MSK
M.S.KENNEDY CORP.

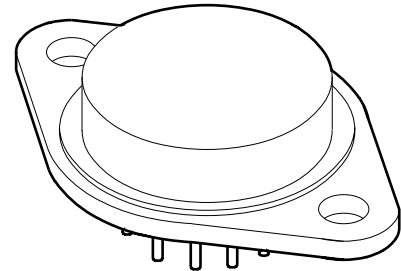# HIGH POWER CLASS C AMPLIFIER
# 161

4707 Dey Road Liverpool, N.Y. 13088

(315) 701-6751

MIL-PRF-38534 QUALIFIED

FEATURES:

• High Output Current
• Wide Supply Range
• Low Cost Class "C" Output Stage
• Wide Common Mode Range
• Low Quiescent Current
• Electrically Isolated Case
• Replaces PA61

MSK 161

DESCRIPTION:

The MSK 161 is a high output current operational amplifier designed to drive resistive or reactive loads. The Class "C" output stage is protected by a user programmable current limit scheme. The MSK 161 is designed to be a low cost solution for low frequency applications where crossover distortion is not critical. The MSK 161 can supply ± 10 amps of output current within its safe operating range and boasts a 16 KHz power bandwidth. A low junction to case thermal resistance of only 1.2°C/W for the output devices keeps junction temperatures low when driving large load currents.

EQUIVALENT SCHEMATIC
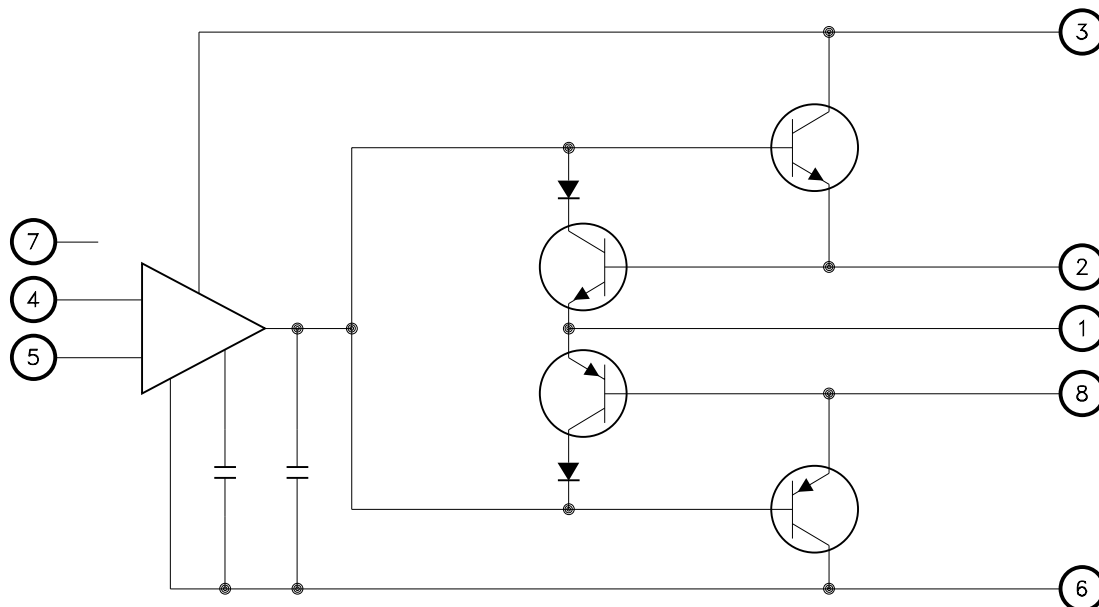
TYPICAL APPLICATIONS

• Programmable Power Supply
• Valve and Actuator Control
• Motor/Syncro Driver
• AC or DC Power Regulator

PIN-OUT INFORMATION

1 Output
2 Positive Current Limit
3 Positive Power Supply
4 Non-Inverting Input

8 Negative Current Limit
7 NC
6 Negative Power Supply
5 Inverting Input

Rev. A 6/02

ABSOLUTE MAXIMUM RATINGS

$\pm V_{CC}$ Supply Voltage . . . . $\pm 45V$
I_{OUT} Output Current . . . . $\pm 10A$
V_{IN} Differential Input Voltage . . . . $\pm V_{CC}$ -3V
T_C Case Operating Temperature Range
  (MSK 161B/E) . . . . -55°C to +125°C
  (MSK 161) . . . . -40°C to +85°C

T_{ST} Storage Temperature Range . . . -65°C to +150°C
T_{LD} Lead Temperature Range . . . . 300°C
  (10 Seconds)
T_J Junction Temperature . . . . 175°C

ELECTRICAL SPECIFICATIONS

$\pm Vcc = 36VDC$ Unless Otherwise Specified

| Parameter	Test Conditions	Group A Subgroup	MSK 161B/E Min.	Typ.	Max.	MSK 161 Min.	Typ.	Max.	Units
STATIC									
Supply Voltage Range ②		-	± 10.0	-	± 45.0	± 10.0	-	± 45.0	V
Quiescent Current	$V_{IN} = 0V$	1	-	± 3.0	± 10.0	-	± 3.0	± 10.0	mA
	$A_V = -10V/V$	2,3	-	-	± 15.0	-	-	-	mA
Thermal Resistance ②	F<60Hz Junction to Case	-	-	1.2	1.8	-	1.2	1.8	°C/W
INPUT									
Input Offset Voltage	$V_{IN} = 0V$ $A_V = 10V/V$	1	-	± 2.0	± 6.0	-	± 2.0	± 10	mV
	Bal.Pins = NC	2,3	-	± 10.0	± 15.0	-	-	-	mV
Input Bias Current	$V_{CM} = 0V$	1	-	± 12.0	± 30.0	-	± 12.0	± 50	nA
	Either Input	2,3	-	-	± 115.0	-	-	-	nA
Input Offset Current	$V_{CM} = 0V$	1	-	± 12.0	± 30.0	-	± 12.0	± 50	nA
		2,3	-	-	± 115.0	-	-	-	nA
Input Impedance ②	F = DC	-	-	200	-	-	200	-	MΩ
Common Mode Range ②		-	-	$\pm V_S$-3	-	-	$\pm V_S$-3	-	V
Common Mode Rejection Ratio ②	F = 1KHz $V_{CM} = \pm 10V$	-	74	100	-	74	100	-	dB
OUTPUT									
Output Voltage Swing	$V_{CC} = \pm 45V$ $R_L = 1K\Omega$ $A_V = -10V/V$	4	± 40	-	-	± 40	-	-	V
Output Current, Peak	$R_{CL} = 0\Omega$ $A_V = -10V/V$ $T_J < 175°C$	4	± 9.0	± 10.0	-	± 9.0	10.0	-	A
Settling Time ① ②	0.1% 2V step	-	-	2.0	-	-	2.0	-	μS
TRANSFER CHARACTERISTICS									
Slew Rate	$V_{OUT} = \pm 25V$ $R_L = 1K\Omega$ $A_V = -10V/V$	4	1.0	2.5	-	1.0	2.5	-	$V/\mu S$
Open Loop Voltage Gain ②	$V_O = \pm 25V$ $R_L = 1K\Omega$ F = 10Hz	4	96	100	-	96	100	-	dB
Gain Bandwidth Product ②	$R_L = 1K\Omega$ F = 1MHz	-	-	1	-	-	1	-	MHz

NOTES:

① $A_V = -1$, measured in false summing junction circuit.
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 specified.
④ Military grade devices ("B" suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤ Subgroups 5 and 6 testing available upon request.
⑥ Subgroup 1,4 $T_A = T_C = +25°C$
   Subgroup 2,5 $T_A = T_C = +125°C$
   Subgroup 3,6 $T_A = T_C = -55°C$

Rev. A 6/02

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:
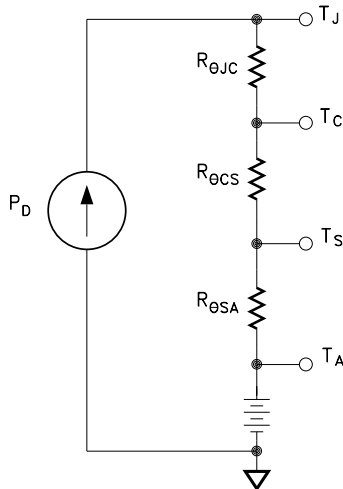
Governing Equation:

$T_J = P_D$ x $(R_{\theta JC} + R_{\theta CS} + R_{\theta SA}) + T_A$

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:

In our example the amplifier application requires the output to drive a 20 volt peak sine wave across a 400Ω load for 50mA of peak output current. For a worst case analysis we will treat the 50mA peak output current as a D.C. output current. The power supplies are ±40 VDC.

1.) Find Power Dissipation
   P_D = [(quiescent current) x $(V_S - (V_S))$] + [$(+V_S - V_O)$ x I_{OUT}]
      = (3.0mA) x (80V) + (20V) x (1A)
      = 0.24W + 20W
      = 20.24W
2.) For conservative design, set T_J = +125°C
3.) For this example, worst case T_A = +50°C
4.) $R_{\theta JC}$ = 1.8°C/W from MSK 161 Data Sheet
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 -50°C)/20.24W) - (1.8°C/W) - (0.15°C/W)
      = 1.76°C/W

The heat sink in this example must have a thermal resistance of no more than 1.76°C/W to maintain a junction temperature of no more than +125°C.
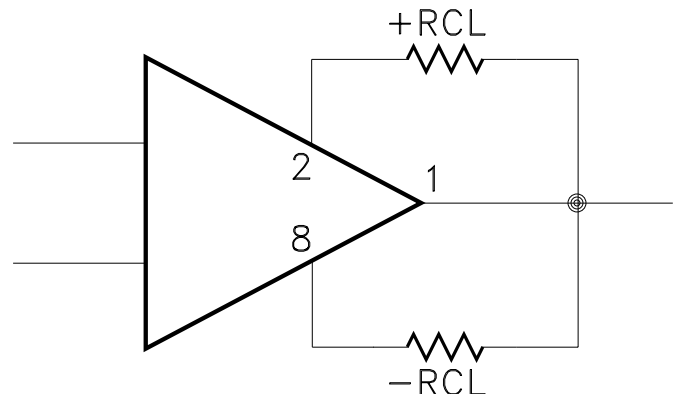
CURRENT LIMIT

The MSK 161 has an on-board current limit scheme designed to shut off the output drivers anytime output current exceeds a predetermined limit. The following formula may be used to determine the value of current limit resistance necessary to establish the desired current limit.

R_{CL} = (OHMs) = (0.65 volts/current limit in amps) - 0.01OHM

The 0.01 ohm term takes into account any wire bond and lead resistance. Since the 0.65 volt term is obtained from the base emitter voltage drop of a bipolar transistor: the equation only holds true for operation at +25°C case temperature. The effect that temperature has on current limit may be seen on the Current Limit vs. Case Temperature Curve in the Typical Performance Curves.
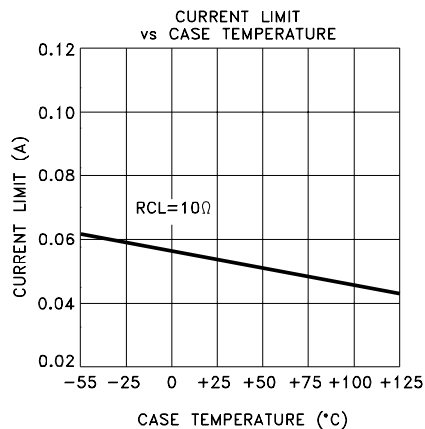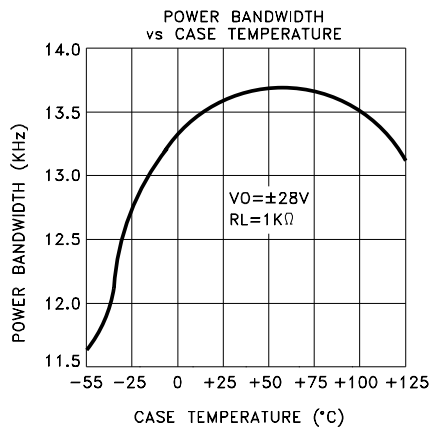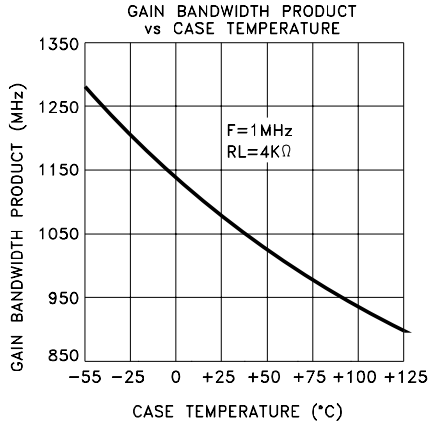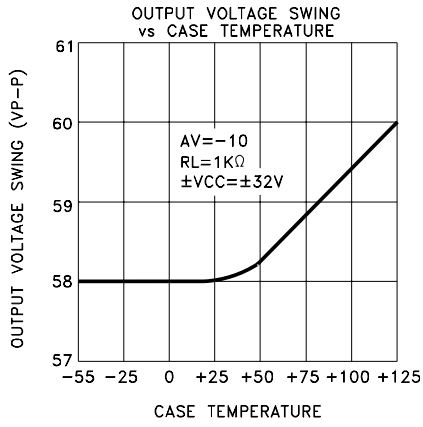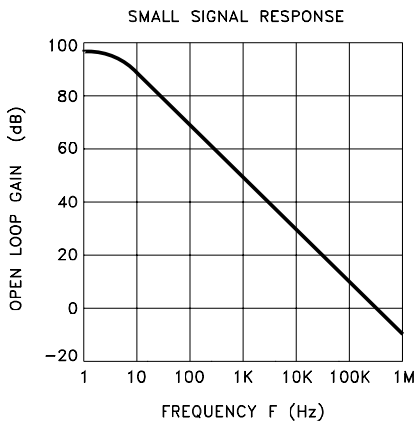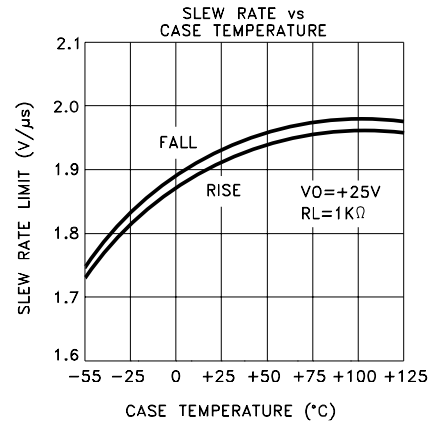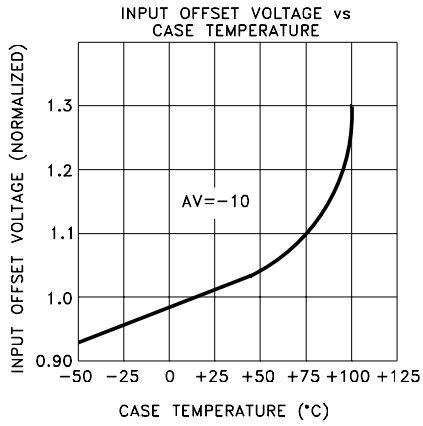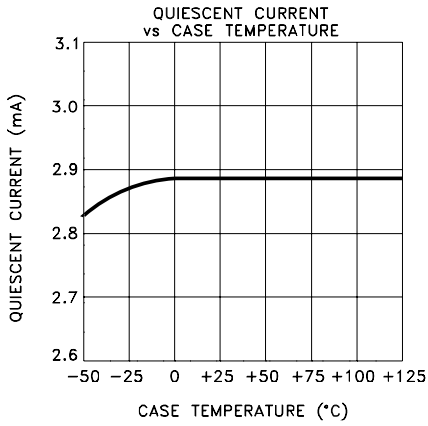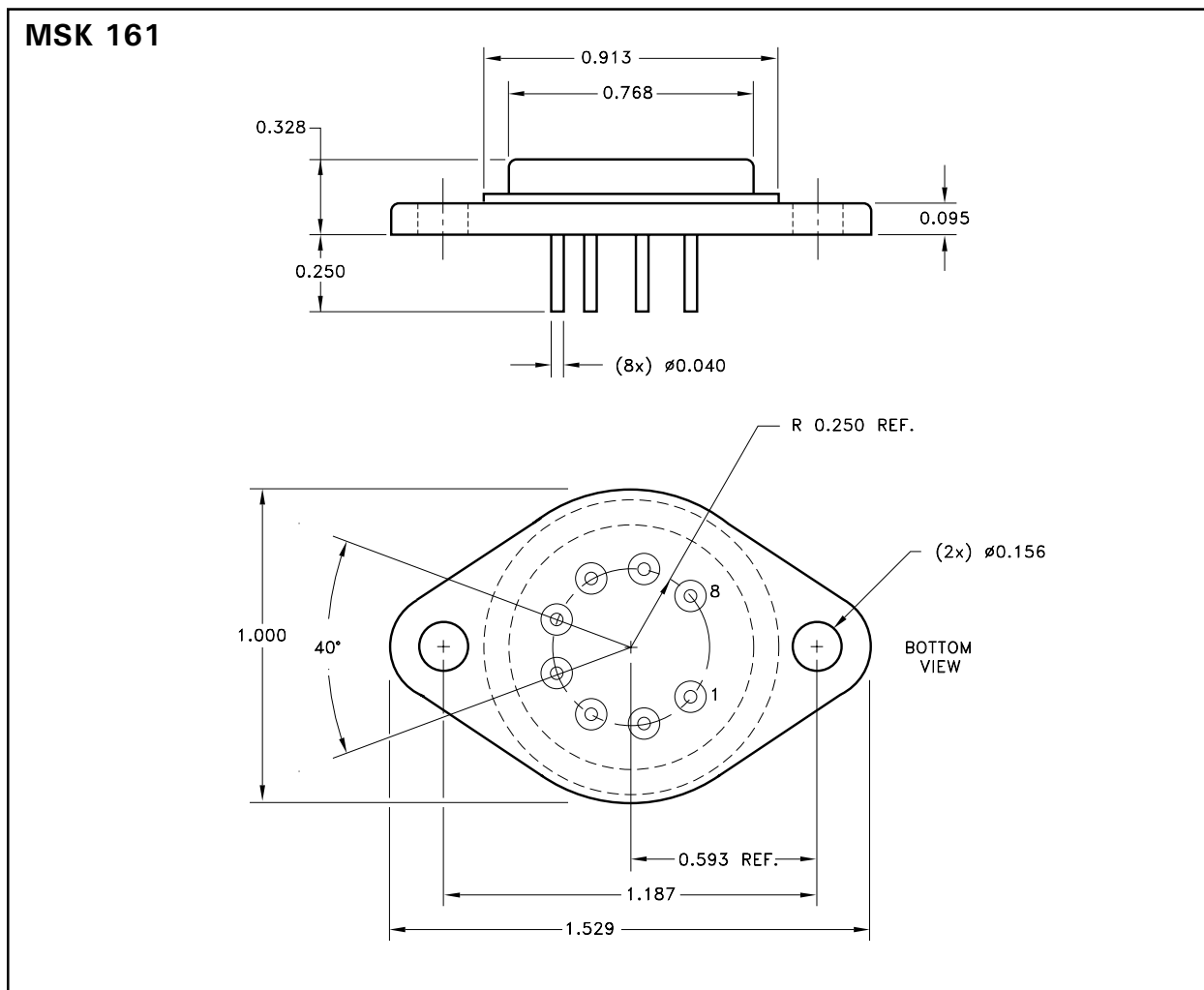
CURRENT LIMIT CONNECTION

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 very high power op-amps, such as the MSK 161, to place a 30-50 microfarad non-electrolytic 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 (pins 7 and 12).

QUIESCENT CURRENT
vs CASE TEMPERATURE

INPUT OFFSET VOLTAGE vs
CASE TEMPERATURE

SLEW RATE vs
CASE TEMPERATURE

SMALL SIGNAL RESPONSE

OUTPUT VOLTAGE SWING
vs CASE TEMPERATURE

GAIN BANDWIDTH PRODUCT
vs CASE TEMPERATURE

POWER BANDWIDTH
vs CASE TEMPERATURE

CURRENT LIMIT
vs CASE TEMPERATURE

4

Rev. A   6/02

MSK 161

NOTE: ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED.

ORDERING INFORMATION

Part Number	Screening Level
MSK161	Industrial
MSK 161E	Extended Reliability
MSK161B	Mil-PRF-38534 Class H

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Rev. A 6/02