MSK

M.S.KENNEDY CORP.

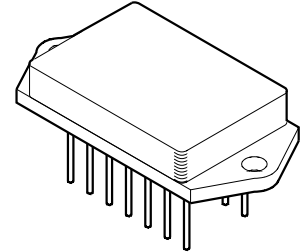# ULTRA HIGH VOLTAGE OPERATIONAL AMPLIFIER

164

4707 Dey Road Liverpool, N.Y. 13088

(315) 701-6751

FEATURES:

- Monolithic MOS Technology
- External Compensation And Null Capability
- High Voltage Operation : 350V
- Low Quiescent Current : 2mA Max.
- High Output Current : 60mA Min.
- No Second Breakdown
- High Speed : 40V/μS Typ.
- Low Cost

MIL-PRF-38534 QUALIFIED

MSK164

DESCRIPTION:

The MSK 164 is an ultra high voltage monolithic MOSFET operational amplifier ideally suited for electrostatic transducer and electrostatic deflection applications. With a total supply voltage rating of 350 volts and 60mA of available output current, the MSK 164 is also an excellent low cost choice for high voltage piezo drive circuits. The MOSFET output frees the MSK 164 from secondary breakdown limitations and power dissipation is kept to a minimum with a quiescent current rating of only 2mA. The MSK 164 has user adjustable compensation and output null pins and is packaged in a 14 pin power dip with bolt down tabs.

EQUIVALENT SCHEMATIC
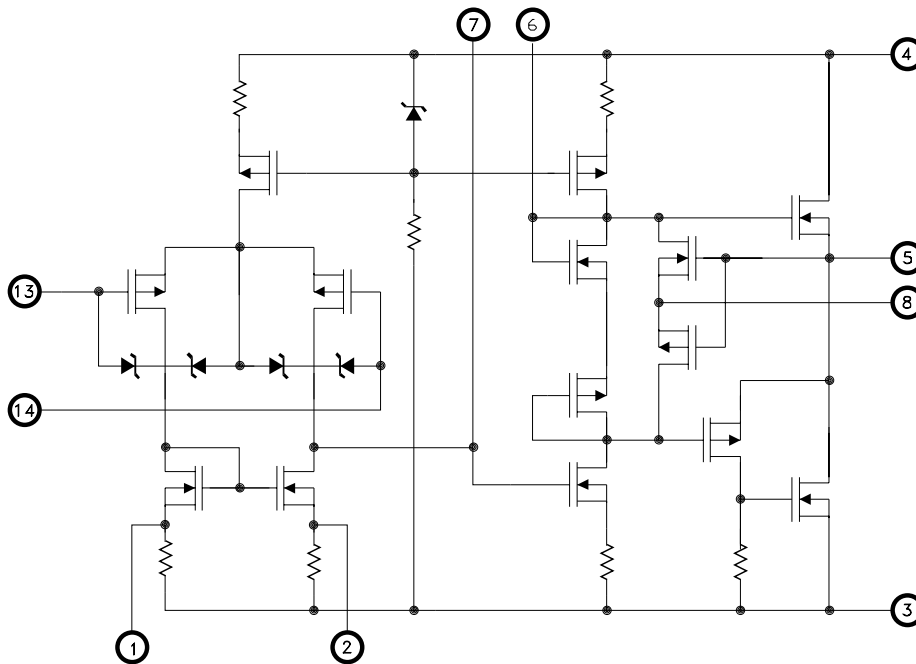
TYPICAL APPLICATIONS

- Piezo Electric Positioning
- Electrostatic Deflection
- Computer to Vacuum Tube Interface
- Ultra High Voltage Op-Amp Applications

PIN-OUT INFORMATION

1	Balance 1	14	Non-Inverting Input
2	Balance 2	13	Inverting Input
3	-Vcc	12	N/C
4	+Vcc	11	N/C
5	Output Drive	10	N/C
6	Comp 1	9	N/C
7	Comp 2	8	Current Sense

Rev. A 8/00

ABSOLUTE MAXIMUM RATINGS

V_{CC} ② Total Supply Voltage 350V
$\pm I_{OUT}$ Output Current (within S.O.A.) 60mA
$\pm I_{OUTP}$ Output Current Peak 120mA
V_{IND} Input Voltage (Differential) . . . . . . $\pm$16V
V_{IN} Input Voltage (Common Mode) . . . . $\pm V_{CC}$
T_J Junction Temperature . . . . 150°C

T_{ST} Storage Temperature . . . . . . -65°C to +150°C
T_{LD} Lead Temperature . . . . 300°C
T_C Case Operating Temperature
   (MSK164B) . . . . -55°C to +125°C
   (MSK164) . . . . -40°C to +85°C
R_{TH} Thermal Resistance (DC)
   Junction to Case . . . . 12°C/W

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①	Group A Subgroup	MSK164B Min.	MSK164B Typ.	MSK164B Max.	MSK164 Min.	MSK164 Typ.	MSK164 Max.	Units
STATIC									
Supply Voltage Range ② ④ ⑨		-	$\pm$50	$\pm$150	$\pm$175	$\pm$50	$\pm$150	$\pm$175	V
Quiescent Current		1	-	$\pm$1.4	$\pm$2.0	-	$\pm$1.4	$\pm$2.0	mA
	$V_{IN}=0V$	2	-	$\pm$2.0	$\pm$3.0	-	-	-	mA
		3	-	$\pm$1.0	$\pm$2.1	-	-	-	mA
INPUT									
Offset Voltage	$V_{IN}=0V$	1	-	$\pm$15	$\pm$30	-	$\pm$15	$\pm$30	mV
Offset Voltage Drift ④	$V_{IN}=0V$	2,3	-	$\pm$40	$\pm$65	-	$\pm$40	-	μV/°C
Offset Voltage vs $\pm V_{CC}$ ④	$V_{IN}=0V$	1	-	$\pm$20	$\pm$32	-	$\pm$20	$\pm$32	μV/V
Input Bias Current ④	$V_{CM}=0V$	1,3	-	$\pm$5	$\pm$50	-	$\pm$5	$\pm$100	pA
		2	-	-	$\pm$50	-	-	-	nA
Input Impedance ④	(DC)	-	-	10^{11}	-	-	10^{11}	-	Ω
Input Capacitance ④		-	-	5	-	-	5	-	pF
Common Mode Rejection ④	$V_{CM}=\pm90VDC$	-	84	94	-	84	94	-	dB
Noise	1Hz$\leq$f$\leq$10Hz	-	-	50	-	-	50	-	μV_{RMS}
OUTPUT									
Output Voltage Swing	$I_{OUT}=\pm40mA$ Peak	4	$\pm$138	$\pm$141	-	$\pm$138	$\pm$141	-	V
Output Current	$V_{OUT}=MAX$	4	$\pm$60	$\pm$120	-	$\pm$60	$\pm$120	-	mA
Power Bandwidth ④	$C_C=10pF$ $V_{OUT}=280V_{PP}$	-	-	26	-	-	26	-	KHz
Resistance ④	No Load $R_{CL}=0\Omega$	-	-	150	-	-	150	-	Ω
Settling Time to 0.1% ③④	$C_C=10pF$ 10V Step	-	-	12	-	-	12	-	μS
Capacitive Load ④	$A_V=+1V/V$	-	10	-	-	10	-	-	nF
TRANSFER CHARACTERISTICS									
Slew Rate	$C_C=Open$	4	20	40	-	20	40	-	V/μS
Open Loop Voltage Gain	$F=15Hz$ $R_L=5K\Omega$	4	94	106	-	94	106	-	dB

NOTES:

① Unless otherwise noted C_C=18pF, R_C=2.2KΩ, $\pm V_{CC}=\pm$150VDC, null pins 1 and 2 are N/C.
② Derate maximum supply voltage 0.5V/°C below T_C=+25°C. No derating is needed above T_C=25°C.
③ A_V=-10V/V measured in false summing junction circuit.
④ Devices shall be capable of meeting the parameter, but need not be tested. Typical parameters are for reference only.
⑤ Industrial grade devices shall be tested to subgroups 1 and 4 unless otherwise requested.
⑥ Military grade devices ('B' suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑦ Subgroup 5 and 6 testing available upon request.
⑧ Subgroup 1,4 T_C = +25°C
   Subgroup 2,5 T_C = +125°C
   Subgroup 3,6 T_A = -55°C
⑨ Electrical specifications are derated for power supply voltages less than $\pm$50VDC.

CURRENT LIMIT

Current limit resistor value can be calculated as follows:

$$R_{CL} = 3/I_{LIM}$$

It is recommended that the user set up the value of current limit as close as possible to the maximum expected output current to protect the amplifier. The minumum value of current limit resistance is 33 ohms. The maximum practical value is 500 ohms. Current limit will vary with case temperature. Refer to the typical performance graphs as a guide. Since load current passes through the current limit resistor, a loss in output voltage swing will occur. The following formula approximates output voltage swing reduction:

$$V_R = I_O * R_{CL}$$

When the device is in current limit, there will be spurious oscillations present on the negative half cycle. The frequency of the oscillation is application dependent and can not be predicted. Oscillation will cease when the device comes out of current limit.

INPUT PROTECTION

Input protection circuitry within the MSK 164 will clip differential input voltages greater than 16 volts. The inputs are also protected against common mode voltages up to the supply rails as well as static discharge. There are 300 ohm current limiting resistors in series with each input. These resistors may become damaged in the event the input overload is capable of driving currents above 1mA. If severe overload conditions are expected, external input current limiting resistors are recommended.

OUTPUT SNUBBER NETWORK

A 100 ohm resistor and a 330pF capacitor connected in series from the output of the amplifier to ground is recommended for applications where load capacitance is less than 330pF. For larger values of load capacitance, the output snubber network may be omitted. If loop stability becomes a problem due to excessively high load capacitance, a 100 ohm resistor may be added between the output of the amplifier (the junction of R_{CL} and pin 8) and the load. A small tradeoff with bandwidth must be made in this configuration. The graph below illustrates the effect of capacitive load on open loop gain. Note that the snubber capacitor must have a voltage rating greater than or equal to the total rail to rail power supply voltage.


SMALL SIGNAL RESPONSE
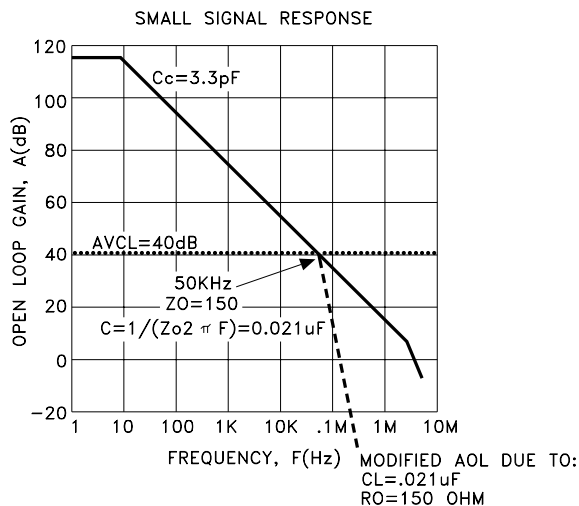
SAFE OPERATING AREA (SOA)

The MOSFET output stage of this power operational amplifier has two distinct limitations:
1. The current handling capability of the die metallization.
2. The junction temperature of the output MOSFET's.

NOTE: The output stage is protected against transient flyback. However, for protection against sustained, high energy flyback, external fast-recovery reverse biased diodes should be connected from the output to ground.
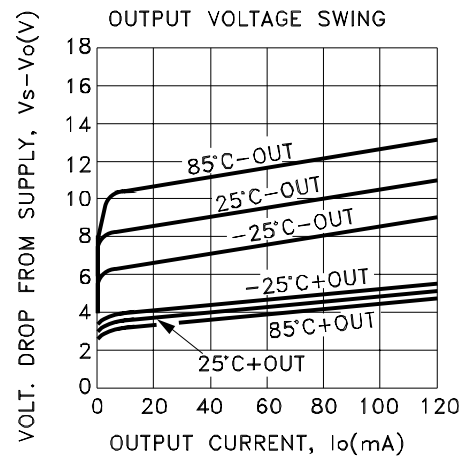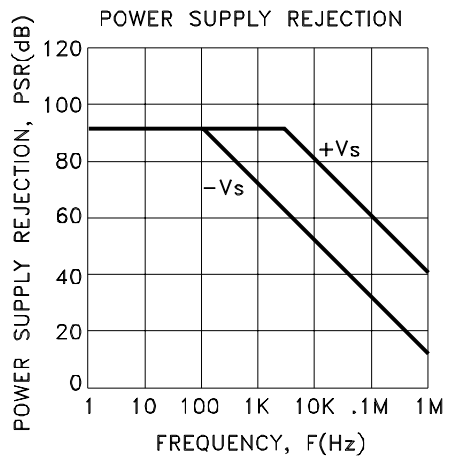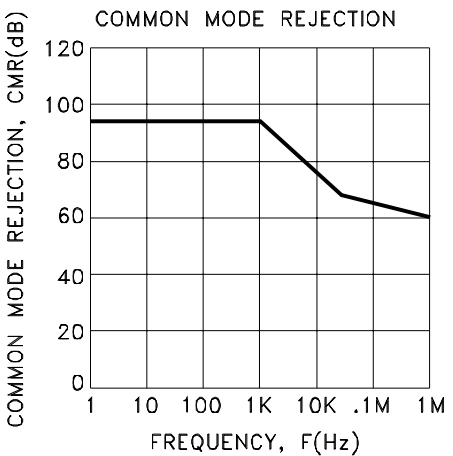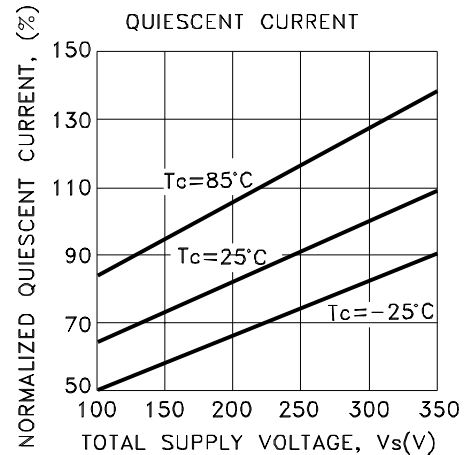

MSK 164 SOA

TYPICAL CONNECTION DIAGRAM
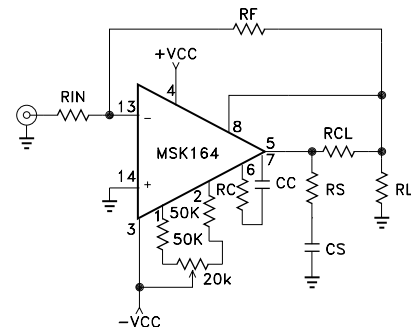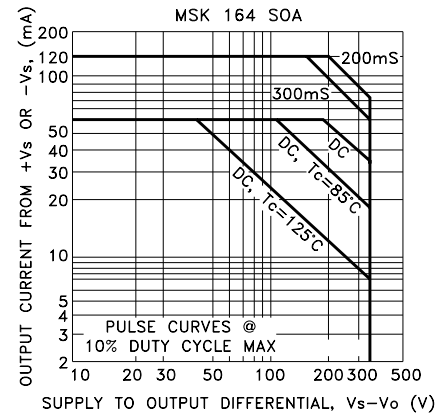
STABILITY

The MSK 164 has sufficient phase margin when compensated for unity gain to be stable with capacitive loads of at least 10nF. However, it is recommended that the parallel sum of the input and feedback resistor be 1000 ohms or less for closed loop gains of ten or less to minimize p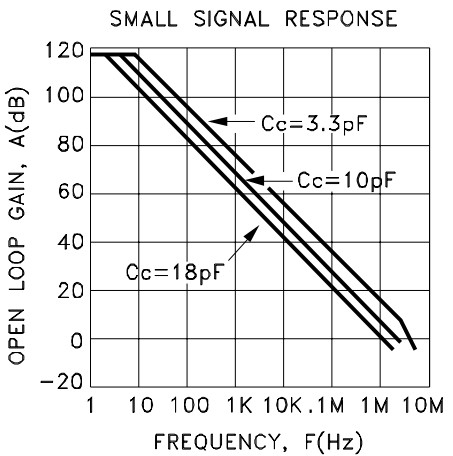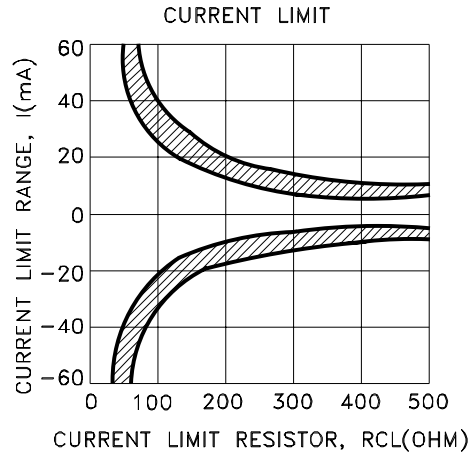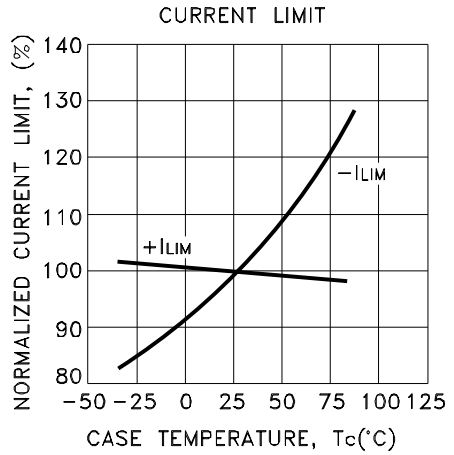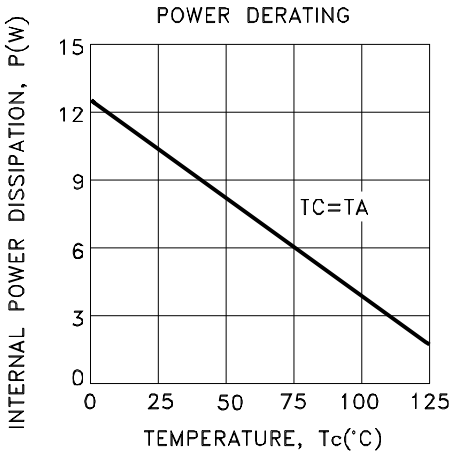hase shift caused by the R-C network formed by the input resistor, feedback resistor and input capacitance. The user can tailor the performance of the MSK 164 to their application using the external compensation pins. The graphs of small signal gain and phase as well as the graphs of slew rate and power response demonstrate the effect of various forms of compensation. The compensation capacitor must be rated at 350 volts working voltage if maximum power supply voltages are used. The compensation resistor and capacitor lead lengths must be kept as short as possible to minimize spurious oscillations. A high quality NPO capacitor is recommended for the compensation capacitor.

EXTERNAL COMPENSATION
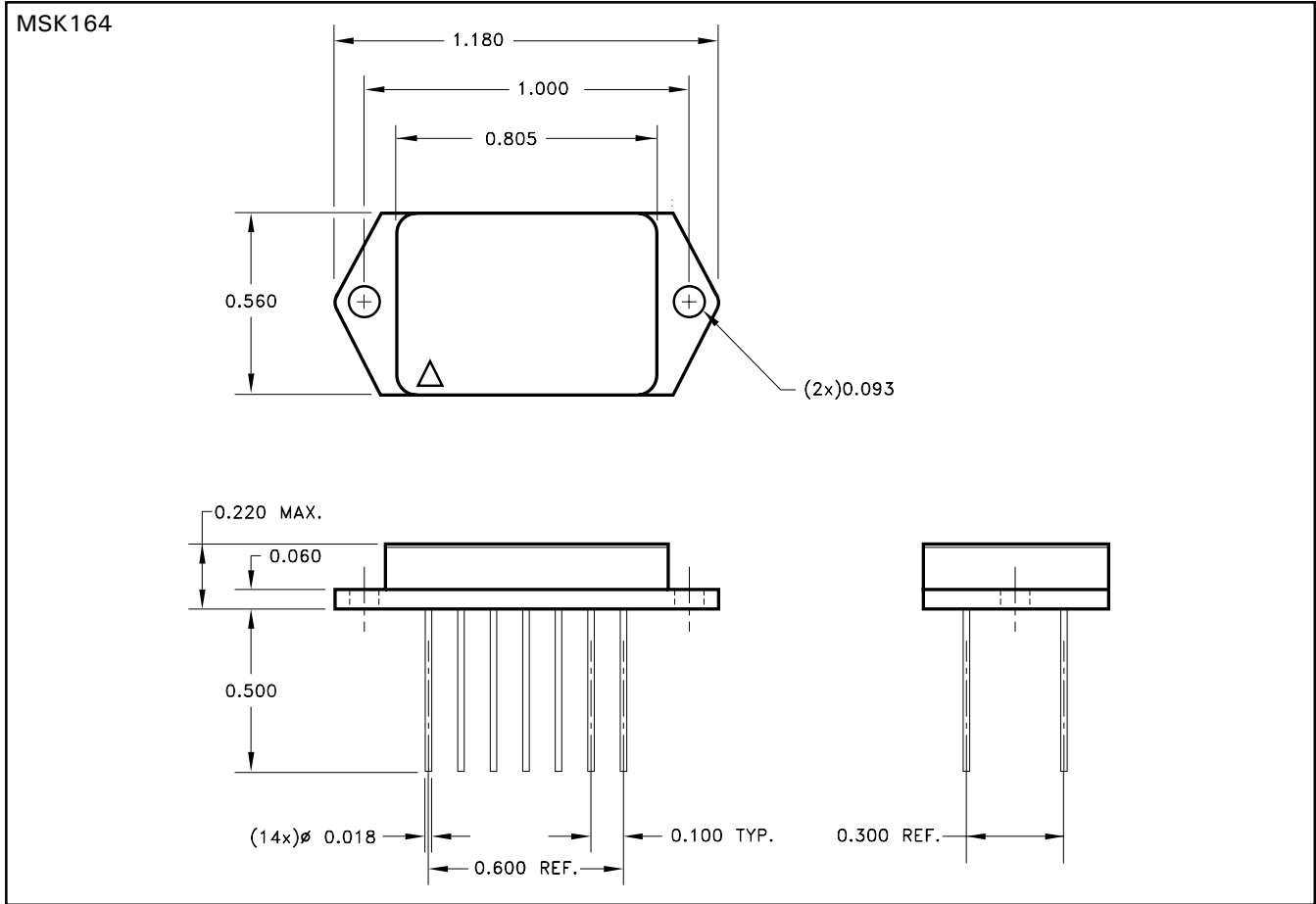
External compensation is only necessary at gains of 30V/V or less. For larger gains, the compensation resistor and capacitor may be omitted. An effective method of checking amplifier stability is to apply the worst case capacitive load to the output of the amplifier and drive a small signal square wave across it. If overshoot is less than 25%, the system will generally be stable.

Rev. A 8/00

TYPICAL PERFORMANCE CURVES

POWER DERATING

INTERNAL POWER DISSIPATION, P(W)

TC=TA

TEMPERATURE, Tc(°C)

CURRENT LIMIT

NORMALIZED CURRENT LIMIT, (%)

+I$_{LIM}$

−I$_{LIM}$

CASE TEMPERATURE, Tc(°C)

CURRENT LIMIT

CURRENT LIMIT RANGE, I(mA)

CURRENT LIMIT RESISTOR, RCL(OHM)

SMALL SIGNAL RESPONSE

OPEN LOOP GAIN, A(dB)

Cc=3.3pF

Cc=10pF

Cc=18pF

FREQUENCY, F(Hz)

PHASE RESPONSE

PHASE, ∅(°)

Cc=3.3pF

Cc=10pF

Cc=18pF

Cc=18pF

Cc=3.3pF

Cc=10pF

FREQUENCY, F(Hz)

POWER RESPONSE

OUTPUT VOLTAGE, Vo(Vpp)

RL=10K OHM

Cc=10pF

Cc=3.3pF

Cc=18pF

FREQUENCY, F(Hz)

HARMONIC DISTORTION

DISTORTION, (%)

Av=20V/V
Cc=3.3pF
RL=2K OHM

Vo=30Vpp

Vo=180Vpp

Vo=60Vpp

FREQUENCY, F(Hz)

SLEW RATE

SLEW RATE, V/us

COMPENSATION CAPACITANCE, Cc(pf)

QUIESCENT CURRENT

NORMALIZED QUIESCENT CURRENT, (%)

Tc=85°C

Tc=25°C

Tc=−25°C

TOTAL SUPPLY VOLTAGE, Vs(V)

COMMON MODE REJECTION

COMMON MODE REJECTION, CMR(dB)

FREQUENCY, F(Hz)

POWER SUPPLY REJECTION

POWER SUPPLY REJECTION, PSR(dB)

+Vs

−Vs

FREQUENCY, F(Hz)

OUTPUT VOLTAGE SWING

VOLT. DROP FROM SUPPLY, Vs−Vo(V)

85°C−OUT

25°C−OUT

−25°C−OUT

−25°C+OUT

85°C+OUT

25°C+OUT

OUTPUT CURRENT, Io(mA)

4

MSK164

1.180

1.000

0.805

0.560

(2x)0.093

0.220 MAX.

0.060

0.500

(14x)ø 0.018

0.600 REF.

0.100 TYP.

0.300 REF.

ESD TRIANGLE INDICATES PIN 1.
ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.

ORDERING INFORMATION

Part Number	Screening Level
MSK164	Industrial
MSK164B	Military-Mil-PRF-38534

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