



M.S.KENNEDY CORP.

INVERTING OPERATIONAL AMPLIFIER 738

4707 Dey Road Liverpool, N.Y. 13088

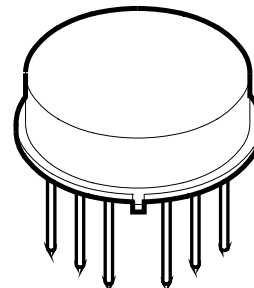
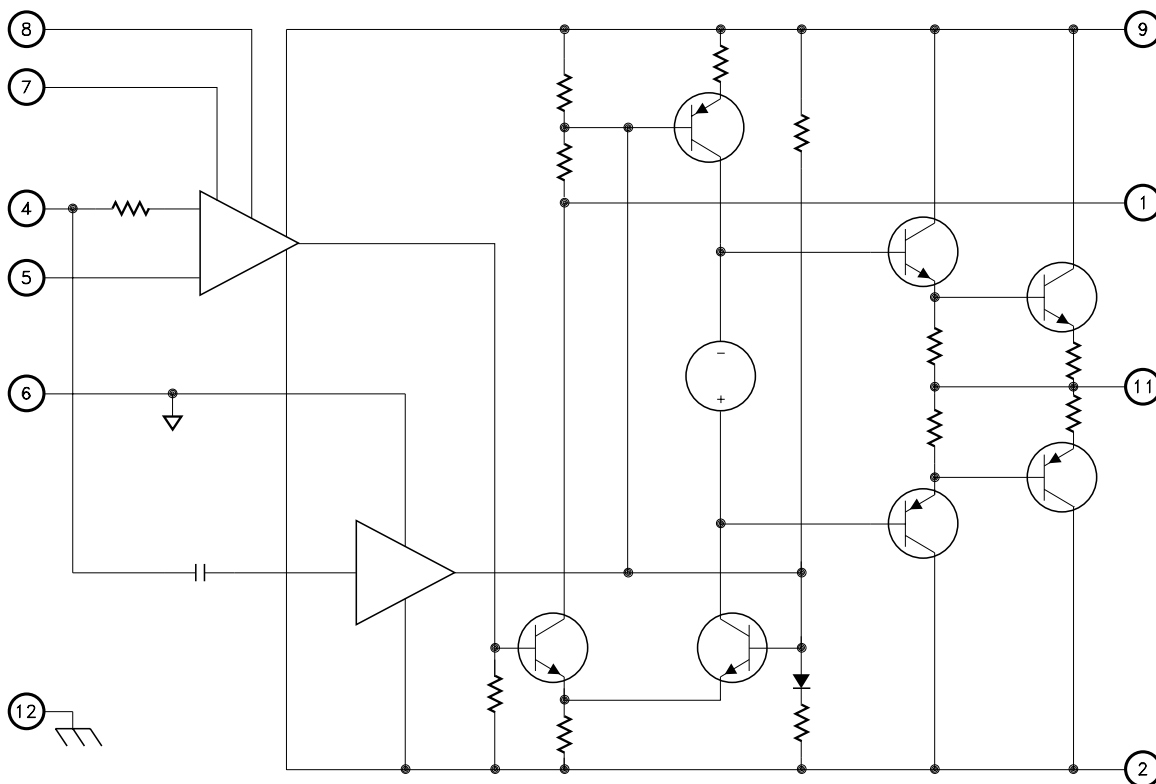
(315) 701-6751

MIL-PRF-38534 CERTIFIED**FEATURES:**

- Very Fast Settling Time
- Very Fast Slew Rate
- Wide Bandwidth
- Low Noise
- Very Accurate (Low Offset)

DESCRIPTION:

The MSK 738 is an inverting operational amplifier that exhibits an impressive combination of high speed and precision D.C. characteristics. The Op-amp's very fast slew rate, very fast settling time and wide bandwidth, along with its extremely low input offset voltage, offset drift and low noise, make it an outstanding performer.

**EQUIVALENT SCHEMATIC****TYPICAL APPLICATIONS**

- High Performance Data Acquisition
- Coaxial Line Driver
- Data Conversion Circuits
- High Speed Communications

PIN-OUT INFORMATION

1 Compensation	7 Balance
2 Negative Power Supply	8 Balance
3 NC	9 Positive Power Supply
4 Inverting Input	10 NC
5 Non-Inverting Input	11 Output
6 Ground	12 Case Connection

ABSOLUTE MAXIMUM RATINGS

$\pm V_{CC}$	Supply Voltage	+18V
I_{OUT}	Peak Output Current	$\pm 200\text{mA}$
V_{IN}	Differential Input Voltage	$\pm 12\text{V}$
T_C	Case Operating Temperature Range	
	(MSK 738B/E)	-55°C to $+125^{\circ}\text{C}$
	(MSK 738)	-40°C to $+85^{\circ}\text{C}$

T_{ST}	Storage Temperature Range . . .	-65°C to $+150^{\circ}\text{C}$
T_{LD}	Lead Temperature Range	300°C (10 Seconds Soldering)
P_D	Power Dissipation	See Curve
T_J	Junction Temperature	150°C

ELECTRICAL SPECIFICATIONS

$\pm V_{CC} = \pm 15\text{V}$ Unless Otherwise Specified

Parameter	Test Conditions	Group A	MSK 738B/E			MSK 738			Units
		Subgroup	Min.	Typ.	Max.	Min.	Typ.	Max.	
STATIC									
Supply Voltage Range ②		-	± 12	± 15	± 18	± 12	± 15	± 18	V
Quiescent Current	V _{IN} = 0V	1	-	± 39	± 40	-	± 39	± 42	mA
	A _V = -1V/V	2,3	-	± 40	± 42	-	-	-	mA
Thermal Resistance ②	Junction to Case Output Devices	-	-	46	-	-	46	-	°C/W
INPUT									
Input Offset Voltage	Bal. Pins = NC V _{IN} = 0V A _V = -100V/V	1	-	± 25	± 75	-	± 50	± 100	μV
Input Offset Voltage Drift ②	V _{IN} = 0V	2,3	-	± 0.5	± 1	-	-	-	μV/°C
Input Offset Adjust	R _{POT} = 10KΩ T _O + V _{CC} A _V = -1V/V	1	Adjust to zero			Adjust to zero			mV
		2,3	Adjust to zero			-	-	-	mV
Input Bias Current ⑦	V _{CM} = 0V	1	-	± 10	± 40	-	± 20	± 60	nA
	Either Input	2,3	-	± 20	± 80	-	-	-	nA
Input Offset Current	V _{CM} = 0V	1	-	2	20	-	10	30	nA
		2,3	-	5	40	-	-	-	nA
Input Impedance ②	F = DC Differential	-	-	5	-	-	5	-	MΩ
Power Supply Rejection Ratio ②	ΔV _{CC} = ± 5V	-	-	1	10	-	2	20	μV/V
Input Noise Voltage ②	F = 0.1Hz To 10Hz	-	-	0.15	-	-	0.2	-	μVp-p
Input Noise Voltage Density ②	F = 1KHz	-	-	3.8	-	-	4	-	nV√Hz
Input Noise Current Density ②	F = 1KHz	-	-	0.6	-	-	0.7	-	pA√Hz
OUTPUT									
Output Voltage Swing	R _L = 100Ω A _V = -3V/V F ≤ 20MHz	4	± 10	± 12	-	± 10	± 11.8	-	V
Output Current	A _V = -3V/V T _J < 150°C	4	± 100	± 120	-	± 100	± 120	-	mA
Settling Time ① ②	0.1% 10V step	4	-	30	40	-	35	45	nS
Full Power Bandwidth	R _L = 100Ω V _O = ± 10V	4	20	22	-	15	20	-	MHz
Bandwidth (Small Signal) ②	R _L = 100Ω	4	175	200	-	165	190	-	MHz
TRANSFER CHARACTERISTICS									
Slew Rate	V _{OUT} = ± 10V R _L = 100Ω A _V = -1.5V/V	4	3200	3500	-	3500	3200	-	V/μS
Open Loop Voltage Gain ②	R _L = 1KΩ F = 1KHz V _{OUT} = ± 10V	4	100	110	-	95	105	-	dB

NOTES:

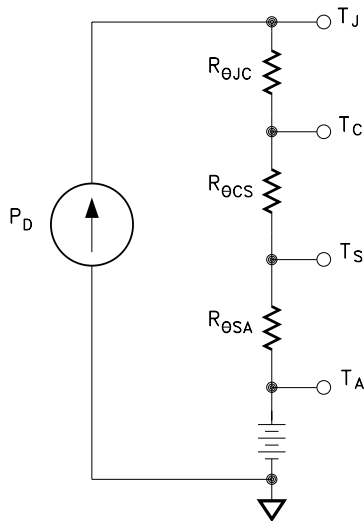
- ① $A_v = -1$, measured in false summing junction circuit.
- ② Guaranteed by design but not tested. Typical parameters are representative of actual device performance but are for reference only.
- ③ Industrial grade and "E" suffix devices shall be tested to subgroups 1 and 4 unless otherwise specified.
- 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 $T_A = T_C = +25^{\circ}\text{C}$
Subgroup 2,5 $T_A = T_C = +125^{\circ}\text{C}$
Subgroup 3,6 $T_A = T_C = -55^{\circ}\text{C}$
- ⑦ Measurement taken 0.5 seconds after application of power using automatic test equipment.

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:

This 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:

$V_{CC} = \pm 16\text{VDC}$

$V_O = \pm 8\text{Vp}$ Sine Wave, Freq. = 1KHz

$R_L = 100\Omega$

For a worst case analysis we will treat the $\pm 8\text{Vp}$ sine wave as an 8VDC output voltage.

1.) Find Driver Power Dissipation

$$\begin{aligned} P_D &= (V_{CC} - V_O) (V_O / R_L) \\ &= (16\text{V} - 8\text{V}) (8\text{V} / 100\Omega) \\ &= 0.64\text{W} \end{aligned}$$

2.) For conservative design, set $T_J = +125^\circ\text{C}$

3.) For this example, worst case $T_A = +90^\circ\text{C}$

4.) $R_{\theta JC} = 46^\circ\text{C/W}$ from MSK 738B Data Sheet

5.) $R_{\theta CS} = 0.15^\circ\text{C/W}$ for most thermal greases

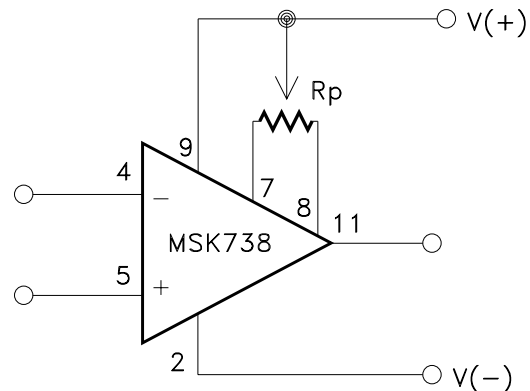
6.) Rearrange governing equation to solve for $R_{\theta SA}$

$$\begin{aligned} R_{\theta SA} &= ((T_J - T_A) / P_D) - (R_{\theta JC}) - (R_{\theta CS}) \\ &= ((125^\circ\text{C} - 90^\circ\text{C}) / 0.64\text{W}) - 45^\circ\text{C/W} - 0.15^\circ\text{C/W} \\ &= 54.7 - 46.15 \\ &= 8.5^\circ\text{C/W} \end{aligned}$$

The heat sink in this example must have a thermal resistance of no more than 8.5°C/W to maintain a junction temperature of no more than $+125^\circ\text{C}$.

OFFSET NULL

Typically, the MSK 738(B) has an input offset voltage of less than $\pm 25\mu\text{V}$. If it is desirable to adjust the offset closer to "zero", or to a value other than "zero", the circuit below is recommended. R_P should be a ten-turn $10\text{K}\Omega$ potentiometer. Typical offset adjust is $\pm 5\text{mV}$.

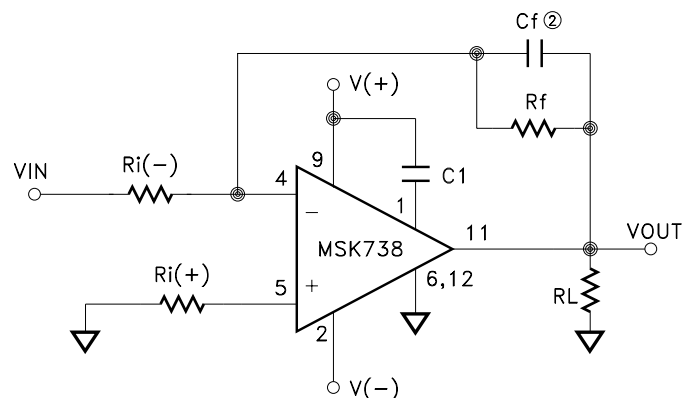


Potentiometer values ranging from $1\text{K}\Omega$ to $1\text{M}\Omega$ can be used with only a small amount of degradation (typically 0.15 to $0.25\mu\text{V}/^\circ\text{C}$) of input offset voltage drift. If the input offset voltage is to be trimmed to a value other than "zero", the following formula can be used to approximate the change in input offset voltage drift:

$$\Delta V_{OSD} = V_{OS} (\text{trimmed}) / 250$$

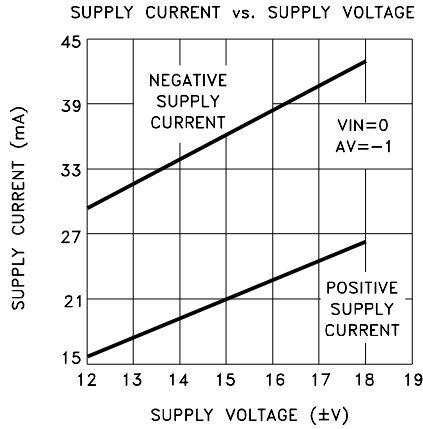
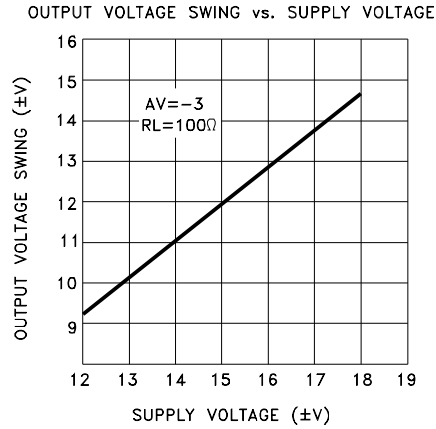
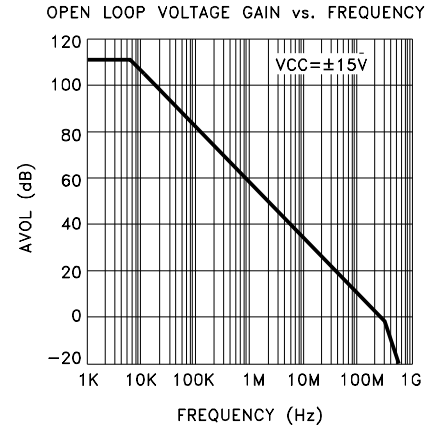
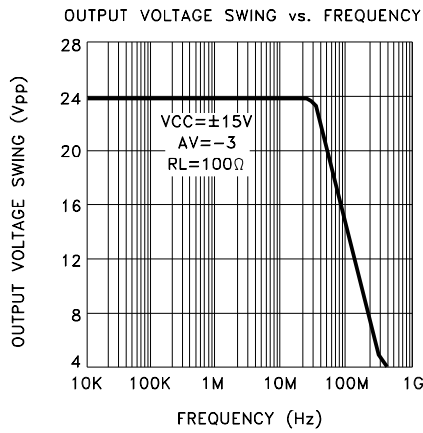
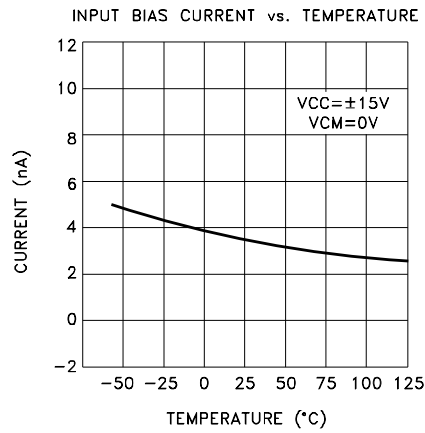
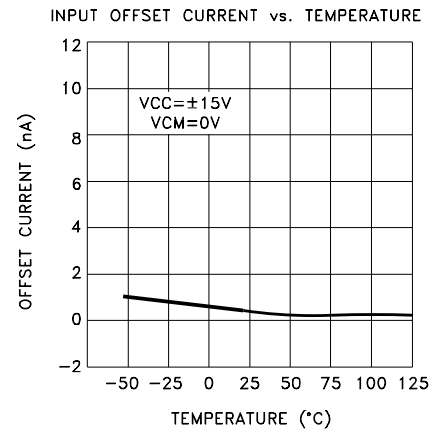
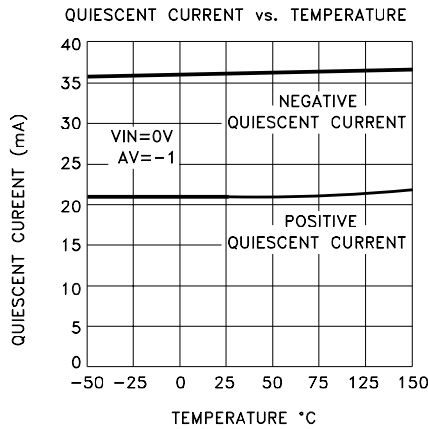
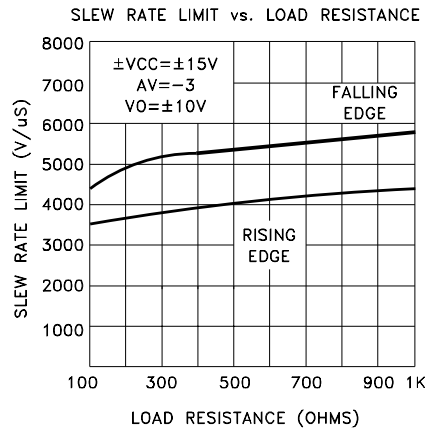
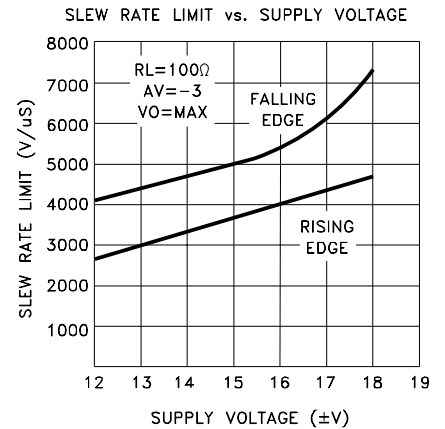
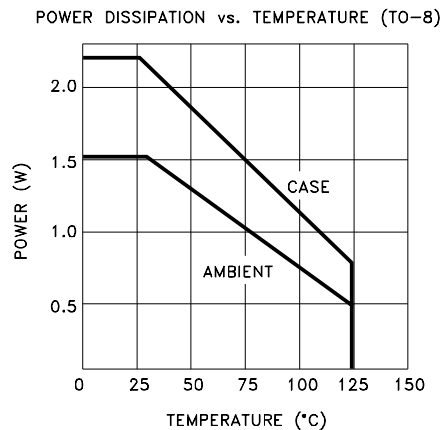
Recommended External Component Selection Guide

APPROXIMATE DESIRED GAIN	$R_i(+)$	$R_i(-)$	$R_f(\text{Ext})$	C_f	C_1
① -1	499 Ω	1K Ω	1K Ω	②	1 μf
① -2	330 Ω	499 Ω	1K Ω	②	1 μf
① -5	169 Ω	200 Ω	1K Ω	②	1 μf
① -8	100 Ω	124 Ω	1K Ω	②	1 μf
① -10	90.9 Ω	100 Ω	1K Ω	②	1 μf
① -20	100 Ω	100 Ω	2K Ω	②	1 μf

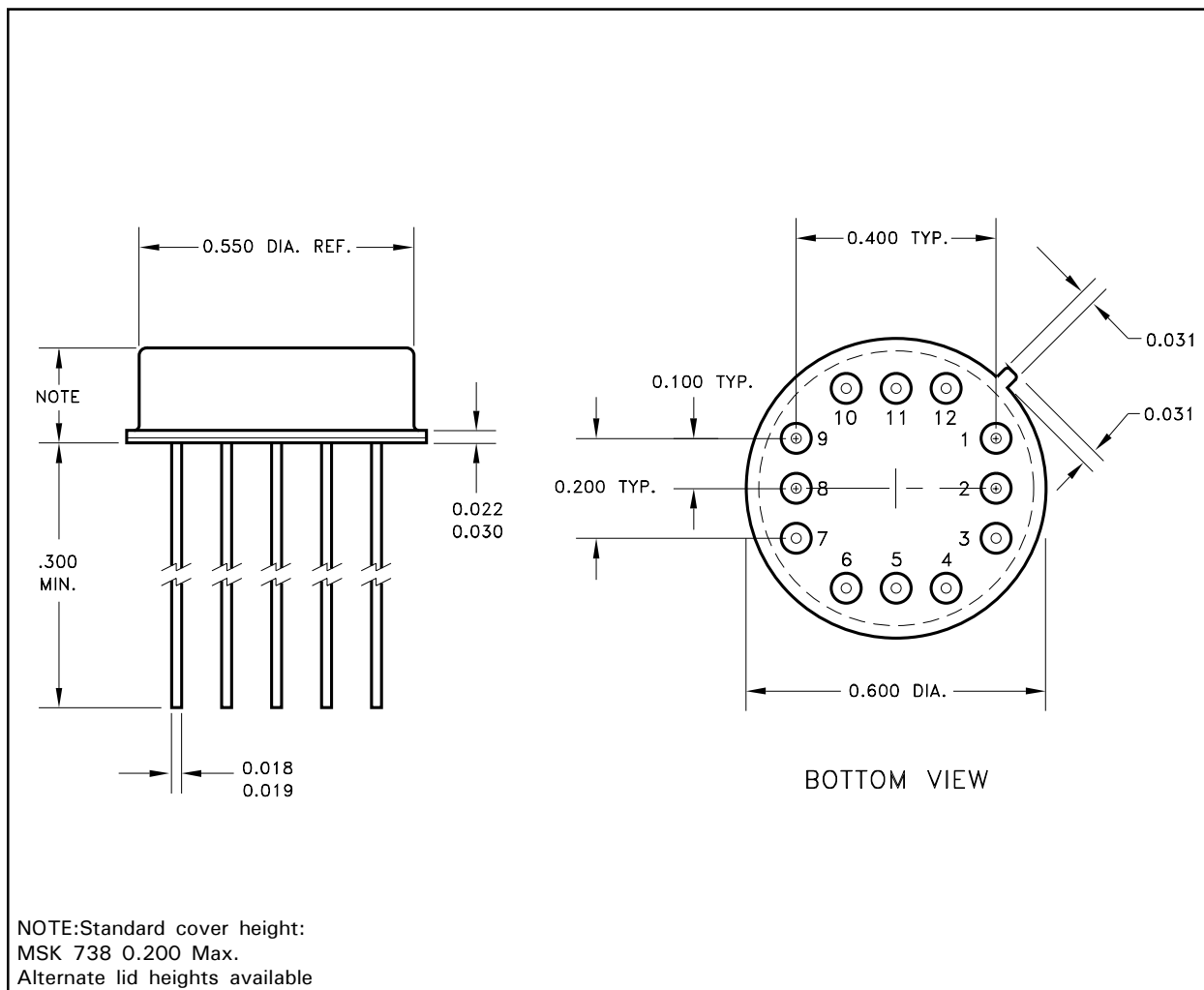


- ① The positive input resistor is selected to minimize any bias current induced offset voltage.
- ② The feedback capacitor will help compensate for stray input capacitance. The value of this capacitor can be dependent on individual applications. A 2 to 9 pF capacitor is usually optimum for most applications.

TYPICAL PERFORMANCE CURVES



MECHANICAL SPECIFICATIONS



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

ORDERING INFORMATION

MSK738 B

SCREENING

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

GENERAL PART NUMBER

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