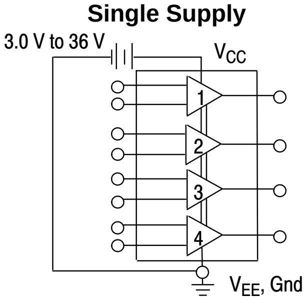
MC3403, MC3303

Single Supply Quad Operational Amplifiers

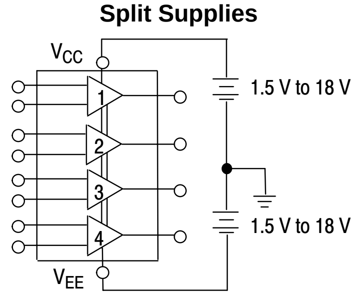
The MC3403 is a low cost, quad operational amplifier with true differential inputs. The device has electrical characteristics similar to the popular MC1741C. However, the MC3403 has several distinct advantages over standard operational amplifier types in single supply applications. The quad amplifier 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

Single Supply



Split Supplies



MAXIMUM RATINGS

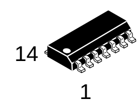
Rating	Symbol	Value	Unit
Power Supply Voltages Single Supply Split Supplies	 V_{CC} V_{CC}, V_{EE}	 36 ±18	Vdc
Input Differential Voltage Range (Note 1)	V_{IDR}	±36	Vdc
Input Common Mode Voltage Range (Notes 1 and 2)	V_{ICR}	±18	Vdc
Storage Temperature Range	T_{stg}	–55 to +125	°C
Operating Ambient Temperature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

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

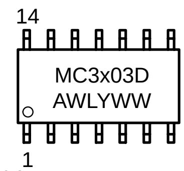
ON Semiconductor™

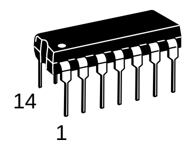
http://onsemi.com

MARKING DIAGRAMS

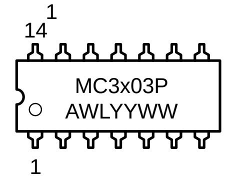


SO–14
D SUFFIX
CASE 751A



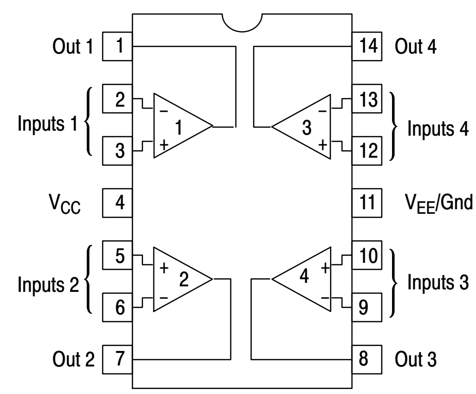


PDIP–14
P SUFFIX
CASE 646



x = 3 or 4
A = Assembly Location
WL = Wafer Lot
YY, Y = Year
WW = Work Week

PIN CONNECTIONS



(Top View)

ORDERING INFORMATION

Device	Package	Shipping
MC3303D	SO–14	55 Units/Rail
MC3303DR2	SO–14	2500 Tape & Reel
MC3303P	PDIP–14	25 Units/Rail
MC3403D	SO–14	55 Units/Rail
MC3403DR2	SO–14	2500 Tape & Reel
MC3403P	PDIP–14	25 Units/Rail

January, 2002 – Rev. 7

Publication Order Number:
MC3403/D

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			MC3303			Unit
		Min	Typ	Max	Min	Typ	Max	
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	–	%

1. MC3303: T_{low} = –40°C, T_{high} = +85°C
   MC3403: T_{low} = 0°C, T_{high} = +70°C
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

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

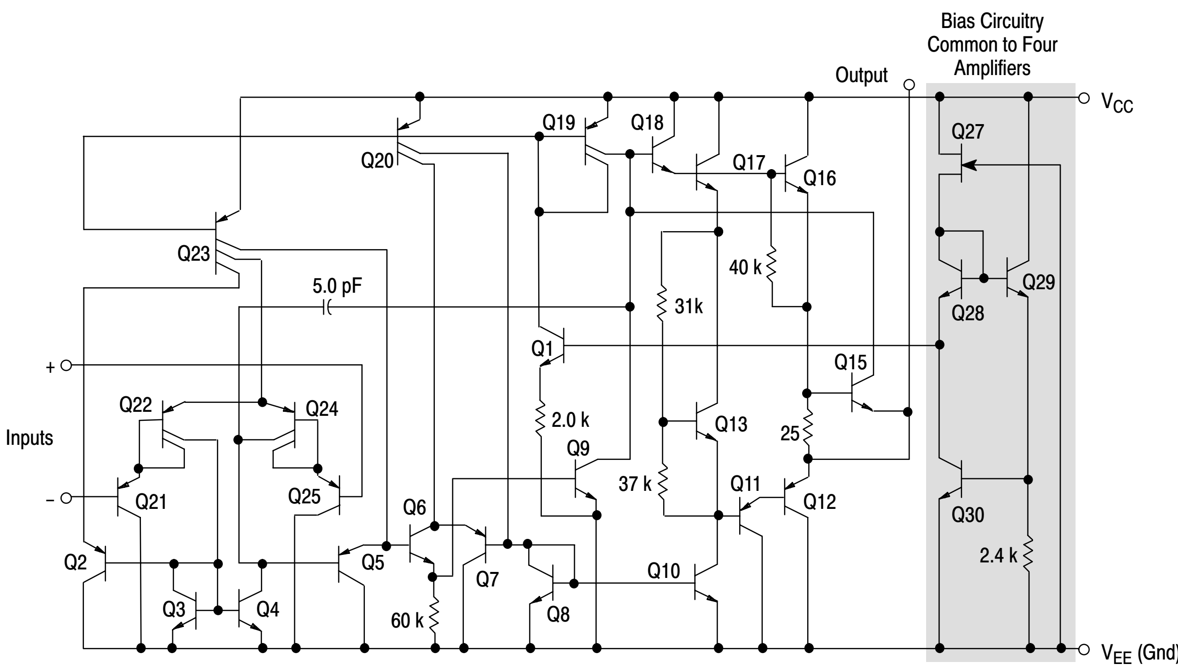


Figure 1. Representative Schematic Diagram
(1/4 of Circuit Shown)

CIRCUIT DESCRIPTION

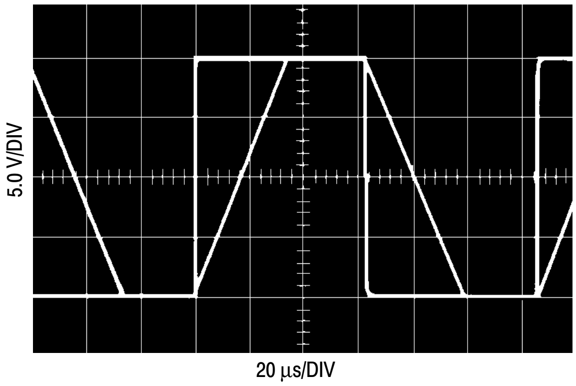


Figure 2. Inverter Pulse Response

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.

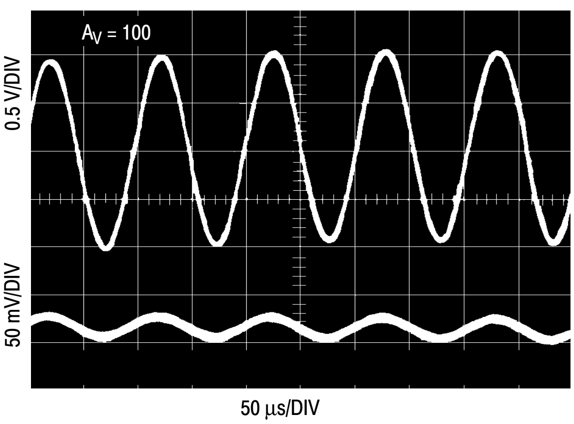


Figure 3. Sine Wave Response

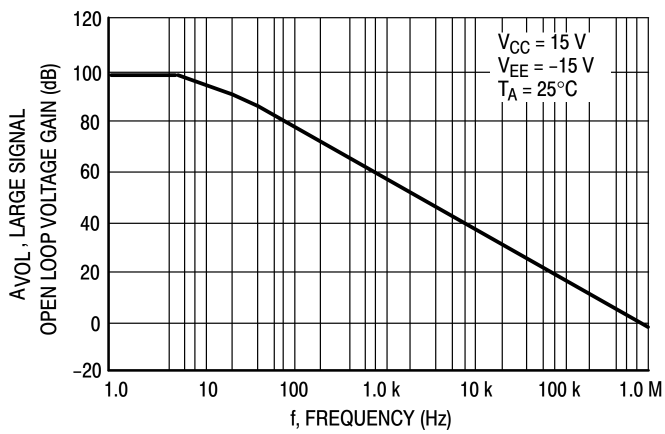


Figure 4. Open Loop Frequency Response

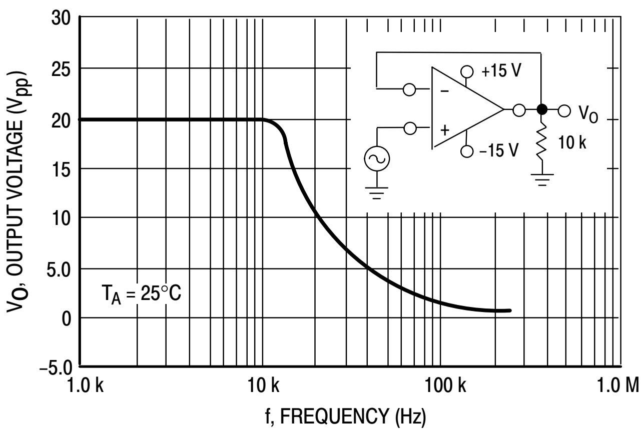


Figure 5. Power Bandwidth

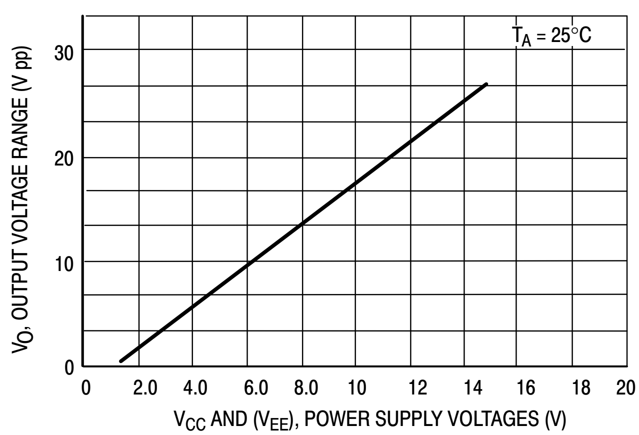


Figure 6. Output Swing versus Supply Voltage

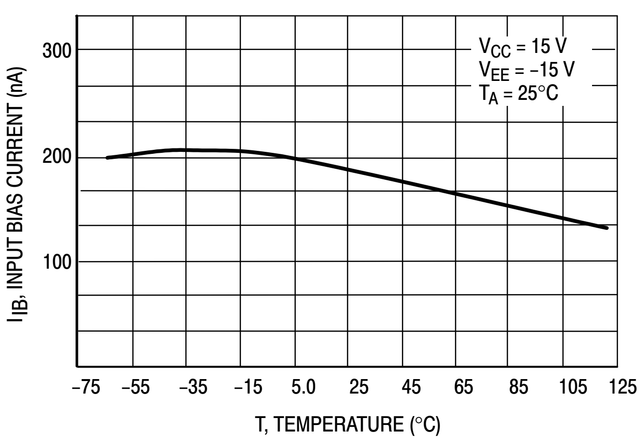


Figure 7. Input Bias Current versus Temperature

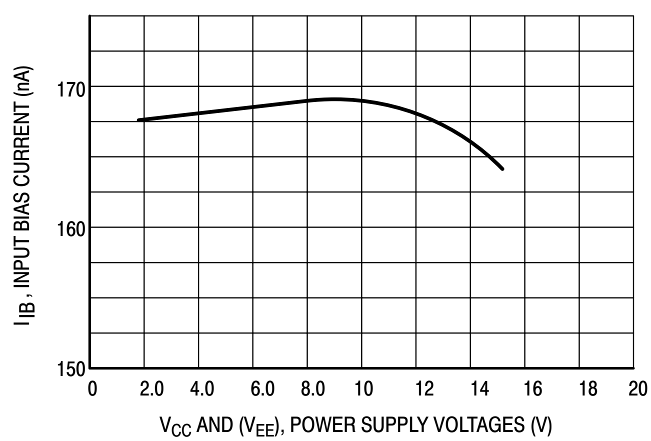
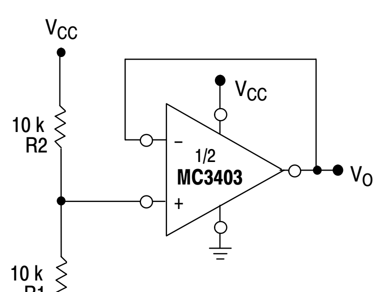


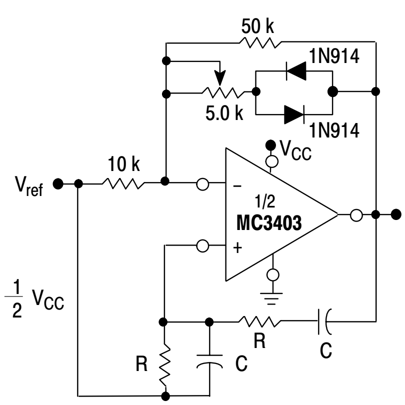
Figure 8. Input Bias Current versus Supply Voltage



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

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

Figure 9. Voltage Reference

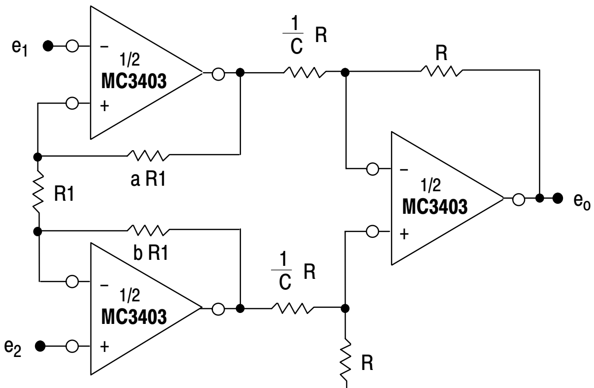


$V_{ref} = \frac{1}{2}\ V_{CC}$

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

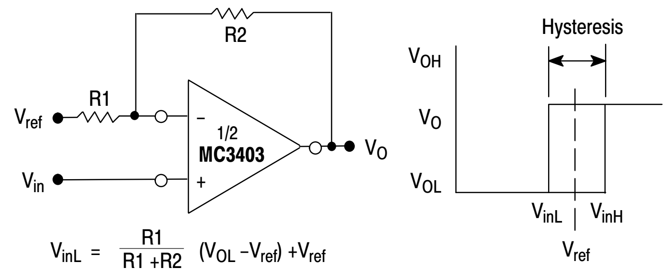
For: f_o = 1.0 kHz
R = 16 kΩ
C = 0.01 μF

Figure 10. Wien Bridge Oscillator



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

Figure 11. High Impedance Differential Amplifier

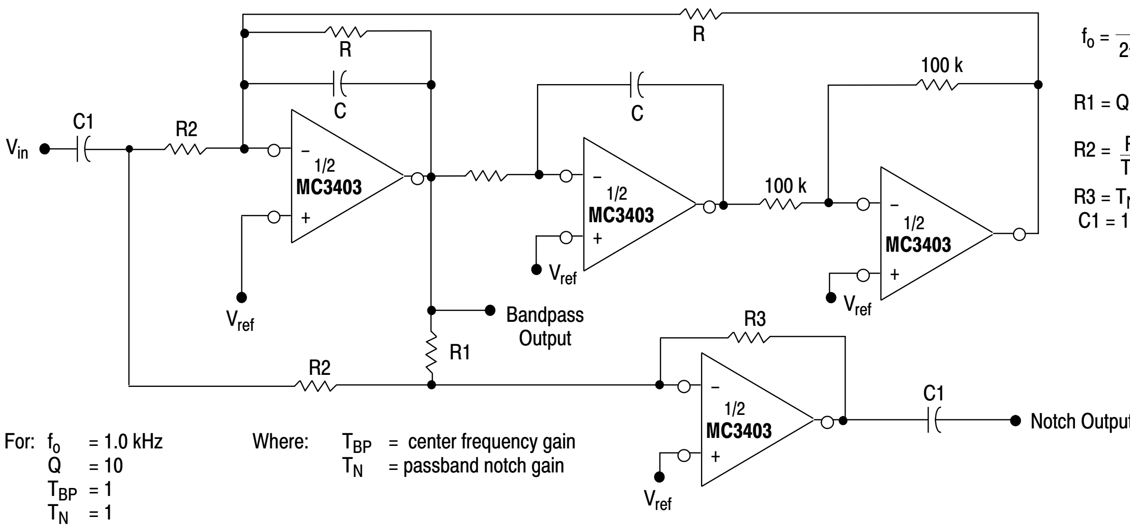


$$V_{inL} = \frac{R1}{R1 + R2}\,(V_{OL} - V_{ref}) + V_{ref}$$

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

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

Figure 12. Comparator with Hysteresis



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

R1 = QR

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

$R3 = T_N R2$

C1 = 10 C

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

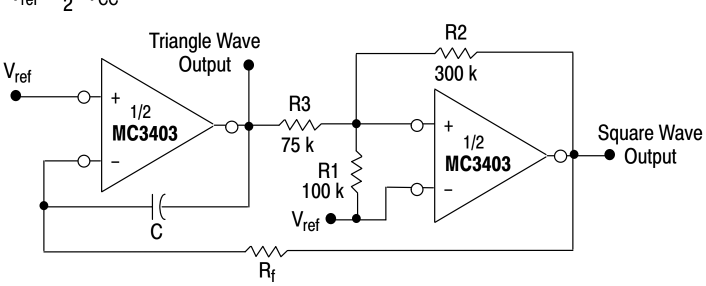
R = 160 kΩ
C = 0.001 μF
R1 = 1.6 MΩ
R2 = 1.6 MΩ
R3 = 1.6 MΩ

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

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

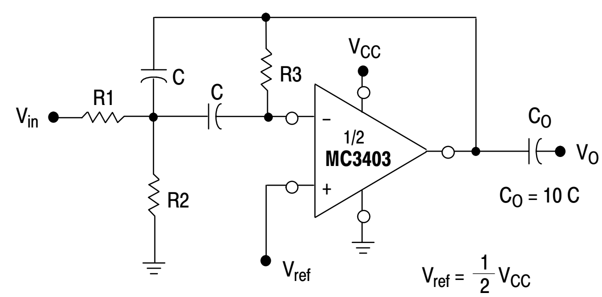
Figure 13. Bi–Quad Filter

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



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

Figure 14. Function Generator



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

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

Choose value f_o, C

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

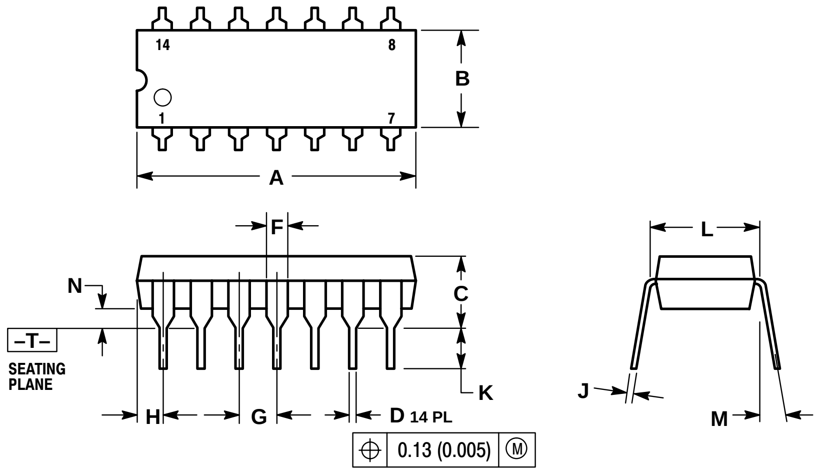
For less than 10% error from operational amplifier $\frac{O_o\,f_o}{BW} < 0.1$
where f_o and BW are expressed in Hz.

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

Figure 15. Multiple Feedback Bandpass Filter

PACKAGE DIMENSIONS

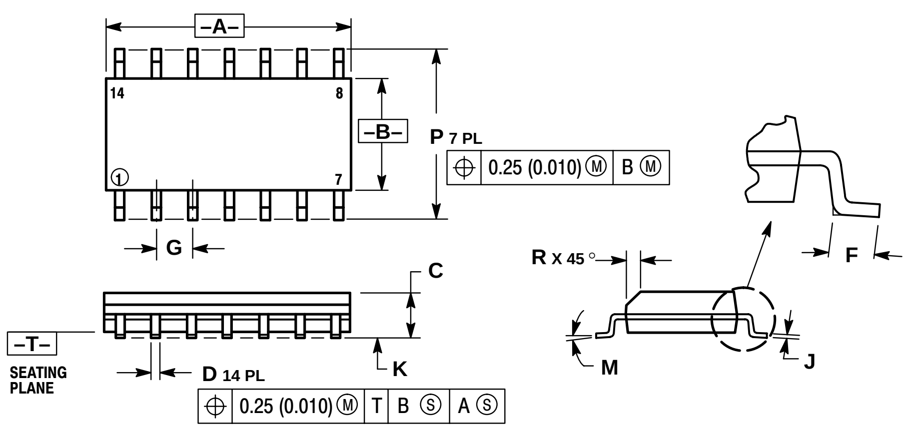
PDIP–14
P SUFFIX
CASE 646–06
ISSUE M



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. ROUNDED CORNERS OPTIONAL.

	INCHES		MILLIMETERS	
DIM	MIN	MAX	MIN	MAX
A	0.715	0.770	18.16	18.80
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	0.290	0.310	7.37	7.87
M	---	10°	---	10°
N	0.015	0.039	0.38	1.01

SO–14
D SUFFIX
CASE 751A–03
ISSUE F



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

PUBLICATION ORDERING INFORMATION

Literature Fulfillment:
Literature Distribution Center for ON Semiconductor
P.O. Box 5163, Denver, Colorado 80217 USA
Phone: 303–675–2175 or 800–344–3860 Toll Free USA/Canada
Fax: 303–675–2176 or 800–344–3867 Toll Free USA/Canada
Email: ONlit@hibbertco.com

N. American Technical Support: 800–282–9855 Toll Free USA/Canada

JAPAN: ON Semiconductor, Japan Customer Focus Center
4–32–1 Nishi–Gotanda, Shinagawa–ku, Tokyo, Japan 141–0031
Phone: 81–3–5740–2700
Email: r14525@onsemi.com

ON Semiconductor Website: http://onsemi.com

For additional information, please contact your local Sales Representative.