

6367253 MOTOROLA SC (TELECOM)

01E 80608 D

T-79-05-20

## ORDERING INFORMATION

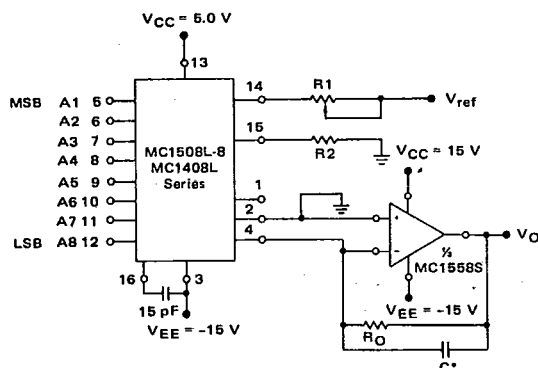
| Device    | Temperature Range | Package     |
|-----------|-------------------|-------------|
| MC1458SD  | 0°C to +70°C      | SO-8        |
| MC1458SG  | 0°C to +70°C      | Metal Can   |
| MC1458SP1 | 0°C to +70°C      | Plastic DIP |
| MC1458SU  | 0°C to +70°C      | Ceramic DIP |
| MC1558SG  | -55°C to +125°C   | Metal Can   |
| MC1558SU  | -55°C to +125°C   | Ceramic DIP |

## DUAL HIGH SLEW RATE INTERNALLY-COMPENSATED OPERATIONAL AMPLIFIERS

The MC1558S is functionally equivalent, pin compatible, and possesses the same ease of use as the popular MC1558 circuit, yet offers 20 times higher slew rate and power bandwidth. This device is ideally suited for D/A converters due to its fast settling time and high slew rate.

- High Slew Rate — 10 V/μs Guaranteed Minimum (for inverting unity gain only)
- No Frequency Compensation Required
- Short-Circuit Protection
- Offset Voltage Null Capability
- Wide Common-Mode and Differential Voltage Ranges
- Low Power Consumption
- No Latch-Up

## TYPICAL APPLICATION OUTPUT CURRENT TO VOLTAGE TRANSFORMATION FOR A D-TO-A CONVERTER



Settling time to within 1/2 LSB ( $\pm 19.5$  mV) is approximately 4.0 μs from the time that all bits are switched.

\*The value of C may be selected to minimize overshoot and ringing (C ≈ 68 pF).

Theoretical  $V_O$

$$V_O = \frac{V_{ref}}{R_1} (R_O) \left[ \frac{A_1}{2} + \frac{A_2}{4} + \frac{A_3}{8} + \frac{A_4}{16} + \frac{A_5}{32} + \frac{A_6}{64} + \frac{A_7}{128} + \frac{A_8}{256} \right]$$

Adjust  $V_{ref}$ ,  $R_1$  or  $R_O$  so that  $V_O$  with all digital inputs at high level is equal to 9.961 volts.

$$\begin{aligned} V_{ref} &= 2.0 \text{ Vdc} \\ R_1 &= R_2 \approx 1.0 \text{ k}\Omega \\ R_O &= 5.0 \text{ k}\Omega \end{aligned}$$

$$V_O = \frac{2 \text{ V}}{1 \text{ k}} (5 \text{ k}) \left[ \frac{1}{2} + \frac{1}{4} + \frac{1}{8} + \frac{1}{16} + \frac{1}{32} + \frac{1}{64} + \frac{1}{128} + \frac{1}{256} \right] = 10 \text{ V} \left[ \frac{255}{256} \right] = 9.961 \text{ V}$$

**MC1458S**  
**MC1558S**

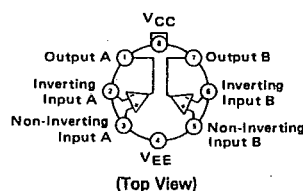
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DUAL  
OPERATIONAL AMPLIFIERS

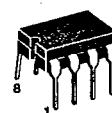
SILICON MONOLITHIC  
INTEGRATED CIRCUIT



**G SUFFIX**  
METAL PACKAGE  
CASE 601-04



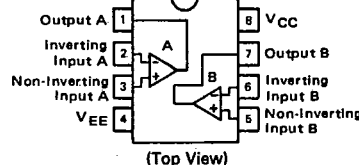
**P1 SUFFIX**  
PLASTIC PACKAGE  
CASE 626-05  
(MC1458S Only)



**U SUFFIX**  
CERAMIC PACKAGE  
CASE 693-02

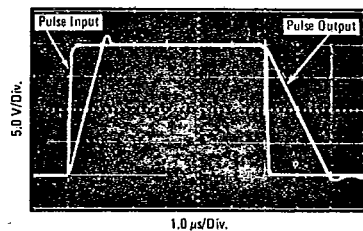
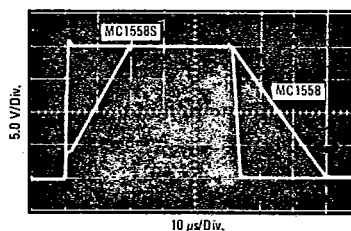


**D SUFFIX**  
PLASTIC PACKAGE  
CASE 751-02  
SO-8  
(MC1458S Only)

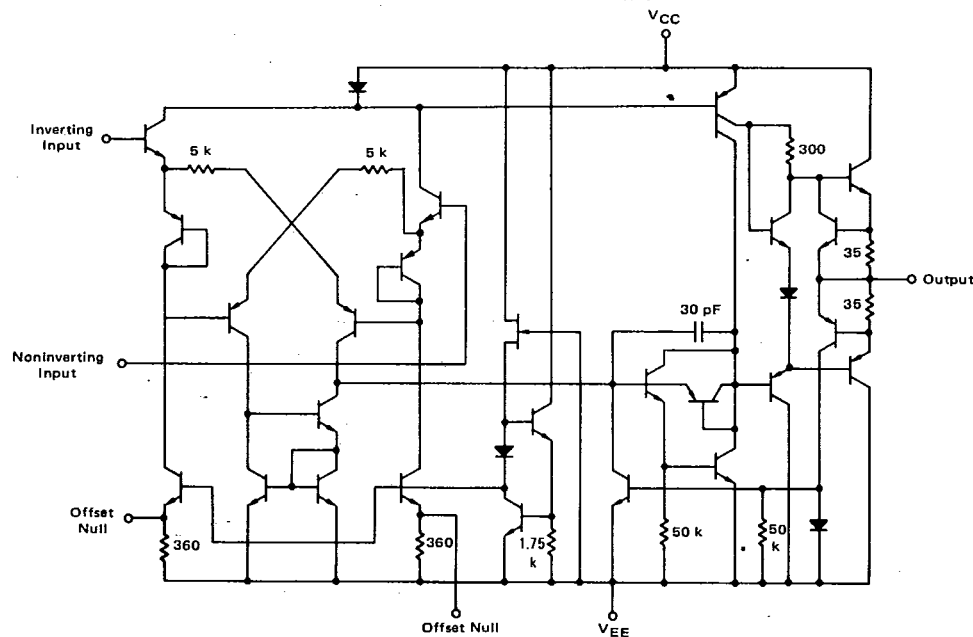


## MC1458S, MC1558S

T-79-05-20

MC1558S LARGE-SIGNAL TRANSIENT RESPONSE  
(Inverting Mode)STANDARD MC1558 versus MC1558S RESPONSE COMPARISON  
(Inverting Mode)

¼ REPRESENTATIVE CIRCUIT SCHEMATIC -

MAXIMUM RATINGS ( $T_A = +25^\circ\text{C}$  unless otherwise noted.)

| Rating                              | Symbol               | MC1558S     | MC1458S     | Unit             |
|-------------------------------------|----------------------|-------------|-------------|------------------|
| Power Supply Voltage                | $V_{CC}$<br>$V_{EE}$ | +22<br>-22  | +18<br>-18  | Vdc              |
| Input Differential Voltage Range ①  | $V_{IDR}$            | $\pm 30$    |             | Volts            |
| Input Common-Mode Voltage Range ②   | $V_{ICR}$            | $\pm 15$    |             | Volts            |
| Output Short Circuit Duration       | $t_S$                | Continuous  |             |                  |
| Operating Ambient Temperature Range | $T_A$                | -55 to +125 | 0 to +70    | $^\circ\text{C}$ |
| Storage Temperature Range           | $T_{stg}$            | -65 to +150 | -65 to +150 | $^\circ\text{C}$ |
| Junction Temperature                | $T_J$                | 175         | 175         | $^\circ\text{C}$ |
|                                     |                      | 150         | 150         | $^\circ\text{C}$ |

Note 1. For supply voltages less than  $\pm 15$  Vdc, the absolute maximum input voltage is equal to the supply voltage.

Note 2. Supply voltage equal to or less than 15 Vdc.

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01E 80610 D

## MC1458S, MC1558S

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ELECTRICAL CHARACTERISTICS ( $V_{CC} = +15$  Vdc,  $V_{EE} = -15$  Vdc,  $T_A = +25^\circ\text{C}$  unless otherwise noted.)

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| Characteristic                                                                                     | Symbol             | MC1558S              |                      |          | MC1458S              |                      |          | Unit            |
|----------------------------------------------------------------------------------------------------|--------------------|----------------------|----------------------|----------|----------------------|----------------------|----------|-----------------|
|                                                                                                    |                    | Min                  | Typ                  | Max      | Min                  | Typ                  | Max      |                 |
| Power Bandwidth (See Figure 3)<br>$A_V = 1$ , $R_L = 2.0$ k $\Omega$ , THD = 5%, $V_O = 20$ V(p-p) | BW <sub>p</sub>    | 150                  | 200                  | —        | 150                  | 200                  | —        | kHz             |
| Large-Signal Transient Response<br>Slew Rate (Figures 10 and 11)<br>V(-) to V(+)<br>V(+) to V(-)   | SR                 | 10<br>10             | 20<br>12             | —<br>—   | 10<br>10             | 20<br>12             | —<br>—   | V/ $\mu$ s      |
| Settling Time (Figures 10 and 11)<br>(to within 0.1%)                                              | $t_{settle}$       | —                    | 3.0                  | —        | —                    | 3.0                  | —        | $\mu$ s         |
| Small-Signal Transient Response<br>(Gain = 1, $E_{in} = 20$ mV, see Figures 7 and 8)               |                    |                      |                      |          |                      |                      |          |                 |
| Rise Time                                                                                          | $t_{TLH}$          | —                    | 0.25                 | —        | —                    | 0.25                 | —        | $\mu$ s         |
| Fall Time                                                                                          | $t_{THL}$          | —                    | 0.25                 | —        | —                    | 0.25                 | —        | $\mu$ s         |
| Propagation Delay Time                                                                             | $t_{PLH}, t_{PHL}$ | —                    | 0.25                 | —        | —                    | 0.25                 | —        | $\mu$ s         |
| Overshoot                                                                                          | OS                 | —                    | 20                   | —        | —                    | 20                   | —        | %               |
| Short-Circuit Output Currents                                                                      | $I_{OS}$           | $\pm 10$             | —                    | $\pm 45$ | $\pm 10$             | —                    | $\pm 45$ | mA              |
| Open-Loop Voltage Gain ( $R_L = 2.0$ k $\Omega$ ) (See Figure 4)<br>$V_O = \pm 10$ V               | $A_{VOL}$          | 50,000               | 200,000              | —        | 20,000               | 100,000              | —        | —               |
| Output Impedance ( $f = 20$ Hz)                                                                    | $z_o$              | —                    | 75                   | —        | —                    | 75                   | —        | $\Omega$        |
| Input Impedance ( $f = 20$ Hz)                                                                     | $z_i$              | 0.3                  | 1.0                  | —        | 0.3                  | 1.0                  | —        | M $\Omega$      |
| Output Voltage Swing<br>$R_L = 10$ k $\Omega$<br>$R_L = 2.0$ k $\Omega$                            | $V_O$              | $\pm 12$<br>$\pm 10$ | $\pm 14$<br>$\pm 13$ | —<br>—   | $\pm 12$<br>$\pm 10$ | $\pm 14$<br>$\pm 13$ | —<br>—   | V <sub>pk</sub> |
| Input Common-Mode Voltage Swing                                                                    | $V_{ICR}$          | $\pm 12$             | $\pm 13$             | —        | $\pm 12$             | $\pm 13$             | —        | V <sub>pk</sub> |
| Common-Mode Rejection Ratio ( $f = 20$ Hz)                                                         | CMRR               | 70                   | 90                   | —        | 70                   | 90                   | —        | dB              |
| Input Bias Current (See Figure 2)                                                                  | $I_{IB}$           | —                    | 200                  | 500      | —                    | 200                  | 500      | nA              |
| Input Offset Current                                                                               | $ I_{IO} $         | —                    | 30                   | 200      | —                    | 30                   | 200      | nA              |
| Input Offset Voltage ( $R_S = \leq 10$ k $\Omega$ )                                                | $ V_{IO} $         | —                    | 1.0                  | 5.0      | —                    | 2.0                  | 6.0      | mV              |
| DC Power Consumption (See Figure 9)<br>(Power Supply = $\pm 15$ V, $V_O = 0$ )                     | $P_C$              | —                    | 70                   | 150      | —                    | 70                   | 170      | mW              |
| Positive Voltage Supply Sensitivity<br>( $V_{EE}$ constant)                                        | PSS+               | —                    | 2.0                  | 150      | —                    | 2.0                  | 150      | $\mu$ V/V       |
| Negative Voltage Supply Sensitivity<br>( $V_{CC}$ constant)                                        | PSS-               | —                    | 10                   | 150      | —                    | 10                   | 150      | $\mu$ V/V       |

\*\* Plastic package offered in limited temperature range device only.

ELECTRICAL CHARACTERISTICS ( $V_{CC} = +15$  Vdc,  $V_{EE} = -15$  Vdc,  $T_A = -55$  to  $+125^\circ\text{C}$  for MC1558S and  $T_A = 0$  to  $70^\circ\text{C}$  for MC1458S, unless otherwise noted.)

| Characteristic                                                                                                    | Symbol    | MC1558S              |                 |                  | MC1458S              |             |               | Unit            |
|-------------------------------------------------------------------------------------------------------------------|-----------|----------------------|-----------------|------------------|----------------------|-------------|---------------|-----------------|
|                                                                                                                   |           | Min                  | Typ             | Max              | Min                  | Typ         | Max           |                 |
| Open Loop Voltage Gain<br>$V_O = \pm 10$ V                                                                        | $A_{VOL}$ | 25,000               | —               | —                | 15,000               | —           | —             | V/V             |
| Output Voltage Swing<br>$R_L = 10$ k $\Omega$<br>$R_L = 2$ k $\Omega$                                             | $V_O$     | $\pm 12$<br>$\pm 10$ | —<br>—          | —<br>—           | $\pm 12$<br>$\pm 10$ | —<br>—      | —<br>—        | V <sub>pk</sub> |
| Input Common-Mode Voltage Range                                                                                   | $V_{ICR}$ | $\pm 12$             | —               | —                | —                    | —           | —             | V <sub>pk</sub> |
| Common-Mode Rejection Ratio ( $f = 20$ Hz)                                                                        | CMRR      | 70                   | —               | —                | —                    | —           | —             | dB              |
| Input Bias Current<br>$T_A = 125^\circ\text{C}$<br>$T_A = -55^\circ\text{C}$<br>$T_A = 0$ to $70^\circ\text{C}$   | $I_{IB}$  | —<br>—<br>—          | 200<br>500<br>— | 500<br>1500<br>— | —<br>—<br>—          | —<br>—<br>— | —<br>—<br>800 | nA              |
| Input Offset Current<br>$T_A = 125^\circ\text{C}$<br>$T_A = -55^\circ\text{C}$<br>$T_A = 0$ to $70^\circ\text{C}$ | $I_{IO}$  | —<br>—<br>—          | 30<br>—<br>—    | 200<br>500<br>—  | —<br>—<br>—          | —<br>—<br>— | —<br>—<br>300 | nA              |
| Input Offset Voltage<br>$R_S = 10$ k $\Omega$                                                                     | $V_{IO}$  | —                    | —               | 6.0              | —                    | —           | 7.5           | mV              |
| DC Power Consumption<br>$V_O = 0$ V                                                                               | $P_C$     | —                    | —               | 200              | —                    | —           | —             | mW              |
| Positive Power Supply Sensitivity<br>$V_{EE} = -15$ V                                                             | PSS+      | —                    | —               | 150              | —                    | —           | —             | $\mu$ V/V       |
| Negative Power Supply Sensitivity<br>$V_{CC} = 15$ V                                                              | PSS-      | —                    | —               | 150              | —                    | —           | —             | $\mu$ V/V       |

## MC1458S, MC1558S

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## TYPICAL CHARACTERISTICS

(V<sub>CC</sub> = +15 Vdc, V<sub>EE</sub> = -15 Vdc, T<sub>A</sub> = +25°C unless otherwise noted.)

FIGURE 1 — OFFSET ADJUST CIRCUIT

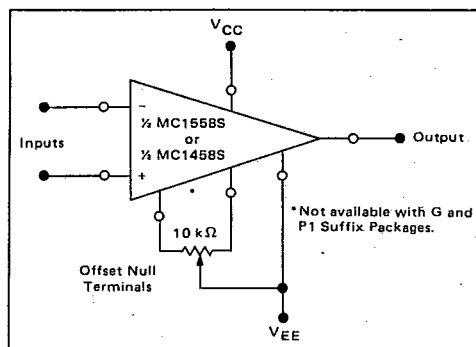


FIGURE 2 — INPUT BIAS CURRENT versus TEMPERATURE

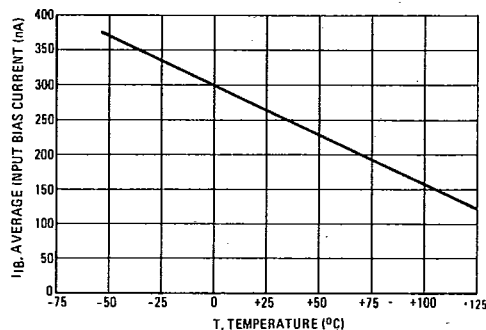


FIGURE 3 — POWER BANDWIDTH — NONDISTORTED OUTPUT VOLTAGE versus FREQUENCY

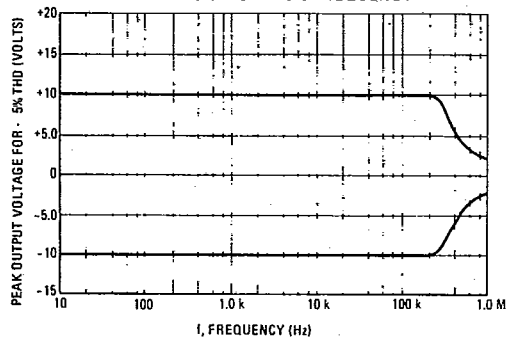


FIGURE 4 — OPEN-LOOP FREQUENCY RESPONSE

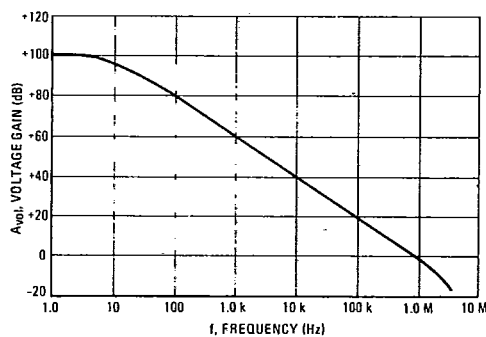
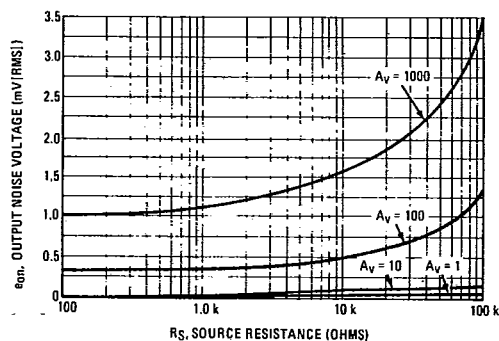


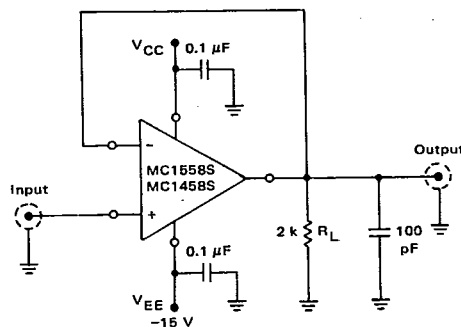
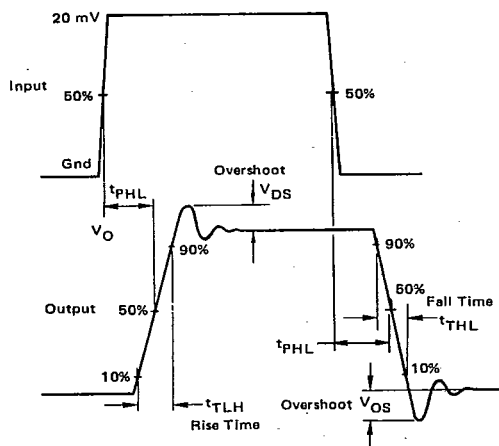
FIGURE 5 — OUTPUT NOISE versus SOURCE RESISTANCE



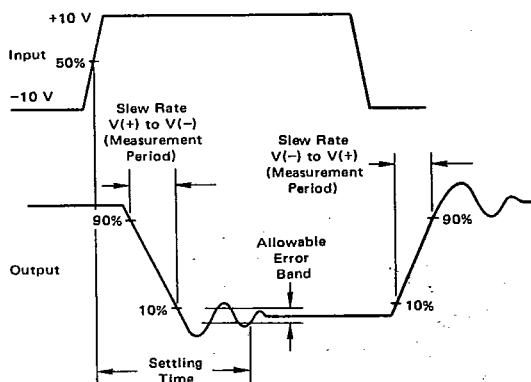
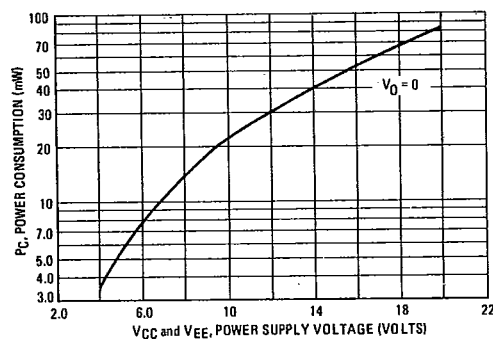
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( $V_{CC} = +15$  Vdc,  $V_{EE} = -15$  Vdc,  $T_A = +25^{\circ}\text{C}$  unless otherwise noted.)

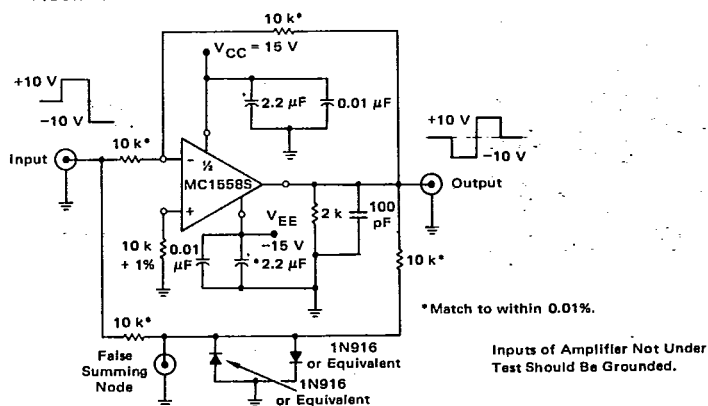
**FIGURE 7 – SMALL-SIGNAL TRANSIENT RESPONSE**



**FIGURE 9 – LARGE-SIGNAL TRANSIENT WAVEFORMS**



**FIGURE 10 – SLEW RATE AND SETTLING TIME TEST CIRCUIT\***



## MC1458S, MC1558S

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## SETTLING TIME

In order to properly utilize the high slew rate and fast settling time of an operational amplifier, a number of system considerations must be observed. Capacitance at the summing node and at the amplifier output must be minimal and circuit board layout should be consistent with common high-frequency considerations. Both power supply connections should be adequately bypassed as close as possible to the device pins. In bypassing, both low and high-frequency components should be considered to avoid the possibility of excessive ringing. In order to achieve optimum damping, the selection of a capacitor in parallel with the feedback resistor may be necessary. A value too small could result in excessive ringing while a value too large will degrade slew rate and settling time.

## SETTLING TIME MEASUREMENT

In order to accurately measure the settling time of an operational amplifier, it is suggested that the "false" summing junction approach be taken as shown in Figure 11. This is necessary since it is difficult to determine when the waveform at the output of the operational amplifier settles to within 0.1% of its final value. Because the output and input voltages are effectively subtracted from each other at the amplifier inverting input, this seems like an ideal node for the measurement. However, the probe capacitance at this critical node can greatly affect the accuracy of the actual measurement.

FIGURE 11 — WAVEFORM AT FALSE SUMMING NODE (Inverting Mode)

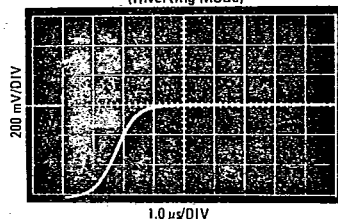
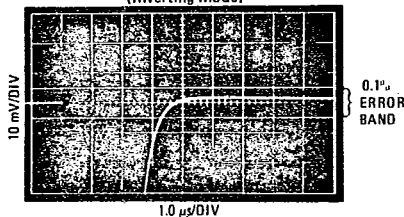


FIGURE 12 — EXPANDED WAVEFORM AT FALSE SUMMING NODE (Inverting Mode)



The solution to these problems is the creation of a second or "false" summing node. The addition of two diodes at this node clamps the error voltage to limit the voltage excursion to the oscilloscope. Because of the voltage divider effect, only one-half of the actual error appears at this node. For extremely critical measurements, the capacitance of the diodes and the oscilloscope, and the settling time of the oscilloscope must be considered. The expression

$$t_{setlg} = \sqrt{x^2 + y^2 + z^2}$$

can be used to determine the actual amplifier settling time, where

$t_{setlg}$  = observed settling time

$x$  = amplifier settling time (to be determined)

$y$  = false summing junction settling time

$z$  = oscilloscope settling time

It should be remembered that to settle within  $\pm 0.1\%$  requires  $7RC$  time constants.

The  $\pm 0.1\%$  factor was chosen for the MC1558S settling time as it is compatible with the  $\pm 1/2$  LSB accuracy of the MC1508L-8 digital-to-analog converter. This D-to-A converter features  $\pm 0.19\%$  maximum error.

## TYPICAL APPLICATION

FIGURE 13 — 12.5-WATT WIDEBAND POWER AMPLIFIER

