MIL-PRF-38534 CERTIFIED

M.S.KENNEDY CORP.

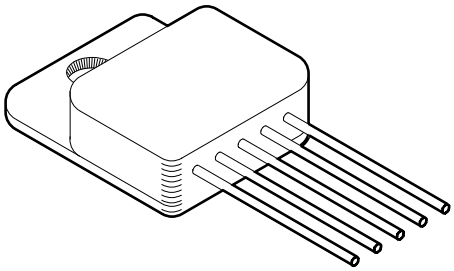
RAD HARD ULTRA LOW DROPOUT POSITIVE LINEAR REGULATOR

5922RH SERIES

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

FEATURES:

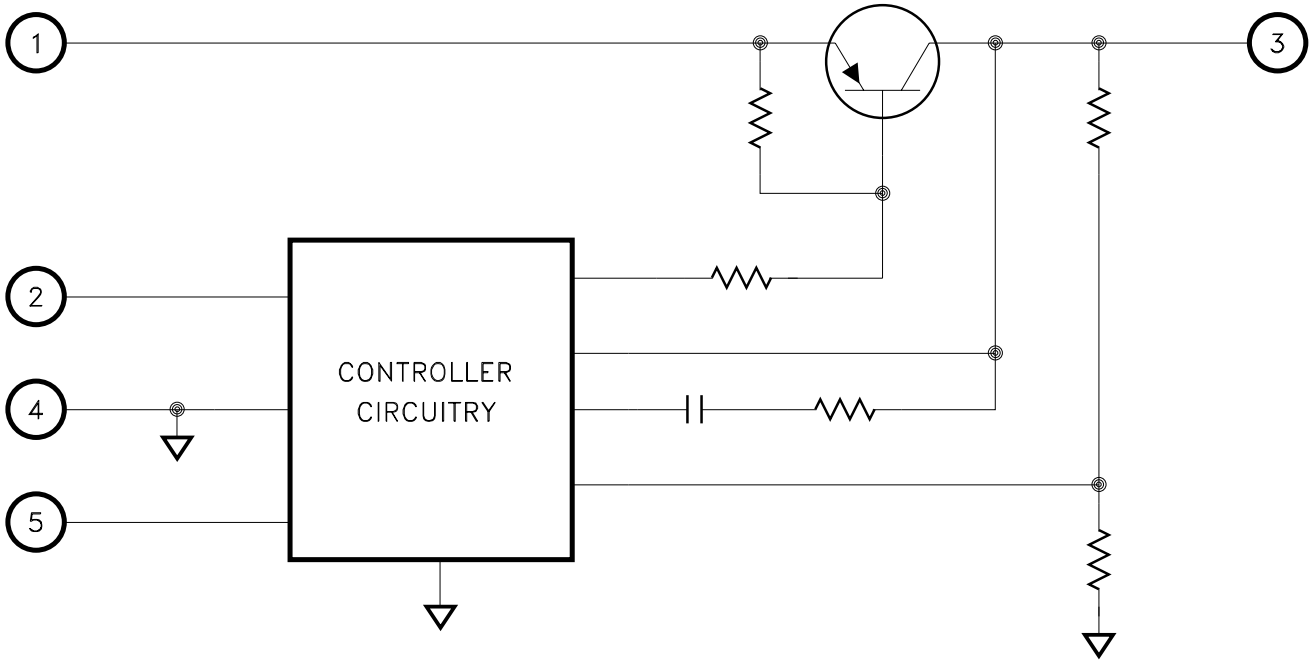
- Total Dose Tested to 300K RAD (Method 1019.7 Condition A)
- Low Dropout for Reduced Power Consumption
- Latching Overload Protection
- Available in 1.5V,1.9V,2.5V,2.8V,3.3V and 5.0V Output Voltages
- Alternate Output Voltages Available
- Output Current Limit
- Available in 3 Lead Form Options: Straight, Up and Down
- Seperate Bias/Vin Pins for Improved Efficiency
- Initial Output Tolerance of 0.5%
- Contact MSK for MIL-PRF-38534 Qualification Status



DESCRIPTION:

The MSK 5922RH is a rad hard fixed linear regulator capable of delivering 5.0 amps of output current. Typical dropout is only 0.22 volts with a 2.5 amp load. Separated power and bias simplifies supply tracking. This device also has latching overload protection. The MSK 5922RH is radiation hardened and specifically designed for space/satellite applications. The device is packaged in a hermetically sealed space efficient 5 pin SIP that is electrically isolated from the internal circuitry allowing for direct heat sinking.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Satellite System Power Supplies
- Switching Power Supply Post Regulators
- Constant Voltage/Current Regulators
- Microprocessor Power Supplies

PIN-OUT INFORMATION

1 VIN
2 VBIAS
3 VOUT
4 GND
5 LATCH

ABSOLUTE MAXIMUM RATINGS ⑧

$+V_{BIAS}$	Bias Supply Voltage . . . . . +10V	T_{ST}	Storage Temperature Range -65°C to +150°C
$+V_{IN}$	Supply Voltage . . . . . +10V	T_{LD}	Lead Temperature Range . . . . . 300°C (10 Seconds)
I_{OUT}	Output Current ⑦ 5A	P_D	Power Dissipation . . . . . See SOA Curve
T_C	Case Operating Temperature Range	T_C	Junction Temperature . . . . . 150°C
	MSK5922K/H/E RH . . . . . -55°C to +125°C		
	MSK5922RH . . . . . -40°C to +85°C		

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ① ⑨ ⑫		Group A Subgroup	MSK5922K/H/E RH Min.	MSK5922K/H/E RH Typ.	MSK5922K/H/E RH Max.	MSK5922RH Min.	MSK5922RH Typ.	MSK5922RH Max.	Units
Input Voltage Range ②	10mA ≤ I_{OUT} ≤ 1.0A		1,2,3	Note 10	-	6.5	Note 10	-	6.5	V
Input Bias Voltage ②	$V_{BIAS} \geq V_{IN}$		1,2,3	2.9	5.0	6.5	2.9	5.0	6.5	V
Quiescent Current	$I_{IN} + I_{BIAS}$, $V_{BIAS} = V_{IN} = 6.5V$, Not including I_{OUT}		1,2,3	-	14	20	-	14	20	mA
Bias Current	$V_{BIAS} = 6.5V$		1,2,3	-	2	4	-	2	4	mA
Output Voltage Tolerance	$V_{IN} = V_{OUT} + 1V$, $I_{OUT} = 1A$		1	-	±0.1	±0.5	-	±0.1	±1.0	%
			2,3	-	-	±2.5	-	-	-	%
		Post Radiation	1	-	-	±4.0	-	-	±4.5	%
Line Regulation ⑨	$I_{OUT} = 50mA$		1	-	±0.1	±0.50	-	0.01	±0.60	%
	$V_{OUT} + 0.4V \leq V_{IN} \leq 6.5V$		2,3	-	-	±2.5	-	-	-	%
Load Regulation ⑨	50mA ≤ I_{OUT} ≤ 3.0A		1	-	±0.06	±0.80	-	0.06	±1.0	%
	$V_{IN} = V_{OUT} + 1V$		2,3	-	-	±2.5	-	-	-	%
Dropout Voltage ⑪	Delta $V_{OUT} = 1\%$, Pin 5(Latch) = GND	$I_{OUT} = 2.5A$	1	-	0.22	0.40	-	0.22	0.45	V
			2,3	-	0.26	0.40	-	-	-	V
		$I_{OUT} = 0.5A$	1	-	0.11	0.30	-	0.11	0.30	V
			2,3	-	0.12	0.30	-	-	-	V
Output Current Limit ⑦ ⑨	$V_{IN} = V_{OUT} + 1V$ Overcurrent Latch Up		1	3.0	-	5	3.0	-	5	A
			2,3	3.0	-	5	-	-	-	A
Ripple Rejection ②	f = 120Hz		4	65	-	-	65	-	-	dB
	$I_{OUT} = 50mA$		5,6	65	-	-	-	-	-	dB
Thermal Resistance ②	Junction to Case @ 125°C Output Device		-	-	2.2	3.0	-	2.2	3.5	°C/W

PART NUMBER	OUTPUT VOLTAGE
MSK5922-1.5	+1.5V
MSK5922-1.9	+1.9V
MSK5922-2.5	+2.5V
MSK5922-2.8	+2.8V
MSK5922-3.3	+3.3V
MSK5922-5.0	+5.0V

NOTES:

① Unless otherwise specified, VIN = VOUT + 1V, VBIAS = 5V and IOUT = 10mA. See figure 2 for typical test circuit.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise requested.
④ Military grade devices ("H" and "K" suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Subgroup 5 and 6 testing available upon request.
⑥ Subgroup 1,4 TC = +25°C
Subgroup 2,5 TC = +125°C
Subgroup 3,6 TA = -55°C
⑦ Output current limit is dependent upon the values of VIN and VOUT. See Figure 1 and typical performance curves.
⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.
⑨ VIN shall be as specified or VIN min., whichever is greater.
⑩ With VBIAS (Pin 2) connected to a separate source, VIN MIN is VOUT + VDROPOUT; see dropout specifications and performance curves.
⑪ Saturation voltage varies with load. See typical performance curves. Latch Pin = GND to prevent latch off during testing, see latch pin description.
⑫ Pre and post irradiation limits, at +25°C, up to 100Krad TID, are identical unless otherwise specified.

APPLICATION NOTES

PIN FUNCTIONS

V_{IN} - This pin provides the input power connection to the MSK 5922RH. This is the supply that will be regulated to the output. Input voltage range is V_{OUT} + $V_{DROPOUT}$ to 6.5V.

VBIAS - This pin provides power to all internal circuitry including bias, start-up, thermal limit and overcurrent latch. VBIAS voltage range is 2.9V to 6.5V. VBIAS should be kept greater than or equal to VIN.

LATCH - The MSK 5922RH LATCH pin is used for both current limit and thermal limit. A capacitor between the LATCH pin and ground sets a time out delay in the event of an over current or short circuit condition. In the event of an overcurrent condition, output short circuit or drop-out condition, the pass transistor and drive circuit will saturate and initiate the latch timing circuit.The capacitor is charged to approximately 1.6V from a 7.2µA (nominal) current source. Exceeding the thermal limit charges the latch capacitor from a larger current source for a near instant shutdown. Once the latch capacitor is charged the device latches off until the latch is reset. Momentarily pull the LATCH pin low, or cycle the power to reset the latch. Cycling the bias power disables the device during the reset operation. Pulling the LATCH pin low immediately enables the device for as long as the LATCH pin is held low plus the time delay to re-charge the latch capacitor whether or not the fault has been corrected. Disable the latch feature by tying the LATCH pin low. With the LATCH pin held low the thermal limit feature is disabled and the current limit feature will force the output voltage to droop but remain active if excessive current is drawn.

GND - Internally connected to ground, this pin should be connected externally by the user to the circuit ground.

V_{OUT} - This is the output pin for the device.

INPUT POWER SUPPLY BYPASSING

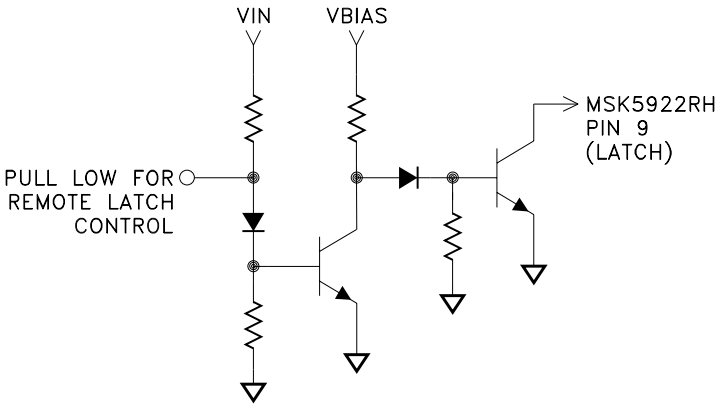
To maximize transient response and minimize power supply transients it is recommended that a 100µF tantalum capacitor is connected between V_{IN} and ground. A 0.1µF ceramic capacitor should also be used for high frequency bypassing.

OUTPUT CAPACITOR SELECTION

Output capacitors are required to maintain regulation and stability. A 220µF surface mount low ESR tantalum capacitor from the output to ground should suffice under most conditions. Ceramic output capacitors should be kept to a minimum (0.1µF typical) and placed directly across the load power connections as close to the load as possible. If the user finds that tighter voltage regulation is needed during output transients, more capacitance may be added. If more capacitance is added to the output, the bandwidth may suffer. See the typical gain and phase curves.

START UP OPTIONS

The MSK 5922RH starts up and begins regulating immediately when VBIAS and VIN are applied simultaneously. Applying VBIAS before VIN starts the MSK 5922RH up in a disabled or latched state. When starting in a latched state the device output can be enabled by pulling the latch pin low to drain the latch capacitor. Hold the latch pin low and release after VIN comes up to ensure automatic startup when applying VBIAS before VIN. The basic circuit below can be adapted to a variety of applications for automatic start up when VBIAS rises before VIN.



OVERCURRENT LATCH-OFF/LATCH PIN CAPACITOR SELECTION

As previously mentioned, the LATCH pin provides over current/output short circuit protection with a timed latch-off circuit. Reference the LATCH pin description note. The latch off time out is determined with an external capacitor connected from the LATCH pin to ground. The time-out period is equal to the time it takes to charge this external capacitor from 0V to 1.6V. The latch charging current is provided by an internal current source. This current is a function of bias voltage and temperature (see latch charging current curve). For instance, at 25°C, the latch charging current is 7.2µA at VBIAS = 3V and 8µA at VBIAS = 6.5V.

In the latch-off mode, some additional current will be drawn from the bias supply. This additional latching current is also a function of bias voltage and temperature (see typical performance curves).

The MSK 5922RH current limit function is directly affected by the input and output voltages. Custom current limit is available; contact the factory for more information.

APPLICATION NOTES CONT.

THERMAL LIMITING

The MSK 5922RH control circuitry has a thermal shutdown temperature of approximately 150°C. This thermal shutdown can be used as a protection feature, but for continuous operation, the junction temperature of the pass transistor must be maintained below 150°C. Proper heat sink selection is essential to maintain these conditions. Exceeding the thermal limit activates the latch feature of the MSK 5922RH. Momentarily pull the latch pin low or cycle the power to reset the latch.

HEAT SINK SELECTION

To select a heat sink for the MSK 5922RH, the following formula for convective heat flow may be used.

Governing Equation:

$$T_J = P_D \times (R_{\theta JC} + R_{\theta CS} + R_{\theta SA}) + T_A$$

Where

T_J = Junction Temperature
P_D = 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
T_A = Ambient Temperature

$$\text{Power Dissipation} = (V_{IN}\text{-}V_{OUT}) \times I_{OUT}$$

Next, the user must select a maximum junction temperature. The absolute maximum allowable junction temperature is 150°C. The equation may now be rearranged to solve for the required heat sink to ambient thermal resistance ($R_{\theta SA}$).

Example:

An MSK 5922-2.5RH is connected for V_{IN} = +3.3V and V_{OUT} = +2.5V. I_{OUT} is a continuous 3A DC level. The ambient temperature is +25°C. The maximum desired junction temperature is +125°C.

$R_{\theta JC}$ = 3.0°C/W and $R_{\theta CS}$ = 0.15°C/W for most thermal greases

$$\text{Power Dissipation} = (3.3V\text{-}2.5V) \times (3A)$$
$$= 2.4 \text{ Watts}$$

Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C - 25°C}{2.4W}\right] - 3.0°C/W - 0.15°C/W$$

$$= 38.5°C/W$$

In this example, a heat sink with a thermal resistance of no more than 38°C/W must be used to maintain a junction temperature of no more than 125°C.

TYPICAL APPLICATIONS CIRCUIT

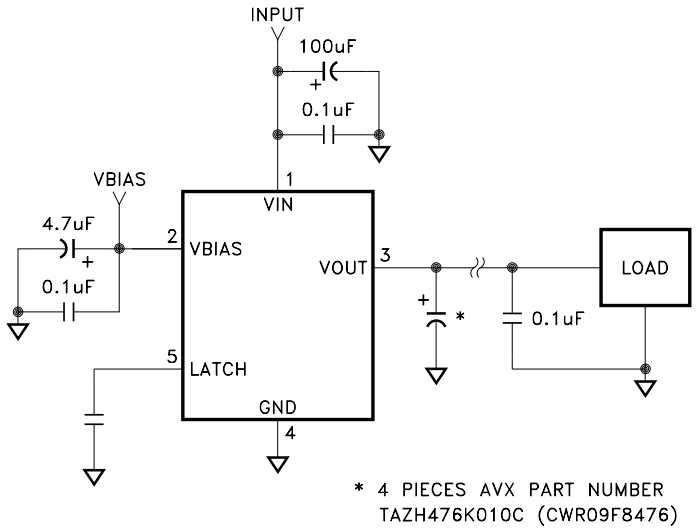


FIGURE 2

TOTAL DOSE RADIATION TEST PERFORMANCE

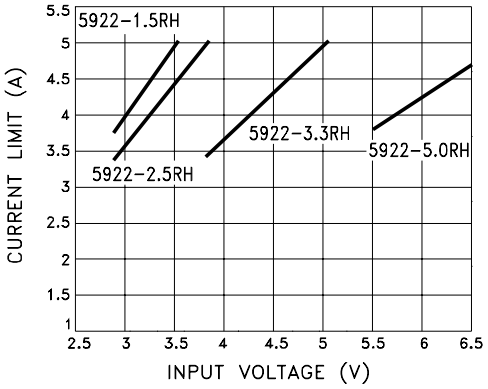
The MSK 5922RH is nearly identical to the MSK 5920RH. It is manufactured with the same materials and component lots that are used in and have been TID tested in the MSK 5920RH. The MSK5920RH TID radiation report is used to provide TID characterization data fo the MSK 5922RH.

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 MSK 5920RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

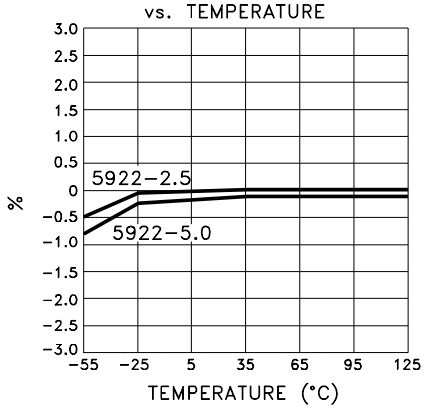
http://www.mskennedy.com/store.asp?pid=9951&catid=19680

TYPICAL PERFORMANCE CURVES

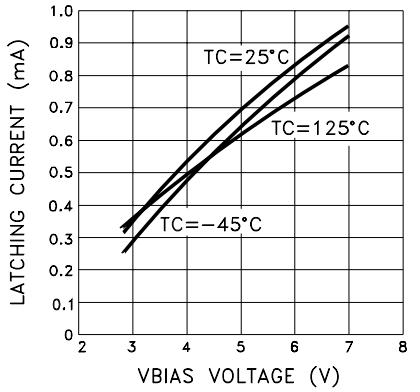
CURRENT LIMIT vs. INPUT VOLTAGE



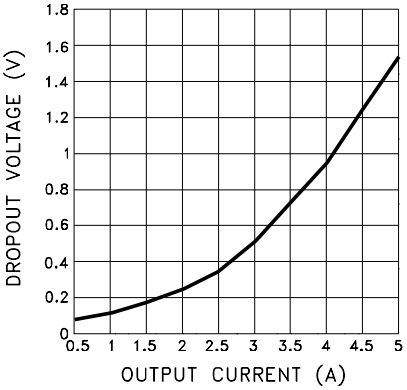
NORMALIZED LOAD REGULATION vs. TEMPERATURE



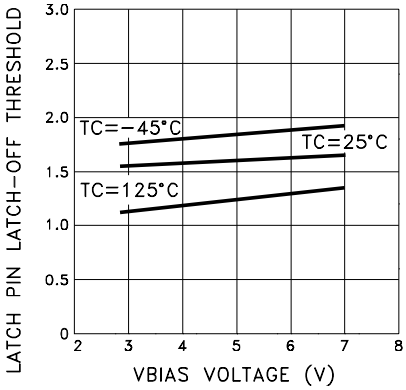
LATCHING CURRENT vs. VBIAS VOLTAGE



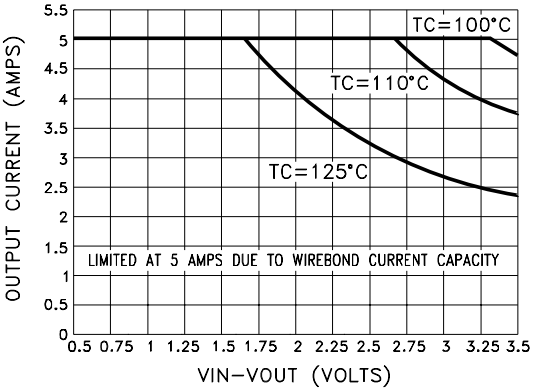
DROPOUT VOLTAGE vs. OUTPUT CURRENT



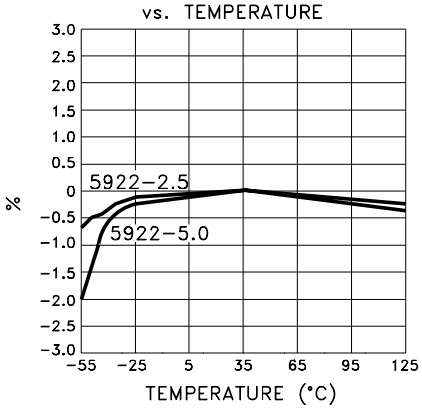
LATCH PIN LATCH-OFF THRESHOLD vs. VBIAS VOLTAGE



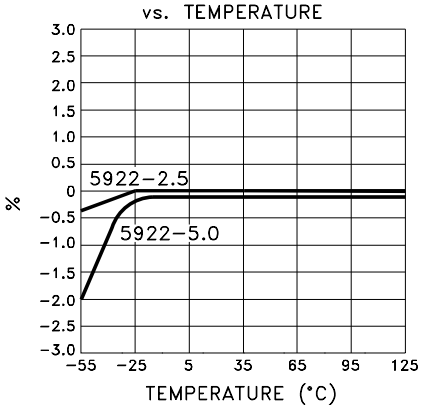
SOA OUTPUT CURRENT vs. VOLTAGE DROP



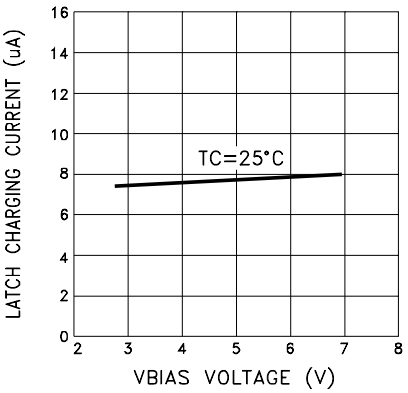
NORMALIZED OUTPUT VOLTAGE vs. TEMPERATURE



NORMALIZED LINE REGULATION vs. TEMPERATURE



LATCH CHARGING CURRENT vs. VBIAS VOLTAGE

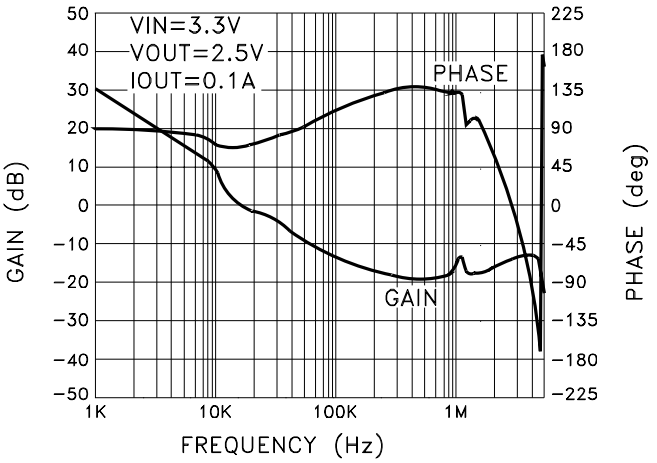


TYPICAL PERFORMANCE CURVES

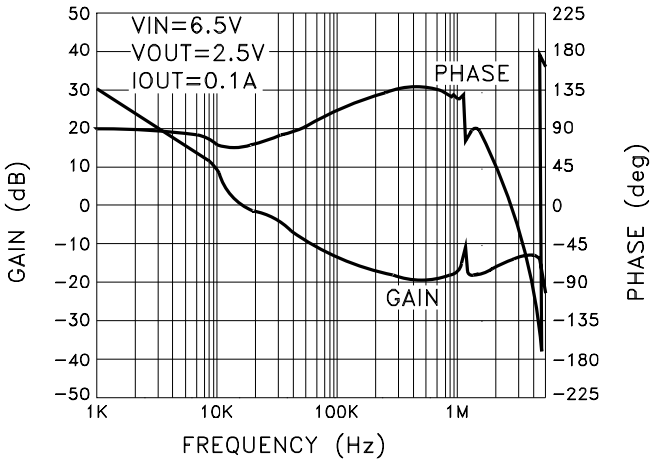
GAIN AND PHASE RESPONSE

The gain and phase response curves are for the MSK typical application circuit and are representative of typical device performance, but are for reference only. The performance should be analyzed for each application to insure individual program requirements are met. External factors such as temperature, input and output voltages, capacitors, etc. all can be major contributors. Please consult factory for additional details.

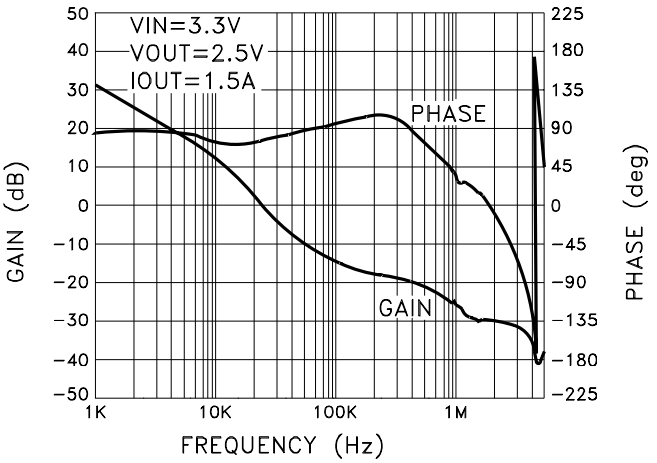
MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



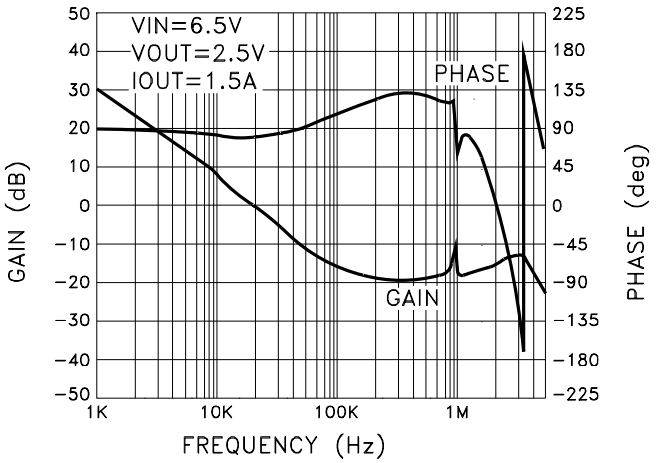
MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



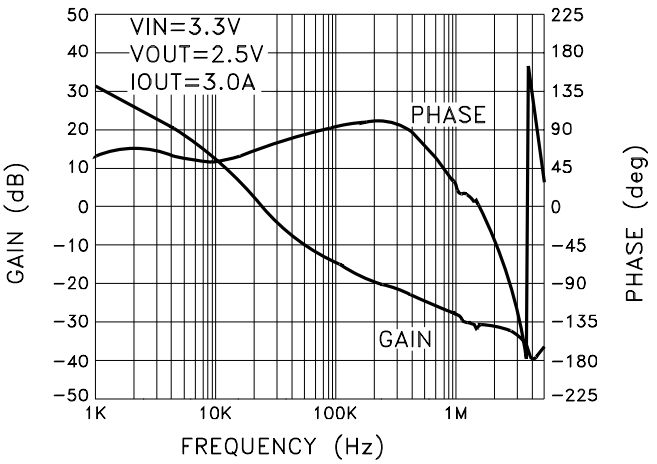
MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



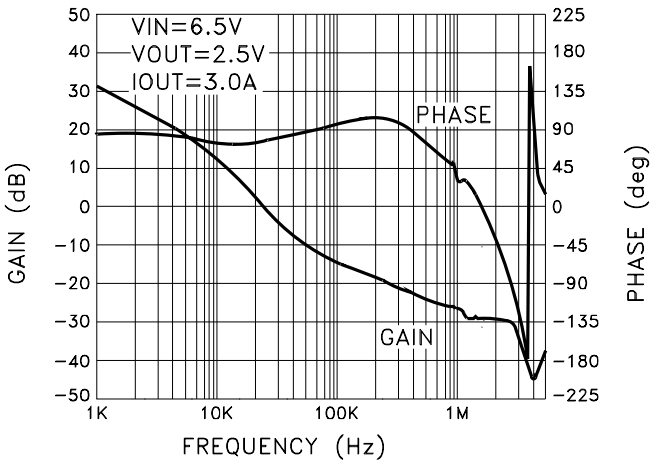
MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



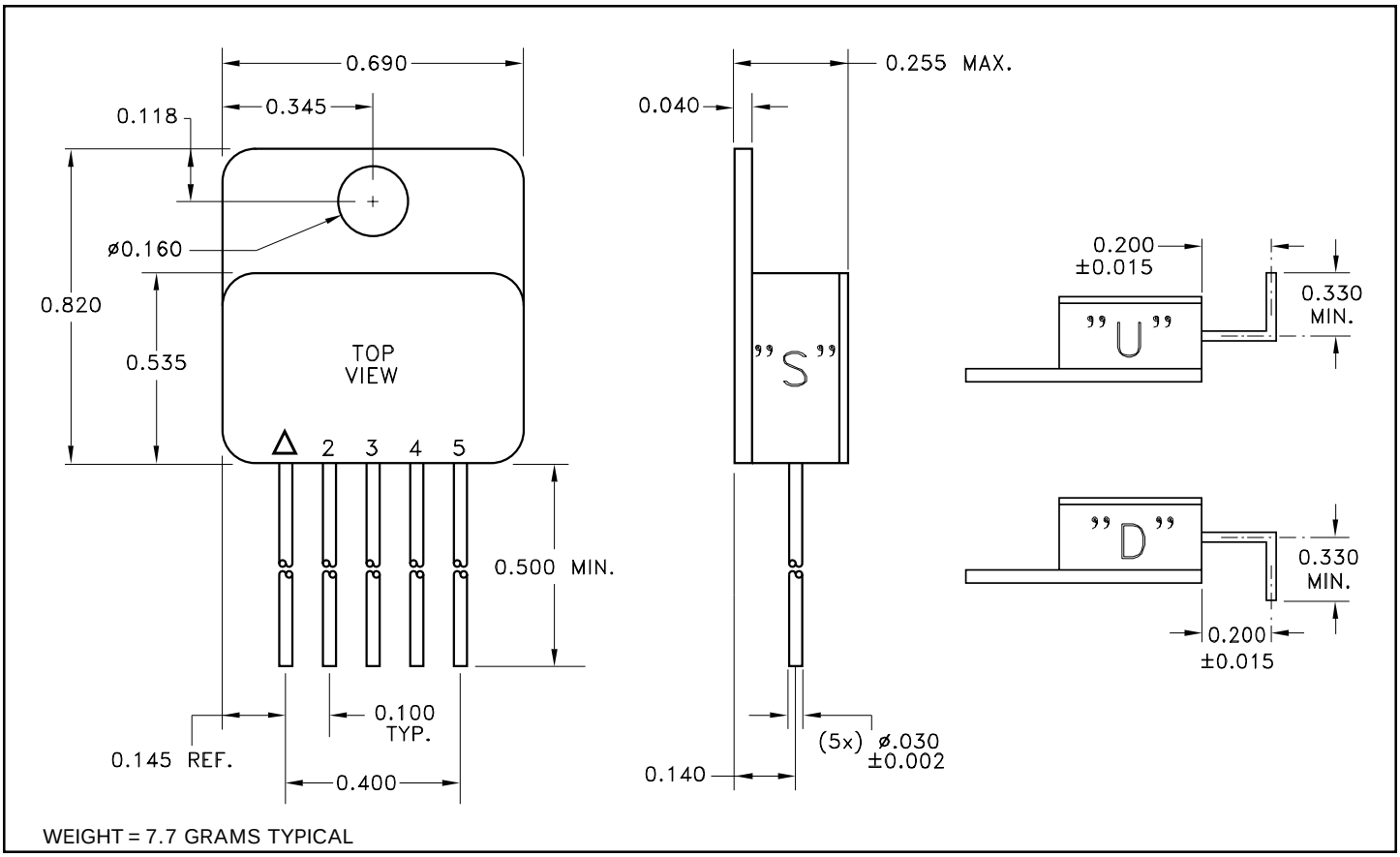
MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



MSK5922–2.5RH GAIN AND PHASE vs. FREQUENCY



MECHANICAL SPECIFICATIONS



WEIGHT = 7.7 GRAMS TYPICAL

ALL DIMENSIONS ARE ± 0.010 INCHES UNLESS OTHERWISE LABELED.
ESD Triangle indicates pin 1.

ORDERING INFORMATION

MSK5922-3.3 K RH U

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

RADIATION HARDENED

SCREENING
BLANK = INDUSTRIAL; E = EXTENDED RELIABILITY
H = MIL-PRF-38534 CLASS H; K = MIL-PRF-38534 CLASS K

OUTPUT VOLTAGE
1.5 = + 1.5V; 1.9 = + 1.9V; 2.5 = + 2.5V; 2.8 = + 2.8V;
3.3 = + 3.3V; 5.0 = + 5.0V

GENERAL PART NUMBER

The above example is a + 3.3V, Class K regulator with leads bent up.

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