MSK

RAD HARD POSITIVE, 0.9A, LDO, SINGLE RESISTOR ADJ VOLTAGE REGULATOR

5979RH

## FEATURES:

· Manufactured using **LT LINEAR TECHNOLOGY** Space Qualified RH3080 Die
· Total Dose Hardened to 300 Krads(Si) (Method 1019.7 Condition A)
· Low Dropout to 300mV (VIN - VOUT, with Seperate CTL Supply)
· Output Adjustable to Zero Volts
· Internal Short Circuit Current Limit
· Output Voltage is Adjustable with 1 External Resistor
· Output Current Capability to 0.9 Amps
· Internal Thermal Overload Protection
· Outputs may be Paralleled for Higher Current
· Available in 3 Lead Form Options with Ceramic Seals: Straight, Up and Down (TO257)
· Contact MSK for MIL-PRF-38534 Qualification Status
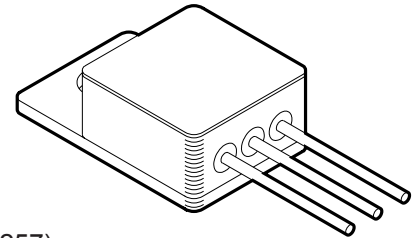
DESCRIPTION:

The MSK5979RH offers low dropout down to 300mV and an output voltage range down to zero volts while offering radiation tolerance for space applications. This, combined with the low θ_{JC}, allows increased output current while providing exceptional device efficiency. Because of the increased efficiency, a small hermetic 3 pin package can be used providing maximum performance while occupying minimal board space. Output voltage is selected by the user through the use of 1 external resistor. Additionally, the regulator offers internal short circuit current and thermal limiting, which allows circuit protection and eliminates the need for external components and excessive derating.

EQUIVALENT SCHEMATIC
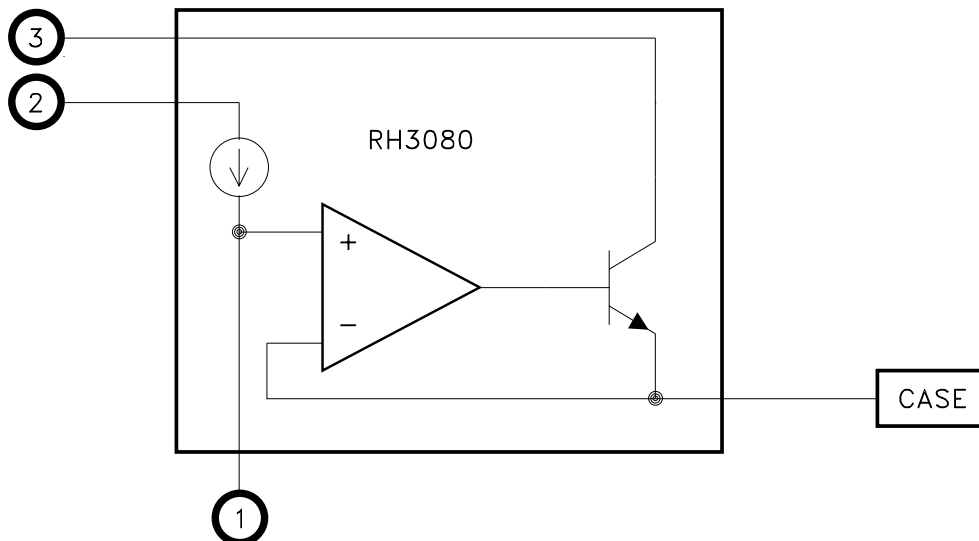
TYPICAL APPLICATIONS

· High Efficiency Linear Regulators
· Constant Voltage/Current Regulators
· Space System Power Supplies
· Switching Power Supply Post Regulators
· Very low Voltage Power Supplies

PIN-OUT INFORMATION

1 SET
2 CTL
3 VIN

CASE VOUT

8548-133 Rev. B 8/15

ABSOLUTE MAXIMUM RATINGS [9]

V_{IN} Input Voltage[7]...+40V,-0.3V
V_{CTL} Control Voltage[7]...+40V,-0.3V
P_D Power Dissipation.............................Internally Limited
I_{OUT} Output Current[8]...0.9A
T_J Junction Temperature ....+150°C

T_{ST} Storage Temperature Range.............-65°C to +150°C
T_{LD} Lead Temperature Range
  (10 Seconds)...300°C
T_C Case Operating Temperature
   MSK5979RH...-40°C to +85°C
   MSK5979K/H ....-55°C to +125°C
   ESD Rating...Class 2

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions [1] [10]		Group A Subgroup	MSK5979K/H			MSK5979RH			Units
				Min.	Typ.	Max.	Min.	Typ.	Max.	
Set Pin Current (Iset)	$V_{CTL} = V_{IN} = 3.0V$ $V_{OUT} = 1.0V$ $1mA \le I_{LOAD} \le 0.9A$		1	9.80	10.0	10.20	9.80	10.0	10.20	uA
			2,3	9.80	-	10.30	-	-	-	uA
		Post Radiation	1	9.7	-	10.5	9.7	-	10.5	uA
Output Offset Voltage (Vos)	$V_{CTL} = V_{IN} = 3.0V$ $V_{OUT} = 1.0V$ $I_{LOAD} = 1mA$		1	-5	0	5	-5	0	5	mV
			2,3	-6	-	6	-	-	-	mV
Load Regulation (△Vos) (△Iset) [2]	$V_{CTL} = V_{IN} = 3.0V$ $V_{OUT} = 1.0V$ $1mA \le I_{Load} \le 0.9A$		1	-2.5	0.7	2.5	-2.5	1.0	2.5	mV
			2,3	-2.5	-	2.5	-	-	-	mV
			1	-	-0.1	-	-	-0.1	-	nA
Line Regulation (△Iset) (△Vos) [2]	$3V \le V_{IN} = V_{CTL} \le 25V$ $V_{OUT} = 1.0V$ $I_{Load} = 1mA$		1	-0.5	0.1	0.5	-0.5	0.1	0.5	nA/V
			2,3	-1.0	-	1.0	-	-	-	nA/V
			1	-	0.003	-	-	0.003	-	mV/V
		Post Radiation	1	-0.7	-	0.7	-0.7	-	0.7	nA/V
VIN Dropout Voltage	$V_{OUT} = 1.0V$ $I_{Load} = 0.9A$ $V_{CTL} = 3.0V$		1	-	320	500	-	320	500	mV
			2,3	-	-	600	-	-	-	mV
Vcontrol Dropout Voltage	$V_{OUT} = 1.0V$ $I_{Load} = 0.9A$ $V_{IN} = 3.0V$		1	-	1.4	1.6	-	1.4	1.6	V
			2,3	-	-	1.7	-	-	-	V
Control Pin Current	$V_{IN} = 2.0V$ $V_{OUT} = 1.0V$ $V_{CTL} = 3.0V$ $I_{Load} = 100mA$		1	-	4.3	6.6	-	4.3	6.6	mA
			2,3	-	-	6.6	-	-	-	mA
Current Limit [8]	$V_{CTL} = V_{IN} = 5.0V$ $V_{OUT} = 1.0V$		1	0.9	1.1	-	0.9	1.1	-	A
			2,3	0.9	-	-	-	-	-	A
Minimum Load Current [6]	$V_{CTL} = V_{IN} = 25V$		-	-	-	1	-	-	1	mA
Ripple Rejection [2]	$F = 120Hz$ $\triangle V_{IN} = 0.5Vpp$		-	-	75	-	-	75	-	dB
Thermal Resistance [2]	Junction to Case @125°C		-	-	4.4	5.0	-	4.4	5.0	°C/W

NOTES:

① Output is decoupled to ground using A 220µF tantalum low ESR capacitor in parallel with 3 pieces of 1.0µF and one 0.1µF ceramic capacitors unless otherwise specified. (See Figure 1)
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade devices shall be tested to subgroup 1 unless otherwise specified.
④ Military grade ("H" suffix) and space grade ("K" suffix) devices shall be 100% tested to subgroups 1,2 and 3.
⑤ Subgroup 1   TA=TC=+25°C
   Subgroup 2   TA=TC=+125°C
   Subgroup 3   TA=TC=-55°C
⑥ Minimum load current verified while testing line regulation.
⑦ Voltage is measured with respect to VOUT.
⑧ Reference the current limit typical performance curve for input to output voltage differential verses output current capabilities.
⑨ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑩ Pre and Post irradiation limits at 25°C, up to 300 Krads(Si) TID, are identical unless otherwise specified.

OUTPUT VOLTAGE

A single resistor (Rset) from the SET pin to ground creates the reference voltage for the internal Error Amplifier. The MSK5979RH SET pin supplies a constant current of 10uA that develops the reference voltage. The output voltage is simply Rset x 10uA. Since the output is internally driven by a unity-gain amplifier, an alternative to using Rset is to connect a high quality reference source to the SET pin. With a minimum load requirement of 1mA on the Output, the Output Voltage can be adjusted to near 0V. To bring the output voltage to 0V, the load must be connected to a slightly negative voltage supply to sink the 1mA minimum load current from a 0V output.
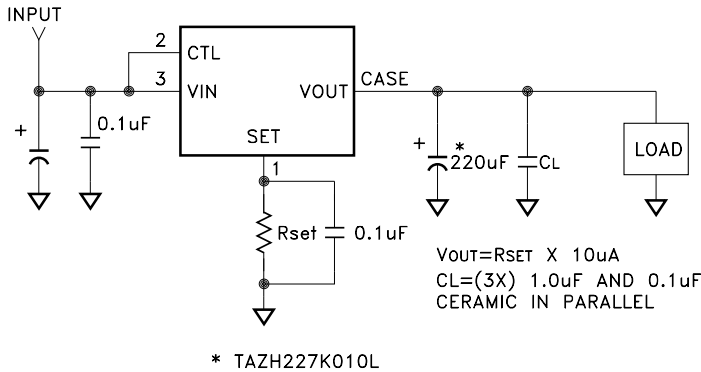
FIGURE 1

OUTPUT CAPACITANCE

For stability purposes, the MSK5979RH requires a minimum output capacitor of 10µF with an ESR of 0.5Ω or less. Tantalum or ceramic capacitors are recommended. A larger capacitance value will improve transient response for increased load current changes. Consideration must also be given to temperature characteristics of the capacitors used.

LOW DROPOUT OPERATION

Using separate VIN and Vcontrol power supplies allows for lower dropout and improved efficiency. Figure 2 shows the MSK5979RH output transistor collector is connected to the VIN pin. The regulator control circuitry is powered by the Vcontrol input. The dropout of the regulator is determined by the saturation voltage of the output transistor, typical 300mV at 0.9A load. The Vcontrol supply must supply the base drive current for the output transistor. The Vcontrol current minus the 10µA set current is supplied to the load. See the Typical Performance Characteristics curves for expected VIN dropout voltage, control pin dropout voltage and current requirements under various conditions. With separate supplies for VIN and Vcontrol, power dissipation is reduced and efficiency improves.
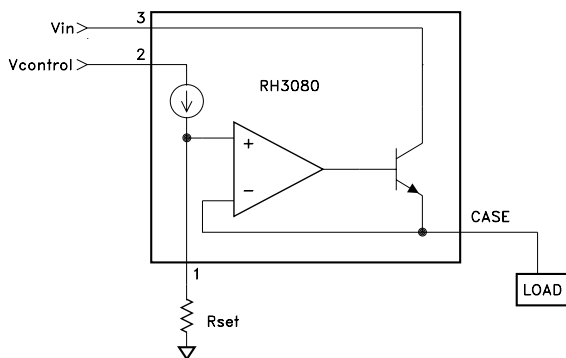

FIGURE 2

ADDITIONAL STABILITY

A capacitor placed in parallel with the SET pin resistor to ground, will improve the output transient response and filter noise in the system. To reduce output noise, typically less than 100pF is all that will be required. Capacitors up to 1µF can be used, however consideration must be given to the effect the time constant created will have on the startup time.

LOAD REGULATION

The MSK5979RH specified load regulation is Kelvin Sensed, therefore the parasitic resistance of the system must be considered to design an acceptable load regulation. The overall load regulation includes the specified MSK5979RH load regulation plus the parasitic resistance multiplied by the load current as shown in Figure 3. RSO is the series resistance of all conductors between the MSK5979RH output and the load. It will directly increase output load regulation error by a voltage drop of ΔIo x Rso. Rss is the series resistance between the set pin and the load. RSS will have little effect on load regulation if the set pin trace is connected as close to the load as possible keeping the load return current on a separate trace as shown. RSR is the series resistance of all of the conductors between the load and the input power source return. RSR will not effect load regulation if the set pin is connected with a Kelvin Sense type connection as shown in Figure 3, but it will increase the effective dropout voltage by a factor of IO x RSR. Keeping RSO and RSR as low as possible will ensure minimal voltage drops and wasted power.
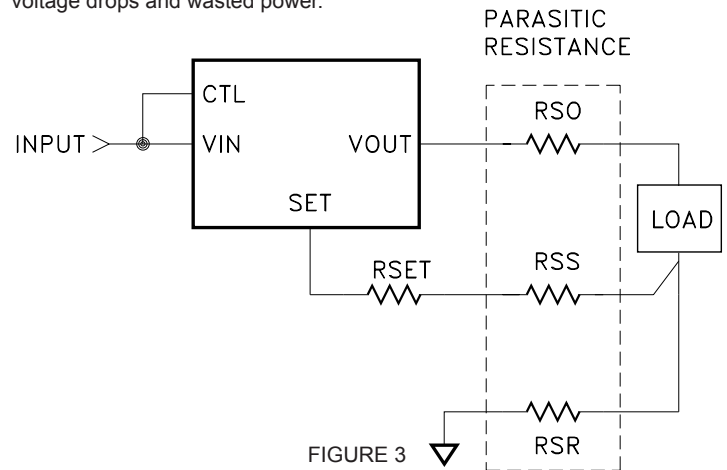

FIGURE 3

PARALLELING DEVICES

When currents greater than 0.9A are needed, the MSK5979RH's may be paralleled to multiply the current capacity. As shown in Figure 4, the Vin and SET pins must be tied together. The VOUT pins are connected to the load with consideration to the conductor resistance. The conductor resistance of each MSK5979RH VOUT connection to the load, must be equal to create equal load sharing. As little as 10mΩ ballast resistance typically ensures better than 80% equal sharing of load current at full load. Additional consideration must be given to the effect the additional VOUT conductor resistance has on load regulation; see paragraph titled "Load Regulation".
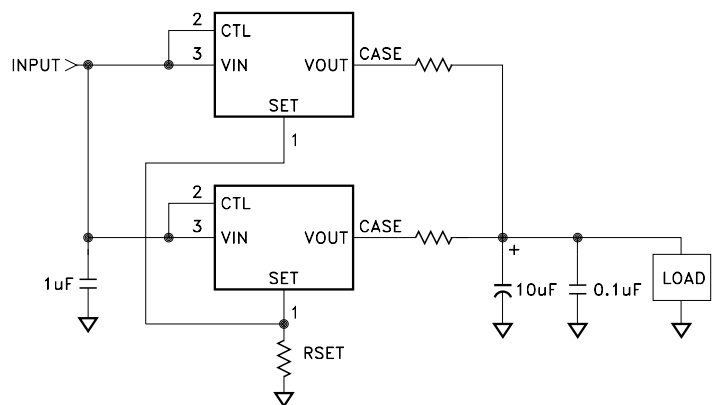

FIGURE 4

8548-133 Rev. B 8/15

IMPROVING INITIAL ACCURACY AND REDUCING TEMPERATURE DRIFT

The initial output accuracy of the MSK5979RH due to set pin current tolerance and set point resistor accuracy can be reduced to 0.2% using the MSK109RH radiation hardened precision reference. Minimal drift of the MSK109RH from temperature extremes and irradiation ensure very tight regulation. The circuit can be configured to use the 2.5V reference to directly set the output at 2.5V or with a slight variation it can provide any output within the operating range of the MSK5979RH down to 0V output. Select Rs to maintain between 1mA and 10mA of current through the reference; see Figure 5 below. Rs may be tied to VIN or another power source. The optional trim resistor can be used to further trim out initial output and system error. Reference the MSK109RH data sheet for application circuits that provide stable output voltages across the full operating range of the MSK5979RH including down to 0V output and the operating characteristics of the MSK109RH.
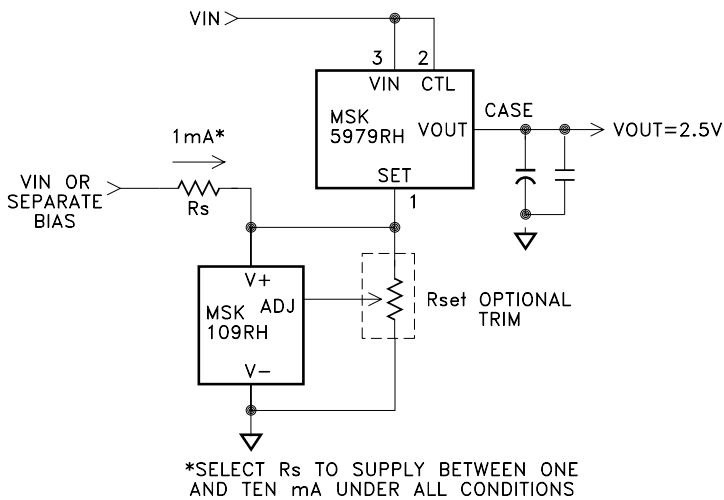
FIGURE 5

ADDING SHUTDOWN

The MSK5979RH can be easily shutdown by either reducing Rset to 0Ω or connecting a transistor from the set pin to ground. By connecting two transistors, as shown in Figure 6, a low current voltage source is all that is required to take the set pin to ground as well as pull the output voltage to ground. Q2 pulls the output voltage to ground when no load is present and only needs to sink 10mA. Use a low leakage switching diode between Vout and Set to avoid overstress during shutdown transitions.
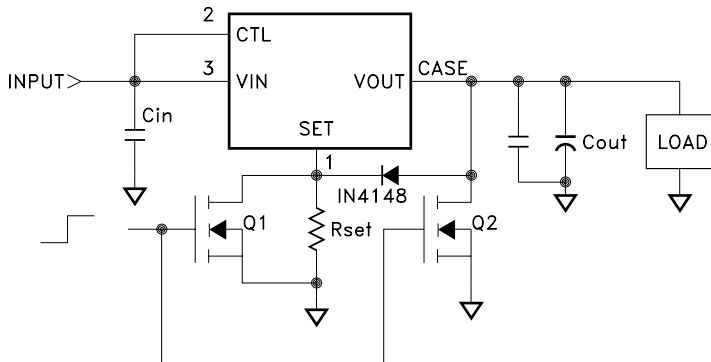
FIGURE 6

HEAT SINKING

To determine if a heat sink is required for your application and if so, what type, refer to the thermal model and governing equation below.

Governing Equation: $Tj = Pd \times (R\theta jc + R\theta cs + R\theta sa) + Ta$

WHERE
Tj = Junction Temperature
Pd = Total Power Dissipation
$R\theta jc$ = Junction to Case Thermal Resistance
$R\theta cs$ = Case to Heat Sink Thermal Resistance
$R\theta sa$ = Heat Sink to Ambient Thermal Resistance
Tc = Case Temperature
Ta = Ambient Temperature
Ts = Heat Sink Temperature

EXAMPLE:

This example demonstrates the thermal calculations for the TO-257 package with the regulator operating at one-half of its maximum rated output current.

Conditions for MSK5979RH:

V_{CTL}=VIN = +3.0V; Iout = +0.45A VOUT=+1.0V

1.) Assume 45° heat spreading model.
2.) Find regulator power dissipation:

    Pd = (VIN - VOUT)(Iout)
    Pd = (3-1)(0.45)
       = 0.9W

3.) For conservative design, set Tj = +125°C Max.
4.) For this example, worst case Ta = +90°C.
5.) $R\theta jc$ = 5.0°C/W from the Electrical Specification Table.
6.) $R\theta cs$= 0.15°C/W for most thermal greases.
7.) Rearrange governing equation to solve for $R\theta sa$:

    $R\theta sa$= ((Tj - Ta)/Pd) - ($R\theta jc$) - ($R\theta cs$)
          = (125°C - 90°C)/0.9W - 5.0°C/W - 0.15°C/W
          = 33.7°C/W

In this case the result is 33.7°C/W. Therefore, a heat sink with a thermal resistance of no more than 33.7°C/W must be used in this application to maintain regulator circuit junction temperature under 125°C.

TOTAL DOSE RADIATION TEST PERFORMANCE

Radiation performance curves for TID testing have been generated for all radiation testing performed by MS Kennedy. These curves show performance trends throughout the TID test process and can be located in the MSK5977RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.
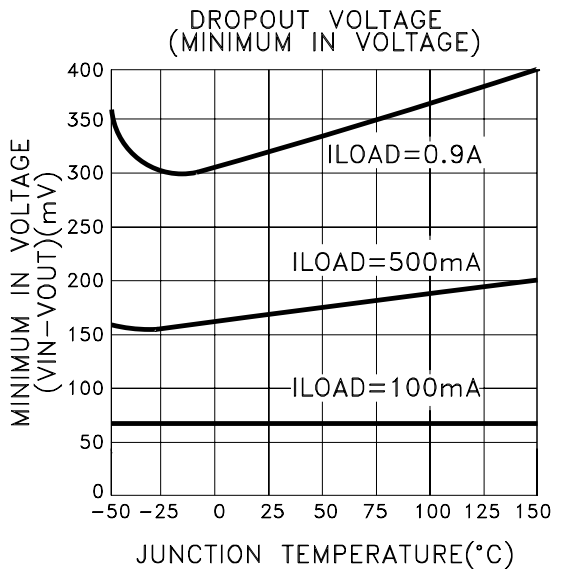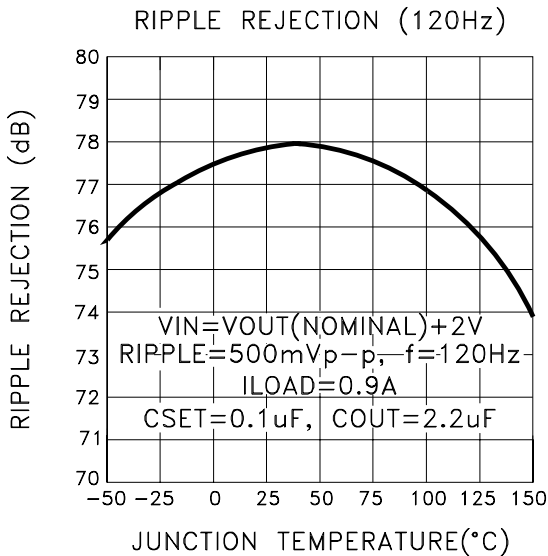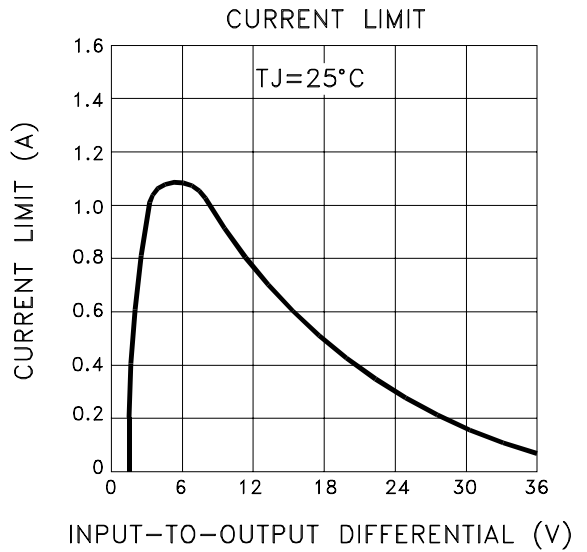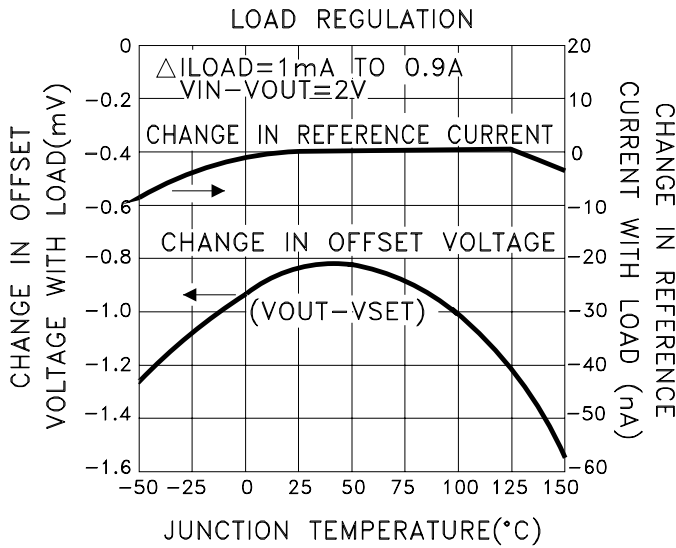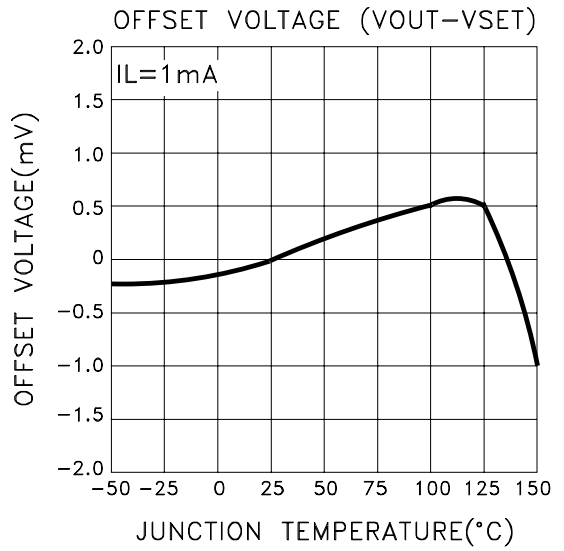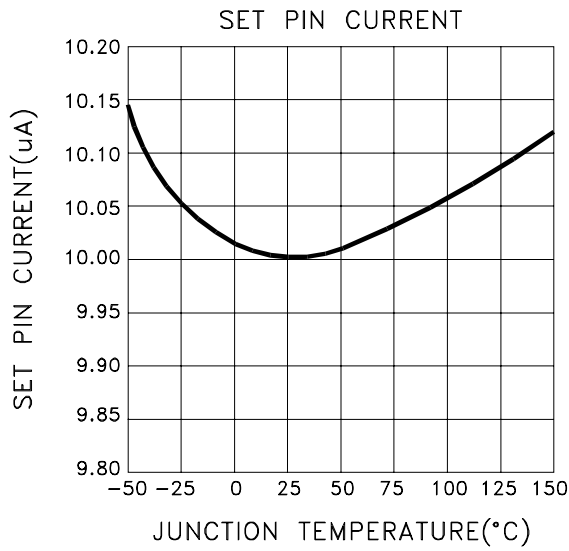
ADDITIONAL APPLICATION INFORMATION

For additional applications information, please reference Linear Technology Corporation's® LT3080 and RH3080 data sheets.
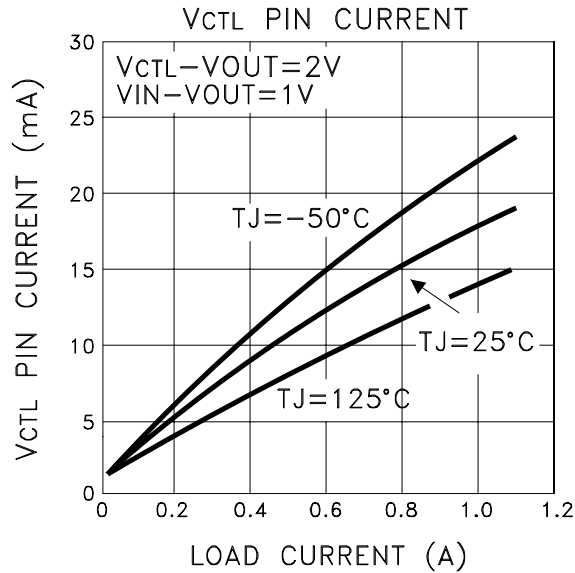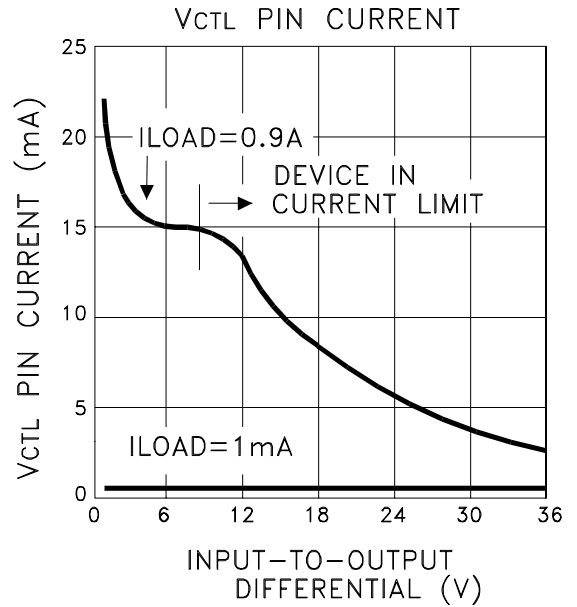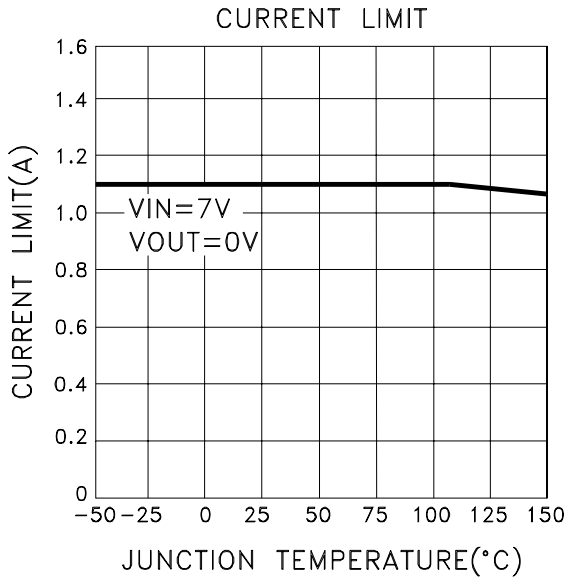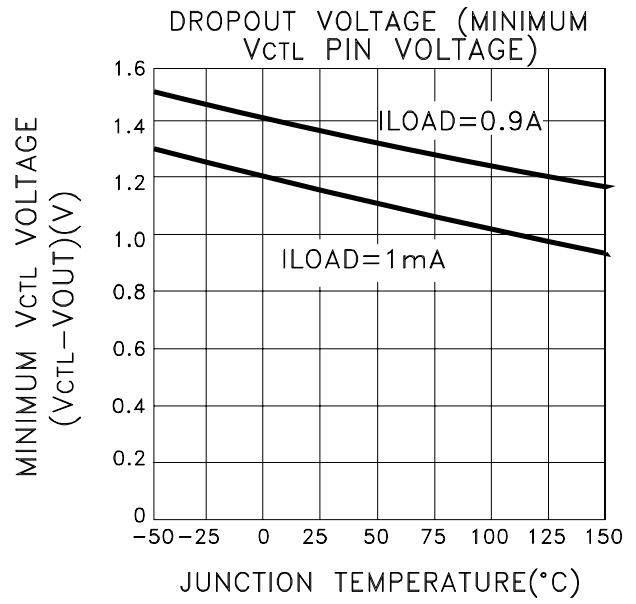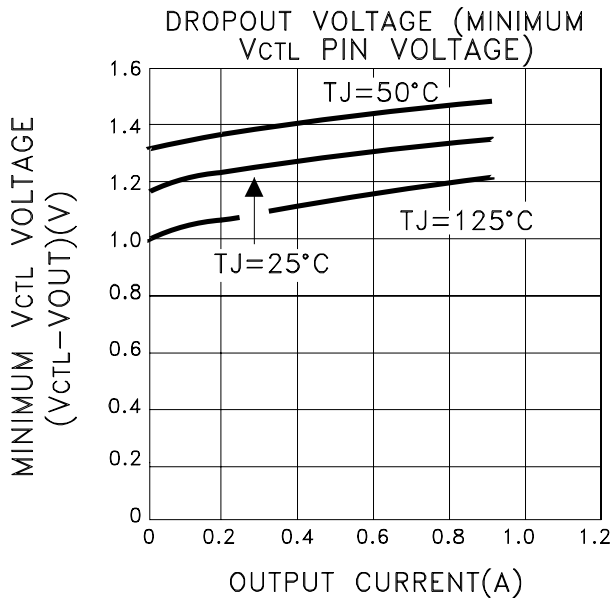
DIE GLASSIVATION

For enhanced radiation tolerance the die has a glassivation thickness of 4KA and is not in accordance with MIL-PRF-38534.
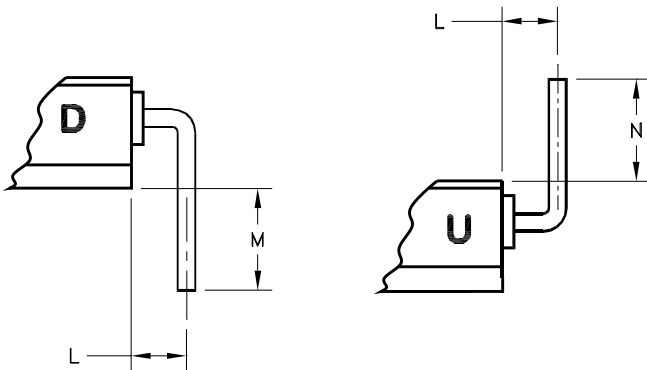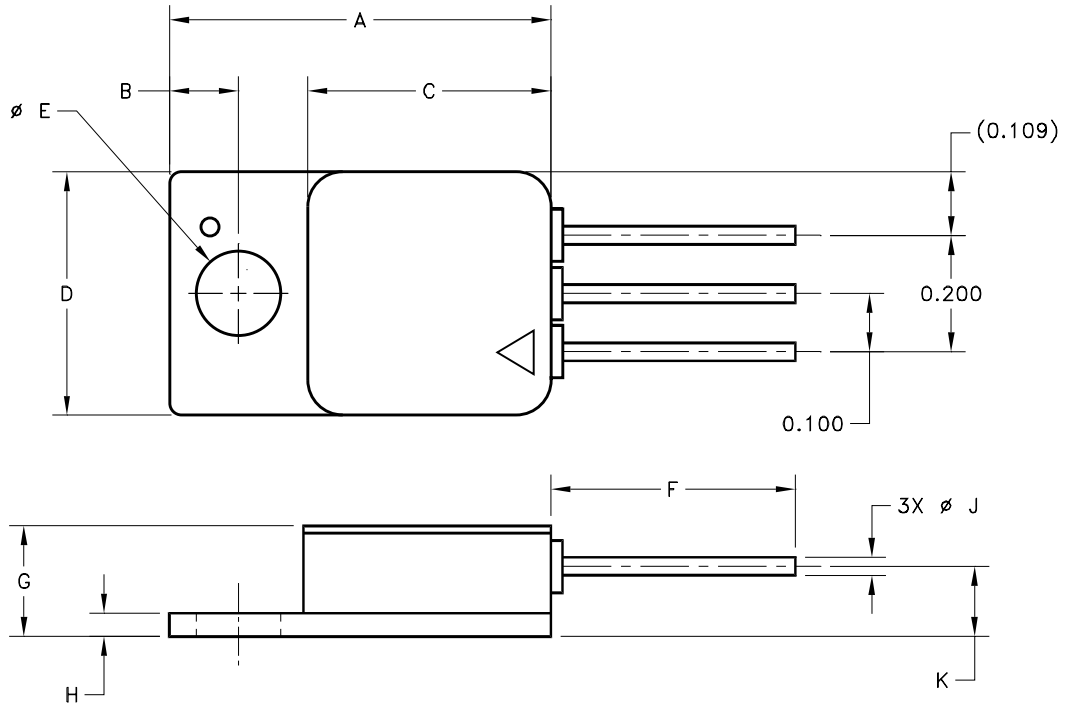
SET PIN CURRENT

SET PIN CURRENT(uA) vs JUNCTION TEMPERATURE(°C)

OFFSET VOLTAGE (VOUT−VSET)

IL=1mA

OFFSET VOLTAGE(mV) vs JUNCTION TEMPERATURE(°C)

LOAD REGULATION

△ILOAD=1mA TO 0.9A
VIN−VOUT=2V

CHANGE IN REFERENCE CURRENT

CHANGE IN OFFSET VOLTAGE
(VOUT−VSET)

CHANGE IN OFFSET VOLTAGE WITH LOAD(mV)
CHANGE IN REFERENCE CURRENT WITH LOAD (nA)
vs JUNCTION TEMPERATURE(°C)

CURRENT LIMIT

TJ=25°C

CURRENT LIMIT (A) vs INPUT−TO−OUTPUT DIFFERENTIAL (V)

RIPPLE REJECTION (120Hz)

VIN=VOUT(NOMINAL)+2V
RIPPLE=500mVp−p, f=120Hz
ILOAD=0.9A
CSET=0.1uF, COUT=2.2uF

RIPPLE REJECTION (dB) vs JUNCTION TEMPERATURE(°C)

DROPOUT VOLTAGE (MINIMUM IN VOLTAGE)

ILOAD=0.9A

ILOAD=500mA

ILOAD=100mA

MINIMUM IN VOLTAGE (VIN−VOUT)(mV) vs JUNCTION TEMPERATURE(°C)

DROPOUT VOLTAGE (MINIMUM V_CTL PIN VOLTAGE)

DROPOUT VOLTAGE (MINIMUM V_CTL PIN VOLTAGE)

CURRENT LIMIT

V_CTL PIN CURRENT

V_CTL PIN CURRENT

REF	MIN	MAX	REF	MIN	MAX
A	0.645	0.665	H	0.035	0.045
B	0.113	0.123	J	0.029	0.033
C	0.407	0.427	K	0.110	0.130
D	0.407	0.427	L	0.085	0.105
E	0.140	0.150	M	0.175	————
F	0.400	————	N	0.175	————
G	————	0.210			

ESD TRIANGLE INDICATES PIN 1
WEIGHT=3.2 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

MSK5979 K RH U

LEAD CONFIGURATIONS
    S= STRAIGHT; U= BENT UP; D= BENT DOWN
RADIATION HARDENED
SCREENING
    BLANK= INDUSTRIAL
    H=MIL-PRF-38534 CLASS H
    K=MIL-PRF-38534 CLASS K
GENERAL PART NUMBER

The above example is an adjustable Class K regulator with leads bent up.

8548-133 Rev. B 8/15

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
-	Released	07/14	Initial Release
A	Released	10/14	Add pin 1 indicator on page 7
B	Released	08/14	Add ESD rating to absolute maximum ratings.

MSK
www.anaren.com/msk