ISO-9001 CERTIFIED BY DSCC

M.S.KENNEDY CORP.

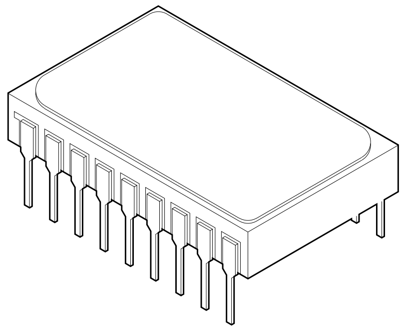
HIGH POWER QUAD OPERATIONAL AMPLIFIER 105

4707 Dey Road Liverpool, N.Y. 13088 (315) 701-6751

FEATURES:

MIL-PRF-38534 CERTIFIED

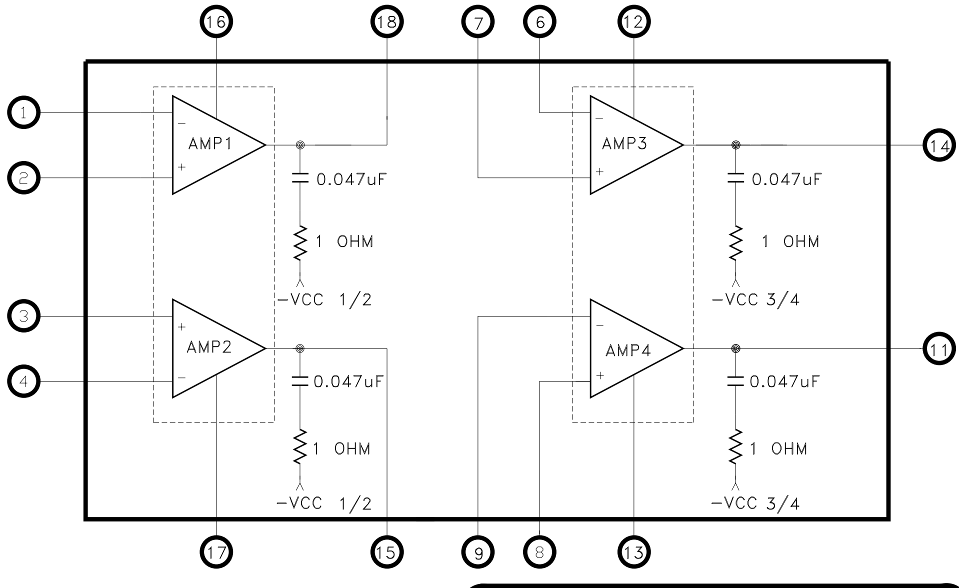
- Low Cost
- Wide Supply Voltage Range: 5V to 40V
- High Output Current: 3A Minimum
- High Efficiency: |Vs-2.2V| at 2.5A
- Internal Current Limit
- Wide Common Mode Range (Includes Negative Supply Voltage)
- Low Distortion
- Internal Output Snubbers for Ultra-Stable Operation



DESCRIPTION:

The MSK 105 is a high power quad operational amplifier. Each amplifier is capable of delivering three amps of current to the load. The MSK 105 is an excellent low cost alternative for bridge mode configurations since all amplifiers are packaged together and will track thermally. The wide common mode range includes the negative rail, facilitating single supply applications. It is possible to have a "ground based" input driving a single supply amplifier with ground acting as the second or "bottom" supply of the amplifier. To maintain stability, output snubber networks have been internally connected to each op amp output (see "amplifier stability" in the attached application notes). The output stage is also current limit protected to approximately 3.0 amps. The MSK 105 is packaged in a space efficient 18-pin ceramic dip. Consult factory for other packaging options if desired.

EQUIVALENT SCHEMATIC



TYPICAL APPLICATIONS

- Half and Full Bridge Motor Drives
- Audio Power Amplifiers
  - Bridge - 60W RMS Per Pair
  - Stereo - 30W RMS Per Channel
- Ideal for Single Supply Systems
  - 5V - Peripheral
  - 12V - Automotive
  - 28V - Avionic

PIN-OUT INFORMATION

1	-Input 1	18	Output 1
2	+Input 1	17	-Vcc 1/2
3	+Input 2	16	+Vcc 1/2
4	-Input 2	15	Output 2
5	N/C	14	Output 3
6	-Input 3	13	-Vcc 3/4
7	+Input 3	12	+Vcc 3/4
8	+Input 4	11	Output 4
9	-Input 4	10	N/C

ABSOLUTE MAXIMUM RATINGS

V_{CC}	Total Supply Voltage	40V
$\pm I_{OUT}$	Output Current (within S.O.A.)	4A
V_{IND}	Input Voltage (Differential)	$\pm V_{CC}$
V_{IN}	Input Voltage (Common Mode)	$+V_{CC}$, $-V_{CC}$-0.5V
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	
	(MSK105B/E)	-55°C to +125°C
	(MSK105)	-40°C to +85°C
R_{TH}	Thermal Resistance (DC) Junction to Case	
	(Per Amplifier)	8.0°C/W
	(Per Die) ⑦	5.0°C/W

ELECTRICAL SPECIFICATIONS

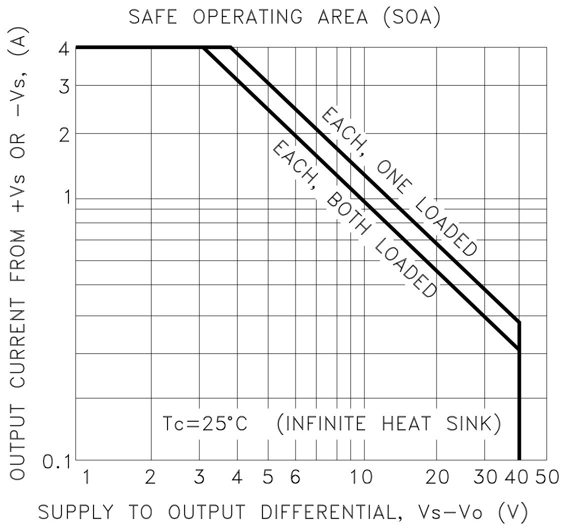
Parameter	Test Conditions ①	Group A Subgroup	MSK105B/E Min.	MSK105B/E Typ.	MSK105B/E Max.	MSK105 Min.	MSK105 Typ.	MSK105 Max.	Units
STATIC									
Supply Voltage Range ②	(Split Supply)	-	±2.5	±15	±20	±2.5	±15	±20	V
Quiescent Current	Total; V_{IN}=0V	1	-	±60	±150	-	±60	±150	mA
		2	-	±120	±210	-	-	-	mA
		3	-	±40	±150	-	-	-	mA
INPUT									
Offset Voltage	V_{IN}=0V	1	-	±0.5	±12	-	±2	±15	mV
Offset Voltage Drift ②	V_{IN}=0V	-	-	±15	-	-	±15	-	μV/°C
Input Bias Current ②	V_{CM}=0V	-	-	±35	±1000	-	±35	±1500	nA
	Full Temp.	-	-	±75	±1000	-	±75	-	nA
Power Supply Rejection ②	ΔV_{CC}=±15V	-	60	80	-	60	80	-	dB
Common Mode Rejection ②	V_{CM}=±10VDC	-	60	85	-	60	85	-	dB
Total Noise	R_L=500Ω A_V=1 C_L=1500pF	-	-	0.1	1.0	-	0.1	1.0	mV
OUTPUT									
Output Voltage Swing	(I_{OUT}=±0.5A)	4	±14	±14.2	-	±14	±14.2	-	V
Output Current	V_{OUT}=MAX	4	±3.0	±4.0	-	±3.0	±4.0	-	A
Current Limit ②		-	-	±4.0	-	-	±4.0	-	A
Power Bandwidth ②	V_{OUT}=28V_{PP}	-	-	13.6	-	-	13.6	-	KHz
Crosstalk	I_{OUT}=1A f=1KHz	-	60	68	-	-	68	-	dB
Capacitive Load ②	A_V=+1V/V	-	-	0.022	-	-	0.022	-	μF
TRANSFER CHARACTERISTICS									
Slew Rate		4	0.5	1.5	-	0.5	1.5	-	V/μS
Open Loop Voltage Gain ②	f=10Hz R_L=500Ω	-	80	100	-	80	100	-	dB

NOTES:

①Unless otherwise noted ±VCC=±15VDC. Specification is for each of the four amplifiers unless otherwise noted.
②Devices shall be capable of meeting the parameter, but need not be tested. Typical parameters are for reference only.
③Industrial grade and 'E' suffix devices shall be tested to subgroups 1 and 4 unless otherwise requested.
④Military grade devices ('B' suffix) shall be 100% tested to subgroups 1,2,3 and 4.
⑤Subgroup 5 and 6 testing available upon request.
⑥Subgroup 1,4 TC=+25°C
Subgroup 2,5 TC=+125°C
Subgroup 3,6 TA=-55°C
⑦Power Dissipation must be equal in both amplifiers of one dual die for this rating to apply.

APPLICATION NOTES

SAFE OPERATING AREA (SOA)



Safe operating area curves are a graphical representation of all of the power limiting factors involved in the output stage of an operational amplifier. Three major power limiting factors are; output transistor wire bond carrying capability, output transistor junction temperature and secondary breakdown effects. To see if your application is meeting or exceeding the limitations of the safe operating area curves, perform the following steps:

1.) Find the worst case output power dissipation. For a split supply, purely resistive load application, this occurs when $V_{OUT} = 1/2\ V_{CC}$.
2.) Take the values of (V_{CC}-V_{OUT}) and the corresponding output current and find their intersection on the safe operating area curves.
3.) Verify this point is below the safe operating area curves.

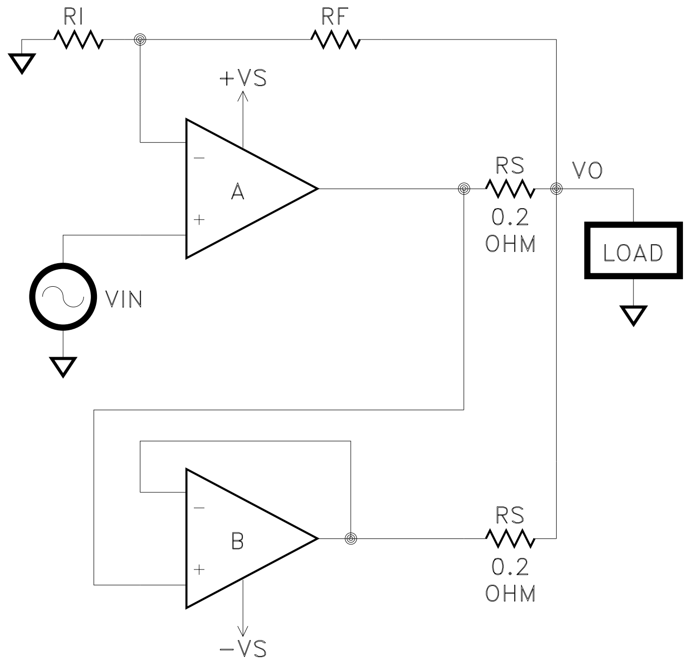
This is a simple task for purely resistive loads, for reactive loads the following table will save extensive analysis. Under transient conditions, capacitive and inductive loads up to the following maximum are safe.

±Vcc	Capacitive Load	Inductive Load
20V	200uF	7.5mH
15V	500uF	25mH
10V	5mF	35mH
5V	50mF	150mH

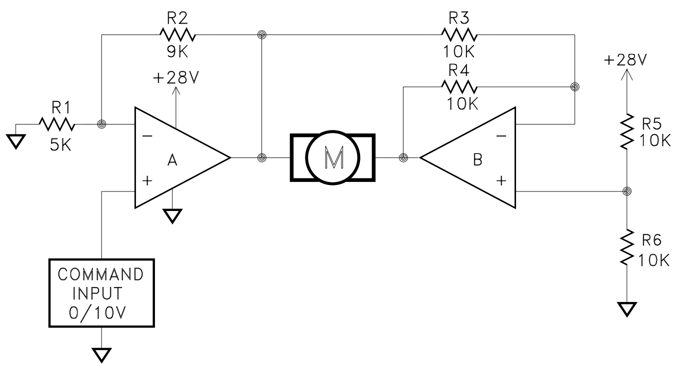
If the inductive load is driven near steady state conditions allowing the output to drop more than 6V below the supply rail while the amplifier is current limiting, the inductor should be capacitively coupled or the supply voltage must be lowered to meet the SOA criteria. It is a good practice to also connect reverse biased fast recovery diodes to the output for protection against sustained high energy flyback.

AMPLIFIER STABILITY

Since both output transistors in this amplifier are NPN, consideration must be taken when stabilizing the output. A one ohm resistor, 0.047uF capacitor snubber network has been added internally from the output to -Vcc on each amplifier. This configuration minimizes local output stage oscillations. As always, adequate power supply bypassing is a necessity for amplifier stability. A parallel combination of a 4.7uF electrolytic (for every amp of output current) and a 0.01uF ceramic disc capacitor should be connected as close as possible to the package power supply pins to ground. The R-C snubber networks shown on the outputs of the amplifiers in the typical circuits are internal and should not be added externally.



PARALLEL CONNECTION
yields single 6A amplifier



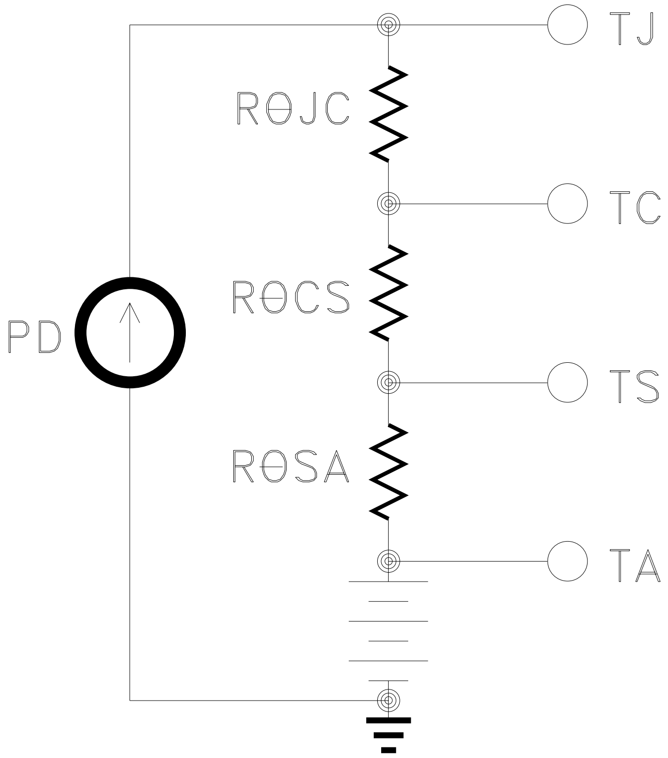
BIDIRECTIONAL MOTOR DRIVE

APPLICATION NOTES CONTINUED

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:

Inside the MSK 105 package are two monolithic dual amplifiers that do not exhibit thermal crossover (die to die) at 45° spreading angle. Therefore, our example will focus on only one of the two die. Further, consideration must be taken to calculate power dissipation on each amplifier of the die to determine worst case power dissipation. Only the worst case amplifier will be used in this example. In our example, the amplifer is required to drive 10 volts across a 20 ohm load. This calculates to 0.5 amps of output current. The power supplies are ±20 Vdc.

1.) To Find Power Dissipation

P_D = [(quiescent current) x (+V_{CC} - (-V_{CC}))] + (V_{CC} - V_O) x I_{OUT}
P_D = 37.5 mA* x 40V + 10V x 0.5A
P_D = 1.5W + 5W
P_D = 6.5W

*quiescent current for one amplifier is 1/4 of entire quiescent current.

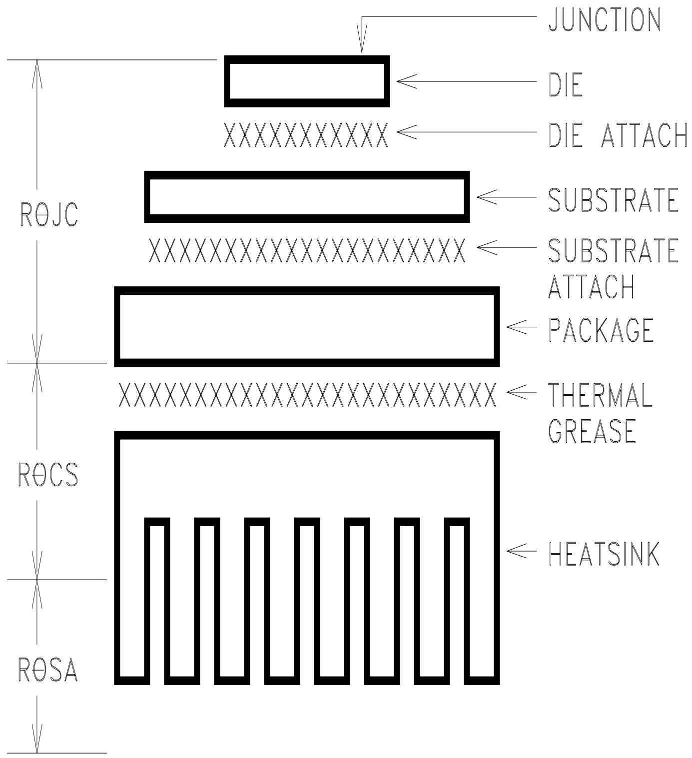
Tj shall be 150°C   Rθjc = 8.0°C/W
Ta shall be 25°C   Rθcs = 0.15°C/W (most thermal greases)

2.) Rearrange the governing equation to solve for $R_{\theta SA}$
(heat sink to air)

Rθsa = ((Tj - TA)/PD) - Rθjc - Rθcs
= ((150°C - 25°C)/6.5W) - 8.0°C/W - 0.15°C/W
= 11.08°C/W

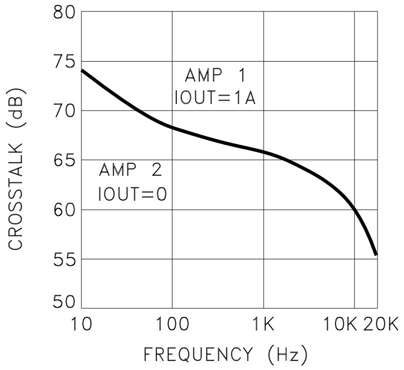
Therefore, to maintain a junction temperature of no more than 150°C for that amplifier, the heat sink must have a thermal resistance of no more than 11.1°C/W.

Thermal Path:

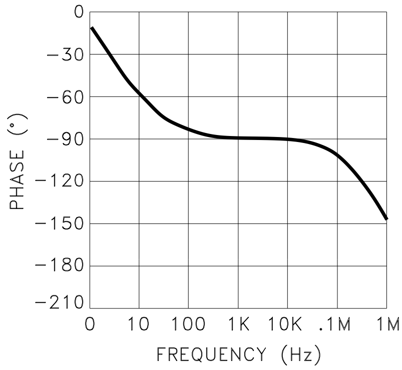


TYPICAL PERFORMANCE CURVES

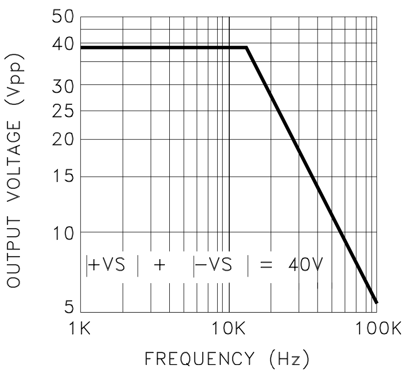
CROSSTALK vs FREQUENCY



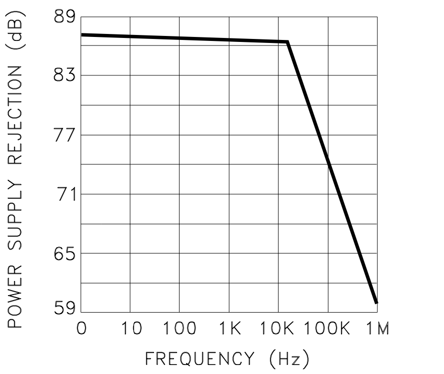
PHASE RESPONSE vs FREQENCY



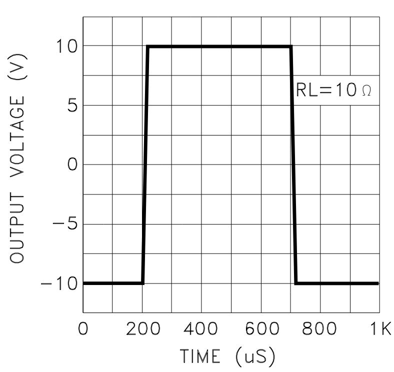
POWER RESPONSE vs FREQUENCY



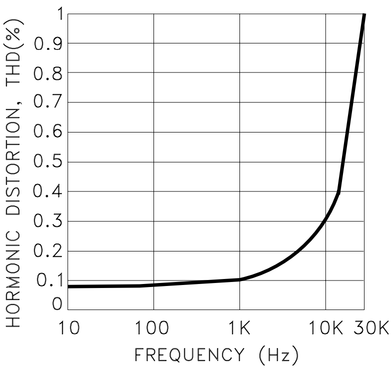
POWER SUPPLY REJECTION vs FREQUENCY



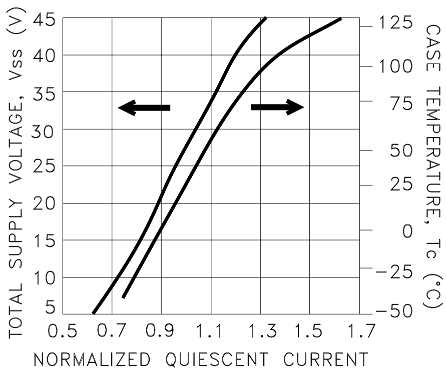
PULSE RESPONSE



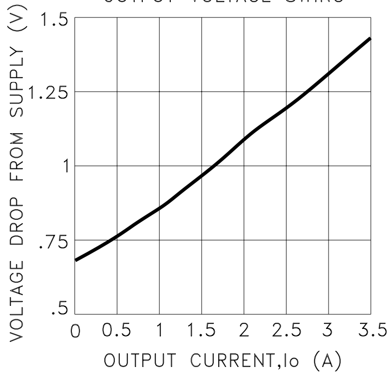
HARMONIC DISTORTION



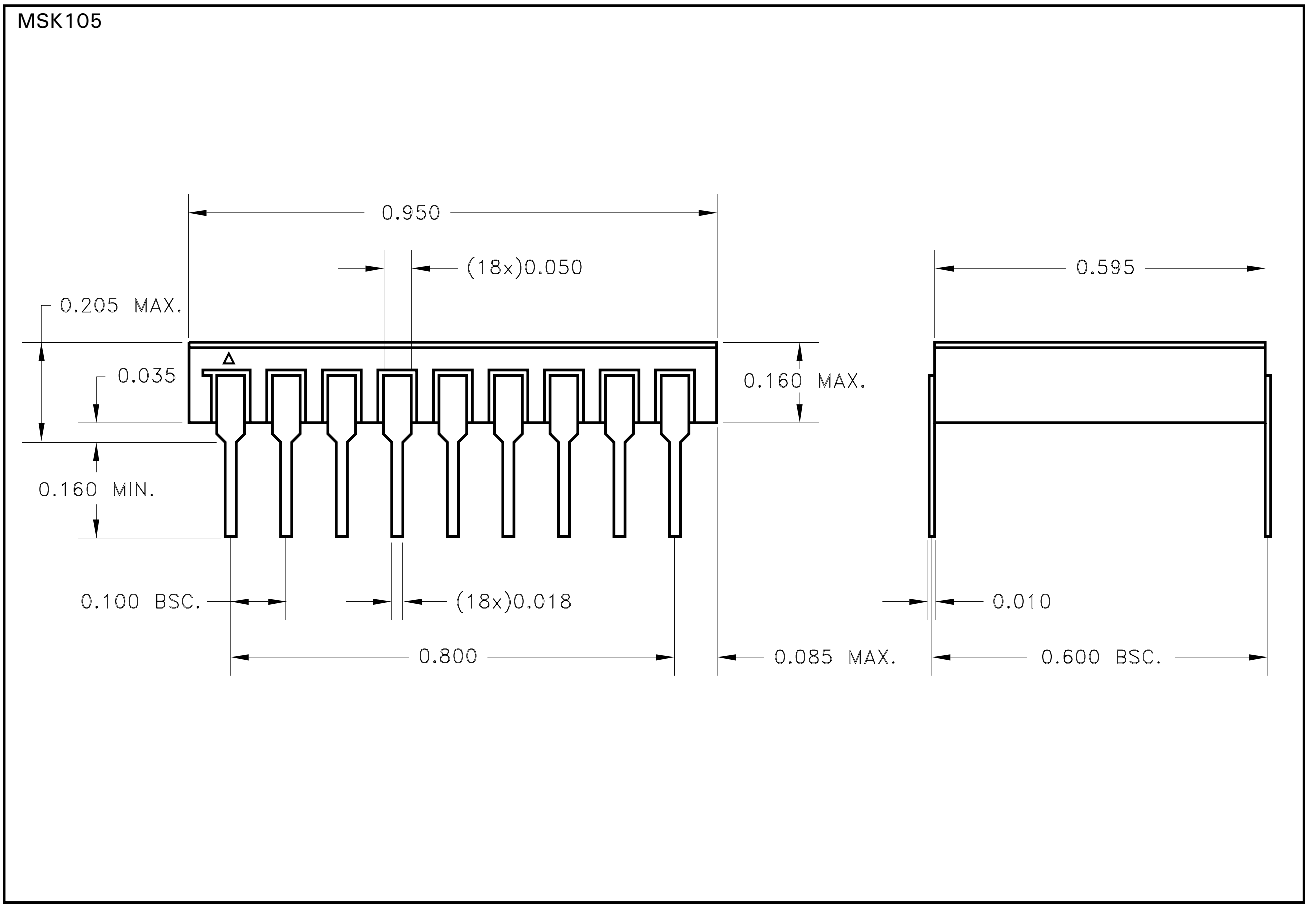
QUIESCENT CURRENT



OUTPUT VOLTAGE SWING



MECHANICAL SPECIFICATIONS



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

ORDERING INFORMATION

Part Number	**Screening Level**
MSK105	Industrial
MSK105E	Extended Reliability
MSK 105B	Class H-Mil-PRF-38534

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