MIL-PRF-38534 CERTIFIED

MSK
M.S.KENNEDY CORP.

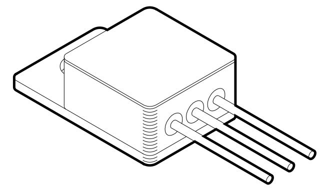
RAD HARD POSITIVE, 1.0 AMP, SINGLE RESISTOR ADJ VOLTAGE REGULATOR

5976RH

4707 Dey Road Liverpool, N.Y. 13088 (315) 701-6751

FEATURES:

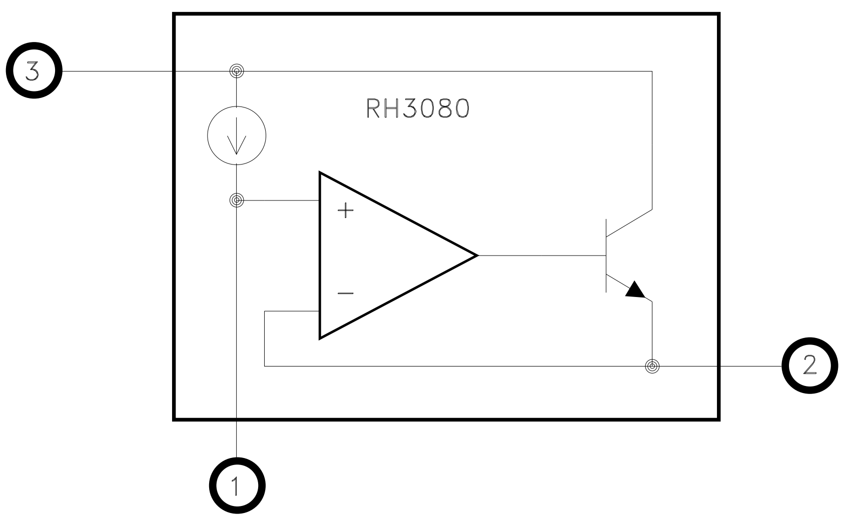
- Manufactured using LINEAR TECHNOLOGY Space Qualified RH3080 Die
- MIL-PRF-38535 Class V Processing & Screening
- Total Dose Tested to TBD Krads(Si) (Method 1019.7 Condition A)
- Output Adjustable to Zero Volts
- Internal Short Circuit Current Limit
- Output Voltage is Adjustable with 1 External Resistor
- Output Current Capability to 1.0 Amps
- Internal Thermal Overload Protection
- Outputs may be Paralleled for Higher Current
- Available in 3 Lead Form Options: Straight, Up and Down
- Contact MSK for MIL-PRF-38535 Qualification and Radiation Status



DESCRIPTION:

The MSK 5976RH offers 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 VOUT
3 VIN

(CASE IS ISOLATED)

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ABSOLUTE MAXIMUM RATINGS ⑧

V_{IN}	Input Voltage 40V	T_{ST}	Storage Temperature Range -65°C to +150°C
P_D	Power Dissipation . . . . . . Internally Limited	T_{LD}	Lead Temperature Range . . . . 300°C (10 Seconds)
I_{OUT}	Output Current ⑦ 1.0A	T_C	Case Operating Temperature
T_J	Junction Temperature . . . . +150°C		MSK 5976RH. . . . . -40°C to +85°C
			MSK 5976V RH. . . . . -55°C to +125°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions	Group A Subgroup	MSK 5976V RH Min.	MSK 5976V RH Typ.	MSK 5976V RH Max.	MSK 5976RH Min.	MSK 5976RH Typ.	MSK 5976RH Max.	Units
Set Pin Current (Iset)	Vin=3.0V Vout=1.0V ImA≤ILOAD≤1.0A	1	9.80	10.0	10.20	9.80	10.0	10.20	uA
		2,3	9.80	-	10.20	-	-	-	uA
	Post Radiation	1	TBD	TBD	TBD	TBD	TBD	TBD	uA
Output Offset Voltage (Vos)	Vin=3.0V Vout=1.0V ILOAD=1mA	1	-5	0	5	-5	0	5	mV
		2,3	-6	-	6	-	-	-	mV
Load Regulation (Δ Vos)	Vin=3.0V Vout=1.0V 1mA≤ILoad≤1.0A	1	-3.5	2.1	3.5	-3.5	2.1	3.5	mV
		2,3	-4.75	-	4.75	-	-	-	mV
(Δ Iset) ②		1	-	-0.1	-	-	-0.1	-	nA
Line Regulation (Δ Iset)	3V≤Vin≤25V Vout=1.0V ILoad=1mA	1	-0.5	0.05	0.5	-0.5	0.05	0.5	nA/V
		2,3	-0.5	-	0.5	-	-	-	nA/V
(Δ Vos) ②		1	-	0.003	-	-	0.003	-	mV/V
Dropout Voltage ⑦	Vout=1.0V ILoad=1.0A	1	-	1.4	1.6	-	1.4	1.6	V
		2,3	-	-	1.6	-	-	-	V
Current Limit	Vin=5.0V Vout=1.0V	1	1.0	1.3	-	1.0	1.3	-	A
		2,3	1.0	-	-	-	-	-	A
	Post Radiation	1	TBD	TBD	TBD	TBD	TBD	TBD	A
Minimum Load Current ⑥	Vin=25V	-	-	-	1	-	-	1	mA
Ripple Rejection ②	F=120Hz Δ Vin=0.5Vpp	-	-	75	-	-	75	-	dB
Thermal Resistance ②	Junction to Case @125°C	-	-	6.4	7.3	-	6.4	7.3	°C/W

NOTES:

① Output is decoupled to ground using a 3.9uF tantalum low ESR capacitor in parallel with a 0.1μF ceramic capacitor 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 Class V 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 Reference the current limit typical performance curve for input to output voltage differential verses output current capabilities.
⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑨ Pre and Post irradiation limits at 25°C, up to TBD TID, are identical unless otherwise specified.

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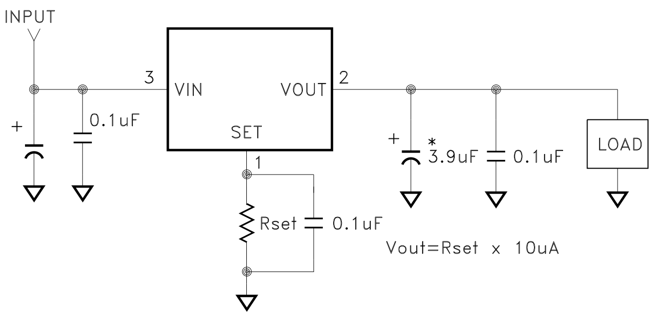
OUTPUT VOLTAGE

A single resistor (Rset) from the SET pin to ground creates the reference voltage for the internal Error Amplifier. The MSK 5976RH 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.



* M39003/10-3085SJ

FIGURE 1

OUTPUT CAPACITANCE

For stability purposes, the MSK 5976RH requires a minimum output capacitor of 2.2µF 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.

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 MSK 5976RH 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 MSK 5976RH load regulation plus the parasitic resistance multiplied by the load current as shown in Figure 2. RSO is the series resistance of all conductors between the MSK 5976RH 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 2, 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.

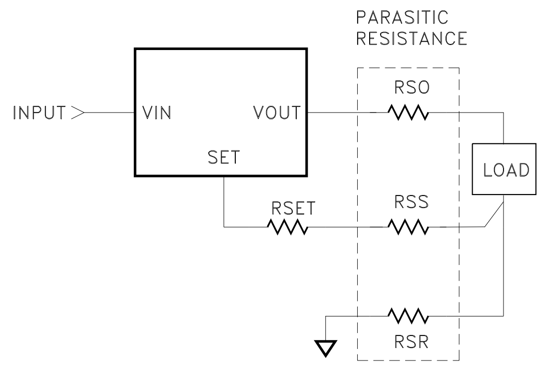


FIGURE 2

PARALLELING DEVICES

When currents greater than 1.0 A are needed, the MSK 5976RH's may be paralleled to multiply the current capacity. As shown in Figure 3, 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 MSK 5976RH 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".

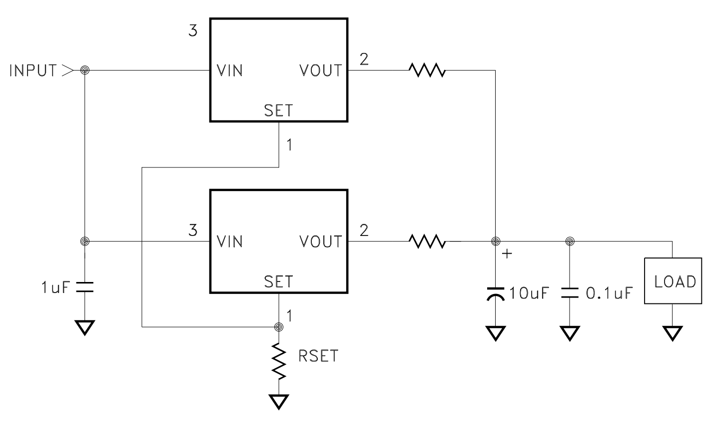


FIGURE 3

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IMPROVING INITIAL ACCURACY AND REDUCING TEMPERATURE DRIFT

The initial output accuracy of the MSK 5976RH due to set pin current tolerance and set point resistor accuracy can be reduced to 0.2% using the MSK 109RH radiation hardened precision reference. Minimal drift of the MSK 109RH 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 MSK 5976RH down to 0V output. Select Rs to maintain between 1mA and 10mA of current through the reference; see Figure 4 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 MSK 109RH data sheet for application circuits that provide stable output voltages across the full operating range of the MSK 5976RH including down to 0V output and the operating characteristics of the MSK 109RH.

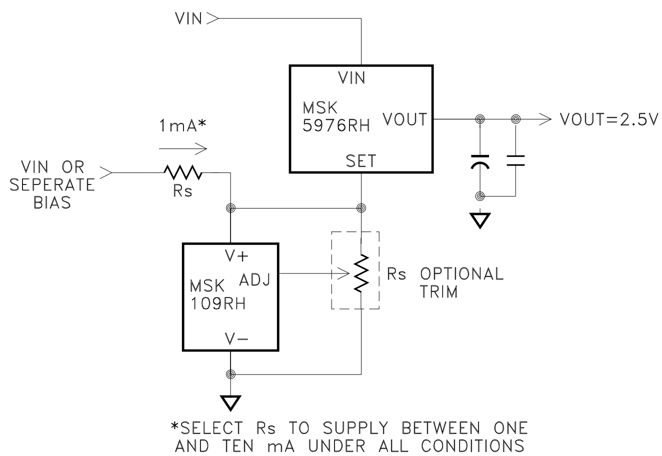

FIGURE 4

ADDING SHUTDOWN

The MSK 5976RH 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 5, 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.

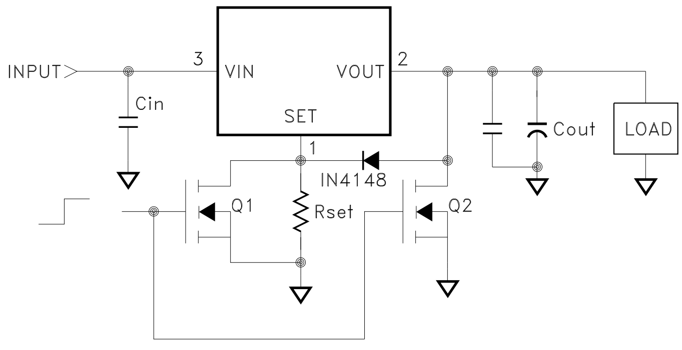

FIGURE 5

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
- Rθjc = Junction to Case Thermal Resistance
- Rθcs = Case to Heat Sink Thermal Resistance
- Rθsa = 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 MSK 5976RH:

Vin = +3.0V; Iout = +0.50A Vout = +1.0V

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

$$Pd = (Vin - Vout)(Iout)$$
$$Pd = (3-1)(0.50)$$
$$= 1.0W$$

3.) For conservative design, set Tj = +125°C Max.
4.) For this example, worst case Ta = +90°C.
5.) Rθjc = 7.3°C/W from the Electrical Specification Table.
6.) Rθcs = 0.15°C/W for most thermal greases.
7.) Rearrange governing equation to solve for Rθsa:

$$R\theta sa = ((Tj - Ta)/Pd) - (R\theta jc) - (R\theta cs)$$
$$= (125°C - 90°C)/1.0W - 7.3°C/W - 0.15°C/W$$
$$= 27.6°C/W$$

In this case the result is 27.6°C/W. Therefore, a heat sink with a thermal resistance of no more than 27.6°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 will be 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 MSK 5976RH radiation test report. The complete radiation test report will be 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.

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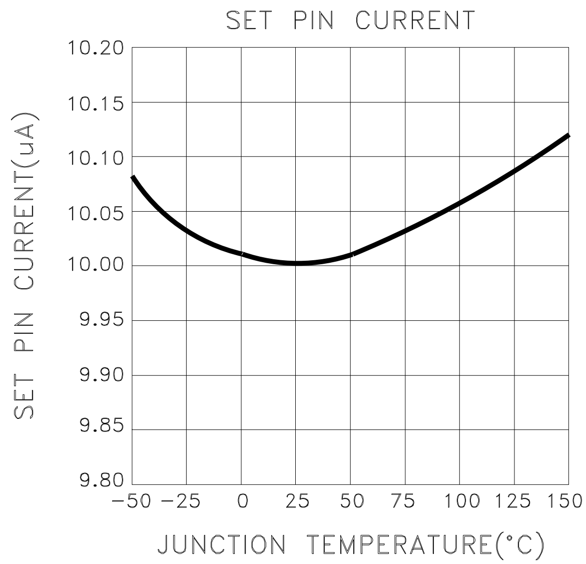
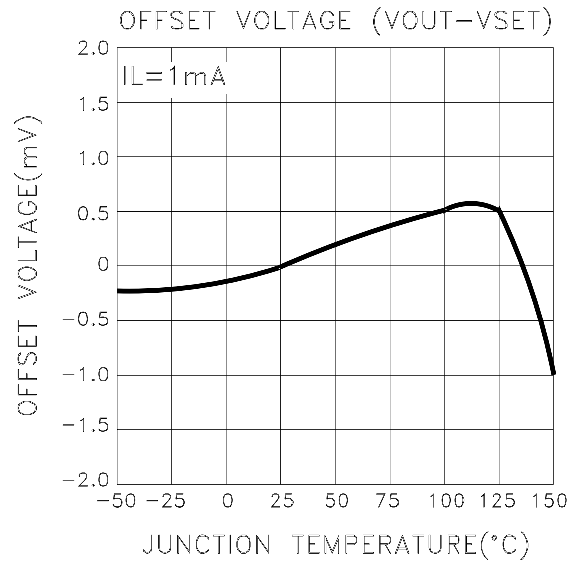
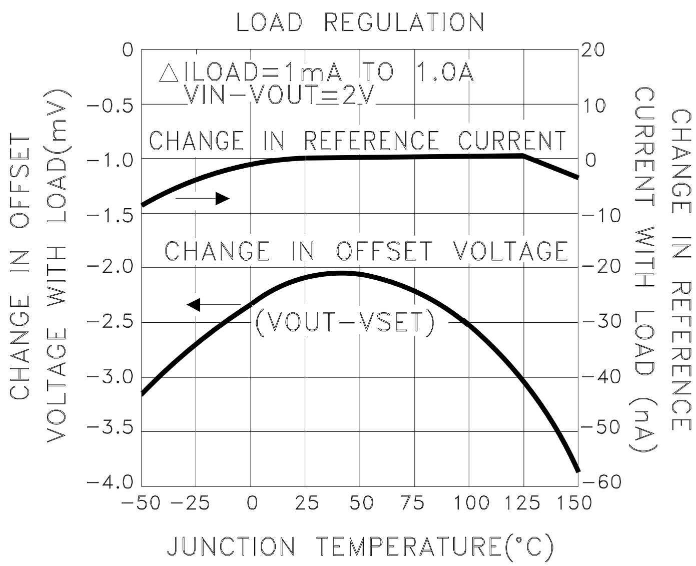
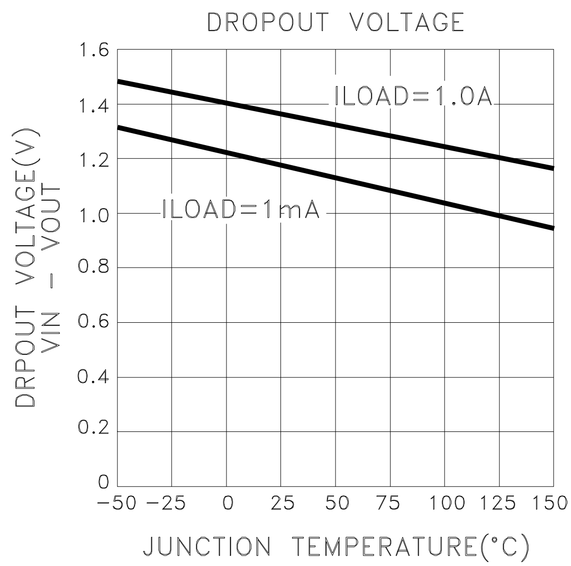
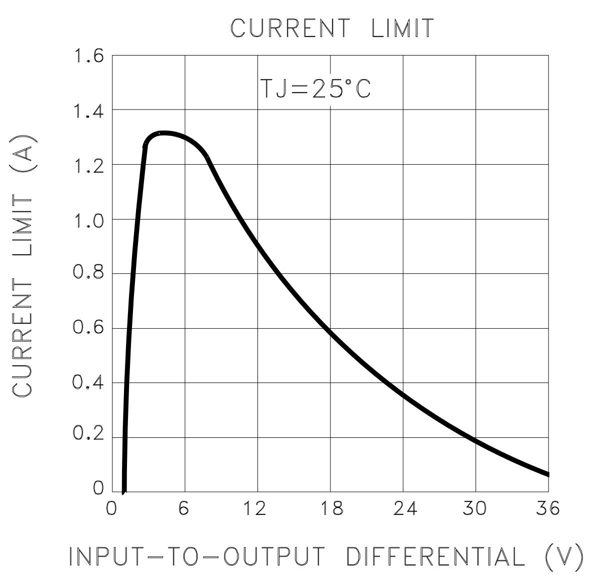
TYPICAL PERFORMANCE CURVES

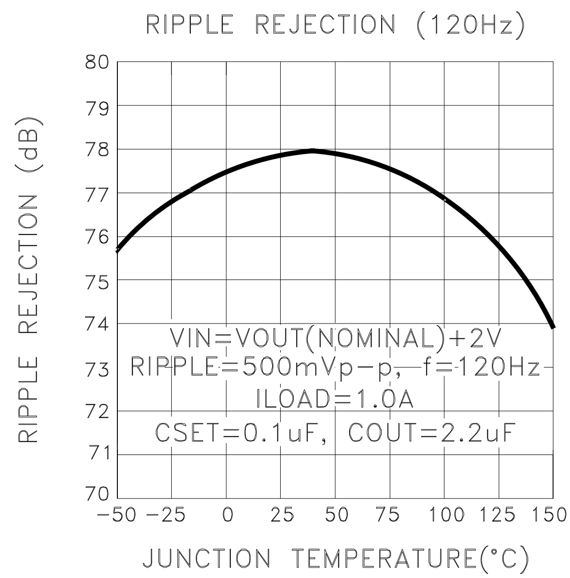












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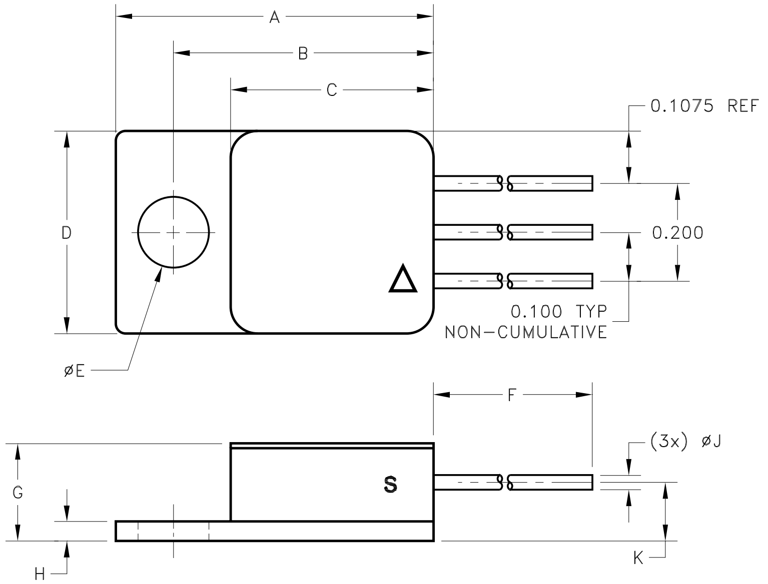
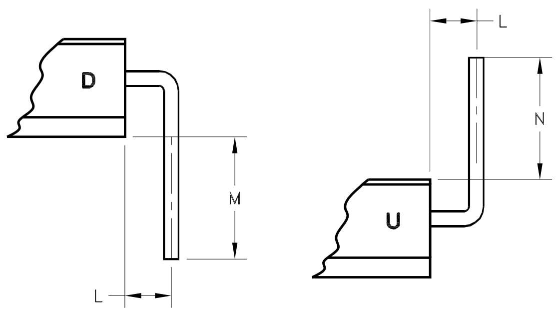
MECHANICAL SPECIFICATIONS





REF	MIN	MAX	REF	MIN	MAX
A	0.640	0.660	H	0.035	0.045
B	0.527	0.537	J	0.028	0.032
C	0.405	0.425	K	0.110	0.130
D	0.405	0.425	L	0.085	0.105
E	0.140	0.150	M	0.200	———
F	0.400	———	N	0.200	———
G	———	0.210			

ESD TRIANGLE INDICATES PIN 1
WEIGHT = 3.2 GRAMS TYPICAL

ORDERING INFORMATION

MSK5976 V RH U

LEAD CONFIGURATIONS
S = STRAIGHT; U = BENT UP; D = BENT DOWN

RADIATION HARDENED

SCREENING
BLANK = INDUSTRIAL
V = MIL-PRF-38535 CLASS V

GENERAL PART NUMBER

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

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