MIL-PRF-38534 CERTIFIED

M.S.KENNEDY CORP.

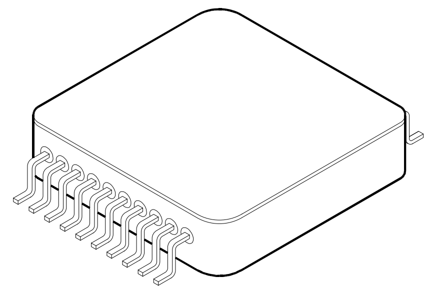
RAD HARD ULTRA LOW DROPOUT ADJUSTABLE POSITIVE LINEAR REGULATOR

5910RH

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

FEATURES:

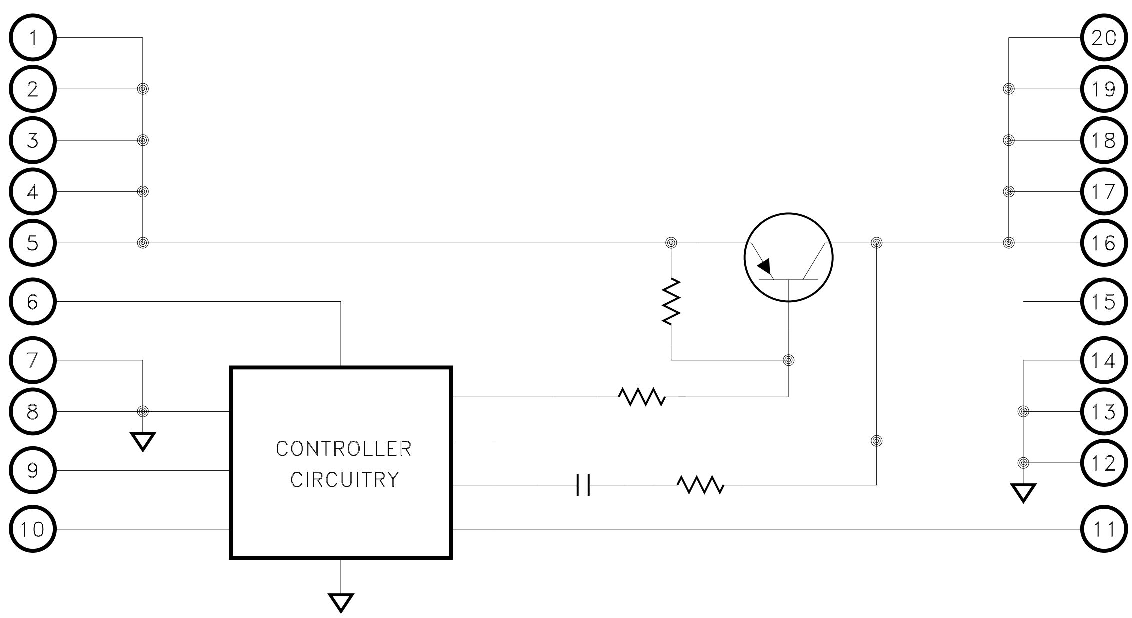
- Total Dose Tested to 300K RAD (Method 1019.7 Condition A)
- Ultra Low Dropout for Reduced Power Consumption
- External Shutdown/Reset Function
- Latching Overload Protection
- Adjustable Output Using Two External Resistors
- Output Current Limit
- Surface Mount Package Available with Lead Forming
- Low Input Voltage for Maximum Efficiency
- Up to 5A Output Current
- Available as SMD 5962R05220
- RAD Certified by DSCC



DESCRIPTION:

The MSK 5910RH is a rad hard adjustable linear regulator capable of delivering 5.0 amps of output current. The typical dropout is only 0.11 volts at 1 amp. An external shutdown/reset function is ideal for power supply sequencing. This device also has latching overload protection that requires no external current sense resistor. The MSK 5910RH is radiation hardened and specifically designed for many space/satellite applications. The device is packaged in a hermetically sealed 20 pin flatpack that can be lead formed for surface mount applications.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

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

PIN-OUT INFORMATION

1	VINA	20	VOUTE
2	VINB	19	VOUTD
3	VINC	18	VOUTC
4	VIND	17	VOUTB
5	VINE	16	VOUTA
6	VBIAS	15	NC
7	GND1	14	GND2
8	GND1	13	GND2
9	Latch	12	GND2
10	Shutdown	11	FB

Rev. O 12/09

ABSOLUTE MAXIMUM RATINGS ⑧

$+V_{BIAS}$	Bias Supply Voltage	10.0V
$+V_{IN}$	Supply Voltage	10.0V
I_{OUT}	Output Current ⑦	5A
T_C	Case Operating Temperature Range	
	MSK5910K/H/E RH	-55°C to +125°C
	MSK5910RH	-40°C to +85°C
T_{ST}	Storage Temperature Range	-65°C to +150°C
T_{LD}	Lead Temperature Range (10 Seconds)	300°C
P_D	Power Dissipation	See SOA Curve
T_C	Junction Temperature	150°C

ELECTRICAL SPECIFICATIONS ⑩

Parameter	Test Conditions ① ⑨	Group A Subgroup	MSK5910K/H/E Min.	MSK5910K/H/E Typ.	MSK5910K/H/E Max.	MSK5910 Min.	MSK5910 Typ.	MSK5910 Max.	Units
Input Voltage Range ②	10mA ≤ I_{OUT} ≤ 1.0A	1,2,3	2.0	-	7.5	2.0	-	7.5	V
Input Bias Voltage ②	V_{BIAS} ≥ V_{IN}	1,2,3	2.9	5.0	7.5	2.9	5.0	7.5	V
Feedback Voltage	I_{OUT} = 1.0A R1 = 187Ω	1	1.225	1.265	1.305	1.202	1.265	1.328	V
		2,3	1.225	-	1.305	-	-	-	V
	Post Radiation	1	1.215	-	1.315	-	-	-	V
Feedback Pin Current ②	V_{FB} = 1.265V 10mA ≤ I_{OUT} ≤ 1.0A	1,2,3	0	-	5.0	0	-	5.0	μA
Quiescent Current	I_{IN} + I_{BIAS}, V_{BIAS} = V_{IN} = 7.5V Not including I_{OUT}	1,2,3	-	14	20	-	14	20	mA
Bias Current	V_{BIAS} = 7.5V	1,2,3	-	2	4	-	2	4	mA
Line Regulation	I_{OUT} = 10mA 2.9V ≤ V_{IN} ≤ 7.5V	1	-	±0.01	±0.50	-	0.01	±0.60	%V_{OUT}
	R1 = 187Ω	2,3	-	-	±0.50	-	-	-	%V_{OUT}
Load Regulation	10mA ≤ I_{OUT} ≤ 1.0A	1	-	±0.06	±0.80	-	0.06	±1.0	%V_{OUT}
	R1 = 976	2,3	-	-	±0.80	-	-	-	%V_{OUT}
Dropout Voltage	Delta FB = 1% I_{OUT} = 1.0A	1	-	0.11	0.40	-	0.11	0.45	V
		2,3	-	0.14	0.40	-	-	-	V
Minimum Output Current ②	2.9V ≤ V_{IN} ≤ 7.5V	1	-	8	10	-	8	10	mA
	R1 = 187Ω	2,3	-	9	10	-	-	-	mA
Output Voltage Range ②	V_{IN} = 7.5V	-	1.5	-	7.0	1.5	-	7.0	V
Output Current Limit ⑦	V_{IN} = 2.5V V_{OUT} = 1.5V	1	3.2	3.6	4.0	3.2	3.6	4.0	A
		2,3	3.0	-	-	-	-	-	A
Shutdown Threshold	V_{OUT} ≤ 0.2V (OFF)	1	1.0	1.3	1.6	1.0	1.3	1.6	V
	V_{OUT} = Nominal (ON)	2,3	1.0	1.3	1.6	-	-	-	V
Shutdown Hysteresis	Difference between voltage	1	-	0.02	0.2	-	0.02	0.2	V
	threshold of V_{SDI} (ON) and V_{SDI} (OFF)	2,3	-	0.03	0.2	-	-	-	V
Ripple Rejection ②	f = 1KHz to 10KHz	4	20	-	-	20	-	-	dB
	10mA ≤ I_{OUT} ≤ 1.0A 1.0V = V_{IN}-V_{OUT}	5,6	20	-	-	-	-	-	dB
Phase Margin ②	I_{OUT} = 450mA	4,5,6	30	80	-	30	80	-	degrees
Gain Margin ②	I_{OUT} = 45OmA	4,5,6	10	30	-	10	30	-	dB
Equivalent Noise Voltage ②	Referred to Feedback Pin	4,5,6	-	-	50	-	-	50	μV_{RMS}
Thermal Resistance ②	Junction to Case @ 125°C Output Device	-	-	7.3	8.4	-	7.3	9.0	°C/W

NOTES:

① Unless otherwise specified, V_{BIAS} = V_{IN} = 5.0V, R1 = 1.62K, $V_{SHUTDOWN}$ = 0V and I_{OUT} = 10mA. I_{OUT} is subtracted from I_Q measurement. See typical application 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" 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 T_C = +25°C
Subgroup 2,5 T_C = +125°C
Subgroup 3,6 T_A = -55°C
⑦ Output current limit is tested with a low duty cycle pulse to minimize junction heating and is dependent on the values of V_{IN}, V_{OUT} and case temperature. See Typical Performance Curves.
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 100Krad TID, are identical unless otherwise specified.
Reference DSCC SMD 5962R05220 for electrical specifications for devices purchased as such.

APPLICATION NOTES

PIN FUNCTIONS

VIN A,B,C,D,E - These pins provide the input power connection to the MSK 5910RH. This is the supply that will be regulated to the output. All five pins must be connected for proper operation.

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 7.5V. VBIAS should be kept greater than or equal to VIN.

GND1 - Internally connected to input ground, these pins should be connected externally by the user to the circuit ground and the GND2 pins.

LATCH - The MSK 5910RH 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. The capacitor is charged to approximately 1.6V from a 7.2µA (nominal) current source. Exceeding the thermal limit will charge 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, toggle the shutdown pin high then low or cycle the power to reset the latch. Toggling the shutdown pin or cycling the bias power both disable the device during the reset operation (see SHUTDOWN pin description). 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.

SHUTDOWN - There are two functions to the SHUTDOWN pin. It may be used to disable the output voltage or to reset the LATCH pin. To activate the shutdown/reset functions the user must apply a voltage greater than 1.3V to the SHUTDOWN pin. The output voltage will turn on when the SHUTDOWN pin is pulled below the threshold voltage. If the SHUTDOWN pin is not used, it should be connected to ground.

FB - The FB pin is the inverting input of the internal error amplifier. The non-inverting input is connected to an internal 1.265V reference. This error amplifier controls the drive to the output transistor to force the FB pin to 1.265V. An external resistor divider is connected to the output, FB pin and ground to set the output voltage.

GND2 - Internally connected to output ground, these pins should be connected externally by the user to the circuit ground and the GND1 pins.

VOUT A,B,C,D,E - These are the output pins for the device. All five pins must be connected for proper operation.

OUTPUT CAPACITOR SELECTION

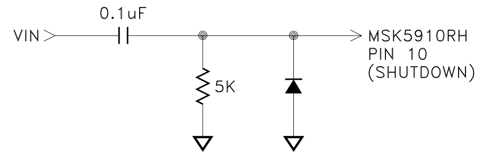
Typically, large bulk capacitance is required at the output of a linear regulator to maintain good load transient response. However, with the MSK 5910RH this is not the case. A 47µF surface mount tantalum capacitor in parallel with a 0.1µF ceramic capacitor from the output to ground should suffice under most conditions. 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 typical gain and phase curves.

POWER SUPPLY BYPASSING

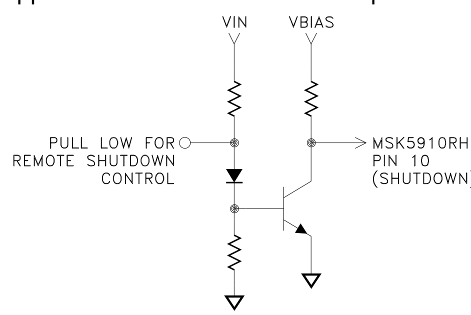
To maximize transient response and minimize power supply transients it is recommended that a 33µF minimum tantalum capacitor is connected between VIN and ground. A 0.1µF ceramic capacitor should also be used for high frequency bypassing.

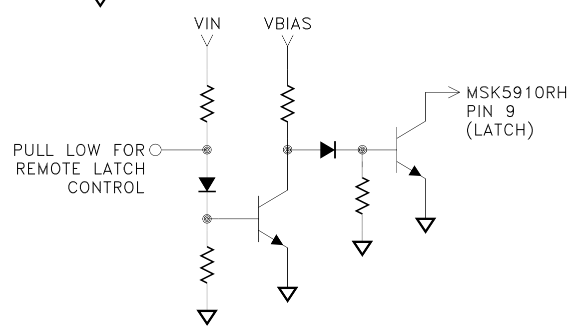
START UP OPTIONS

The MSK 5910RH starts up and begins regulating immediately when VBIAS and VIN are applied simultaneously. Applying VBIAS before VIN starts the MSK 5910RH up in a disabled or latched state. When starting in a latched state the device output can be enabled either by pulling the latch pin low to drain the latch capacitor or pulsing the shutdown pin high. The shutdown pulse duration is partially dependent upon the size of the latch capacitor and should be characterized for each application; 30uS is typically adequate for a 1uF latch capacitor at 25°C. A momentary high pulse on the shutdown pin can be achieved using the RC circuit below if VIN rises rapidly. The resistor and capacitor must be selected based on the required pulse duration, the rise characteristic of VIN and the shutdown pin threshold (see shutdown pin threshold and current curves).



The shutdown pin can be held high and pulled low after VIN comes up or the latch pin held low and released after VIN comes up to ensure automatic startup when applying VBIAS before VIN. Either of the basic circuits 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 = 7V.

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 5910RH 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 5910RH 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 5910RH. See LATCH pin description for instructions to reset the latch or disable the latch feature.

HEAT SINK SELECTION

To select a heat sink for the MSK 5910RH, 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

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

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 5910RH is connected for V_{IN} = +5V and V_{OUT} = +3.3V. I_{OUT} is a continuous 1A DC level. The ambient temperature is +25°C. The maximum desired junction temperature is +125°C.

$R_{\theta JC}$ = 8.5°C/W and $R_{\theta CS}$ = 0.15°C/W for most thermal greases

$$\text{Power Dissipation} = (5V - 3.3V) \times (1A) = 1.7\text{Watts}$$

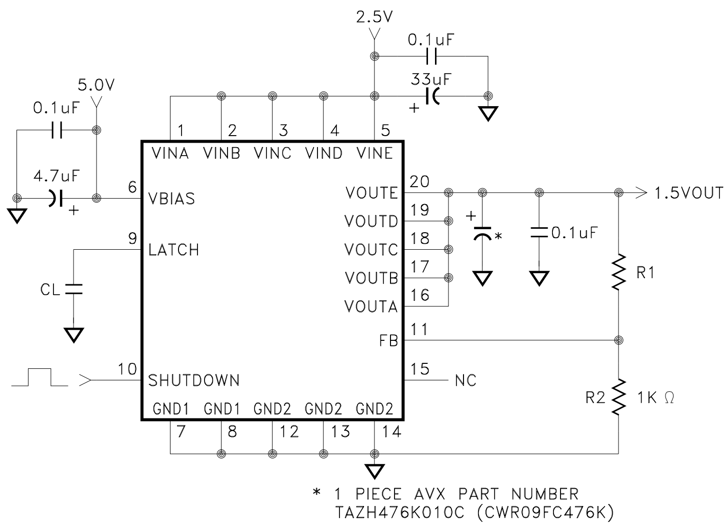
Solve for $R_{\theta SA}$:

$$R_{\theta SA} = \left[\frac{125°C - 25°C}{1.7W}\right] - 8.4°C/W - 0.15°C/W$$

$$= 50.3°C/W$$

In this example, a heat sink with a thermal resistance of no more than 50°C/W must be used to maintain a junction temperature of no more than 125°C.

TYPICAL APPLICATIONS CIRCUIT



$V_{OUT} = 1.265(1 + R1/R2)$

OUTPUT VOLTAGE SELECTION

As noted in the above typical applications circuit, the formula for output voltage selection is

$$V_{OUT} = 1.265\left[1 + \frac{R1}{R2}\right]$$

A good starting point for this output voltage selection is to set R2 = 1K. By rearranging the formula it is simple to calculate the final R1 value.

$$R1 = R2\left[\frac{V_{OUT}}{1.265} - 1\right]$$

Table 1 below lists some of the most probable resistor combinations based on industry standard usage.

TABLE 1

OUTPUT VOLTAGE (V)	R2 (Ω)	R1 (nearest 1%) (Ω)
1.5	1K	187
1.8	1K	422
2.0	1K	576
2.5	1K	976
2.8	1K	1.21K
3.3	1K	1.62K
4.0	1K	2.15K
5.0	1K	2.94K

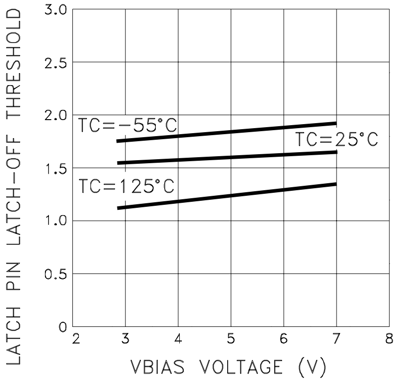
TOTAL DOSE RADIATION TEST PERFORMANCE

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 MSK 5910RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the MSK website.

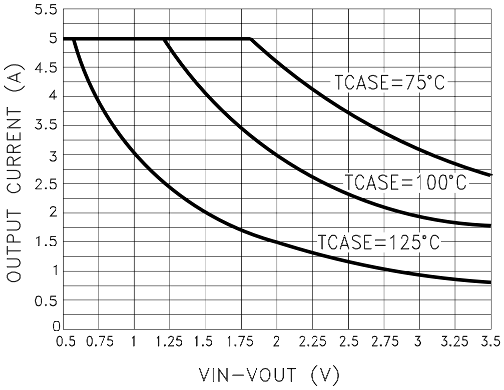
http://www.mskennedy.com/store.asp?pid=9951&catid=19680

TYPICAL PERFORMANCE CURVES

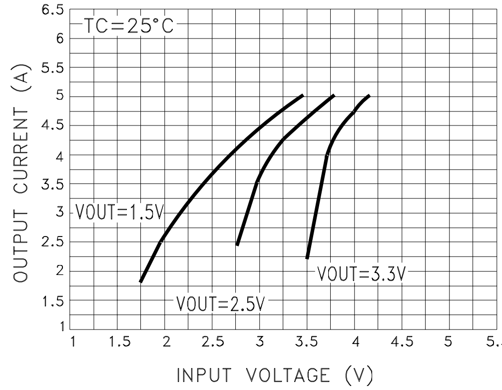
LATCH PIN LATCH-OFF THRESHOLD vs. VBIAS VOLTAGE



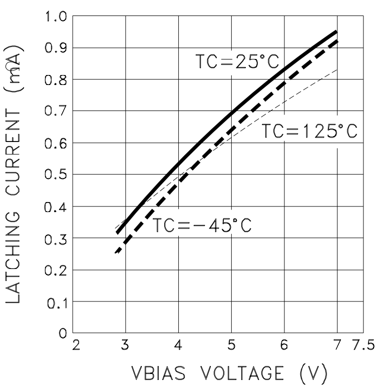
SOA OUTPUT CURRENT vs. VOLTAGE DROP



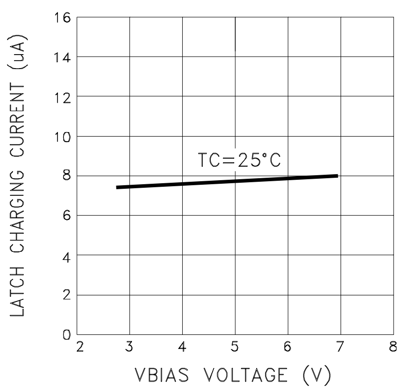
CURRENT LIMIT vs. INPUT VOLTAGE



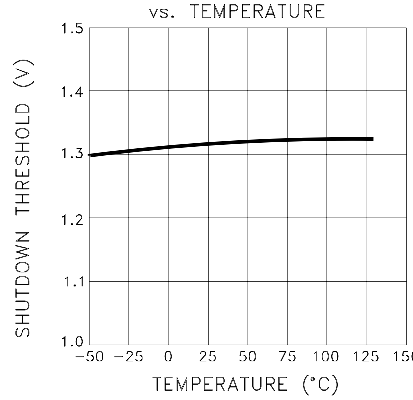
LATCHING CURRENT vs. VBIAS VOLTAGE



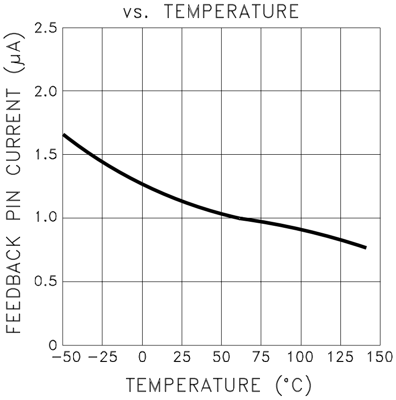
LATCH CHARGING CURRENT vs. VBIAS VOLTAGE



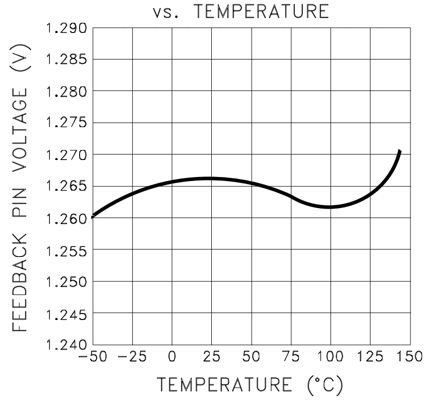
SHUTDOWN VOLTAGE THRESHOLD vs. TEMPERATURE



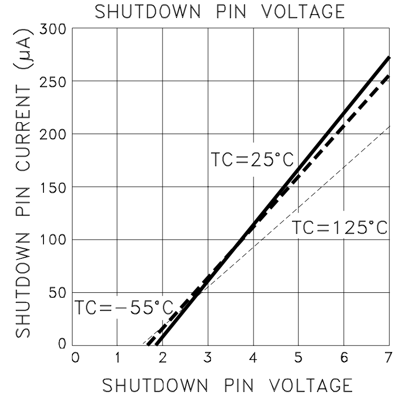
FEEDBACK PIN BIAS CURRENT vs. TEMPERATURE



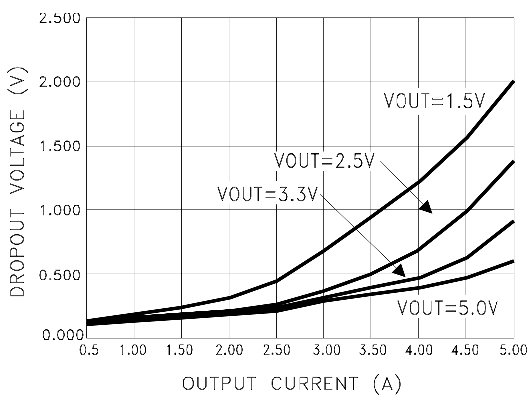
FEEDBACK PIN VOLTAGE vs. TEMPERATURE



SHUTDOWN PIN CURRENT vs. SHUTDOWN PIN VOLTAGE



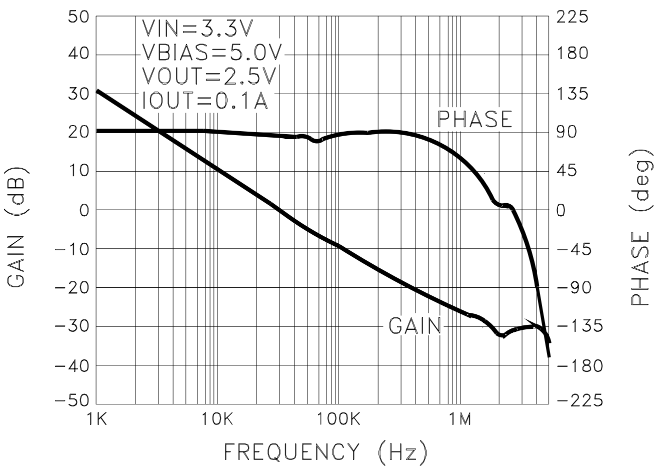
DROPOUT VOLTAGE vs. OUTPUT CURRENT



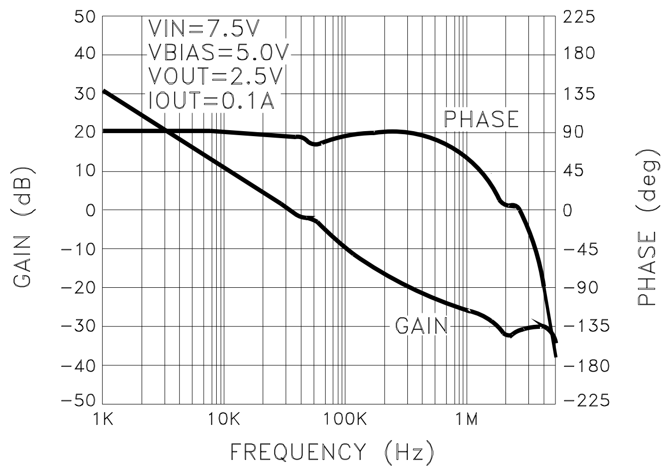
GAIN AND PHASE RESPONSE

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.

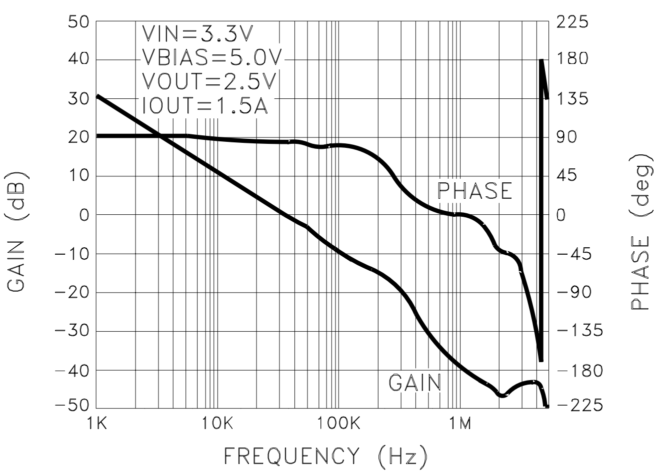
MSK5910RH GAIN AND PHASE vs. FREQUENCY



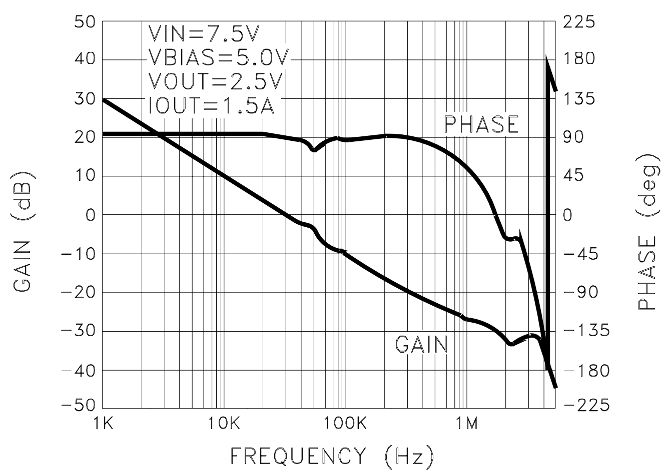
MSK5910RH GAIN AND PHASE vs. FREQUENCY



MSK5910RH GAIN AND PHASE vs. FREQUENCY



MSK5910RH GAIN AND PHASE vs. FREQUENCY



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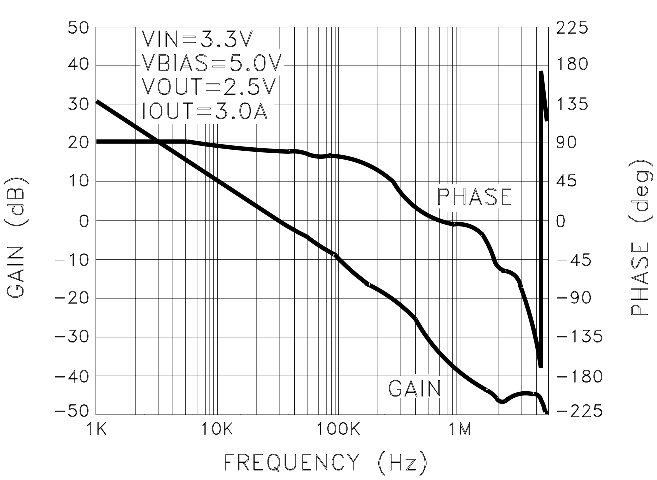
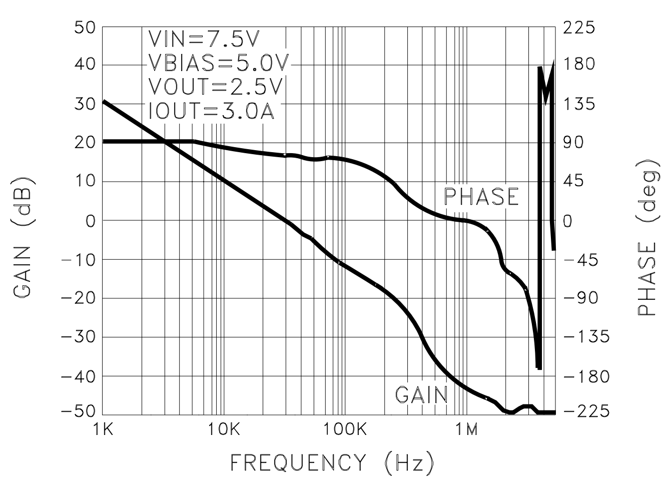
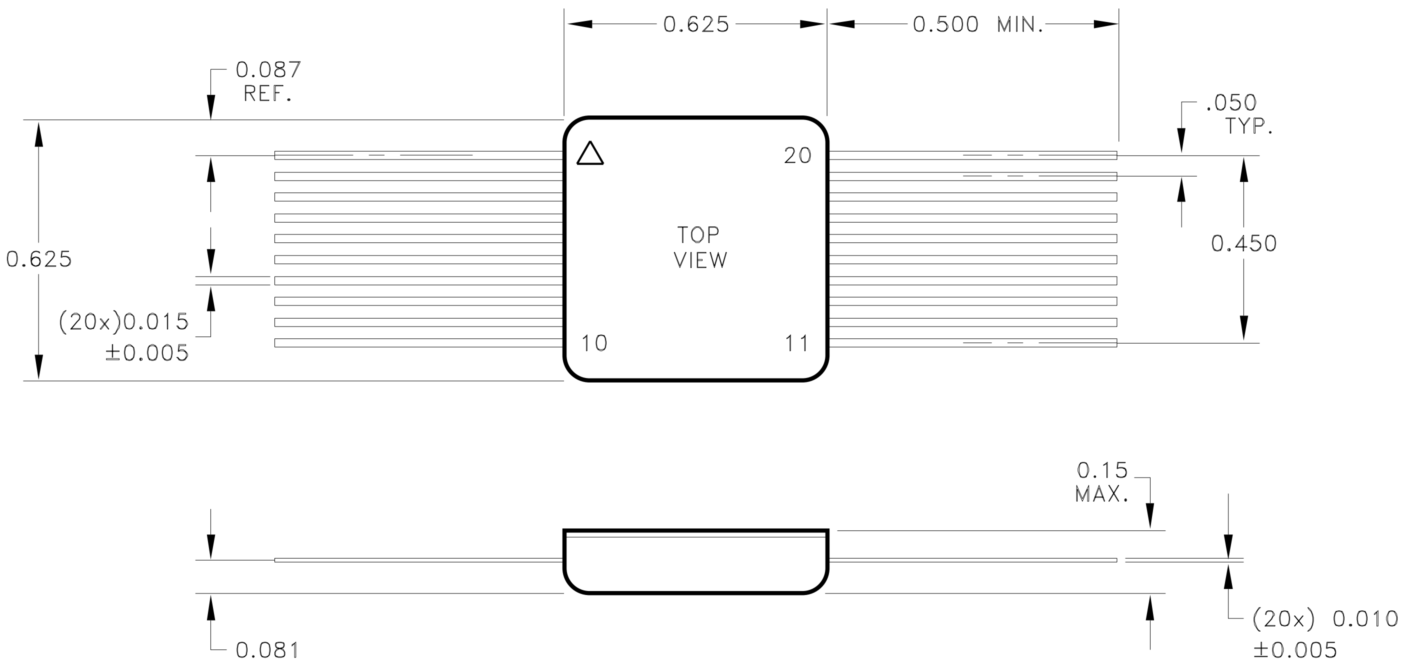


MSK5910RH GAIN AND PHASE vs. FREQUENCY



MECHANICAL SPECIFICATIONS

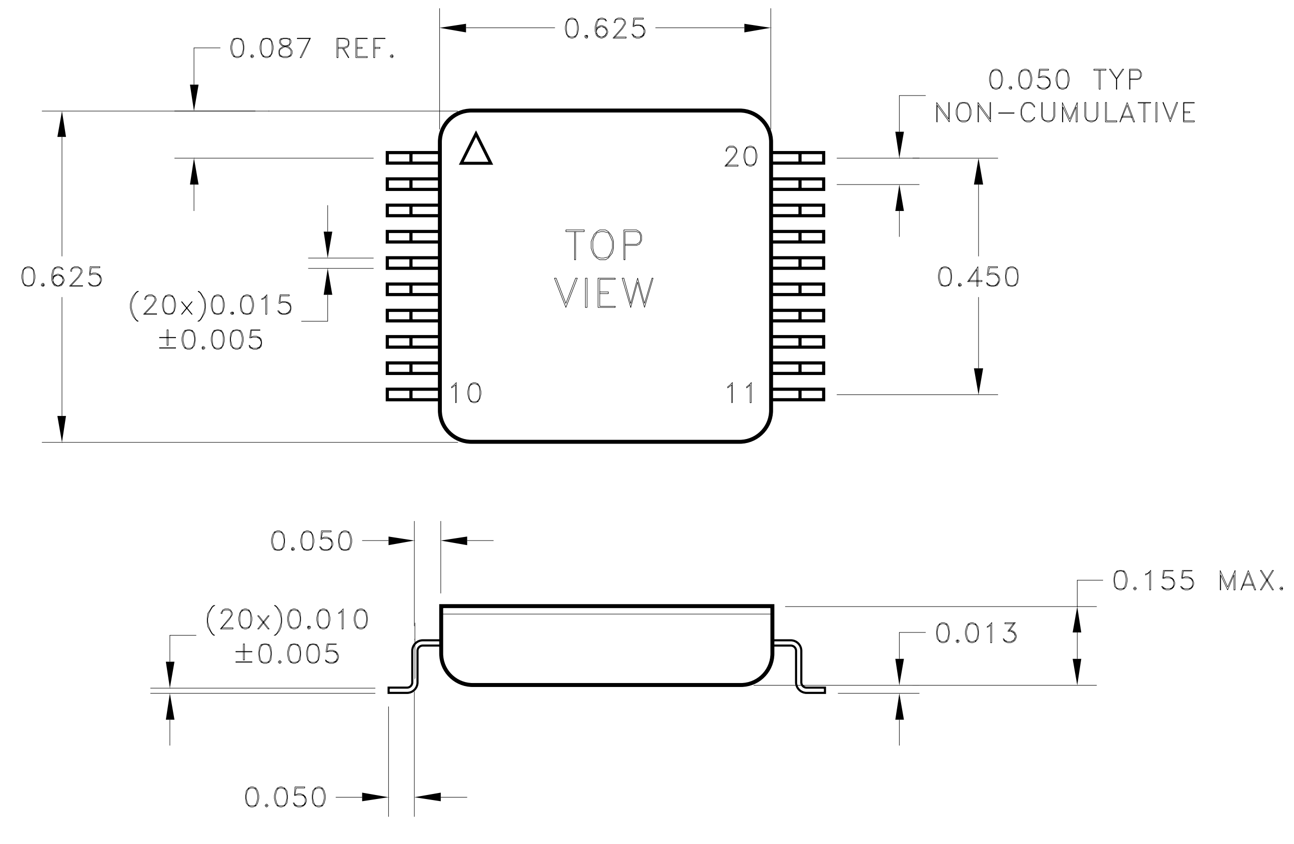


WEIGHT = 3.5 GRAMS TYPICAL

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

ORDERING INFORMATION

PART NUMBER	SCREENING LEVEL	LEADS
MSK5910RH	INDUSTRIAL	STRAIGHT
MSK5910ERH	EXTENDED RELIABILITY	
MSK5910HRH	MIL-PRF-38534 CLASS H	
MSK5910KRH	MIL-PRF-38534 CLASS K	
5962R05220	DSCC SMD	



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

ORDERING INFORMATION

PART NUMBER	SCREENING LEVEL	LEADS
MSK5910RHG	INDUSTRIAL	GULL WING
MSK5910ERHG	EXTENDED RELIABILITY	
MSK5910HRHG	MIL-PRF-38534 CLASS H	
MSK5910KRHG	MIL-PRF-38534 CLASS K	
5962R05220	DSCC SMD	

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