ISO 9001 CERTIFIED BY DSCC

M.S KENNEDY CORP.

RADIATION HARDENED HIGH POWER OP-AMP

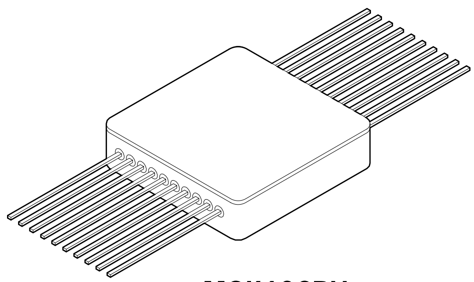
106RH

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

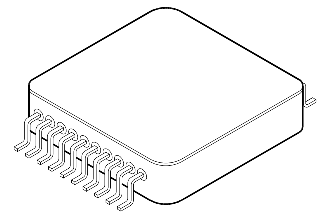
MIL-PRF-38534 CERTIFIED

FEATURES:

- Total Dose Rated to 100K Rad
- High Output Current - 2 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- Rad Hard Design
- Output Short Circuit Capability
- Replacement for MSK0021FP
- Available as SMD #TBD



MSK106RH

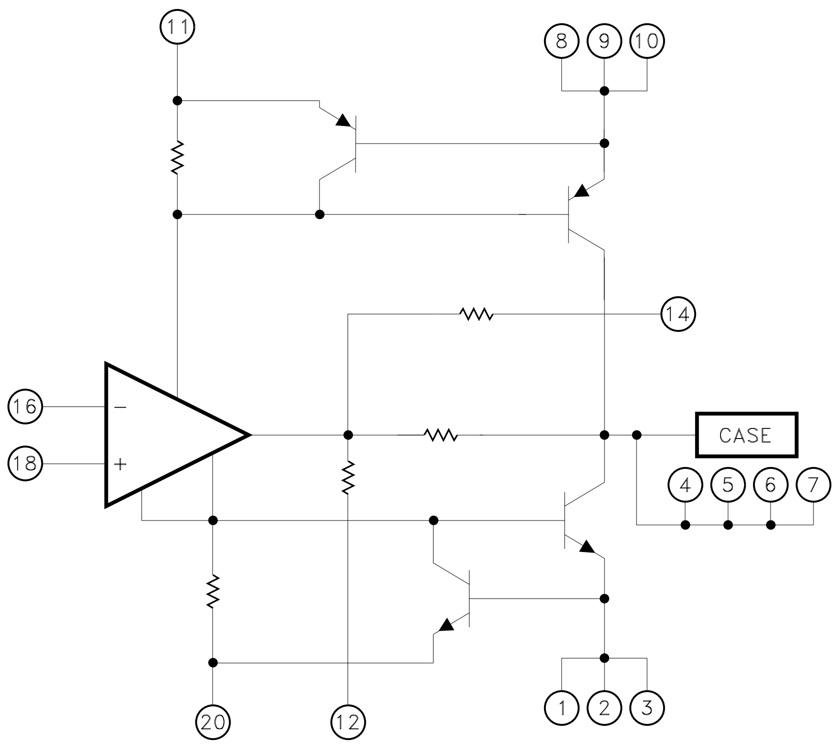


MSK106RHG

DESCRIPTION:

The MSK 106RH is a Radiation Hardened Class C power operational amplifier. This amplifier offers large output currents, making it an excellent choice for motor drive circuits. The amplifier and load can be protected from fault conditions through the use of internal current limit circuitry that can be user programmed with two external resistors. These devices are also compensated with a single external capacitor. The MSK 106RH is packaged in a 20 pin hermetic metal flatpack that is available with straight or gull wing leads.

EQUIVALENT SCHEMATIC



PIN-OUT INFORMATION

1 ISC-	20 -VCC
2 ISC-	19 NC
3 ISC-	18 +VIN
4 VOUT	17 NC
5 VOUT	16 -VIN
6 VOUT	15 NC
7 VOUT	14 Compensation
8 ISC+	13 NC
9 ISC+	12 GND
10 ISC+	11 +VCC

CASE IS ALSO VOUT

TYPICAL APPLICATIONS

- Servo Amplifier
- Audio Amplifier
- Motor Driver
- Programmable Power Supply

ABSOLUTE MAXIMUM RATINGS ⑨

$\pm V_{CC}$	Supply Voltage	±22V
I_{OUT}	Peak Output Current	.2A
V_{IN}	Differential Input Voltage	±30V
V_{IN}	Common Mode Input Voltage	±15V
R_{TH}	Thermal Resistance. Junction to Case (@ 125°C)	6.0°C/W
T_{ST}	Storage Temperature Range	-65° to +150°C
T_{LD}	Lead Temperature Range (10 Seconds)	300°C
T_J	Junction Temperature	150°C
T_C	Case Operating Temperature Range	
	Military Versions (K/H/E)	-55°C to +125°C
	Industrial Versions	-40°C to +85°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ⑧	Group A Subgroup	Military ⑤ Min.	Military ⑤ Typ.	Military ⑤ Max.	Industrial ④ Min.	Industrial ④ Typ.	Industrial ④ Max.	Units
STATIC									
Supply Voltage Range ②		-	±5	±15	±22	±5	±15	±22	V
Quiescent Current	V_{IN} = 0V	1	-	±1.7	±3.5	-	±1.7	±4.0	mA
		2,3	-	-	±7.5	-	-	-	mA
Power Consumption ②	V_{IN} = 0V	1,2,3	-	75	225	-	75	225	mW
INPUT									
Input Offset Voltage	V_{IN} = 0V	1	-	±0.5	±3.0	-	±0.5	±5.0	mV
		2,3	-	±2.0	±5.0	-	-	-	mV
Input Bias Current	V_{CM} = 0V Either Input	1	-	±100	±500	-	±150	±500	nA
		2,3	-	±0.4	±2.0	-	-	-	μA
Input Offset Current	V_{CM} = 0V	1	-	±2.0	±100	-	±2.0	±300	nA
		2,3	-	-	±300	-	-	-	nA
Input Capacitance ③	F=DC	-	-	3	-	-	3	-	pF
Input Resistance ②	F=DC	-	0.3	1.0	-	0.3	1.0	-	MΩ
Common Mode Rejection Ratio	F = 10Hz V_{CM} = ±10V	4	70	90	-	70	90	-	dB
		5,6	70	90	-	-	-	-	dB
Power Supply Rejection Ratio	V_{CC} = ±5V to ±15V	1	80	95	-	80	95	-	dB
		2,3	80	-	-	-	-	-	dB
Input Noise Voltage ③	F = 10Hz to 10KHz	-	-	5	-	-	5	-	μVRMS
OUTPUT									
Output Voltage Swing	R_L = 100Ω F = 100Hz	4	±13.5	±14	-	±13.0	±14	-	V
		5,6	±13.5	±14	-	-	-	-	V
	R_L = 10Ω F = 100Hz	4	±11	±12	-	±10.5	±12	-	V
Output Short Circuit Current	R_{SC} = 0.5Ω V_{OUT} = MAX	4	0.8	1.2	1.6	0.7	1.2	1.7	A
	R_{SC} = 5Ω V_{OUT} = GND	4	50	150	250	50	150	250	mA
Settling Time ③	0.1% 2V step	-	-	4	-	-	4	-	μS
TRANSFER CHARACTERISTICS									
Slew Rate	V_{OUT} = ±10V R_L = 10Ω	4	1.2	1.6	-	1.2	1.6	-	V/μS
Open Loop Voltage Gain	F = 10Hz R_L = 1KΩ	4	100	105	-	100	105	-	dB
		5,6	88	96	-	-	-	-	dB
Transition Times	1V to 2V P Rise and Fall	4	-	0.3	1.0	-	0.3	1.2	μS
Overshoot	1V to 2V P Small Signal		-	5	20	-	5	20	%

NOTES:

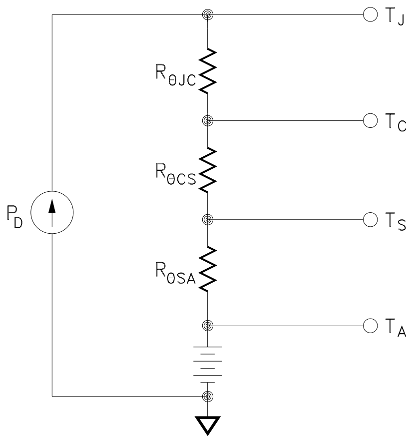
① Unless otherwise specified, $\pm V_{CC}$ = ±15V, C_C = 3000pF.
② Guaranteed by design but not tested.
③ Typical parameters are representative of actual device performance but are for reference only.
④ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
⑤ Military grade devices (K/H suffix) shall be 100% tested to subgroups 1, 2, 3 and 4.
Subgroup 1, 4 T_A = T_C = +25°C
Subgroup 2, 5 T_A = T_C = +125°C
Subgroup 3, 6 T_A = T_C = -55°C
⑥ Reference DSCC SMD TBD for electrical specifications for devices purchased as such.
⑦ Subgroup 5 and 6 testing available upon request.
⑧ For complete radiation test data, consult "MSK 106RH Total Dose Test Report".
⑨ Continuous operation at or above absolute maximum ratings may adversly effect the device performance and/or life cycle.

APPLICATION NOTES

HEAT SINKING

To select the correct heat sink for your application, refer to the thermal model and governing equation below.

Thermal Model:



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_C	=	Case Temperature
T_A	=	Ambient Temperature
T_S	=	Sink Temperature

Example:

In our example the amplifier application requires the output to drive a 10 volt peak sine wave across a 10 ohm load for 1 amp of output current. For a worst case analysis we will treat the 1 amp peak output current as a D.C. output current. The power supplies are ±15 VDC.

1.) Find Power Dissipation
$P_D = [(\text{quiescent current}) \times (+V_{CC} - (V_{CC}))] + [(V_S - V_O) \times I_{OUT}]$
$= (3.5\text{ mA}) \times (30V) + (5V) \times (1A)$
$= 0.1W + 6W$
$= 6.1W$
2.) For conservative design, set $T_J = +125°C$.
3.) For this example, worst case $T_A = +25°C$.
4.) $R_{\theta JC} = 6.0°C/W$
5.) Rearrange governing equation to solve for $R_{\theta SA}$:
$R_{\theta SA} = (T_J - T_A) / P_D - (R_{\theta JC}) - (R_{\theta CS})$
$= (125°C - 25°C) / 6.1W - (6.0°C/W) - (0.15°C/W)$
$= 10.2°C/W$

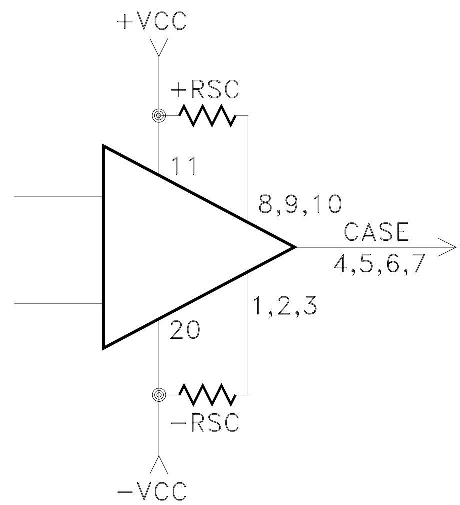
The heat sink in this example must have a thermal resistance of no more than 10.2°C/W to maintain a junction temperature of less than +125°C.

CURRENT LIMIT

The MSK 106RH has an on-board current limit scheme designed to limit the output drivers anytime output current exceeds a predetermined limit. The following formula may be used to determine the value of the current limit resistance necessary to establish the desired current limit.

$$Rsc = \frac{0.7}{Isc}$$

Current Limit Connection

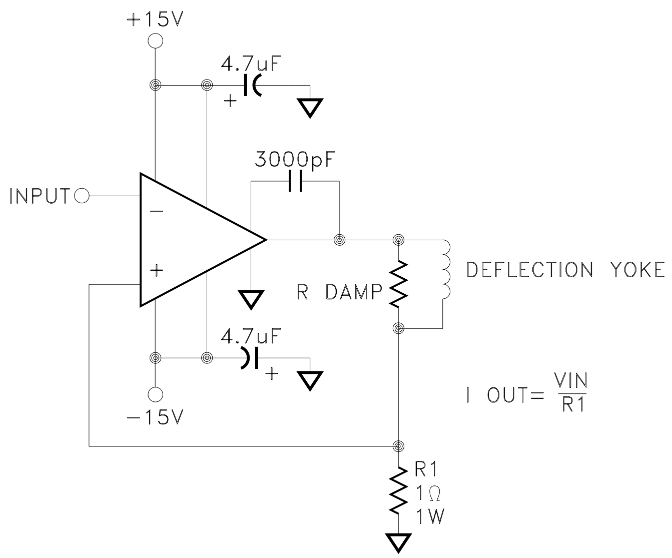


See "Application Circuits" in this data sheet for additional information on current limit connections.

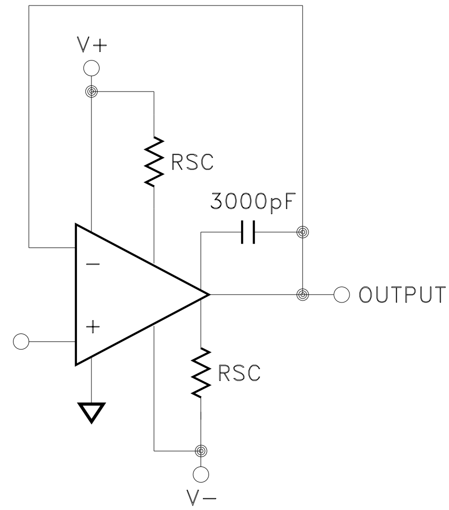
POWER SUPPLY BYPASSING

Both the negative and the positive power supplies must be effectively decoupled with a high and low frequency bypass circuit to avoid power supply induced oscillation. An effective decoupling scheme consists of a 0.1 microfarad ceramic capacitor in parallel with a 4.7 microfarad tantalum capacitor from each power supply pin to ground. It is also a good practice with high power op-amps, such as the MSK 106RH, to place a 30-50 microfarad capacitor with a low effective series resistance, in parallel with the other two power supply decoupling capacitors. This capacitor will eliminate any peak output voltage clipping which may occur due to poor power supply load regulation. All power supply decoupling capacitors should be placed as close to the package power supply pins as possible.

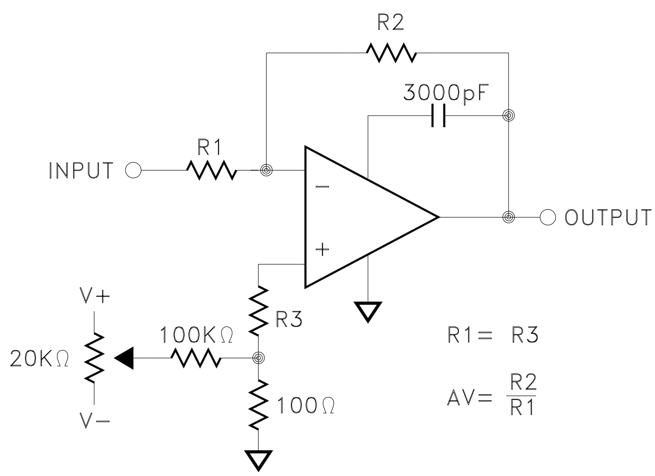
APPLICATION CIRCUITS



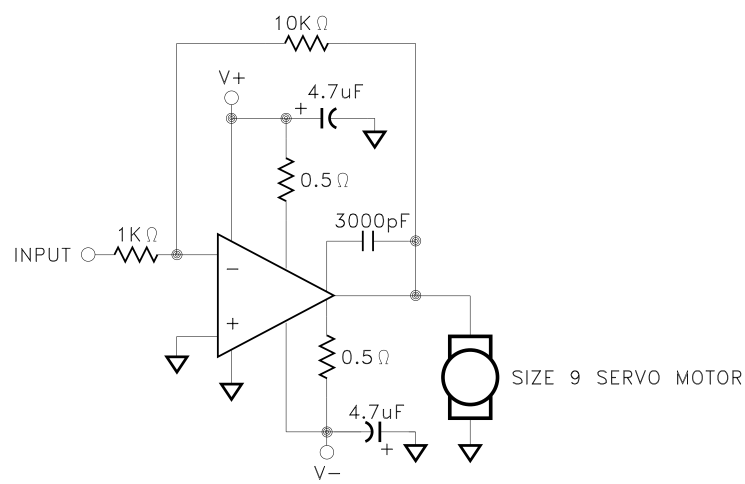
CRT DEFLECTION YOKE DRIVER



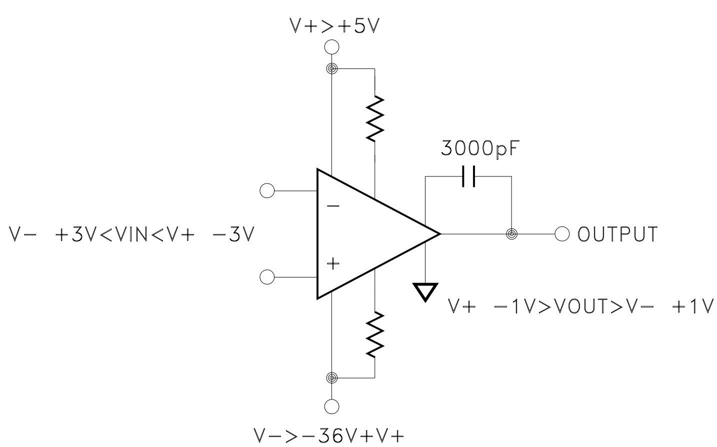
UNITY GAIN CIRCUIT WITH SHORT CIRCUIT LIMITING



OFFSET VOLTAGE NULL CIRCUIT

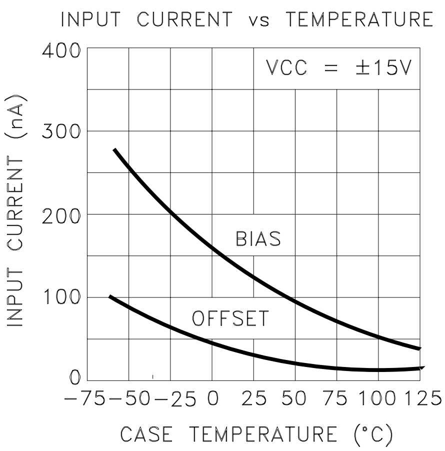


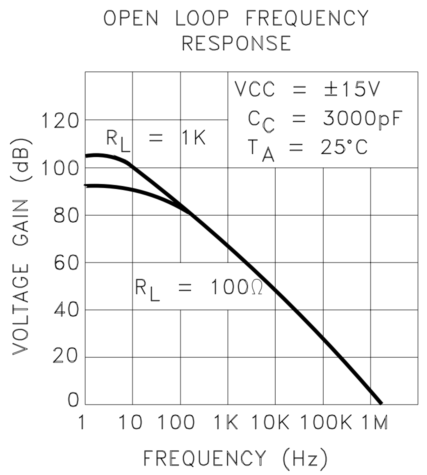
DC SERVO AMPLIFIER

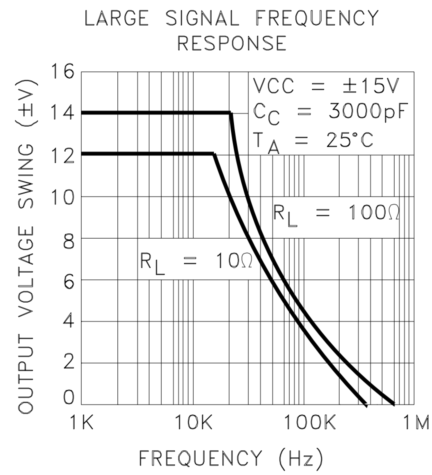


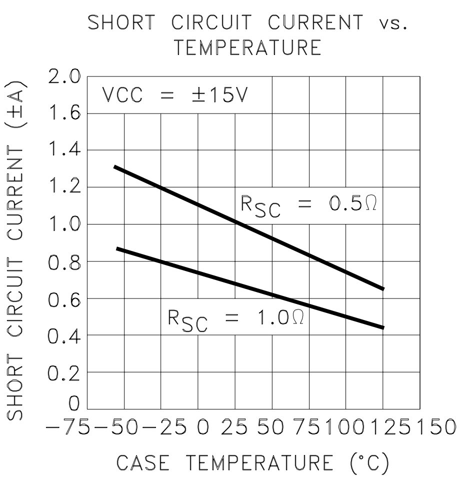
NON SYMMETRICAL SUPPLIES

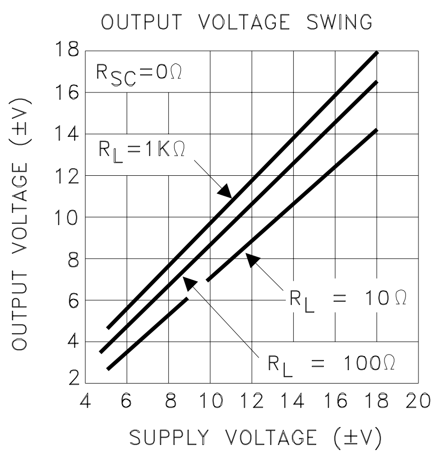
TYPICAL PERFORMANCE CURVES

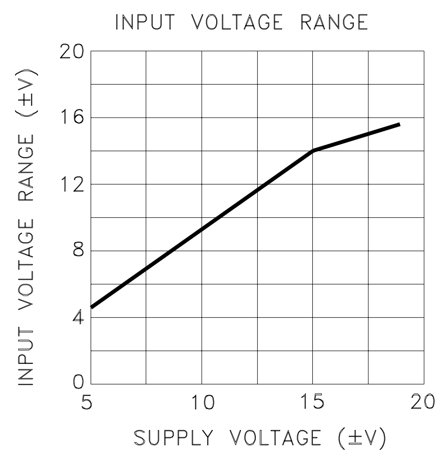


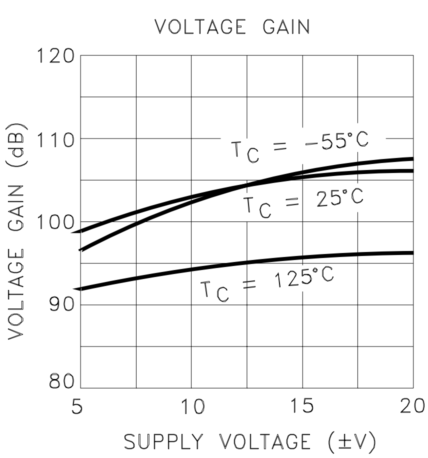


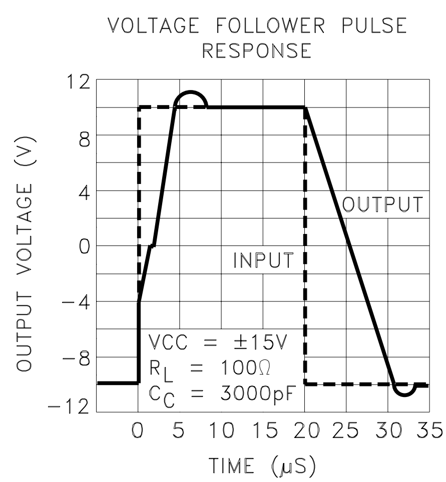






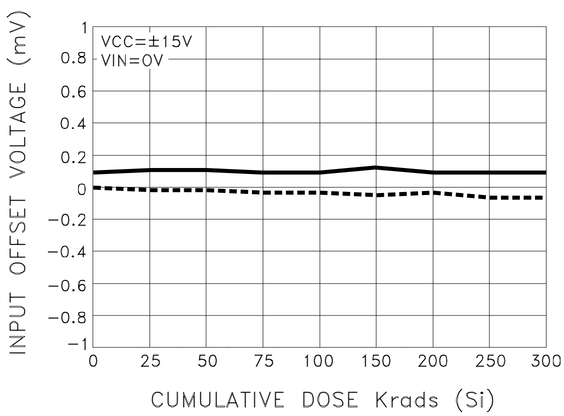




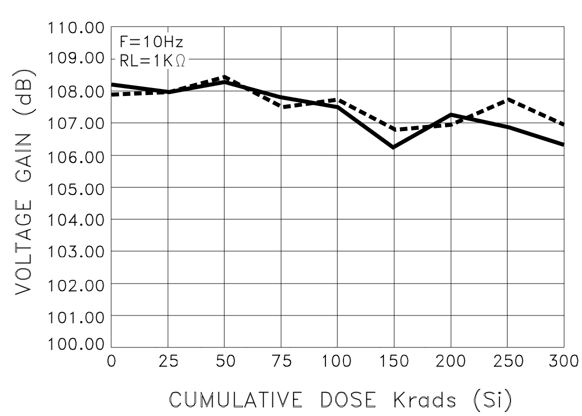


RADIATION PERFORMANCE CURVES

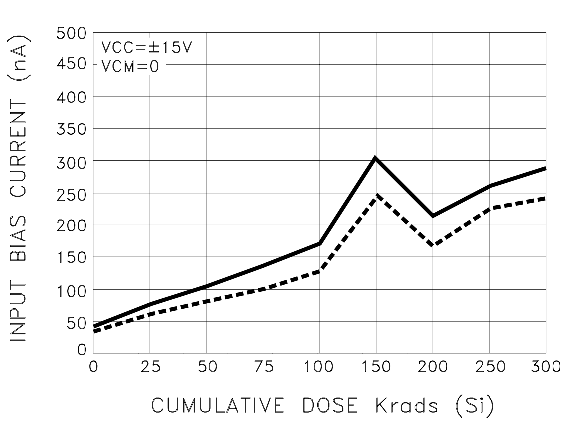
INPUT OFFSET VOLTAGE



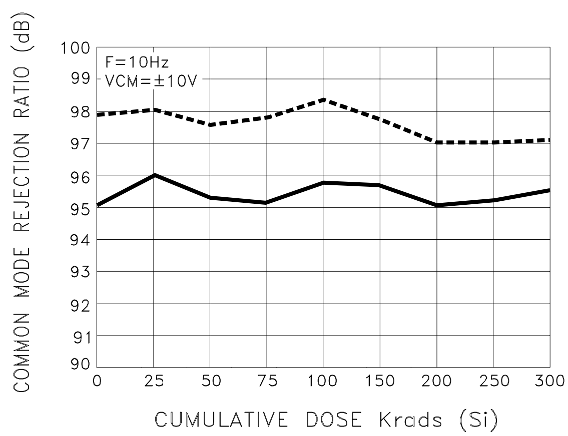
VOLTAGE GAIN



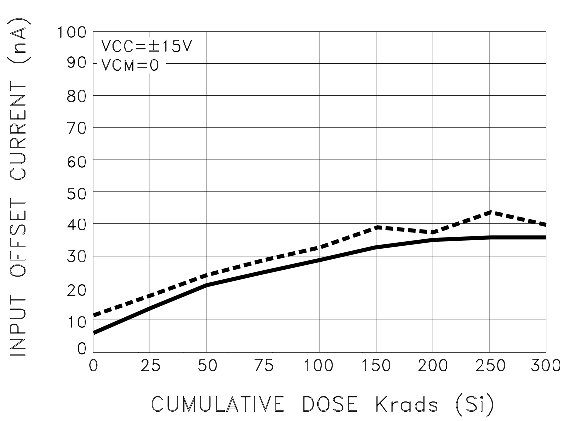
INPUT BIAS CURRENT



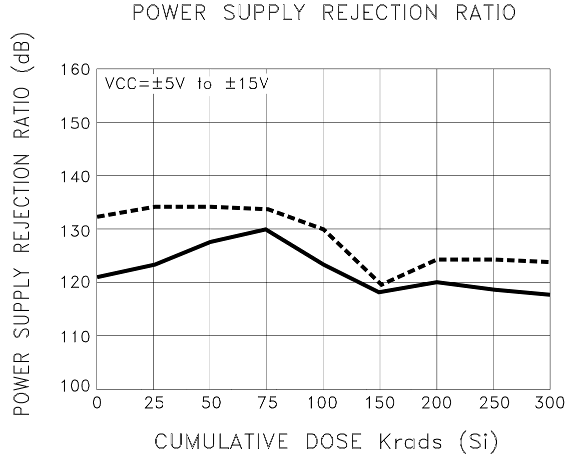
COMMON MODE REJECTION RATIO



INPUT OFFSET CURRENT



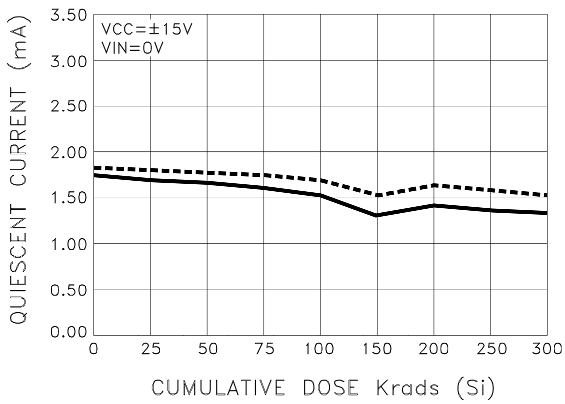
POWER SUPPLY REJECTION RATIO



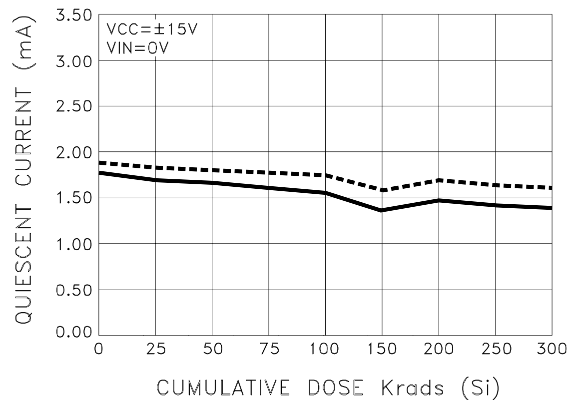
—— AVERAGE BIASED
- - - - AVERAGE UNBIASED

RADIATION PERFORMANCE CURVES CONT'D

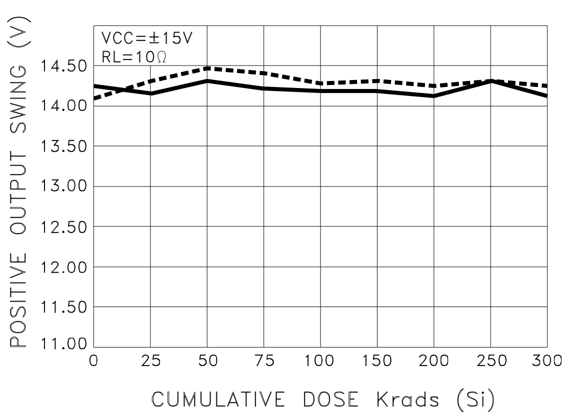
POSITIVE QUIESCENT CURRENT



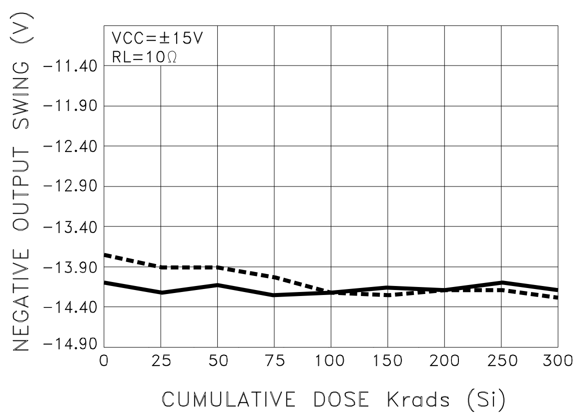
NEGATIVE QUIESCENT CURRENT



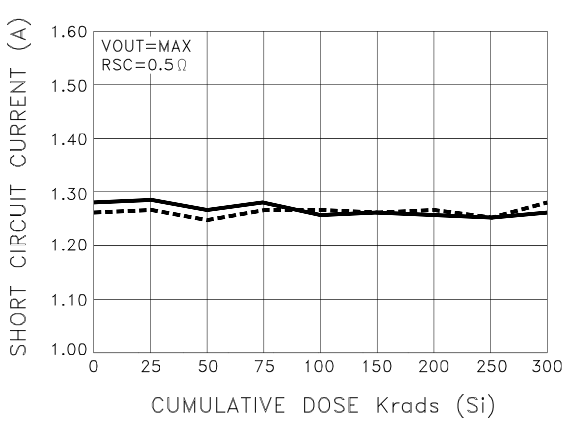
POSITIVE OUTPUT SWING



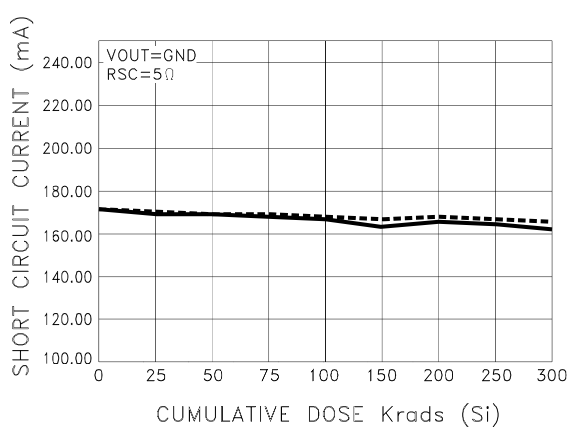
NEGATIVE OUTPUT SWING



SHORT CIRCUIT CURRENT

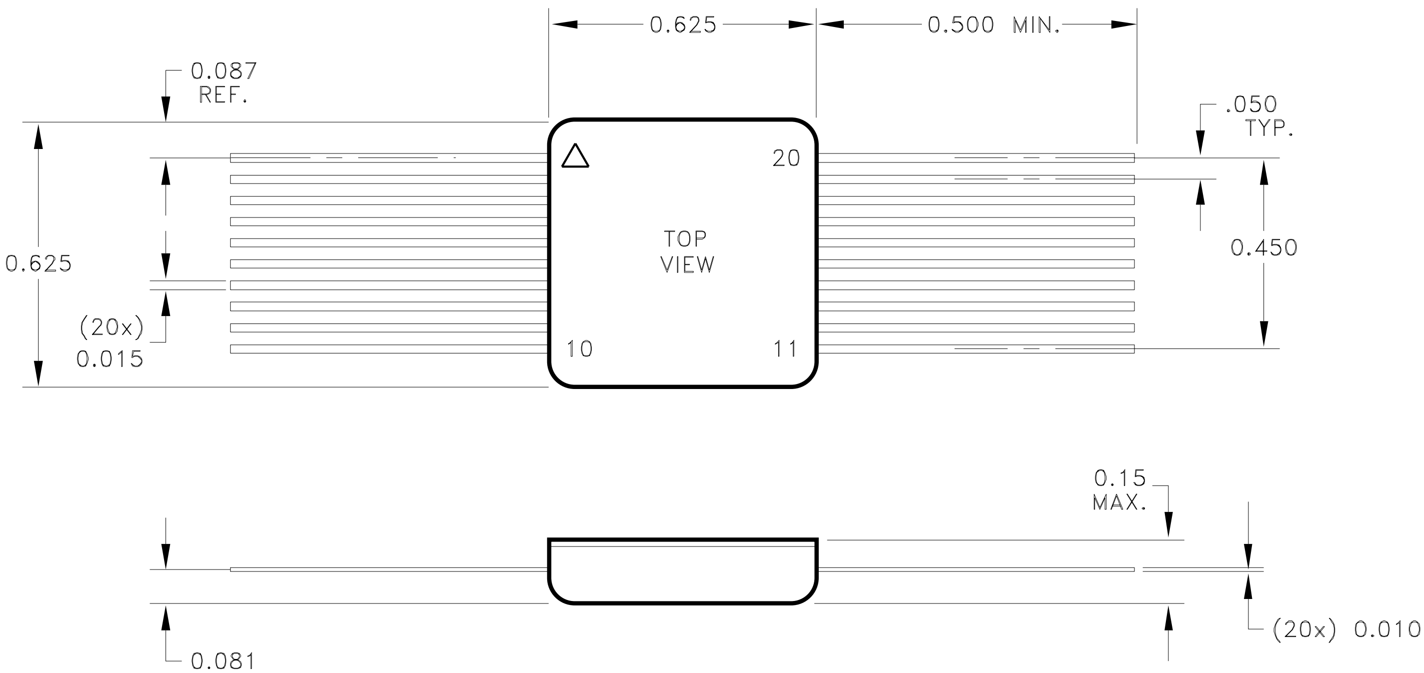


SHORT CIRCUIT CURRENT



AVERAGE BIASED
AVERAGE UNBIASED

MECHANICAL SPECIFICATIONS CONTINUED



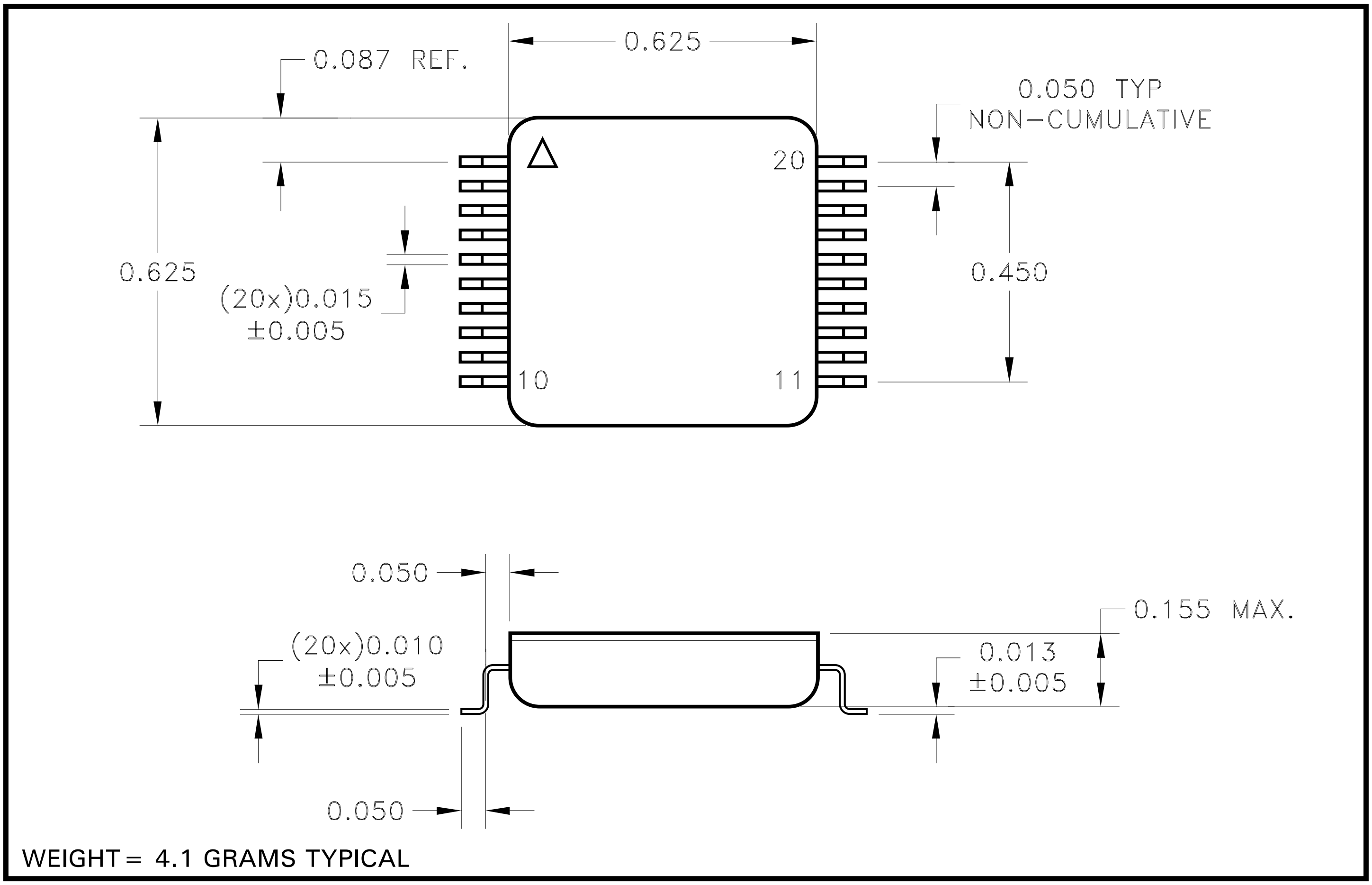
WEIGHT = 4.1 GRAMS TYPICAL

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

ORDERING INFORMATION

Part Number	Screening Level
MSK106RH	INDUSTRIAL
MSK106E RH	EXTENDED RELIABILITY
MSK106H RH	MIL-PRF-38534 CLASS H
MSK106K RH	MIL-PRF-38534 CLASS K
SMD TBD	TBD

MECHANICAL SPECIFICATIONS CONTINUED



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

ORDERING INFORMATION

Part Number	Screening Level
MSK106RHG	INDUSTRIAL
MSK106E RHG	EXTENDED RELIABILITY
MSK106H RHG	MIL-PRF-38534 CLASS H
MSK106K RHG	MIL-PRF-38534 CLASS K
SMD TBD	TBD

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Please visit our website for the most recent revision of this datasheet.
Contact MSK for MIL-PRF-38534 Class H, Class K and Appendix G (radiation) status.