US431ALCL

UNiSEM

US431L/431AL

LOW -VOLTAGE ADJUSTABLE PRECISION SHUNT REGULATOR

PRELIMINARY DATASHEET

FEATURES

- **SOT23-5 package**
- **0.5% Voltage Reference Initial Accuracy (US431AL)**
- **Low Operational Cathode Current (80 uA max)**
- **Unconditionally Stable with only 1uF**
- Adjustable Output from 1.24V to 6V
- 0.25Ω Typical Output Impedance
- Pin to Pin Compatible with TLV431

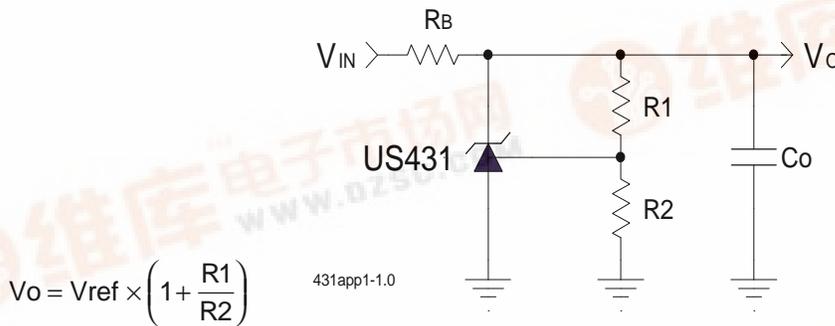## APPLICATIONS

- Precision Voltage Reference
- Linear Regulator Controller
- Secondary Side Controller for the Low Voltage Power Supply Applications

DESCRIPTION

The US431L product is a 3 terminal adjustable shunt regulator that can also be used as a precision voltage reference. Its output voltage may be set to any value between Vref(1.24V) and 6V with two external resistors as shown in the typical application circuit. Other applications of this device include the use as a merged amplifier and reference in applications such as Linear regulator or as the secondary side controller in low voltage power supply applications. The US431L only requires 80uA maximum quiescent current before regulating, making it ideal as a voltage reference for battery type applications.

TYPICAL APPLICATION

$$Vo = Vref \times \left(1 + \frac{R1}{R2}\right)$$

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Typical application of the US431L as a shunt regulator / voltage reference.

PACKAGE ORDER INFORMATION

Ta (°C)	5 LEAD SOT23-5	3 PIN PLASTIC TO-92	8 PIN PLASTIC SOIC
0 TO 70	US431LCL	US431LCZ	US431LCS
0 TO 70	US431ALCL	US431ALCZ	US431ALCS

Rev. 1.2
5/11/98

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ABSOLUTE MAXIMUM RATINGS

Input Voltage (Vin) 7V
Continuous Cathode Current Range .... -20 mA to +20 mA
Reference Current Range .... -0.05 mA to 3 mA
Storage Temperature Range ....   -65°C TO 150°C
Operating Junction Temperature Range .... 0°C TO 150°C

PACKAGE   INFORMATION

5 PIN SOT 23 (L)	3 PIN PLASTIC TO-92 (Z)	8 PIN PLASTIC SOIC (S)
TOP VIEW	BOTTOM VIEW	TOP VIEW
NC 1 5 Anode NC 2 Cathode 3 4 Ref	● 1 Ref ● 2 Anode ● 3 Cathode	Cathode 1 8 Ref NC 2 7 NC Anode 3 6 Anode NC 4 5 NC
$\theta_{JA} = 450°C/W$	$\theta_{JA} = 162°C/W$	$\theta_{JA} = 160°C/W$

ELECTRICAL SPECIFICATIONS

Unless otherwise specified ,these specifications apply over Ta=0 to 70 °C, C_o =1uF. Typical values refer to Ta=25 °C.Low duty cycle pulse testing are used which keeps junction and case temperatures equal to the ambient temperature.

PARAMETER	SYM	TEST CONDITION	MIN	TYP	MAX	UNITS
Reference Voltage US431L	Vref	I_K=10mA,V_{KA}=Vref,Ta=25°C I_K=10mA,V_{KA}=Vref	1.228 1.221	1.240 1.240	1.252 1.259	V
Reference Voltage US431AL	Vref	I_K=10mA,V_{KA}=Vref,Ta=25°C I_K=10mA,V_{KA}=Vref	1.234 1.228	1.240 1.240	1.246 1.252	V
Vref deviation over full temperature range	Vref(dev)	V_{KA}=Vref, I_K=10mA Note 1		4	12	mV
Ratio of Vref change to Cathode voltage change	dVref/dV$_{KA}$	I_K=10mA , dV_{KA}=Vref to 6 V		-1.5	-2.7	mV/V
Reference pin current		I_K=10mA , R1=10kΩ , R2=open		0.15	0.5	uA
Iref deviation over full temperature range	Iref(dev)	I_K=10mA , R1=10kΩ , R2=open Note 1		0.05	0.3	uA
Minimum cathode current	I_K(min)	V_{KA}=Vref		55	80	uA
Off state cathode current	Ioff	V_{KA}=6V , Vref=0V		0.001	0.1	uA
Dynamic impedance	Zka0	V_{KA}=Vref, f<1 kHz, I_K=0.1 to 15 mA , Note 2		0.25	0.4	Ω

Note 1 : The deviation parameters, Vref(dev) and Iref(dev) are defined as the differences between the maximum and the minimum values obtained over the rated temperature range. The average full range temperature coeficient of the reference input voltage is defined as :

$$|\alpha Vref| = \frac{\left(\frac{Vref(dev)}{Vref(25°C)}\right) \times 10^6}{\Delta T_A}$$

Where:

$|\alpha Vref|$ unit is ppm/°C

ΔT_A is the rated operating free air temperature of the device.

αVref can be positive or negative depending on whether minimum Vref or maximum Vref, respectively occurs at the lower temperature.

Note 2 :

Thedynamic impedance when VKA = Vref is defined as :

$$|Zka0| = \frac{\Delta VKA}{\Delta IK}$$

When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

$$|Zka| = \frac{\Delta V}{\Delta I} = |Zka0| \times \left(1 + \frac{R1}{R2}\right)$$

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Pin Descriptions

| SOT 23	TO 92	8 PIN SOIC		
PIN#	PIN#	PIN#	PIN SYMBOL	Pin Description
4	1	8	Ref	A resistor divider from this pin to the Cathode pin and ground sets the output voltage.
3	3	1	Cathode	The output of the shunt regulator .A minimum of 1uF capacitor must be connected from this pin to Anode pin to insure unconditional stability.
5	2	3,6	Anode	Ground pin. This pin must be connected to the lowest potential in the system & all other pins must be at higher potential with respect to this pin.
1,2	NA	2,4,5,7	NC	These pins are not connected internally.

BLOCK DIAGRAM

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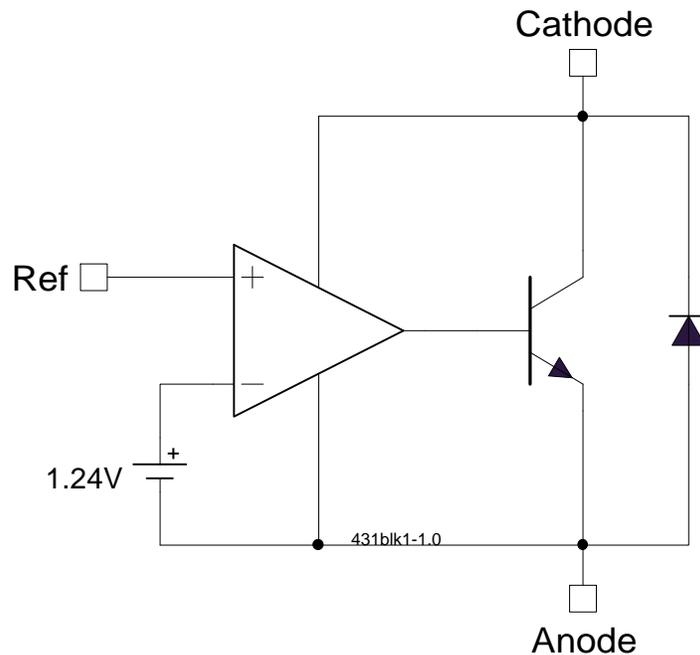
Figure 1 - Simplified block diagram of the US431L

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APPLICATION INFORMATION

Output Voltage Setting

The US431L can be programmed to any voltages in the range of 1.24 to 6V with the addition of R1 and R2 external resistors according to the following formula:

$$Vo = V_{KA} = Vref \times \left(1 + \frac{R1}{R2}\right) + Iref \times R1$$

The US431L keeps a constant voltage of 1.240V between the Ref pin and ground pin. By placing a resistor R2 across these two pins a constant current flows through R2, adding to the Iref current and into the R1 resistor producing a voltage equal to the (1.240/R2)*R1 + Iref * R1 which will be added to the 1.240V to set the output voltage as shown in the above equation. Since the Input bias current of the Ref pin is 0.5 uA max , it adds a very small error to the output voltage and for most applications can be ignored . For example, in a typical 5V to 3.3V application where R2=1.21kΩ and R1=2kΩ the error due to the Iadj is only 1mV which is about 0.03% of the nominal set point.
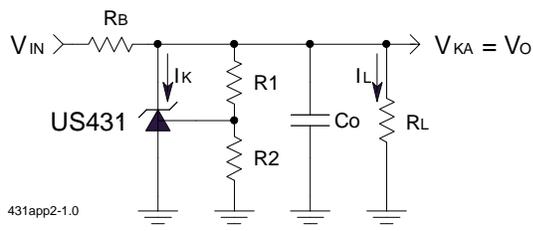

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Figure 2 - Typical application of the US431L for programming the output voltage.

Biasing Resistor (R$_B$) Selection

The biasing resistor R$_B$ is selected such that it does not limit the input current under the minimum input supply and maximum load and biasing current.
An example is given below on how to properly select the biasing resistor.
Assuming :
V$_{MIN}$ = 4.5 V
V$_{MAX}$ = 6 V
V$_{KA}$ = 3.3 V
I$_L$ = 10 mA

The maximum value for the biasing resistor is calculated using the following equations :

$$R_{BMAX} = \frac{V_{MIN} - V_{KA}}{I_{B\,MAX} + I_{LMAX}}$$

$$I_{BMAX} = I_{KMIN} + I_R$$

Where :

V$_{MIN}$ = Minimum supply voltage

I$_{LMAX}$ = Maximum load current

I$_{BMAX}$ = Maximum bias current

I$_{KMIN}$ = Maximum value for the minimum

cathode current spec

I$_R$ = Current through R1

Assuming R1=2kΩ as before,

$$I_R = \frac{3.3 - 1.24}{2} = 1.03 \text{ mA}$$

$$I_{BMAX} = 0.08 + 1.03 = 1.11 \text{ mA}$$

$$R_{B\,MAX} = \frac{4.5 - 3.3}{1.11 + 10} = 108 \ \Omega$$

Selecting R$_B$ = 100 Ω

The maximum power dissipation of the resistor is calculated under the maximum supply voltage as follows :

$$P_{RB(MAX)} = \frac{\left(V_{MAX} - V_{KA}\right)^2}{R_B}$$

Where :

V$_{MAX}$ = Maximum supply voltage

P$_{RB(MAX)}$ = Maximum R$_B$ power dissipation

$$P_{RB(MAX)} = \frac{(6 - 3.3)^2}{100} = 73 \text{ mW}$$

Thermal Design

The US431L is offered in the plastic TO-92 (Z) or the surface mount SOT23-5 (L) packages. The TO-92 package has the maximum power dissipation capability of 775mW at Ta=25°C with the derating factor of -6.2mW/°C.The SOT23-5 package has the maximum power dissipation capability of 150mW at Ta =25°C with the derating factor of -1.2mW/°C.
Table below summarizes the maximum power dissipation capability of each package versus ambient temperature.

Pkg	Ambient Temperature (Ta) -°C				
	25	40	50	60	70
TO 92	775mW	682mW	620mW	558mW	496mW
SOT23-5	150mW	132mW	120mW	108mW	96mW

In our previous example, the maximum power dissipation of the device is calculated under no load and maximum input supply condition.

The maximum power is calculated using the following equation :

$$P_{MAX} = V_{KA} \times \left(\frac{V_{MAX} - V_{KA}}{R_B} \right)$$

Where :

$P_{MAX} =$ Maximum power dissipation of the 431L

For our example :

$$P_{MAX} = 3.3 \times \left(\frac{6 - 3.3}{100} \right) = 89 \text{ mW}$$

As shown in the power dissipation table, both packages can handle this power dissipation.

Stability

The US431L has many different regions of stability domain as a function of the cathode current which are typical characteristics of the 3 terminal shunt regulators. However in general the device will be **unconditionaly stable for any cathode current if the capacitor, C_o = 1 uF or bigger** is connected from Cathode to Anode pins. If the cathode current is always kept higher than 500uA under minimum line and maximum load conditions , the C_o can be cut to 0.01uF and the system will be stable.
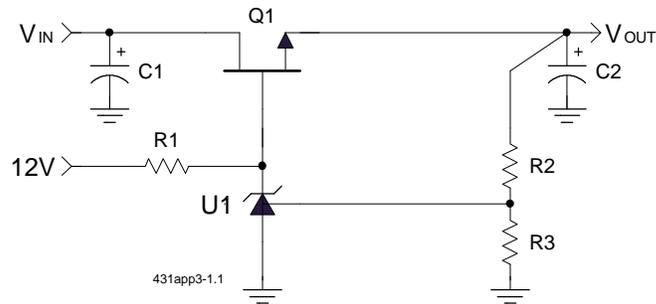
TYPICAL APPLICATION
I740 Application

Figure 3- Low cost 3.3V to 2.7V 0utput for Intel I740 application.

Ref Desig	Description	Qty	Part #	Manuf
U1	Shunt Regulator	1	US431L	Unisem
C1,2	Capacitor	2	Elect,220uF,6.3V,ECAOJFQ221	Panasonic
R1	Resistor	1	6.2kΩ, 5%, SMT	
R2	Resistor	1	118Ω, 1%, SMT	
R3	Resistor	1	100Ω, 1% SMT	
HS1	Heat Sink		Use minimum of 1" Square Copper Pad area for load current <4A	