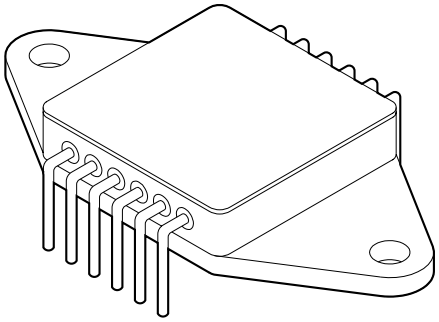
MIL-PRF-38534 CERTIFIED FACILITY

HIGH POWER OPERATIONAL AMPLIFIER 115

FEATURES:

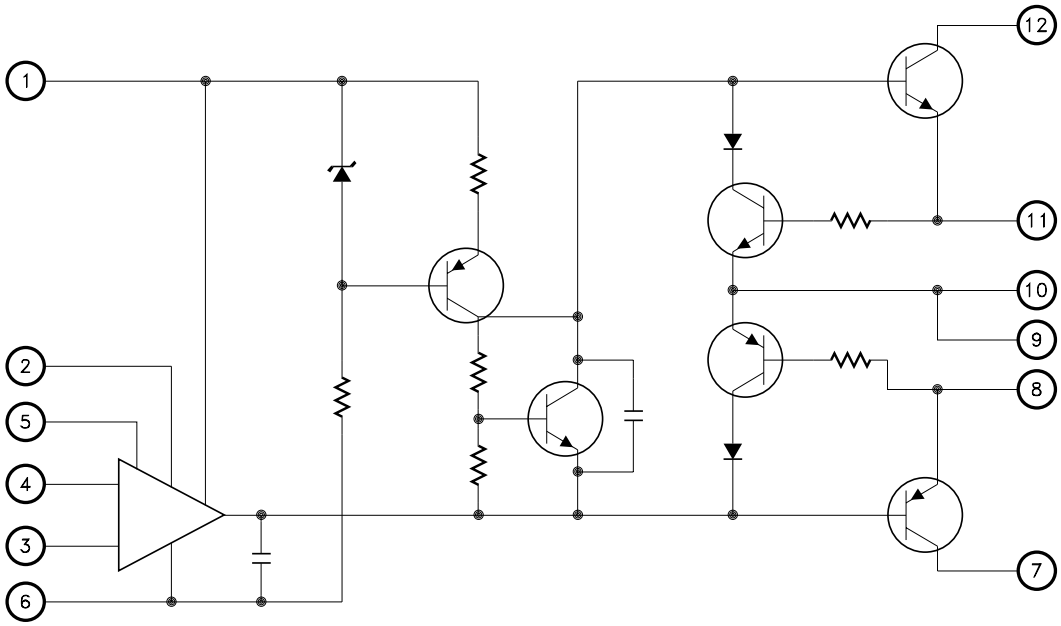
- High Output Current - 15A peak
- Ultra Low Thermal Resistance - 0.5°C/W Typ.
- Excellent Linearity - Class A/B Output
- Wide Supply Range - ±10V to ±50V
- High Output Power Dissipation Capability
- Output Short Circuit Protected
- User Programmable Current Limit
- Isolated Case Allows Direct Heat Sinking
- Low Quiescent Current -±22mA. Typ.
- Contact MSK for MIL-PRF-38534 Qualification Status



DESCRIPTION:

The MSK115 is a High Power Operational Amplifier. Due to the extremely low thermal resistance from the transistor junctions to the case, the MSK115 can dissipate extreme amounts of power at a case temperature of 125°C. The amplifier

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Magnetic Deflection Circuit Driver
- Programmable Power Supplies
- Motor, Valve and Actuator Control
- Audio Amplifier

PIN-OUT INFORMATION

1	+Vcc	12	+Vc
2	Balance	11	+Current Limit
3	Inverting Input	10	Output
4	Non-Inverting Input	9	Output
5	Balance	8	-Current Limit
6	-Vcc	7	-Vc

ABSOLUTE MAXIMUM RATINGS ⑧

$\pm V_{CC}$	Supply Voltage..... ±50V	T_{ST}	Storage Temperature Range..... -65°C to +150°C
I_{OUT}	Output Current..... 15A	T_{LD}	Lead Temperature Range
V_{IN}	Differential Input Voltage..... ±37V		(10 Seconds)..... 300°C
T_C	Case Operating Temperature Range	P_D	Power Dissipation ..... See S0A Curve
	MSK115B..... -55°C to+125°C	T_J	Junction Temperature
	MSK115..... -40°C to +85°C		

ELECTRICAL SPECIFICATIONS

Parameter	Test Conditions ①	Group A Subgroup	MSK115B Min.	MSK115B Typ.	MSK115B Max.	MSK115 Min.	MSK115 Typ.	MSK115 Max.	Units
STATIC									
Supply Voltage Range ③		-	±10	-	±50	±10	-	±45	V
Quiescent Current	V_{IN} = 0V	1	-	±22	±35	-	±22	±40	mA
	A_V = -10V/V	2, 3	-	±28	±45	-	-	-	mA
Thermal Resistance ③	Junction to Case @ 25°C	-	-	0.5	0.6	-	0.5	0.7	°C/W
INPUT									
Input Offset Voltage	V_{IN} = 0V A_V = 10V/V	1	-	±2	±6	-	±2	±10	mV
	Bal. Pins = NC	2, 3	-	±3	±12	-	-	-	mV
Input Offset Adjust	R_{POT} = 10KΩ Wiper to -V_{CC}	7	Adjust to zero			Adjust to zero			mV
	A_V = -10V/V	8A, 8B	Adjust to zero			-	-	-	mV
Input Bias Current	V_{CM} = 0V	1	-	±10	±30	-	±10	±50	nA
	Either Input	2, 3	-	±15	±250	-	-	-	nA
Input Offset Current	V_{CM} = 0V	1	-	±5	±30	-	±5	±50	nA
		2, 3	-	±10	±100	-	-	-	nA
Input Impedance ③	F = DC	-	50	250	-	35	250	-	MΩ
Common Mode Range ③		-	-	±35	-	-	±35	-	V
Common Mode Rejection Ratio ③	F = 100Hz V_{CM} = ±5V	-	80	100	-	74	100	-	dB
OUTPUT									
Output Voltage Swing	R_L = 500Ω A_V = -10V/V	4	±35	±37	-	±33	±37	-	V
	R_L = 10Ω R_{SC} = 0Ω	-	±35	±36	-	±33	±36	-	V
Output Current, Peak	A_V = -10V/V V_{OUT} = MAX	4	15	-	-	10	-	-	A
Settling Time ②③	0.1% 10V step	-	-	2	-	-	5	-	µS
TRANSFER CHARACTERISTICS									
Slew Rate	V_{OUT} = ±10V R_L = 500Ω A_V = -10V/V	4	2.5	5	-	1	2.5	-	V/µS
Open Loop Voltage Gain ③	R_L = 500Ω F = 10Hz	4	95	105	-	85	105	-	dB
Gain Bandwidth Product ③	R_L = 10Ω F = 1 MHz	-	-	4	-	-	3	-	MHz

NOTES:

① Unless otherwise specified, ±V_{CC} = ±40VDC.

② AV = -1, measured in false summing junction circuit.

③ Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.

④ Industrial grade devices shall be tested to subgroups 1, 4 and 7 unless otherwise specified.

⑤ Military grade devices ("B" suffix) shall be 100% tested to subgroups 1, 2, 3, 4, 7, 8A and 8B.

⑥ Subgroups 5 and 6 testing available upon request.

⑦ Subgroup 1, 4, 7 $T_A = T_C$ = +25°C
2, 5, 8A $T_A = T_C$ = +125°C
3, 6, 8B $T_A = T_C$ = -55°C

⑧ Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

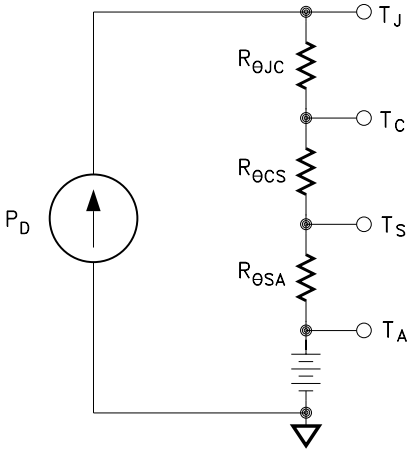
⑨ Internal solder reflow temperature is 180°C, do not exceed.

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 20 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 ±40 VDC.

1.) Find Power Dissipation
P_D = [(quiescent current) x (V_S-(V_S))]+[(+V_S-V_O) x I_{OUT}]
= (25mA) x (80V)+(20V) x (1A)
= 2W+20W
= 22W
2.) For conservative design, set T_J = +125°C
3.) For this example, worst case T_A = +50°C
4.) $R_{\theta JC}$ = 0.55°C/W from MSK 115B 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)/22W) - (0.55°C/W) - (0.15°C/W)
= 2.71°C/W

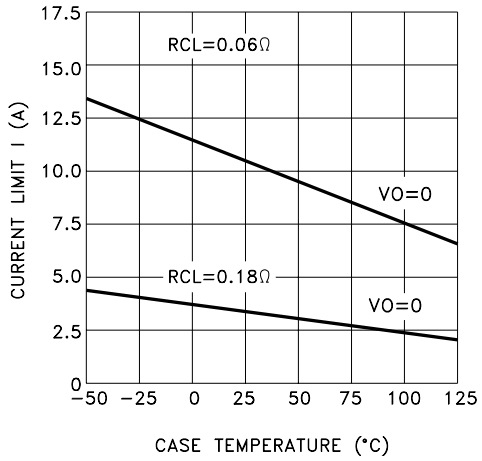
The heat sink in this example must have a thermal resistance of no more than 2.71°C/W to maintain a junction temperature of no more than +125°C.

CURRENT LIMIT

The MSK115 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 curve below illustrates the effect of case temperature on current limit.



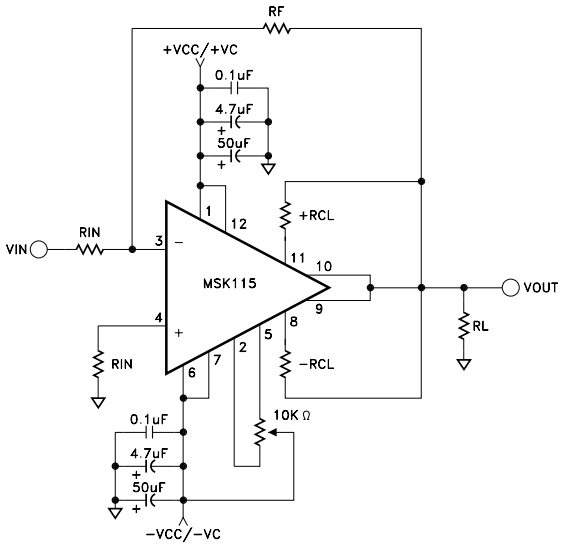
POWER SUPPLY BYPASSING

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 MSK115, to place a 30-50 microfarad nonelectrolytic 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 output stage power supply pins as possible (pins 7 and 12).

APPLICATION NOTES CONT'D

BALANCE PINS

Pins 2 & 5 of the MSK115 are used to null unwanted input offset voltage. Connect as shown in the typical connection schematic. If the balance pins are not used, they should be left open/not connected.



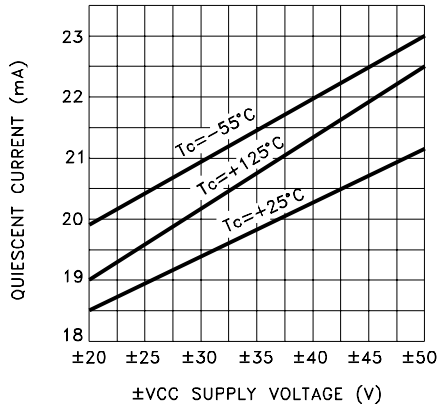
PIN DESCRIPTIONS		
NUMBER	**NAME**	**FUNCTION**
1	① +VCC	POSITIVE SUPPLY VOLTAGE FOR FRONT END OP-AMP
2	BALANCE	USED TO PROVIDE OFFSET VOLTAGE NULL, SEE APPLICATION NOTES
3	INVERTING INPUT	INVERTING INPUT FOR THE OP-AMP
4	NON-INVERTING INPUT	NON-INVERTING INPUT FOR THE OP-AMP
5	BALANCE	USED TO PROVIDE OFFSET VOLTAGE NULL, SEE APPLICATION NOTES
6	① -VCC	NEGATIVE SUPPLY VOLTAGE FOR FRONT END OP-AMP
7	① -VC	POWER SUPPLY CONNECTION TO THE COLLECTOR OF THE NEGATIVE OUTPUT TRANSISTOR. PROVIDES OUTPTU VOLTAGE/CURRENT.
8	-CURRENT LIMIT (-CL)	USED TO PROVIDE CURRENT LIMIT PROTECTION TO THE NEGATIVE OUTPUT TRANSISTOR.
9	OUTPUT	OP-AMP OUTPUT, CONNECT TO PIN 10 EXTERNALLY.
10	OUTPUT	OP-AMP OUTPUT, CONNECT TO PIN 9 EXTERNALLY.
11	+CURRENT LIMIT (+CL)	USED TO PROVIDE CURRENT LIMIT PROTECTION TO THE POSITIVE OUTPUT TRANSISTOR
12	① +VC	POWER SUPPLY CONNECTION TO THE COLLECTOR OF THE POSITIVE OUTPUT TRANSISTOR. PROVIDES OUTPUT VOLTAGE/CURRENT.

① THE OUTPUT STAGE COLLECTORS (VC) ARE NORMALLY CONNECTED TO THE CORRESPONDING VCC PINS EXTERNALLY.

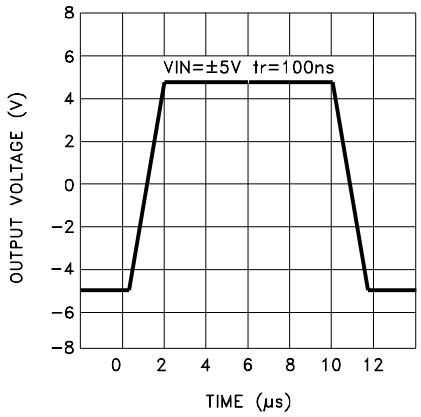
THEY ARE BROUGHT OUT ON SEPERATE PINS FOR FLEXIBILITY FR THE USER.

TYPICAL PERFORMANCE CURVES

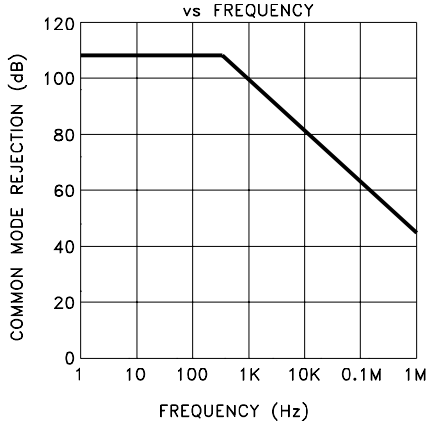
QUIESCENT CURRENT vs. SUPPLY VOLTAGE



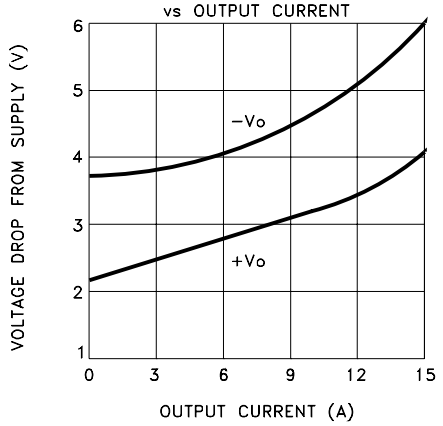
PULSE RESPONSE



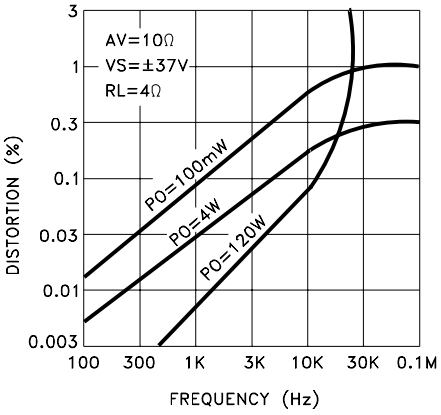
COMMON MODE REJECTION vs FREQUENCY



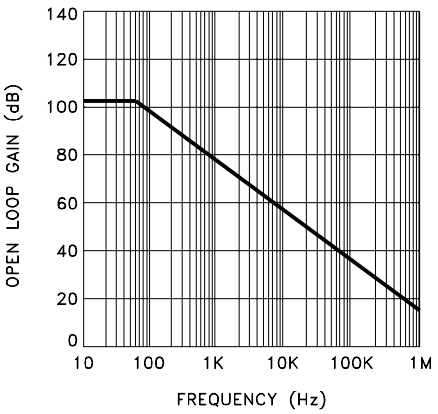
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



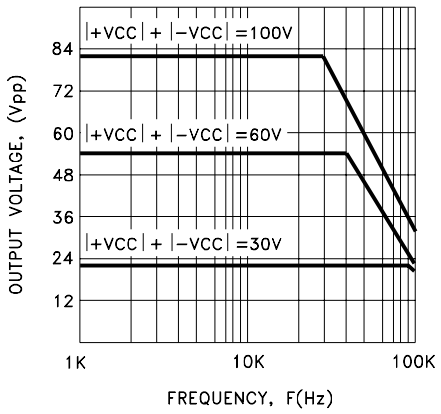
HARMONIC DISTORTION



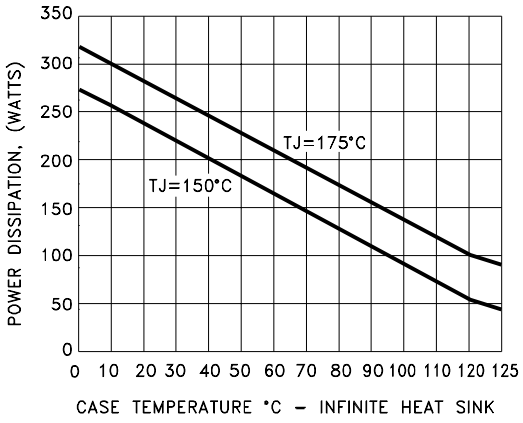
OPEN LOOP GAIN vs. FREQUENCY



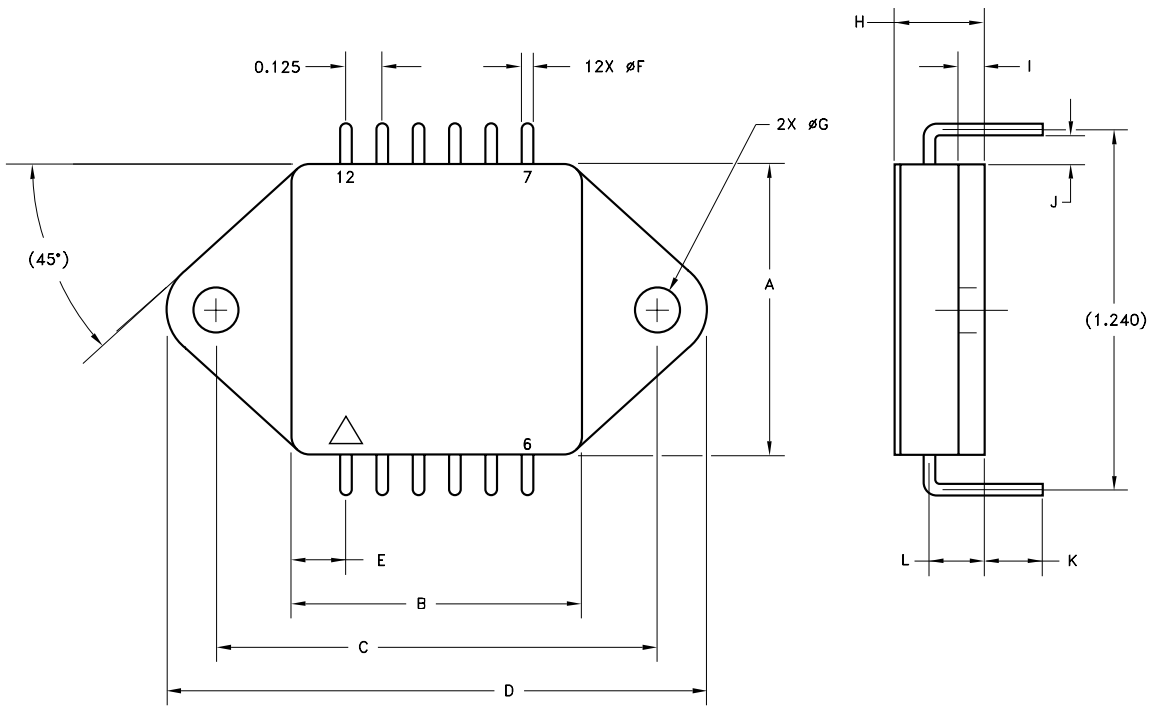
POWER RESPONSE vs FREQUENCY



SOA CURVE



MECHANICAL SPECIFICATIONS



REF	MIN	MAX
A	.995	1.005
B	.995	1.005
C	1.515	1.525
D	———	1.875
E	.182	.192
F	.035	.045
G	.151	.161
H	———	.310
I	.085	.095
J	.095	.105
K	.175	.250
L	.185	.195

ESD TRIANGLE INCICATES PIN 1
WEIGHT = 31 GRAMS TYPICAL

ALL DIMENSIONS ARE SPECIFIED IN INCHES

ORDERING INFORMATION

Part Number	Screening Level
MSK115	Industrial
MSK115B	MIL-PRF-38534 Class H

REVISION HISTORY

REV	STATUS	DATE	DESCRIPTION
E	Released	04/14	Add form #, update thermal specifications, add new note for solder reflow and clarify mechanical specifications
F	Released	09/21	Remove MIL-PRF-38535