ISO-9001 CERTIFIED BY DSCC

HIGH POWER CLASS C AMPLIFIER 161

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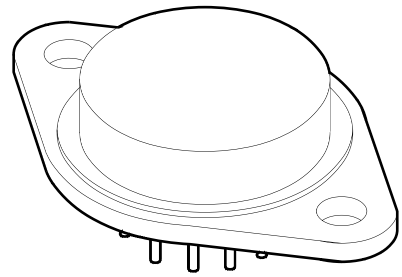
MIL-PRF-38534 QUALIFIED

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

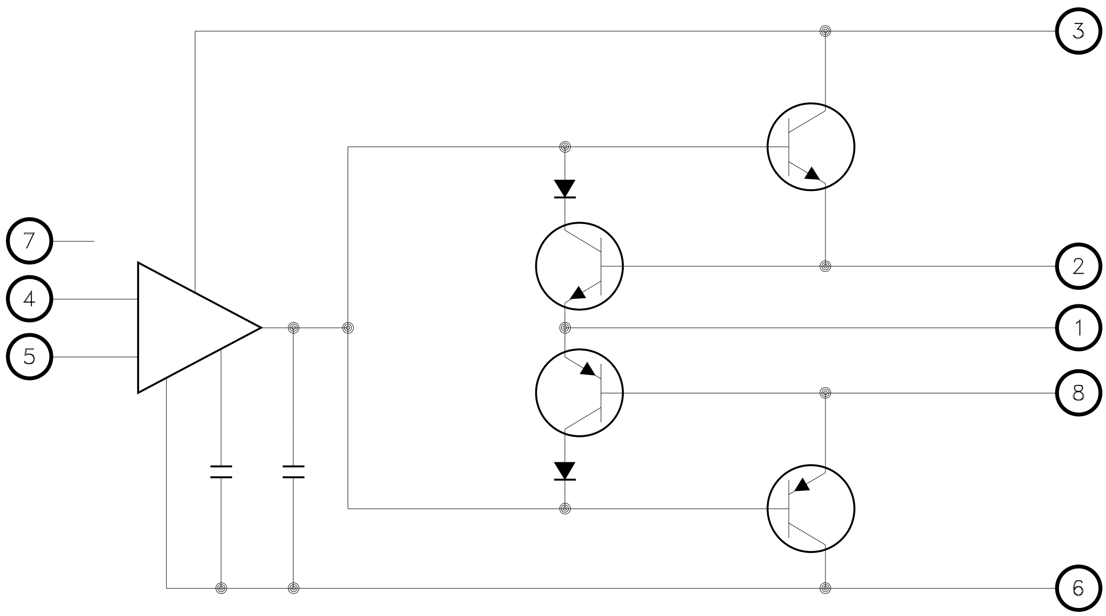


MSK 161

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

Rev. A 6/02

ABSOLUTE MAXIMUM RATINGS

$\pm V_{CC}$	Supply Voltage	±45V
I_{OUT}	Output Current	±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 (10 Seconds)	300°C
T_J	Junction Temperature	175°C

ELECTRICAL SPECIFICATIONS

±Vcc = 36VDC Unless Otherwise Specified

Parameter	Test Conditions	Group A Subgroup	MSK 161B/E Min.	MSK 161B/E Typ.	MSK 161B/E Max.	MSK 161 Min.	MSK 161 Typ.	MSK 161 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		-	-	±Vs-3	-	-	±Vs-3	-	V
Common Mode Rejection Ratio ②	F = 1KHz V_{CM} = ±10V	-	74	100	-	74	100	-	dB
OUTPUT									
Output Voltage Swing	V_{CC} = ±45V R_L = 1KΩ A_V = -10V/V	4	±40	-	-	±40	-	-	V
Output Current, Peak	R_{CL} = 0Ω 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} = ±25V R_L = 1KΩ A_V = -10V/V	4	1.0	2.5	-	1.0	2.5	-	V/µS
Open Loop Voltage Gain ②	V_O = ±25V R_L = 1KΩ F = 10Hz	4	96	100	-	96	100	-	dB
Gain Bandwidth Product ②	R_L = 1KΩ F = 1MHz	-	-	1	-	-	1	-	MHz

NOTES:

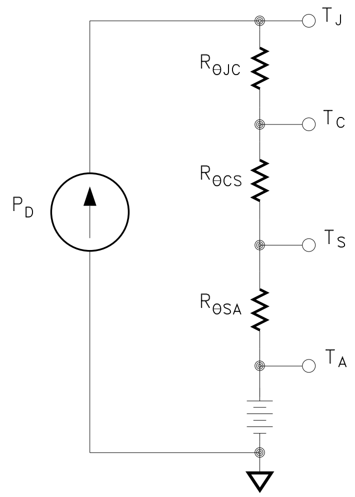
① AV = -1, measured in false summing junction circuit.
② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
③ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
④ Military 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

APPLICATION NOTES

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:

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.

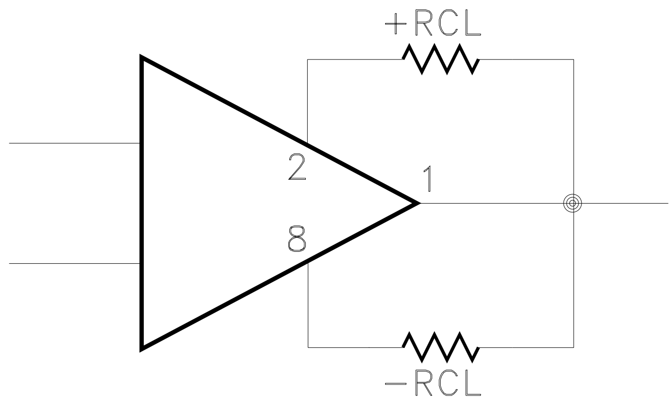
CURRENT LIMIT

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

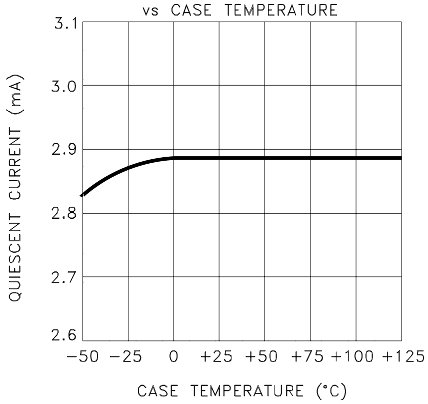


POWER SUPPLY BYPASSING

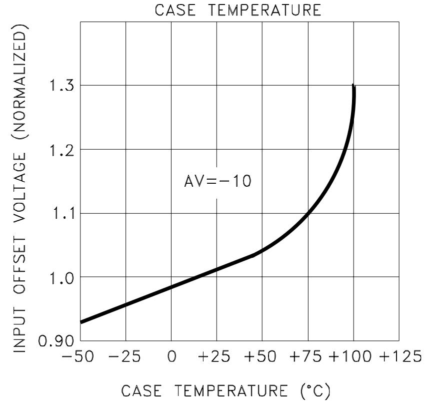
Both the negative and the positive power supplies must be effectively decoupled with a high and low frequency bypass circuit to avoid power supply induced oscillation. An effective decoupling scheme consists of a 0.1 microfarad ceramic capacitor in parallel with a 4.7 microfarad tantalum capacitor from 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).

TYPICAL PERFORMANCE CURVES

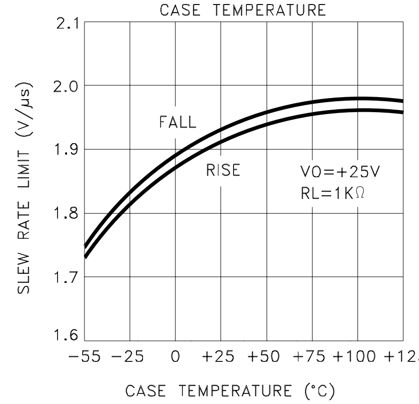
QUIESCENT CURRENT
vs CASE TEMPERATURE



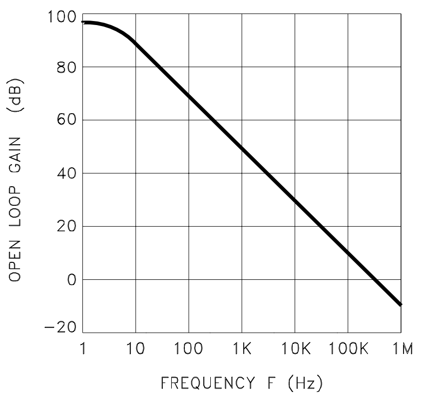
INPUT OFFSET VOLTAGE vs
CASE TEMPERATURE



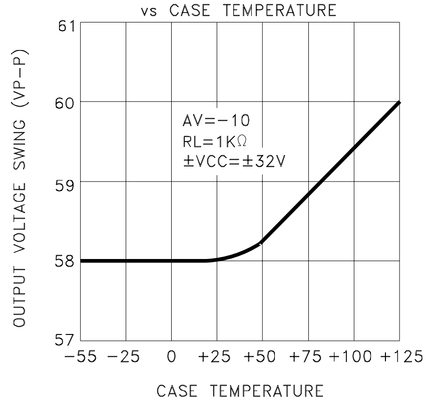
SLEW RATE vs
CASE TEMPERATURE



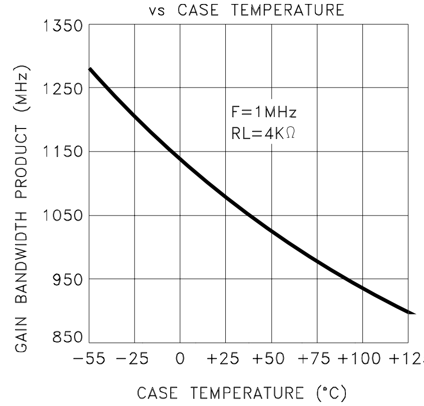
SMALL SIGNAL RESPONSE



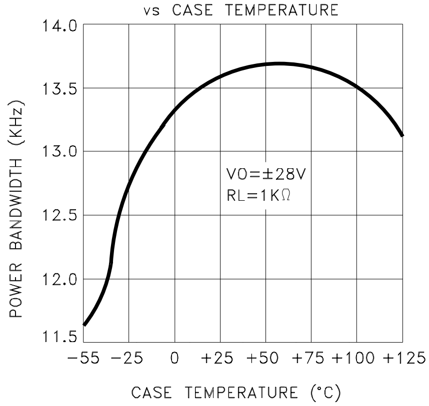
OUTPUT VOLTAGE SWING
vs CASE TEMPERATURE



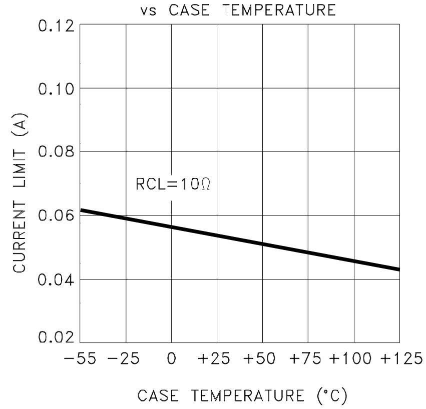
GAIN BANDWIDTH PRODUCT
vs CASE TEMPERATURE



POWER BANDWIDTH
vs CASE TEMPERATURE

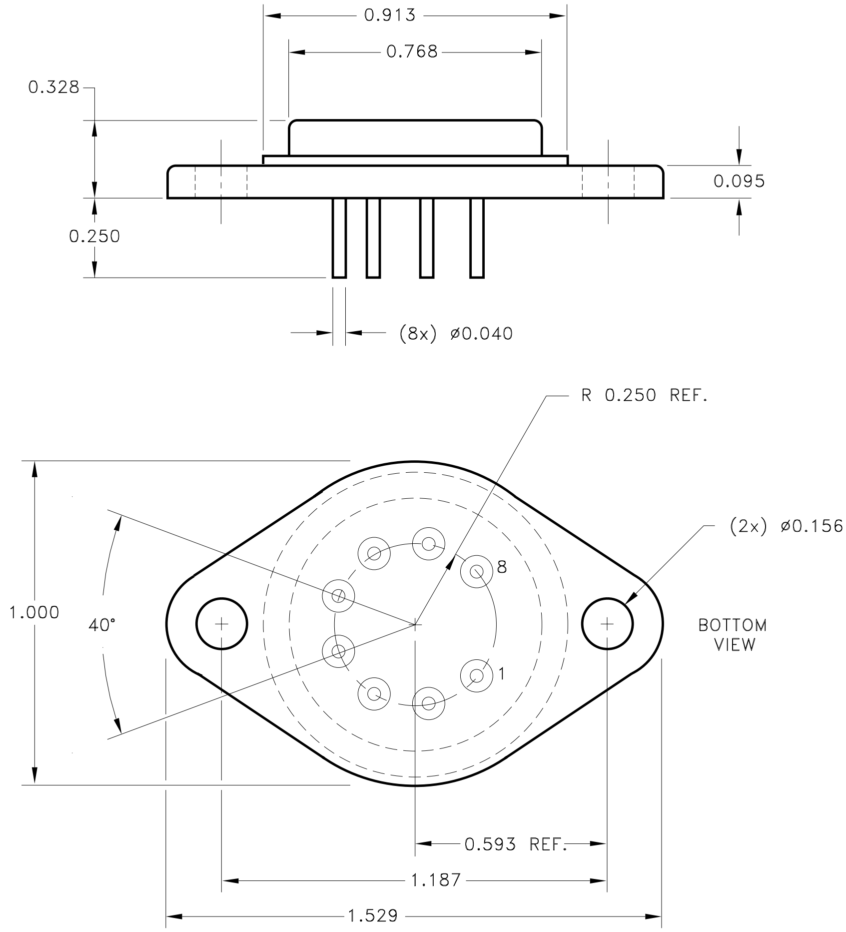


CURRENT LIMIT
vs CASE TEMPERATURE



MECHANICAL SPECIFICATIONS

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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