MOTOROLA

MC33076

# Dual High Output Current, Low Power, Low Noise Bipolar Operational Amplifier

The MC33076 operational amplifier employs bipolar technology with innovative high performance concepts for audio and industrial applications. This device uses high frequency PNP input transistors to improve frequency response. In addition, the amplifier provides high output current drive capability while minimizing the drain current. The all NPN output stage exhibits no deadband crossover distortion, large output voltage swing, excellent phase and gain margins, low open loop high frequency output impedance and symmetrical source and sink AC frequency performance.

The MC33076 is tested over the automotive temperature range and is available in an 8–pin SOIC package (D suffix) and in both the standard 8 pin DIP and 16–pin DIP packages for high power applications.
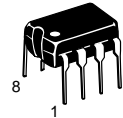
- 100 Ω Output Drive Capability
- Large Output Voltage Swing
- Low Total Harmonic Distortion
- High Gain Bandwidth: 7.4 MHz
- High Slew Rate: 2.6 V/μs
- Dual Supply Operation: ±2.0 V to ±18 V
- High Output Current: ISC = 250 mA typ
- Similar Performance to MC33178

DUAL HIGH OUTPUT CURRENT OPERATIONAL AMPLIFIER
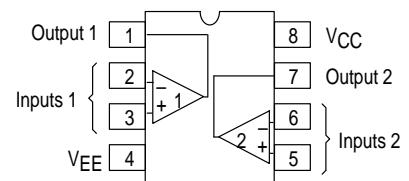
SEMICONDUCTOR TECHNICAL DATA
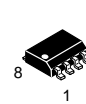
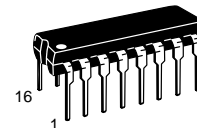**D SUFFIX**
PLASTIC PACKAGE
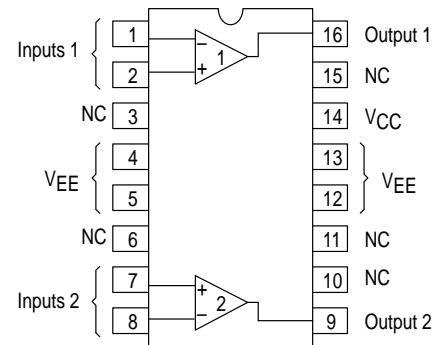CASE 751
(SO–8)

P1 SUFFIX
PLASTIC PACKAGE
CASE 626

PIN CONNECTIONS

Output 1 — 1
Inputs 1 { 2, 3
V_{EE} — 4
8 — V_{CC}
7 — Output 2
6, 5 } Inputs 2

(8 Pin Pkg, Top View)

P2 SUFFIX
PLASTIC PACKAGE
CASE 648C
DIP (12+2+2)

PIN CONNECTIONS

Inputs 1 { 1, 2
NC — 3
V_{EE} { 4, 5
NC — 6
Inputs 2 { 7, 8

16 — Output 1
15 — NC
14 — V_{CC}
13, 12 } V_{EE}
11 — NC
10 — NC
9 — Output 2

(16 Pin Pkg, Top View)

Equivalent Circuit Schematic
(Each Amplifier)
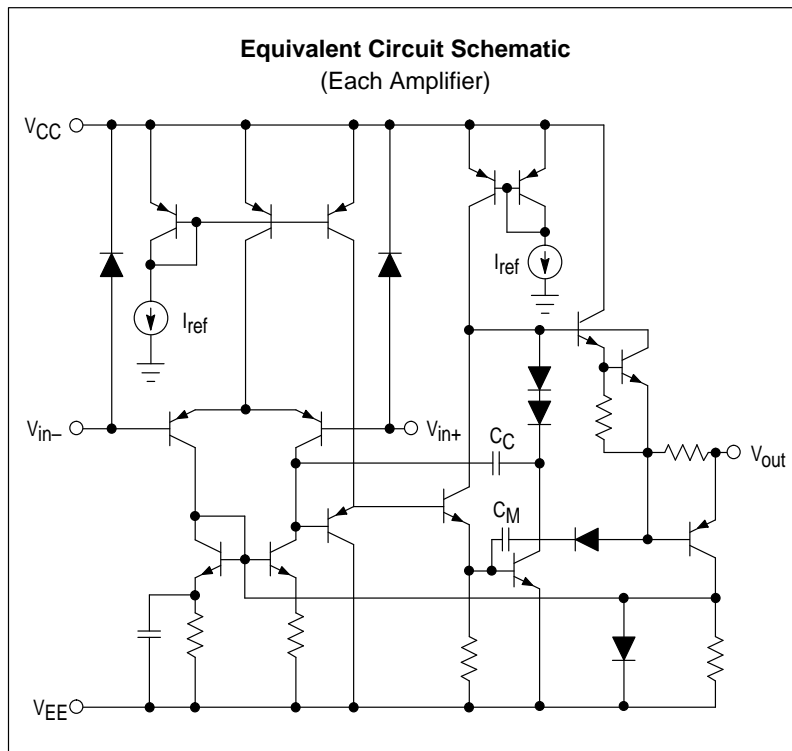
ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC33076D		SO–8
MC33076P1	$T_A = -40°$ to $+85°C$	Plastic DIP
MC33076P2		Power Plastic

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Rev 0

MC33076

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltage (Note 2)	V_{CC} to V_{EE}	+36	V
Input Differential Voltage Range	V_{IDR}	(Note 1)	V
Input Voltage Range	V_{IR}	(Note 1)	V
Output Short Circuit Duration (Note 2)	t_{SC}	5.0	sec
Maximum Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	−60 to +150	°C
Maximum Power Dissipation	P_D	(Note 2)	mW

NOTES: 1. Either or both input voltages should not exceed V_{CC} or V_{EE}.
    2. Power dissipation must be considered to ensure maximum junction temperature (T_J) is not exceeded (see power dissipation performance characteristic, Figure 1).
    See applications section for further information.

DC ELECTRICAL CHARACTERICISTICS (V_{CC} = +15 V, V_{EE} = −15 V, T_A = 25°C, unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit

Input Offset Voltage (R_S = 50 Ω, V_{CM} = 0 V)
(V_S = ±2.5 V to ±15 V)
  T_A = +25°C
  T_A = −40° to +85°C
	2	$|V_{IO}|$	
			
			—
			—
				
				0.5
				0.5
					
					4.0
					5.0
						mV

Input Offset Voltage Temperature Coefficient (R_S = 50 Ω, V_{CM} = 0 V) T_A = −40° to +85°C		$\Delta V_{IO}/\Delta T$	 —	 2.0	 —	µV/°C

Input Bias Current (V_{CM} = 0 V)
  T_A = +25°C
  T_A = −40° to +85°C
	3, 4	I_{IB}	
			—
			—
				
				100
				—
					
					500
					600
						nA

Input Offset Current (V_{CM} = 0 V)
  T_A = +25°C
  T_A = −40° to +85°C
		$|I_{IO}|$	
			—
			—
				
				5.0
				—
					
					70
					100
						nA

Common Mode Input Voltage Range	5	V_{ICR}	−13 +14	−14 	 13	V

Large Signal Voltage Gain (V_O = −10 V to +10 V)
(T_A = +25°C)
  R_L = 100 Ω
  R_L = 600 Ω
(T_A = −40° to +85°C)
  R_L = 600 Ω
	6	A_{VOL}	
			
			25
			50
			
			25
				
				—
				200
				
				—
					
					—
					—
					
					—
						kV/V

Output Voltage Swing (V_{ID} = ±1.0 V)
(V_{CC} = +15 V, V_{EE} = −15 V)
  R_L = 100 Ω
  R_L = 100 Ω
  R_L = 600 Ω
  R_L = 600 Ω
(V_{CC} = +2.5 V, V_{EE} = −2.5 V)
  R_L = 100 Ω
  R_L = 100 Ω
	7, 8, 9	
		
		V_{O+}
		V_{O-}
		V_{O+}
		V_{O-}
		
		V_{O+}
		V_{O-}
			
			10
			—
			13
			—
			
			1.2
			—
				
				+11.7
				−11.7
				+13.8
				−13.8
				
				+1.66
				−1.74
					
					—
					−10
					—
					−13
					
					—
					−1.2
						V

Common Mode Rejection (V_{in} = ±13 V)	10	CMR	80	116	—	dB
Power Supply Rejection (V_{CC}/V_{EE} = +15 V/−15 V, +5.0 V/−15 V, +15 V/−5.0 V)	11	PSR	 80	 120	 —	dB

MC33076

DC ELECTRICAL CHARACTERICISTICS (V_{CC} = +15 V, V_{EE} = −15 V, T_A = 25°C, unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit

Output Short Circuit Current (V_{ID} = ±1.0 V Output to Gnd)
(V_{CC} = +15 V, V_{EE} = −15 V)
  Source
  Sink
(V_{CC} = +2.5 V, V_{EE} = −2.5 V)
  Source
  Sink
	12, 13	I_{SC}	
			
			190
			—
			
			63
			—
				
				+250
				−280
				
				+94
				−80
					
					—
					−215
					
					—
					−46
						mA

Power Supply Current per Amplifier (V_O = 0 V)
(V_S = ±2.5 V to ±15 V)
  T_A = +25°C
  T_A = −40° to +85°C
	14	I_D	
			
			—
			—
				
				2.2
				—
					
					2.8
					3.3
						mA

AC ELECTRICAL CHARACTERICISTICS (V_{CC} = +15 V, V_{EE} = −15 V, T_A = 25°C, unless otherwise noted.)

Characteristics	Figure	Symbol	Min	Typ	Max	Unit
Slew Rate (V_{in} = −10 V to +10 V, R_L = 100 Ω, C_L = 100 pF, A_V = +1)	15	SR	1.2	2.6	—	V/μs
Gain Bandwidth Product (f = 20 kHz)	16	GBW	4.0	7.4	—	MHz
Unity Gain Frequency (Open Loop) (R_L = 600 Ω, C_L = 0 pF)	—	f_U	—	3.5	—	MHz
Gain Margin (R_L = 600 Ω, C_L = 0 pF)	19, 20	A_m	—	15	—	dB
Phase Margin (R_L = 600 Ω, C_L = 0 pF)	19, 20	$\varnothing_m$	—	52	—	Deg
Channel Separation (f = 100 Hz to 20 kHz)	21	CS	—	−120	—	dB
Power Bandwidth (V_O = 20 V_{pp}, R_L = 600 Ω, THD ≤ 1%)	—	BW_p	—	32	—	kHz

Total Harmonic Distortion (R_L = 600 Ω, V_O = 2.0 V_{pp}, A_V = +1)
  f = 1.0 kHz
  f = 10 kHz
  f = 20 kHz
	22	THD	
			—
			—
			—
				
				0.0027
				0.011
				0.022
					
					—
					—
					—
						%

Open Loop Output Impedance (V_O = 0 V, f = 2.5 MHz, A_V = 10)	23	$\lvert Z_O \rvert$	—	75	—	Ω
Differential Input Resistance (V_{CM} = 0 V)	—	R_{in}	—	200	—	kΩ
Differential Input Capacitance (V_{CM} = 0 V)	—	C_{in}	—	10	—	pF

Equivalent Input Noise Voltage (R_S = 100 Ω)
  f = 10 Hz
  f = 1.0 kHz
	24	e_n	
			—
			—
				
				7.5
				5.0
					
					—
						nV/√Hz

Equivalent Input Noise Current
  f = 10 Hz
  f = 1.0 kHz
	—	i_n	
			—
			—
				
				0.33
				0.15
					
					—
					—
						pA/√Hz

MC33076

Figure 1. Maximum Power Dissipation versus Temperature
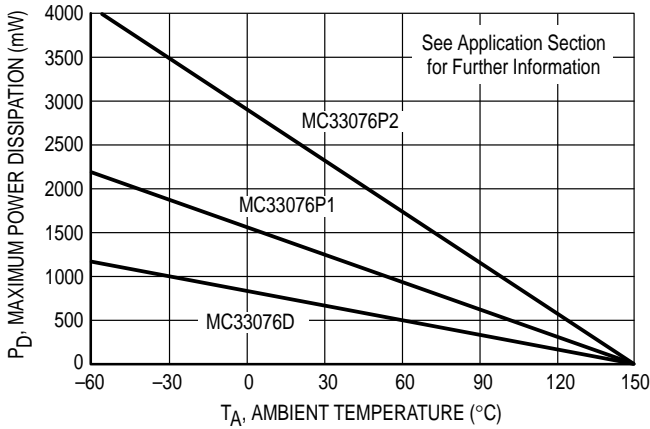

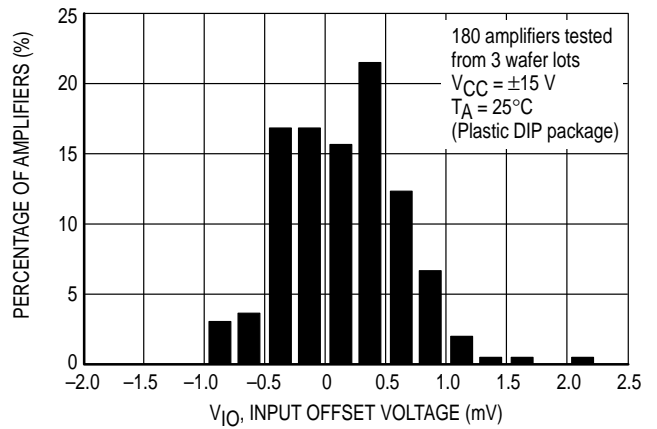**Figure 2. Distribution of Input Offset Voltage**

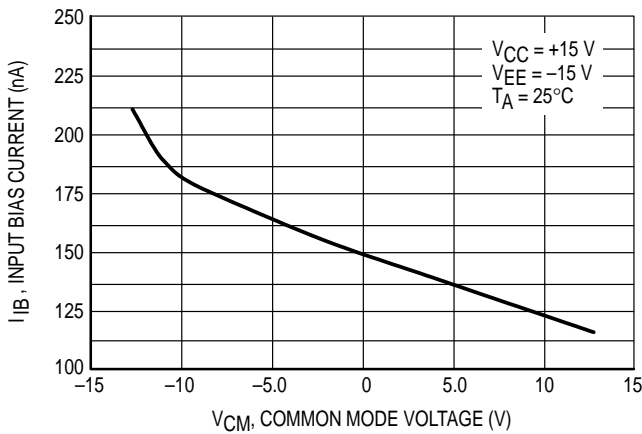**Figure 3. Input Bias Current versus Common Mode Voltage**

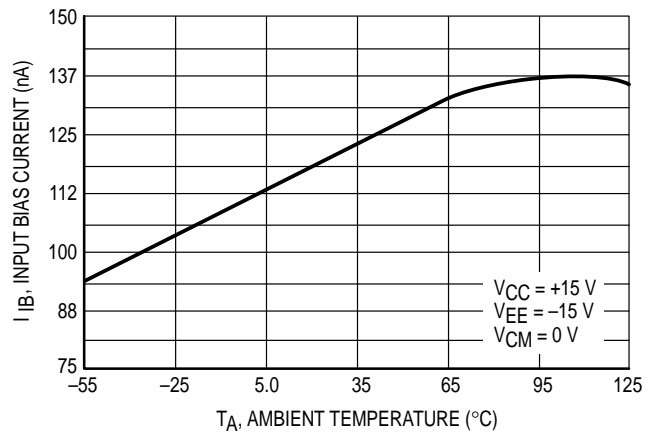**Figure 4. Input Bias Current versus Temperature**

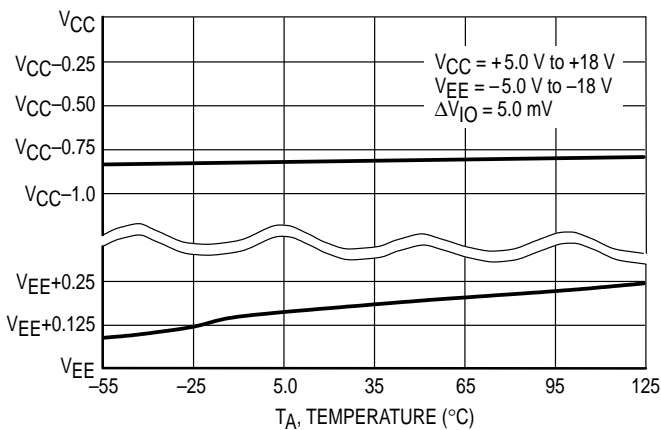**Figure 5. Input Common Mode Voltage Range versus Temperature**

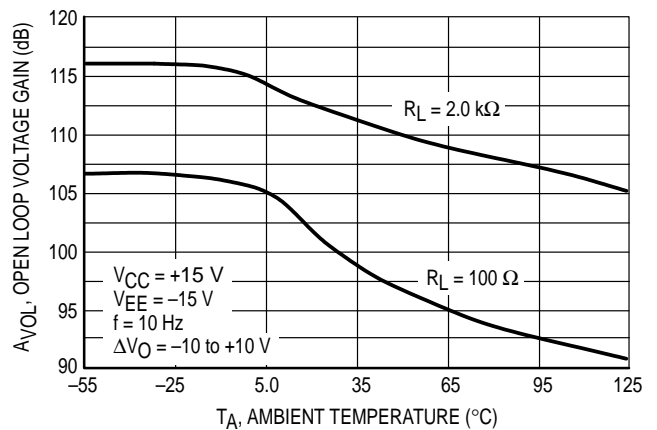**Figure 6. Open Loop Voltage Gain versus Temperature**

MC33076
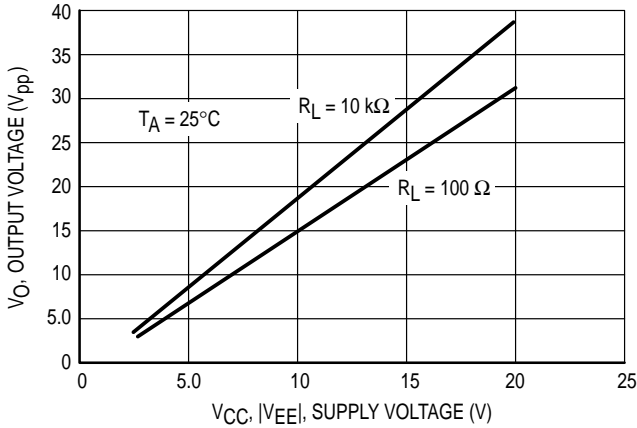
Figure 7. Output Voltage Swing versus Supply Voltage

Figure 8. Maximum Peak–to–Peak Output Voltage Swing versus Load Resistance
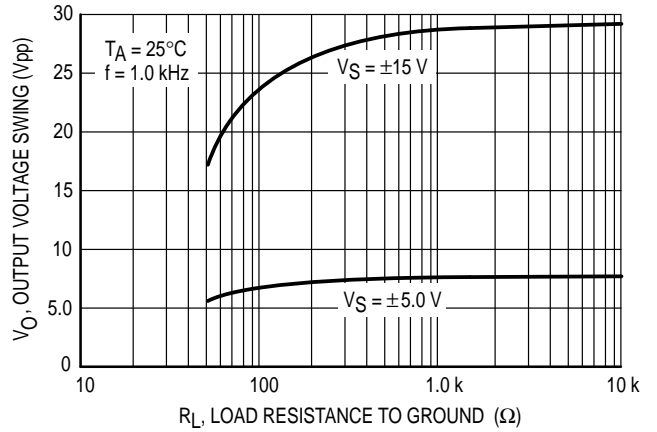
Figure 9. Output Voltage versus Frequency
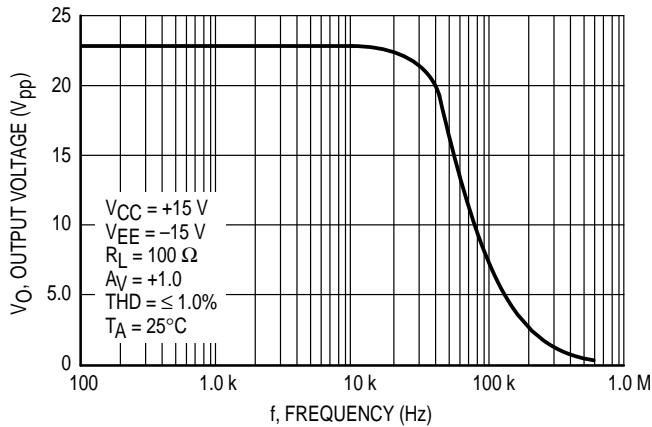
Figure 10. Common Mode Rejection versus Frequency Over Temperature
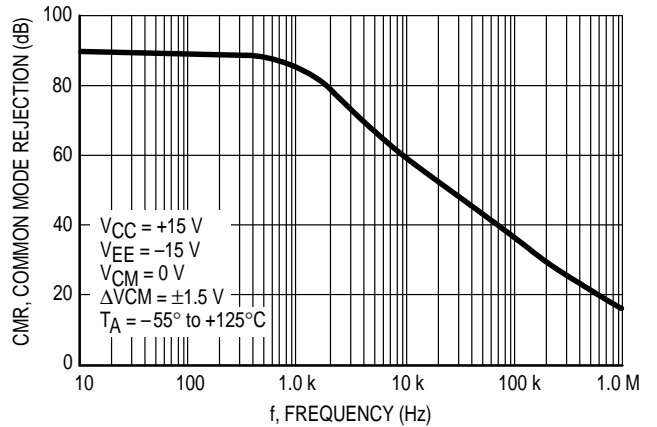
Figure 11. Power Supply Rejection versus Frequency Over Temperature
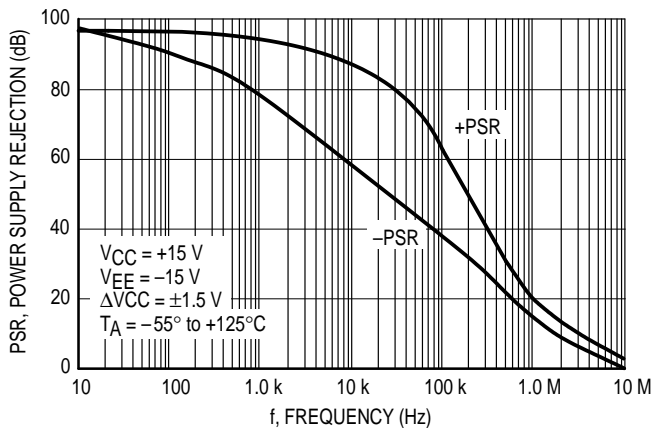
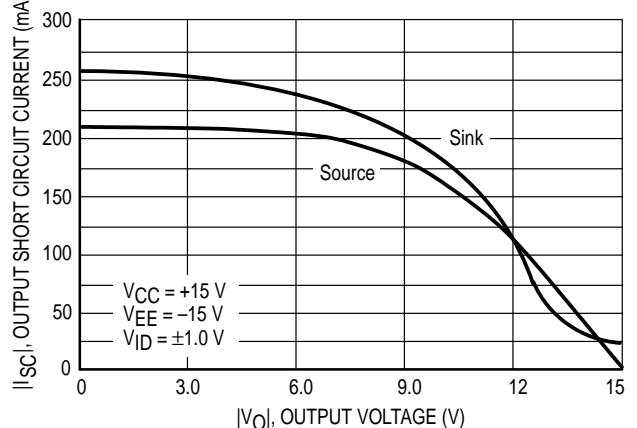### Figure 12. Output Short Circuit Current versus Output Voltage
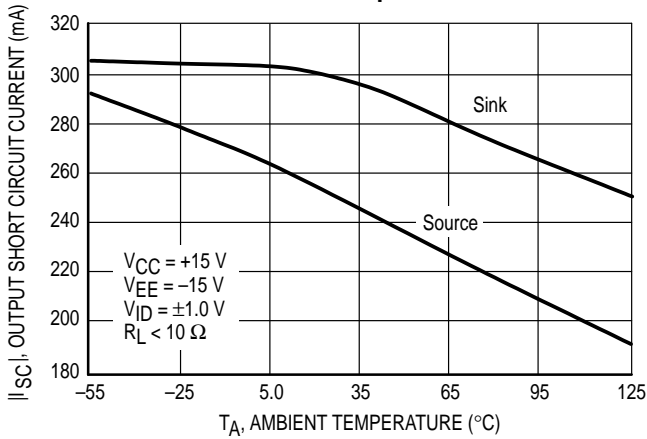
MC33076

Figure 13. Output Short Circuit Current versus Temperature

Sink

Source

$V_{CC} = +15$ V
$V_{EE} = -15$ V
$V_{ID} = \pm 1.0$ V
$R_L < 10 \; \Omega$

|I$_{SC}$|, OUTPUT SHORT CIRCUIT CURRENT (mA)

T$_A$, AMBIENT TEMPERATURE (°C)

Figure 14. Supply Current versus Supply Voltage with No Load

$T_A = +125°C$

$T_A = +25°C$

$T_A = -55°C$

I$_D$, SUPPLY CURRENT/AMPLIFIER (mA)

V$_{CC}$ |V$_{EE}$|, SUPPLY VOLTAGE (V)
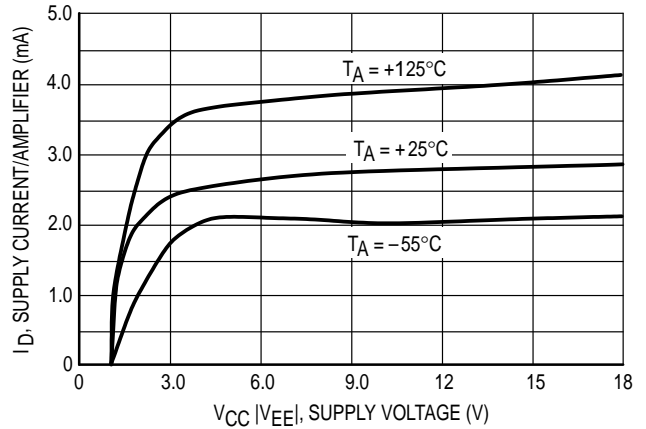
Figure 15. Slew Rate versus Temperature

SR, SLEW RATE (V/µS)

ΔV_{in}
100Ω
$100pF$

$V_{CC} = +15$ V
$V_{EE} = -15$ V
$\Delta V_{in} = 20$ Vpp

T$_A$, AMBIENT TEMPERATURE (°C)
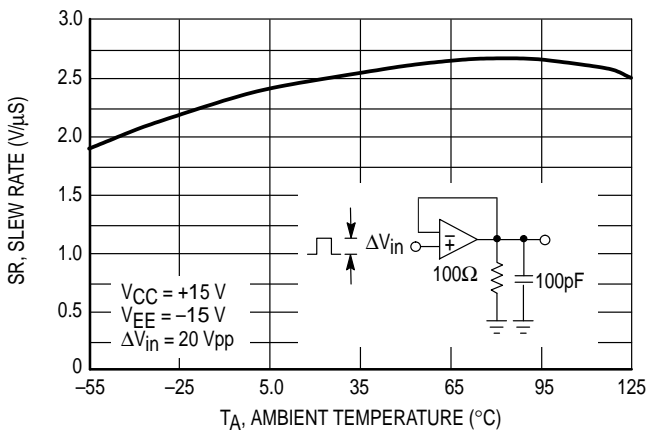
Figure 16. Gain Bandwidth Product versus Temperature

GBW, GAIN BANDWIDTH PRODUCT (MHz)

$V_{CC} = +15$ V
$V_{EE} = -15$ V
$f = 100$ Hz
$R_L = 100 \; \Omega$
$C_L = 0$ pF

T$_A$, AMBIENT TEMPERATURE (°C)
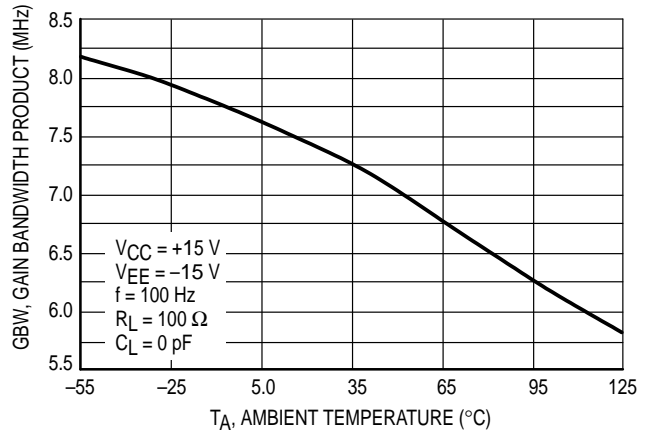
Figure 17. Voltage Gain and Phase versus Frequency

1A
2A
1B
2B

1A) Phase, $V_S = \pm 18$ V
2A) Phase, $V_S = \pm 1.5$ V
1B) Gain, $V_S = \pm 18$ V
2B) Gain, $V_S = \pm 1.5$ V

A$_V$, VOLTAGE GAIN (dB)

∅, EXCESS PHASE (DEGREES)
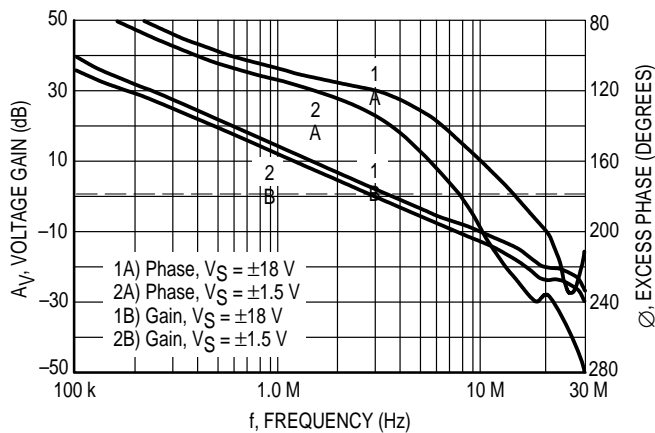
f, FREQUENCY (Hz)

Figure 18. Voltage Gain and Phase versus Frequency

1B
1A
2B
2A

1A) Phase, (R = 100 Ω)
2A) Phase, (R = 100 Ω, C = 300 pF)
1B) Gain, (R = 100 Ω)
2B) Gain, (R = 100 Ω, C = 300 pF)

A$_V$, VOLTAGE GAIN (dB)

∅, EXCESS PHASE (DEGREES)

f, FREQEUNCY (Hz)

MC33076
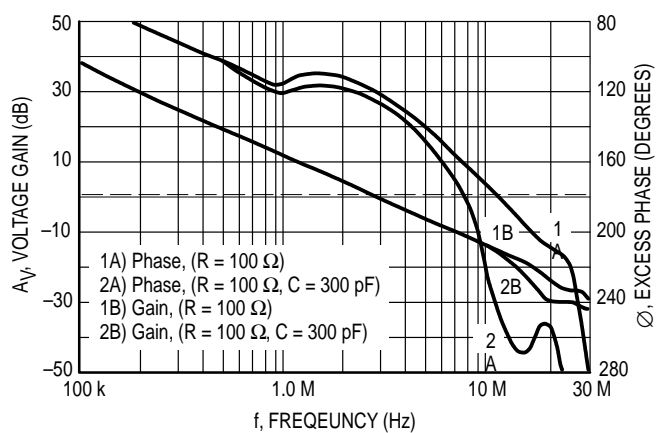
**Figure 19. Phase Margin and Gain Margin
versus Differential Source Resistance**

V_{CC} = +15 V
V_{EE} = −15 V
R_T = R_1 + R_2
V_O = 0 V
T_A = 25°C

Gain Margin

Phase Margin

A_m, GAIN MARGIN (dB)

$\varnothing_m$, PHASE MARGIN (DEGREES)

R_T, DIFFERENTIAL SOURCE RESISTANCE (Ω)
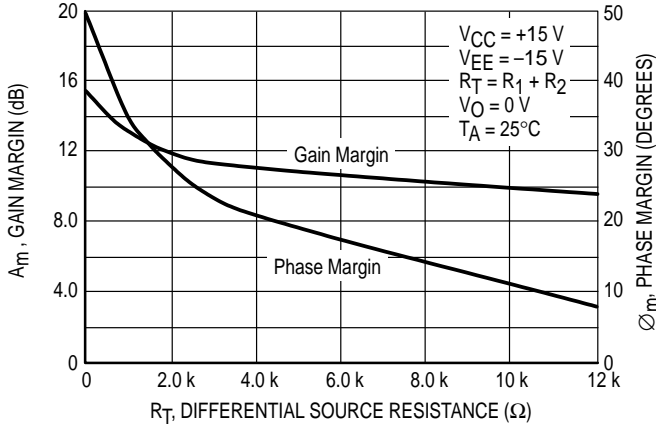
**Figure 20. Open Loop Gain Margin and Phase
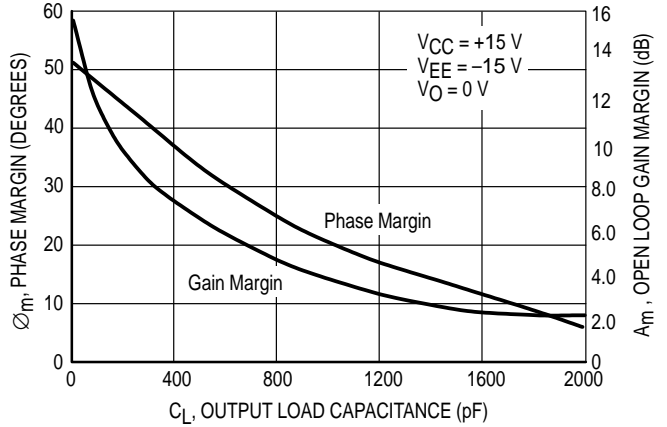Margin versus Output Load Capacitance**

V_{CC} = +15 V
V_{EE} = −15 V
V_O = 0 V

Phase Margin

Gain Margin

$\varnothing_m$, PHASE MARGIN (DEGREES)

A_m, OPEN LOOP GAIN MARGIN (dB)

C_L, OUTPUT LOAD CAPACITANCE (pF)

**Figure 21. Channel Separation
versus Frequency**

Drive Channel
V_{CC} = +15 V
V_{EE} = −15 V
R_L = 100 Ω
T_A = 25°C

CS, CHANNEL SEPARATION (dB)
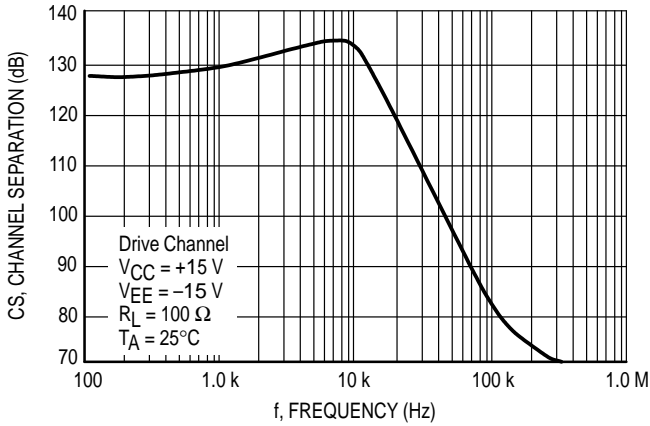
f, FREQUENCY (Hz)

**Figure 22. Total Harmonic Distortion
versus Frequency**

V_{CC} = +15 V
V_{EE} = −15 V
R_L = 100 Ω
V_O = 2.0 Vpp
T_A = 25°C

AV = +1000

AV = +100

AV = +10

AV = +1

THD, TOTAL HARMONIC DISTORTION (%)
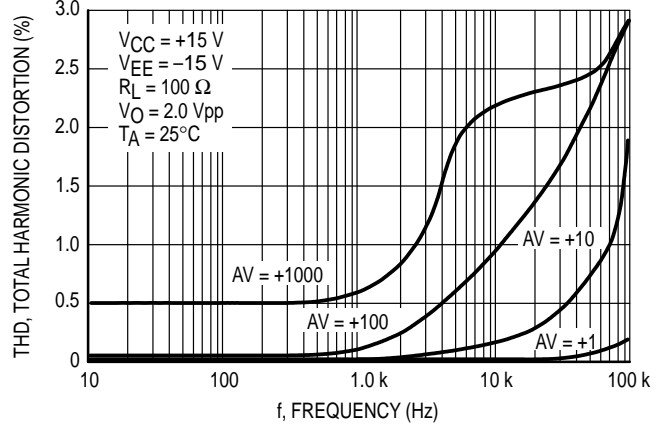
f, FREQUENCY (Hz)

**Figure 23. Output Impedance
versus Frequency**

V_{CC} = +15 V
V_{EE} = −15 V
V_{CM} = 0 V
V_O = 0 V
T_A = 25°C

AV = 1000

AV = 100

AV = 10

AV = 1.0

Z_O, OUTPUT IMPEDANCE (Ω)
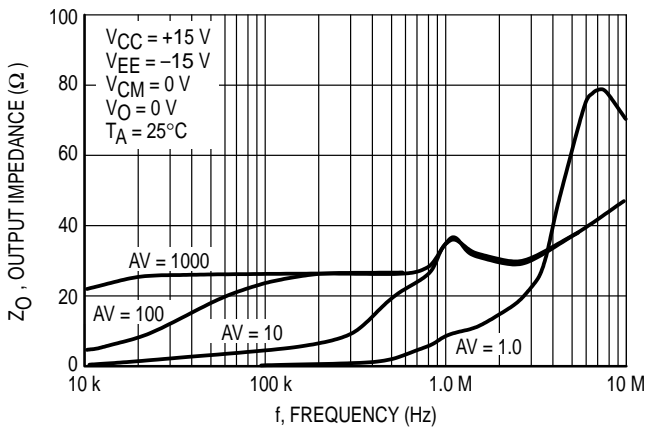
f, FREQUENCY (Hz)

**Figure 24. Input Referred Noise Voltage
versus Frequency**

V_{CC} = +15 V
V_{EE} = −15 V
T_A = 25°C

V_O

Input Noise Voltage
Test Circuit

e_n, INPUT REFERRED NOISE VOLTAGE (NV/$\sqrt{Hz}$)
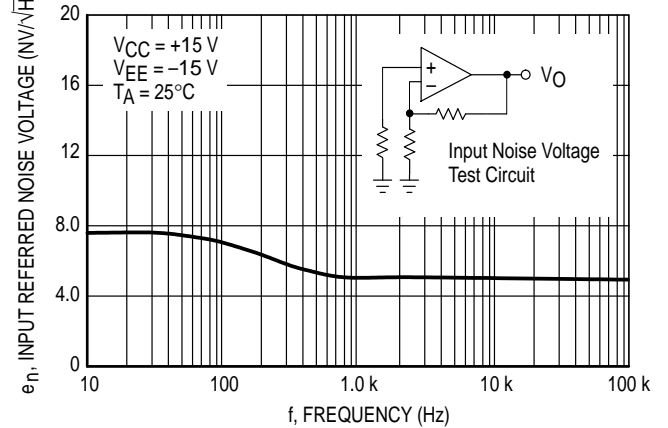
f, FREQUENCY (Hz)

**Figure 25. Percent Overshoot
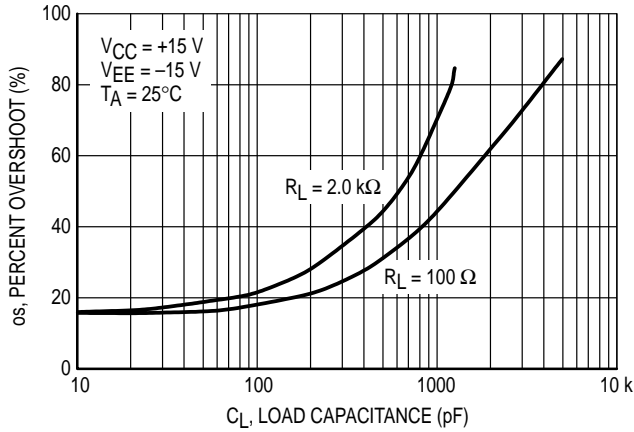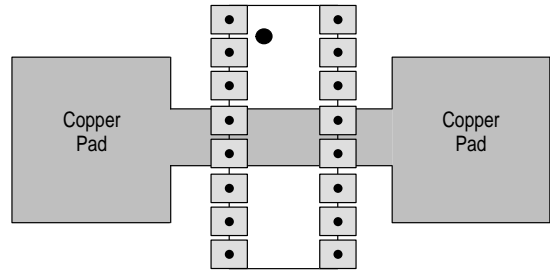versus Load Capacitance**

Figure 26. PC Board Heatsink Example


APPLICATIONS INFORMATION

The MC33076 dual operational amplifier is available in the standard 8–pin plastic dual–in–line (DIP) and surface mount packages, and also in a 16–pin batwing power package. To enhance the power dissipation capability of the power package, Pins 4, 5, 12, and 13 are tied together on the leadframe, giving it an ambient thermal resistance of 52°C/W typically, in still air. The junction–to–ambient thermal resistance ($R_{\theta JA}$) can be decreased further by using a copper padb on the printed circuit board (as shown in Figure 26) to draw the heat away from the package. *Care must be taken not to exceed the maximum junction temperature or damage to the device may occur.*

MC33076

OUTLINE DIMENSIONS

D SUFFIX
PLASTIC PACKAGE
CASE 751–05
(SO–8)
ISSUE R
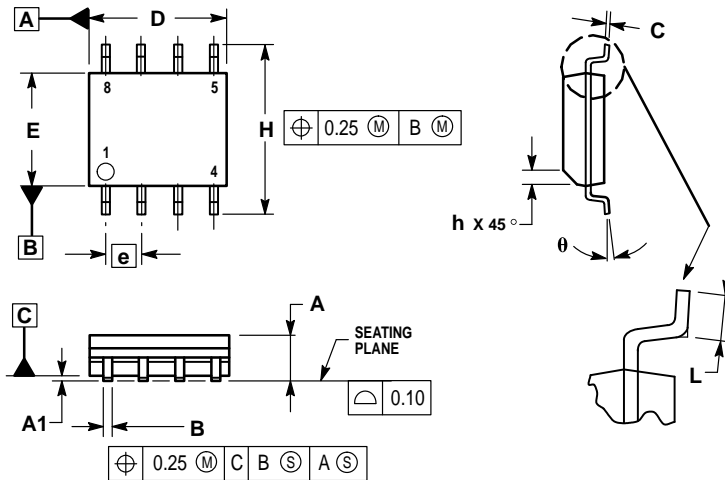
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS ARE IN MILLIMETERS.
3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE MOLD PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF THE B DIMENSION AT MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS	
	MIN	MAX
A	1.35	1.75
A1	0.10	0.25
B	0.35	0.49
C	0.18	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.25
θ	0 °	7 °

P1 SUFFIX
PLASTIC PACKAGE
CASE 626–05
ISSUE K
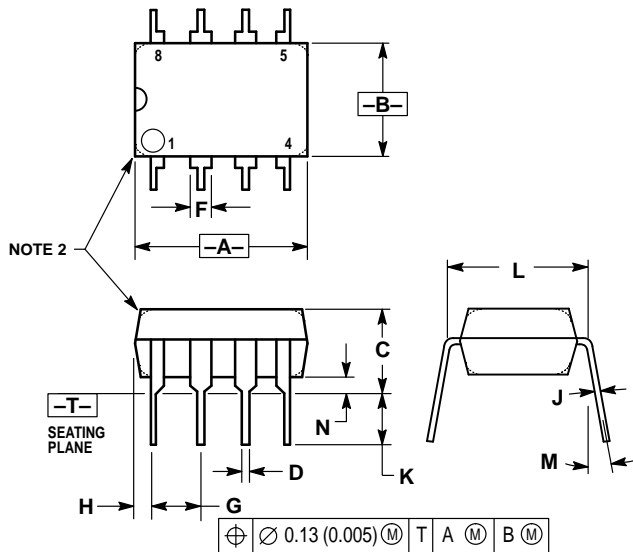
NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	9.40	10.16	0.370	0.400
B	6.10	6.60	0.240	0.260
C	3.94	4.45	0.155	0.175
D	0.38	0.51	0.015	0.020
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	0.76	1.27	0.030	0.050
J	0.20	0.30	0.008	0.012
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	—	10 °	—	10 °
N	0.76	1.01	0.030	0.040

MC33076

OUTLINE DIMENSIONS

P2 SUFFIX
PLASTIC PACKAGE
CASE 648C–03
(DIP (12+2+2))
ISSUE C
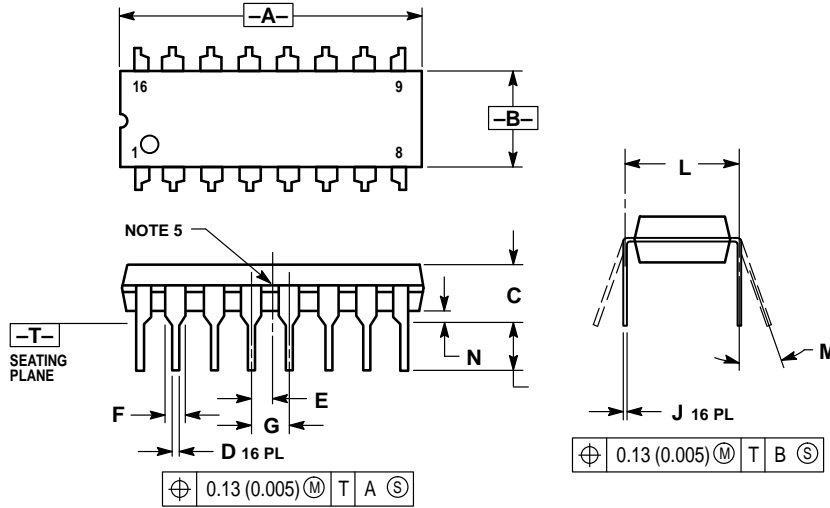
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
4. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
5. INTERNAL LEAD CONNECTION BETWEEN 4 AND 5, 12 AND 13.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.740	0.840	18.80	21.34
B	0.240	0.260	6.10	6.60
C	0.145	0.185	3.69	4.69
D	0.015	0.021	0.38	0.53
E	0.050 BSC		1.27 BSC	
F	0.040	0.70	1.02	1.78
G	0.100 BSC		2.54 BSC	
J	0.008	0.015	0.20	0.38
K	0.115	0.135	2.92	3.43
L	0.300 BSC		7.62 BSC	
M	0°	10°	0°	10°
N	0.015	0.040	0.39	1.01

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MOTOROLA ANALOG IC DEVICE DATA

MOTOROLA

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MC33076/D