ I FULL LOAD (Note 2, 6)		0.2	1	%
$\frac{\Delta V_O}{\Delta T}$	Output Voltage(Note 6) Temperature Coef.		20	100	ppm/°C
Dropout Voltage	$\Delta V_{OUT} = -1\%$, (Note 3)				
	SP29150 IO = 100mA		80	200	mV
	IO = 750mA		220		mV
	IO = 1.5A		350	600	mV
	SP29300 IO = 100mA		80	175	mV
	IO = 1.5A		250		mV
	IO = 3A		370	600	mV
	SP29500 IO = 250mA		125	250	mV
	IO = 2.5A		250		mV
	IO = 5A		370	600	mV
Ground Current	SP29150 IO = 750mA, VIN = VOUT + 1V		8	20	mA
	IO = 1.5A		22		
	SP29300 IO = 1.5A, VIN = VOUT + 1V		10	35	mA
	IO = 3A		37		
	SP29500 IO = 2.5A, VIN = VOUT + 1V		15	50	mA
	IO = 5A		70		
IGNDDO Ground Pin Current at Dropout	VIN = 0.5V less than specified VOUT. I OUT = 10mA				
	SP29150		0.9		mA
	SP29300		1.7		mA
	SP29500		2.1		mA
Current Limit	SP29150 VOUT = 0V (Note 4)		2.1	3.5	A

	SP29300	V _{OUT} = 0V (Note 4)		4.5	5.0	A
	SP29500	V _{OUT} = 0V (Note 4)		7.5	10.0	A
en, Output Noise Voltage (10Hz to 100kHz) IL = 100mA	CL = 10μF			400		μV (rms)
	CL = 33μF			260		
Ground Current in Shutdown	SP29150/1/2/3 only VEN= 0.4V			2	10 30	μA μA
Reference Voltage			1.228 1.215	1.240	1.252 1.265	V V _{max}
Adjust Pin Bias Current	(Note 8)		1.203		1.2777	V
Adjust Pin Bias Current				40	80 120	nA
Reference Voltage Temperature Coefficient	(Note 7)			20		ppm/°C
Adjust Pin Bias Current Temperature Coefficient				0.1		nA/°C
Flag Output (Error Comparator) SP29xxx						
Output leakage Current	VoH=26V			0.01	1.00 2.00	μA
Output Low Voltage	Device set for 5V. VIN = 4.5V IOL = 250μA			220	300 400	mV
Upper Threshold Voltage	Device set for 5V (Note 9)			40 25	60	mV
Lower Threshold Voltage	Device set for 5V (Note 9)				75	95 140
Hysteresis	Device set for 5V (Note 9)				15	mV
ENABLE Input SP29xxx						
Input Logic Voltage Low (OFF) High (ON)			2.4		0.8	V
Enable Pin Input Current	VEN=26V			100	600 750	μA
	VEN=0.8V				1 2	μA

Regulator Output Current in Shutdown	(Note 10)		10	500	μA
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Notes

Note 1: Maximum positive supply voltage of 60V must be of limited duration (<100msec) and duty cycle ($\leq 1\%$). The maximum continuous supply voltage is 26V.

Note 2: Full Load current (IFL) is defined as 1.5A for the MIC29150, 3A for the MIC29300, 5A for the MIC29500, and 7.5A for the MIC29750 families.

Note 3: Dropout voltage is defined as the input-to-output differential when the output voltage drops to 99% of its nominal value with $V_{OUT} + 1V$ applied to V_{IN}

Note 4: $V_{IN} = V_{OUT} (\text{nominal}) + 1V$. For example, use $V_{IN} = 4.3V$ for a 3.3V regulator or use 6V for a 5V regulator. Employ pulse-testing procedures to minimize temperature rise.

Note 5: 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.

Note 6: Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

Note 7: 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 $V_{IN} = 20V$ (a 4W pulse) for $T = 10ms$.

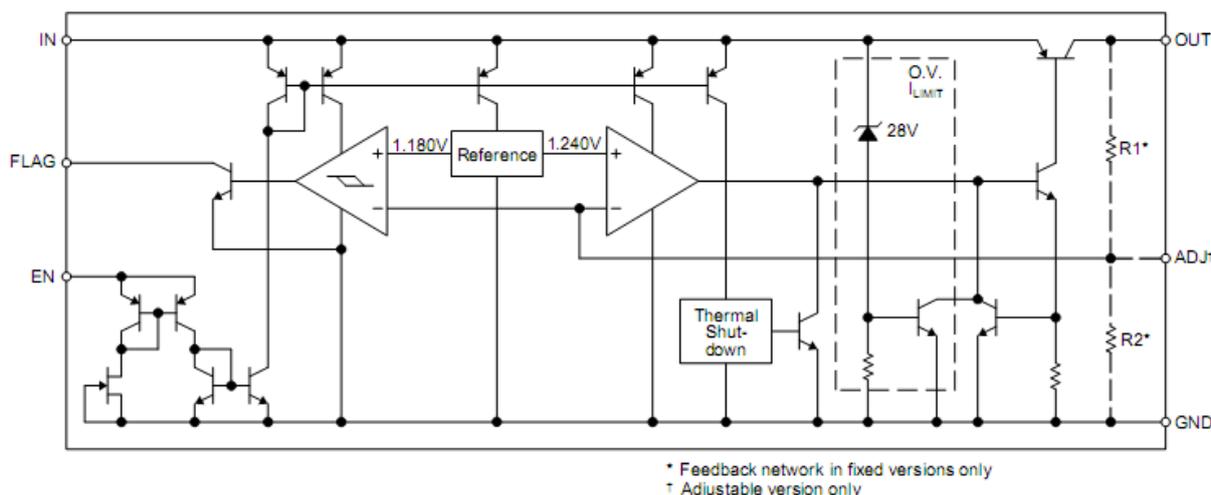
Note 8: $V_{REF} \leq V_{OUT} \leq (V_{IN} - 1V)$, $2.3V \leq V_{IN} \leq 26V$, $10mA < I_L \leq I_{FL}$, $T_J \leq T_{J\text{MAX}}$.

Note 9: 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 $95mV \times 5V / 1.240V = 384mV$. 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.

Note 10: $V_{EN} \leq 0.8V$ and $V_{IN} \leq 26V$, $V_{OUT} = 0$.

Note 11: 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.

Block Diagram



Typical Applications

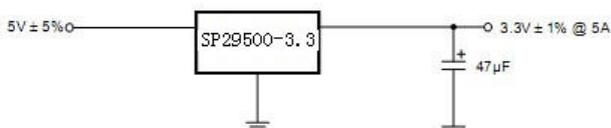


Figure 1. Fixed output voltage.

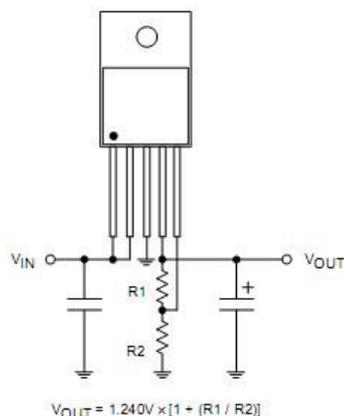


Figure 2. Adjustable output voltage configuration. For best results, the total series resistance should be small enough to pass the minimum regulator load current.

Applications Information

The SP29150/29300/29500 are high performance low-dropout voltage regulators suitable for all mode rate to high-current voltage regulator applications. Their 300mV to 400mV dropout voltage at full load make them 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 VCE

saturation voltage.

A trade-off for the low dropout voltage is a varying base drive requirement. But Micrel’s Super β PNP™ process reduces this drive requirement to merely 1% of the load current. The SP29150–29500 family of regulators 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.

Transient protection allows de-vice (and load) survival even when the input voltage spikes between -20V and +60V. When the input voltage exceeds about 35V to 40V, the overvoltage sensor temporarily dis- ables the regulator. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow. SP29xx1 and SP29xx2 versions offer a logic level ON/OFF control: when disabled, the devices draw nearly zero current.

An additional feature of this regulator family is a common pinout: a design's current requirement may change up or down yet use the same board layout, as all of these regulators have identical

pinouts.

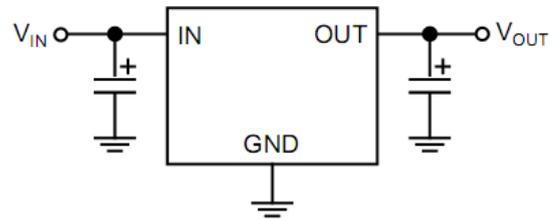


Figure 3. Linear regulators require only two capacitors for operation.

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.

$$P_D = I_{OUT}(1.01V_{IN} - V_{OUT})$$

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

$$\theta_{SA} = \frac{T_{JMAX} - T_A}{P_D} - (\theta_{JC} + \theta_{CS})$$

Where T_{J MAX} ≤ 125°C and θ_{CS} is between 0 and 2°C/W. The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage and distribute the heat between this resistor and the regulator. The low dropout properties of Micrel Super βeta PNP regulators allow very significant reductions in

regulator power dissipation and the associated heat sink without compromising performance. When this technique is employed, a capacitor of at least 0.1μF is needed directly between the input and regulator ground. Please refer to Application Note 9 and Application Hint 17 for further details and examples on thermal design and heat sink specification.

Capacitor Requirements

For stability and minimum 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. SP29150—29500 regulators are stable with the following minimum capacitor values at full load

Device	Full Load Capacitor
SP29150.....	10μF
SP29300.....	10μF
SP29500.....	10μF

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 ca-pacitors are recommended for systems where fast load transient response is important.

Where the regulator is powered from a source

with a 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 SP29150–29750 regulators are specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. The following minimum load current swamps any expected leakage current across the operating temperature range:

MIC29150.....	5mA
MIC29300.....	7mA
MIC29500.....	10 mA

Adjustable Regulator Design

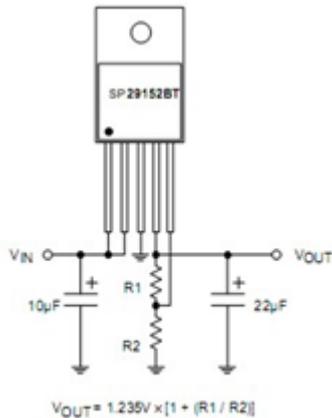


Figure 4. Adjustable Regulator with Resistors

The adjustable regulator versions, SP29xxx, allow programming the output voltage anywhere between quite large, up to 1MΩ, because of the very high input impedance and low bias current of the sense comparator. The resistor values are calculated by:

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

Where VO is the desired output voltage. Figure 4 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current

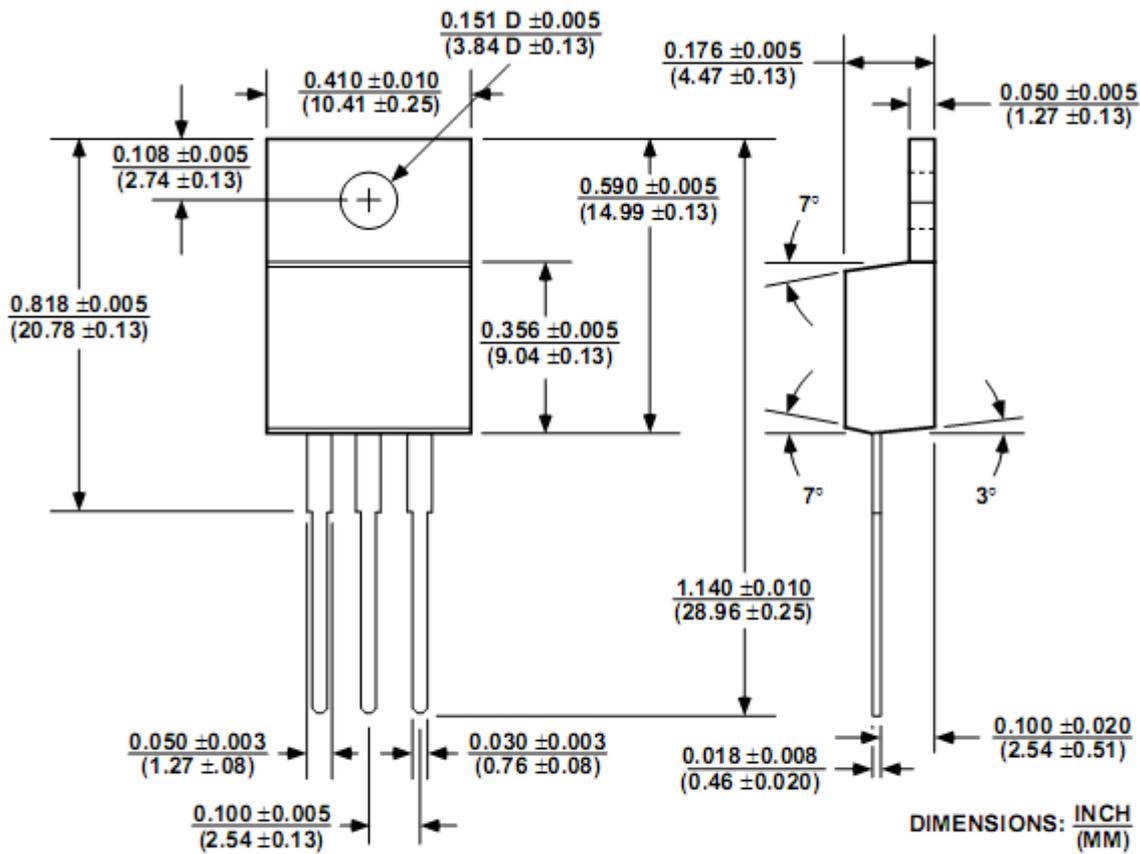
required for proper operation (see above).

Error Flag

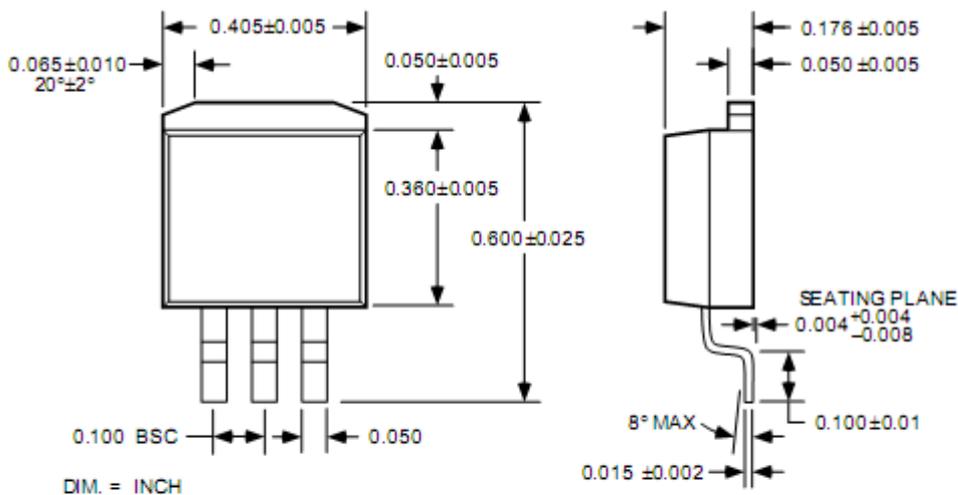
SP29xx1 and SP29xx3 versions feature an Error Flag which looks at the output voltage and signals an error condition when this voltage drops 5% Below its expected value. The error flag is an open collector output that pulls low under fault condition it may sink 10mA. Low output voltage signifies a number of possible problems, including an over-voltage. The flag output is inoperative during an over-current fault (the device is in current limit) and low input voltage. The flag output is inoperative during over-temperature shutdown conditions.

SP29xx1 and SP29xx2 versions feature an enable (EN) input that allows ON/OFF control of 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



3-Lead TO-220 (T)



3-Lead TO-263 (U)

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