



# MC3303 MC3403 - MC3503

## LOW POWER QUAD BIPOLAR OPERATIONAL AMPLIFIERS

- SHORT-CIRCUIT PROTECTED OUTPUTS
- CLASS AB OUTPUT STAGE FOR MINIMAL CROSSOVER DISTORTION
- SINGLE SUPPLY OPERATION: +3V TO +36V
- DUAL SUPPLIES:  $\pm 15V$  TO  $\pm 18V$
- LOW INPUT BIAS CURRENT: 500nA MAX
- INTERNALLY COMPENSATED
- SIMILAR PERFORMANCE TO POPULAR UA741

### DESCRIPTION

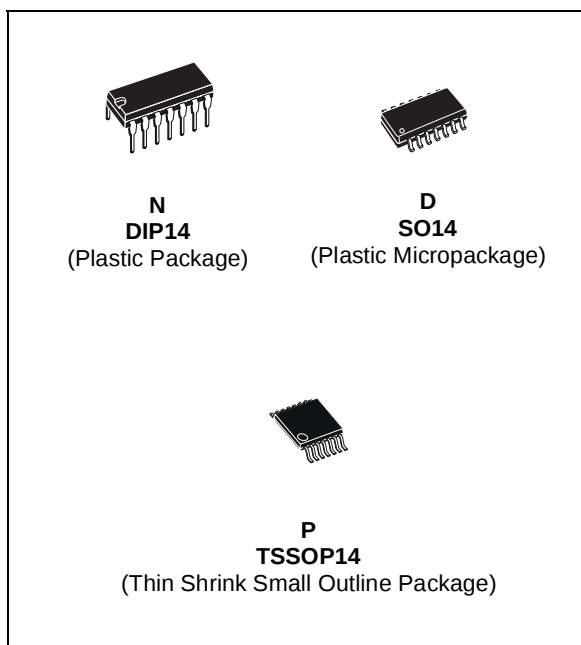
The MC3403 is a low-cost, quad operational amplifier with true differential inputs. The device has electrical characteristics similar to the popular UA741. However the MC3403, has several distinct advantages over standard operational amplifiers types in single supply applications. The quad amplifier can operate at supply voltage as low as 3 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.

### ORDER CODE

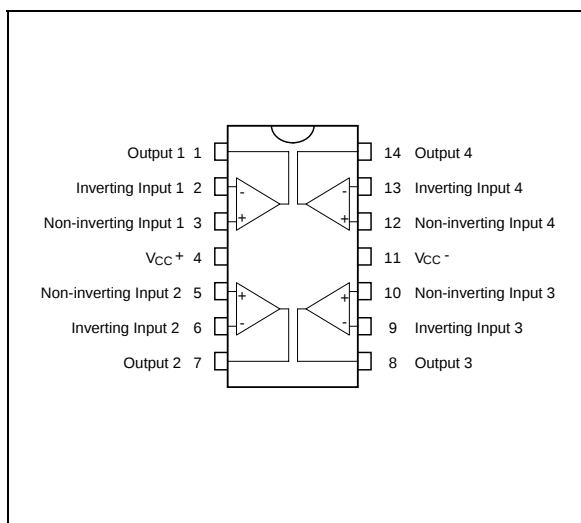
| Part Number | Temperature Range | Package |   |   |
|-------------|-------------------|---------|---|---|
|             |                   | N       | D | P |
| MC3303      | -40°C, +105°C     | •       | • | • |
| MC3403      | 0°C, +70°C        | •       | • | • |
| MC3503      | -55°C, +125°C 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

**Example : MC3403N**

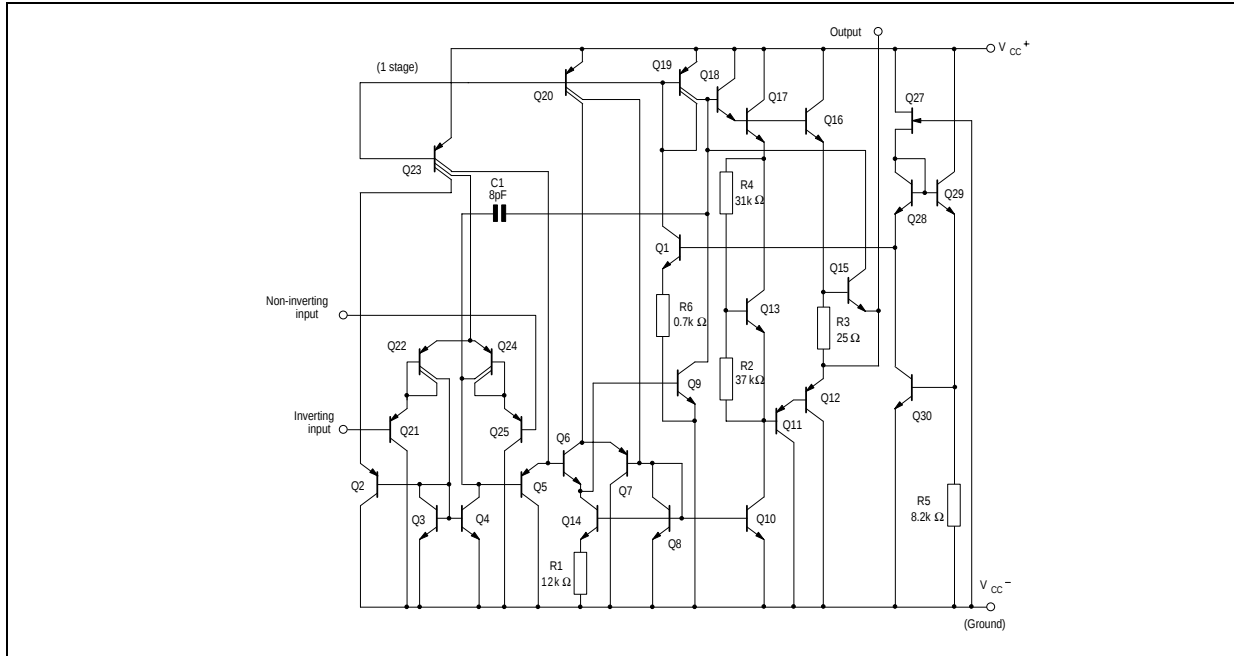
N = Dual in Line Package (DIP)  
D = Small Outline Package (SO) - also available in Tape & Reel (DT)  
P = Thin Shrink Small Outline Package (TSSOP) - only available in Tape & Reel (PT)



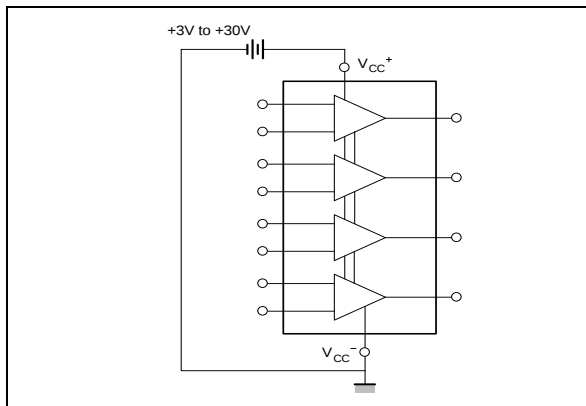
### PIN CONNECTIONS (top view)



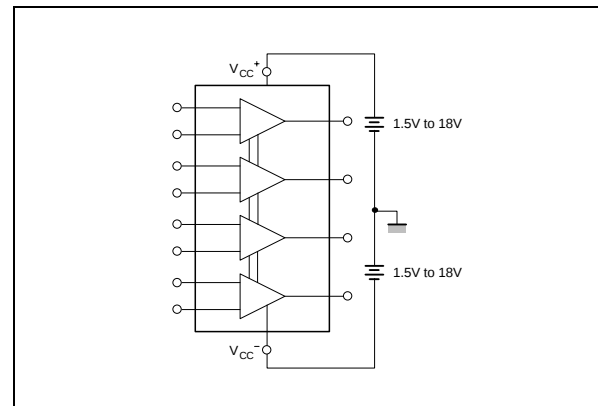
## SCHEMATIC DIAGRAM (each amplifier)



## SCHEMATIC DIAGRAM



## DUAL SUPPLIES



## ABSOLUTE MAXIMUM RATINGS

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

- For supply voltage less than  $\pm 15V$ , the absolute maximum input voltage is equal to the supply voltage.
- Any of the amplifier outputs can be shorted to ground indefinitely; however more than one should not be simultaneously shorted as the maximum junction will be exceeded.

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

| Symbol        | Parameter                                                                                                                                                                            | Min.                 | Typ.       | Max.             | Unit       |
|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|------------|------------------|------------|
| $V_{io}$      | 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>$T_{min} \leq T_{amb} \leq T_{max}$                                                                                               |                      | 5          | 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>$R_L \leq 10k\Omega$<br>$R_L \leq 2k\Omega$<br>$R_L \leq 10k\Omega$<br>$R_L \leq 2k\Omega$ | 12<br>10<br>12<br>10 | 13.5<br>13 |                  | V          |
| SR            | Slew Rate ( $V_i = \pm 10V$ , $R_L = 2k\Omega$ , $C_L = 100pF$ , $T_{amb} = 25^{\circ}C$ , unity gain)                                                                               | 0.35                 | 0.5        |                  | V/ $\mu s$ |
| $t_r, t_f$    | Rsie Time ( $V_o = \pm 20mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ , $T_{amb} = 25^{\circ}C$ , unity gain)                                                                              |                      | 0.18       |                  | $\mu s$    |
| $K_{ov}$      | Overshoot ( $V_i = \pm 20mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ , $T_{amb} = 25^{\circ}C$ , unity gain)                                                                              |                      | 10         |                  | %          |
| $Z_i$         | Input Impedance                                                                                                                                                                      | 0.3                  | 1          |                  | M $\Omega$ |
| $Z_o$         | Output Impedance                                                                                                                                                                     |                      | 75         |                  | $\Omega$   |
| $B_{om}$      | Power Bandwidth ( $R_L = 2k\Omega$ , $C_L = 100pF$ , $A_v = 1$ , $T_{amb} = 25^{\circ}C$ , $V_o = 2V_{pp}$ , THD $\leq 5\%$ )                                                        |                      | 9          |                  | kHz        |
| B             | Unity Gain Bandwidth $V_o = 10mV$ , $R_L = 2k\Omega$ , $C_L = 100pF$ , $T_{amb} = 25^{\circ}C$ , unity gain)                                                                         |                      | 1          |                  | MHz        |

| Symbol          | Parameter                                                                                                                                                                                  | Min. | Typ. | Max. | Unit                                 |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|------|------|--------------------------------------|
| GBP             | Gain Bandwidth Product ( $V_O = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$<br>$f = 100\text{ kHz}$ , $T_{\text{amb}} = 25^\circ\text{C}$ )                           | 0.7  | 1    |      | MHz                                  |
| THD             | Total Harmonic Distortion ( $f = 1\text{ kHz}$ , $A_v = 20\text{ dB}$ , $R_L = 2\text{ k}\Omega$<br>$C_L = 100\text{ pF}$ , $V_O = 2V_{\text{pp}}$ , $T_{\text{amb}} = 25^\circ\text{C}$ ) |      | 0.02 |      | %                                    |
| $e_n$           | Equivalent Input Noise Voltage ( $f = 1\text{ kHz}$ , $R_s = 100\Omega$ )                                                                                                                  |      | 43   |      | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |
| $\phi_m$        | Phase Margin                                                                                                                                                                               |      | 60   |      | Degrees                              |
| $DV_{io}$       | Input Offset Voltage Drift<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                                     |      | 10   |      | $\mu\text{V}/^\circ\text{C}$         |
| $DI_{io}$       | Input Offset Current Drift<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                                                     |      | 50   |      | $\text{pA}/^\circ\text{C}$           |
| $V_{O1}/V_{O2}$ | Channel Separation                                                                                                                                                                         |      | 120  |      | dB                                   |

**ELECTRICAL CHARACTERISTICS**

$V_{CC}^+ = 5\text{V}$ ,  $V_{CC}^- = \text{Ground}$ ,  $T_{\text{amb}} = 25^\circ\text{C}$  (unless otherwise specified)

| Symbol    | Parameter                                                                                                                                                                                       | Min.                          | Typ.                            | Max.       | Unit |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|---------------------------------|------------|------|
| $V_{io}$  | Input Offset Voltage ( $R_s \leq 10\text{ k}\Omega$ )<br>$T_{\text{amb}} = 25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                        |                               | 1                               | 5<br>6     | mV   |
| $I_{io}$  | Input Offset Current<br>$T_{\text{amb}} = 25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                         |                               | 5                               | 50<br>200  | nA   |
| $I_{ib}$  | Input Bias Current<br>$T_{\text{amb}} = 25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                                                                           |                               | 40                              | 500<br>800 | nA   |
| $A_{vd}$  | Large Signal Voltage Gain ( $V_O = 1.4\text{V to } 2.4\text{V}$ , $R_L = 2\text{ k}\Omega$ )<br>$T_{\text{amb}} = 25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 10<br>5                       | 200                             |            | V/mV |
| SVR       | Supply Voltage Rejection Ratio ( $R_s \leq 10\text{ k}\Omega$ )<br>$T_{\text{amb}} = 25^\circ\text{C}$<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                              | 77<br>77                      | 90                              |            | dB   |
| $I_{cc}$  | Supply Current, all Amp, no load<br>MC3503                                                                                                                                                      |                               | 2.8                             | 7<br>4     | mA   |
| $V_{opp}$ | Output Voltage Range ( $R_L = 10\text{ k}\Omega$ )<br>$V_{CC} = +5\text{V}$<br>$+5 < V_{CC} \leq +30\text{V}$                                                                                   | 3.3<br>$V_{CC}^+ - 2\text{V}$ | 3.5<br>$V_{CC}^+ - 1.7\text{V}$ |            | V    |

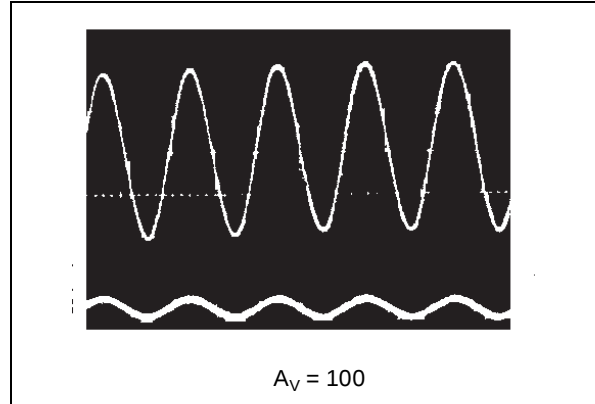
## CIRCUIT DESCRIPTION

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 to ground, in single supply operation, without saturation either the input devices or the differential to single-ended converter.

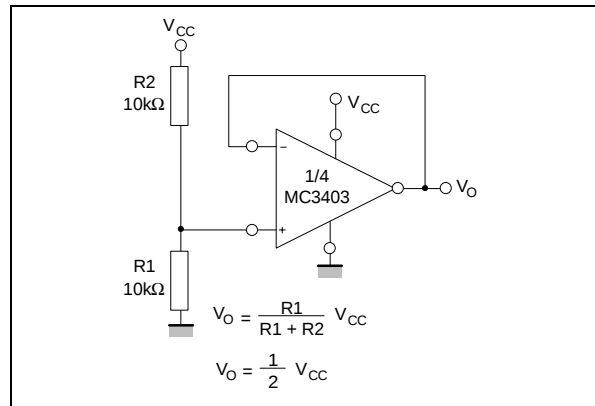
The second stage consists of a standard current source load amplifier stage. The output stage is unique because it allows the output to swing to ground in single supply operation and yet does not exhibit any crossover distortion in split supply operations. This is possible because class AB operation 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.

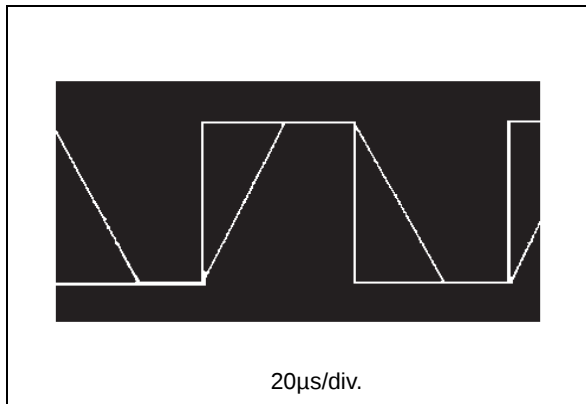


## APPLICATION INFORMATION

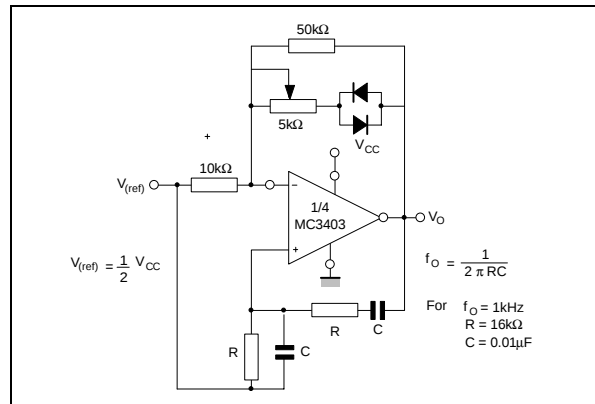
### VOLTAGE REFERENCE



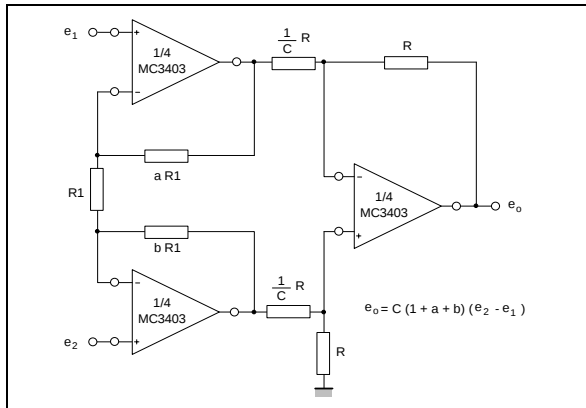
### TYPICAL PERFORMANCE CURVES



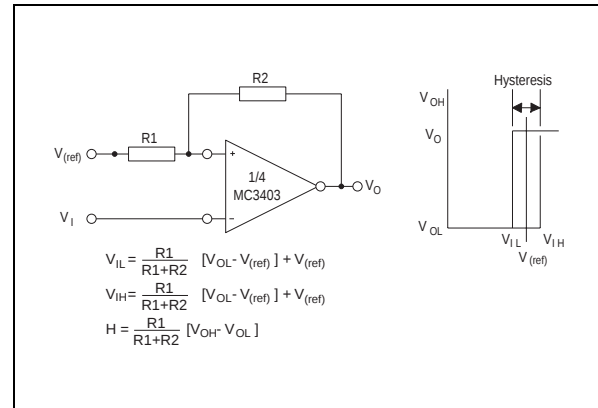
### WIEN BRIDGE OSCILLATOR



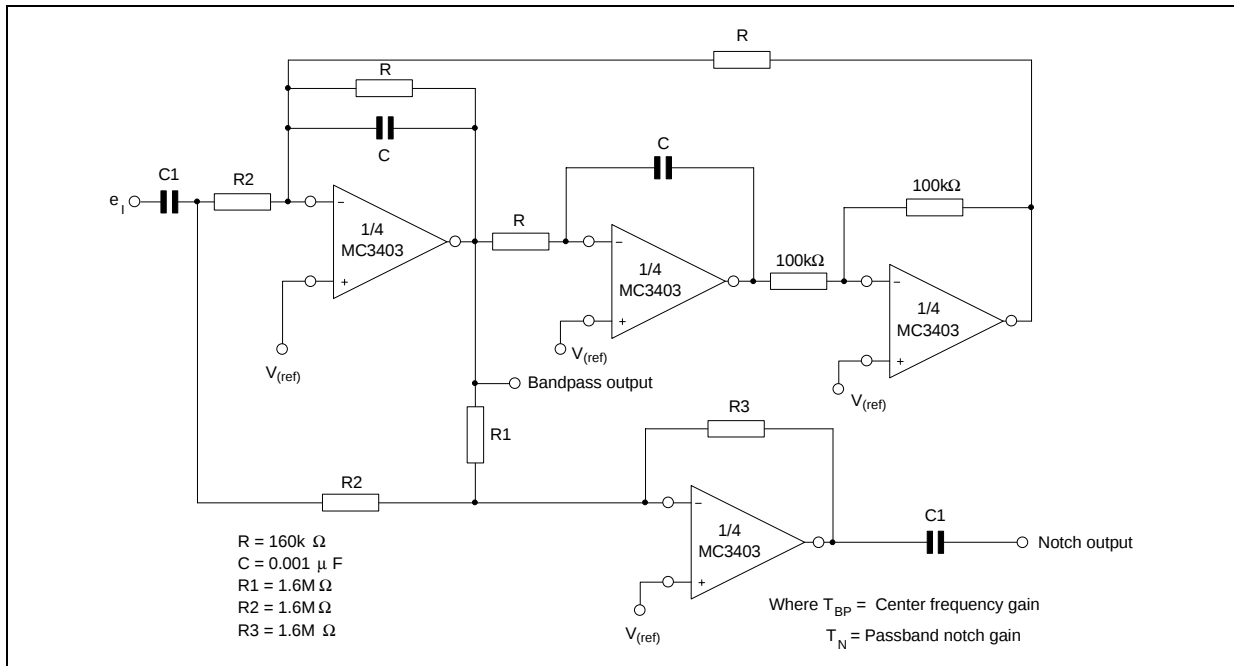
### HIGH IMPEDANCE DIFFERENTIAL AMPLIFIER



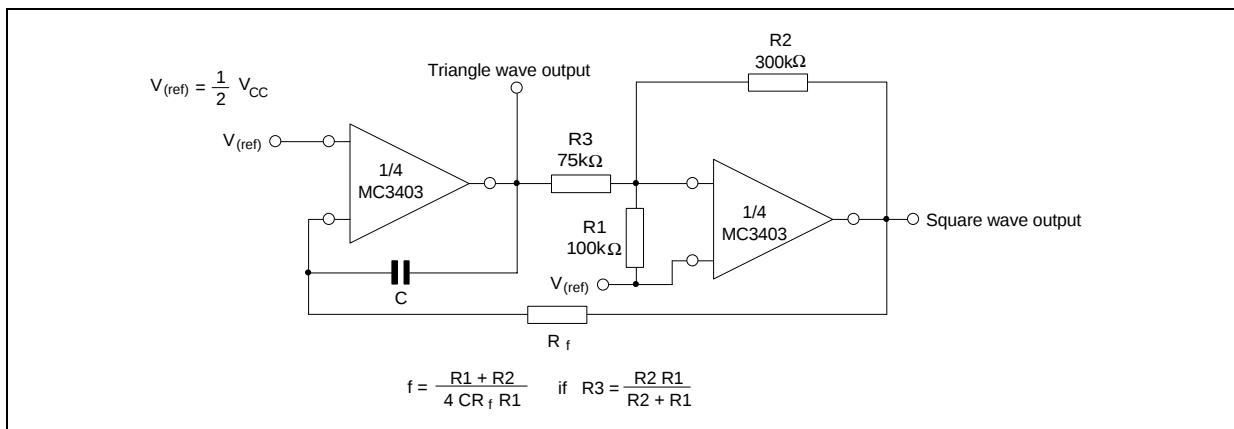
### COMPARATOR WITH HYSTERESIS



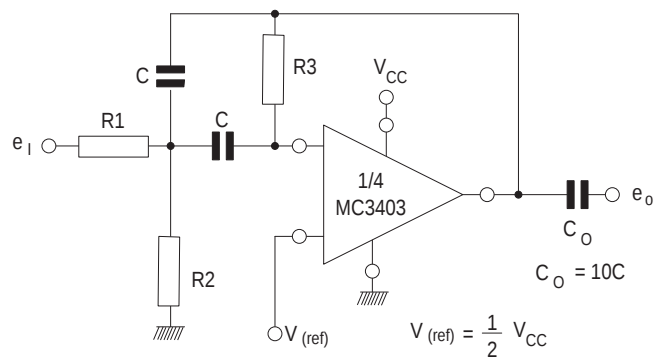
### BI-QUAD FILTER



### FUNCTION GENERATOR



## MULTIPLE FEEDBACK BANDPASS FILTER



Given  $f_o$  = center frequency ; chose values  $f_o$ ,  $C$  than  
 $A(f_o)$  = gain at center frequency

$$R3 = \frac{Q}{f_o C}$$

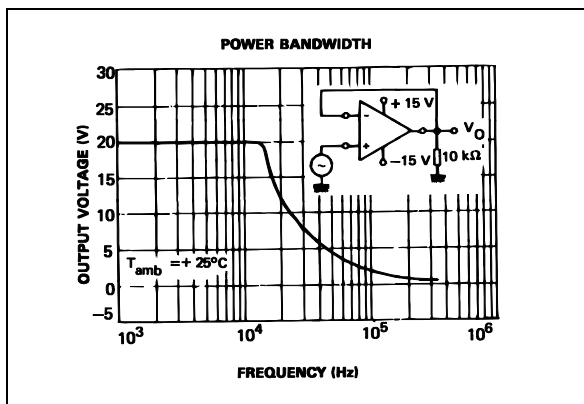
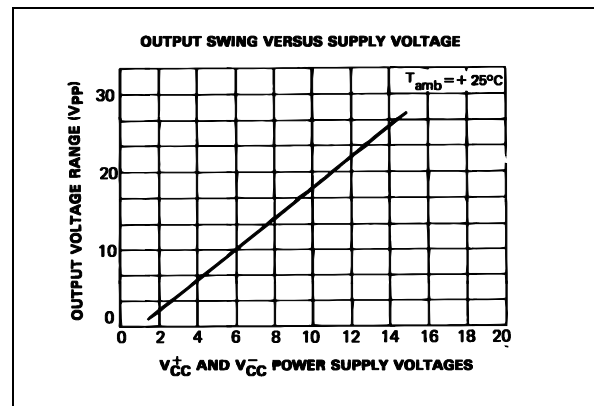
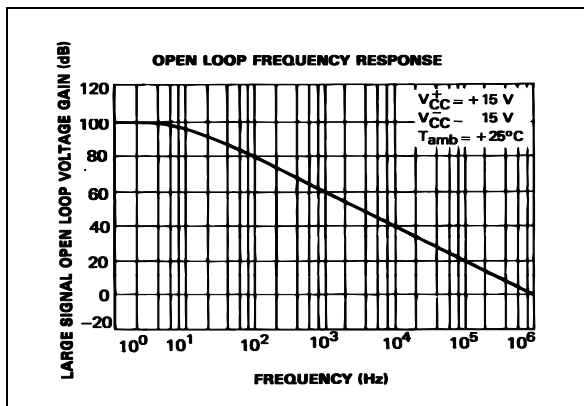
$$R1 = \frac{R3}{2A(f_o)}$$

$$R2 = \frac{R1 R3}{4Q^2 R1 - R3}$$

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

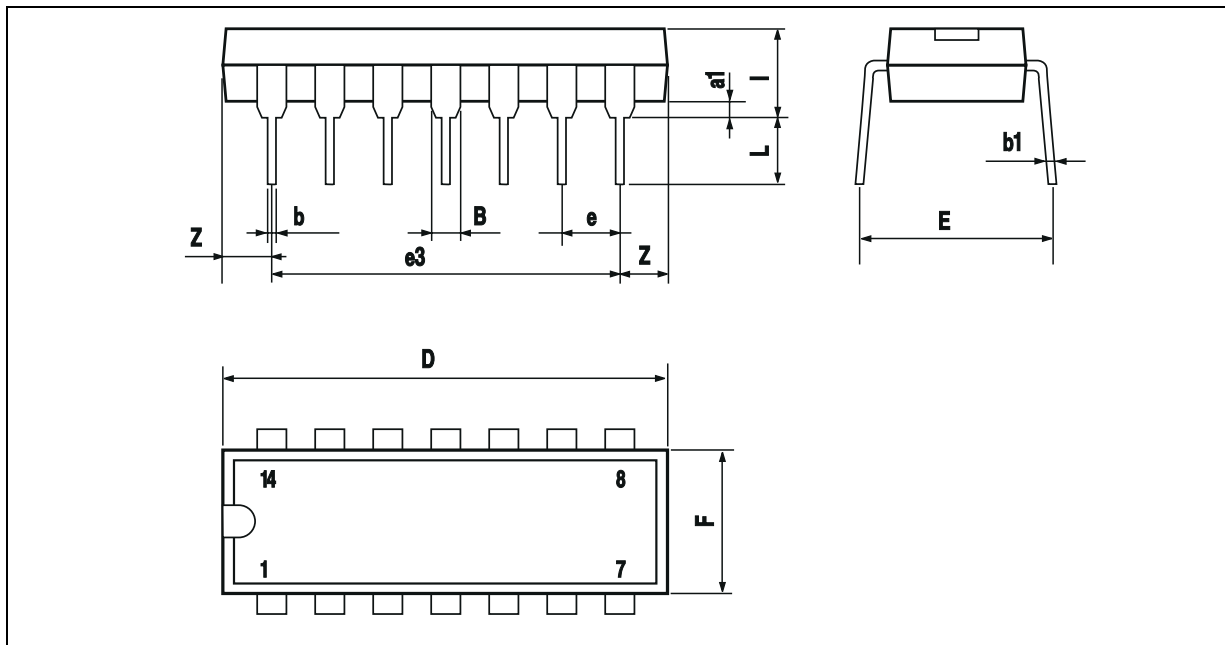
If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters

## TYPICAL PERFORMANCE CURVES



## PACKAGE MECHANICAL DATA

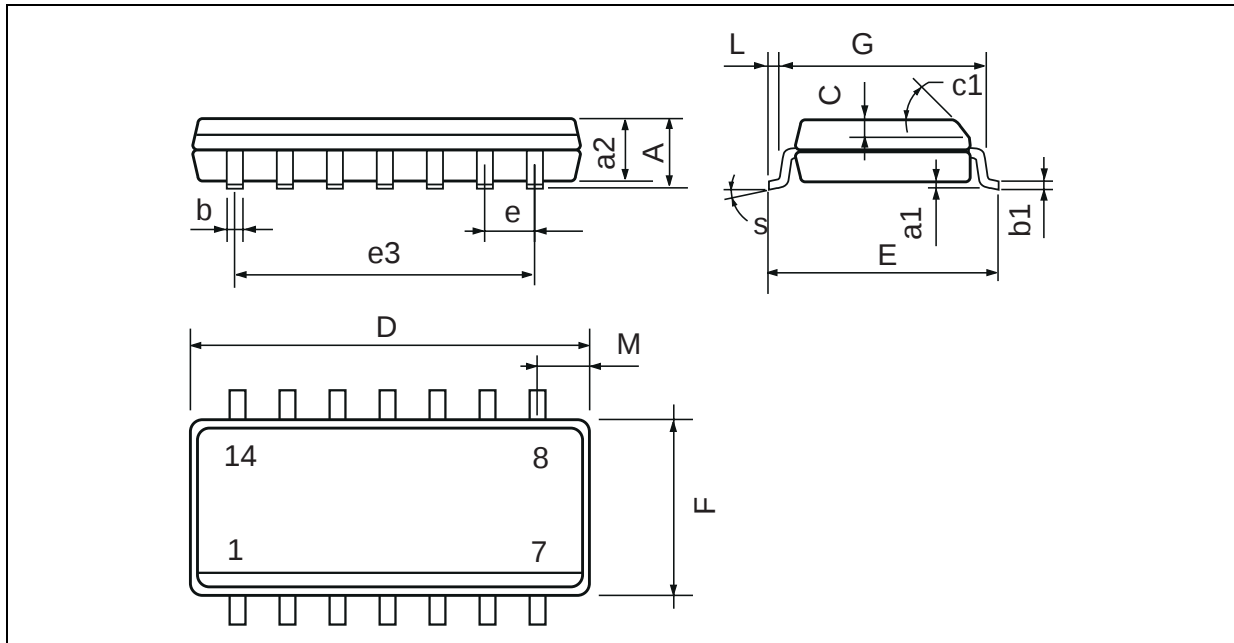
14 PINS - PLASTIC PACKAGE



| Dimensions | Millimeters |       |      | Inches |       |       |
|------------|-------------|-------|------|--------|-------|-------|
|            | Min.        | Typ.  | Max. | Min.   | Typ.  | Max.  |
| $a_1$      | 0.51        |       |      | 0.020  |       |       |
| $B$        | 1.39        |       | 1.65 | 0.055  |       | 0.065 |
| $b$        |             | 0.5   |      |        | 0.020 |       |
| $b_1$      |             | 0.25  |      |        | 0.010 |       |
| $D$        |             |       | 20   |        |       | 0.787 |
| $E$        |             | 8.5   |      |        | 0.335 |       |
| $e$        |             | 2.54  |      |        | 0.100 |       |
| $e_3$      |             | 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 |

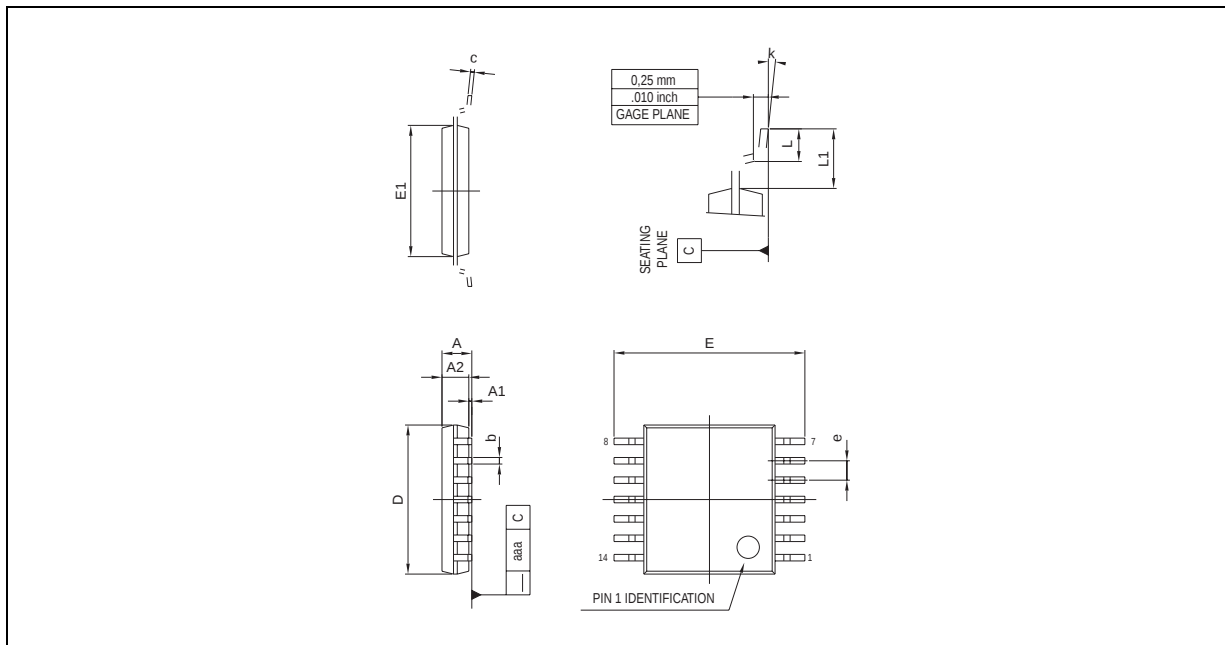
**PACKAGE MECHANICAL DATA**

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 (1)      | 8.55        |      | 8.75 | 0.336  |       | 0.344 |
| E          | 5.8         |      | 6.2  | 0.228  |       | 0.244 |
| e          |             | 1.27 |      |        | 0.050 |       |
| e3         |             | 7.62 |      |        | 0.300 |       |
| F (1)      | 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.)   |      |      |        |       |       |

Note : (1) D and F do not include mold flash or protrusions - Mold flash or protrusions shall not exceed 0.15mm (.066 inc) ONLY FOR DATA BOOK.

**PACKAGE MECHANICAL DATA****14 PINS - THIN SHRINK SMALL OUTLINE PACKAGE**

| Dimensions | Millimeters |       |       | Inches |       |       |
|------------|-------------|-------|-------|--------|-------|-------|
|            | Min.        | Typ.  | Max.  | Min.   | Typ.  | Max.  |
| A          |             |       | 1.20  |        |       | 0.05  |
| A1         | 0.05        |       | 0.15  | 0.01   |       | 0.006 |
| A2         | 0.80        | 1.00  | 1.05  | 0.031  | 0.039 | 0.041 |
| b          | 0.19        |       | 0.30  | 0.007  |       | 0.15  |
| c          | 0.09        |       | 0.20  | 0.003  |       | 0.012 |
| D          | 4.90        | 5.00  | 5.10  | 0.192  | 0.196 | 0.20  |
| E          |             | 6.40  |       |        | 0.252 |       |
| E1         | 4.30        | 4.40  | 4.50  | 0.169  | 0.173 | 0.177 |
| e          |             | 0.65  |       |        | 0.025 |       |
| k          | 0°          |       | 8°    | 0°     |       | 8°    |
| L          | 0.450       | 0.600 | 0.750 | 0.018  | 0.024 | 0.030 |
| L1         |             | 1.00  |       |        | 0.039 |       |
| aaa        |             |       | 0.100 |        |       | 0.004 |

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