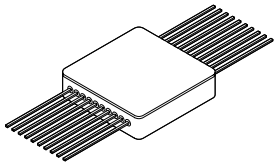
MIL-PRF-38534 AND 38535 CERTIFIED FACILITY

HIGH POWER OP-AMP

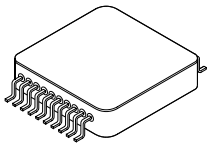
0021 SERIES

FEATURES:

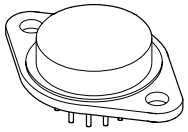
- Available as SMD #5962-8508801
- High Output Current - 2 Amps Peak
- Low Power Consumption-Class C Design
- Programmable Current Limit
- High Slew Rate
- Continuous Output Short Circuit Duration
- Replacement for LH0021
- Functionally Equivalent Rad Hard Device MSK106RH



MSK0021FP



MSK0021FPG

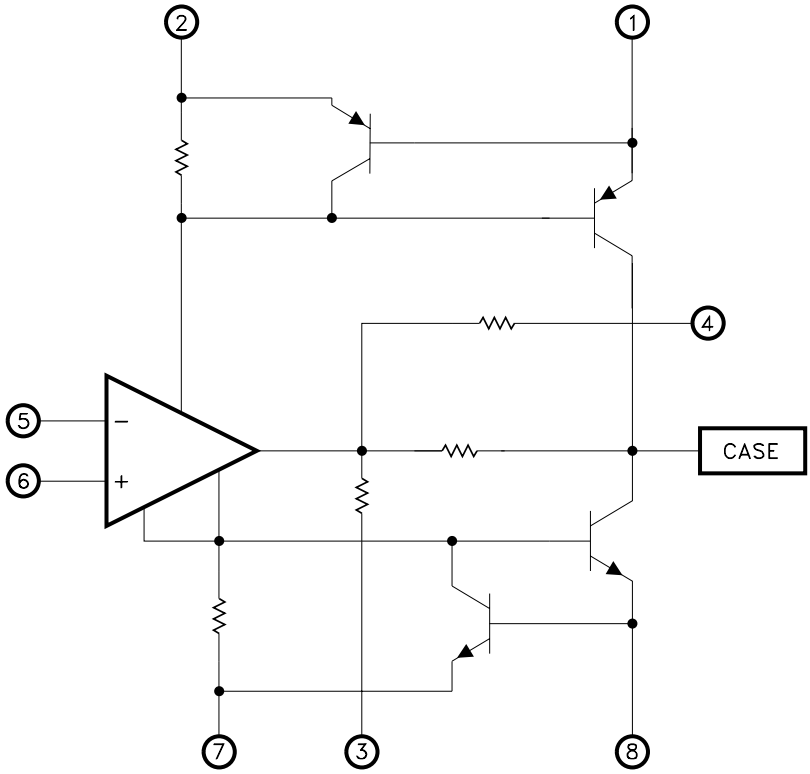


MSK0021

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 Amplifer
- Motor Driver
- Audio Amplifier
- Programmable Power Supply

ABSOLUTE MAXIMUM RATINGS ⑧

±VCC	Supply Voltage ±18V	T_{ST}	Storage Temperature Range -65° to +150°C
I_{OUT}	Peak Output Current 2A	T_{LD}	Lead Temperature Range (10 Seconds) 300°C
VIN	Differential Input Voltage ±30V	P_D	Power Dissipation (TO-3) 6W
VIN	Common Mode Input Voltage ±15V	T_J	Junction Temperature 150°C
R_{TH}	Thermal Resistance-Junction to Case	T_C	Case Operating Temperature Range
	MSK0021 2.0° C/W		Military Versions (H/B) -55°C to +125°C
	MSK0021FP/FPG 6.0° C/W		Industrial Versions -40°C to +85°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions	Group A Subgroup	Military ⑤ Min.	Typ.	Max.	Industrial ④ Min.	Typ.	Max.	Units
STATIC									
Supply Voltage Range ②		-	±12	±15	±18	±12	±15	±18	V
Quiescent Current	VIN = 0V	1,2,3	-	±1.0	±3.5	-	±1.0	±4.0	mA
Power Consumption ②	VIN = 0V	1,2,3	-	75	105	-	90	120	mW
INPUT									
Input Offset Voltage	VIN = 0V, 5V ≤ VCC ≤ 18V	1	-	±0.5	±3.0	-	±0.5	±5.0	mV
		2, 3	-	±2.0	±5.0	-	-	-	µV/°C
Input Bias Current	V_{CM} = 0V, 5V ≤ VCC ≤ 18V	1	-	±100	±300	-	±150	±500	nA
	Either Input	2, 3	-	±0.4	±1.0	-	-	-	µA
Input Offset Current	V_{CM} = 0V	1	-	±2.0	±100	-	±2.0	±300	nA
	5V ≤ VCC ≤ 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_{CM} = ±10V	4	70	90	-	70	90	-	dB
		5,6	70	90	-	-	-	-	dB
Power Supply Rejection Ratio	VCC= ±5V to ±15V	1	80	95	-	80	95	-	dB
		2,3	80	-	-	-	-	-	dB
Input Noise Voltage ③	F = 10Hz to 10KHz	-	-	5	-	-	5	-	μV_{RMS}
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 VOUT = MAX	4	0.8	1.2	1.6	0.7	1.2	1.7	A
	R_{SC} = 5Ω VOUT = GND	4	50	150	250	50	150	250	mA
Settling Time ③	0.1% 2V step	-	-	4	-	-	4	-	µS
TRANSFER CHARACTERISTICS									
Slew Rate	VOUT = ±10V R_L = 100Ω	4	1.5	3.0	-	1.2	3.0	-	V/µS
Open Loop Voltage Gain	F = 10Hz R_L = 1KΩ	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:

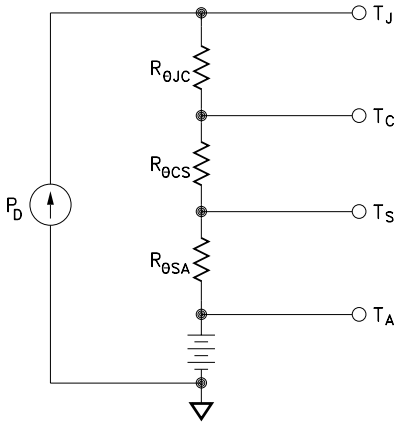
① Unless otherwise specified, ±VCC= ±15V, C_C = 3000pF.
② Guaranteed by design but not tested.
③ Typical parameters are representative of actual device performance but are for reference only.
④ Industrial devices shall be tested to subgroups 1 and 4 unless otherwise specified.
⑤ Military grade devices (B/H suffix) shall be 100% tested to subgroups 1, 2, 3 and 4.
Subgroup 1, 4 T_A=T_C=+25°C
Subgroup 2, 5 T_A=T_C=+125°C
Subgroup 3, 6 T_A=T_C= -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 ±15 VDC.

1.) Find Power Dissipation
P_D=[(quiescent current) X (+VCC- (-VCC))] + [(V_S - V_O) X I_{OUT}]
=(3.5 mA) X (30V) + (5V) X (1A)
=0.1W + 5W
=5.1W
2.) For conservative design, set T_J = +125°C.
3.) For this example, worst case T_A = +25°C.
4.) $R_{\theta JC}$ = 2.0°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°C - 25°C) / 5.1W - (2.0°C/W) - (0.15°C/W)
= 17.5°C/W

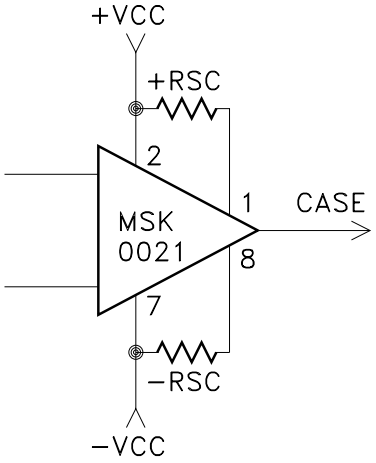
The heat sink in this example must have a thermal resistance of no more than 17.5°C/W to maintain a junction temperature of less than +125°C.

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.

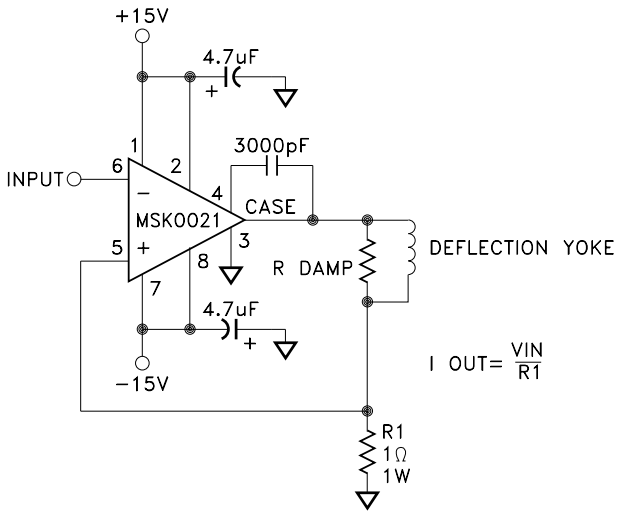
POWER SUPPLY BYPASSING

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.

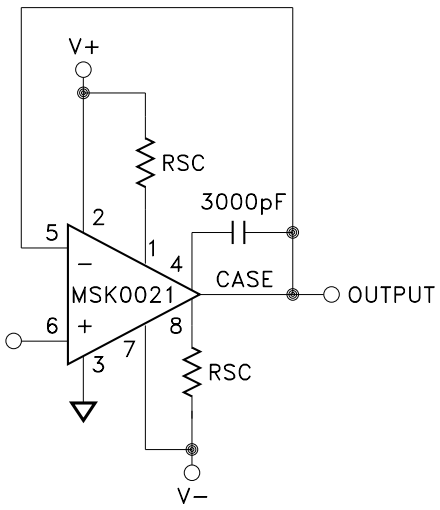
SAFE OPERATING AREA

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.

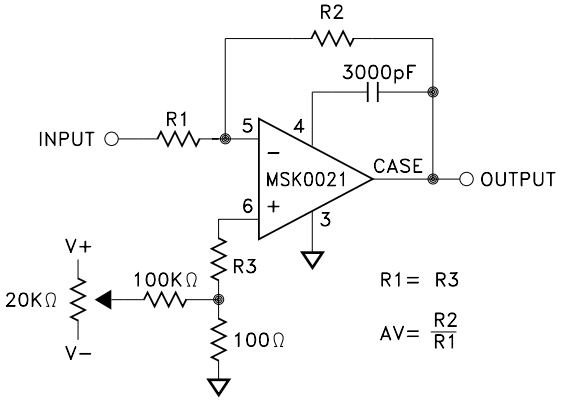
APPLICATION CIRCUITS



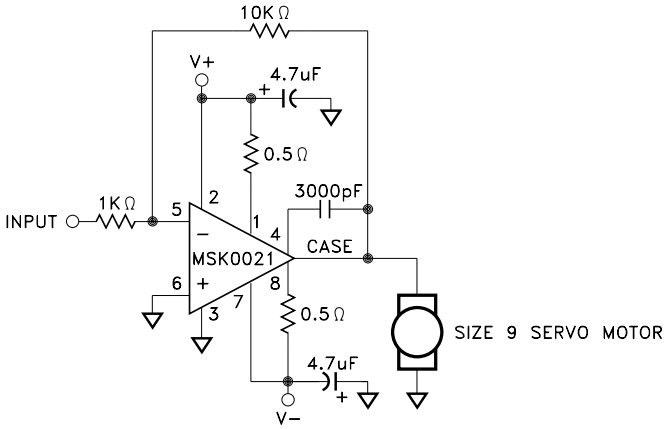
CRT DEFLECTION YOKE DRIVER



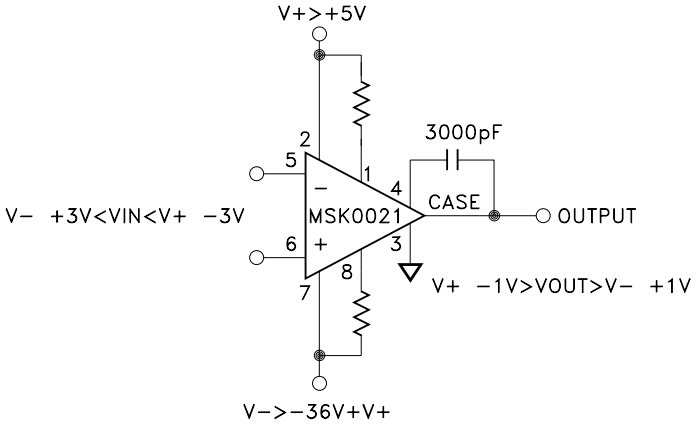
UNITY GAIN CIRCUIT WITH
SHORT CIRCUIT LIMITING



OFFSET VOLTAGE NULL CIRCUIT



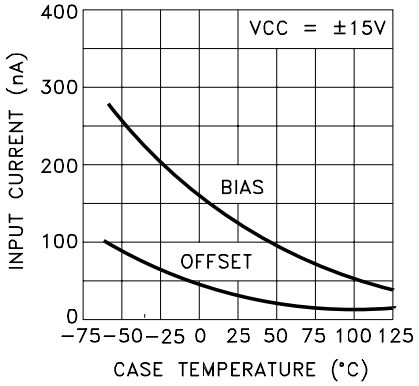
DC SERVO AMPLIFIER



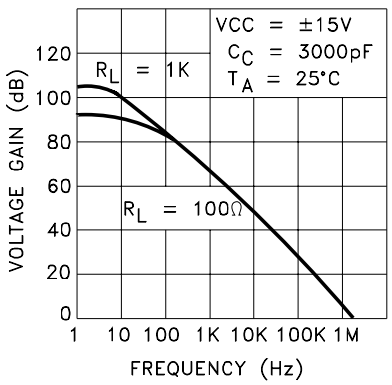
NON SYMMETRICAL SUPPLIES

TYPICAL PERFORMANCE CURVES

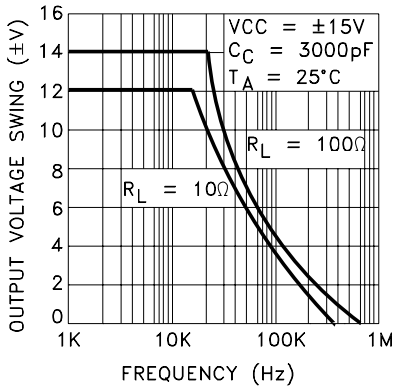
INPUT CURRENT vs TEMPERATURE



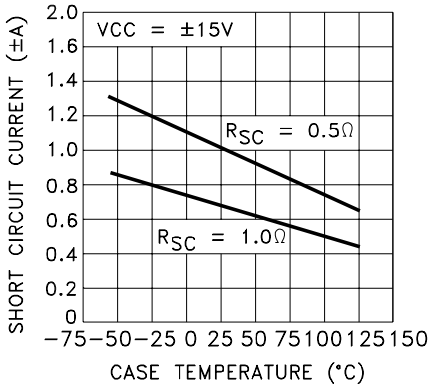
OPEN LOOP FREQUENCY RESPONSE



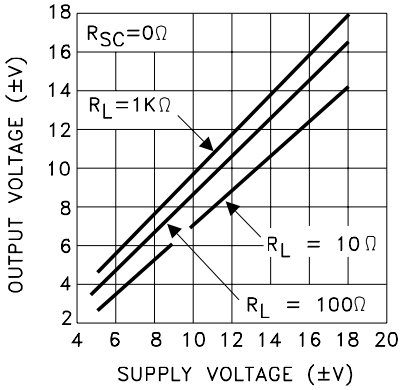
LARGE SIGNAL FREQUENCY RESPONSE



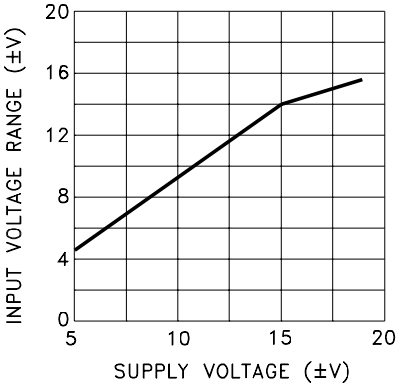
SHORT CIRCUIT CURRENT vs. TEMPERATURE MSK0021



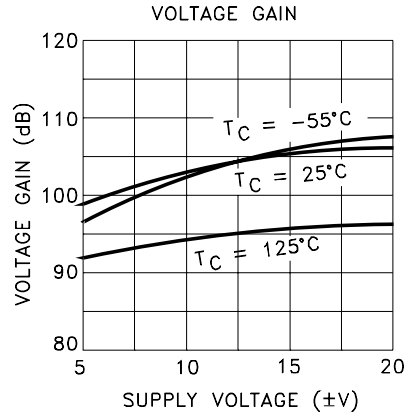
OUTPUT VOLTAGE SWING



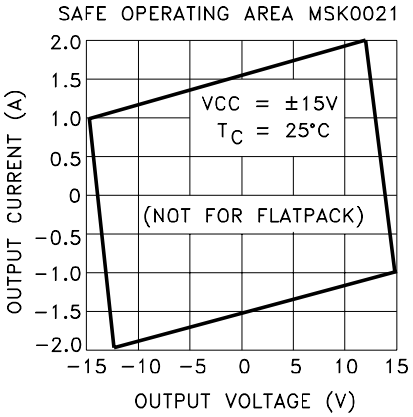
INPUT VOLTAGE RANGE



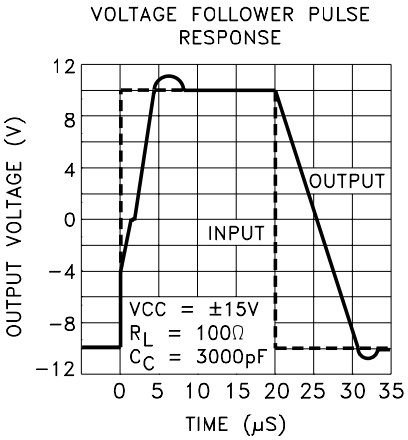
VOLTAGE GAIN



SAFE OPERATING AREA MSK0021

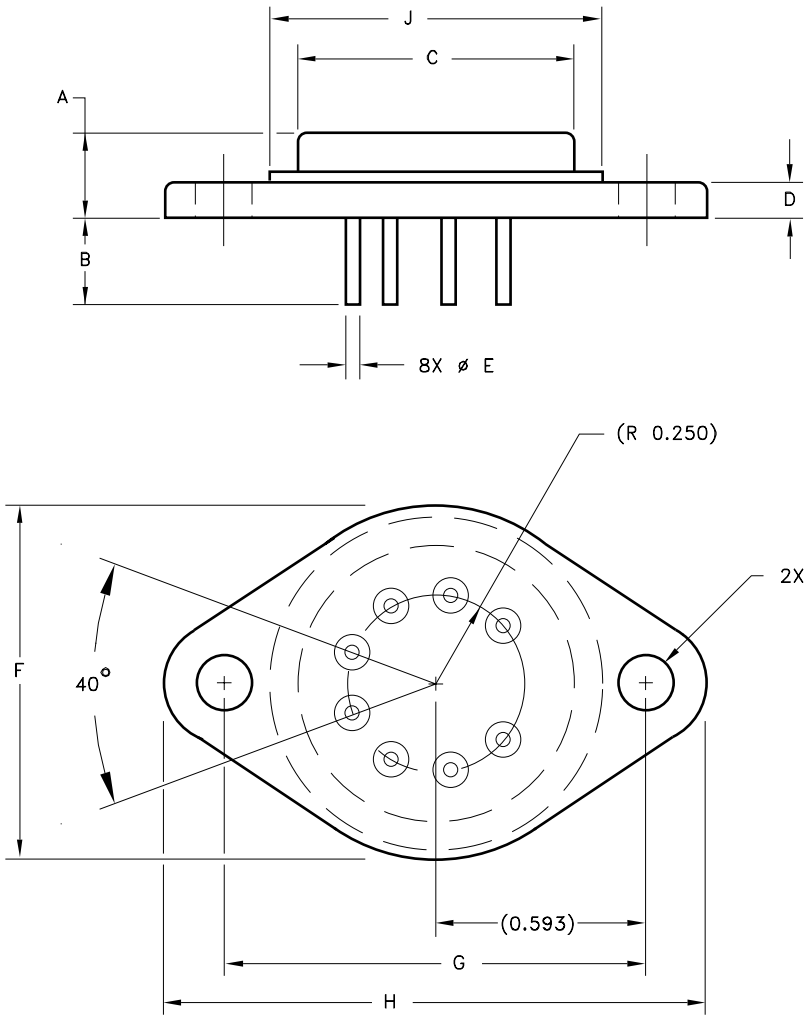


VOLTAGE FOLLOWER PULSE RESPONSE



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

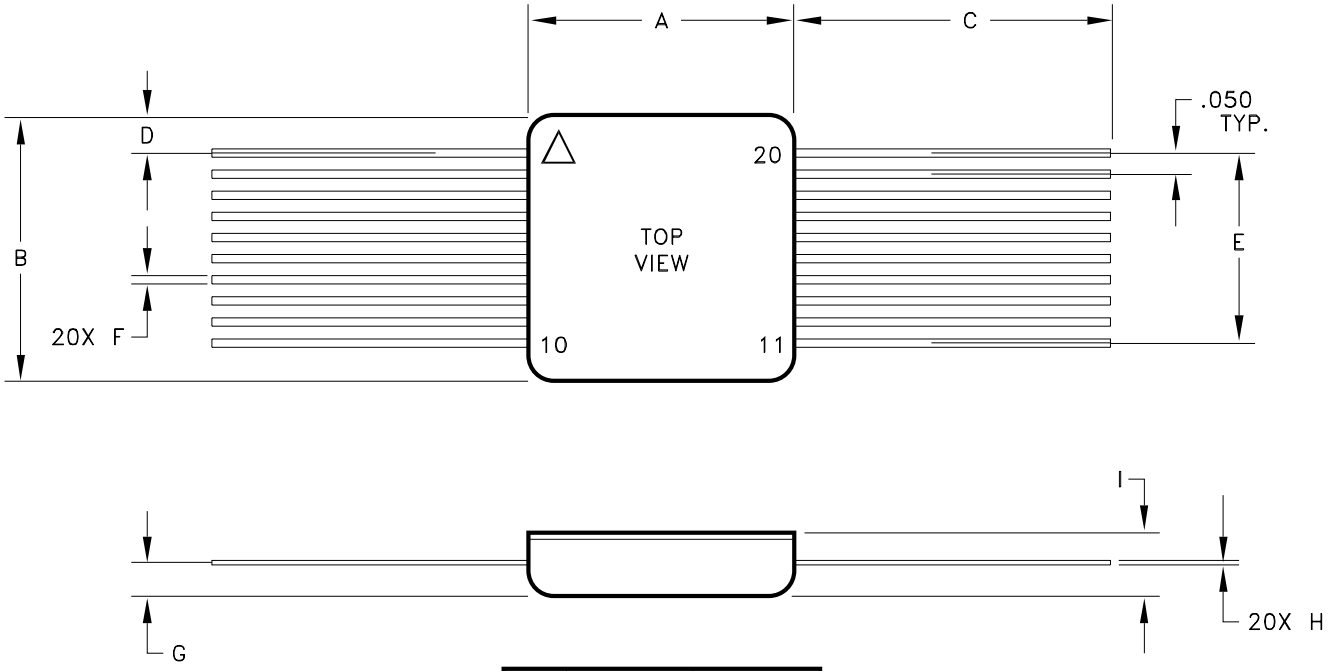
ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

Part Number	Screening Level
MSK0021	Industrial
MSK0021B	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

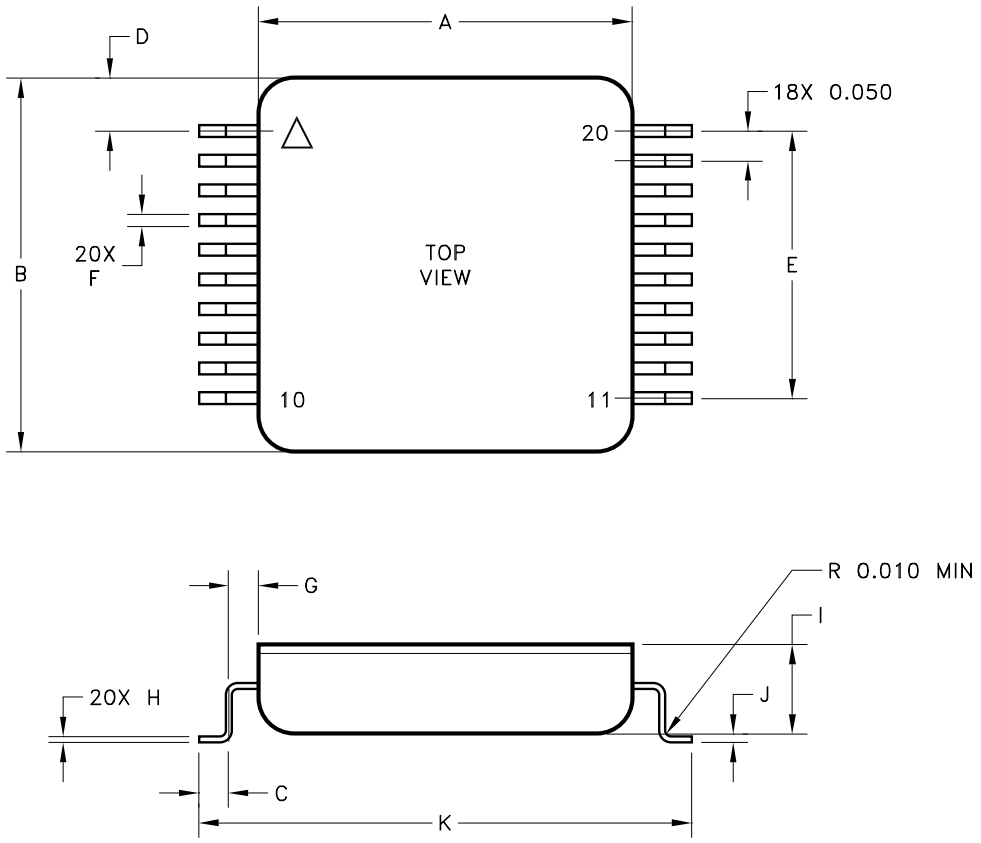
ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

Part Number	Screening Level
MSK0021FP	Industrial
MSK0021FPH	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 ±VCC in IB, IOS, VOS test paragraphs change AV units from dB to V/mV.

MSK
www.anaren.com/msk