TOP ONE SEMI CONDUCTOR

SP29150/29300/29500 Series

High-Current Low-Dropout Regulators

General Description

The SP29150/29300/29500 are high current, high accuracy, low-dropout voltage regulators. Using Micrel's proprietary Super ßeta 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.

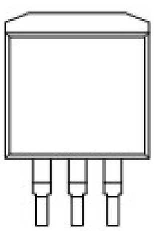
Features

- 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
- Zero-Current Shutdown Mode (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

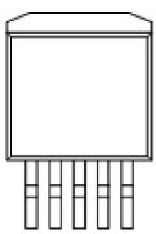
- Battery Powered Equipment
- High-Efficiency "Green" Computer Systems
- Automotive Electronics
- High-Efficiency Linear Power Supplies
- High-Efficiency Post-Regulator For Switching Supply

Pin Configuration



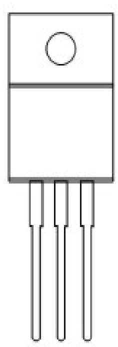
1 2 3

SP29150/29300BU



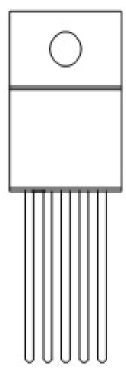
1 2 3 4 5

SP C29151/29152/29153BU
C29301/29302/29303BU
C29501/29502/29503BU



1 2 3

SP29150/29300/
29500BT



1 2 3 4 5

SP29151/29152/29153BT
29301/29302/29303BT
29501/29502/29503BT

Pinout On all devices, the Tab is grounded.

SP29150/29300/29500 Three Terminal

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 θJC..2°C/W
TO-263 θJC..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 ≤ IOUT ≤ I FULL LOAD (Note 2, 6)		0.2	1	%
ΔVO / ΔT	Output Voltage(Note 6) Temperature Coef.		20	100	ppm/°C
Dropout Voltage	ΔVOUT = – 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 VOUT = 0V (Note 4)		4.5	5.0	A
	SP29500 VOUT = 0V (Note 4)		7.5	10.0	A
en, Output Noise Voltage (10Hz to 100kHz) IL = 100mA	CL = 10µF CL = 33µF		400 260		µV (rms)
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 Vmax
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

Notes

Note 1: Maximum positive supply voltage of 60V must be of limited duration (<100msec) and duty cycle (≤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 VOUT + 1V applied to VIN

Note 4: VIN = VOUT (nominal) + 1V. For example, use VIN = 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 VIN = 20V (a 4W pulse) for T = 10ms.

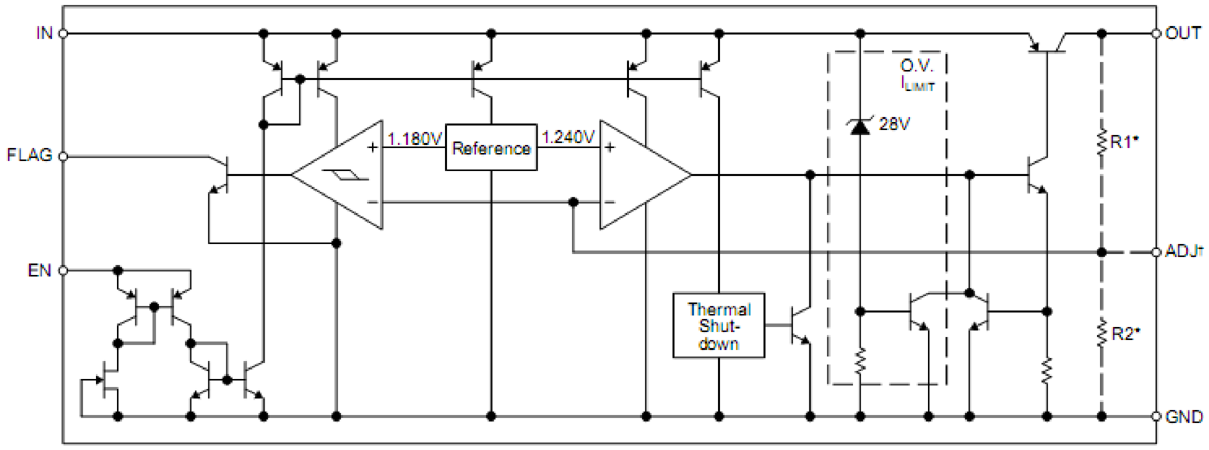
Note 8: VREF ≤ VOUT ≤ (VIN – 1 V), 2.3V ≤ VIN ≤ 26V, 10mA < I
L ≤ IFL, TJ ≤ TJ MAX.

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 = VOUT /VREF = (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 95 mV x 5V/1.240 V = 384mV. Thresholds remain constant as a percent of VOUT as VOUT is varied, with the dropout warning occurring at typically 5% below nominal,
7.7% guaranteed.

Note 10: VEN ≤ 0.8V and VIN ≤ 26V, VOUT = 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



* Feedback network in fixed versions only
† Adjustable version only

Typical Applications

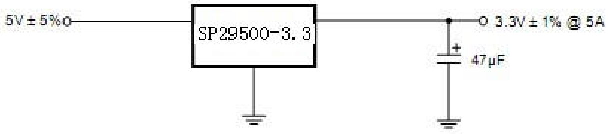


Figure 1. Fixed output voltage.

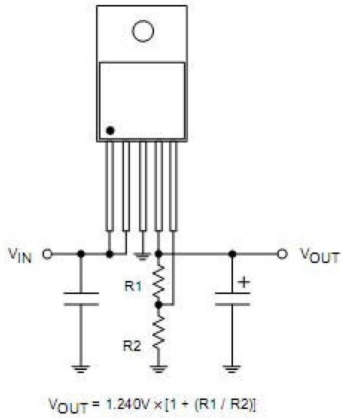


Figure 2. Adjustable output voltage configuration. For best results, the total series resistance should be small enough to pass the minimum regulator load current.

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 PNPoutput 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 ßeta PNP™ process re- duces this drive requirement to merely 1% of the load current. The SP29150–29500family 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 de-vice 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.

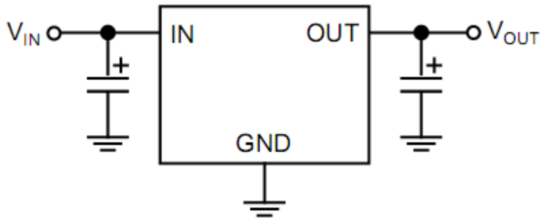


Figure 3. Linear regulators require only two capacitors for operation.

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, TA
- Output Current, IOUT
- Output Voltage, VOUT
- Input Voltage, VIN

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 IOUT.Then the heat sink thermal resistance is determined with this formula:

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

Where TJ MAX ≤ 125°C and θCS 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 ßeta 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.

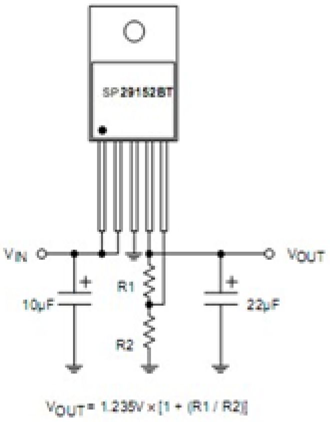
Where the regulator is powered from a source with a high AC impedance, a 0.1μF capacitor connected between Input andN GND is recommended. This capacitor should have good characteristics to above 250kHz.

Minimum Load Current

The SP29150–29750 regulators are specified between fi-nite loads. If the output current is too small, leakage currentsdominate and the output voltage rises. The following mini-mum load current swamps any expected leakage current across the operating temperature range:

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

Adjustable Regulator Design



The adjustable regulator versions,SP29xxx,allow programming the output voltage anywhere betweenbe quite large, up to 1MΩ, because of the very the family. Two resistors are used. Resistors can high input impedance and low bias current of the 1.25V and the 26V maximum operating rating of 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).

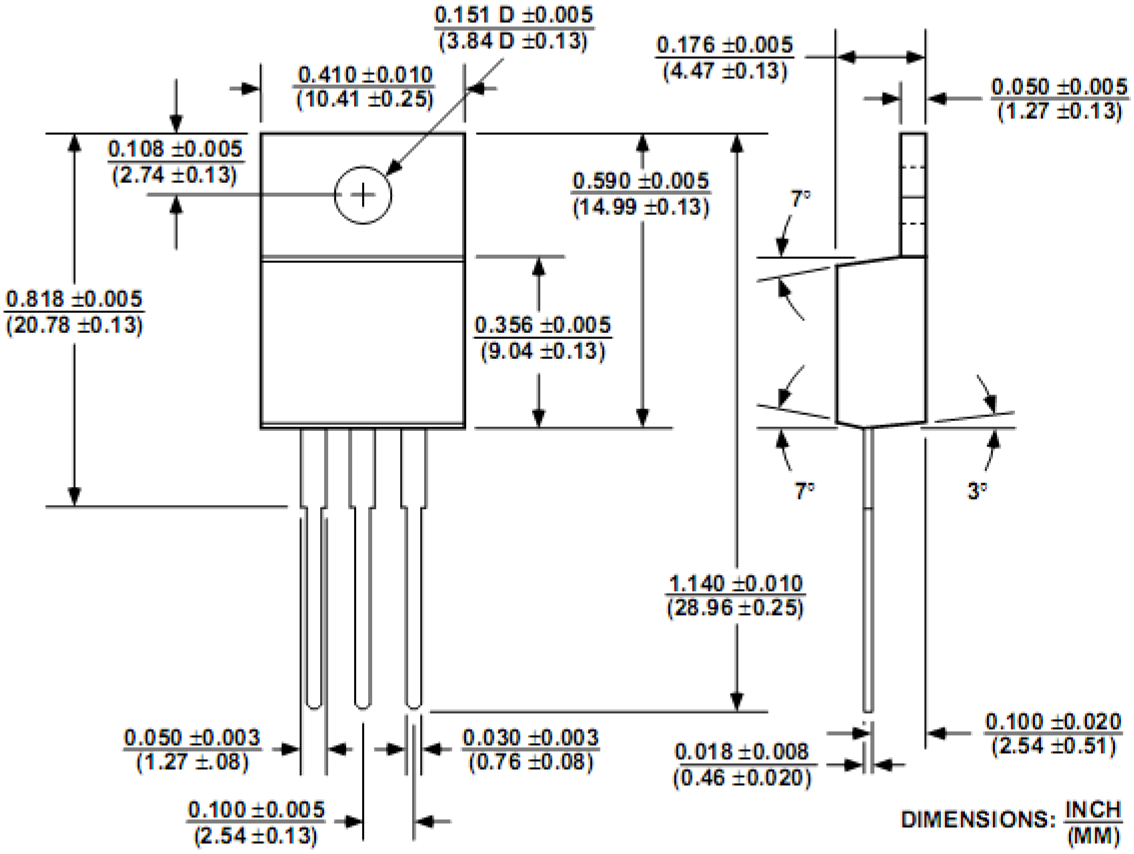
Error Flag

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 errorflag 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 overtempera-ture shutdown conditions.

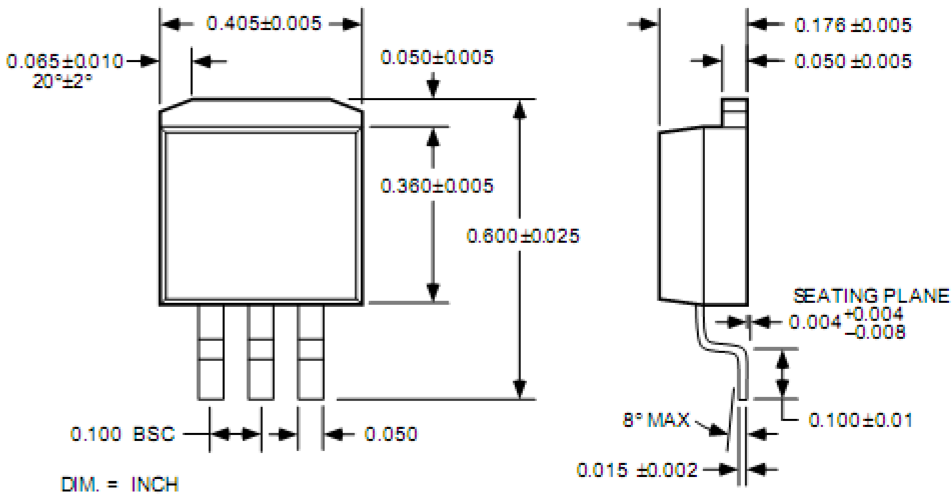
Enable Input

SP29xx1 and SP29xx2 versions feature an enable (EN) input that allows ON/OFF control of the Device is dis- abled—only microamperes of leakage current flows. The EN input has TTL/ CMOS compatible thresholds for simple inter- facing 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)