M.S.KENNEDY CORP.

HIGH VOLTAGE OPERATIONAL AMPLIFIER 0004

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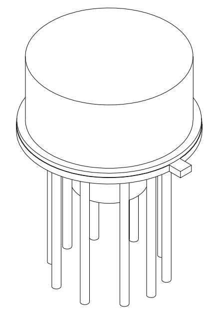
MIL-PRF-38534 QUALIFIED

FEATURES:

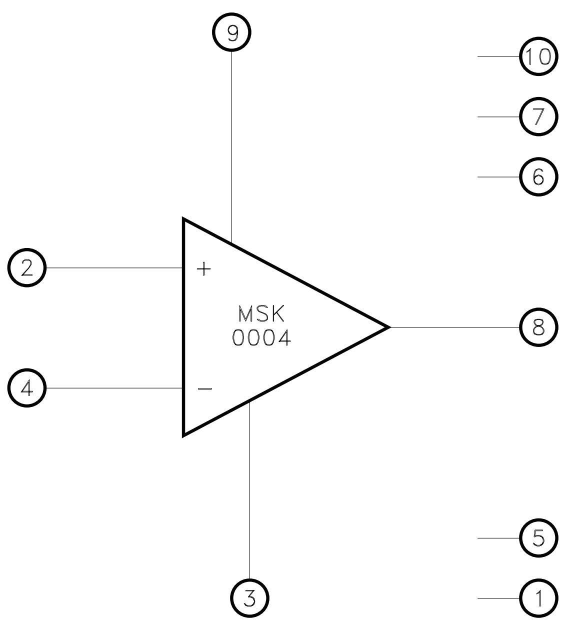
- Pin Similar Replacement for the LH0004
- Wide Supply Voltage Range: ±10V to ±50V
- Low Offset Current: 15nA
- High Voltage Gain: 200KV/V
- Internal Compensation
- Output Overload Protection
- Thermal Overload Protection



DESCRIPTION:

The MSK 0004 is a high voltage operational amplifier for use in high performance signal conditioning applications, as well as resolver excitation designs. These devices offer maximum reliability by providing internal output overload protection and thermal overload protection. Monolithic design and internal compensation make the MSK 0004 an excellent replacement for many general purpose operational amplifiers and specifically the LH0004. The MSK 0004 is internally compensated and can replace the LH0004 in most applications without any changes to existing circuitry. The device is packaged in an hermetically sealed 10 pin metal can.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Precision High Voltage Power Supply
- High Voltage Regulators
- Signal Conditioning
- Resolver Excitation
- Transducer Power Supply

PIN-OUT INFORMATION

1	NC	10	NC
2	+Input	9	+Vcc
3	-Vcc	8	Output
4	-Input	7	NC
5	NC	6	NC

ABSOLUTE MAXIMUM RATINGS

V_{CC}	Supply Voltage	±50V
V_{IN}	Differential Input Voltage	±40V
T_C	Case Operating Temperature Range	
	MSK0004H/E	-55°C to +125°C
	MSK0004	-40°C to +85°C
T_{ST}	Storage Temperature Range	-65°C to +150°C
T_{LD}	Lead Temperature Range (10 Seconds)	300°C
T_C	Junction Temperature	175°C

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①	Group A Subgroup	MSK0004H/E Min.	MSK0004H/E Typ.	MSK0004H/E Max.	MSK0004 Min.	MSK0004 Typ.	MSK0004 Max.	Units
STATIC									
Supply Voltage Range ②		-	±10	±40	±50	±10	±40	±45	V
Quiescent Current		1	-	±3.0	±4.5	-	±3.0	±5.0	mA
		2,3	-	-	±4.5	-	-	-	mA
INPUT									
Input Offset Voltage	AV=10	1	-	±1.0	±6.0	-	±1.0	±7.5	mV
		2,3	-	-	±7.0	-	-	-	mV
Input Offset Voltage Drift ②		-	-	±15	-	-	±15	-	μV/°C
Input Bias Current ②	V_{CM}=0V	1	-	±12	±30	-	±12	±50	nA
		2,3	-	-	±50	-	-	-	nA
Input Offset Current ②	V_{CM}=0V	1	-	±15	±30	-	±15	±40	nA
Common Mode Rejection Ratio ②	V_{CM}=±20V_{DC}	-	74	100	-	74	100	-	dB
Input Impedence ②	DC	-	40	250	-	40	250	-	MΩ
OUTPUT									
Output Voltage Swing	f=1KHz	4	±35	±37	-	±35	±37	-	V
Power Bandwidth ②	V_{OUT}=±35V_{PK}	-	-	23	-	-	23	-	KHz
Output Resistance ②	No Load	-	-	500	-	-	500	-	Ω
Capacitive Load ②	R_L=1KΩ	-	-	50	-	-	50	-	pF
TRANSFER CHARACTERISTICS									
Slew Rate	V_{OUT}=±30V_{PK}	4	2.5	5.0	-	2.5	5.0	-	V/μS
Open Loop Voltage Gain ②	V_{OUT}=±30V_{PK} f=10KHz	4	100K	200K	-	100K	200K	-	V/V
Thermal Resistance	Junction to Case @ 125°C	-	-	16	19	-	16	22	°C/W

NOTES:

① Unless otherwise specified, V_{CC}=±40V_{DC} and V_{IN}=0V.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise requested.
④ Military grade devices ("H" suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Subgroup 5 and 6 testing available upon request.
⑥ Subgroup 1,4 T_C=+25°C
Subgroup 2,5 T_C=+125°C
Subgroup 3,6 T_A=-55°C

APPLICATION NOTES

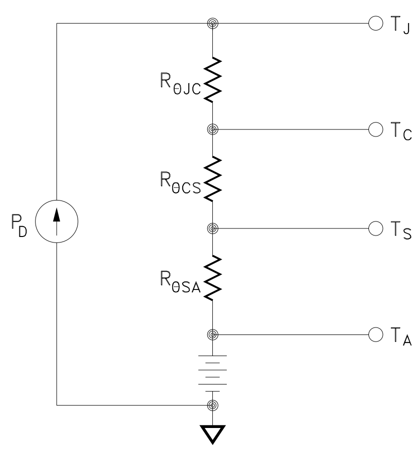
POWER SUPPLY BYPASSING

Both the negative and positive power supplies must be effectively decoupled with a high and low frequency bypass circuit to avoid power supply induced oscillation. An effective deecoupling 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.

HEAT SINKING

To determine if a heat sink is necessary for your application and if so, what type, 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:

The example demonstrates a worst case analysis for the op-amp output stage. This occurs when the output voltage is 1/2 the power supply voltage. Under this condition, maximum power transfer occurs and the output is under maximum stress.

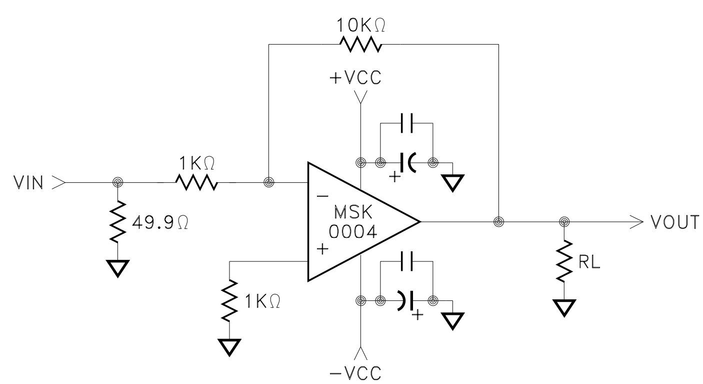
Conditions:
$V_{CC} = \pm 40VDC$
$V_O = \pm 20Vp$ Sine Wave, Freq. = 1KHz
$R_L = 1K\Omega$

For a worst case analysis we treat the ±20Vp sine wave as an 8 VDC output voltage.

1.) Find driver power dissipation
$P_D = (V_{CC}-V_O)\ (V_O/R_L)$
$= (40V-20V)\ (20V/1K\Omega)$
$= 400mW$
2.) For conservative design, set $T_J = +125°C$.
3.) For this example, worst case $T_A = +100°C$.
4.) $R_{\theta JC} = 16°C/W$.
5.) $R_{\theta CS} = 0.15°C/W$ for most thermal greases.
6.) Rearrange governing equation to solve for $R_{\theta SA}$:
$R_{\theta SA} = ((T_J - T_A) / P_D) - (R_{\theta JC}) - (R_{\theta CS})$
$= (125°C - 100°C)/0.4W - 16°C/W - 0.15°C/W$
$= 62.5 - 16.15$
$= 46.4°C/W$

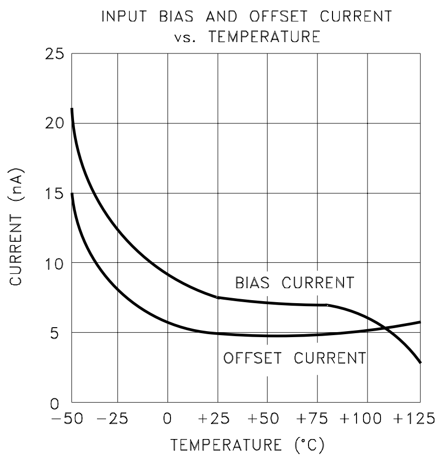
The heat sink in this example must have a thermal resistance of no more than 46.4°C/W to maintain a junction temperature of less than +125°C.

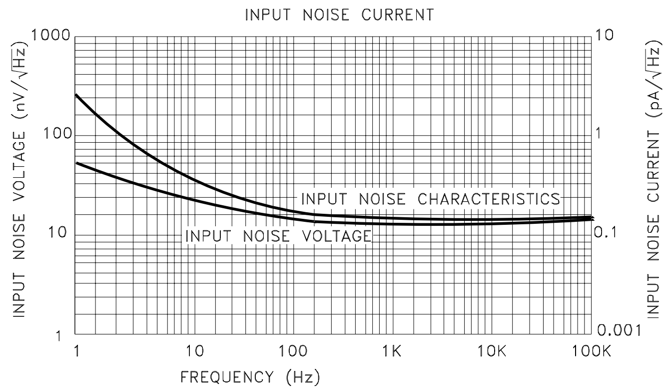
TYPICAL APPLICATION CIRCUIT

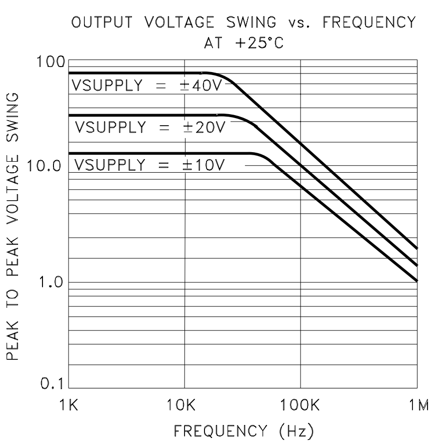


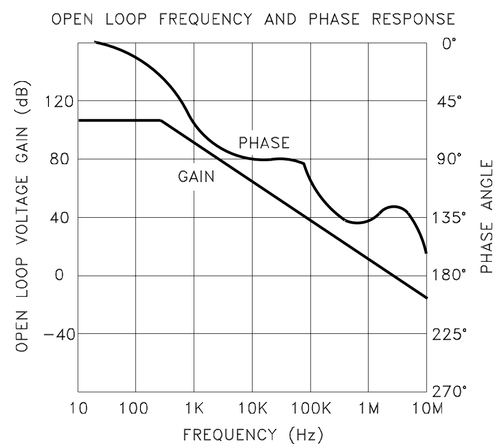
REPLACING THE LH0004

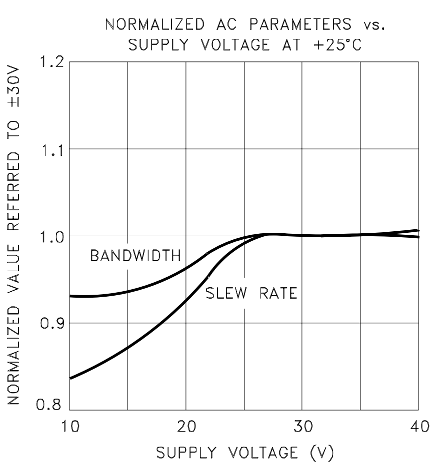
The MSK 0004 is not an exact copy of the LM0004 but it is only slightly different. The MSK 0004 is internally compensated and is lower cost. Pins 1,5,6,7 and 10 are not connected internally in the MSK0004.

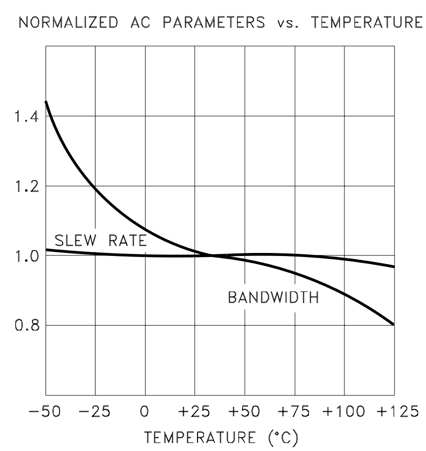

INPUT BIAS AND OFFSET CURRENT
vs. TEMPERATURE
CURRENT (nA)
25
20
15
10
5
0
BIAS CURRENT
OFFSET CURRENT
−50 −25 0 +25 +50 +75 +100 +125
TEMPERATURE (°C)


INPUT NOISE CURRENT
INPUT NOISE VOLTAGE (nV/√Hz)
1000
100
10
1
10
1
0.1
0.001
INPUT NOISE CURRENT (pA/√Hz)
INPUT NOISE CHARACTERISTICS
INPUT NOISE VOLTAGE
1 10 100 1K 10K 100K
FREQUENCY (Hz)

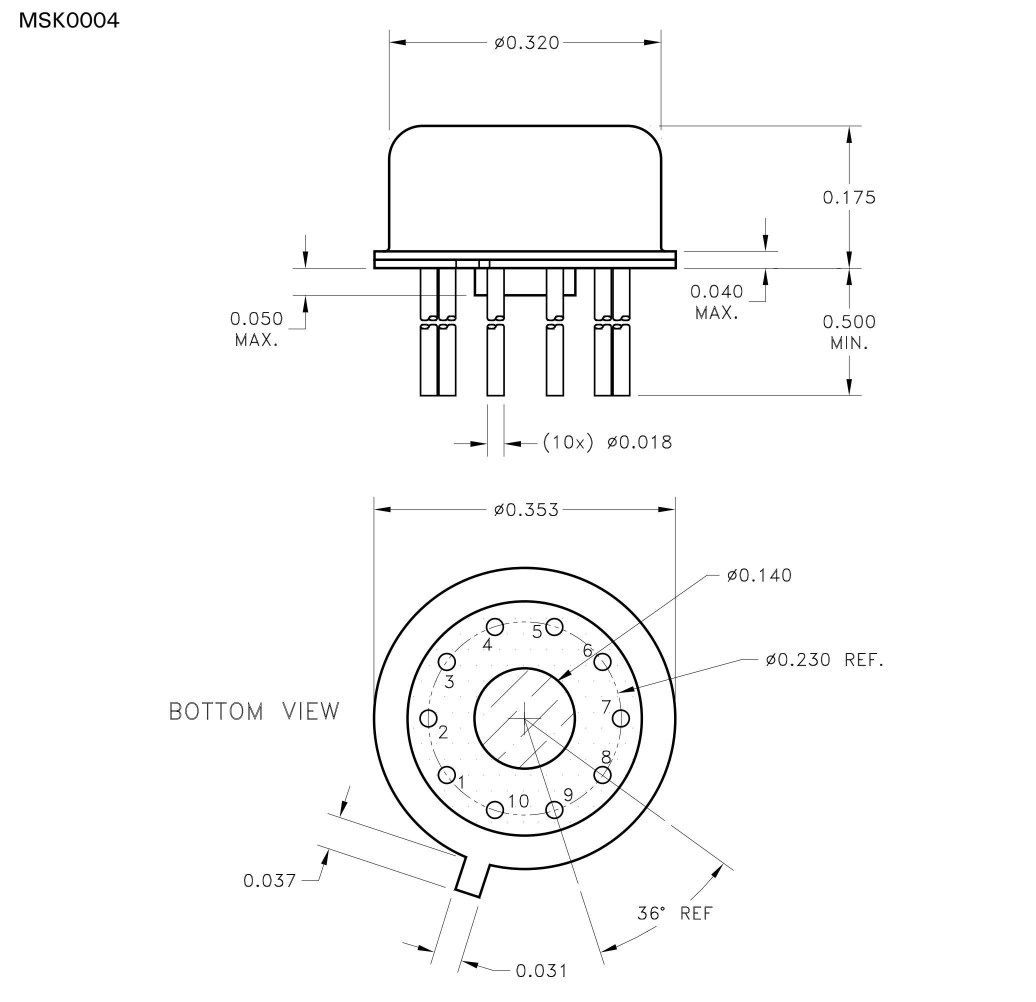

OUTPUT VOLTAGE SWING vs. FREQUENCY
AT +25°C
PEAK TO PEAK VOLTAGE SWING
100
10.0
1.0
0.1
VSUPPLY = ±40V
VSUPPLY = ±20V
VSUPPLY = ±10V
1K 10K 100K 1M
FREQUENCY (Hz)


OPEN LOOP FREQUENCY AND PHASE RESPONSE
OPEN LOOP VOLTAGE GAIN (dB)
120
80
40
0
−40
0°
45°
90°
135°
180°
225°
270°
PHASE ANGLE
PHASE
GAIN
10 100 1K 10K 100K 1M 10M
FREQUENCY (Hz)


NORMALIZED AC PARAMETERS vs.
SUPPLY VOLTAGE AT +25°C
NORMALIZED VALUE REFERRED TO ±30V
1.2
1.1
1.0
0.9
0.8
BANDWIDTH
SLEW RATE
10 20 30 40
SUPPLY VOLTAGE (V)


NORMALIZED AC PARAMETERS vs. TEMPERATURE
1.4
1.2
1.0
0.8
SLEW RATE
BANDWIDTH
−50 −25 0 +25 +50 +75 +100 +125
TEMPERATURE (°C)

MECHANICAL SPECIFICATIONS



ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.

ORDERING INFORMATION

MSK0004 H

SCREENING
BLANK= INDUSTRIAL; E=EXTENDED RELIABILITY
H= MIL-PRF-38534 CLASS H

GENERAL PART NUMBER

The above example is a Military grade hybrid.

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