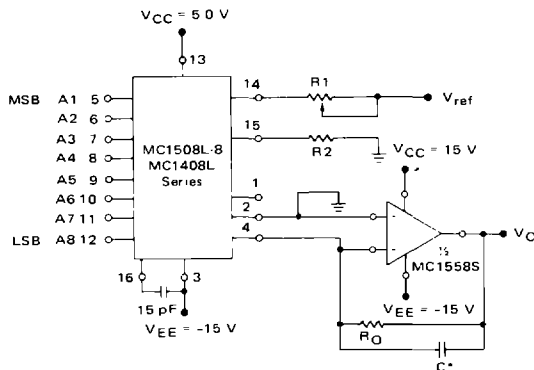**MC1458S**
MC1558S

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

DUAL
OPERATIONAL AMPLIFIERS

SILICON MONOLITHIC
INTEGRATED CIRCUIT

G SUFFIX
METAL PACKAGE
CASE 601

(Top View)
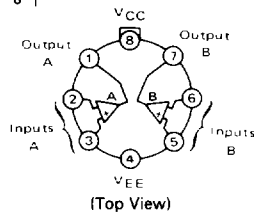
P1 SUFFIX
PLASTIC PACKAGE
CASE 626
(MC1458S Only)

U SUFFIX
CERAMIC PACKAGE
CASE 693

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

(Top View)

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

Settling time to within 1/2 LSB (±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

$$V_O = \frac{V_{ref}}{R1}\,(R_O)\left[\frac{A1}{2} + \frac{A2}{4} + \frac{A3}{8} + \frac{A4}{16} + \frac{A5}{32} + \frac{A6}{64} + \frac{A7}{128} + \frac{A8}{256}\right]$$

Adjust V_{ref}, R1 or R_O so that V_O with all digital inputs at high level is equal to 9.961 volts.

$$V_{ref} = 2.0 \text{ Vdc}$$
$$R1 = R2 \cong 1.0 \text{ k}\Omega$$
$$R_O = 5.0 \text{ k}\Omega$$

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

ORDERING INFORMATION

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

MOTOROLA LINEAR/INTERFACE DEVICES

MC1458S, MC1558S

MC1558S LARGE-SIGNAL TRANSIENT RESPONSE (Inverting Mode)	**STANDARD MC1558 versus MC1558S RESPONSE COMPARISON** (Inverting Mode)
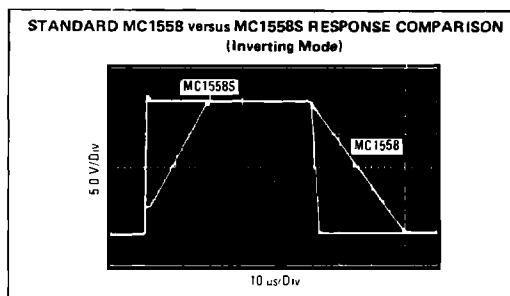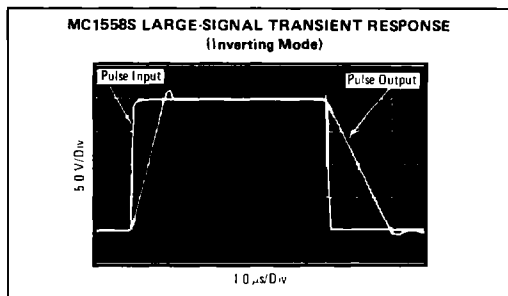
½ REPRESENTATIVE CIRCUIT SCHEMATIC
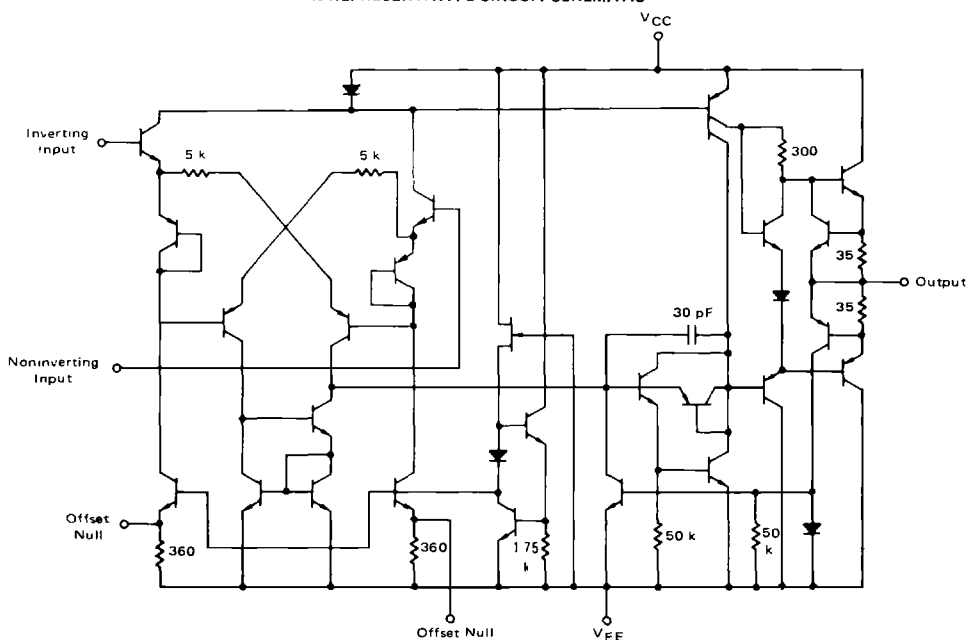
MAXIMUM RATINGS (T$_A$ = +25°C unless otherwise noted)

Rating	Symbol	MC1558S	MC1458S	Unit
Power Supply Voltage	V$_{CC}$	+22	+18	Vdc
	V$_{EE}$	−22	−18	
Input Differential Voltage Range ①	V$_{IDR}$	±30		Volts
Input Common-Mode Voltage Range ②	V$_{ICR}$	±15		Volts
Output Short Circuit Duration	t$_S$	Continuous		
Operating Ambient Temperature Range	T$_A$	−55 to +125	0 to +70	°C
Storage Temperature Range	T$_{stg}$	−65 to +150	−65 to +150	°C
Junction Temperature Ceramic and Metal Package	T$_J$	175	175	°C
Plastic Package		150	150	°C

Note 1   For supply voltages less than ±15 Vdc, the absolute maximum input voltage is equal to the supply voltage.
Note 2.   Supply voltage equal to or less than 15 Vdc.

ELECTRICAL CHARACTERISTICS (V$_{CC}$ = +15 Vdc, V$_{EE}$ = -15 Vdc, T$_A$ = +25°C unless otherwise noted.)

Characteristic	Symbol	MC1558S			MC1458S			Unit
		Min	Typ	Max	Min	Typ	Max	
Power Bandwidth (See Figure 3) A$_V$ = 1, R$_L$ = 2.0 kΩ, THD = 5%, V$_O$ = 20 V(p-p)	BW$_p$	150	200	–	150	200	–	kHz
Large-Signal Transient Response Slew Rate (Figures 10 and 11)	SR							V/µs
V(-) to V(+)		10	20	–	10	20	–	
V(+) to V(-)		10	12	–	10	12	–	
Settling Time (Figures 10 and 11) (to within 0.1%)	t$_{setlg}$	–	3.0	–	–	3.0	–	µs
Small-Signal Transient Response (Gain = 1, E$_{in}$ = 20 mV, see Figures 7 and 8)								
Rise Time	t$_{TLH}$	–	0.25	–	–	0.25	–	µs
Fall Time	t$_{THL}$	–	0.25	–	–	0.25	–	µs
Propagation Delay Time	t$_{PLH}$, t$_{PHL}$	–	0.25	–	–	0.25	–	µs
Overshoot	OS	–	20	–	–	20	–	%
Short-Circuit Output Currents	I$_{OS}$	±10	–	±45	±10	–	±45	mA
Open Loop Voltage Gain (R$_L$ = 2.0 kΩ) (See Figure 4) V$_O$ = ±10 V	A$_{VOL}$	50,000	200,000	–	20,000	100,000	–	–
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 Swing	V$_O$							V$_{pk}$
R$_L$ = 10 kΩ		±12	±14	–	±12	±14	–	
R$_L$ = 2.0 kΩ		±10	±13	–	±10	±13	–	
Input Common Mode Voltage Swing	V$_{ICR}$	±12	±13	–	±12	±13	–	V$_{pk}$
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$_S$ ≤ 10 kΩ)	|V$_{IO}$|	–	1.0	5.0	–	2.0	6.0	mV
DC Power Consumption (See Figure 9) (Power Supply = ±15 V, V$_O$ = 0)	P$_C$	–	70	150	–	70	170	mW
Positive Voltage Supply Sensitivity (V$_{EE}$ constant)	PSS+	–	2.0	150	–	2.0	150	µV/V
Negative Voltage Supply Sensitivity (V$_{CC}$ constant)	PSS-	–	10	150	–	10	150	µV/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°C for MC1558S and T$_A$ = 0 to 70°C for MC1458S, unless otherwise noted.)

Characteristic	Symbol	MC1558S			MC1458S			Unit
		Min	Typ	Max	Min	Typ	Max	
Open Loop Voltage Gain V$_O$ = ±10 V	A$_{VOL}$	25,000	–	–	15,000	–	–	V/V
Output Voltage Swing	V$_O$							V$_{pk}$
R$_L$ = 10 kΩ		±12	–	–	±12	–	–	
R$_L$ = 2 kΩ		±10	–	–	±10	–	–	
Input Common-Mode Voltage Range	V$_{ICR}$	±12	–	–	–	–	–	V$_{pk}$
Common-Mode Rejection Ratio (f = 20 Hz)	CMRR	70	–	–	–	–	–	dB
Input Bias Current	I$_{IB}$							nA
T$_A$ = 125°C		–	200	500	–	–	–	
T$_A$ = -55°C		–	500	1500	–	–	–	
T$_A$ = 0 to 70°C		–	–	–	–	–	800	
Input Offset Current	I$_{IO}$							nA
T$_A$ = 125°C		–	30	200	–	–	–	
T$_A$ = -55°C		–	–	500	–	–	–	
T$_A$ = 0 to 70°C		–	–	–	–	–	300	
Input Offset Voltage R$_S$ ≤ 10 kΩ	V$_{IO}$	–	–	6.0	–	–	7.5	mV
DC Power Consumption V$_O$ = 0	P$_C$	–	–	200	–	–	–	mW
Positive Power Supply Sensitivity V$_{EE}$ = -15 V	P$_{SS+}$	–	–	150	–	–	–	µV/V
Negative Power Supply Sensitivity V$_{CC}$ = 15 V	P$_{SS-}$	–	–	150	–	–	–	µV/V

MOTOROLA LINEAR/INTERFACE DEVICES

TYPICAL CHARACTERISTICS

(V_{CC} = +15 Vdc, V_{EE} = -15 Vdc, T_A = +25°C unless otherwise noted.)

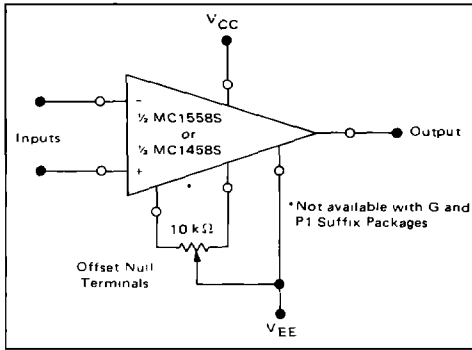### FIGURE 1 – OFFSET ADJUST CIRCUIT

FIGURE 2 – INPUT BIAS CURRENT versus TEMPERATURE
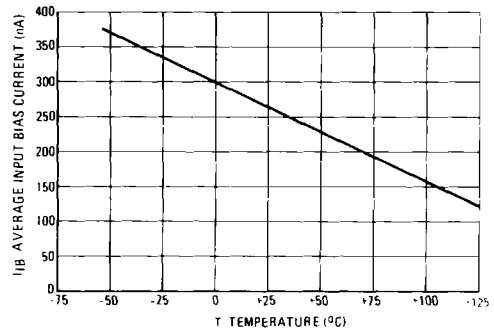

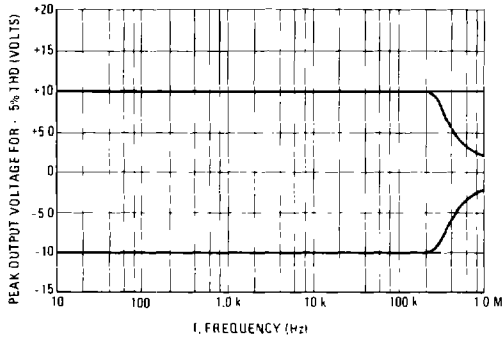### FIGURE 3 – POWER BANDWIDTH – NONDISTORTED OUTPUT VOLTAGE versus FREQUENCY
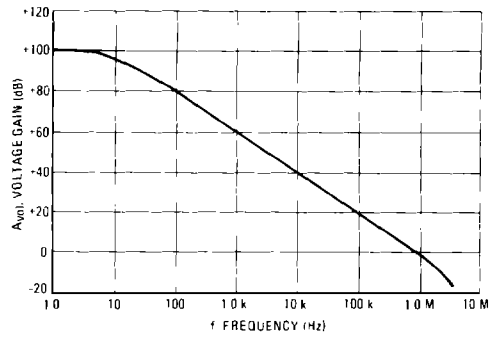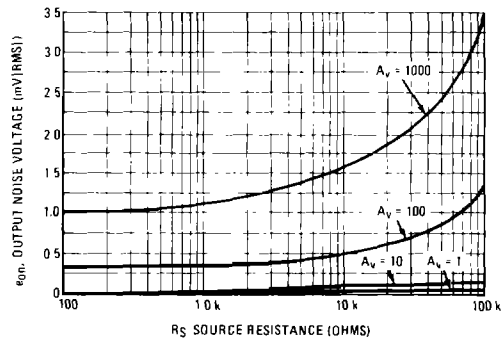

FIGURE 4 – OPEN-LOOP FREQUENCY RESPONSE

FIGURE 5 – OUTPUT NOISE versus SOURCE RESISTANCE

TYPICAL CHARACTERISTICS
(V_{CC} = +15 Vdc, V_{EE} = –15 Vdc, T_A = +25°C unless otherwise noted.)

2

FIGURE 6 – SMALL-SIGNAL TRANSIENT RESPONSE DEFINITIONS

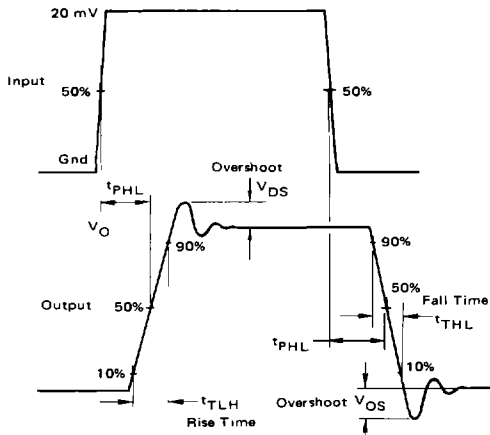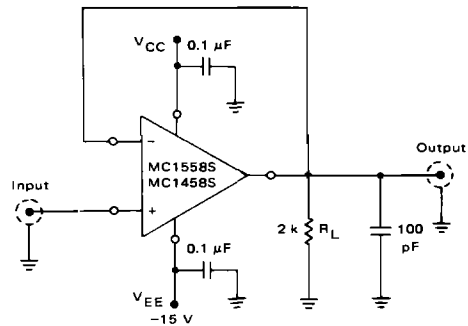FIGURE 7 – SMALL-SIGNAL TRANSIENT RESPONSE

FIGURE 8 – POWER CONSUMPTION versus POWER SUPPLY VOLTAGES

FIGURE 9 – LARGE-SIGNAL TRANSIENT WAVEFORMS
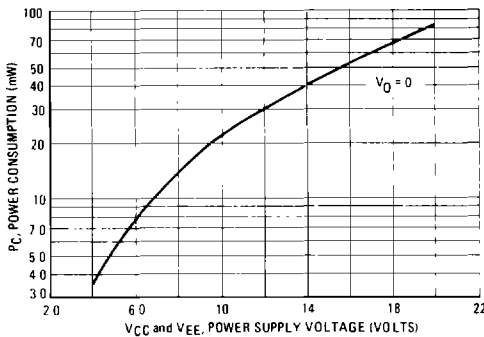
FIGURE 10 – SLEW RATE AND SETTLING TIME TEST CIRCUIT*

*Match to within 0.01%

Inputs of Amplifier Not Under Test Should Be Grounded.

MOTOROLA LINEAR/INTERFACE DEVICES

2
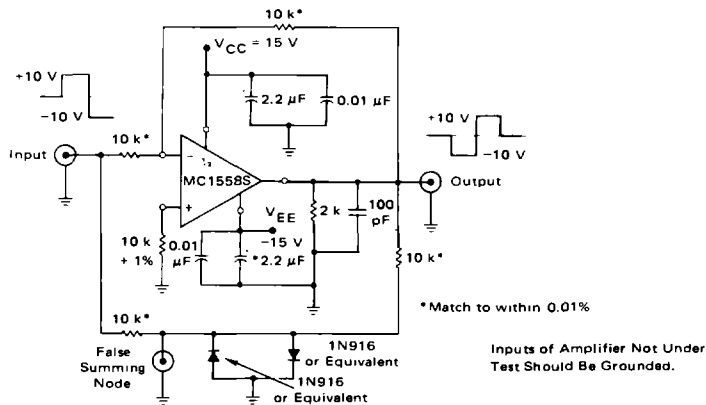
SETTLING TIME

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 it's 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

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 ±0.1% requires 7RC time constants.

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

TYPICAL APPLICATION

FIGURE 13 — 12 5-WATT WIDEBAND POWER AMPLIFIER

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

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

Delivers 12.5 watt into 4.0 ohms with less than 1% THD to 100 kHz.
Pins not shown are not connected.

*Bias current adjustment to eliminate Crossover Distortion.
**Epoxy to power transistor heat sink or case for maximum Thermal Feedback.