MSK
M.S.KENNEDY CORP.

FET INPUT DIFFERENTIAL OP-AMP
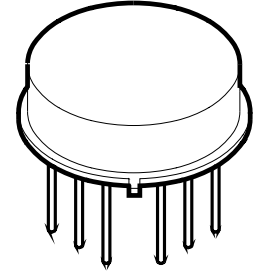
032

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(315) 701-6751

FEATURES:

• Fast Slew Rate
• Fast Settling Time
• FET Input
• Wide Bandwidth
• Electrically Isolated
• LH0032 Pin Compatible Upgrade
• Contact MSK for MIL-PRF-38534 Qualification Status

DESCRIPTION:

The MSK 032 is a high speed, FET input, differential operational amplifier. Intended to replace the popular LH0032, the MSK 032 offers improved performance, much greater consistency from lot to lot, and improved stability over its operating temperature range.

The MSK 032's wide bandwidth, accuracy and output drive capability make it a superior choice for applications such as video amplifiers, buffer amplifiers, comparator circuits and other high frequency signal transfer circuits. As with all MSK products, the MSK 032 is conservatively specified and is available in military and industrial grades.

EQUIVALENT SCHEMATIC
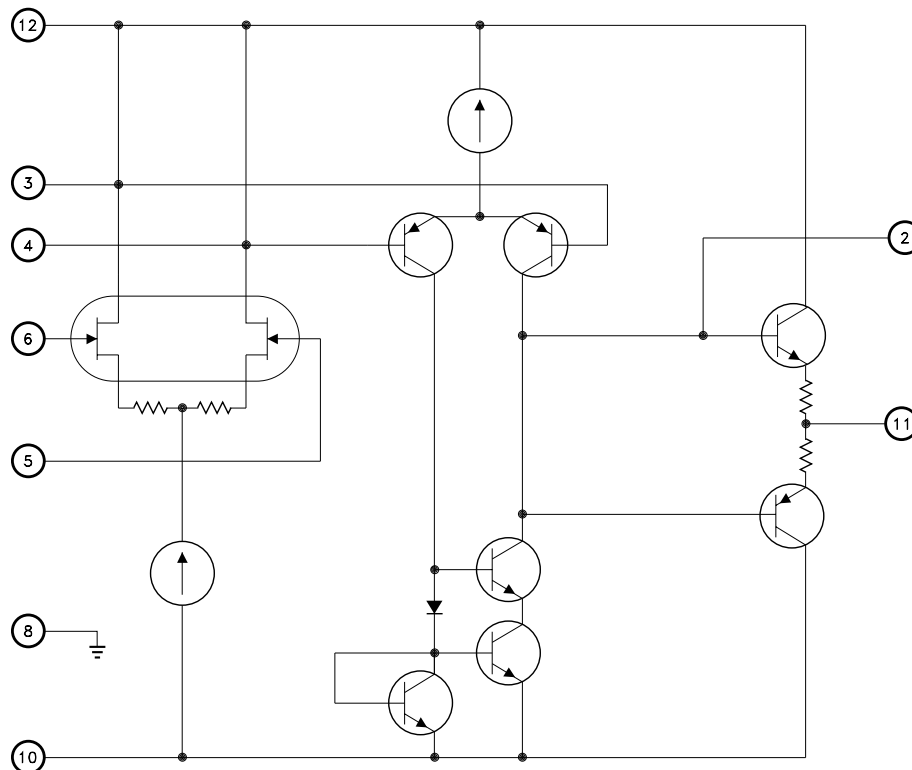
TYPICAL APPLICATIONS

• Video Amplifiers
• Buffer Amplifiers
• Comparator Circuits

PIN-OUT INFORMATION

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

ABSOLUTE MAXIMUM RATINGS [8]

$\pm V_{CC}$	Supply Voltage . . . . $\pm 18V$	
I_{OUT}	Output Current . . . . $\pm 40mA$	
V_{IN}	Differential Input Voltage . . . . $\pm 30V$	
T_C	Case Operating Temperature Range	
	(MSK 032B/E) . . . . -55°C to +125°C	
	(MSK 032) . . . . -40°C to +85°C	
R_{TH}	Thermal Resistance . . . . 187°C/W	
	(Output Switches) (Junction to Case)	

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

$\pm Vcc = \pm 15VDC$ Unless Otherwise Specified

| Parameter	Test Conditions	Group A Subgroup	MSK 032B/E Min.	Typ.	Max.	MSK 032 Min.	Typ.	Max.	Units
STATIC									
Supply Voltage Range [2] [7]		-	± 10	± 15	± 18	± 10	± 15	± 18	V
Quiescent Current	$V_{IN} = 0V$	1	-	± 15	± 20	-	± 15	± 22	mA
		2,3	-	± 18	± 25	-	-	-	mA
INPUT									
Input Offset Voltage	Bal.Pins = NC $V_{IN} = 0V$ $A_V = -10V/V$	1	-	± 0.5	± 5	-	± 1	± 7	mV
Input Offset Voltage Drift	Bal.Pins = NC $V_{IN} = 0V$	2,3	-	± 10	± 25	-	-	-	$\mu V/°C$
Input Offset Adjust	$R_{POT} = 10K\Omega$ To $+V_{CC}$	1	Adjust to Zero			Adjust to Zero			mV
		2,3	Adjust to Zero			-	-	-	mV
Input Bias Current	$V_{CM} = 0V$	1	-	± 50	± 250	-	± 75	± 300	pA
	Either Input	2,3	-	± 0.2	± 10	-	-	-	nA
Input Offset Current	$V_{CM} = 0V$	1	-	10	100	-	20	150	pA
		2,3	-	0.1	5	-	-	-	nA
Input Impedance [2]	$F = DC$	-	-	10^{12}	-	-	10^{12}	-	Ω
Power Supply Rejection Ratio [2]	$\Delta Vcc = \pm 5V$	-	60	70	-	55	70	-	dB
Common Mode Rejection Ratio [2]	$F = DC$ $V_{CM} = \pm 10V$	-	70	80	-	65	80	-	dB
Input Noise Voltage	$F = 10Hz$ To $1KHz$	-	-	1.5	-	-	1.5	-	$\mu Vrms$
Equivalent Input Noise	$F = 1KHz$	-	-	40	-	-	40	-	$nV\sqrt{Hz}$
OUTPUT									
Output Voltage Swing	$F \leq 5MHz$ $R_L = 510\Omega$	4	± 10	± 12	-	± 10	± 12	-	V
Output Current	$R_L = 510\Omega$	4	± 20	± 30	-	± 20	± 30	-	mA
Settling Time to 1% [1] [2]	$R_L = 1K\Omega$ 10V step	4	-	50	60	-	55	65	nS
Settling Time to 0.1% [2]	$R_L = 1K\Omega$ 10V step	4	-	60	90	-	70	100	nS
Full Power Bandwidth	$R_L = 510\Omega$ $Vo = \pm 10V$	4	8	9	-	7	8	-	MHz
Bandwidth (Small Signal) [2]	$R_L = 510\Omega$	4	80	90	-	75	80	-	MHz
TRANSFER CHARACTERISTICS									
Slew Rate Limit	$V_{OUT} = \pm 10V$ $R_L = 510\Omega$	4	500	600	-	475	550	-	$V/\mu S$
Open Loop Voltage Gain [2]	$V_{OUT} = \pm 10V$ $R_L = 1K\Omega$	4	80	90	-	75	85	-	dB

NOTES:
[1] AV = -1, measured in false summing junction circuit.
[2] Devices shall be capable of meeting the parameter, but need not be tested. Typical parameters 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] Subgroup 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 $T_A = T_C = -55°C$
[7] Electrical specifications are derated for power supply voltages other than $\pm 15VDC$.
[8] Continuous operation at or above absolute maximum ratings may adversely effect the device performance and/or life cycle.

Rev. C 9/06

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:
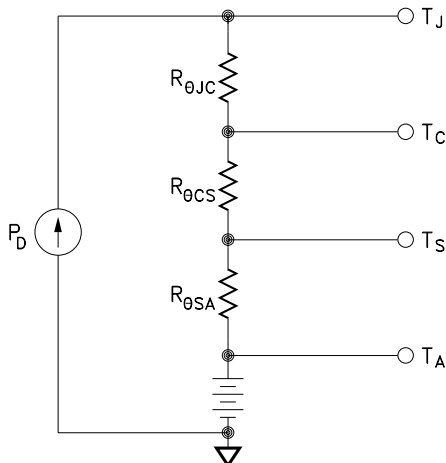
Governing Equation:

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

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:
  $V_{cc} = \pm 16VDC$
  $V_o = \pm 8V_p$ Sine Wave, Freq. = 1KHz
  $R_L = 510\Omega$
For a worst case analysis we treat the +8Vp sine wave as an 8 VDC output voltage.
1.) Find driver power dissipation
  $P_D = (V_{cc} - V_o)(V_o / R_L)$
     $= (16V - 8V)(8V / 510\Omega)$
     $= 125.5mW$
2.) For conservative design, set $T_J = +125°C$
3.) For this example, worst case $T_A = +100°C$
4.) $R_{\theta JC} = 187°C/W$ from MSK 032B Data Sheet
5.) $R_{\theta CS} = 0.15°C/W$ for most thermal greases
6.) Rearrange governing equation to solve for $R_{\theta SA}$

$R_{\theta SA} = ((T_J - T_A)/P_D) - (R_{\theta JC}) - (R_{\theta CS})$.
   $= ((125°C - 100°C)/0.13W) - 187°C/W - 0.15°C/W$
   $= 192.3 - 187.15$
   $= 5.2°C/W$
The heat sink in this example must have a thermal resistance of no more than 5.2°C/W to maintain a junction temperature of no more than +125°C.

SLEW RATE vs. SLEW RATE LIMIT
SLEW RATE

$SR = 2\pi V_pF$: Slew rate is based upon the sinusoidal linear response of the amplifier and is calculated from the full power bandwidth frequency.
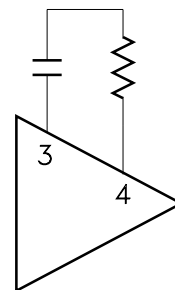
SLEW RATE LIMIT

dv/dt: The slew rate limit is based upon the amplifier's response to a step input and is measured between 10% and 90%. MSK measures T_R or T_F, whichever is greater at $\pm 10V_{OUT}$, $R_L = 510\Omega$

$$SRL = \frac{V_O - 20\%}{T_R \text{ or } T_F}$$

COMPENSATION

The MSK 032, can be frequency compensated by connecting an R-C snubber circuit from pin 3 to pin 4 as shown below.
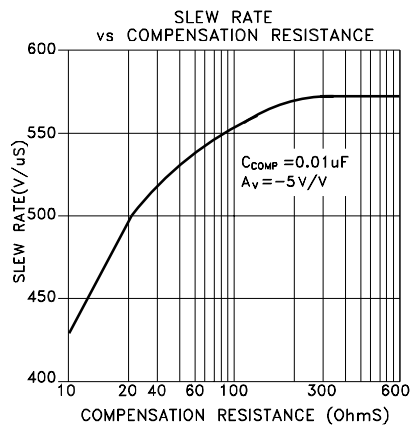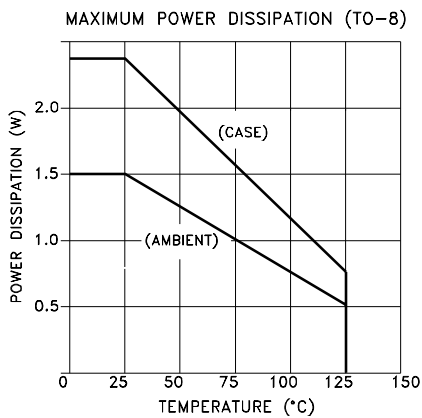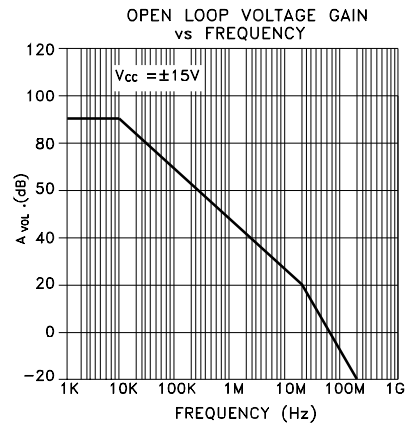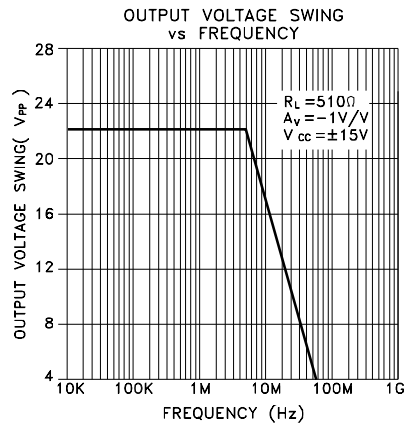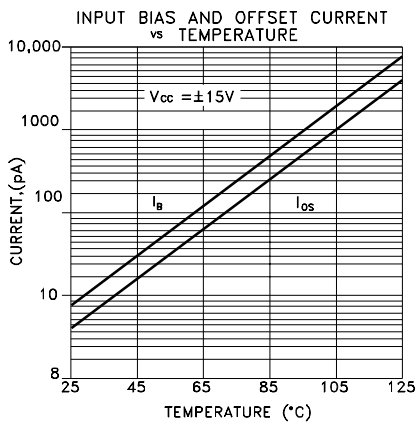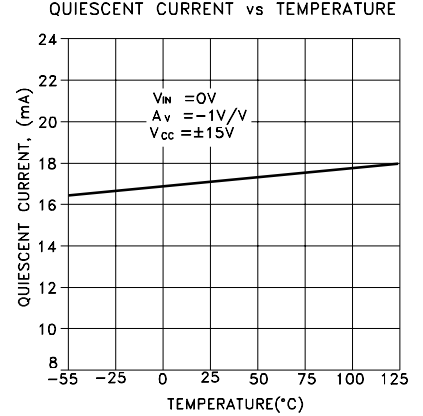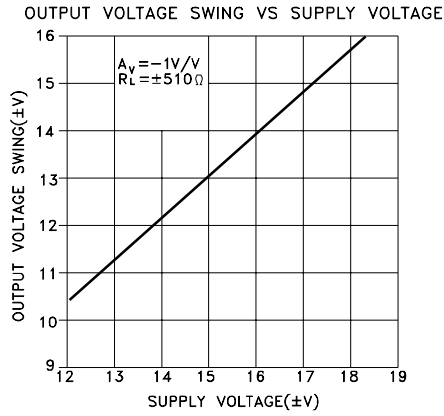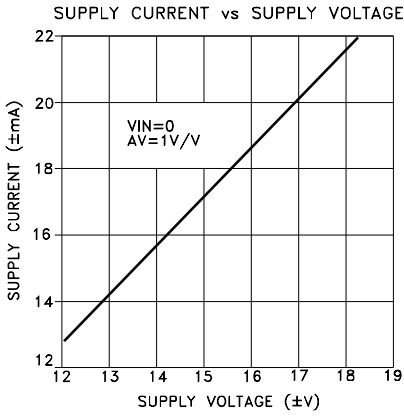

The recommended capacitor value is $0.01\mu F$ and the resistor value can range from 2Ω to 500Ω. The effects of this R-C snubber can be seen on the typical performance curve labeled Slew Rate vs. Compensation Resistance. The graph clearly illustrates the decrease in transition time as snubber resistance increases. This occurs because the high frequency components of the input square wave are above the corner frequency of the R-C snubber and are applied common mode to the bases of the second differential pair, (pins 3 and 4). There is no differential gain for these higher frequencies since the input signal is applied common mode. Without the high frequency components appearing at the output, the slew rate and bandwidth of the op-amp are limited. However, at the cost of speed and bandwidth the user gains circuit stability. A good design rule to follow is: as closed loop gain decreases, circuit stability decreases, therefore snubber resistance should decrease to maintain stability and avoid oscillation. The MSK 032 can also be compensated using the standard LH0032 techniques.
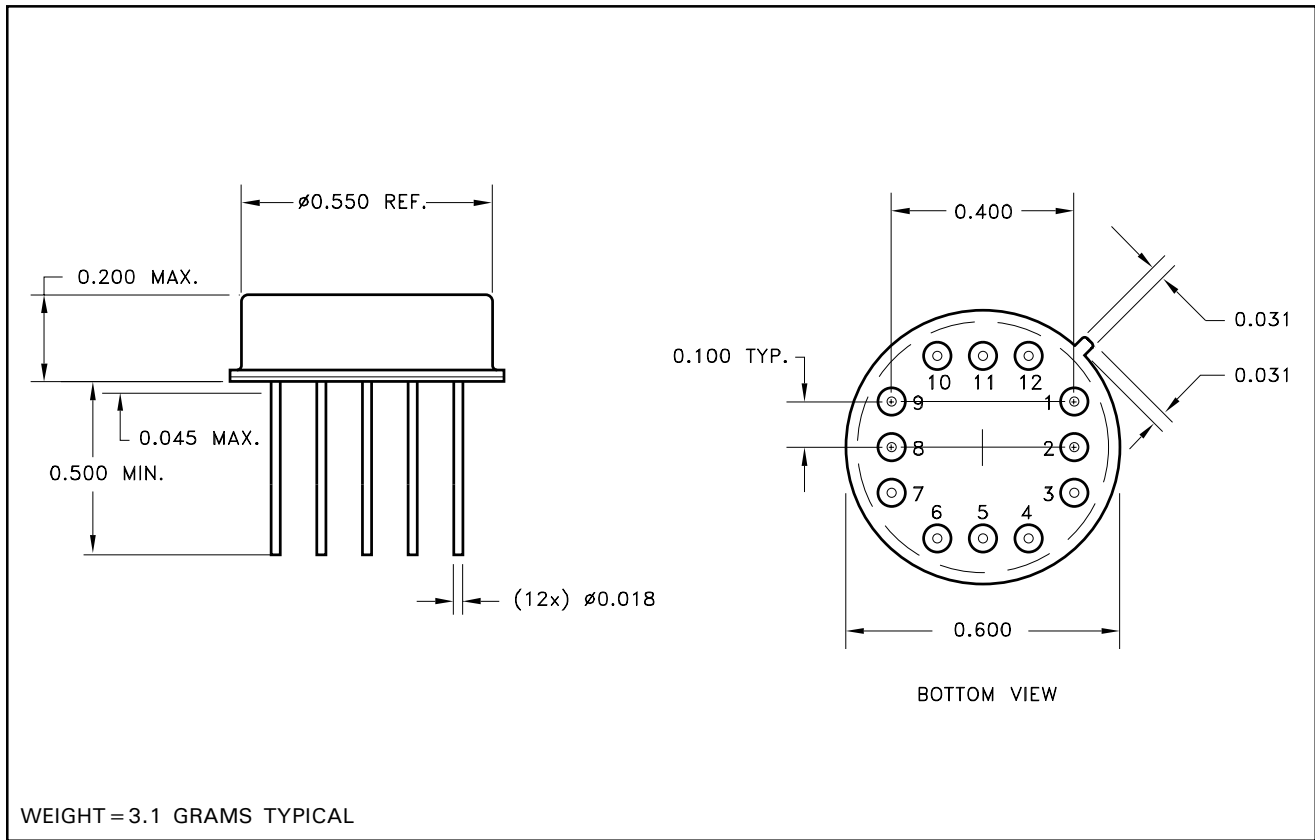
POWER SUPPLY BYPASSING

Both the negative and 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.

TYPICAL PERFORMANCE CURVES

SUPPLY CURRENT vs SUPPLY VOLTAGE

VIN=0
AV=1V/V

OUTPUT VOLTAGE SWING VS SUPPLY VOLTAGE

$A_V = -1V/V$
$R_L = \pm 510\Omega$

QUIESCENT CURRENT vs TEMPERATURE

$V_{IN} = 0V$
$A_V = -1V/V$
$V_{CC} = \pm 15V$

INPUT BIAS AND OFFSET CURRENT vs TEMPERATURE

$V_{CC} = \pm 15V$

I_B I_{OS}

OUTPUT VOLTAGE SWING vs FREQUENCY

$R_L = 510\Omega$
$A_V = -1V/V$
$V_{CC} = \pm 15V$

OPEN LOOP VOLTAGE GAIN vs FREQUENCY

$V_{CC} = \pm 15V$

MAXIMUM POWER DISSIPATION (TO-8)

(CASE)

(AMBIENT)

SLEW RATE vs COMPENSATION RESISTANCE

$C_{COMP} = 0.01uF$
$A_V = -5V/V$

ø0.550 REF.

0.200 MAX.

0.045 MAX.

0.500 MIN.

(12x) ø0.018

0.400

0.100 TYP.

0.031

0.031

10 11 12

9   1

8   2

7   3

6   5   4

0.600

BOTTOM VIEW

WEIGHT = 3.1 GRAMS TYPICAL

ALL DIMENSIONS ARE ±0.010 INCHES UNLESS OTHERWISE LABELED

ORDERING INFORMATION

Part Number	Screening Level
MSK032	Industrial
MSK032E	Extended Reliability
MSK032B	Mil-PRF-38534 Class H
MSK032S	Mil-PRF-38534 Class K

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