

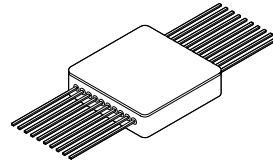


# HIGH POWER OP-AMP

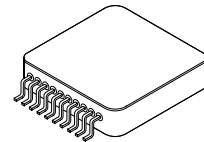
# 0021 SERIES

### FEATURES:

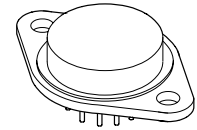
- Available as SMD #5962-8508801
- High Output Current - 2 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- High Slew Rate
- Continuous Output Short Circuit Duration
- Replacement for LH0021
- Functionally Equivalent Rad Hard Device MSK106RH



MSK0021FP



MSK0021FPG

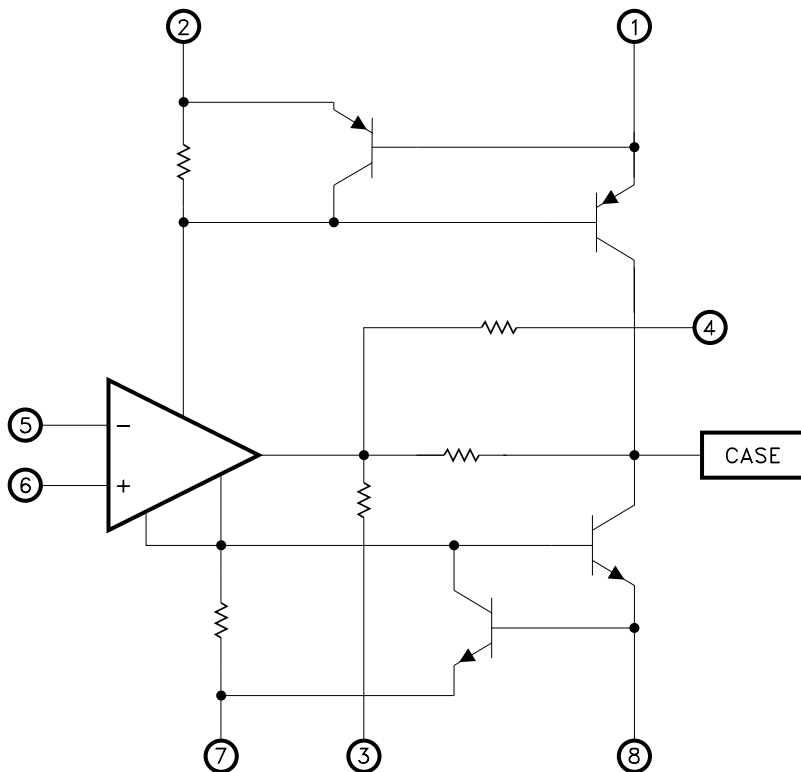


MSK0021

### DESCRIPTION:

The MSK0021, 0021FP and 0021FPG 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 MSK0021 is available in a hermetically sealed 8 pin TO-3 package. The MSK0021FP is packaged in a 20 pin hermetic metal flatpack and the 0021FPG is lead formed by MSK.

### EQUIVALENT SCHEMATIC



### PIN-OUT INFORMATION

#### MSK0021

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

#### CASE-OUTPUT

#### MSK0021FP/MSK0021FPG

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

## ABSOLUTE MAXIMUM RATINGS

⑧

±VCC	Supply Voltage.....	±18V
I <sub>OUT</sub>	Peak Output Current.....	2A
V <sub>IN</sub>	Differential Input Voltage.....	±30A
V <sub>IN</sub>	Common Mode Input Voltage.....	±15V
R <sub>TH</sub>	Thermal Resistance-Junction to Case	
	MSK0021.....	2.0° C/W
	MSK0021FP/FPG.....	6.0° C/W

T <sub>ST</sub>	Storage Temperature Range.....	-65°C to +150°C
T <sub>LD</sub>	Lead Temperature Range	
	(10 Seconds).....	300°C
P <sub>D</sub>	Power Dissipation (TO-3) .....	6W
T <sub>J</sub>	Junction Temperature	
T <sub>C</sub>	Case Operating Temperature Range	
	Military Versions (H/B) .....	-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.	
STATIC									
Supply Voltage Range ②		-	±12	±15	±18	±12	±15	±18	V
Quiescent Current	V <sub>IN</sub> = 0V	1, 2, 3	-	±1.0	±3.5	-	±1.0	±4.0	mA
Power Consumption ②	V <sub>IN</sub> = 0V	1, 2, 3	-	75	105	-	90	120	mW
INPUT									
Input Offset Voltage	V <sub>IN</sub> = 0V	1	-	±0.5	±3.0	-	±0.5	±5.0	mV
	5V ≤ V <sub>CC</sub> ≤ 18V	2, 3	-	±2.0	±5.0	-	-	-	µV/°C
Input Bias Current	V <sub>CM</sub> = 0V, 5V ≤ V <sub>CC</sub> ≤ 18V	1	-	±100	±300	-	±150	±500	nA
	Either Input	2, 3	-	±0.4	±1.0	-	-	-	µA
Input Offset Current	V <sub>CM</sub> = 0V	1	-	±2.0	±100	-	±2.0	±300	nA
	5V ≤ V <sub>CC</sub> ≤ 18V	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 <sub>CM</sub> = ±10V	4	70	90	-	70	90	-	dB
		5, 6	70	90	-	-	-	-	dB
Power Supply Rejection Ratio	V <sub>CC</sub> = ±5V to ±15V	1	80	95	-	80	95	-	dB
		2, 3	80	-	-	-	-	-	dB
Input Noise Voltage ③	F = 10Hz to 10KHz	-	-	5	-	-	5	-	µV <sub>RMS</sub>
OUTPUT									
Output Voltage Swing	R <sub>L</sub> = 100Ω F = 100Hz	4	±13.5	±14	-	±13.0	±14	-	V
		5, 6	±13.5	±14	-	-	-	-	V
Output Short Circuit Current	R <sub>SC</sub> = 10Ω F = 100Hz	4	±11	±12	-	±10.5	±12	-	V
	R <sub>SC</sub> = 0.5Ω V <sub>OUT</sub> = MAX	4	0.8	1.2	1.6	0.7	1.2	1.7	A
Settling Time ③	R <sub>SC</sub> = 5Ω V <sub>OUT</sub> = GND	4	50	150	250	50	150	250	mA
	0.1% 2V step	-	-	4	-	-	4	-	µS
TRANSFER CHARACTERISTICS									
Slew Rate	V <sub>OUT</sub> = ±10V R <sub>L</sub> = 100Ω	4	1.5	3.0	-	1.2	3.0	-	V/µS
Open Loop Voltage Gain	F = 10Hz R <sub>L</sub> = 100Ω	4	100	175	-	100	175	-	V/mV
		5, 6	25	63	-	-	-	-	V/mV
Transition Times	Rise and Fall	4	-	0.3	1.0	-	0.3	1.2	µS
Overshoot	Small Signal	4	-	5	20	-	5	20	%

### NOTES:

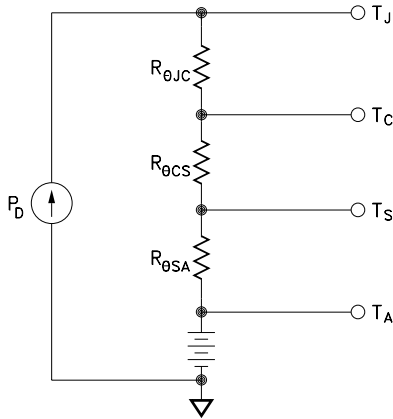
- ① Unless otherwise specified, ±VCC = ±15V, CC = 3000pF.
- ② Guaranteed by design but not tested.
- ③ Typical parameters are representative of actual device performance but are for reference only.
- ④ Industrial devices shall be tested to subgroups 1 and 4 unless otherwise specified..
- ⑤ Military grade devices (B/H suffix) shall be 100% tested to subgroups 1, 2, 3 and 4.
  - Subgroup 1, 4 TA = TC = +25°C
  - 2, 5 TA = TC = +125°C
  - 3, 6 TA = TC = -55°C
- ⑥ Reference DSCC SMD 5962-8508801 for electrical specifications for devices purchased as such.
- 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.

## 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  
 $P_D = [(quiescent\ current) \times (+VCC - (-VCC))] + [(V_s - V_o) \times I_{OUT}]$   
 $= (3.5\ mA) \times (30V) + (5V) \times (1A)$   
 $= 0.1W + 5W$   
 $= 5.1W$
- 2.) For conservative design, set  $T_J = +125^\circ C$ .
- 3.) For this example, worst case  $T_A = +25^\circ C$ .
- 4.)  $R_{\theta JC} = 2.0^\circ C/W$  typically for the TO-3 package.
- 5.) Rearrange governing equation to solve for  $R_{\theta SA}$ :  
 $R_{\theta SA} = (T_J - T_A) / P_D - (R_{\theta JC}) - (R_{\theta CS})$   
 $= (125^\circ C - 25^\circ C) / 5.1W - (2.0^\circ C/W) - (0.15^\circ C/W)$   
 $= 17.5^\circ C/W$

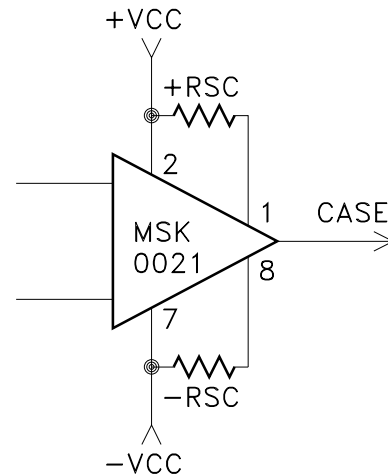
The heat sink in this example must have a thermal resistance of no more than  $17.5^\circ C/W$  to maintain a junction temperature of less than  $+125^\circ C$ .

### CURRENT LIMIT

The MSK0021 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.

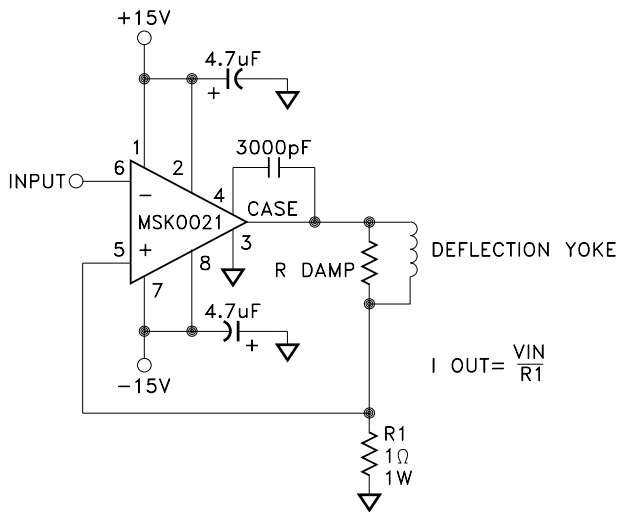
### POWER SUPPLY BYPASSING

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 MSK0021, 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

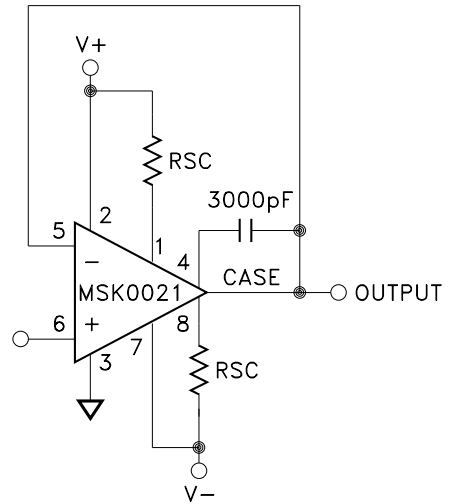
The safe operating area curve is a graphical representation of the power handling capability of the amplifier under various conditions. The wire bond current carrying capability, transistor junction temperature and secondary breakdown limitations are all incorporated into the safe operating area curves.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

# APPLICATION CIRCUITS

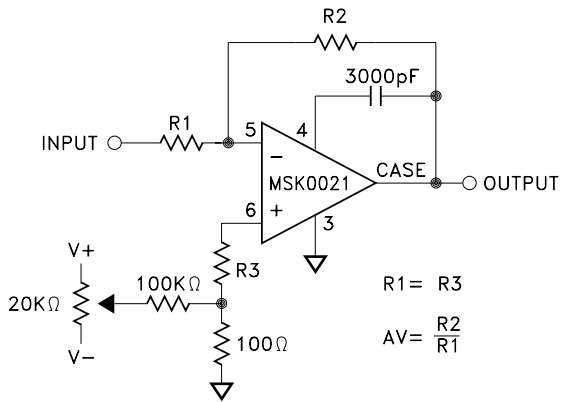


CRT DEFLECTION YOKE DRIVER

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



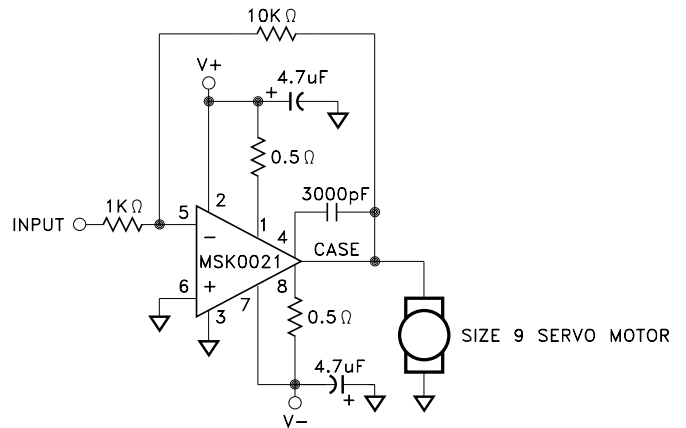
UNITY GAIN CIRCUIT WITH SHORT CIRCUIT LIMITING



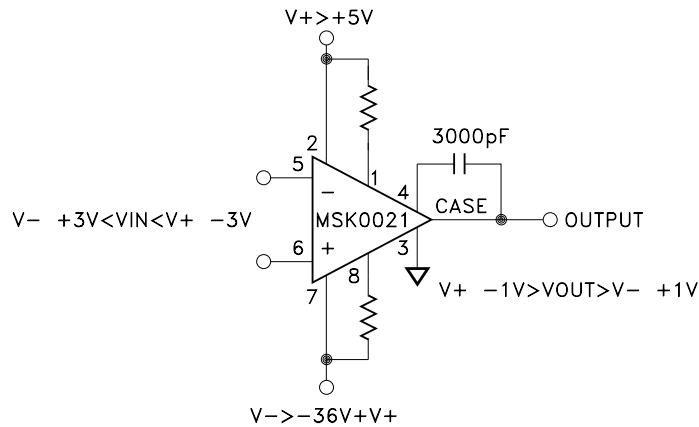
OFFSET VOLTAGE NULL CIRCUIT

$$R_1 = R_3$$

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

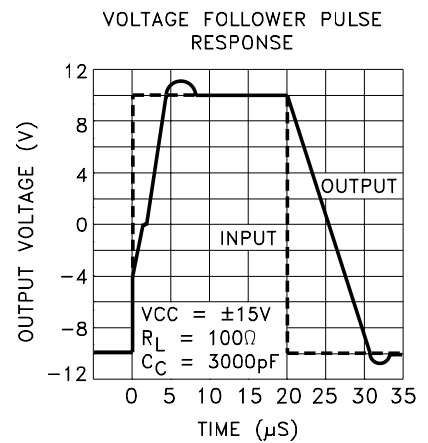
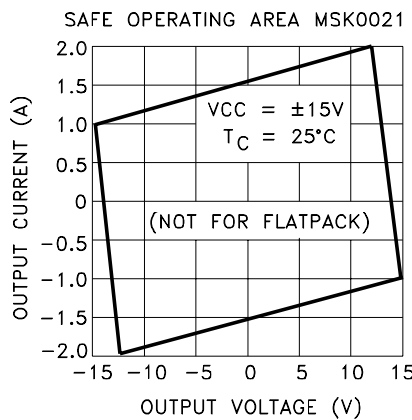
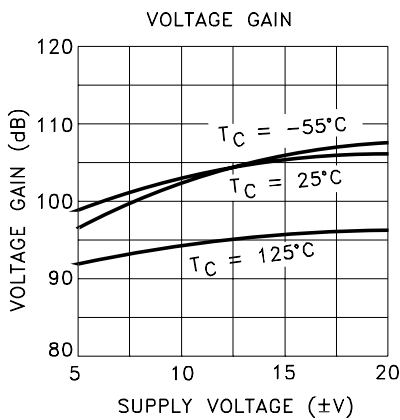
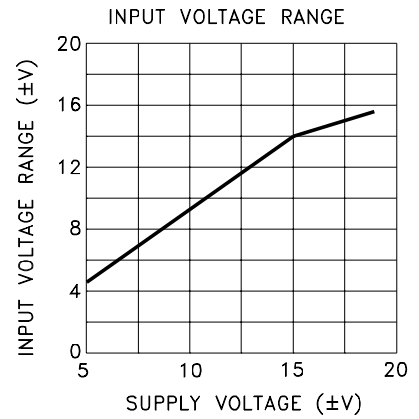
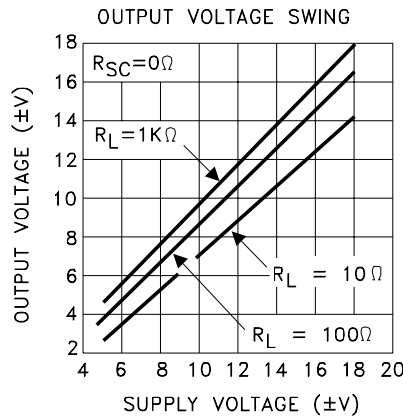
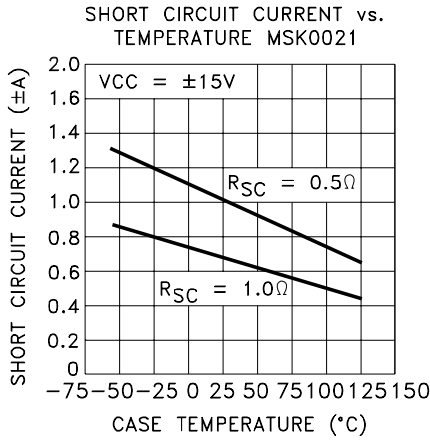
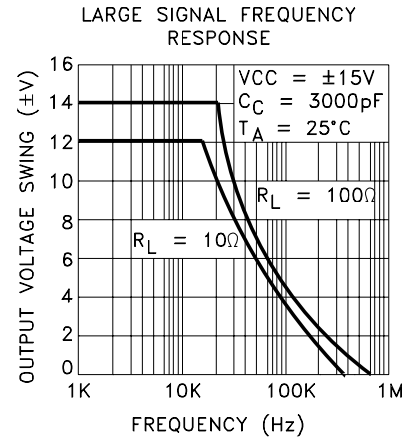
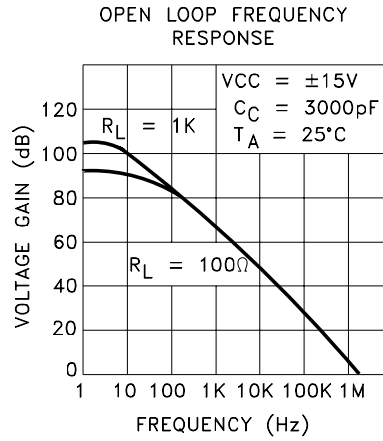
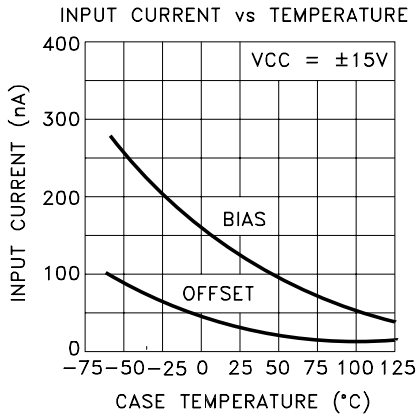


DC SERVO AMPLIFIER



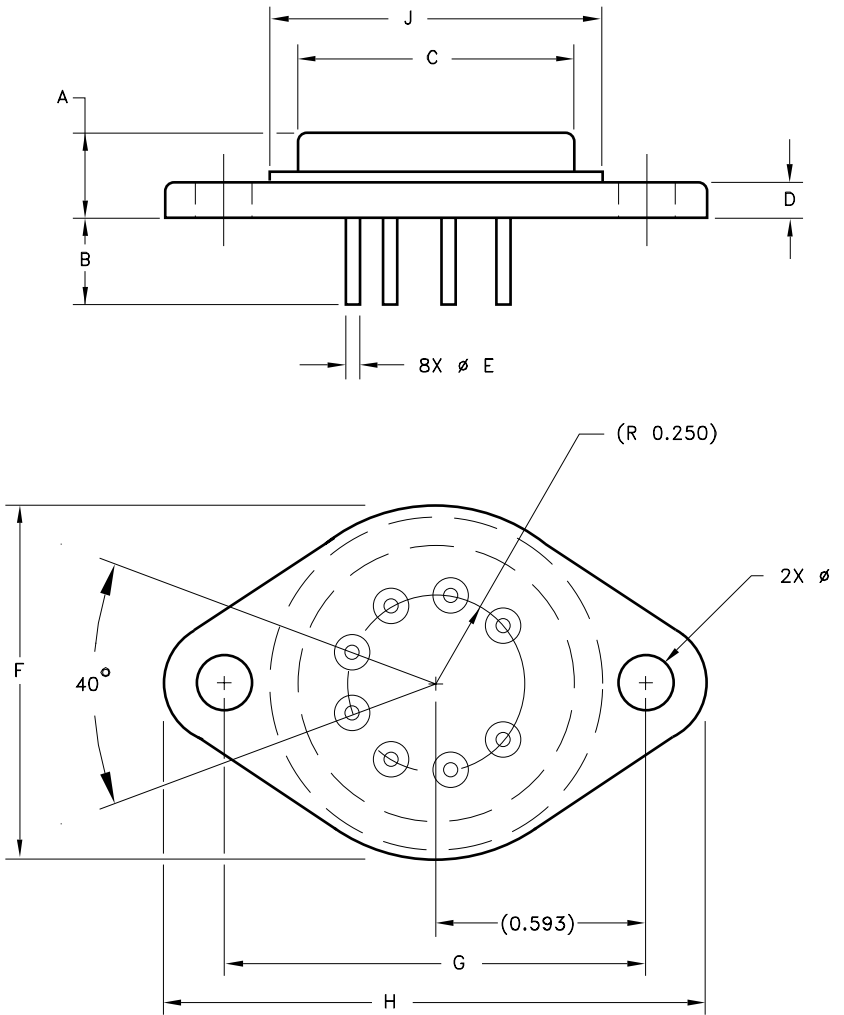
NON SYMMETRICAL SUPPLIES

# TYPICAL PERFORMANCE CURVES



# MECHANICAL SPECIFICATIONS

MSK0021



REF	MIN	MAX
A	0.260	0.395
B	0.220	0.280
C	0.760	0.775
D	0.085	0.105
E	0.036	0.044
F	0.980	1.020
G	1.177	1.197
H	1.509	1.549
I	0.153	0.159
J	0.900	0.925

WEIGHT=14 GRAMS TYPICAL

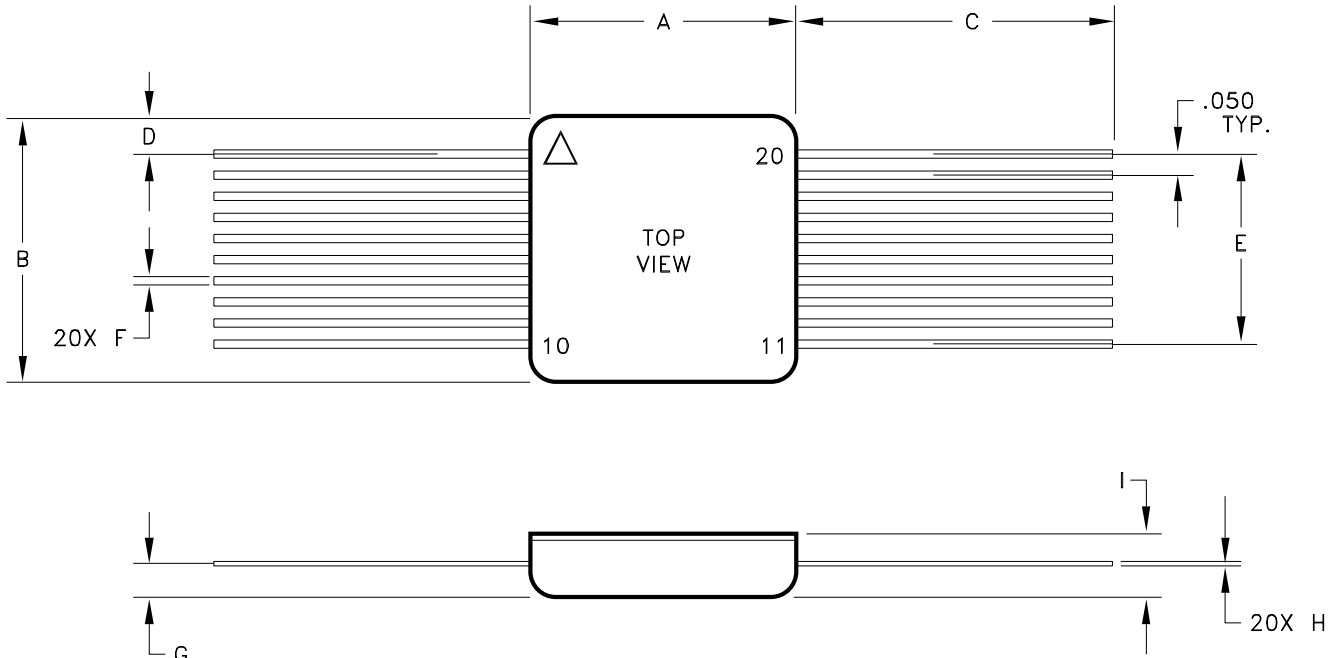
ALL DIMENSIONS ARE SPECIFIED IN INCHES

## ORDERING INFORMATION

Part Number	Screening Level
MSK 0021	Industrial
MSK 0021B	MIL-PRF-38534 Class H
5962-8508801X	DSCC-SMD

**MECHANICAL SPECIFICATIONS CONTINUED**

MSK0021FP



REF	MIN	MAX
A	0.620	0.630
B	0.620	0.630
C	0.500	
D	0.087	REF.
E	0.445	0.455
F	0.013	0.017
G	0.076	0.086
H	0.008	0.012
I	0.145	0.155

ESD TRIANGLE INDICATES PIN 1  
WEIGHT=4 GRAMS TYPICAL

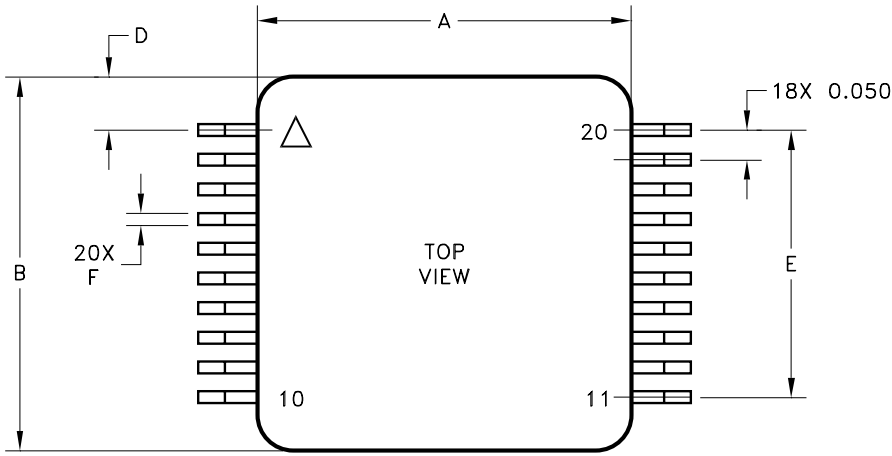
ALL DIMENSIONS ARE SPECIFIED IN INCHES

**ORDERING INFORMATION**

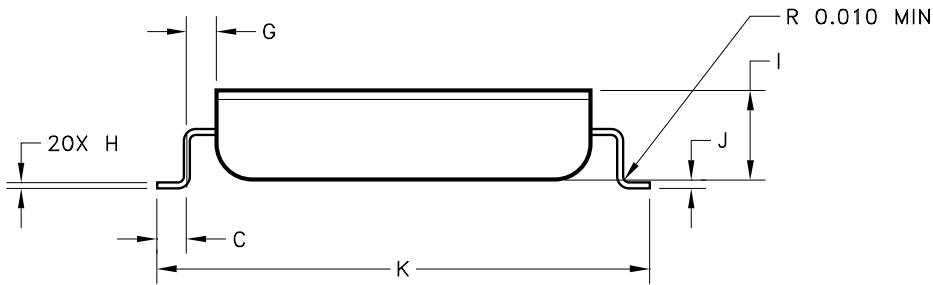
Part Number	Screening Level
MSK 0021FP	Industrial
MSK 0021FPH	MIL-PRF-38534 Class H
TBD	DSCC-SMD

**MECHANICAL SPECIFICATIONS CONTINUED**

MSK0021FPG



REF	MIN	MAX
A	0.620	0.630
B	0.620	0.630
C	0.045	0.055
D	0.087 REF.	
E	0.445	0.455
F	0.013	0.018
G	0.045	0.055
H	0.008	0.012
I		0.155
J	0.010	0.015
J	0.008	0.018
K	0.805	0.845



ESD TRIANGLE INDICATES PIN 1  
WEIGHT=4 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

**ORDERING INFORMATION**

Part Number	Screening Level
MSK 0021FPG	Industrial
MSK 0021FPG H	MIL-PRF-38534 Class H
TBD	DSCC-SMD



## REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
E	Released	09/15	Change $\pm V_{CC}$ in IB, IOS, VOS test paragraphs change AV units from dB to V/mV.
F	Released	09/21	Remove MIL-PRF-38535

TTM Technologies  
[www.ttmtech.com](http://www.ttmtech.com)

---

The information contained herein is believed to be accurate at the time of printing. TTM Technologies reserves the right to make changes to its products or specifications without notice, however and assumes no liability for the use of its products. Please visit our website for the most recent revision of this data sheet.