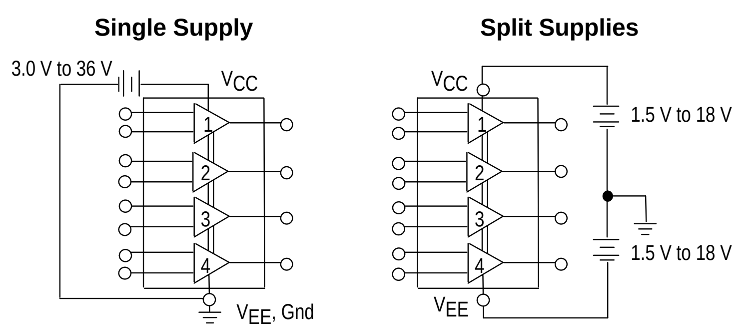
MOTOROLA

Quad Low Power Operational Amplifiers

MC3403 MC3303

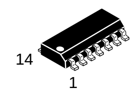
The MC3403 is a low cost, quad operational amplifier with true differential inputs. The device has electrical characteristics similar to the popular MC1741C. However, the MC3403 has several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier can operate at supply voltages as low as 3.0 V or as high as 36 V with quiescent currents about one third of those associated with the MC1741C (on a per amplifier basis). The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications. The output voltage range also includes the negative power supply voltage.

- Short Circuit Protected Outputs
- Class AB Output Stage for Minimal Crossover Distortion
- True Differential Input Stage
- Single Supply Operation: 3.0 V to 36 V
- Split Supply Operation: ±1.5 V to ±18 V
- Low Input Bias Currents: 500 nA Max
- Four Amplifiers Per Package
- Internally Compensated
- Similar Performance to Popular MC1741C
- Industry Standard Pinouts
- ESD Diodes Added for Increased Ruggedness

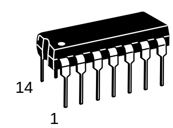


QUAD DIFFERENTIAL INPUT OPERATIONAL AMPLIFIERS

SEMICONDUCTOR TECHNICAL DATA

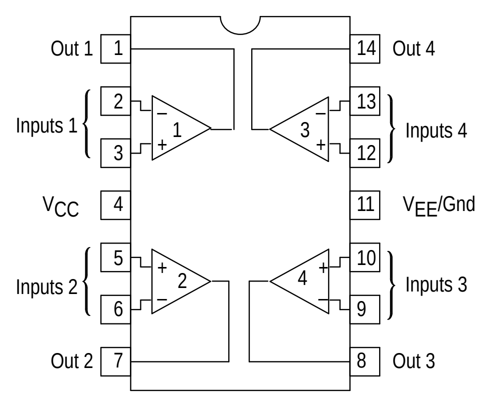


D SUFFIX
PLASTIC PACKAGE
CASE 751A
(SO–14)



P SUFFIX
PLASTIC PACKAGE
CASE 646

PIN CONNECTIONS



(Top View)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	 V_{CC} V_{CC}, V_{EE}	 36 ±18	Vdc
Input Differential Voltage Range (Note 1)	V_{IDR}	±36	Vdc
Input Common Mode Voltage Range (Notes 1, 2)	V_{ICR}	±18	Vdc
Storage Temperature Range	T_{stg}	–55 to +125	°C
Operating Ambient Temperature Range MC3303 MC3403	T_A	 –40 to +85 0 to +70	°C
Junction Temperature	T_J	150	°C

NOTES: 1. Split power supplies.
2. For supply voltages less than ±18 V, the absolute maximum input voltage is equal to the supply voltage.

ORDERING INFORMATION

Device	Operating Temperature Range	Package
MC3303D MC3303P	T_A = – 40° to +85°C	SO–14 Plastic DIP
MC3403D MC3403P	T_A = 0° to +70°C	SO–14 Plastic DIP

ELECTRICAL CHARACTERISTICS (V_{CC} = +15 V, V_{EE} = –15 V for MC3403; V_{CC} = +14 V, V_{EE} = Gnd for MC3303 T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	MC3403 Min	MC3403 Typ	MC3403 Max	MC3303 Min	MC3303 Typ	MC3303 Max	Unit
Input Offset Voltage $T_A = T_{high}$ to T_{low} (Note 1)	V_{IO}	– –	2.0 –	10 12	– –	2.0 –	8.0 10	mV
Input Offset Current $T_A = T_{high}$ to T_{low}	I_{IO}	– –	30 –	50 200	– –	30 –	75 250	nA
Large Signal Open Loop Voltage Gain V_O = ±10 V, R_L = 2.0 kΩ $T_A = T_{high}$ to T_{low}	A_{VOL}	 20 15	 200 –	 – –	 20 15	 200 –	 – –	V/mV
Input Bias Current $T_A = T_{high}$ to T_{low}	I_{IB}	– –	–200 –	–500 –800	– –	–200 –	–500 –1000	nA
Output Impedance f = 20 Hz	z_o	–	75	–	–	75	–	Ω
Input Impedance f = 20 Hz	z_i	0.3	1.0	–	0.3	1.0	–	MΩ
Output Voltage Range R_L = 10 kΩ R_L = 2.0 kΩ R_L = 2.0 kΩ, $T_A = T_{high}$ to T_{low}	V_O	 ±12 ±10 ±10	 ±13.5 ±13 –	 – – –	 12 10 10	 12.5 12 –	 – – –	V
Input Common Mode Voltage Range	V_{ICR}	+13 V $-V_{EE}$	+13 V $-V_{EE}$	–	+12 V $-V_{EE}$	+12.5 V $-V_{EE}$	–	V
Common Mode Rejection R_S ≤ 10 k Ω	CMR	70	90	–	70	90	–	dB
Power Supply Current (V_O = 0) R_L = ∞	I_{CC}, I_{EE}	–	2.8	7.0	–	2.8	7.0	mA
Individual Output Short–Circuit Current (Note 2)	I_{SC}	±10	±20	±45	±10	±30	±45	mA
Positive Power Supply Rejection Ratio	PSRR+	–	30	150	–	30	150	µV/V
Negative Power Supply Rejection Ratio	PSRR–	–	30	150	–	30	150	µV/V
Average Temperature Coefficient of Input Offset Current $T_A = T_{high}$ to T_{low}	$\Delta I_{IO}/\Delta T$	–	50	–	–	50	–	pA/°C
Average Temperature Coefficient of Input Offset Voltage $T_A = T_{high}$ to T_{low}	$\Delta V_{IO}/\Delta T$	–	10	–	–	10	–	µV/°C
Power Bandwidth A_V = 1, R_L = 10 kΩ, V_O = 20 V(p–p), THD = 5%	BWp	–	9.0	–	–	9.0	–	kHz
Small–Signal Bandwidth A_V = 1, R_L = 10 kΩ, V_O = 50 mV	BW	–	1.0	–	–	1.0	–	MHz
Slew Rate A_V = 1, V_i = –10 V to +10 V	SR	–	0.6	–	–	0.6	–	V/µs
Rise Time A_V = 1, R_L = 10 kΩ, V_O = 50 mV	t_{TLH}	–	0.35	–	–	0.35	–	µs
Fall Time A_V = 1, R_L = 10 kΩ, V_O = 50 mV	t_{TLH}	–	0.35	–	–	0.35	–	µs
Overshoot A_V = 1, R_L = 10 kΩ, V_O = 50 mV	os	–	20	–	–	20	–	%
Phase Margin A_V = 1, R_L = 2.0 kΩ, V_O = 200 pF	φm	–	60	–	–	60	–	Degrees
Crossover Distortion (V_{in} = 30 mVpp,V_{out}= 2.0 Vpp, f = 10 kHz)	–	–	1.0	–	–	1.0	–	%

NOTES: 1. T_{high} = +70°C for MC3403, +85°C for MC3303
T_{low} = 0°C for MC3403, –40°C for MC3303
2. Not to exceed maximum package power dissipation.

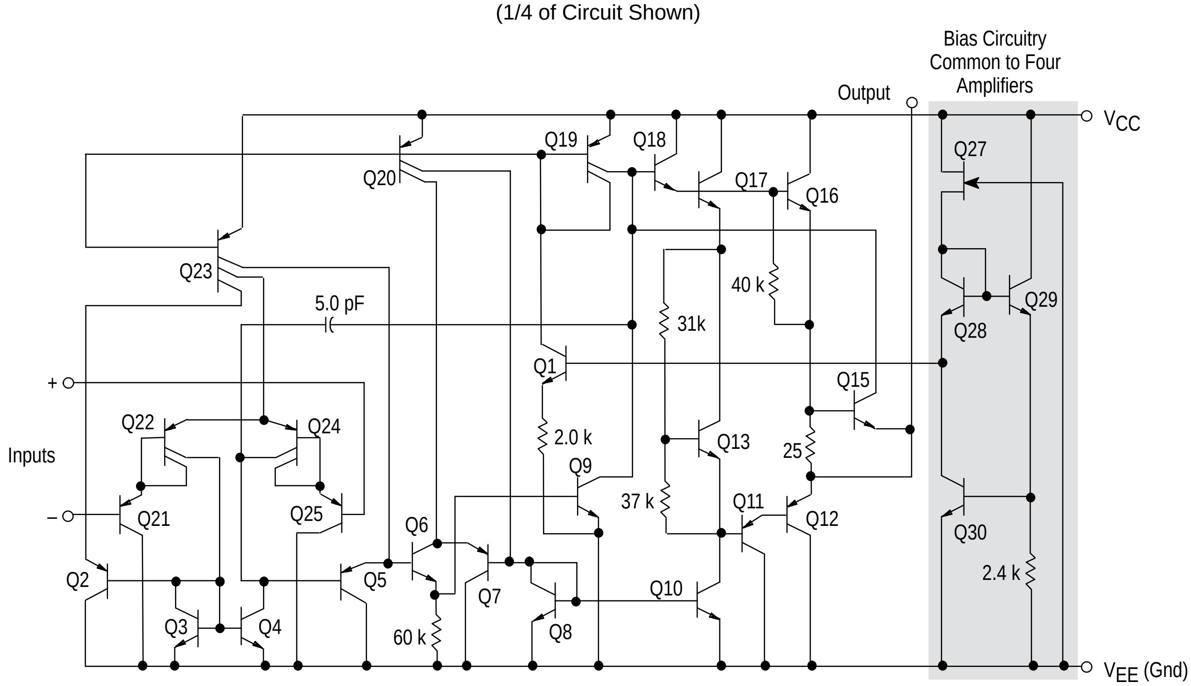
ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0 V, V_{EE} = Gnd, T_A = 25°C, unless otherwise noted.)

Characteristic	Symbol	MC3403			MC3303			Unit
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	V_{IO}	–	2.0	10	–	–	10	mV
Input Offset Current	I_{IO}	–	30	50	–	–	75	nA
Input Bias Current	I_{IB}	–	–200	–500	–	–	–500	nA
Large Signal Open Loop Voltage Gain R_L = 2.0 kΩ	A_{VOL}	10	200	–	10	200	–	V/mV
Power Supply Rejection Ratio	PSRR	–	–	150	–	–	150	µV/V
Output Voltage Range (Note 3) R_L = 10 kΩ, V_{CC} = 5.0 V R_L = 10 kΩ, 5.0 ≤ V_{CC} ≤ 30 V	V_{OR}	 3.3 V_{CC}–2.0	 3.5 V_{CC}–1.7	 – –	 3.3 V_{CC}–2.0	 3.5 V_{CC}–1.7	 – –	Vpp
Power Supply Current	I_{CC}	–	2.5	7.0	–	2.5	7.0	mA
Channel Separation f = 1.0 kHz to 20 kHz (Input Referenced)	CS	–	–120	–	–	–120	–	dB

NOTES: 3. Output will swing to ground with a 10 kΩ pull down resistor.

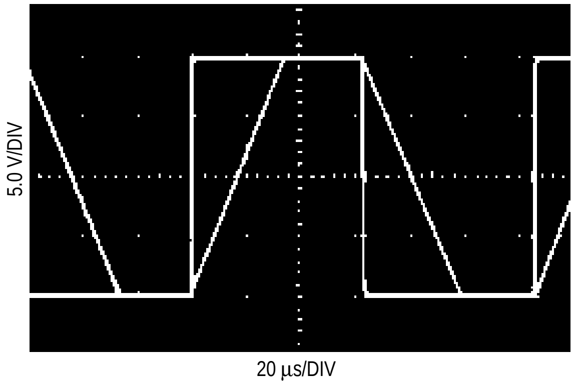
Representative Schematic Diagram

(1/4 of Circuit Shown)



CIRCUIT DESCRIPTION

Inverter Pulse Response



The MC3403/3303 is made using four internally compensated, two–stage operational amplifiers. The first stage of each consists of differential input device Q24 and Q22 with input buffer transistors Q25 and Q21 and the differential to single ended converter Q3 and Q4. The first stage performs not only the first stage gain function but also performs the level shifting and transconductance reduction functions. By reducing the transconductance, a smaller compensation capacitor (only 5.0 pF) can be employed, thus saving chip area. The transconductance reduction is accomplished by splitting the collectors of Q24 and Q22. Another feature of this input stage is that the input common mode range can include the negative supply or ground, in single supply operation, without saturating either the input devices or the differential to single–ended converter. The second stage consists of a standard current source load amplifier stage.

The output stage is unique because it allows the output to swing to ground in single supply operation and yet does not exhibit any crossover distortion in split supply operation. This is possible because Class AB operation is utilized.

Each amplifier is biased from an internal voltage regulator which has a low temperature coefficient, thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

Figure 1. Sine Wave Response

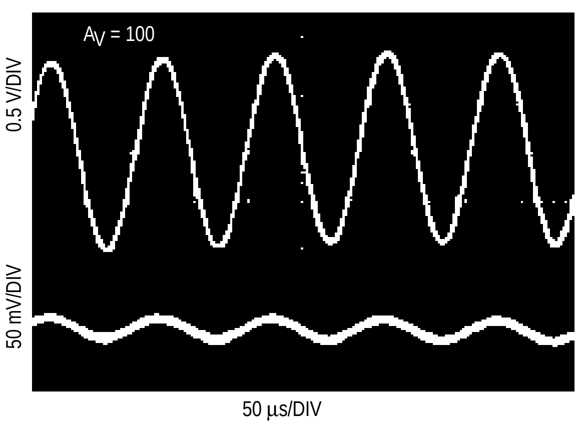


Figure 2. Open Loop Frequency Response

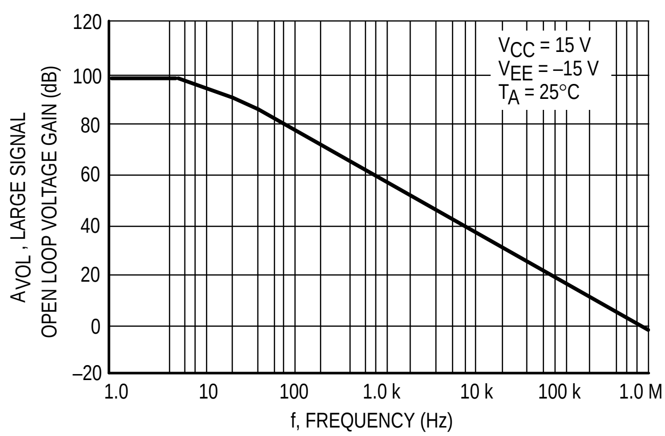


Figure 3. Power Bandwidth

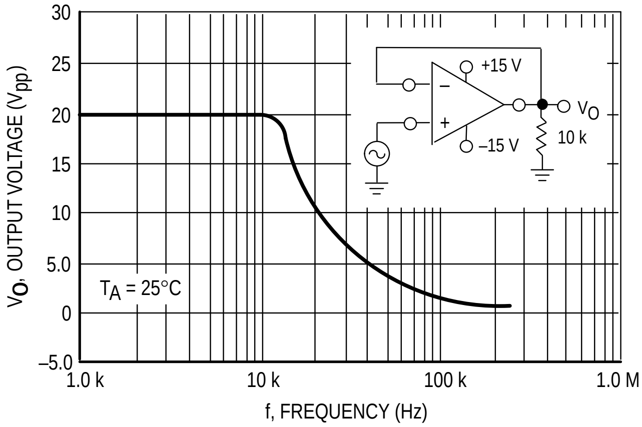


Figure 4. Output Swing versus Supply Voltage

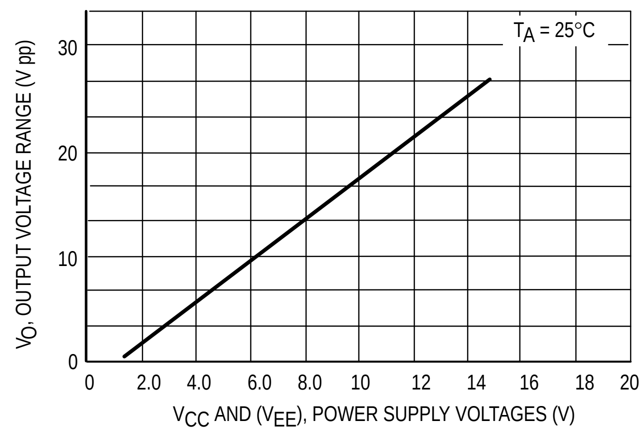


Figure 5. Input Bias Current versus Temperature

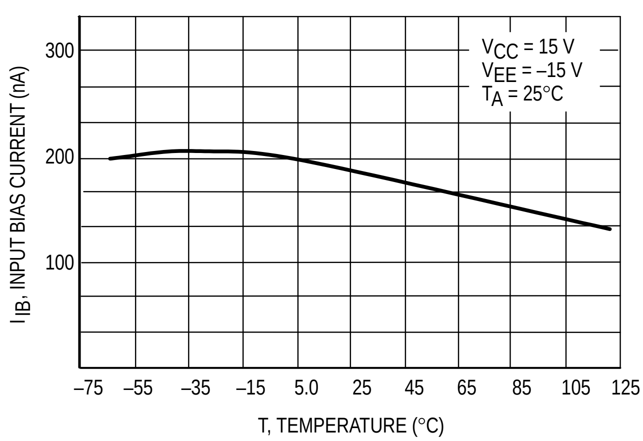


Figure 6. Input Bias Current versus Supply Voltage

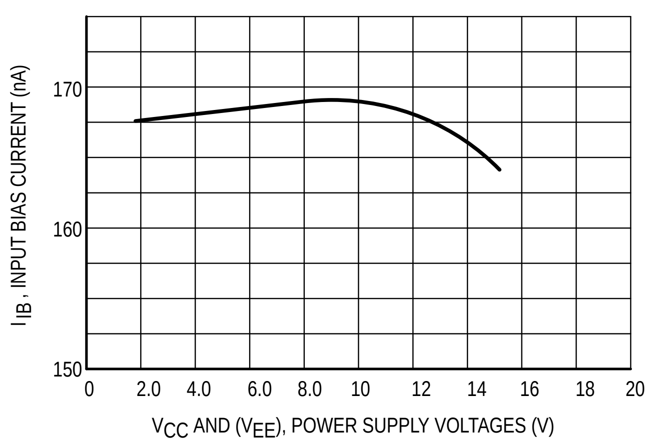
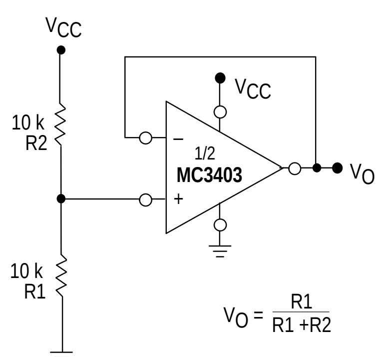


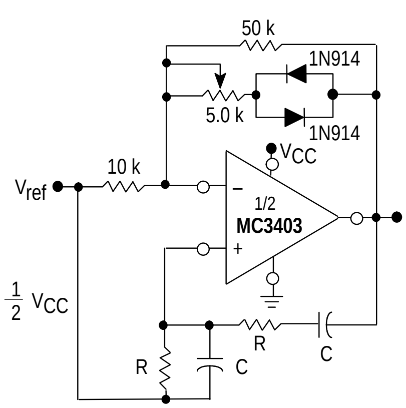
Figure 7. Voltage Reference



$$V_O = \frac{R1}{R1 + R2}$$

$$V_O = \frac{1}{2}\ V_{CC}$$

Figure 8. Wien Bridge Oscillator

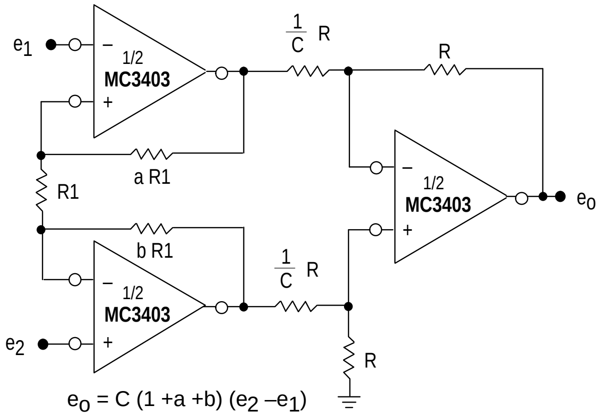


$$V_{ref} = \frac{1}{2}\ V_{CC}$$

$$f_o = \frac{1}{2\pi RC}$$

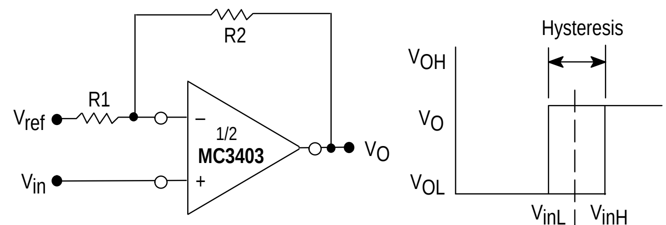
For: f_o = 1.0 kHz
R = 16 kΩ
C = 0.01 μF

Figure 9. High Impedance Differential Amplifier



$e_O = C\,(1 + a + b)\,(e_2 - e_1)$

Figure 10. Comparator with Hysteresis

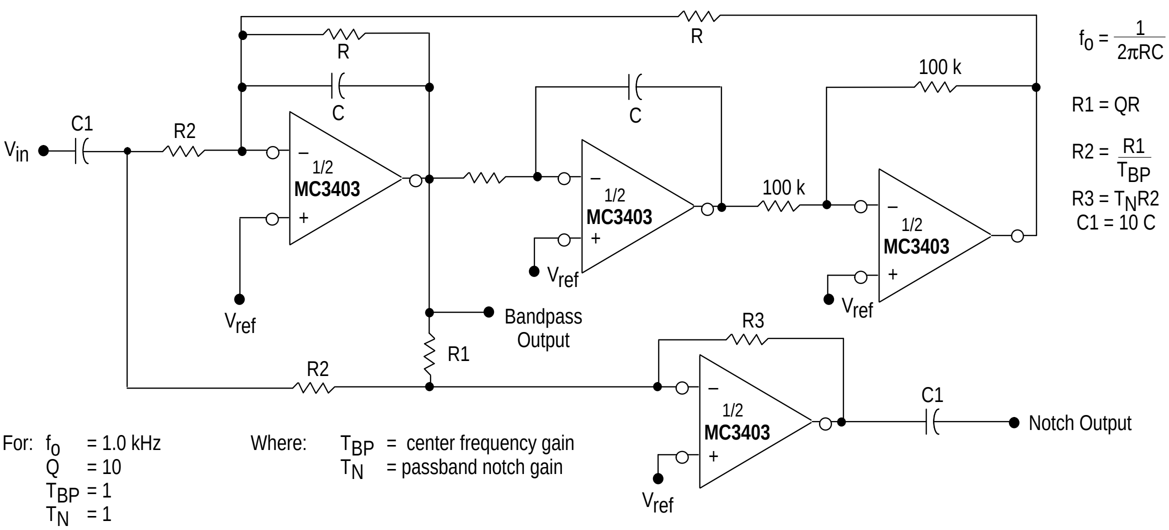


$$V_{inL} = \frac{R1}{R1 + R2}\,(V_{OL} - V_{ref}) + V_{ref}$$

$$V_{inH} = \frac{R1}{R1 + R2}\,(V_{OH} - V_{ref}) + V_{ref}$$

$$V_h = \frac{R1}{R1 + R2}\,(V_{OH} - V_{OL})$$

Figure 11. Bi–Quad Filter



$f_0 = \dfrac{1}{2\pi RC}$

R1 = QR

$R2 = \dfrac{R1}{T_{BP}}$

$R3 = T_N R2$

C1 = 10 C

$V_{ref} = \frac{1}{2} V_{CC}$

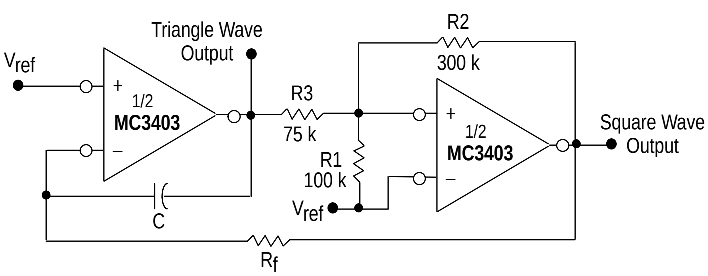
R = 160 kΩ
C = 0.001 μF
R1 = 1.6 MΩ
R2 = 1.6 MΩ
R3 = 1.6 MΩ

For: f_0 = 1.0 kHz
Q = 10
T_{BP} = 1
T_N = 1

Where: T_{BP} = center frequency gain
T_N = passband notch gain

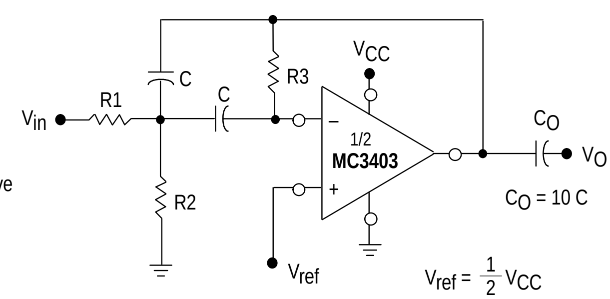
Figure 12. Function Generator

$V_{ref} = \frac{1}{2} V_{CC}$



$$f = \frac{R1 + R_C}{4\,CR_f\,R1} \quad \text{if } R3 = \frac{R2\,R1}{R2 + R1}$$

Figure 13. Multiple Feedback Bandpass Filter



$V_{ref} = \frac{1}{2} V_{CC}$

Given: f_0 = center frequency
$A(f_0)$ = gain at center frequency

Choose value f_0, C

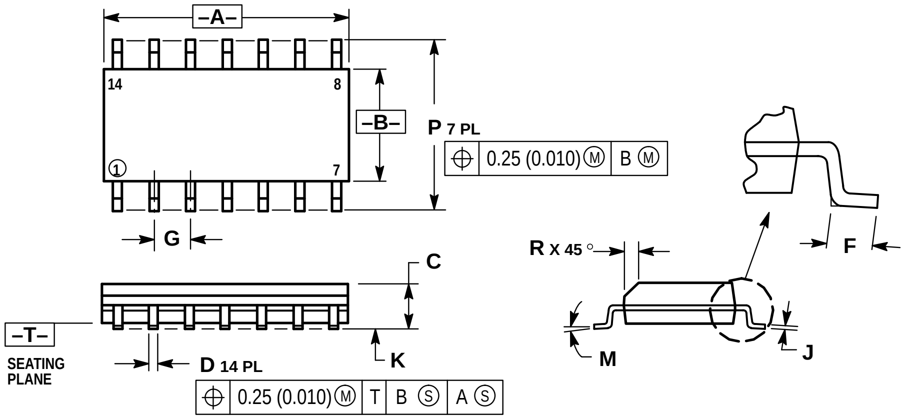
Then: $R3 = \dfrac{Q}{\pi f_0 C}$ $R1 = \dfrac{R3}{2\,A(f_0)}$ $R2 = \dfrac{R1\,R5}{4Q^2\,R1 - R5}$

For less than 10% error from operational amplifier $\dfrac{O_0\,f_0}{BW} < 0.1$ where f_0 and BW are expressed in Hz.

If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

OUTLINE DIMENSIONS

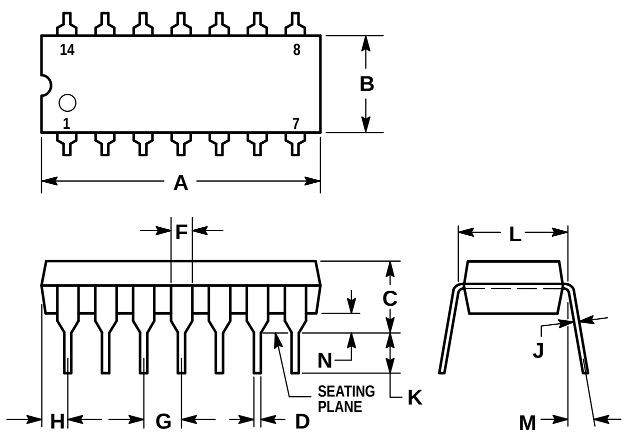
D SUFFIX
PLASTIC PACKAGE
CASE 751A–03
ISSUE F
(SO–14)



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0 °	7 °	0 °	7 °
P	5.80	6.20	0.228	0.244
R	0.25	0.50	0.010	0.019

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.

	INCHES		MILLIMETERS	
DIM	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

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