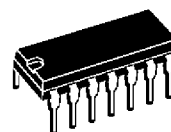


## LOW POWER QUAD BIPOLAR OPERATIONAL AMPLIFIERS

- SHORT-CIRCUIT PROTECTED OUTPUTS
- CLASS AB OUTPUT STAGE FOR MINIMAL CROSSOVER DISTORTION
- SINGLE SUPPLY OPERATION : +3 V TO +36V
- DUAL SUPPLIES :  $\pm 1.5V$  TO  $\pm 18V$
- LOW INPUT BIAS CURRENT : 500nA MAX
- INTERNALLY COMPENSATED
- SIMILAR PERFORMANCE TO POPULAR UA741

### DESCRIPTION

The MC3403 is a low-cost, quad operational amplifier with true differential inputs. The device has electrical characteristics similar to the popular UA741. 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 volts or as high as 36 volts with quiescent currents about one third of those associated with the UA741 (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.



**N**  
**DIP14**  
(Plastic Package)



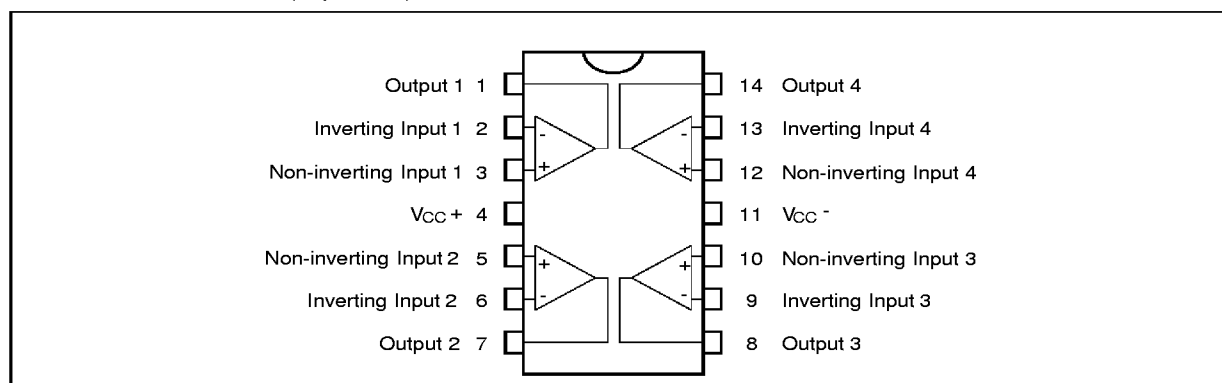
**D**  
**SO14**  
(Plastic Micropackage)

### ORDER CODES

| Part Number | Temperature Range | Package |   |
|-------------|-------------------|---------|---|
|             |                   | N       | D |
| MC3303      | -40°C, +105°C     | •       | • |
| MC3403      | 0°C, +70°C        | •       | • |
| MC3503      | -55°C, +125°C     | •       | • |

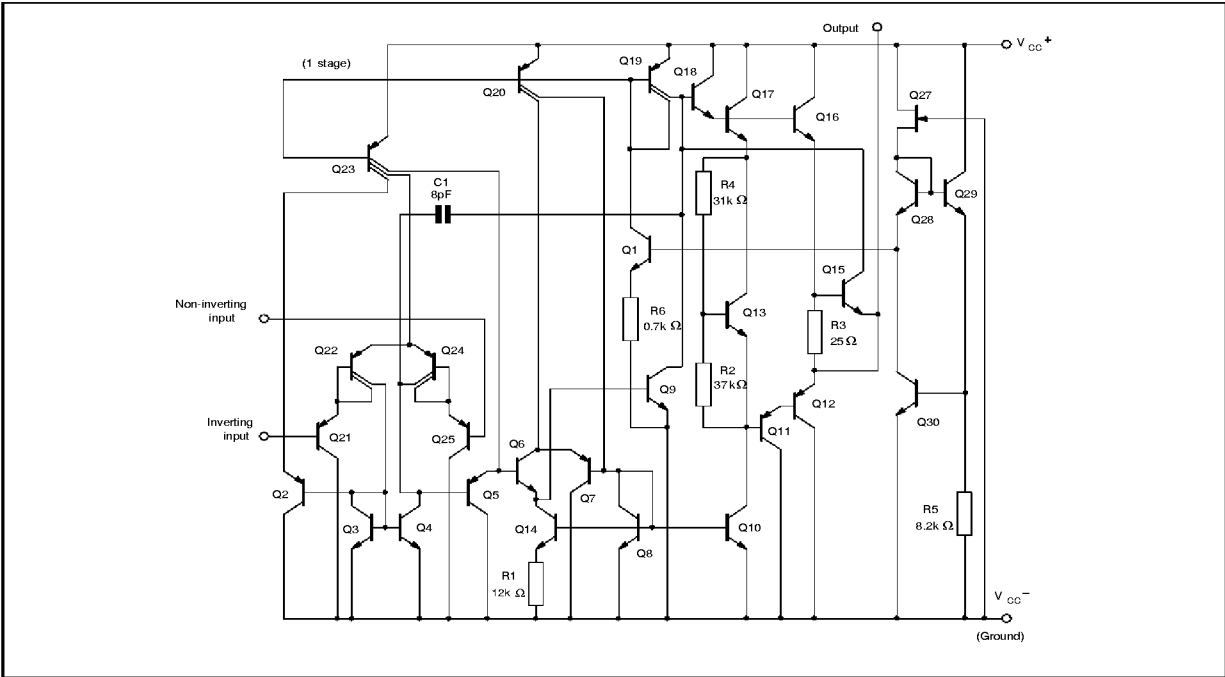
**Example :** MC3403N

### PIN CONNECTIONS (top view)

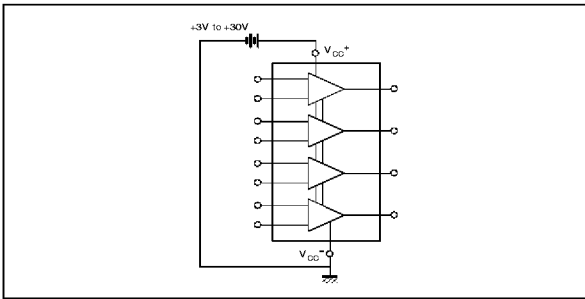


MC3303 - MC3403 - MC3503

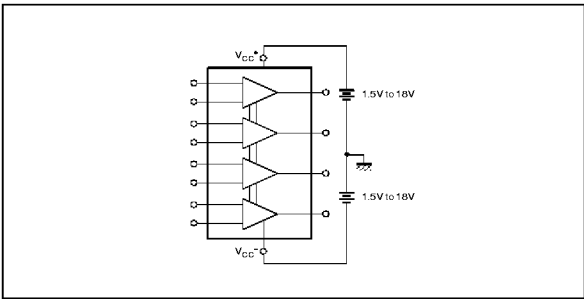
SCHEMATIC DIAGRAM (each amplifier)



SINGLE SUPPLY



DUAL SUPPLIES



ABSOLUTE MAXIMUM RATINGS

| Symbol     | Parameter                              | MC3503          | MC3403          | MC3303          | Unit               |
|------------|----------------------------------------|-----------------|-----------------|-----------------|--------------------|
| $V_{CC}$   | Supply Voltage                         | $\pm 18$ or 36  | $\pm 18$ or 36  | $\pm 18$ or 36  | V                  |
| $V_{id}$   | Differential Input Voltage             | $\pm 36$        | $\pm 36$        | $\pm 36$        | V                  |
| $V_i$      | Input Voltage (note 1)                 | $\pm 18$        | $\pm 18$        | $\pm 18$        | V                  |
| —          | Output Short-circuit Duration (note 2) | Infinite        |                 |                 | —                  |
| $P_{tot}$  | Power Dissipation                      | 500             | 500             | 500             | mW                 |
| $T_{oper}$ | Operating Free-air Temperature Range   | $-55$ to $+125$ | 0 to $+70$      | $-40$ to $+105$ | $^{\circ}\text{C}$ |
| $T_{stg}$  | Storage Temperature Range              | $-65$ to $+150$ | $-65$ to $+150$ | $-65$ to $+150$ | $^{\circ}\text{C}$ |

Notes : 1. For supply voltages less than  $\pm 15\text{V}$ , the absolute maximum input voltage is equal to the supply voltage.  
2. Any of the amplifier outputs can be shorted to ground indefinitely ; however more than one should not be simultaneously shorted as the maximum junction temperature will be exceeded.

**ELECTRICAL CHARACTERISTICS** $V_{CC} = \pm 15V$ ,  $T_{amb} = +25^{\circ}C$ , (unless otherwise specified)

| Symbol        | Parameter                                                                                                                                                                  | MC3303 - MC3403<br>MC3503 |            |                  | Unit                   |
|---------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------|------------|------------------|------------------------|
|               |                                                                                                                                                                            | Min.                      | Typ.       | Max.             |                        |
| $V_{IO}$      | Input Offset Voltage ( $R_S \leq 10k\Omega$ )<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                          |                           | 1          | 5<br>6           | mV                     |
| $I_{IO}$      | Input Offset Current<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                                   |                           | 2          | 50<br>200        | nA                     |
| $I_{IB}$      | Input Bias Current<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                                     |                           | 40         | 500<br>800       | nA                     |
| $A_{vd}$      | Large Signal Voltage Gain ( $V_O = \pm 10V$ , $R_L = 2k\Omega$ )<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                       | 50<br>25                  | 200        |                  | V/mV                   |
| SVR           | Supply Voltage Rejection Ratio ( $R_S \leq 10k\Omega$ )<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                | 77<br>77                  | 90         |                  | dB                     |
| $I_{CC}$      | Supply Current, all Amp, no Load<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$<br>MC3503<br>MC3503                                                   |                           | 2.8        | 7<br>4<br>8<br>5 | mA                     |
| $V_{icm}$     | Input Common Mode Voltage Range<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                                        | - 15<br>- 15              |            | + 13<br>+ 13     | V                      |
| CMR           | Common Mode Rejection Ratio ( $R_S \leq 10k\Omega$ )<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$                                                   | 70<br>70                  | 90         |                  | dB                     |
| $I_{OS}$      | Output Short-circuit Current                                                                                                                                               | 10                        | 30         | 45               | mA                     |
| $\pm V_{opp}$ | Output Voltage Swing<br>$T_{amb} = 25^{\circ}C$<br>$T_{min.} \leq T_{amb} \leq T_{max.}$<br>$R_L = 10k\Omega$<br>$R_L = 2k\Omega$<br>$R_L = 2k\Omega$<br>$R_L = 10k\Omega$ | 12<br>10<br>10<br>12      | 13.5<br>13 |                  | V                      |
| SR            | Slew Rate ( $V_I = \pm 10V$ , $R_L = 2k\Omega$ , $C_L = 100pF$ ,<br>$T_{amb} = 25^{\circ}C$ , unity gain)                                                                  | 0.35                      | 0.5        |                  | V/ $\mu s$             |
| $t_r, t_f$    | Rise Time and Fall Time ( $V_O = \pm 20mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ ,<br>$T_{amb} = 25^{\circ}C$ , unity gain)                                                   |                           | 0.18       |                  | $\mu s$                |
| $K_{OV}$      | Overshoot ( $V_I = \pm 20mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ ,<br>$T_{amb} = 25^{\circ}C$ , unity gain)                                                                 |                           | 10         |                  | %                      |
| $Z_I$         | Input Impedance                                                                                                                                                            | 0.3                       | 1          |                  | M $\Omega$             |
| $Z_O$         | Output Impedance                                                                                                                                                           |                           | 75         |                  | $\Omega$               |
| $B_{om}$      | Power Bandwidth ( $R_L = 2k\Omega$ , $C_L = 100pF$ , $A_v = 1$ , $T_{amb} = 25^{\circ}C$ ,<br>$V_O = 2V_{pp}$ , THD $\leq 5\%$ )                                           |                           | 9          |                  | kHz                    |
| B             | Unity Gain Bandwidth ( $V_O = 10mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ ,<br>$T_{amb} = 25^{\circ}C$ , unity gain)                                                          |                           | 1          |                  | MHz                    |
| GBP           | Gain Bandwidth Product ( $V_O = 10mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ ,<br>$f = 100kHz$ , $T_{amb} = 25^{\circ}C$ )                                                     | 0.7                       | 1          |                  | MHz                    |
| THD           | Total Harmonic Distortion ( $f = 1kHz$ , $A_v = 20dB$ , $R_L = 2k\Omega$ ,<br>$V_O = 2V_{pp}$ , $C_L = 100pF$ , $T_{amb} = 25^{\circ}C$ )                                  |                           | 0.02       |                  | %                      |
| $e_n$         | Equivalent Input Noise Voltage ( $f = 1kHz$ , $R_s = 100\Omega$ )                                                                                                          |                           | 43         |                  | $\frac{nV}{\sqrt{Hz}}$ |

## MC3303 - MC3403 - MC3503

### ELECTRICAL CHARACTERISTICS (continued)

| Symbol              | Parameter                                                              | MC3303 - MC3403 - MC3503 |      |      | Unit              |
|---------------------|------------------------------------------------------------------------|--------------------------|------|------|-------------------|
|                     |                                                                        | Min.                     | Typ. | Max. |                   |
| $\phi_m$            | Phase Margin                                                           |                          | 60   |      | Degrees           |
| DV <sub>IO</sub>    | Input Offset Voltage Drift<br>$T_{min.} \leq T_{amb} \leq T_{max.}$    |                          | 10   |      | $\mu V/^{\circ}C$ |
| DI <sub>IO</sub>    | Input Offset Current Drift<br>$T_{min.} \leq T_{amb} \leq 25^{\circ}C$ |                          | 50   |      | pA/ $^{\circ}C$   |
| V <sub>O1/V02</sub> | Channel Separation                                                     |                          | 120  |      | dB                |

### ELECTRICAL CHARACTERISTICS

V<sub>CC</sub><sup>+</sup> = 5V, V<sub>CC</sub><sup>-</sup> = Ground, T<sub>amb</sub> = 25°C (unless otherwise specified)

| Symbol           | Parameter                                                                                                                                                             | MC3303 - MC3403 - MC3503                |                                           |            | Unit |
|------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------|------------|------|
|                  |                                                                                                                                                                       | Min.                                    | Typ.                                      | Max.       |      |
| V <sub>IO</sub>  | Input Offset Voltage (R <sub>S</sub> ≤ 10kΩ)<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                   |                                         | 1                                         | 5<br>6     | mV   |
| I <sub>IO</sub>  | Input Offset Current<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                           |                                         | 2                                         | 50<br>200  | nA   |
| I <sub>IB</sub>  | Input Bias Current<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                                                             |                                         | 40                                        | 500<br>800 | nA   |
| A <sub>vd</sub>  | Large Signal Voltage Gain (V <sub>O</sub> = 1.4 to 2.4V, R <sub>L</sub> = 2kΩ)<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub> | 10<br>5                                 | 200                                       |            | V/mV |
| SVR              | Supply Voltage Rejection Ratio (R <sub>S</sub> ≤ 10kΩ)<br>T <sub>amb</sub> = 25°C<br>T <sub>min.</sub> ≤ T <sub>amb</sub> ≤ T <sub>max.</sub>                         | 77<br>77                                | 90                                        |            | dB   |
| I <sub>CC</sub>  | Supply Current (All Amp)<br>MC3503                                                                                                                                    |                                         | 2.5                                       | 7<br>4     | mA   |
| V <sub>opp</sub> | Output Voltage Range (R <sub>L</sub> = 10kΩ)<br>V <sub>CC</sub> = +5V<br>+5 < V <sub>CC</sub> ≤ +30V                                                                  | 3.3<br>V <sub>CC</sub> <sup>+</sup> -2V | 3.5<br>V <sub>CC</sub> <sup>+</sup> -1.7V |            | V    |

## CIRCUIT DESCRIPTION

The MC3403 is made using four internally compensated, two-stage operational amplifiers. The first stage of each consists of differential input devices 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 8pF) can be employed, thus saving chip area.

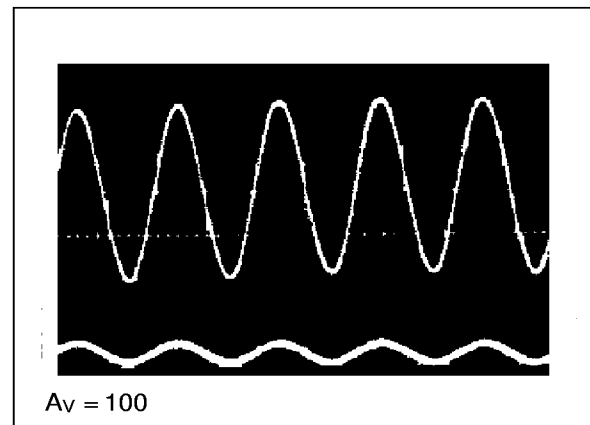
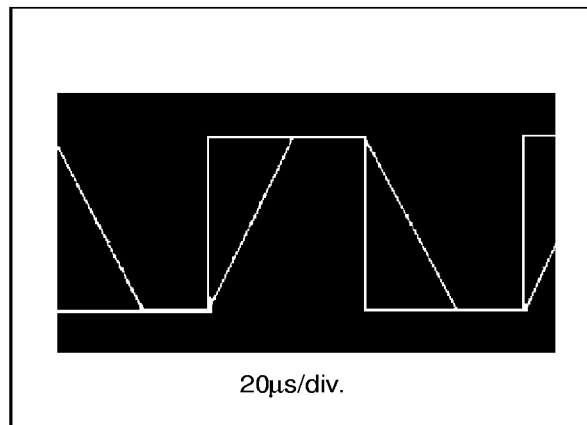
The transconductance reduction is accomplished by splitting the collectors of Q24 and Q22. Another feature of this input stage is that the input common-mode range can include the negative supply of

ground, in single supply operation, without saturation 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 operations. This is possible because class AB operation is utilized.

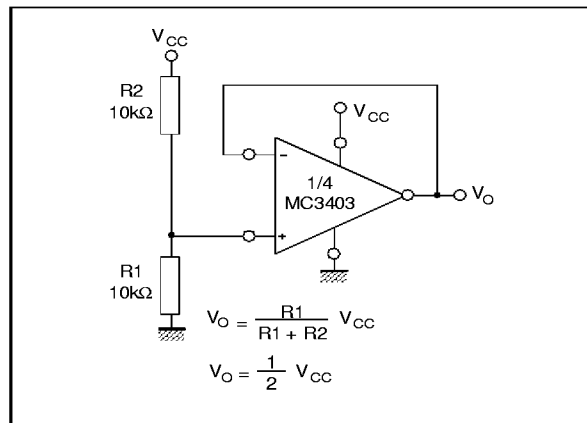
Each amplifier is biased from an internal voltage regulator which has a low temperature coefficient thus giving each amplifier good temperature characteristics as well as excellent power supply rejection.

## TYPICAL PERFORMANCE CURVES

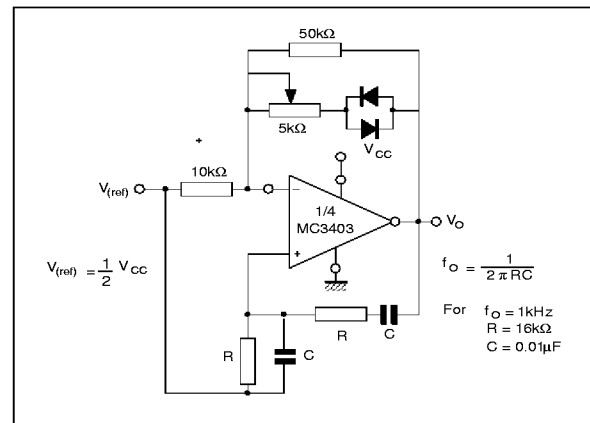


## APPLICATION INFORMATION

### VOLTAGE REFERENCE

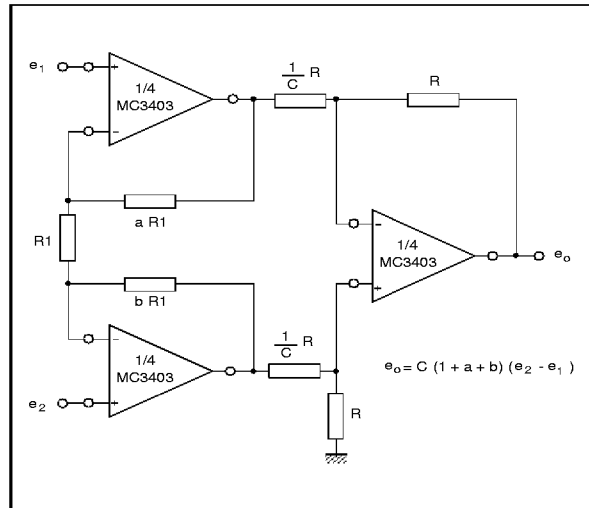


### WIEN BRIDGE OSCILLATOR

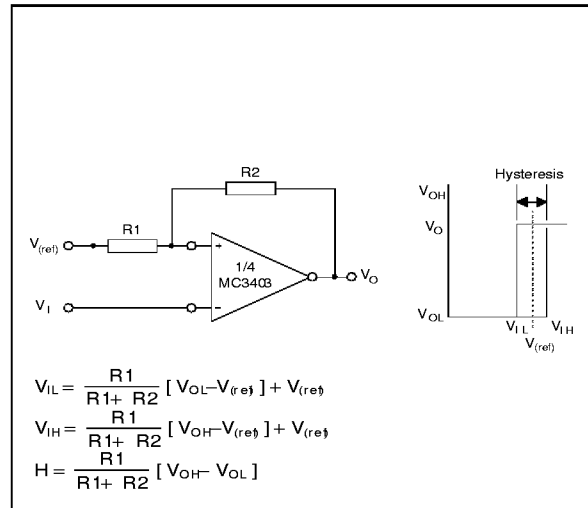


# APPLICATION INFORMATION (continued)

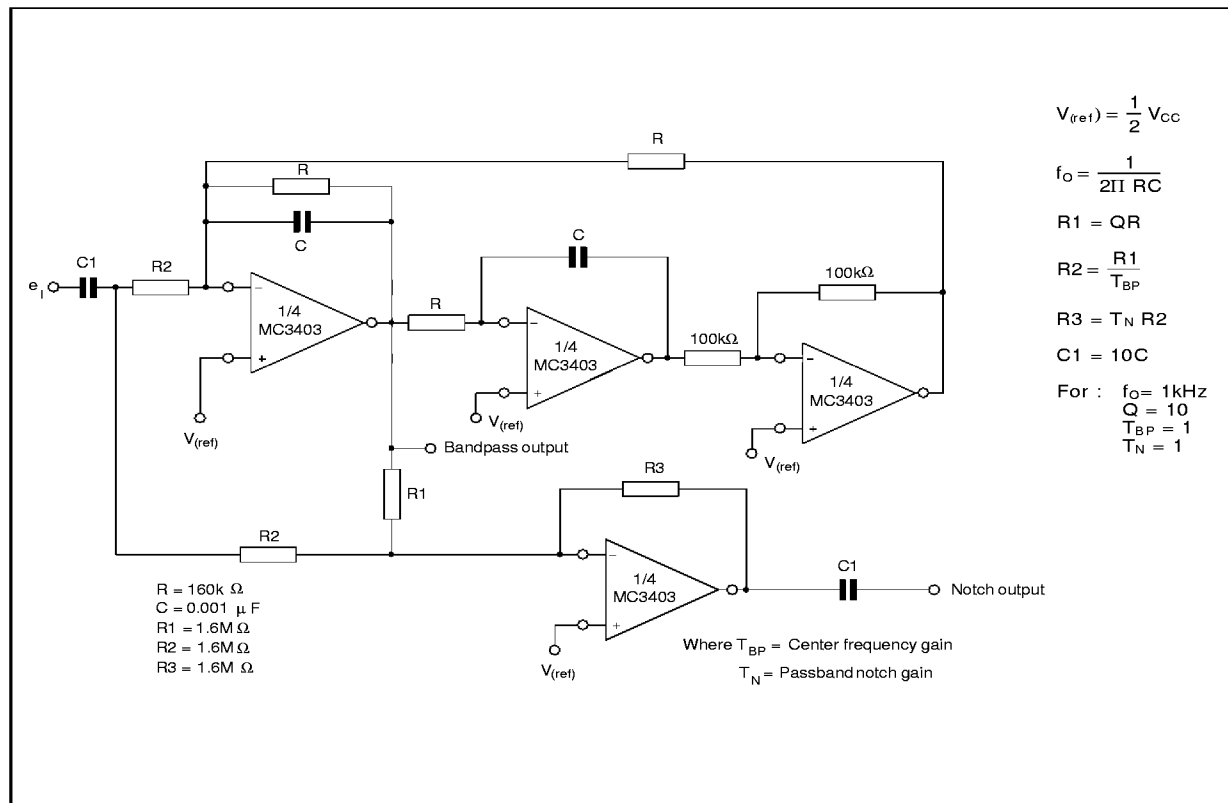
## HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER



## COMPARATOR WITH HYSTERESIS

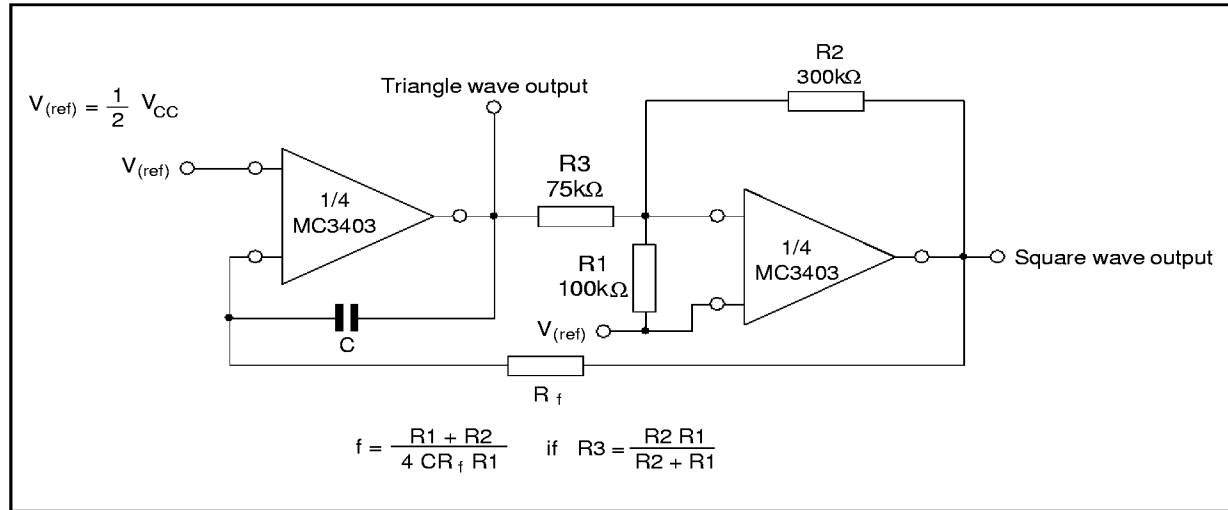


## BI-QUAD FILTER

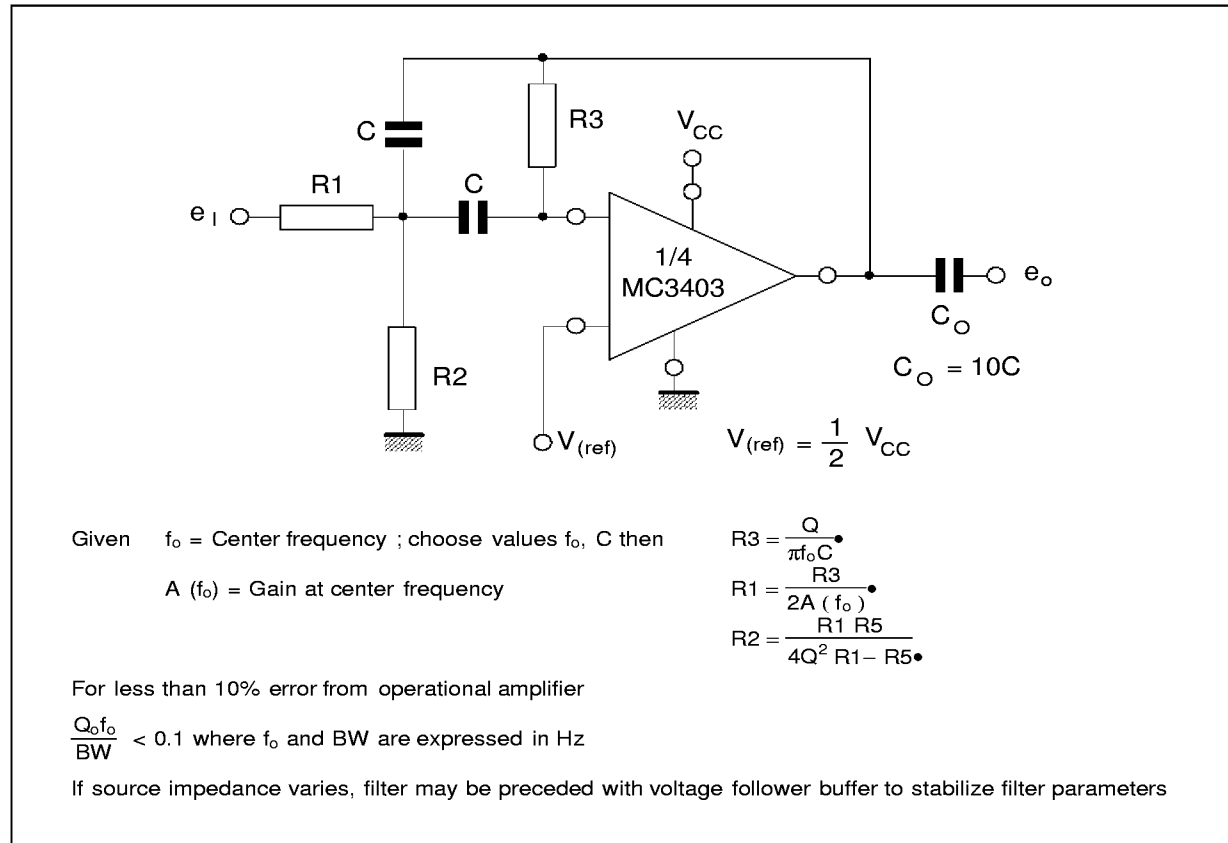


## APPLICATION INFORMATION (continued)

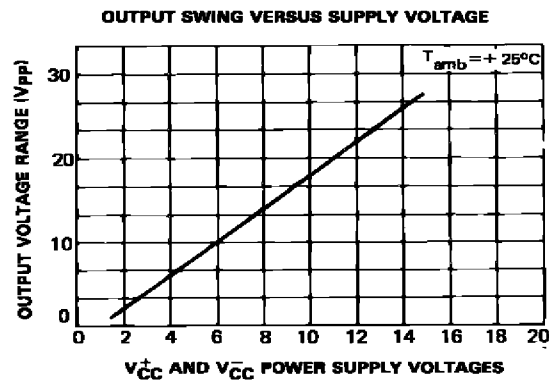
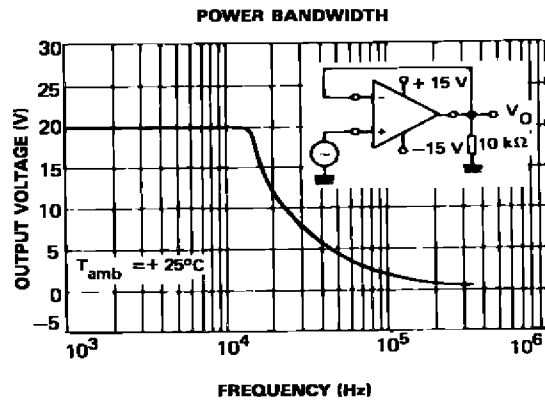
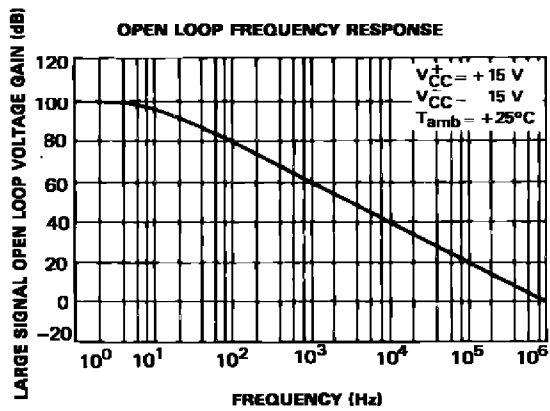
### FUNCTION GENERATOR

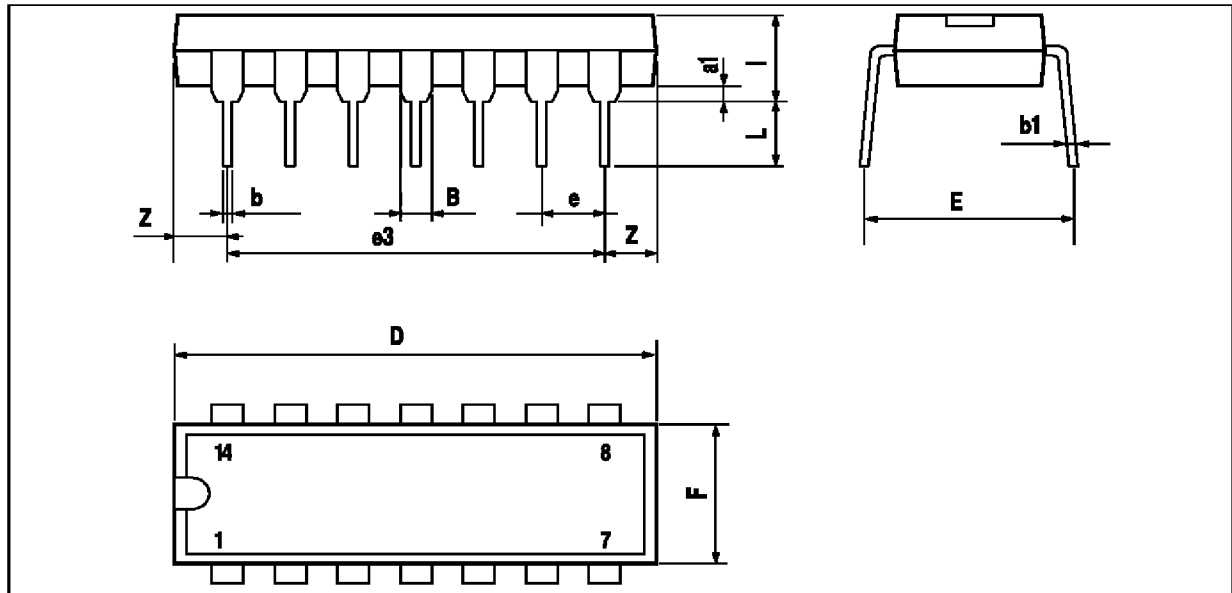


### MULTIPLE FEEDBACK BANDPASS FILTER



TYPICAL PERFORMANCE CURVES



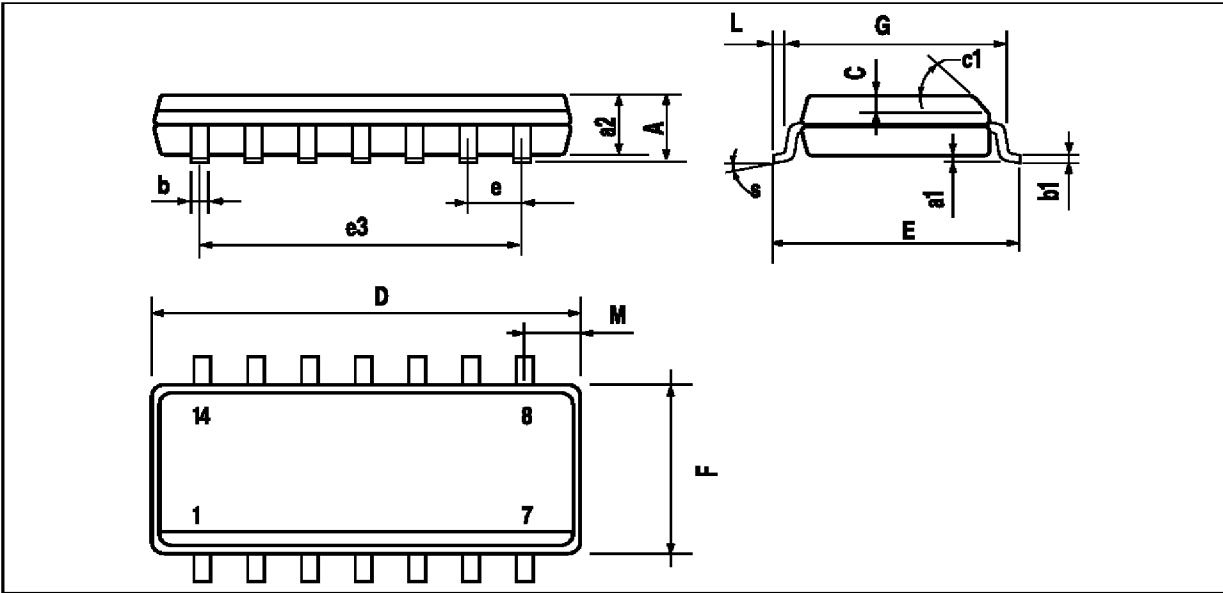
**PACKAGE MECHANICAL DATA**  
 14 PINS - PLASTIC DIP


PM-DIP14.EPS

| Dimensions | Millimeters |       |      | Inches |       |       |
|------------|-------------|-------|------|--------|-------|-------|
|            | Min.        | Typ.  | Max. | Min.   | Typ.  | Max.  |
| a1         | 0.51        |       |      | 0.020  |       |       |
| B          | 1.39        |       | 1.65 | 0.055  |       | 0.065 |
| b          |             | 0.5   |      |        | 0.020 |       |
| b1         |             | 0.25  |      |        | 0.010 |       |
| D          |             |       | 20   |        |       | 0.787 |
| E          |             | 8.5   |      |        | 0.335 |       |
| e          |             | 2.54  |      |        | 0.100 |       |
| e3         |             | 15.24 |      |        | 0.600 |       |
| F          |             |       | 7.1  |        |       | 0.280 |
| i          |             |       | 5.1  |        |       | 0.201 |
| L          |             | 3.3   |      |        | 0.130 |       |
| Z          | 1.27        |       | 2.54 | 0.050  |       | 0.100 |

DIP14.TBL

PACKAGE MECHANICAL DATA  
14 PINS - PLASTIC MICROPACKAGE (SO)



| Dimensions | Millimeters |      |      | Inches |       |       |
|------------|-------------|------|------|--------|-------|-------|
|            | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A          |             |      | 1.75 |        |       | 0.069 |
| a1         | 0.1         |      | 0.2  | 0.004  |       | 0.008 |
| a2         |             |      | 1.6  |        |       | 0.063 |
| b          | 0.35        |      | 0.46 | 0.014  |       | 0.018 |
| b1         | 0.19        |      | 0.25 | 0.007  |       | 0.010 |
| C          |             | 0.5  |      |        | 0.020 |       |
| c1         | 45° (typ.)  |      |      |        |       |       |
| D          | 8.55        |      | 8.75 | 0.336  |       | 0.334 |
| E          | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e          |             | 1.27 |      |        | 0.050 |       |
| e3         |             | 7.62 |      |        | 0.300 |       |
| F          | 3.8         |      | 4.0  | 0.150  |       | 0.157 |
| G          | 4.6         |      | 5.3  | 0.181  |       | 0.208 |
| L          | 0.5         |      | 1.27 | 0.020  |       | 0.050 |
| M          |             |      | 0.68 |        |       | 0.027 |
| S          | 8° (max.)   |      |      |        |       |       |

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