GAMMA MICROELECTRONICS

GM2931

LOW DROPOUT POSITIVE VOLTAGE REGULATOR

Power Management

Description

The GM2931 positive low dropout voltage regulators are available in adjustable and fixed-output versions. The GM2931s have quiescent current of 1mA or less when supplying 10mA loads. Together with the extremely low dropout voltage required for proper regulation (0.2V for output currents of 10mA) these qualities make the GM2931 the ideal regulator for standby power systems. Applications include memory standby circuits, CMOS and other low power processor power supplies and any precision systems requiring up to 100mA of output current.

The GM2931 protects itself and the regulated circuitry from reverse battery installations or two-battery jumps up to 20V. During line transients, such as a load dump (60V) when the input voltage to the regulator might temporarily exceed the specified maximum operating voltage, the GM2931 automatically shuts down to protect both itself and the load. The GM2931 is not damaged by temporary mirror-image insertion. Of course, the GM2931 includes common regulator features such as short circuit and thermal overload protection.

Features

- **Output Current 100 mA**
- **Adjustable and fixed-output versions**
- **Ultra Low Quiescent Current - 100µA typical**
- **Very Low Dropout Voltage - 300mV typical**
- **Reverse Battery Protection**
- **60V Load Dump Protection**
- **-50V Reverse Transient Protection**
- **Short Circuit and Thermal Overload Protection**
- **Current Limiting protection**
- **Mirror-Image Insertion Protection**
- **TO-92, SOT-89, TO-252 and SOP-8 Packages**
- **Direct replacement for LM2931 but with lower ground current, higher output accuracy, tighter line and load regulation**

Application

High-efficiency linear regulator
Battery-powered systems
Portable/Palmtop/notebook computers
Portable consumer electronics
Portable instrumentation
SMPS post-regulators

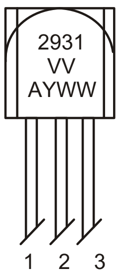
Revision 1, Jun. 2004

GM2931

PRELIMINARY

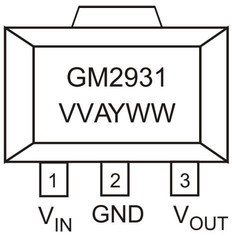
◆ MARKING INFORMATION & PIN CONFIGURATIONS (TOP VIEW)

TO-92

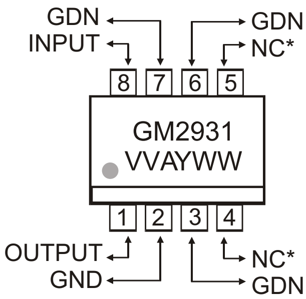


1. INPUT
2. GND
3. OUTPUT

SOT-89

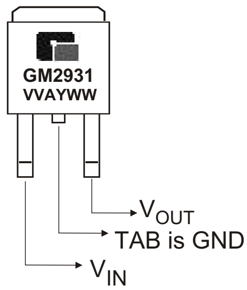


SOP-8 (SO-8)



NC* = Not internally connected.

TO-252-3 (DPAK)



V V =Output Voltage (5.0:5.0V)
A =Assembly Location
Y =Year
W W =Work Week

◆ ORDERING INFORMATION

Ordering Number	Output Voltage	Package	Shipping
GM2931			
GM2931-3.3T92B	3.3V	TO-92	1,000 Units/ ESD Bag
GM2931-3.3T92RL	3.3V	TO-92	2,000 Units/ Ammo Pack(Tape)
GM2931-3.3ST89R	3.3V	SOT-89	1,000 Units/ Tape & Reel
GM2931-3.3S8T	3.3V	SO-8	100 Units/ Tube
GM2931-3.3S8R	3.3V	SO-8	2,500 Units/ Tape &Reel
GM2931-3.3TC3T	3.3V	TO-252	80 Units/ Tube
GM2931-3.3TC3T	3.3V	TO-252	2,500 Units/ Tape & Reel
GM2931-5.0T92B	5.0V	TO-92	1,000 Units/ ESD Bag
GM2931-5.0T92RL	5.0V	TO-92	2,000 Units/ Ammo Pack(Tape)
GM2931-5.0ST89R	5.0V	SOT-89	1,000 Units/ Tape & Reel
GM2931-5.0S8T	5.0V	SO-8	100 Units/ Tube
GM2931-5.0S8R	5.0V	SO-8	2,500 Units/ Tape &Reel
GM2931-5.0TC3T	5.0V	TO-252	80 Units/ Tube
GM2931-5.0TC3T	5.0V	TO-252	2,500 Units/ Tape & Reel

umber identification, please see last page.

◆ ABSOLUTE MAXIMUM RATINGS *

PARAMETER	VALUE	UNIT
Input Voltage Range	-20 to +35	V
ESD Tolerance (Note 3)	2000	V
Operating Ambient Temperature Range	-55 to +150	°C
Storage Temperature Range	-65 to +150	°C
Lead Temperature (Soldering, 5 Seconds)	260	°C

* Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Electrical specifications do not apply when operating the device beyond its rated operating conditions.

(Note 1) See circuit in Typical Applications. To ensure constant junction temperature, low duty cycle pulse testing is used.

(Note 2) The maximum power dissipation is a function of maximum junction temperature T_{Jmax}, total thermal resistance R_{JA}, and ambient temperature T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{Jmax} - T_A)/ R_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the GM2931 will go into thermal shutdown. For the GM2931 in the TO-92 package, R_{JA} is 195°C/W; in the SOP-8 package, R_{JA} is 160°C/W.

(Note 3) Human body model, 100 pF discharged through 1.5 k .

ELECTRICAL CHARACTERISTICS GM2931-3.3

(V_{IN} = 14V, I_O = 100µA, T_J = 25°C , C_O = 100µF), unless otherwise noted

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage (fixed version)	-25°C ≤ T_J ≤ 85°C	3.25	3.30	3.35	V
	Full operating temperature	3.23	3.30	3.35	
	100µA ≤ I_L ≤ 100mA, T_J ≤ T_{JMAX}	3.21	3.30	3.39	
Output Voltage Temperature Coef.	(Note 1)	-	50	150	ppm/°C
Line Regulation (Note 2)	13V ≤ V_{IN} ≤26V (Note 3)	-	0.1	0.4	%
Load Regulation (Note 2)	1mA ≤ I_L ≤ 100mA	-	0.1	0.3	%
Dropout Voltage (Note 4)	I_L = 10mA	-	60	200	mV
	I_L = 100mA	-	300	600	
Ground Current (Note 5)	I_L = 100µA	-	100	150	µA
	I_L = 10mA	-	0.9	1.5	mA
	I_L = 100mA	-	8	12	
Dropout Ground Current (Note 5)	V_{IN} = V_{OUT} -50V, I_L = 100µA	-	110	170	µA
Current Limit	V_{OUT} = 0	-	160	200	mA
Thermal Regulation (Note 6)	-	-	0.05	0.2	%/W
Output Noise Voltage 10Hz- 100kHz, I_L = 10mA	C_L = 2.2µF	-	500	-	µVrms
	C_L = 3.3µF	-	350	-	
	C_L = 3.3µF	-	120	-	
Ripple Rejection Ratio	f = 120Hz, I_O = 10mA, C_O = 100µF, V_{IN} = V_O +3V+2Vpp	60	-	-	dB
Adjustable Versions					
Reference Voltage	-	1.21	1.235	1.26	V
	Over temperature (Note 7)	1.185	-	1.285	
Feedback Pin Bias Current	-	-	20	40	nA
Reference Voltage Temperature coef.	(Note 1)	-	50	-	ppm/°C
Feedback Pin Bias Current temp. Coef.	-	-	0.1	-	nA/°C
Shutdown Input					
Input Logic Voltage Current	Low (Regulator ON)	-	1.3	0.7	V
	High (Regulator OFF)	2	-	-	
Shutdown pin Input Current	V_S = 2.4V	-	30	50	µA
	V_S = 26V	-	450	600	
Regulator Output Current Shutdown (Note 8)	5V ≤ V_{OUT} ≤ 15V	-	-	10	µA
	3.3V ≤ V_{OUT} ≤ 5V	-	-	20	
	2V ≤ V_{OUT} ≤ 3.3V	-	-	30	

(Note 1) Output or reference voltage temperature coefficients defined as worst case voltage change divided by total temperature range.

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

(Note 3) Line regulation is tested at 150°C for I_L=1mA. For I_L=100µA and T_J=125°C, line regulation is guaranteed by design to 0.2%.

(Note 4) Dropout voltage is defined as the input to output differential at which the output voltage drops 2% below its 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 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} ≤ V_{OUT} ≤ (V_{IN} - 1V), 2.3V ≤ V_{IN} ≤ 26V, 100µA ≤ I_L ≤ 100mA, T_J ≤ $T_{J\,MAX}$.

V_{IN} ≤ 26V, V_{OUT} = 0V

◆ ELECTRICAL CHARACTERISTICS GM2931-5.0

(V_{IN} = 14V, I_O = 100µA, T_J = 25°C , C_O = 100µF), unless otherwise noted

Parameter	Conditions	Min	Typ	Max	Unit
Output Voltage (fixed version)	-25°C ≤ T_J ≤ 85°C	4.90	5.00	5.10	V
	Full operating temperature	4.75	5.00	5.25	
	100µA ≤ I_L ≤ 100mA, T_J ≤ T_{JMAX}	4.50	5.00	5.50	
Output Voltage Temperature Coef.	(Note 1)	-	50	150	ppm/°C
Line Regulation (Note 2)	13V ≤ V_{IN} ≤ 26V (Note 3)	-	0.1	0.4	%
Load Regulation (Note 2)	1mA ≤ I_L ≤ 100mA	-	0.1	0.3	%
Dropout Voltage (Note 4)	I_L = 10mA	-	60	200	mV
	I_L = 100mA	-	300	600	
Ground Current (Note 5)	I_L = 100µA	-	100	150	µA
	I_L = 10mA	-	0.9	1.5	mA
	I_L = 100mA	-	8	12	
Dropout Ground Current (Note 5)	V_{IN} = V_{OUT} -50V, I_L = 100µA	-	110	170	µA
Current Limit	V_{OUT} = 0	-	160	200	mA
Thermal Regulation (Note 6)	-	-	0.05	0.2	%/W
Output Noise Voltage 10Hz- 100kHz, I_L = 10mA	C_L = 2.2µF	-	500	-	µVrms
	C_L = 3.3µF	-	350	-	
	C_L = 3.3µF	-	120	-	
Ripple Rejection Ratio	f = 120Hz, I_O = 10mA, C_O = 100µF, V_{IN} = V_O +3V+2Vpp	60	-	-	dB
Adjustable Versions					
Reference Voltage	-	1.21	1.235	1.26	V
	Over temperature (Note 7)	1.185	-	1.285	
Feedback Pin Bias Current	-	-	20	40	nA
Reference Voltage Temperature coef.	(Note 1)	-	50	-	ppm/°C
Feedback Pin Bias Current temp. Coef.	-	-	0.1	-	nA/°C
Shutdown Input					
Input Logic Voltage Current	Low (Regulator ON)	-	1.3	0.7	V
	High (Regulator OFF)	2	-	-	
Shutdown pin Input Current	V_S = 2.4V	-	30	50	µA
	V_S = 26V	-	450	600	
Regulator Output Current Shutdown (Note 8)	5V ≤ V_{OUT} ≤ 15V	-	-	10	µA
	3.3V ≤ V_{OUT} ≤ 5V	-	-	20	
	2V ≤ V_{OUT} ≤ 3.3V	-	-	30	

(Note 1) Output or reference voltage temperature coefficients defined as worst case voltage change divided by total temperature range.

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

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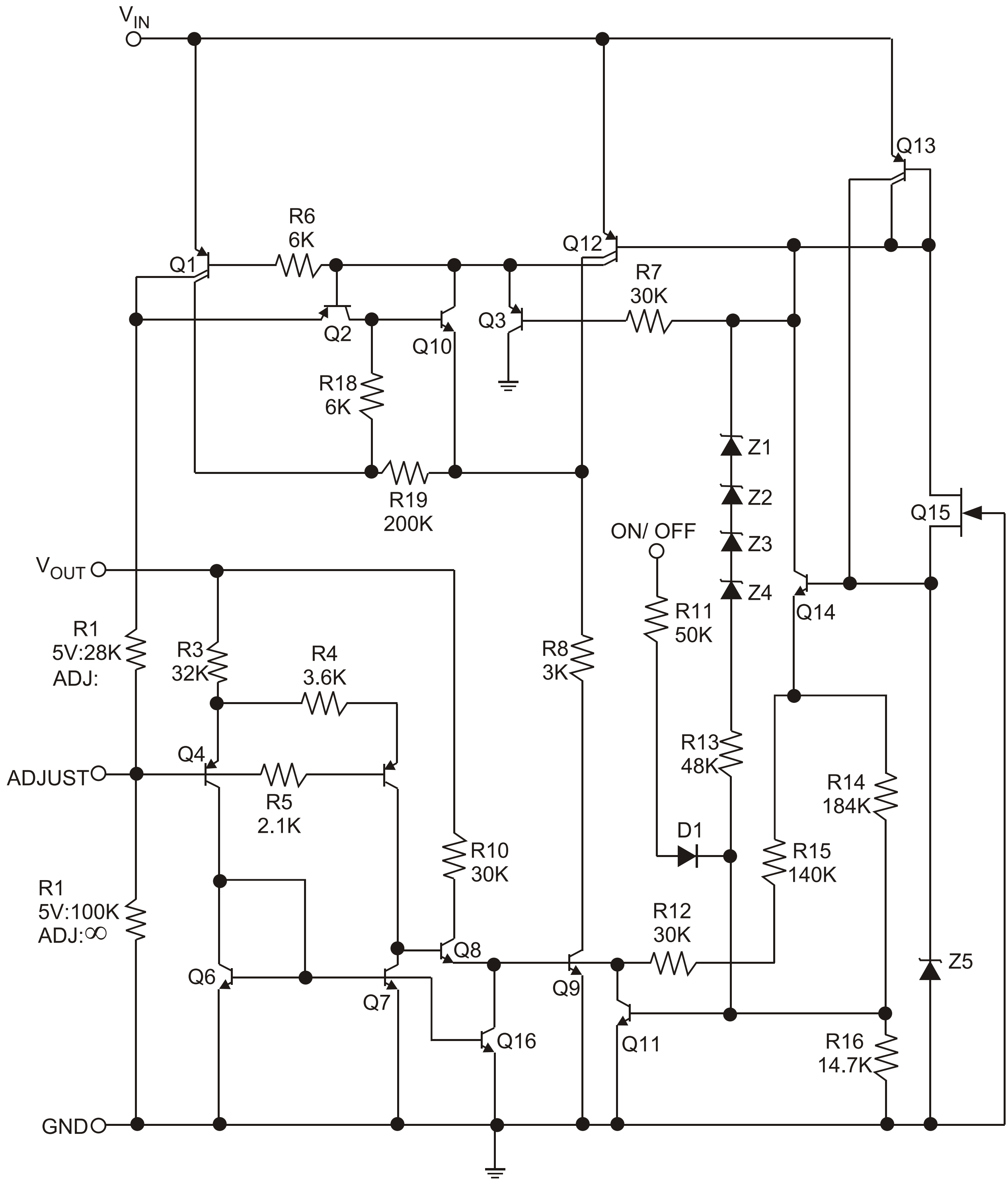
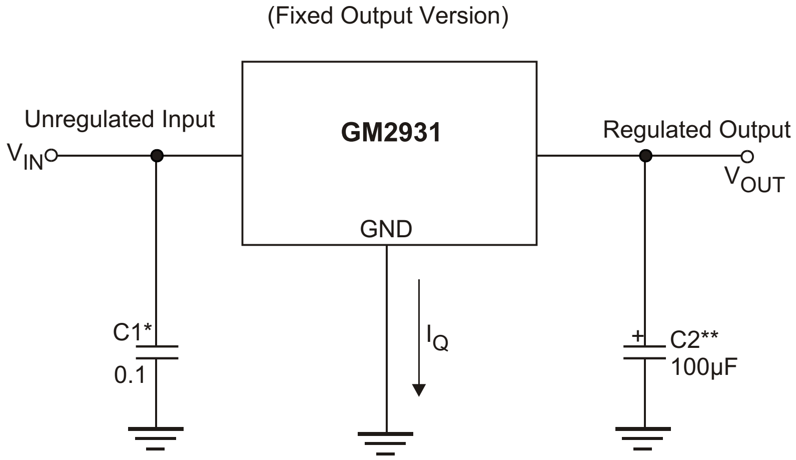
(Note 7) V_{REF} ≤ V_{OUT} ≤ (V_{IN} - 1V), 2.3V ≤ V_{IN} ≤ 26V, 100µA ≤ I_L ≤ 100mA, T_J ≤ $T_{J\,MAX}$.

(N ... V, V_{OUT} = 0

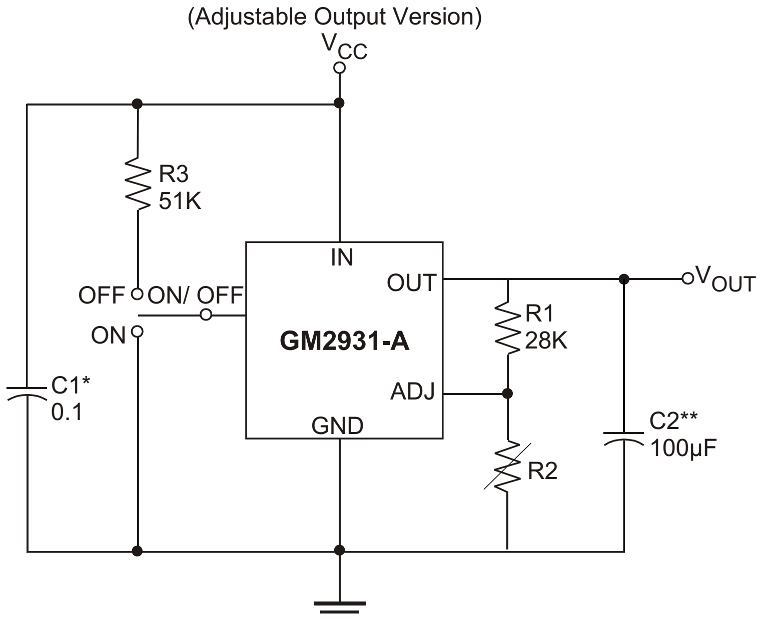
◆ SCHEMATIC BLOCK DIAGRAM



◆ TYPICAL APPLICATION CIRCUITS



* Required if regulator is located far from power supply filter.
** C2 must be at least 100 µF to maintain stability. May be increased without bound to maintain regulation during transients. Locate as close as possible to the regulator. This capacitor must be rated over the same operating temperature range as the regulator. The equivalent series resistance (ESR) of this capacitor is critical; see curve.



$$V_{OUT} = \text{Reference Voltage X } \frac{R1 + R2}{R1}$$

Note: Using 27k for R1 will automatically compensate for errors in V_{OUT} due to the input bias current of the ADJ pin (approximately 1µA).

◆ APPLICATION INFORMATION

The GM2931, as all LDO regulators, requires an output capacitor for stability. The required capacitor value varies greatly depending upon the application circuit and other factors. 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 GM2931 may vary depending on the manufacturer of the capacitor. Real bench testing is the only real to determine the proper capacitor type and value for your application. In general, the better quality of the capacitor (i.e. fancier and more expensive!), the lower the capacitance value required to do the job.

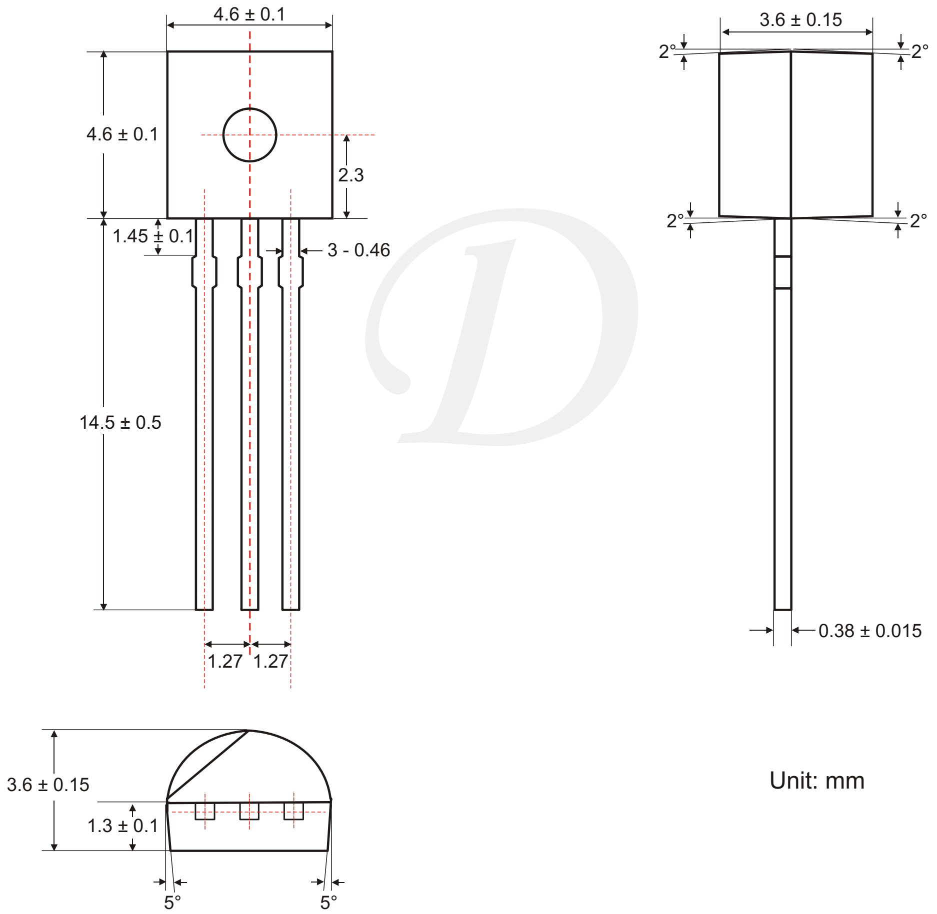
As an example, while a high-quality 100 μF aluminum electrolytic covers all general application circuits, you can get similar results with a 47μF tantalum capacitor. This factor of two can generally be applied to any special application circuit also. Another significant charateristic of electrolytics is their performance over temperature. While the GM2931 is designed to operate to -40°C, the electrolyte in many aluminum types will freeze around -30°C, reducing their effective value to zero. Since the capacitance is needed for regulator stability, the natural result is oscillation 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. Coincidentally, the worst-case stability for the GM2931 also occurs at minimum temperatures. As a result, in applications where the regulator junction temperature will never be less than 25°C, the output capacitor can be reduced approximately by a factor of two over the value needed for the entire temperature range. In this case, a tantalum of only 22μF would probably work OK, where a high-quality aluminum of 47μF would provide similar results in such an application.

Another noteworty characteristic of the GM2931 and regulators in general is that stability decreases with higher output currents. This sensible fact has important implications. In many applications, the GM2931 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. Roughly speaking, 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°C junction temperature and above were continued to include a maximum of 10mA of output current, then the 22μF output capacitor could be reduced to only 10μF.

In the case of the GM2931 adjustable regulator, the minimum value of output capacitance is a function of the output voltage. Generally, the required capacitance value decreases with higher output voltages, since internal loop gain is reduced.

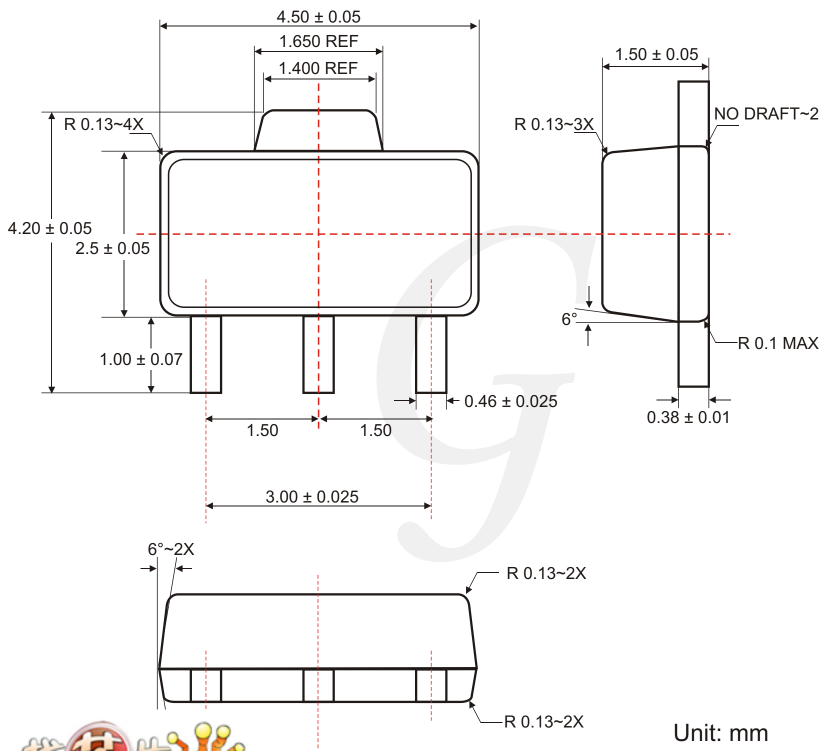
By now you should have a good idea of how to proceed with bench testing for your application to determine the minimum capacitance value to optimize your circuit., Since worst-case occurs at minimum operating temperatures and maximum operating currents, the entire circuit, including the electrolytic, 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 this way).

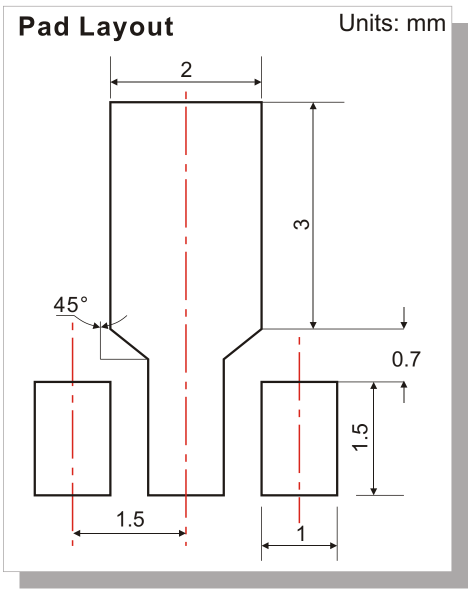
TO-92 PACKAGE OUTLINE DIMENSIONS



Unit: mm

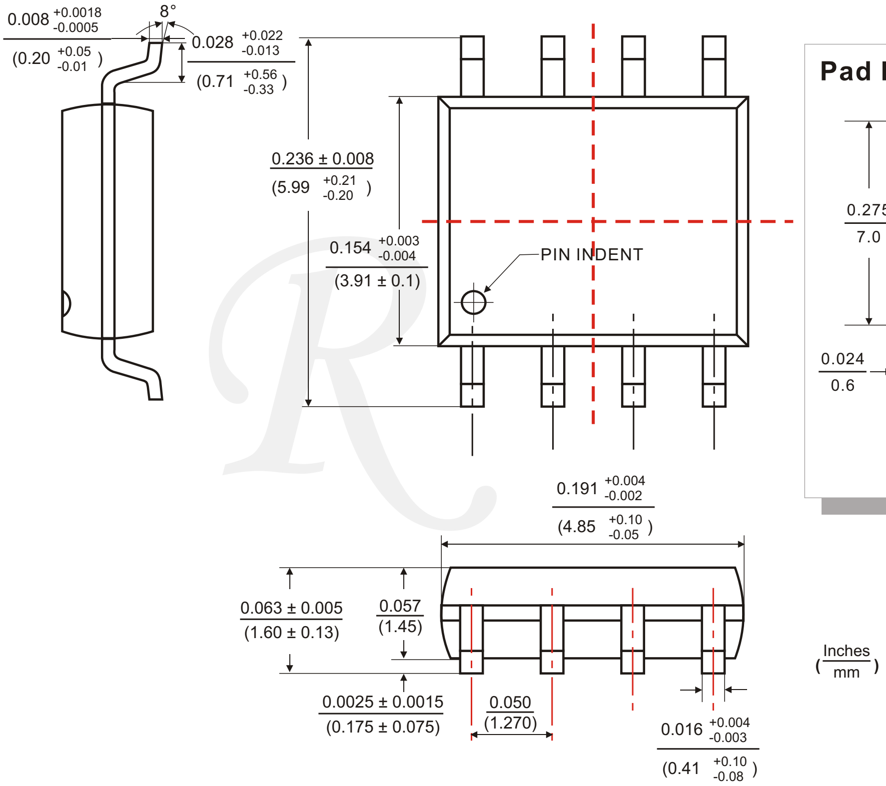
SOT-89 PACKAGE OUTLINE DIMENSIONS

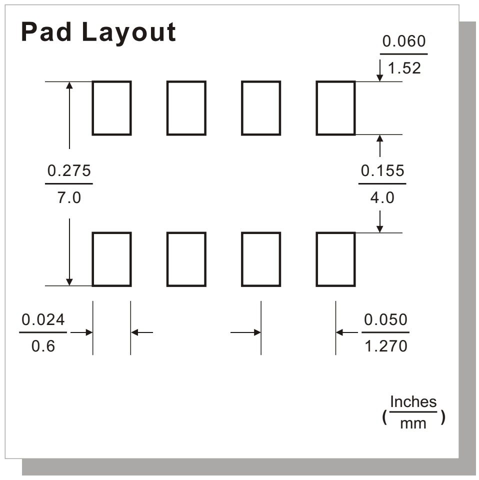




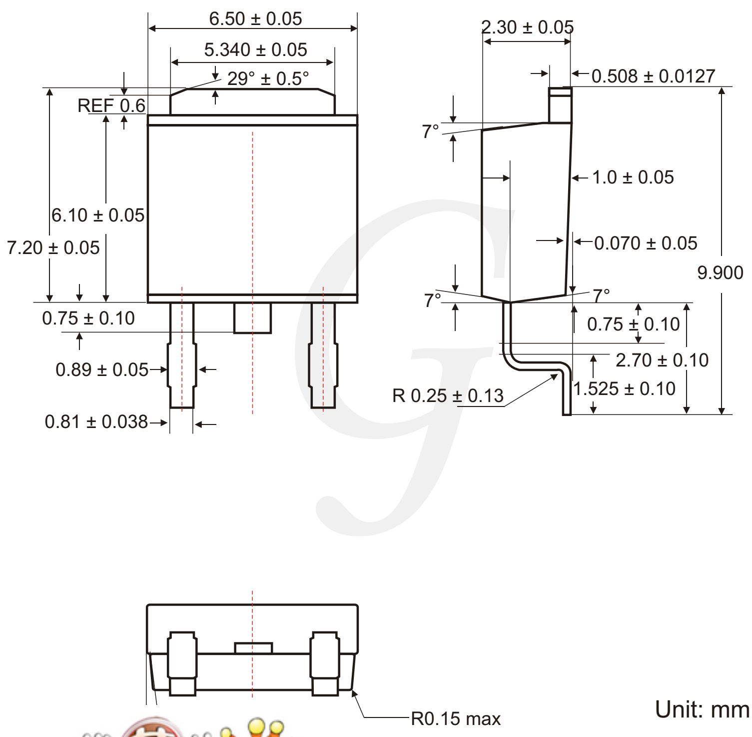
Unit: mm

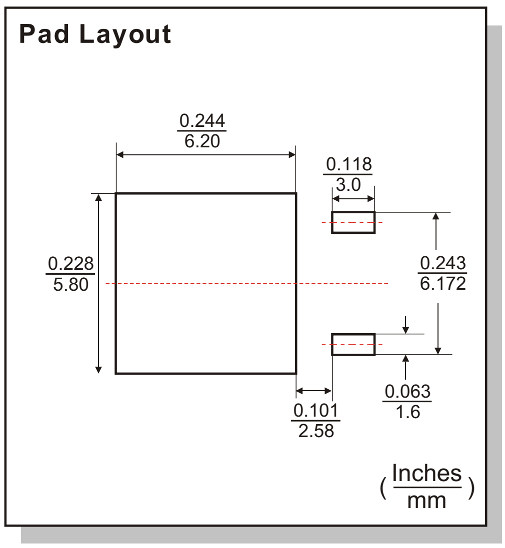
◆ SOP-8(SO-8) PACKAGE OUTLINE DIMENSIONS





◆ TO-252-2 PACKAGE OUTLINE DIMENSIONS





Unit: mm

◆ ORDERING NUMBER