



# HIGH POWER OP-AMP

# 0021 SERIES

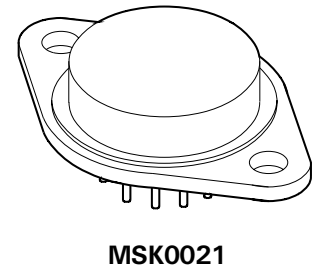
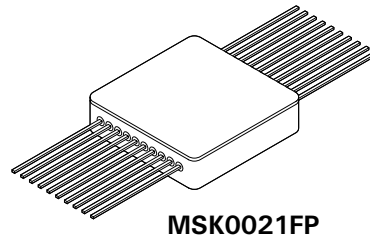
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**MIL-PRF-38534 QUALIFIED**

**FEATURES:**

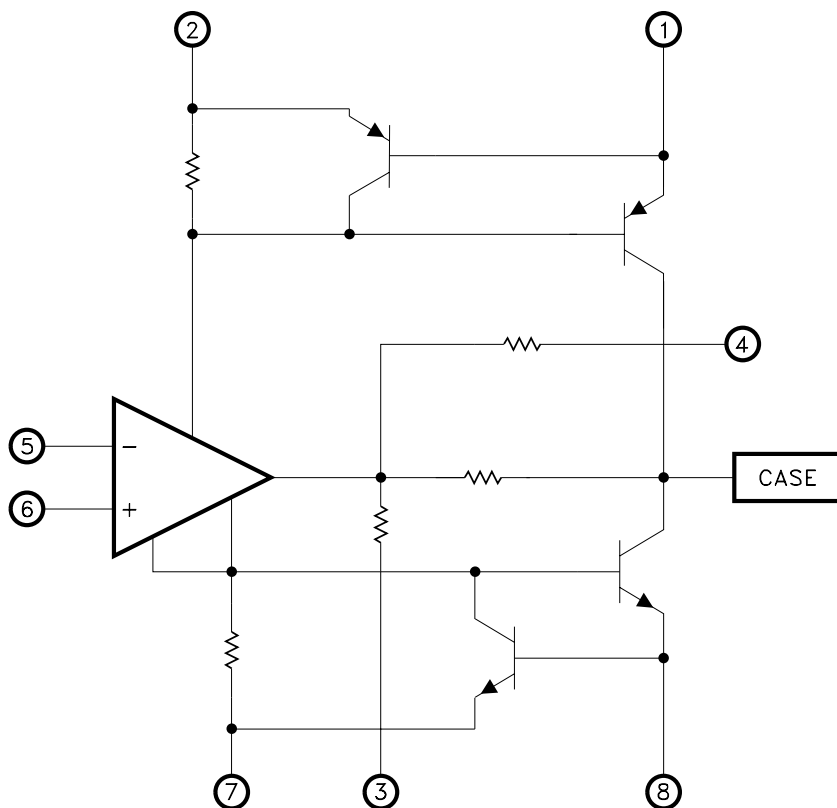
- Available as SMD #5962-8508801
- High Output Current - 2 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- High Slew Rate
- Continuous Output Short Circuit Duration
- Replacement for LH0021



**DESCRIPTION:**

The MSK 0021 and 0021FP are general purpose Class C power operational amplifiers. These amplifiers offer large output currents, making them an excellent low cost 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 0021 is available in a hermetically sealed 8 pin TO-3 package. The MSK 0021FP is packaged in a 20 pin hermetic metal flatpack.

**EQUIVALENT SCHEMATIC**



**PIN-OUT INFORMATION**

**MSK0021**

- 1 ISC+
  - 2 +VCC
  - 3 GND
  - 4 Compensation
  - 5 -Input
  - 6 +Input
  - 7 -VCC
  - 8 ISC
- CASE-OUTPUT

**MSK0021 FP**

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

CASE IS ALSO VOUT

**TYPICAL APPLICATIONS**

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

## ABSOLUTE MAXIMUM RATINGS

|              |                                     |           |
|--------------|-------------------------------------|-----------|
| $\pm V_{CC}$ | Supply Voltage                      | $\pm 18V$ |
| $I_{OUT}$    | Peak Output Current                 | .2A       |
| $V_{IN}$     | Differential Input Voltage          | $\pm 30V$ |
| $V_{IN}$     | Common Mode Input Voltage           | $\pm 15V$ |
| $R_{TH}$     | Thermal Resistance-Junction to Case |           |
|              | MSK 0021                            | 2.0° C/W  |
|              | MSK 0021FP                          | 6.0° C/W  |

|     |                                     |                 |
|-----|-------------------------------------|-----------------|
| TST | Storage Temperature Range           | -65° to +150°C  |
| TLD | Lead Temperature Range (10 Seconds) | 300°C           |
| PD  | Power Dissipation (TO-3)            | .6W             |
| TJ  | Junction Temperature                | 150°C           |
| TC  | Case Operating Temperature Range    |                 |
|     | Military Versions (H/B/E)           | -55°C to +125°C |
|     | Industrial Versions                 | -40°C to +85°C  |

## ELECTRICAL SPECIFICATIONS

| Parameter                       | Test Conditions                      | Group A Subgroup | Military ⑤ |           |           | Industrial ④ |           |           | Units             |
|---------------------------------|--------------------------------------|------------------|------------|-----------|-----------|--------------|-----------|-----------|-------------------|
|                                 |                                      |                  | Min.       | Typ.      | Max.      | Min.         | Typ.      | Max.      |                   |
| <b>STATIC</b>                   |                                      |                  |            |           |           |              |           |           |                   |
| Supply Voltage Range ②          |                                      | -                | $\pm 12$   | $\pm 15$  | $\pm 18$  | $\pm 12$     | $\pm 15$  | $\pm 18$  | V                 |
| Quiescent Current               | $V_{IN} = 0V$                        | 1, 2, 3          | -          | $\pm 1.0$ | $\pm 3.5$ | -            | $\pm 1.0$ | $\pm 4.0$ | mA                |
| Power Consumption ②             | $V_{IN} = 0V$                        | 1, 2, 3          | -          | 75        | 105       | -            | 90        | 120       | mW                |
| <b>INPUT</b>                    |                                      |                  |            |           |           |              |           |           |                   |
| Input Offset Voltage            | $V_{IN} = 0V$                        | 1                | -          | $\pm 0.5$ | $\pm 3.0$ | -            | $\pm 0.5$ | $\pm 5.0$ | mV                |
|                                 |                                      | 2, 3             | -          | $\pm 2.0$ | $\pm 5.0$ | -            | -         | -         | $\mu V/^{\circ}C$ |
| Input Bias Current              | $V_{CM} = 0V$<br>Either Input        | 1                | -          | $\pm 100$ | $\pm 300$ | -            | $\pm 150$ | $\pm 500$ | nA                |
|                                 |                                      | 2, 3             | -          | $\pm 0.4$ | $\pm 1.0$ | -            | -         | -         | $\mu A$           |
| Input Offset Current            | $V_{CM} = 0V$                        | 1                | -          | $\pm 2.0$ | $\pm 100$ | -            | $\pm 2.0$ | $\pm 300$ | nA                |
|                                 |                                      | 2, 3             | -          | -         | $\pm 300$ | -            | -         | -         | nA                |
| Input Capacitance ③             | F = DC                               | -                | -          | 3         | -         | -            | 3         | -         | pF                |
| Input Resistance ②              | 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 ③           | F = 10Hz to 10KHz                    | -                | -          | 5         | -         | -            | 5         | -         | $\mu V_{RMS}$     |
| <b>OUTPUT</b>                   |                                      |                  |            |           |           |              |           |           |                   |
| Output Voltage Swing            | $R_L = 100\Omega$ F = 100Hz          | 4                | $\pm 13.5$ | $\pm 14$  | -         | $\pm 13.0$   | $\pm 14$  | -         | V                 |
|                                 |                                      | 5, 6             | $\pm 13.5$ | $\pm 14$  | -         | -            | -         | -         | V                 |
| Output Short Circuit Current    | $R_{SC} = 0.5\Omega$ $V_{OUT} = MAX$ | 4                | 0.8        | 1.2       | 1.6       | 0.7          | 1.2       | 1.7       | A                 |
|                                 | $R_{SC} = 5\Omega$ $V_{OUT} = GND$   | 4                | 50         | 150       | 250       | 50           | 150       | 250       | mA                |
| Settling Time ③                 | 0.1% 2V step                         | -                | -          | 4         | -         | -            | 4         | -         | $\mu S$           |
| <b>TRANSFER CHARACTERISTICS</b> |                                      |                  |            |           |           |              |           |           |                   |
| Slew Rate                       | $V_{OUT} = \pm 10V$ $R_L = 10\Omega$ | 4                | 1.5        | 3.0       | -         | 1.2          | 3.0       | -         | V/ $\mu S$        |
| Open Loop Voltage Gain          | F = 10Hz $R_L = 1K\Omega$            | 4                | 100        | 105       | -         | 100          | 105       | -         | dB                |
|                                 |                                      | 5, 6             | 88         | 96        | -         | -            | -         | -         | dB                |
| Transition Times                | Rise and Fall                        | 4                | -          | 0.3       | 1.0       | -            | 0.3       | 1.2       | $\mu S$           |
| Overshoot                       | Small Signal                         | 4                | -          | 5         | 20        | -            | 5         | 20        | %                 |

### NOTES:

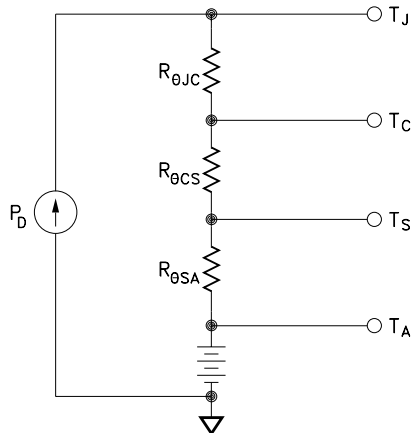
- ① Unless otherwise specified,  $\pm V_{CC} = \pm 15V$ ,  $C_c = 3000pF$ .
- ② Guaranteed by design but not tested.
- ③ Typical parameters are representative of actual device performance but are for reference only.
- ④ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
- ⑤ Military grade devices (B/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  $T_A = T_c = -55^{\circ}C$
- ⑥ Reference DSCC SMD 5962-8508801 for electrical specifications for devices purchased as such.
- ⑦ Subgroup 5 and 6 testing available upon request.

## 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: (TO-3 PACKAGE)

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  $\pm 15$  VDC.

##### 1.) Find Power Dissipation

$$\begin{aligned} P_D &= [(quiescent\ current) \times (+V_{CC} - (V_{CC}))] + [(V_s - V_o) \times I_{OUT}] \\ &= (3.5\ mA) \times (30V) + (5V) \times (1A) \\ &= 0.1W + 6W \\ &= 6.1W \end{aligned}$$

##### 2.) For conservative design, set $T_J = +150^\circ\text{C}$ .

##### 3.) For this example, worst case $T_A = +25^\circ\text{C}$ .

##### 4.) $R_{\theta JC} = 2.0^\circ\text{C/W}$ typically for the TO-3 package.

##### 5.) Rearrange governing equation to solve for $R_{\theta SA}$ :

$$\begin{aligned} R_{\theta SA} &= (T_J - T_A) / P_D - (R_{\theta JC}) - (R_{\theta CS}) \\ &= (150^\circ\text{C} - 25^\circ\text{C}) / 6.1W - (2.0^\circ\text{C/W}) - (0.15^\circ\text{C/W}) \\ &= 18.5^\circ\text{C/W} \end{aligned}$$

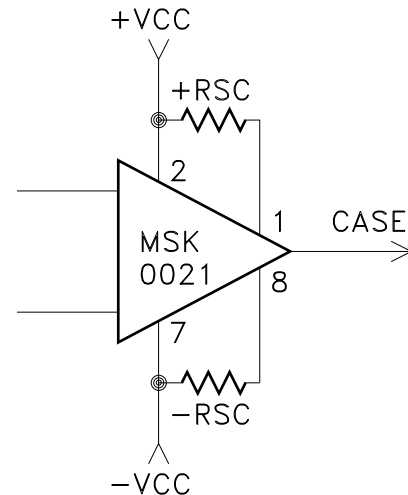
The heat sink in this example must have a thermal resistance of no more than  $18.5^\circ\text{C/W}$  to maintain a junction temperature of less than  $+150^\circ\text{C}$ .

### CURRENT LIMIT

The MSK 0021 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.

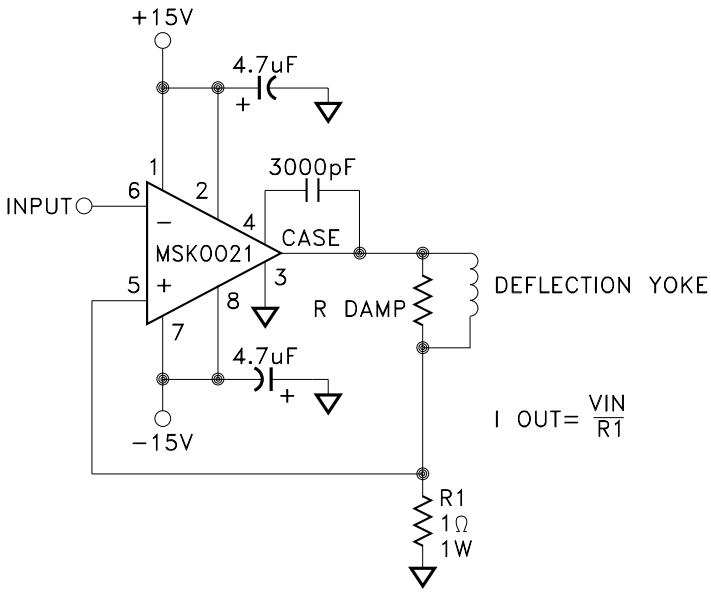
### POWER SUPPLY BYPASSING

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. It is also a good practice with high power op-amps, such as the MSK 0021, 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.

### SAFE OPERATING AREA

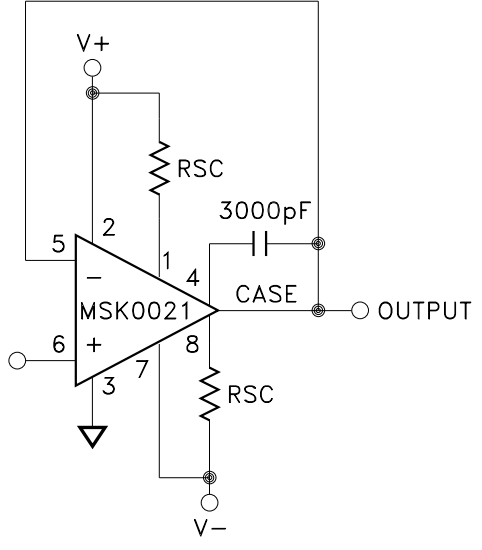
The safe operating area curve is a graphical representation of the power handling capability of the amplifier under various conditions. The wire bond current carrying capability, transistor junction temperature and secondary breakdown limitations are all incorporated into the safe operating area curves.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

# APPLICATION CIRCUITS

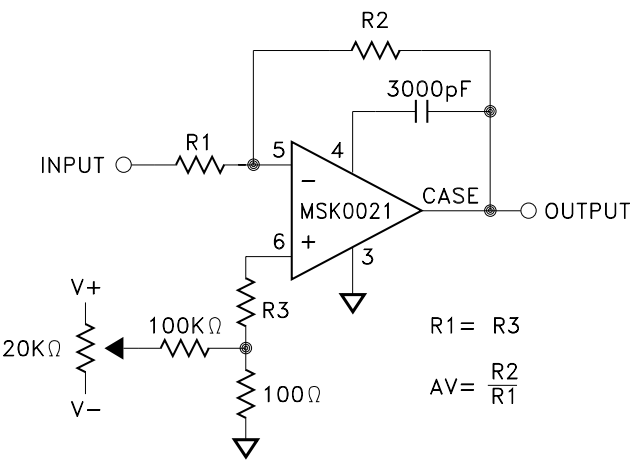


CRT DEFLECTION YOKE DRIVER

$$I_{OUT} = \frac{V_{IN}}{R1}$$



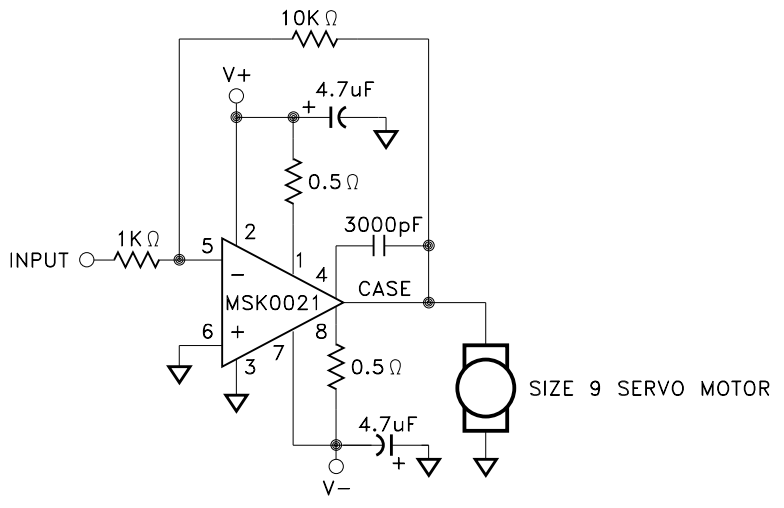
UNITY GAIN CIRCUIT WITH SHORT CIRCUIT LIMITING



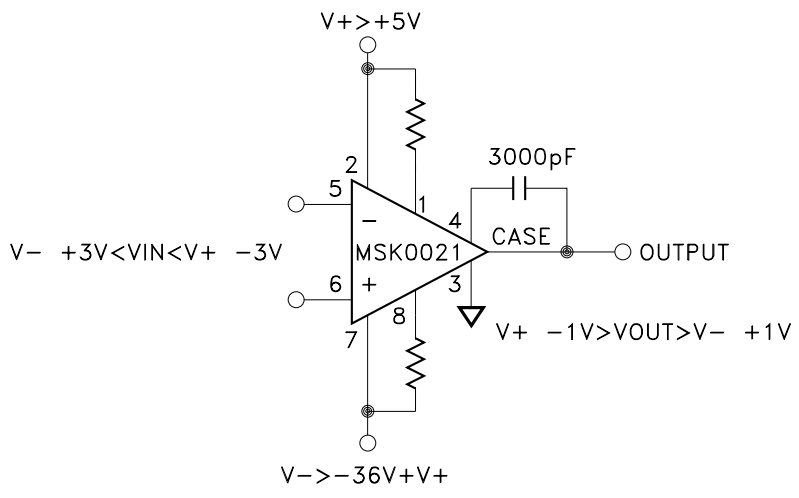
OFFSET VOLTAGE NULL CIRCUIT

$$R1 = R3$$

$$A_V = \frac{R2}{R1}$$

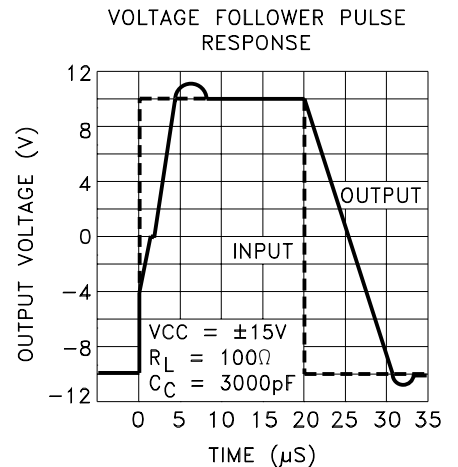
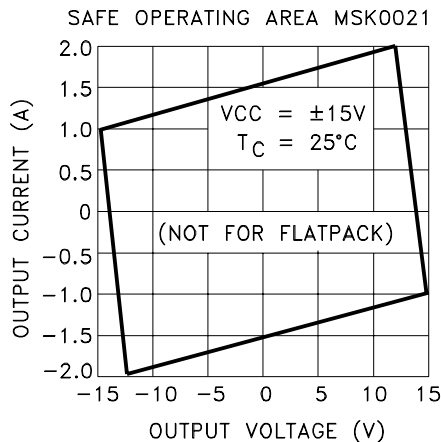
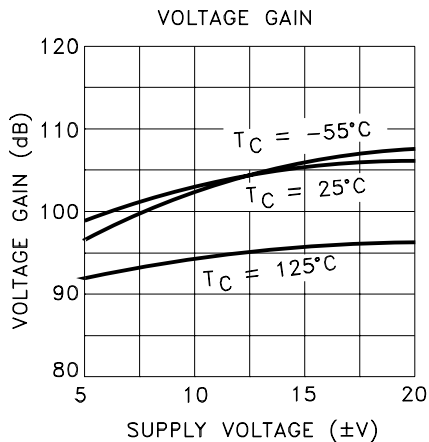
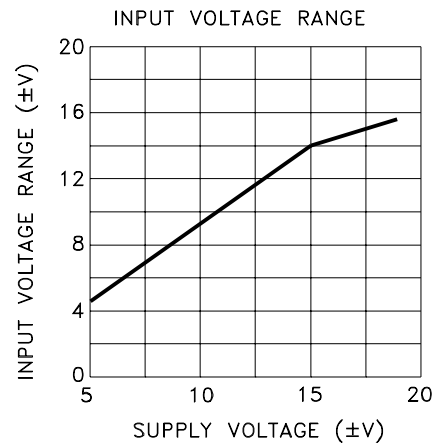
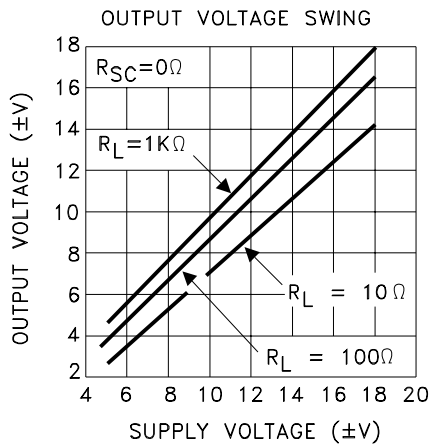
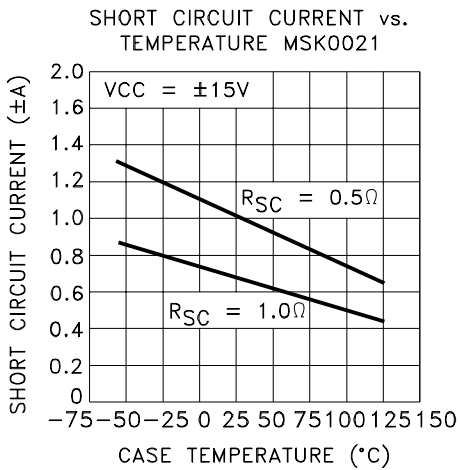
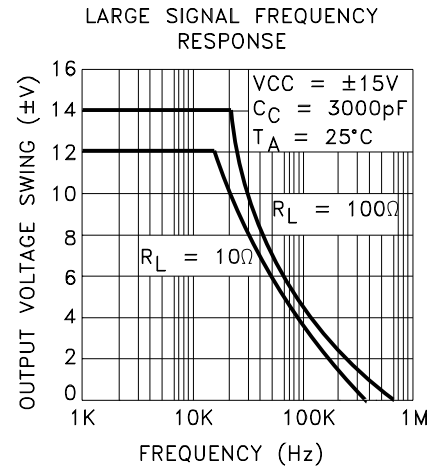
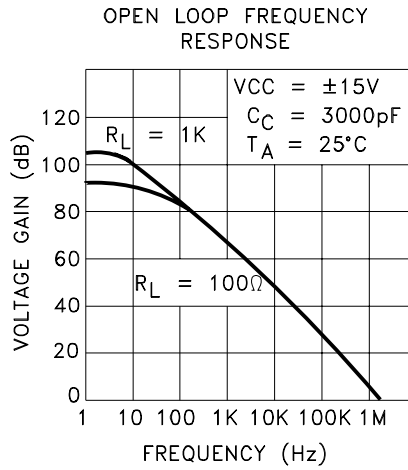
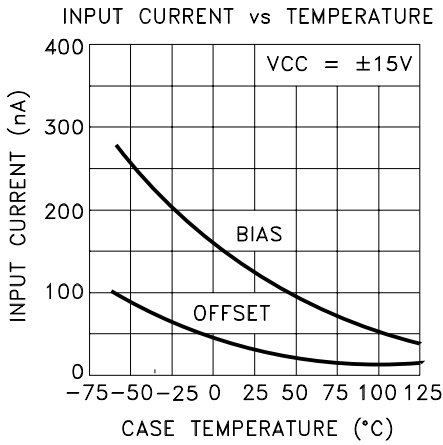


DC SERVO AMPLIFIER

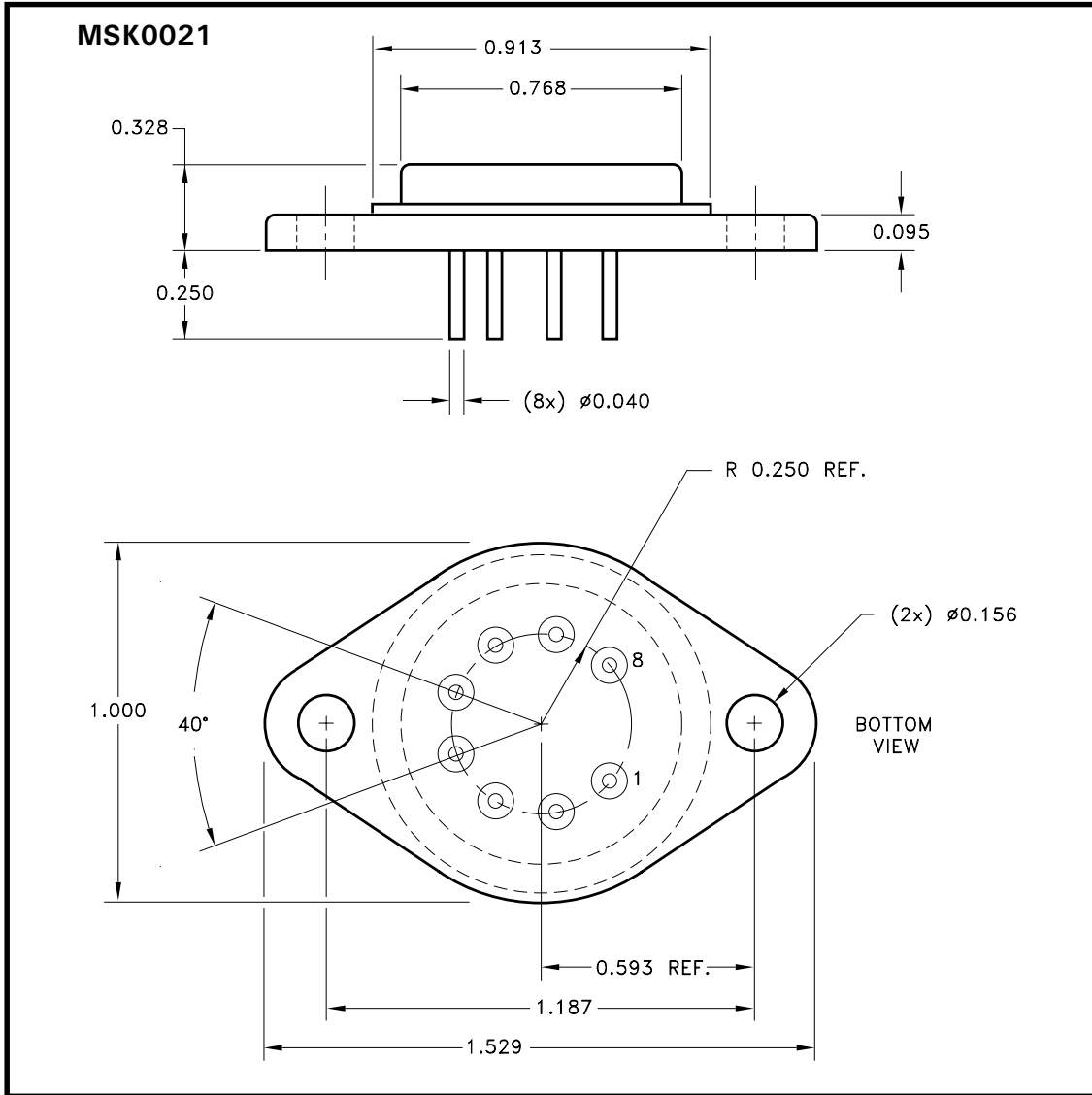


NON SYMMETRICAL SUPPLIES

# TYPICAL PERFORMANCE CURVES



**MECHANICAL SPECIFICATIONS**

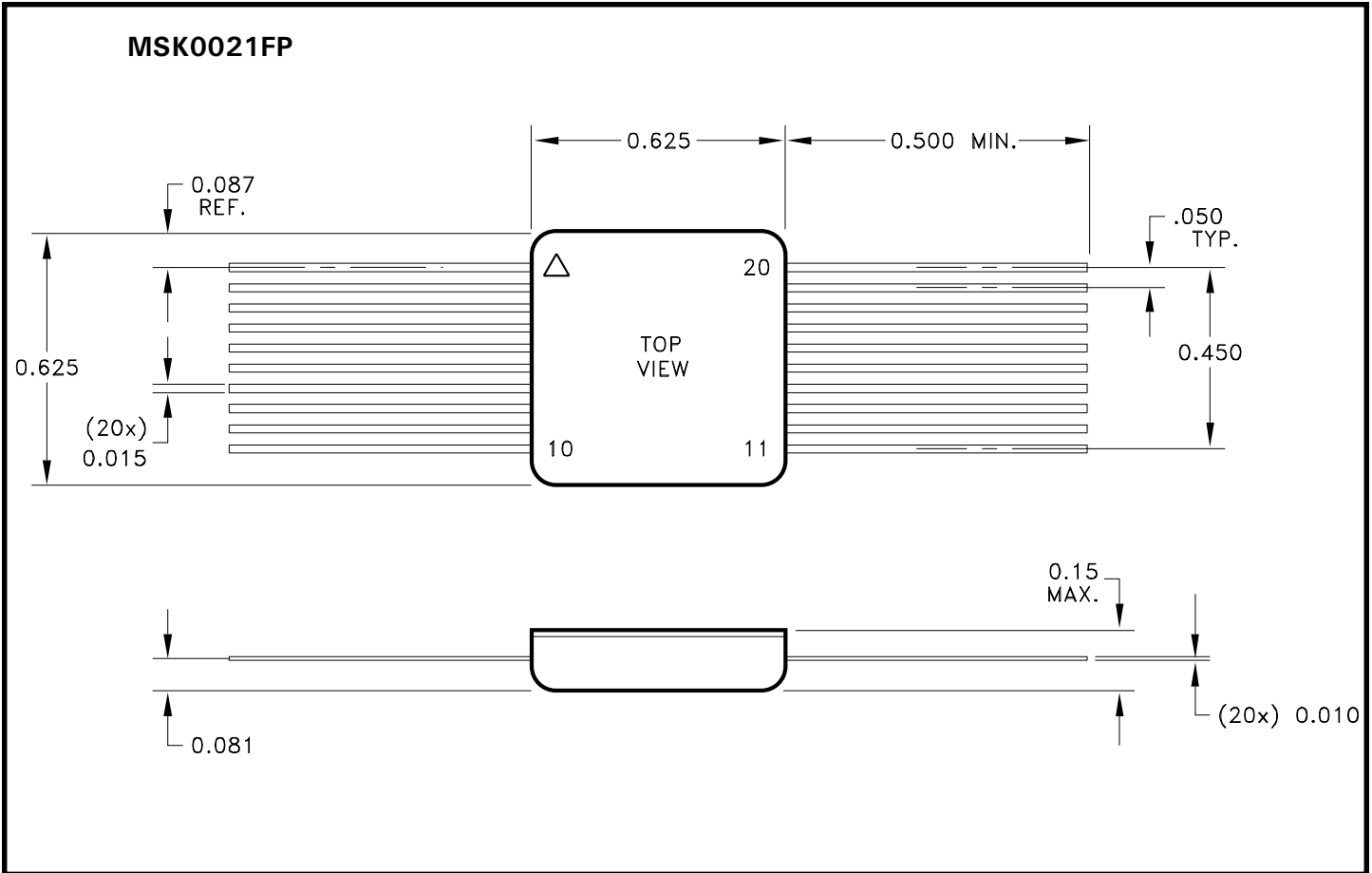


NOTE: ALL DIMENSIONS ARE  $\pm 0.010$  INCHES UNLESS OTHERWISE LABELED

**ORDERING INFORMATION**

| Part Number   | Screening Level       |
|---------------|-----------------------|
| MSK 0021      | Industrial            |
| MSK 0021 B    | MIL-PRF-38534 CLASS H |
| MSK 0021 E    | EXTENDED RELIABILITY  |
| 5962-8508801X | DSCC - SMD            |

**MECHANICAL SPECIFICATIONS CONTINUED**



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

**ORDERING INFORMATION**

| Part Number  | Screening Level       |
|--------------|-----------------------|
| MSK 0021FP   | Industrial            |
| MSK 0021FP H | MIL-PRF-38534 CLASS H |
| MSK 0021FP E | EXTENDED RELIABILITY  |
| TBD          | DSCC - SMD            |

LEAD FORMING IS AVAILABLE ON FLATPACK DEVICES.

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