

# Ultra Low Dropout Voltage Regulator

The PJ2931 voltage regulator features a very low quiescent current of 1mA or less when supplying 10mA loads. This unique characteristic and the extremely low input-output differential required for proper regulation (0.2V for output currents of 10mA) make the PJ2931 the ideal regulator for standby power systems. Applications include memory standby circuits, CMOS and other low power processor power supplies as well as systems demanding as much as 100mA of output current.

Designed originally for automotive applications, the PJ2931 and all regulated circuitry are protected from reverse battery installations or 2 battery jumps. During line transients, such as a load dump (60V) when the input voltage to the regulator can momentarily exceed the specified maximum operating voltage, the regulator will automatically shut down to protect both internal circuits and the load. The PJ2931 can not be harmed by temporary mirror-image insertion. Familiar regulator features such as short circuit and thermal overload protection are also provided.

Fixed output of 5V is available in the popular TO-92 and SOT-89 package. An adjustable output version, with on/off switch, is available in SOP-8 package.

### FEATURES

- Very low quiescent current
- Output current up to 100mA
- Input-Output differential less than 0.6V
- Reverse battery protection
- Unregulated DC input can withstand +60V positive transients and -20V reverse battery
- Short circuit protection
- Internal thermal overload protection
- Available as adjustable with TTL compatible switch
- 100% electrical burn-in in thermal limit
- Available in plastic SOP-8, TO-92, SOT-89 package

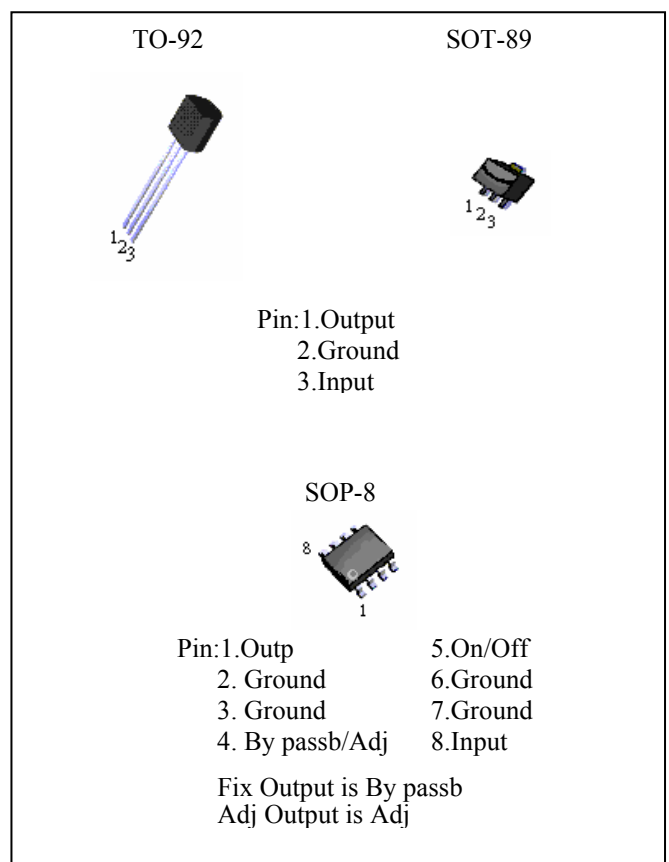
### ORDER INFORMATION

Device	Operating Temperature (Ambient)	Package
PJ2931CT-xx	-20°C ~ +85°C	TO-92
PJ2931CY-xx		SOT-89
PJ2931CS-xx		SOP-8
PJ2931CS-Adj		

xx = Output Voltage (2.85V, 3.3V, 5.0V)

### ABSOLUTE MAXIMUM RATINGS

Input Supply Voltage	+26V
Internal Power Dissipation (Note 1)	Internally Limited
Operating Temperature Range	-20°C to +85°C
Maximum Junction Temperature	125°C
Storage Temperature Range	-40°C to +150°C
Lead Temp.(Soldering, 10 seconds)	210°C



**ELECTRICAL CHARACTERISTICS**( $V_{IN}=14V, I_o=10mA, T_j=25^{\circ}C$  (Note 1),  $C_o=100\mu F$  (unless otherwise specified))

Parameter	Conditions	PJ2931			Units
		Min.	Typ.	Max.	
Output Voltage (Fix Type)	$-20^{\circ}C \leq T_j \leq 85^{\circ}C$	$0.985 V_o $	$V_o$	$1.015 V_o $	V
	Full operating temperature	$0.980 V_o $	-	$1.020 V_o $	
	$I_o = 100\mu A \sim 100mA, T_j \leq T_j \text{ max}$	$0.975 V_o $	-	$1.025 V_o $	
Input Supply Voltage		-	-	26	
Line Regulation	$13V \leq V_{IN} \leq 16V$	-	4	30	mV
Load Regulation	$5mA \leq I_o \leq 100mA$	-	14	50	mV
Dropout Voltage	$I_o=10mA$	-	60	200	V
	$I_o=100mA$	-	300	600	
Ground Current	$I_o=100\mu A$	-	0.1	0.15	mA
	$I_o=10mA$	-	0.9	1.5	
	$I_o=100mA$	-	8	12	
Current Iinit	$V_{out}=0$	-	160	200	mA
Output Noise Voltage	10Hz-100KHz, $C_{OUT}=100\mu F$	-	500	-	uVRMS
Ripple Rejection Ratio	$I_o = 10mA, f_o=120Hz$	60	-	-	dB

**Adjustable Type Only**

Reference Voltage	$V_{out} = 3V, I_o \leq 100mA, R_1=27K$	1.21	1.235	1.26	V
	Full Operation Temperature	1.185	-	1.285	
Feedback Pin Bias Current		-	20	40	nA
Reference Voltage Temperature		-	50	-	Ppm/ $^{\circ}C$

**Shutdown Input**

Input Logic Voltage	Low (Regulator ON)	-	1.3	0.7	V
	High (Regulator OFF)	2	-	-	
Shutdown Pin Input Current	$V_s=2.4V$	-	30	50	uA
	$V_s=26V$	-	450	600	
Regulator Output Current in Shutdown		-	3	10	

Note 1: Output or reference voltage temp. coefficients defined as the worst case voltage change divided by the total temp. range.

Note 2: Regulations is measured at constant junction temperature, using pulse testing with a low duty cycle. Changes in output voltage due to heating effects is covered under the specification for thermal regulation.

Note 3: Line regulation is tested at  $125^{\circ}C$  for  $I_L=1mA$ , For  $I_L=100\mu A$  and  $T_J=125^{\circ}C$ .

Note 4: Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below it's nominal value measured at 1V differential.

Note 5: Ground pin current is the regulator quiescent current. The total current drawn from the source is the sum of the ground pin current and output load current.

Note 6: Thermal regulation is the change in output voltage at a time T after a change in power dissipation, excluding load or line regulation effects. Specifications are for a 50mA load pulse (1.25W) for  $T=10ms$ .

Note 7:  $V_{ref} \leq V_{out} \leq (V_{in}-1V), 2.3V \leq V_{in} \leq 26V, 100\mu A \leq I_L \leq 100mA, T_J \leq T_{JMAX}$

Note 8:  $V_{shutdown} \geq 2V, V_{in} \leq 26V, V_{out}=0V$

### Application Hints

One of the distinguishing factors of the PJ2931 series regulators is the requirement of an output capacitor for device stability. The value required varies greatly depending upon the application circuit and other factors. Thus some comments on the characteristics of both capacitors and the regulator are in order.

High frequency characteristics of electrolytic capacitors depend greatly on the type and even the manufacturer. As a result, a value of capacitance that works well with the PJ2931 for one brand or type may not necessary be sufficient with an electrolytic of different origin. Sometimes actual bench testing, as described later, will be the only means to determine the proper capacitor and value. Experience has shown that, as a rule of thumb, the more expensive and higher quality electrolytic generally allows a smaller value for regulator stability. As an example, while a high-quality 100 $\mu$ F aluminum electrolytic covers all general application circuits, similar stability can be obtained with a tantalum electrolytic of only 47 $\mu$ F. This factor of two can generally be applied to any special application circuit also.

Another critical characteristic of electrolytic is their performance over temperature. While the PJ2931 is designed to operate to -20 $^{\circ}$ C, the same is not always true with all electrolytic (hot is generally not a problem). The electrolyte in many aluminum types will freeze around -250 $^{\circ}$ C, reducing their effective value to zero. Since the capacitance is needed for regulator stability, the natural result is oscillation (and lots of it) at the regulator output. For all application circuits where cold operation is necessary, the output capacitor must be rated to operate at the minimum temperature. By coincidence, worst-case stability for the PJ2931 also occurs at minimum temperatures. As a result, in applications where the regulator junction temperature will never be less than 25 $^{\circ}$ C, the output capacitor can be reduced approximately by a factor of two over the value needed for the entire temperature range. To continue our example with the tantalum electrolytic, a value of only 22 $\mu$ F would probably thus suffice. For high-quality aluminum, 47 $\mu$ F would be adequate in such an application.

Another regulator characteristic that is noteworthy is that stability decreases with higher output currents. This sensible fact has important connotations. In many applications, the PJ2931 is operated at only a few milliamps of output current or less. In such a circuit, the output capacitor can be further reduced in value. As a rough estimation, a circuit that is required to deliver a maximum of 10mA of output current from the regulator would need an output capacitor of only half the value compared to the same regulator required to deliver the full output current of 100mA. If the example of the tantalum capacitor in the circuit rated at 25 $^{\circ}$ C junction temperature and above were continued to include a maximum of 10 mA of output current, then the 22  $\mu$ F output capacitor could be reduced to only 10  $\mu$ F.

In the case of the PJ2931CS adjustable regulator in SOP-8 package, the minimum value of output capacitance is a function of the output voltage. As a general rule, the value decreases with higher output voltages, since internal loop gain is reduced.

At this point, the procedure for bench testing the minimum value of an output capacitor in a special application circuit should be clear. Since worst-case occurs at minimum operating temperatures and maximum operating currents, the entire circuit, including the electrolytic, should be cooled to the minimum temperature. The input voltage to the regulator should be maintained at 0.6V above the output to keep internal power dissipation and die heating to a minimum. Worst-case occurs just after input power is applied and before the die has had a chance to heat up. Once the minimum value of capacitance has been found for the brand and type of electrolytic in question, the value should be doubled for actual use to account for production variations both in the capacitor and the regulator. (All the values in this section and the remainder of the data sheet were determined in this fashion.)

### Definition of Terms

**Dropout Voltage:** The input-output voltage differential at which the circuit ceases to regulate against further reduction in input voltage. Measured when the output voltage has dropped 100 mV from the nominal value obtained at 14V input, dropout voltage is dependent upon load current and junction temperature.

**Input Voltage:** The DC voltage applied to the input terminals with respect to ground.

**Input-Output Differential:** The voltage difference between the unregulated input voltage and the regulated output voltage for which the regulator will operate.

**Line Regulation:** The change in output voltage for a change input voltage. The measurement is made under conditions of low dissipation or by using pulse techniques such that the average chip temperature is not significantly affected.

**Load Regulation:** The change in output voltage for a change in load current at constant chip temperature.

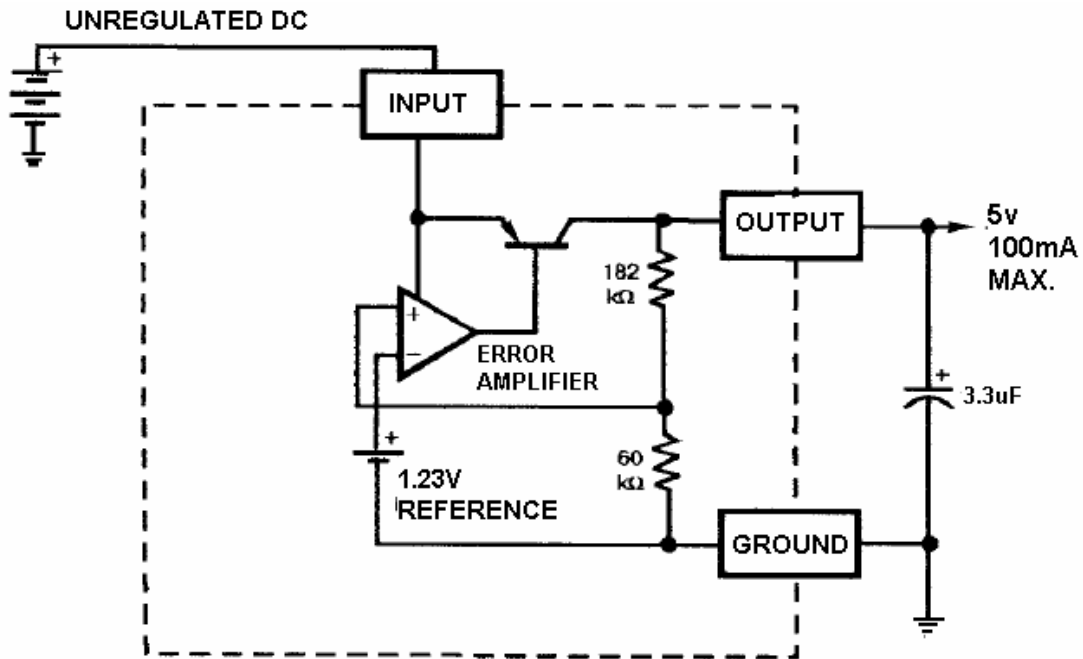
**Output Noise Voltage:** The rms AC voltage at the output, with constant load and no input ripple, measured over a specified frequency range.

**Quiescent Current:** That part of the positive input current that does not contribute to the positive load current. The regulator ground lead current.

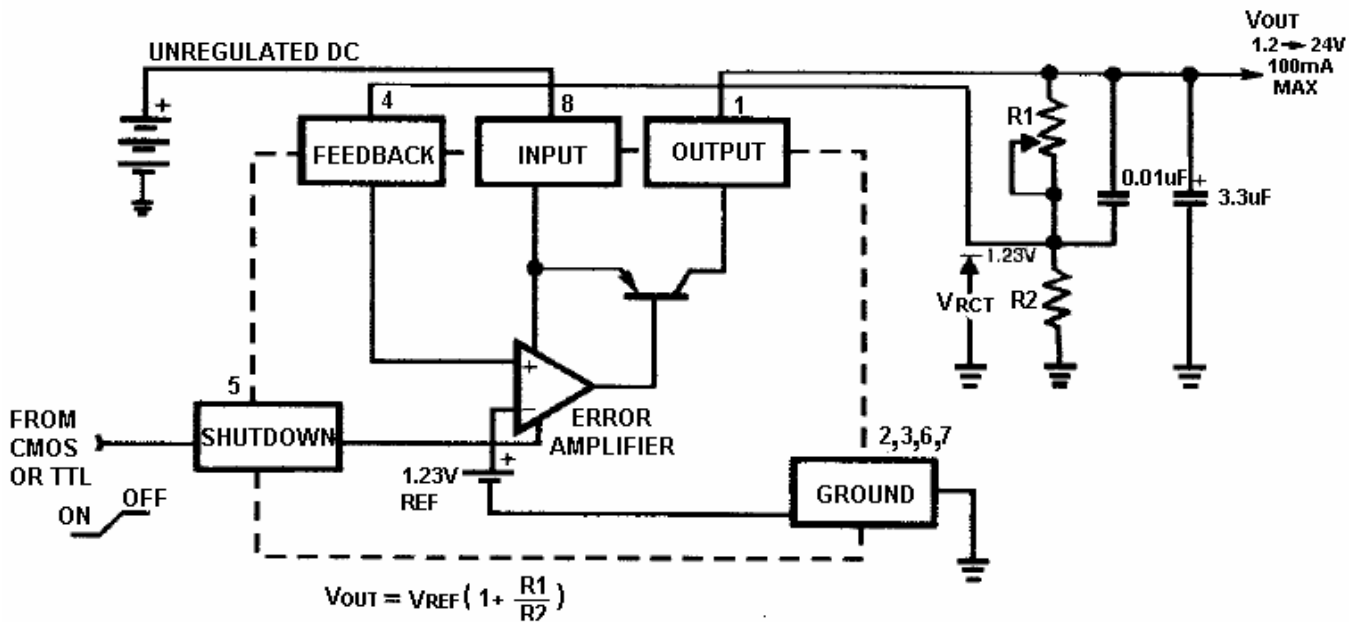
**Ripple Rejection:** The ratio of the peak-to-peak input ripple voltage to the peak-to-peak output ripple voltage.

**Temperature Stability of Output Voltage:** The percentage change in output voltage for a thermal variation from room temperature true to either temperature extreme.

BLOCK DIAGRAMS and TYPICAL APPLICATION

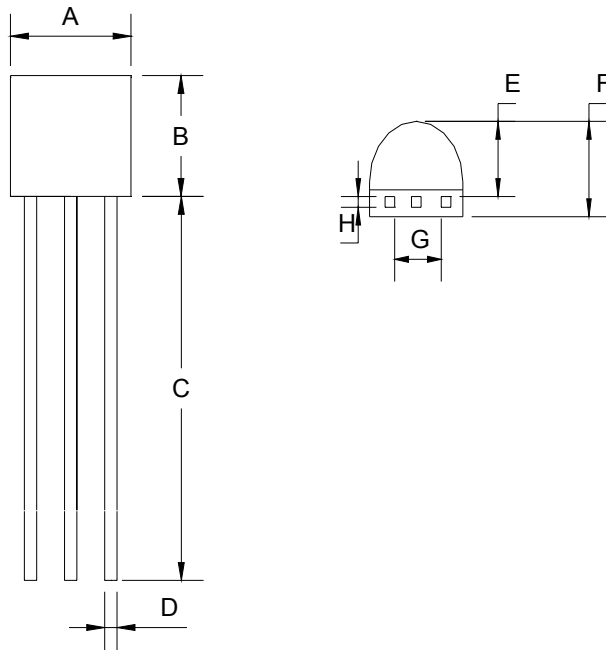


Fix Voltage Type Regulator

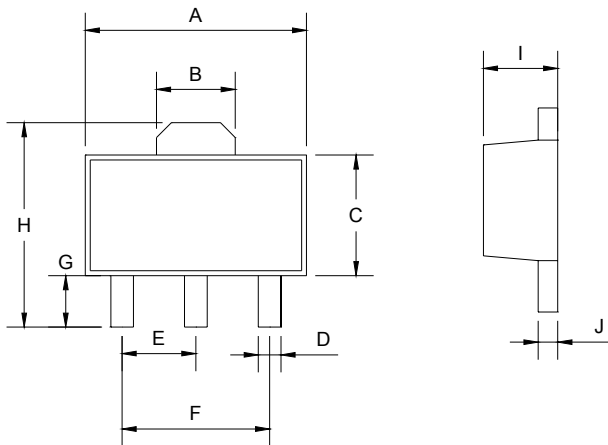


Adjustable Regulator

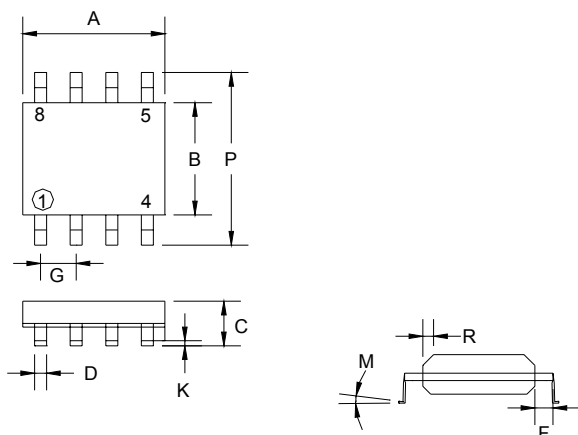
Ultra Low Dropout Voltator



TO-92 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.30	4.70	0.169	0.185
B	4.30	4.70	0.169	0.185
C	14.3	14.3	0.536	0.563
D	0.435	0.485	0.017	0.019
E	2.19	2.81	0.086	0.111
F	3.30	3.70	0.130	0.146
G	2.42	2.66	0.095	0.105
H	0.375	0.425	0.015	0.017



SOT-89 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.4	4.6	0.173	0.181
B	1.5	1.7	0.059	0.070
C	2.30	2.60	0.090	0.102
D	0.40	0.52	0.016	0.020
E	1.50	1.50	0.059	0.059
F	3.00	3.00	0.118	0.118
G	0.89	1.20	0.035	0.047
H	4.05	4.25	0.159	0.167
I	1.4	1.6	0.055	0.063
J	0.35	0.44	0.014	0.017



SOP-8 DIMENSION				
DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.196
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27BSC		0.05BSC	
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.229	0.244
R	0.25	0.50	0.010	0.019