

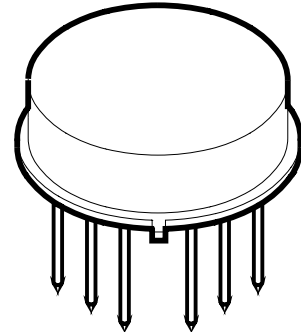


# RAD HARD MEDIUM POWER OP-AMP

# 0041RH

## FEATURES:

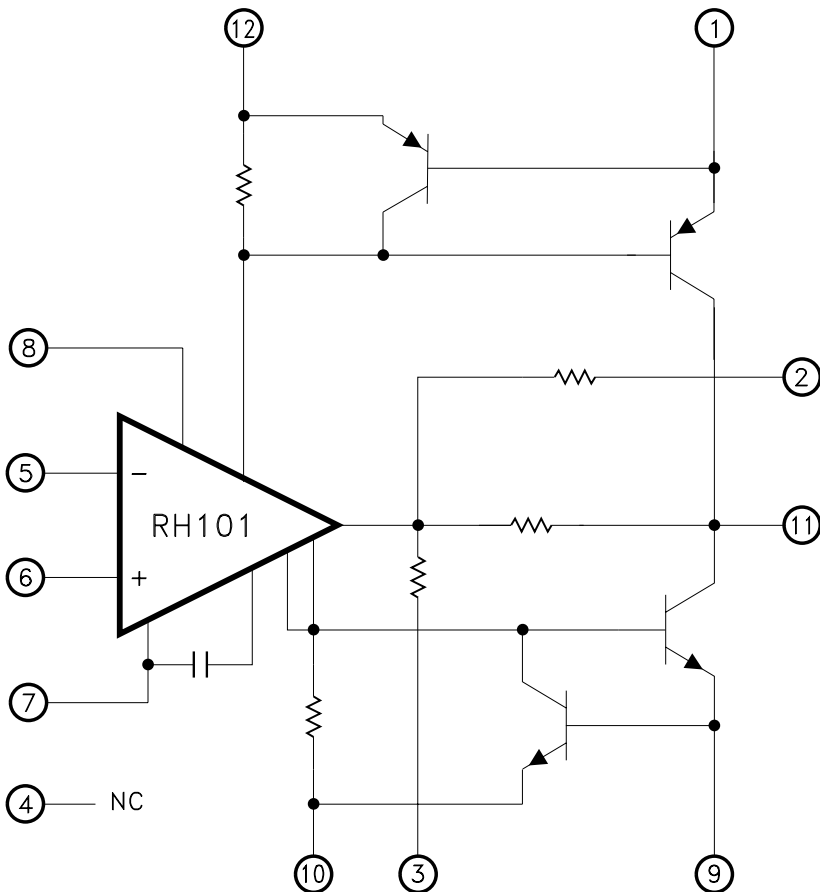
- Manufactured using  Space Qualified RH101 Die
- Total Dose Hardened to 100 Krads(Si) (Method 1019.7 Condition A)
- Output Current - 0.5 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- Continuous Output Short Circuit Duration
- Rad Hard LH0041Replacement
- Functionally Equivalent Non Rad Hard Device MSK0041



## DESCRIPTION:

The MSK0041RH is a general purpose Class C power operational amplifier. This amplifier offers high output currents, making it an excellent choice for motor drive circuits. It is the industry wide RAD HARD replacement for the LH0041. 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. This device is also compensated with a single external capacitor. The MSK0041RH is available in a hermetically sealed 12 pin TO-8 package.

## EQUIVALENT SCHEMATIC



## TYPICAL APPLICATIONS

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

## PIN-OUT INFORMATION

- |    |              |
|----|--------------|
| 1  | ISC+         |
| 2  | Compensation |
| 3  | GND          |
| 4  | NC           |
| 5  | -Input       |
| 6  | +Input       |
| 7  | Balance      |
| 8  | Balance      |
| 9  | ISC-         |
| 10 | -VCC         |
| 11 | Output       |
| 12 | +VCC         |

CASE = ISOLATED

## ABSOLUTE MAXIMUM RATINGS

⑧

$\pm V_{CC}$	Supply Voltage.....	$\pm 22V$
$I_{OUT}$	Peak Output Current.....	0.5A
$V_{IN}$	Differential Input Voltage.....	$\pm 30A$
$V_{IN}$	Common Mode Input Voltage.....	$\pm 15V$

$T_{ST}$	Storage Temperature Range.....	$-65^{\circ}C$ to $+150^{\circ}C$
$T_{LD}$	Lead Temperature Range (10 Seconds).....	$300^{\circ}C$
$T_J$	Junction Temperature	
$T_C$	Case Operating Temperature Range	
	MSK0041K/HRH .....	$-55^{\circ}C$ to $+125^{\circ}C$
	MSK0041RH .....	$-40^{\circ}C$ to $+85^{\circ}C$

## ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ① ⑨	Group A Subgroup	MSK0041K/HRH ⑥			MSK0041RH ⑤			Units	
			Min.	Typ.	Max.	Min.	Typ.	Max.		
STATIC										
Supply Voltage Range ③		-	$\pm 5$	$\pm 15$	$\pm 18$	$\pm 5$	$\pm 15$	$\pm 18$	V	
Quiescent Current	$V_{IN} = 0V$	1, 2, 3	-	$\pm 1.0$	$\pm 3.5$	-	$\pm 1.0$	$\pm 4.0$	mA	
Power Consumption ③	$V_{IN} = 0V$	1, 2, 3	-	75	105	-	90	120	mW	
INPUT										
Input Offset Voltage ②	$V_{IN} = 0V$	1	-	$\pm 0.5$	$\pm 3.0$	-	$\pm 0.5$	$\pm 6.0$	mV	
		2, 3	-	$\pm 2.0$	$\pm 5.0$	-	-	-	mV	
Input Bias Current ②	$V_{CM} = 0V$ Either Input	1	-	$\pm 100$	$\pm 300$	-	$\pm 150$	$\pm 500$	nA	
		2, 3	-	$\pm 0.4$	$\pm 1.0$	-	-	-	$\mu A$	
			Post Radiation	1	-	$\pm 300$	$\pm 500$	-	$\pm 300$	$\pm 600$
Input Offset Current ②	$V_{CM} = 0V$	1	-	$\pm 2.0$	$\pm 100$	-	$\pm 2.0$	$\pm 200$	nA	
		2, 3	-	-	$\pm 300$	-	-	-	nA	
Input Capacitance ④	$F = DC$	-	-	3	-	-	3	-	pF	
Input Resistance ③	$F = DC$	-	0.3	1.0	-	0.3	1.0	-	M $\Omega$	
Common Mode Rejection Ratio	$F = 10Hz$ $V_{CM} = \pm 10V$	4	70	90	-	70	90	-	dB	
		5, 6	70	90	-	-	-	-	dB	
Power Supply Rejection Ratio	$V_{CC} = \pm 5V$ to $\pm 15V$	1	80	95	-	80	95	-	dB	
		2, 3	80	-	-	-	-	-	dB	
Input Noise Voltage ④	$F = 10Hz$ to $10KHz$	-	-	5	-	-	5	-	$\mu V_{RMS}$	
OUTPUT										
Output Voltage Swing	$R_L = 100\Omega$ $F = 100Hz$	4	$\pm 13$	$\pm 14$	-	$\pm 13$	$\pm 14$	-	V	
		5, 6	$\pm 13$	$\pm 14$	-	-	-	-	V	
Output Short Circuit Current	$R_{SC} = 3.3\Omega$ $V_{OUT} = MAX$	4	-300	-	300	-300	-	300	mA	
TRANSFER CHARACTERISTICS										
Slew Rate	$V_{OUT} = \pm 10V$ $R_L = 100\Omega$		4	1.2	3.0	-	1.0	3.0	-	V/ $\mu S$
			Post Radiation	4	1.1	-	-	0.9	-	-
Open Loop Voltage Gain	$F = 10Hz$ $R_L = 1K\Omega$		4	100	105	-	100 ③	105	-	dB
			5, 6	88	96	-	-	-	-	dB
Transition Times	$V_{OUT} = 1V$ Rise and Fall		4	-	0.3	1.0	-	0.3	1.5	$\mu S$
			Post Radiation	4	-	-	1.2	-	-	1.6
Overshoot	Small Signal	4	-	5	20	-	5	30	%	
Thermal Resistance ③	Junction to Case @ $125^{\circ}C$ Each Output Device	-	-	85	90	-	85	90	$^{\circ}C/W$	
Open Loop Voltage Gain	$F = 10Hz$ $R_L = 100\Omega$	4, 5, 6	88	-	-	88	-	-	dB	

### NOTES:

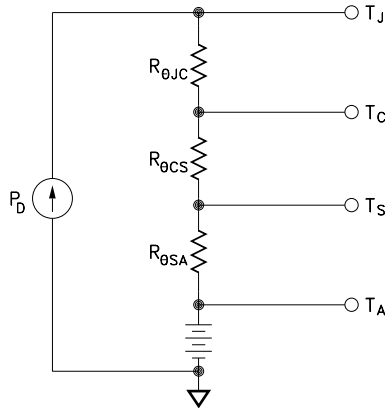
- ① Unless otherwise specified,  $\pm V_{CC} = \pm 15V$ ,  $C_C = 3000pF$ .
- ② Specification applies for  $\pm 5V \leq \pm V_{CC} \leq \pm 18V$ .
- ③ Guaranteed by design but not tested.
- ④ Typical parameters are representative of actual device performance but are for reference only.
- ⑤ Industrial grade devices shall be tested to subgroups 1 and 4 unless otherwise specified.
- ⑥ Military grade devices (H suffix) shall be 100% tested to subgroups 1, 2, 3 and 4.
  - Subgroup 1, 4  $T_A = T_C = +25^{\circ}C$
  - Subgroup 2, 5  $T_A = T_C = +125^{\circ}C$
  - Subgroup 3, 6  $T_A = T_C = -55^{\circ}C$
- ⑦ Subgroup 5 and 6 testing available upon request.
- 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  $+25^{\circ}C$ , are identical up to 100Krad TID unless otherwise specified.

## 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 100 ohm load for 0.1 amp of output current. For a worst case analysis we will treat the 0.1 amp peak output current as a D.C. output current. The power supplies are  $\pm 15$  VDC.

- 1.) Find Power Dissipation  

$$P_D = [(quiescent\ current) \times (+VCC - (VCC))] + [(V_s - V_o) \times I_{out}]$$

$$= (3.5\ mA) \times (30V) + (5V) \times (0.1A)$$

$$= 0.1W + 0.5W$$

$$= 0.6W$$
- 2.) For conservative design, set  $T_J = +150^\circ C$ .
- 3.) For this example, worst case  $T_A = +25^\circ C$ .
- 4.)  $R_{\theta JC} = 85^\circ C/W$
- 5.) Rearrange governing equation to solve for  $R_{\theta SA}$ :  

$$R_{\theta SA} = (T_J - T_A) / P_D - (R_{\theta JC}) - (R_{\theta CS})$$

$$= (150^\circ C - 25^\circ C) / 0.6W - (85^\circ C/W) - (0.15^\circ C/W)$$

$$= 123^\circ C/W$$

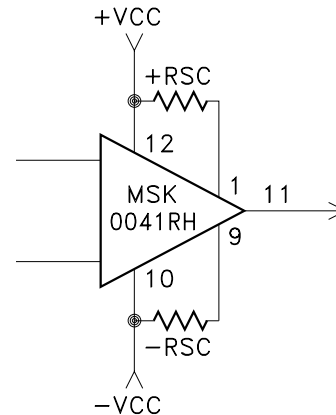
The heat sink in this example must have a thermal resistance of no more than  $123^\circ C/W$  to maintain a junction temperature of less than  $+150^\circ C$ . This calculation assumes a case to sink thermal resistance of  $0.15^\circ C/W$ .

### CURRENT LIMIT

The MSK0041RH 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.

$$R_{sc} = \frac{0.7}{I_{sc}}$$

#### 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. 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.

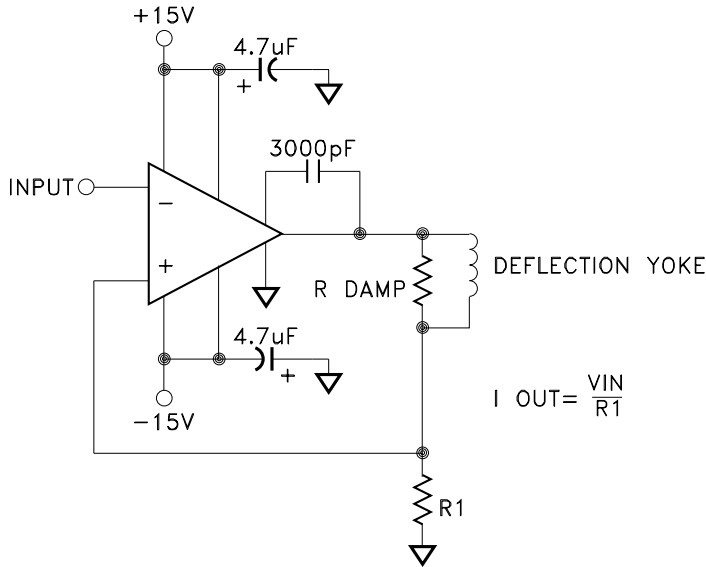
### SAFE OPERATING AREA

The safe operating area curve is a graphical representation of the power handling capability of the amplifier under various conditions. The wire bond current carrying capability, transistor junction temperature and secondary breakdown limitations are all incorporated into the safe operating area curves. All applications should be checked against the curves to ensure high M.T.B.F.

### TOTAL DOSE RADIATION TEST PERFORMANCE

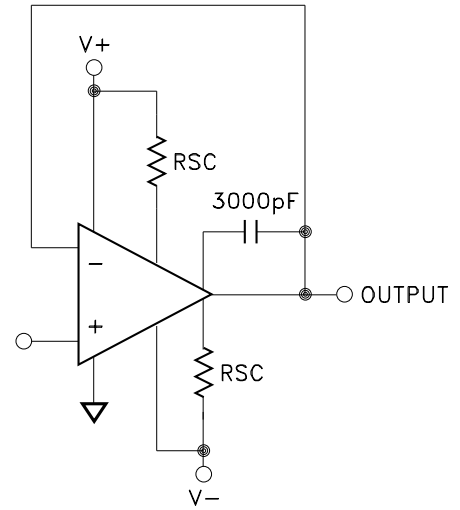
Radiation performance curves for TID testing have been generated for all radiation testing performed by TTM Technologies. These curves show performance trends throughout the TID test process and can be located in the MSK0041RH radiation test report. The complete radiation test report is available in the RAD HARD PRODUCTS section on the TTM Technologies website.

# APPLICATION CIRCUITS

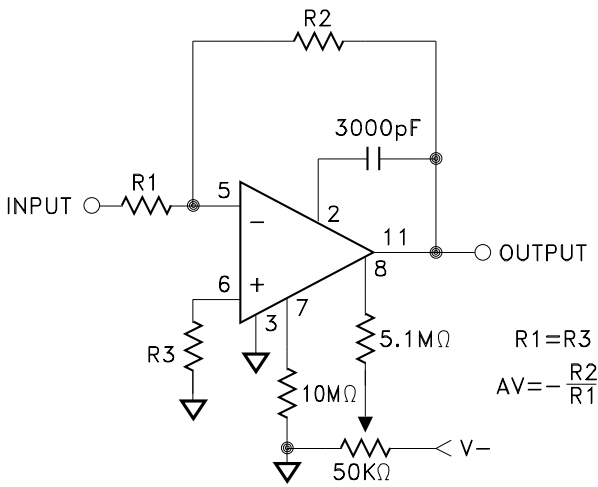


CRT DEFLECTION YOKE DRIVER

$$I_{OUT} = \frac{V_{IN}}{R_1}$$



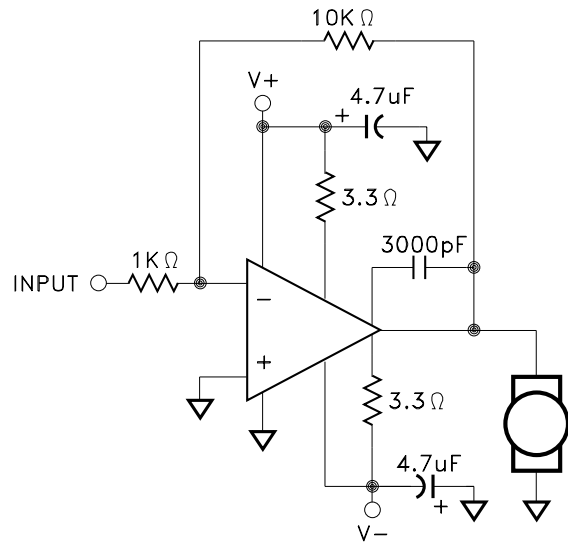
UNITY GAIN CIRCUIT WITH SHORT CIRCUIT LIMITING



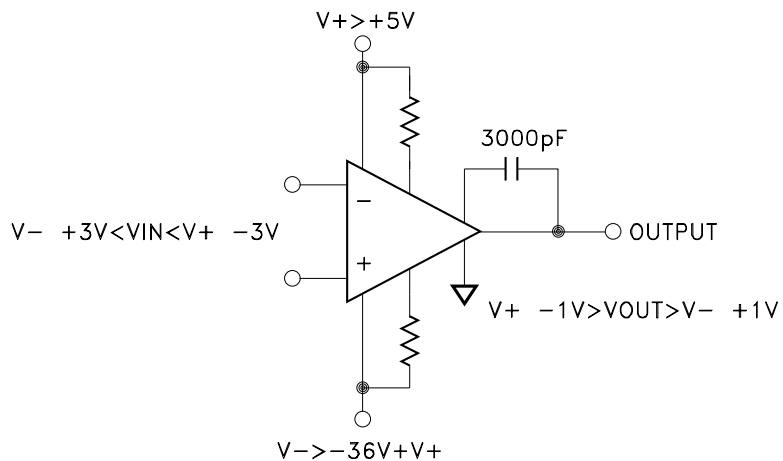
OFFSET VOLTAGE NULL CIRCUIT

$$R_1 = R_3$$

$$A_V = -\frac{R_2}{R_1}$$

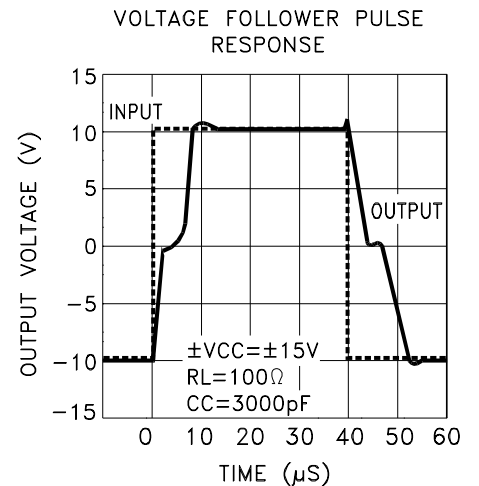
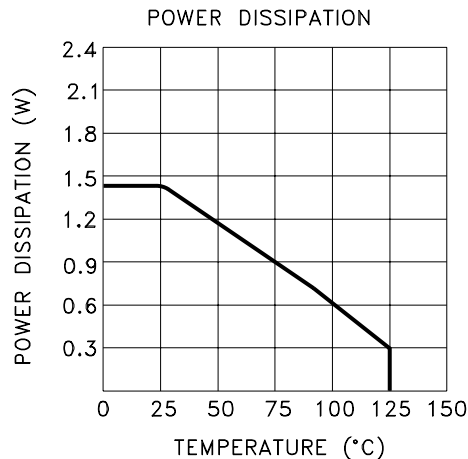
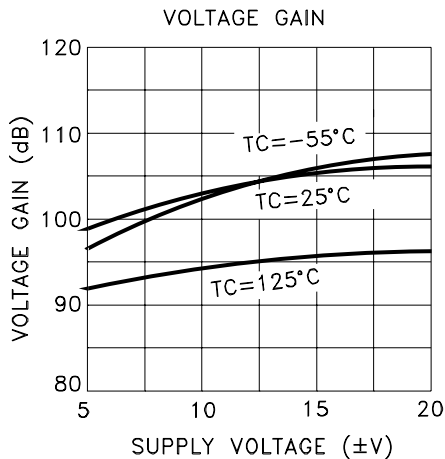
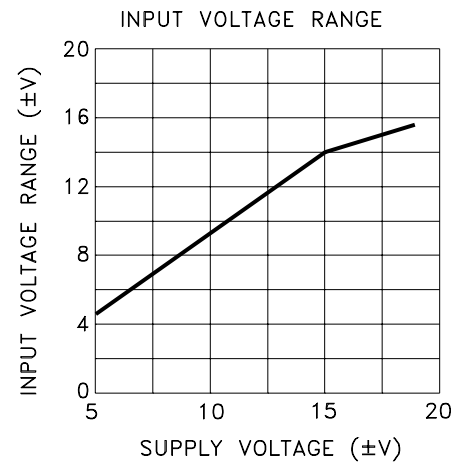
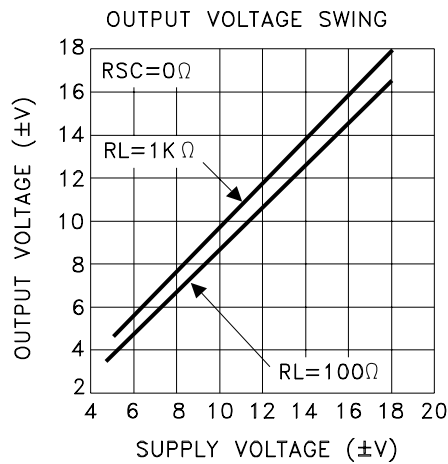
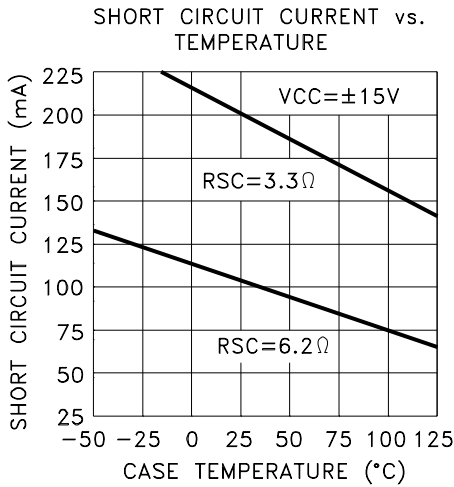
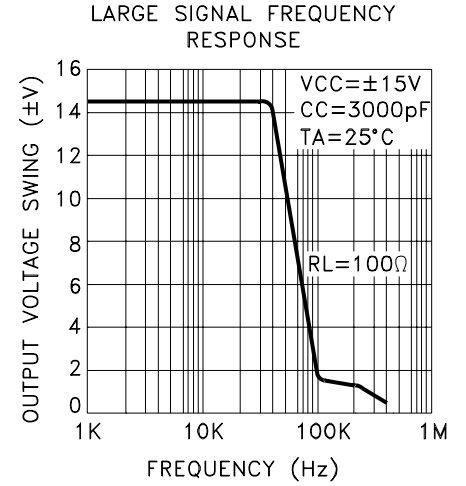
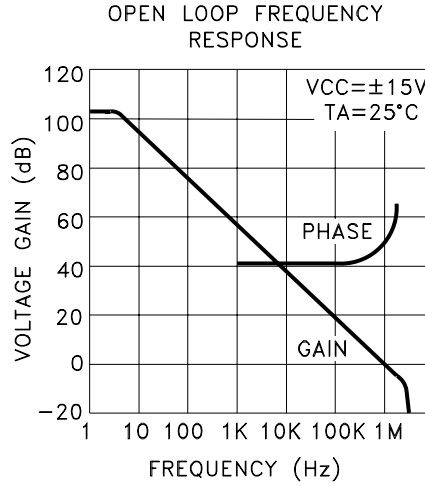
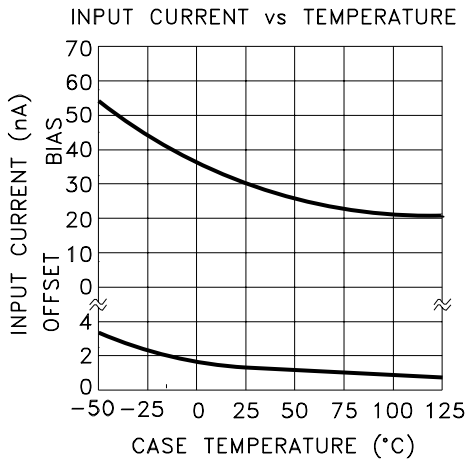


DC SERVO AMPLIFIER

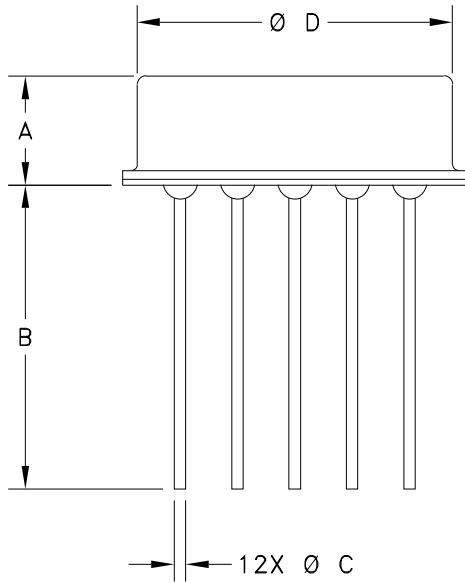


NON SYMMETRICAL SUPPLIES

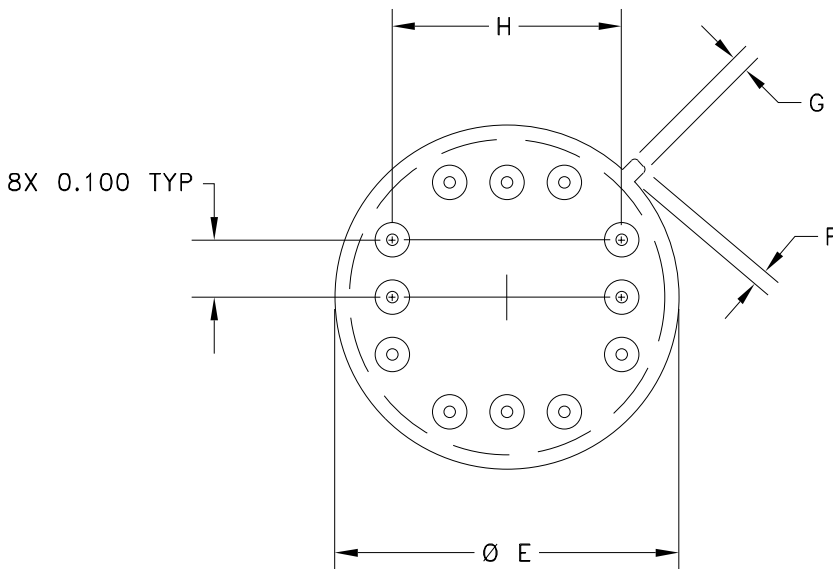
# TYPICAL PERFORMANCE CURVES



## MECHANICAL SPECIFICATIONS



REF	MIN	MAX
A	0.180	0.200
B	0.500	—
C	0.016	0.020
D	0.550	REF
E	0.590	0.615
F	0.026	0.036
G	0.026	0.036
H	0.395	0.405



WEIGHT = 3.2 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

## ORDERING INFORMATION

Part Number	Screening Level
MSK0041RH	Industrial
MSK0041HRH	MIL-PRF-38534 CLASS H
MSK0041KRH	MIL-PRF-38534 CLASS K

## REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
F	Released	07/15	Update format. Correct thermal calculation example.
G	Released	03/18	Update E dimension from 0.595 min - 0.605 max to 0.590 min - 0.615 max
H	Released	09/21	Remove MIL-PRF-38535
J	Released	09/22	Correct datasheet units and maximum values

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