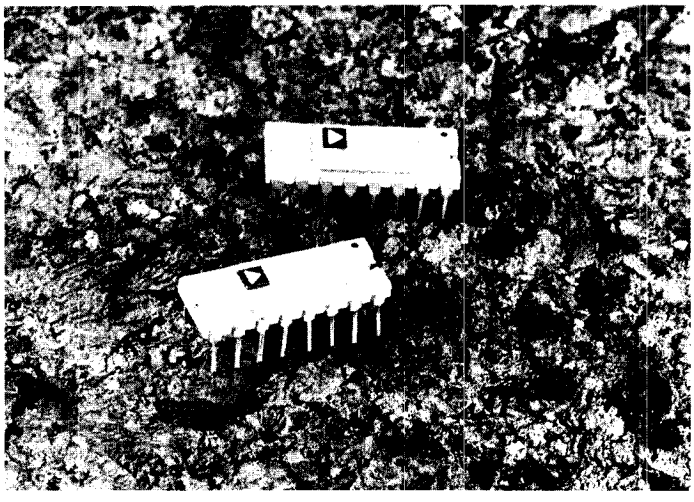
ANALOG DEVICES

# 8 Bit Monolithic D/A Converter

# AD559

FEATURES

- Replaces the Motorola 1408/1508 8-Bit DAC
- Guaranteed Monotonicity and Relative Accuracy Over Full Temperature Range
- Single Chip Monolithic Construction
- Hermetic 16 Pin Ceramic DIP
- High Stability SiCr Thin Film Resistors
- Low Cost



## PRODUCT DESCRIPTION

The AD559 is a low cost integrated circuit 8-bit digital-to-analog converter consisting of specially designed, precision bipolar switches, a control amplifier, and high stability silicon chromium thin-film resistors, all on a single monolithic chip. The single chip is mounted in a hermetically-sealed ceramic 16 lead dual in-line package.

A unique combination of advanced circuit design, and high stability SiCr thin film resistor processing provides the AD559 with true 8-bit accuracy at low I.C. costs. The maximum error over the full operating temperature range is limited to ½LSB and the gain temperature coefficient is 20ppm/°C typical. Monotonicity is guaranteed over the full operating temperature range of the devices.

The AD559 is recommended for all low cost, 8-bit DAC requirements and as a replacement for the Motorola 1408/1508 8-bit DAC, in most applications. The AD559K is specified for operation over the 0 to +75°C temperature range and the AD559S for operation over the full extended temperature range, -55°C to +125°C.

## PRODUCT HIGHLIGHTS

1. Monolithic I.C. construction makes the AD559 a logical choice where low cost is a prime consideration.
2. The AD559 replaces the Motorola 1408/1508 8-bit DAC in most applications. However, the capacitor needed to stabilize the 1408/1508 is not required when using the AD559.
3. High stability, thin film resistors enable the AD559 to provide low differential nonlinearity temperature coefficients, thus guaranteeing monotonicity and relative accuracy over the full operating temperature range.
4. Low digital input currents make the AD559 low voltage CMOS as well as TTL/DTL compatible.
5. The AD559 multiplies in two quadrants when a varying reference voltage is applied. When multiplication is not required, a fixed reference is used.
6. The device incorporates a newly developed, fully differential non-saturating precision current switching cell structure which provides increased immunity to supply voltage variations and also reduces nonlinearities due to thermal transients as the various bits are switched; nearly all critical components operate at constant power dissipation.

# SPECIFICATIONS (typical @ +25°C, $V_{CC}$ = +5V dc, $V_{EE}$ = -15V dc and $I_{REF}$ = 2mA, unless otherwise specified)

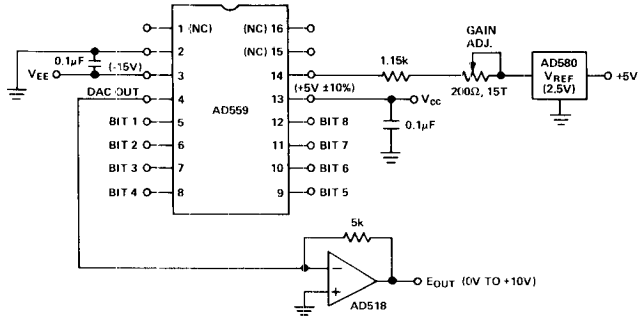
| Model | AD559KD/BIN | AD559SD/BIN |
|---|---|---|
| DATA INPUTS | | |
| Bit ON "Logic" 1 | ≥2.0V @ 1μA max | * |
| Bit OFF "Logic" 0 | ≤0.8V @ -100μA max | * |
| OUTPUT | | |
| Current (All Bits ON and $I_{REF}$ = +2.00mA) | 1.99mA, ±2% max Over Operating Temp Range | * |
| Resistance | 4MΩ | * |
| Capacitance | 33pF | * |
| Compliance Voltage (See Fig. 3) | -1.5 to +10.5V | * |
| Zero (All Bits OFF) | 200nA max Over Operating Temp Range | 1μA max Over Operating Temp Range |
| Full Scale Power Supply Sensitivity ($V_{CC}$ or $V_{EE}$) | 1μA/V max | * |
| RESOLUTION | 8 Bits | * |
| ACCURACY (Error Relative to Full Scale) | ½LSB max (0.19% of F.S.) | * |
| DIFFERENTIAL NONLINEARITY | ½LSB max | * |
| SETTLING TIME TO ½LSB (All Bits ON-to-OFF or OFF-to-ON) | 300ns Current Settling into Short Circuit | * |
| MAJOR CARRY SWITCHING TRANSIENT TO 90% COMPLETE | 100ns | * |
| NOISE | | |
| 0.1 to 10Hz (All Bits ON) | 8nA (p-p) | * |
| POWER REQUIREMENT Over Full Operating Range | | |
| $V_{CC}$ | +4.5V dc to +5.5V dc @ 8mA max | * |
| $V_{EE}$ | -11.5V dc to -16.5V dc @ 16mA max | * |
| TEMPERATURE RANGE | | |
| Operating | 0 to +75°C | -55°C to +125°C |
| Storage | -55°C to +150°C | * |
| TEMPERATURE COEFFICIENT | | |
| Gain | 20ppm of F.S./°C | * |
| Differential Nonlinearity | 2ppm of F.S./°C | * |
| MONOTONICITY | Guaranteed for 8 Bits Over Operating Temp Range | * |
| RATIOMETRIC PERFORMANCE | | |
| Reference Current | 0 to +3mA, Unipolar | * |
| Accuracy @ 200μA Ref. Current | 2LSB | * |
| Accuracy @ 2mA, ±1mA Ref. Current | ½LSB | * |
| Reference Feedthrough (All Bits OFF and 0 to +2mA p-p Sine Wave Ref. Current) Frequency for ½LSB p-p Output | 24kHz | * |
| Reference Amp Slew Rate (All Bits ON and 2mA Step Change in Ref. Current) | 4mA/μs | * |
| Output Settling Time to ½LSB (All Bits ON and 2mA Step Change in Ref. Current) | 1μs | * |
| Control Amplifier Small-Signal Closed Loop Bandwidth | 1.5MHz | * |
| Control Amplifier Full-Power Bandwidth | 500kHz | * |

*Specifications same as AD559KD.

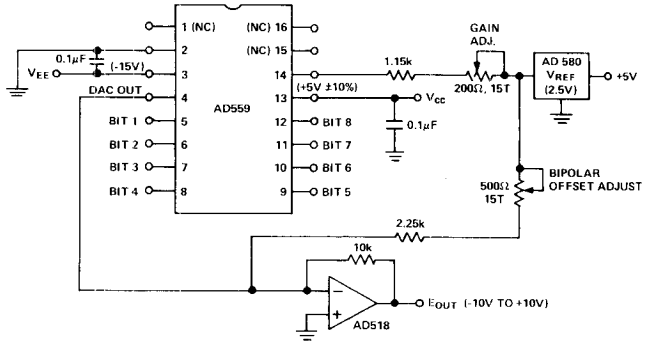
Specifications subject to change without notice.

Figure 1 shows a typical connection scheme for the AD559. The control amplifier input current of +2.0mA is obtained from an AD580, 2.5V voltage reference. Pin 14, the summing node of the control amplifier, is maintained at 0V (virtual ground). Reference voltages other than +2.5V may be used by selecting $R_{REF} + R_g$ such that $V_{REF}/(R_{REF} + R_g) = 2mA$.

Note, however, that increasing $R_{REF} + R_g$ above 3.5kΩ (or $V_{REF} > 7V$) makes the control amplifier transient response underdamped and increases the settling time. The settling time can be restored to its specified value by connecting a resistor $R_X$ between pins 14 and 2 where $R_X \| (R_{REF} + R_g) = 1.25k\Omega$. $R_X$ returns the control amplifier bandwidth to the value which minimizes settling time. (Since $R_X$ is connected across 0V, the device gain is unaffected.)




*a) Unipolar Output*




*b) Bipolar Output*

*Figure 1. Typical Connection Diagram for the AD559*

**CALIBRATION PROCEDURE FOR UNIPOLAR OUTPUTS**

1. With all bits OFF, adjust the external operational amplifier null pot for $E_{OUT}$ = 0.000V.
2. With all bits ON, adjust the gain trim for $E_{OUT}$ = Nominal Full Scale -1LSB = +9.961V. (1LSB = 10V/256 = 39.1mV).

**CALIBRATION PROCEDURE FOR BIPOLAR OUTPUTS**

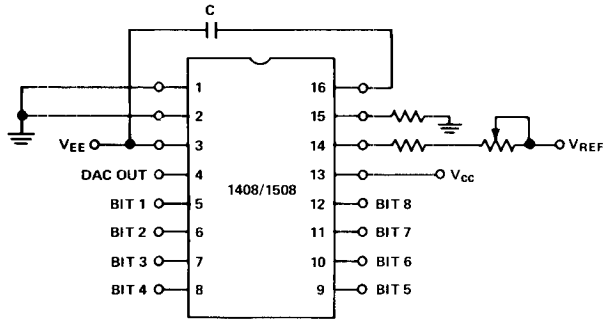
1. With all bits OFF, adjust the bipolar offset trim for $E_{OUT}$ = -10.000V.
2. With Bit 1 (MSB) ON and Bits 2 through 8 OFF, adjust the gain trim for $E_{OUT}$ = 0.000V.
3. With all bits ON, check that $E_{OUT}$ = +10V -1LSB = +9.921V. (1LSB = 20V/256 = 78.2mV.)

**THE AD559 AS A REPLACEMENT FOR THE 1408/1508 8-BIT DAC**

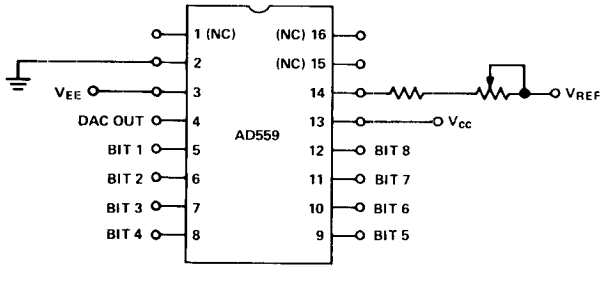
The AD559 is a superior alternative to the Motorola 1408/1508 8-bit DAC in most applications. Internal compensation is provided, thus eliminating the need for the external capacitor required by the Motorola device. Furthermore, the AD559's digital input currents are several orders of magnitude lower than the 1408/1508, making the AD559 completely CMOS compatible. The AD559 has the additional advantage of guaranteeing not only relative accuracy, but also differential nonlinearity (±½LSB max at +25°C) and complete monotonicity over the full operating temperature range.

Figure 2 is a comparative connection diagram for use in 1408/1508 replacement applications. The compensation capacitor, reference amplifier, balance resistor and compliance range control (pins 16, 15, and 1, respectively) are not required by the AD559; these pins are left uncommitted, enabling the user to plug the AD559 into existing circuits containing these components as well as to design it into new applications where these parts are omitted.

The AD559 is unconditionally stable for all reference voltages up to +10V. For reference voltages greater than +7V, a resistor, $R_X$ (where $R_X \| R_{REF} + R_g$) = 1.25k may be used to minimize device settling time by compensating for the larger input resistance required at the control amplifier.




*a) 1408/1508*




*b) AD559*

*Figure 2. 1408/1508 – AD559 Pin Out Comparison*

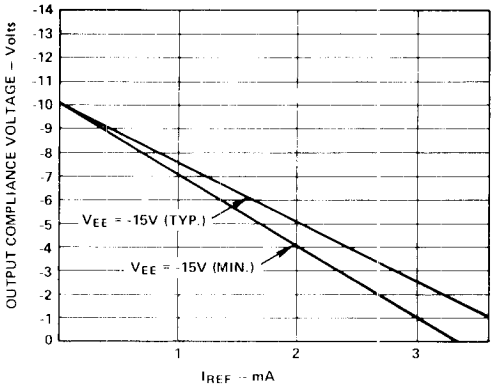



*Figure 3. AD559 Output Compliance Voltage vs. Reference Current for $V_{EE} = -15V$*

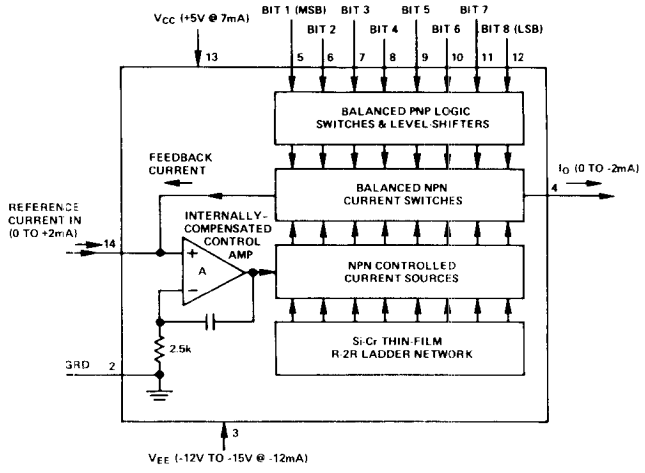
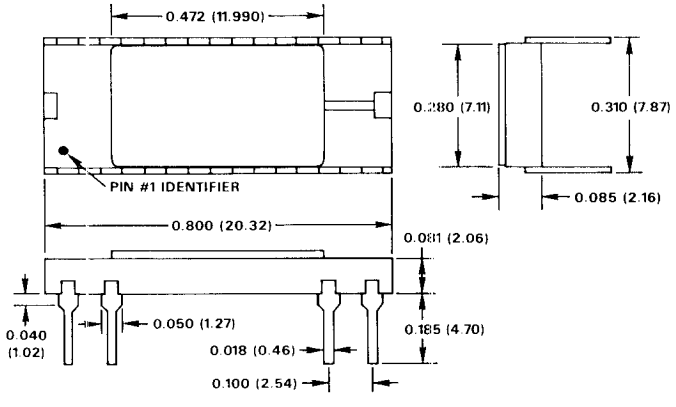



*Figure 4. AD559 Block Diagram*




*Dimensions shown in inches and (mm)*

*Figure 5. Physical Dimensions*