JFET Input Operational Amplifiers
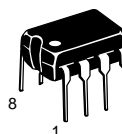
MC34001, B
MC34002, B
MC34004, B

These low cost JFET input operational amplifiers combine two state–of–the–art analog technologies on a single monolithic integrated circuit. Each internally compensated operational amplifier has well matched high voltage JFET input devices for low input offset voltage. The BIFET technology provides wide bandwidths and fast slew rates with low input bias currents, input offset currents, and supply currents.

The ON Semiconductor BIFET family offers single, dual and quad operational amplifiers which are pin–compatible with the industry standard MC1741, MC1458, and the MC3403/LM324 bipolar devices. The MC34001/34002/34004 series are specified from 0° to +70°C.

- Input Offset Voltage Options of 5.0 mV and 10 mV Maximum
- Low Input Bias Current: 40 pA
- Low Input Offset Current: 10 pA
- Wide Gain Bandwidth: 4.0 MHz
- High Slew Rate: 13 V/µs
- Low Supply Current: 1.4 mA per Amplifier
- High Input Impedance: 10^{12} Ω
- High Common Mode and Supply Voltage Rejection Ratios: 100 dB
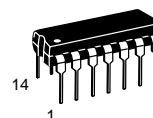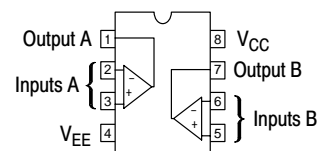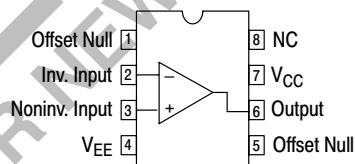- Industry Standard Pinouts

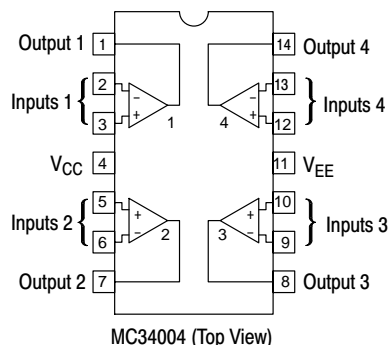## JFET INPUT OPERATIONAL AMPLIFIERS

P SUFFIX
PLASTIC PACKAGE
CASE 626

D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO–8)

PIN CONNECTIONS

Offset Null	1		8	NC
Inv. Input	2	−	7	V_{CC}
Noninv. Input	3	+	6	Output
V_{EE}	4		5	Offset Null

MC34001 (Top View)

MC34002 (Top View)

P SUFFIX
PLASTIC PACKAGE
CASE 646

PIN CONNECTIONS

MC34004 (Top View)

ORDERING INFORMATION

Op Amp Function	Device	Operating Temperature Range	Package
Single	MC34001BD, D	T_A = 0° to+ 70°C	SO–8
	MC34001BP, P		Plastic DIP
Dual	MC34002BD, D	T_A = 0° to +70°C	SO–8
	MC34002BP, P		Plastic DIP
Quad	MC34004BP, P	T_A = 0° to +70°C	Plastic DIP

March, 2002 – Rev. 2

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}, V_{EE}	±18	V
Differential Input Voltage (Note 1)	V_{ID}	±30	V
Input Voltage Range	V_{IDR}	±16	V
Open Short Circuit Duration	t_{SC}	Continuous	
Operating Ambient Temperature Range	T_A	0 to +70	°C
Operating Junction Temperature	T_J	150	°C
Storage Temperature Range	T_{stg}	−65 to +150	°C

NOTES: 1. Unless otherwise specified, the absolute maximum negative input voltage is equal to the negative power supply.

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

Characteristics	Symbol	Min	Typ	Max	Unit

Input Offset Voltage ($R_S \leq$ 10 k)
  MC3400XB
  MC3400X
	V_{IO}	—
		—
			3.0
			5.0
				5.0
				10
					mV

Average Temperature Coefficient of Input Offset Voltage $R_S \leq$ 10 k, T_A = T_{low} to T_{high} (Note 2)	$\Delta V_{IO}/\Delta T$	—	10	—	µV/°C

Input Offset Current (V_{CM} = 0) (Note 3)
  MC3400XB
  MC3400X
	I_{IO}	—
		—
			25
			25
				100
				100
					pA

Input Bias Current (V_{CM} = 0) (Note 3)
  MC3400XB
  MC3400X
	I_{IB}	—
		—
			50
			50
				200
				200
					pA

Input Resistance	r_i	—	10^{12}	—	Ω
Common Mode Input Voltage Range	V_{ICR}	±11 —	+15 −12	— —	V

Large Signal Voltage Gain (V_O = ±10 V, R_L = 2.0 k)
  MC3400XB
  MC3400X
	A_{VOL}	50
		25
			150
			100
				—
				—
					V/mV

Output Voltage Swing
  ($R_L \geq$ 10 k)
  ($R_L \geq$ 2.0 k)
	V_O	±12
		±10
			±14
			±13
				—
				—
					V

Common Mode Rejection Ratio ($R_S \leq$ 10 k)
  MC3400XB
  MC3400X
	CMRR	80
		70
			100
			100
				—
				—
					dB

Supply Voltage Rejection Ratio ($R_S \leq$ 10 k) (Note 4)
  MC3400XB
  MC3400X
	PSRR	80
		70
			100
			100
				—
				—
					dB

Supply Current (Each Amplifier)
  MC3400XB
  MC3400X
	I_D	—
		—
			1.4
			1.4
				2.5
				2.7
					mA

Slew Rate (A_V = 1.0)	SR	—	13	—	V/µs
Gain–Bandwidth Product	GBW	—	4.0	—	MHz
Equivalent Input Noise Voltage (R_S = 100 Ω, f = 1000 Hz)	e_n	—	25	—	nV/$\sqrt{Hz}$
Equivalent Input Noise Current (f = 1000 Hz)	i_n	—	0.01	—	pA/$\sqrt{Hz}$

NOTES: 2. T_{low} = 0°C for MC34001/34001B T_{high} = +70°C for MC34001/34001B
            MC34002   MC34002
            MC34004/34004B   MC34004/34004B

3. The input bias currents approximately double for every 10°C rise in junction temperature, T_J. Due to limited test time, the input bias currents are correlated to junction temperature. Use of a heatsink is recommended if input bias current is to be kept to a minimum.

4. Supply voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously, in accordance with common practice.

MC34001, B MC34002, B MC34004, B

ELECTRICAL CHARACTERISTICS (V_{CC} = +15 V, V_{EE} = −15 V, T_A = T_{low} to T_{high} [Note 2].)

Characteristics	Symbol	Min	Typ	Max	Unit
Input Offset Voltage ($R_S \leq$ 10 k) MC3400XB MC3400X	V_{IO}	— —	— —	7.0 13	mV
Input Offset Current (V_{CM} = 0) (Note 3) MC3400XB MC3400X	I_{IO}	— —	— —	4.0 4.0	nA
Input Bias Current (V_{CM} = 0) (Note 3) MC3400XB MC3400X	I_{IB}	— —	— —	8.0 8.0	nA
Common Mode Input Voltage Range	V_{ICR}	±11	—	—	V
Large Signal (V_O = ±10 V, R_L = 2.0 k) MC3400XB MC3400X	A_{VOL}	25 15	— —	— —	V/mV
Output Voltage Swing (R $\geq$ 10 k) (R $\geq$ 2.0 k)	V_O	±12 ±10	— —	— —	V
Common Mode Rejection Ratio ($R_S \leq$ 10 k) MC3400XB MC3400X	CMRR	80 70	— —	— —	dB
Supply Voltage Rejection Ratio ($R_S \leq$ 10 k) (Note 4) MC3400XB MC3400X	PSRR	80 70	— —	— —	dB
Supply Current (Each Amplifier) MC3400XB MC3400X	I_D	— —	— —	2.8 3.0	mA

NOTES: 2. T_{low} = 0°C for MC34001/34001B T_{high} = +70°C for MC34001/34001B
        MC34002   MC34002
        MC34004/34004B   MC34004/34004B

3. The input bias currents approximately double for every 10°C rise in junction temperature, T_J. Due to limited test time, the input bias currents are correlated to junction temperature. Use of a heatsink is recommended if input bias current is to be kept to a minimum.

4. Supply voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously, in accordance with common practice.

MC34001, B MC34002, B MC34004, B

Figure 1. Input Bias Current versus Temperature
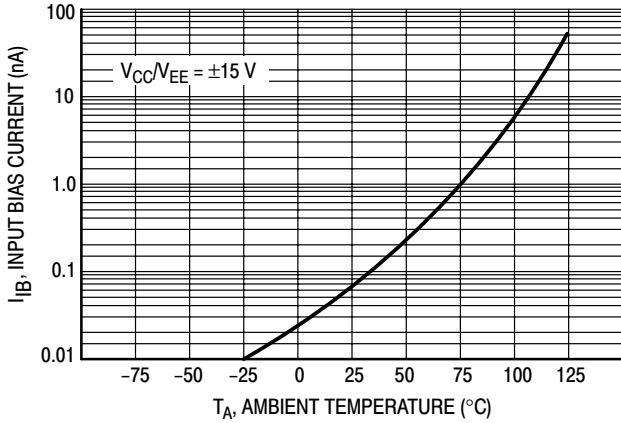
Figure 2. Output Voltage Swing versus Frequency
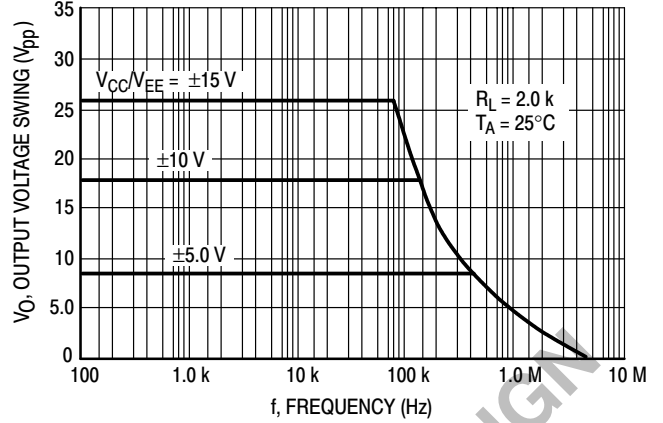
Figure 3. Output Voltage Swing versus Load Resistance
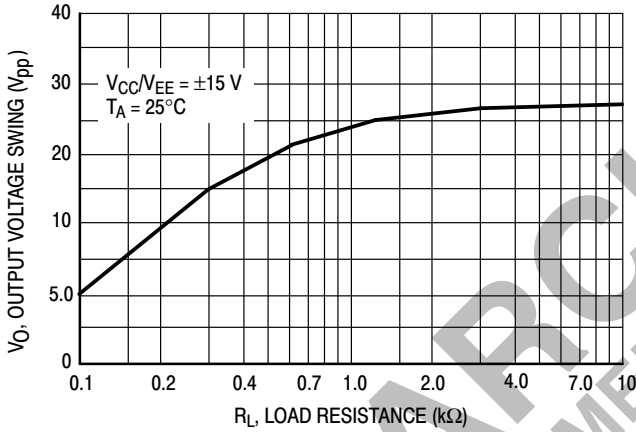
Figure 4. Output Voltage Swing versus Supply Voltage
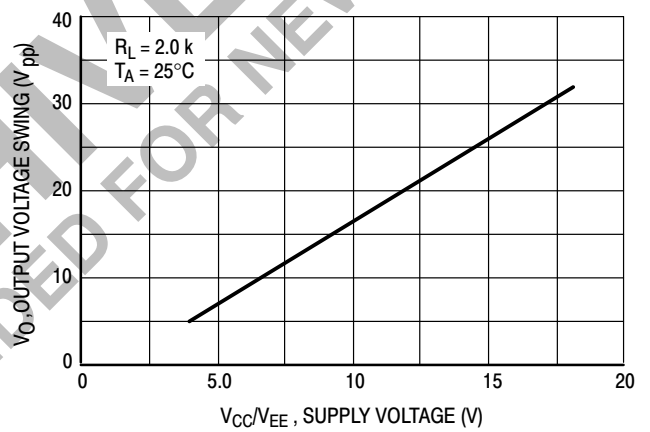
Figure 5. Output Voltage Swing versus Temperature
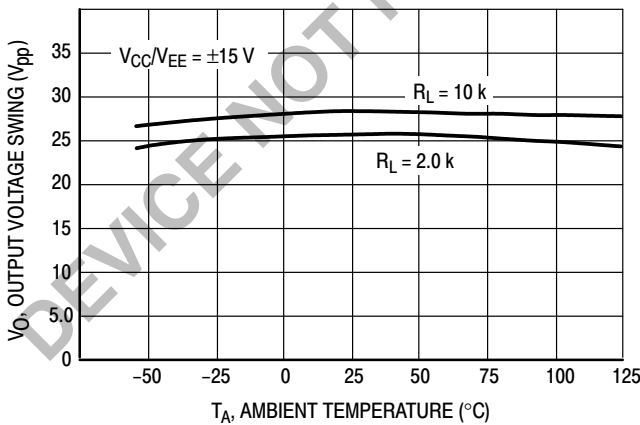
Figure 6. Supply Current per Amplifier versus Temperature
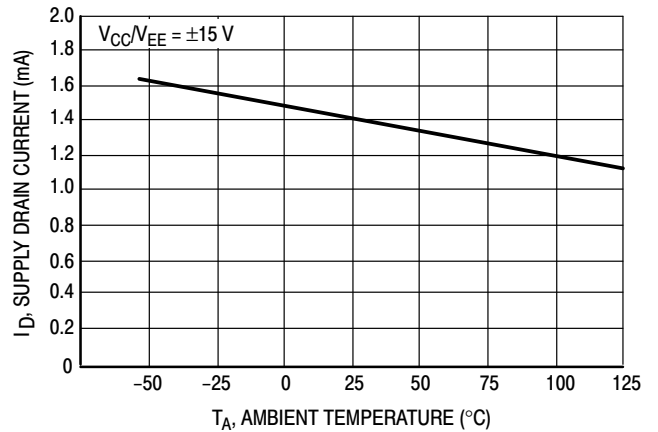
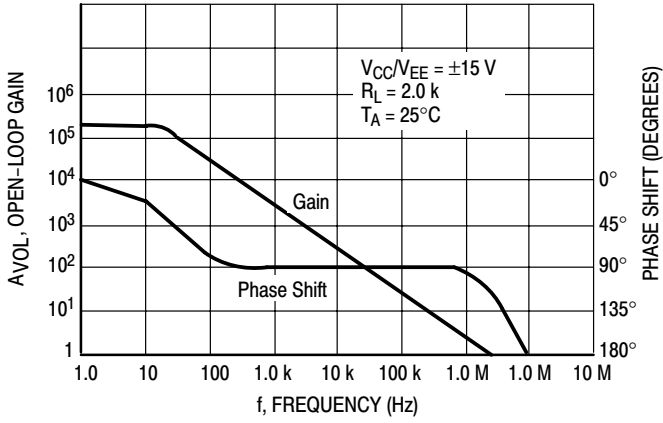**Figure 7. Large–Signal Voltage Gain and
Phase Shift versus Frequency**

$V_{CC}/V_{EE} = \pm15$ V
$R_L = 2.0$ k
$T_A = 25°C$

Gain

Phase Shift

A_{VOL}, OPEN–LOOP GAIN

PHASE SHIFT (DEGREES)

f, FREQUENCY (Hz)

**Figure 8. Large–Signal Voltage Gain
versus Temperature**

$V_{CC}/V_{EE} = \pm15$ V
$V_O = \pm10$ V
$R_L = 2.0$ k

A_{VOL}, VOLTAGE GAIN (V/mV)

T_A, AMBIENT TEMPERATURE (°C)
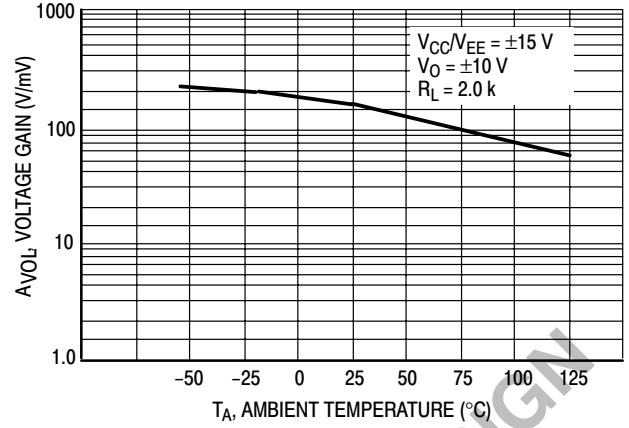
**Figure 9. Normalized Slew Rate
versus Temperature**

NORMALIZED SLEW RATE

T_A, AMBIENT TEMPERATURE (°C)
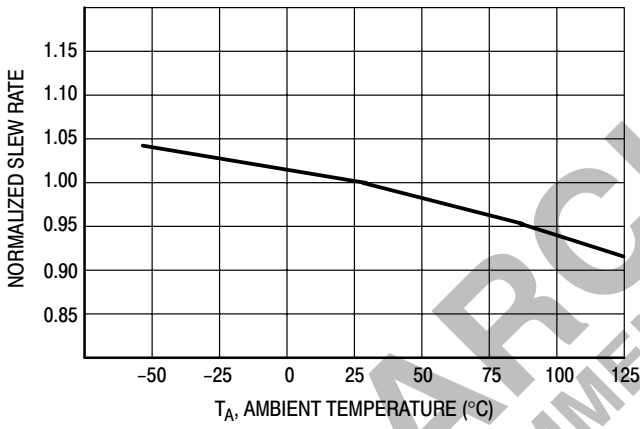
**Figure 10. Equivalent Input Noise Voltage
versus Frequency**

$V_{CC}/V_{EE} = \pm15$ V
$A_V = 10$
$R_S = 100\ \Omega$
$T_A = 25°C$

e_n, EQUIVALENT INPUT NOISE VOLTAGE (nV/$\sqrt{\text{Hz}}$)
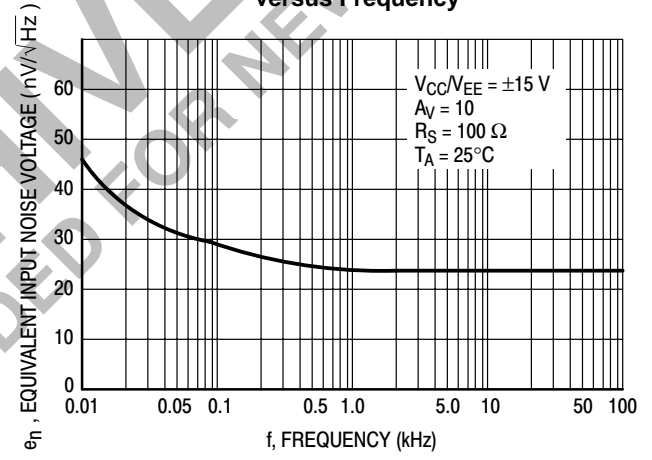
f, FREQUENCY (kHz)

**Figure 11. Total Harmonic Distortion
versus Frequency**

$V_{CC}/V_{EE} = \pm15$ Vdc
$A_V = 1.0$
$V_O = 6.0$ V (RMS)
$T_A = 25°C$

THD, TOTAL HARMONIC DISTORTION (%)

f, FREQUENCY (kHz)
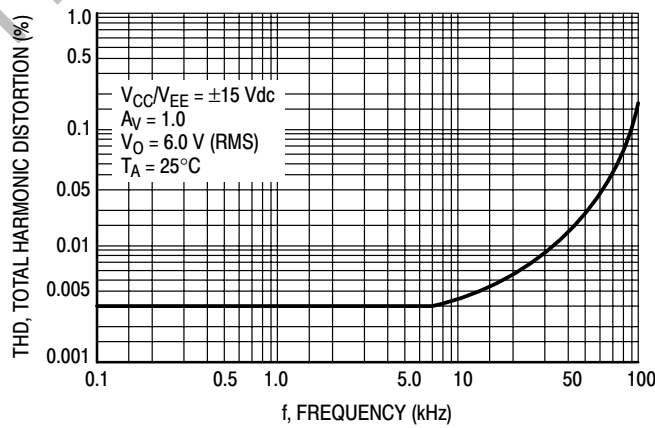
MC34001, B MC34002, B MC34004, B

Representative Circuit Schematic
(Each Amplifier)
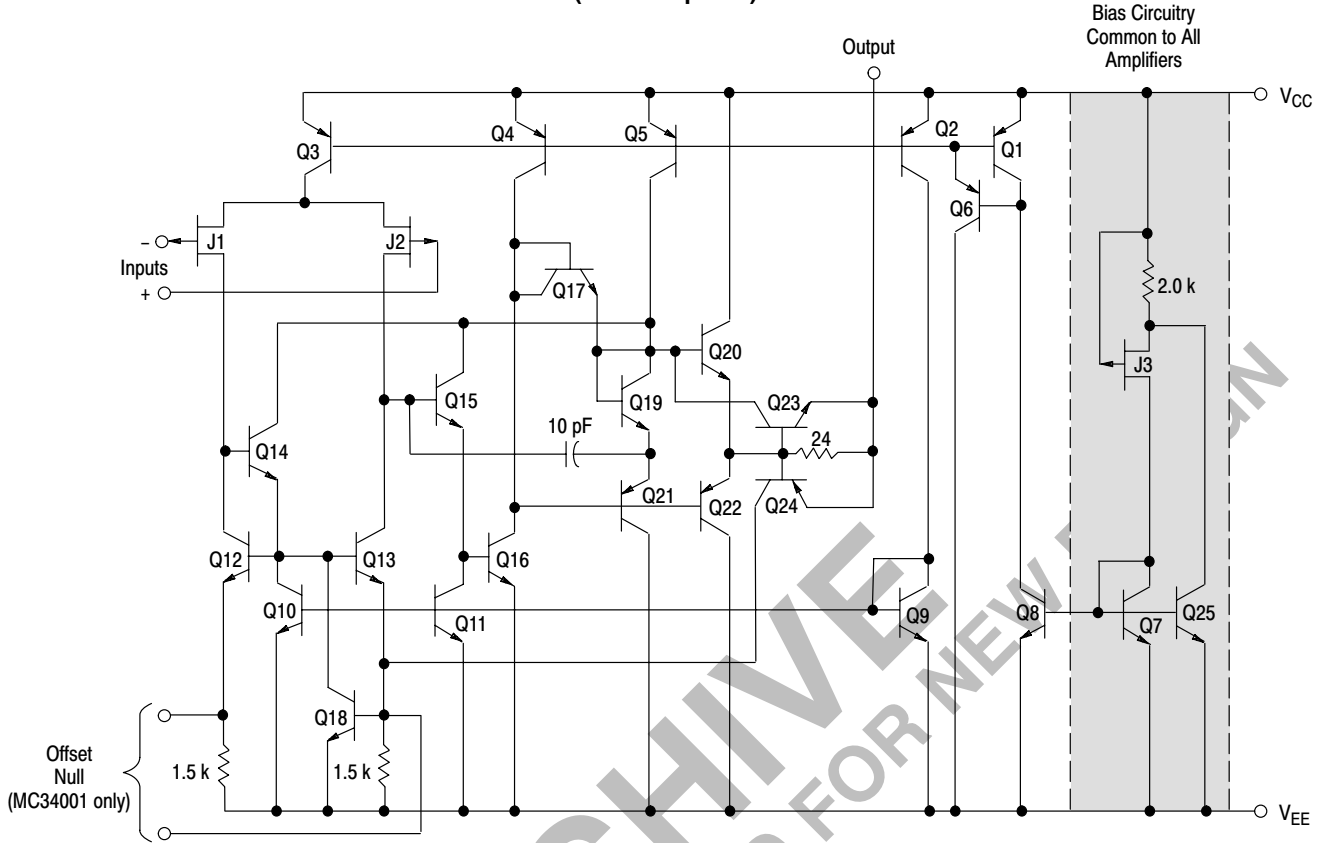
Figure 12. Output Current to Voltage Transformation
for a D–to–A Converter
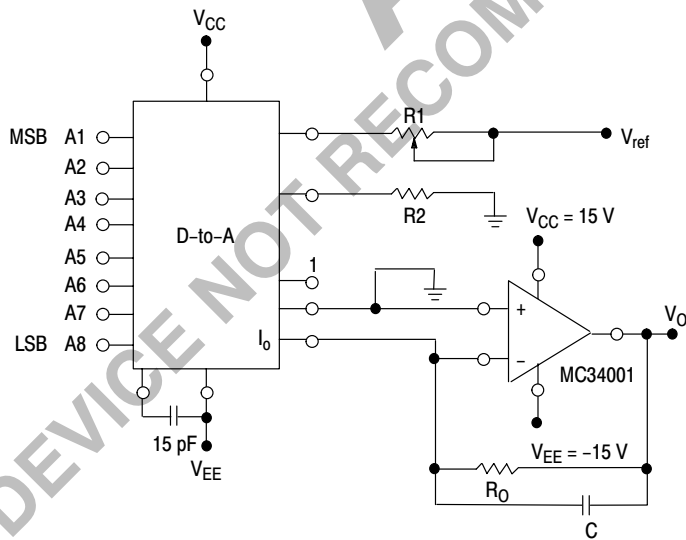
Settling time to within 1/2 LSB is approximately 4.0 μs from the time all bits are switched (C = 68 pF).

The value of C may be selected to minimize overshoot and ringing.

Theoretical V_O

$$V_O = \frac{V_{ref}}{R1}\ (R_O) \left[\frac{A1}{2} + \frac{A2}{4} + \frac{A3}{8} + \frac{A4}{16} + \frac{A5}{32} + \frac{A6}{64} + \frac{A7}{128} + \frac{A8}{256} \right]$$

MC34001, B MC34002, B MC34004, B

Figure 13. Positive Peak Detector

*Polycarbonate capacitor
D1 = Hi-speed, low-reverse leakage diode
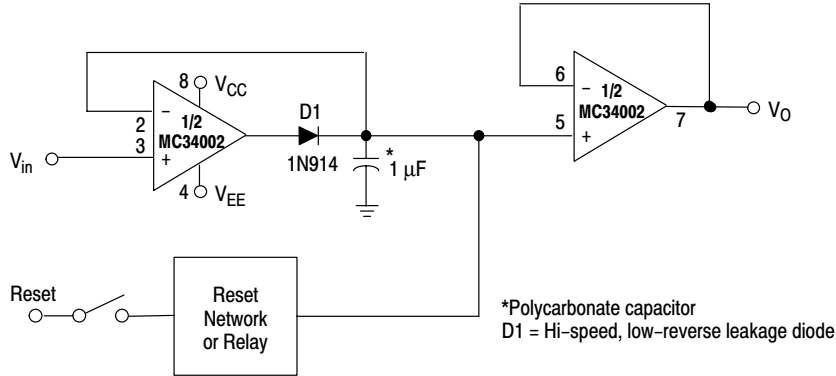
Figure 14. Long Interval RC Timer

*Polycarbonate or Polystyrene Capacitor
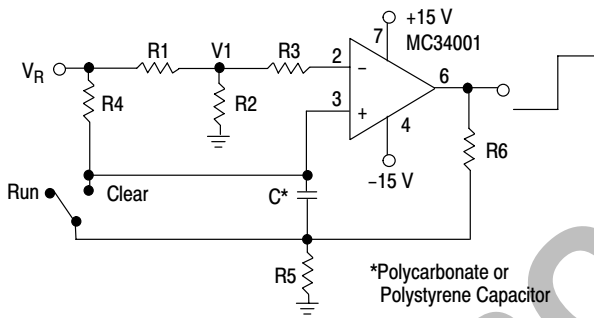
Time (t) = R4 Cn (V_R/V_R-V_I), $R_3 = R_4$, $R_5 = 0.1 R_6$
   If R1 = R2: t = 0.693 R4C

Design Example: 100 Second Timer
V_R = 10 V   C = l.0 μF $R_3 = R_4$ = 144 M
R_6 = 20 k R_5 = 2.0 k   R1 = R2 = 1.0 k

Figure 15. Isolating Large Capacitive Loads
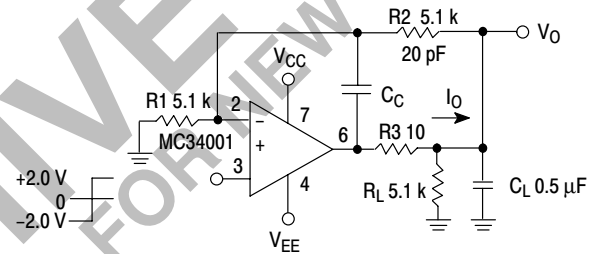
Overshoot < 10%
t_s = 10 μs
When driving large C_L, the V_O slew rate is determined by C_L and $I_{O(max)}$:

$$\frac{\Delta V_O}{\Delta t} = \frac{I_O}{C_L} = \frac{0.02}{0.5} \text{ V/μs} = 0.04 \text{ V/μs (with } C_L \text{ shown)}$$

Figure 16. Wide BW, Low Noise, Low Drift Amplifier
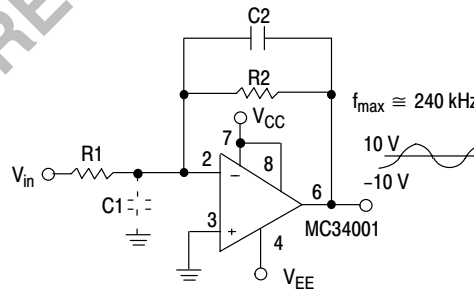
Power BW: $f_{max} = \dfrac{S_r}{2\pi\ Vp} \cong 240$ kHz

Parasitic input capacitance (C1 $\cong$ 3.0 pF plus any additional layout capacitance) interacts with feedback elements and creates undesirable high-frequency pole. To compensate add C2 such that: $R2C2 \cong R1C1$.

OUTLINE DIMENSIONS

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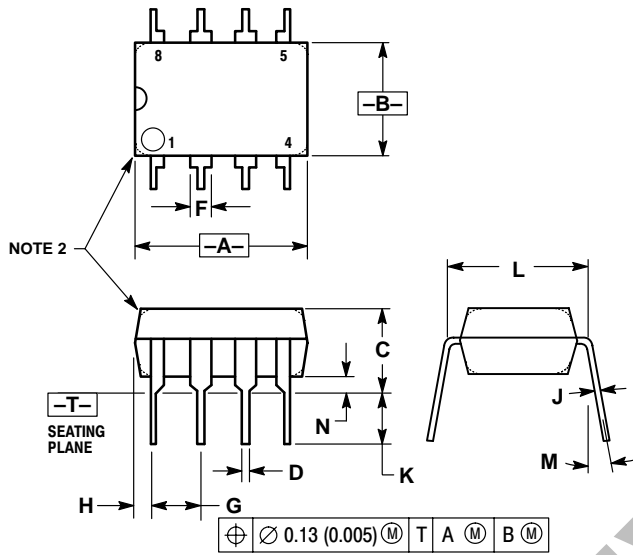
NOTES:
1. DIMENSION L TO CENTER OF LEAD WHEN FORMED PARALLEL.
2. PACKAGE CONTOUR OPTIONAL (ROUND OR SQUARE CORNERS).
3. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.

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

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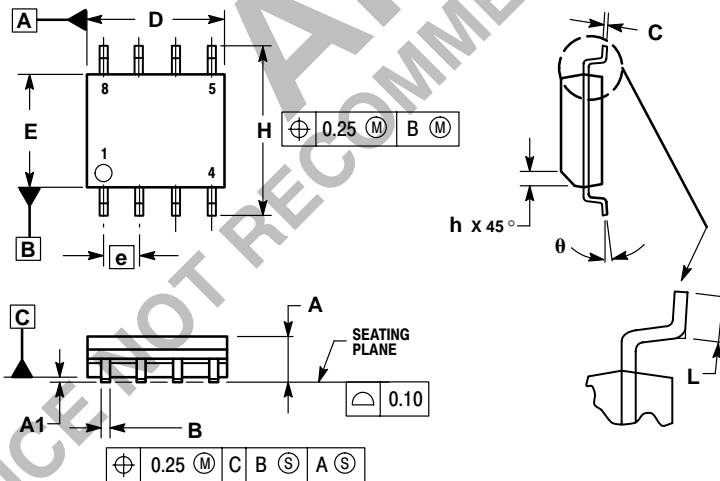
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. DIMENSIONS ARE IN MILLIMETERS.
3. DIMENSION D AND E DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.
5. DIMENSION B DOES NOT INCLUDE MOLD PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 TOTAL IN EXCESS OF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

OUTLINE DIMENSIONS

P SUFFIX
PLASTIC PACKAGE
CASE 646–06
ISSUE L
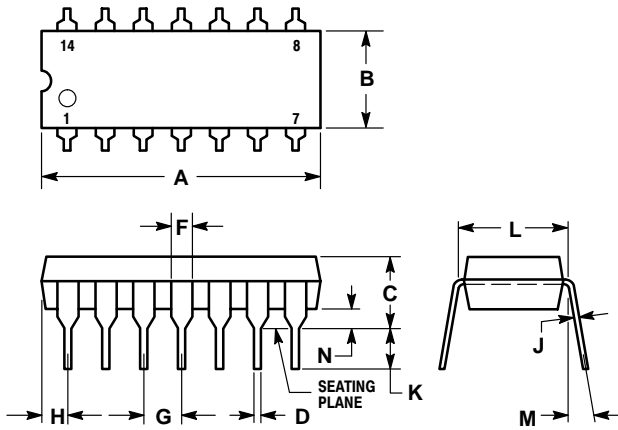
NOTES:
1. LEADS WITHIN 0.13 (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
2. DIMENSION L TO CENTER OF LEADS WHEN FORMED PARALLEL.
3. DIMENSION B DOES NOT INCLUDE MOLD FLASH.
4. ROUNDED CORNERS OPTIONAL.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.715	0.770	18.16	19.56
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
F	0.040	0.070	1.02	1.78
G	0.100 BSC		2.54 BSC	
H	0.052	0.095	1.32	2.41
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	0.039	0.39	1.01