

# ADJUSTABLE PRECISION ZENER SHUNT REGULATOR

## ZR2431

ISSUE 3 DECEMBER 1997

### DEVICE DESCRIPTION

The ZR2431 is a three terminal adjustable shunt regulator offering excellent temperature stability and output current handling capability up to 25mA. The output voltage may be set to any chosen voltage between 1.24 and 15 volts by selection of two external divider resistors.

The devices can be used as a replacement for zener diodes in many applications requiring an improvement in zener performance.

The ZR2431 is particularly used in the feedback control loop of switch mode power supplies. In this application the device 1.24 volt reference enables the generation of low voltage supplies, typically 3.3 volts or 3 volts.

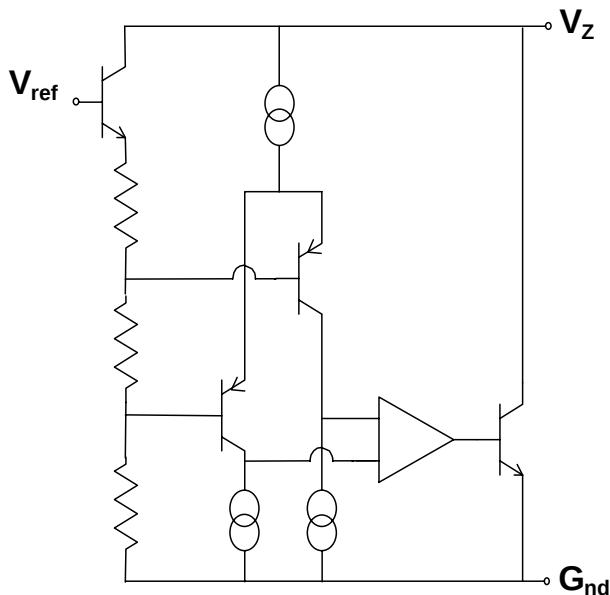
### FEATURES

- Surface mount SOT23, SOT223, SOT89 and SO8 packages
- TO92 package
- 2.5% and 1% tolerance
- Maximum temperature coefficient 52 ppm/°C
- Temperature compensated for operation over the full temperature range
- Programmable output voltage
- 100μA to 25mA current sink capability
- Low output noise

### APPLICATIONS

- Shunt regulator
- Series regulator
- Voltage monitor
- Over voltage/ under voltage protection
- Switch mode power supplies

### SCHEMATIC DIAGRAM



## ABSOLUTE MAXIMUM RATING

|                                   |              |
|-----------------------------------|--------------|
| Cathode Voltage (V <sub>Z</sub> ) | 15V          |
| Cathode Current                   | 50mA         |
| Operating Temperature             | -40 to 85°C  |
| Storage Temperature               | -55 to 125°C |

## Recommended Operating Conditions

|                 | Min              | Max  |
|-----------------|------------------|------|
| Cathode Voltage | V <sub>REF</sub> | 15V  |
| Cathode Current | 100μA            | 25mA |

## Power Dissipation (T<sub>amb</sub>=25°C, T<sub>jmax</sub>=150°C)

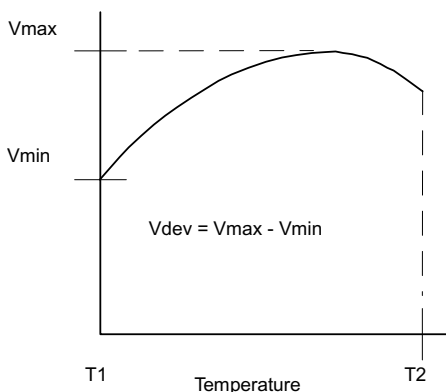
|        |       |
|--------|-------|
| SOT23  | 330mW |
| SOT223 | 2W    |
| SO8    | 780mW |
| TO92   | 780mW |
| SOT89  | 1.5W  |

## ELECTRICAL CHARACTERISTICS

### TEST CONDITIONS (Unless otherwise stated): T<sub>amb</sub>=25°C

| PARAMETER                                                                 | SYMBOL                              | VALUE |      |       | UNITS | CONDITIONS                                                                                  |
|---------------------------------------------------------------------------|-------------------------------------|-------|------|-------|-------|---------------------------------------------------------------------------------------------|
|                                                                           |                                     | MIN   | TYP  | MAX   |       |                                                                                             |
| Reference Voltage                                                         | V <sub>ref</sub>                    | 1.209 | 1.24 | 1.271 | V     | I <sub>L</sub> =10mA (Fig1), V <sub>Z</sub> =V <sub>ref</sub>                               |
|                                                                           |                                     | 1.228 | 1.24 | 1.252 |       |                                                                                             |
| Deviation of Reference Input Voltage over Temperature                     | V <sub>dev</sub>                    |       | 4.0  | 8.0   | mV    | I <sub>L</sub> =10mA, V <sub>Z</sub> =V <sub>ref</sub><br>T <sub>a</sub> =full range (Fig1) |
| Ratio of the change in Reference Voltage to the Change in Cathode Voltage | $\frac{\Delta V_{ref}}{\Delta V_Z}$ |       | 0.5  | 2.0   | mV/V  | V <sub>Z</sub> from V <sub>ref</sub> to 10V<br>I <sub>Z</sub> =10mA (Fig2)                  |
| Reference Input Current                                                   | I <sub>ref</sub>                    | 0.02  | 0.11 | 0.4   | μA    | R1=10k, R2=O/C, I <sub>L</sub> =10mA (Fig2)                                                 |
| Deviation of Reference Input Current over Temperature                     | ΔI <sub>ref</sub>                   |       | 0.02 | 0.2   | μA    | R1=10k, R2=O/C, I <sub>L</sub> =10mA<br>T <sub>a</sub> =full range (Fig2)                   |
| Minimum Cathode Current for Regulation                                    | I <sub>Zmin</sub>                   |       | 30   | 100   | μA    | †                                                                                           |
| Off-state Current                                                         | I <sub>Zoff</sub>                   |       | 10   | 30    | μA    | V <sub>Z</sub> =15V, V <sub>ref</sub> =0V (Fig3)                                            |
| Dynamic Output Impedance                                                  | R <sub>Z</sub>                      |       | 0.25 | 2     | Ω     | V <sub>Z</sub> =V <sub>ref</sub> (Fig1), f=0Hz, I <sub>L</sub> =10mA                        |

Deviation of reference input voltage, V<sub>dev</sub>, is defined as the maximum variation of the reference input voltage over the full temperature range.



The average temperature coefficient of the reference input voltage, V<sub>ref</sub> is defined as:

$$V_{ref} (ppm/^{\circ}C) = \frac{V_{dev} \times 1000000}{V_{ref} (T_1 - T_2)}$$

The dynamic output impedance, R<sub>Z</sub>, is defined as:

$$R_Z = \frac{\Delta V_Z}{\Delta I_Z}$$

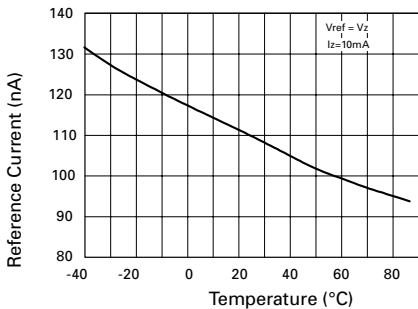
When the device is programmed with two external resistors, R1 and R2, (fig 2), the dynamic output impedance of the overall circuit, R', is defined as:

$$R' = R_Z \left( 1 + \frac{R_1}{R_2} \right)$$

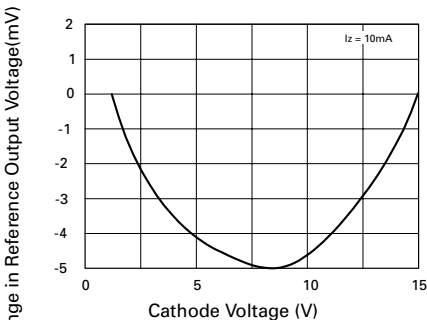
† With a capacitance of greater than 100pF between cathode and anode, minimum cathode current must be 0.2mA.

**ZR2431**

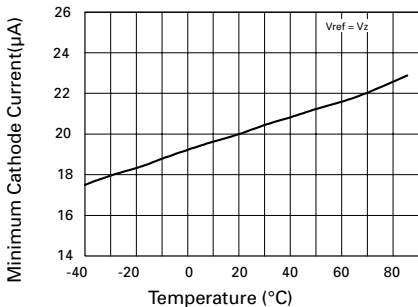
**TYPICAL CHARACTERISTICS**



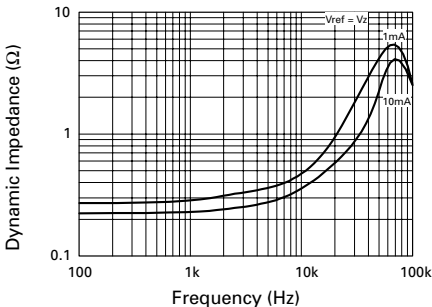
**Reference Current v Temperature**



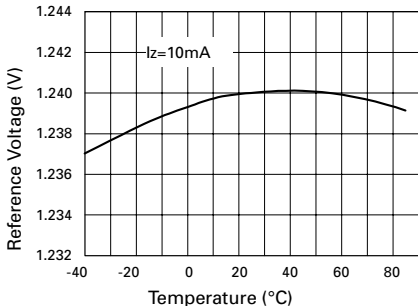
**Change in  $V_{ref}$  v Cathode Voltage**



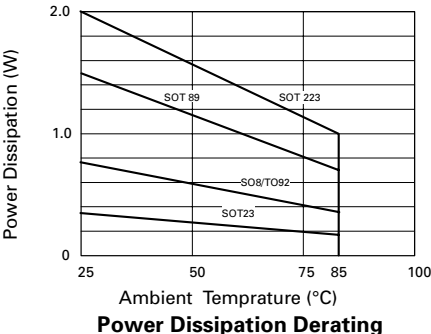
**Cathode Current v Temperature**



**Dynamic Impedance v Frequency**

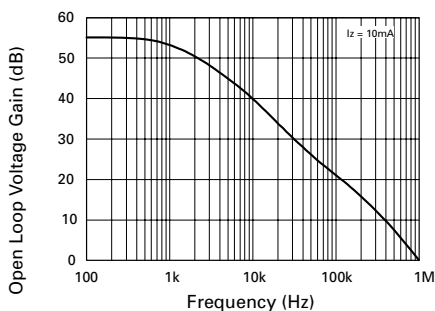


**Reference Voltage v Temperature**

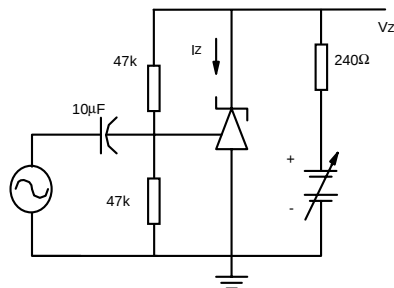


**Power Dissipation Derating**

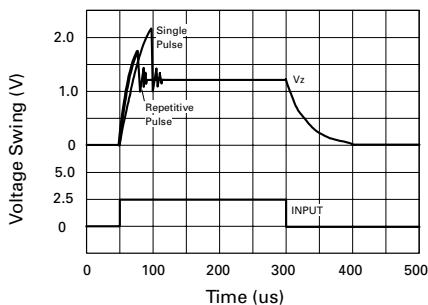
## TYPICAL CHARACTERISTICS



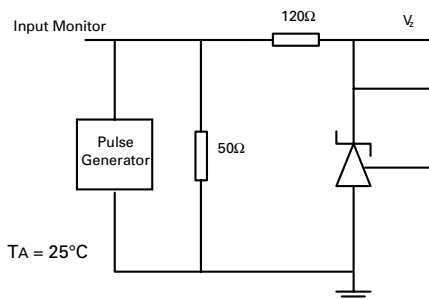
**Gain v Frequency**



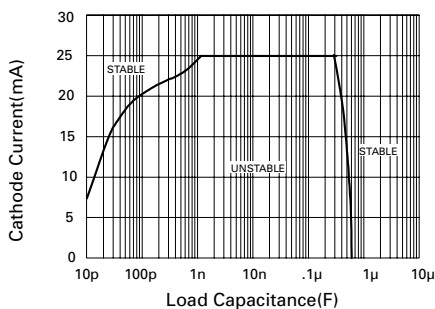
**Test Circuit for Open Loop Voltage Gain**



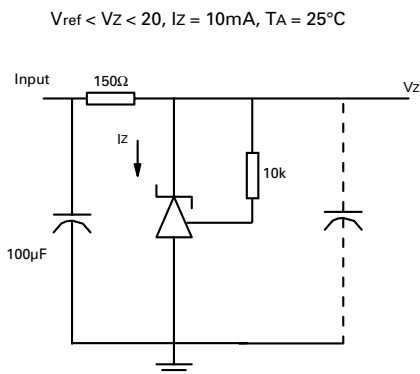
**Pulse Response**



**Test Circuit for Pulse Response**



**Stability Boundary Conditions**



**Test Circuit for Stability Boundary Conditions**

# ZR2431

## DC TEST CIRCUITS

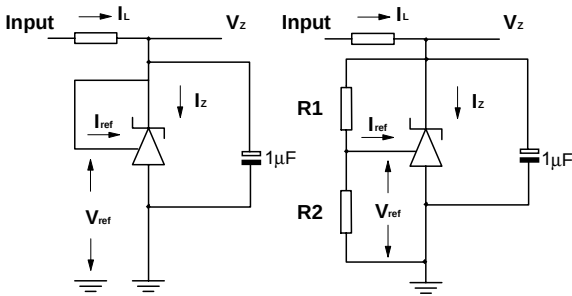


Fig 1 – Test Circuit for  $V_z = V_{ref}$  Fig 2 – Test Circuit for  $V_z > V_{ref}$

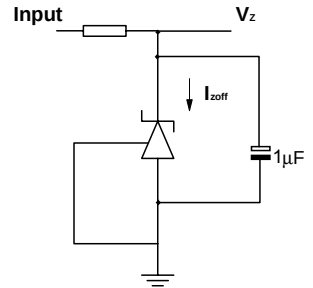
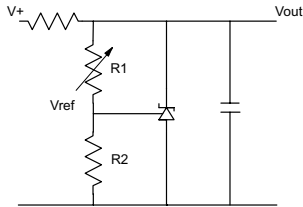


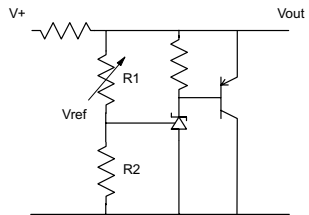
Fig 3 – Test Circuit for Off State current

## APPLICATION CIRCUITS



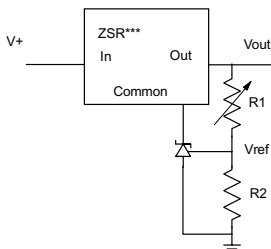
$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

SHUNT REGULATOR



$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

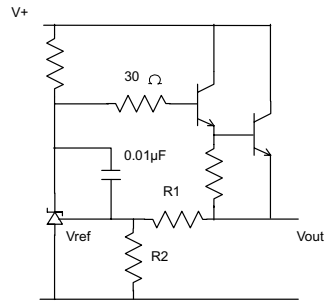
HIGHER CURRENT SHUNT REGULATOR



$$V_{out\_MIN} = V_{ref} + V_{reg}$$

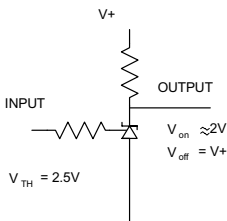
$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

OUTPUT CONTROL OF A THREE TERMINAL FIXED REGULATOR

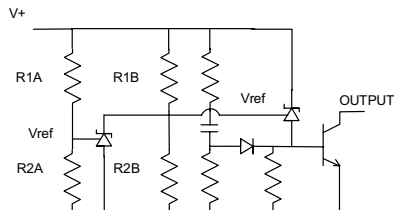


$$V_{out} = \left(1 + \frac{R1}{R2}\right) V_{ref}$$

SERIES REGULATOR



SINGLE SUPPLY COMPARATOR  
WITH TEMPERATURE  
COMPENSATED THRESHOLD



$$\text{Low limit} = \left(1 + \frac{R1B}{R2B}\right) V_{ref}$$

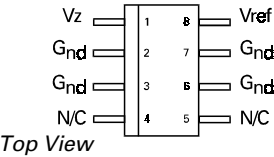
$$\text{High limit} = \left(1 + \frac{R1A}{R2A}\right) V_{ref}$$

OVER VOLTAGE / UNDER VOLTAGE  
PROTECTION CIRCUIT

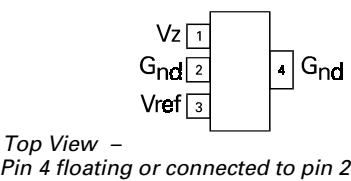
# ZR2431

## CONNECTION DIAGRAMS

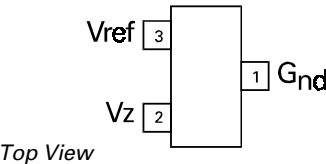
### SO8 Package Suffix – N8



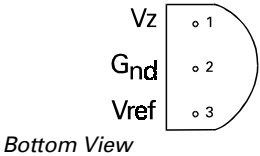
### SOT223 Package Suffix – G



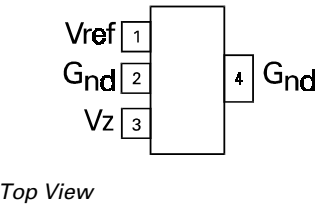
### SOT23 Package Suffix – F



### TO92 Package Suffix – C



### SOT89 Package Suffix – Z



## ORDERING INFORMATION

| Part Number | Package | Tol % | Part Mark |
|-------------|---------|-------|-----------|
| ZR2431N802  | SO8     | 2.5   | ZR243102  |
| ZR2431N801  | SO8     | 1     | ZR243101  |
| ZR2431G02   | SOT223  | 2.5   | ZR243102  |
| ZR2431G01   | SOT223  | 1     | ZR243101  |
| ZR2431F02   | SOT23   | 2.5   | 24D       |
| ZR2431F01   | SOT23   | 1     | 24E       |
| ZR2431Z02   | SOT89   | 2.5   | 24D       |
| ZR2431Z01   | SOT89   | 1     | 24E       |
| ZR2431C02   | TO92    | 2.5   | ZR243102  |
| ZR2431C01   | TO92    | 1     | ZR243101  |