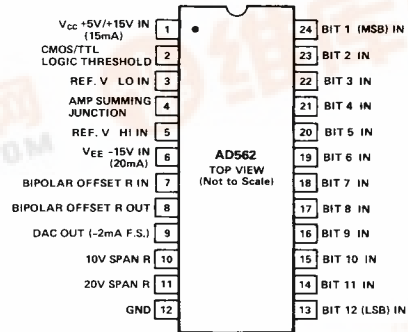# ANALOG DEVICES

IC 12-Bit D/A Converters
AD562/AD563*

2

FEATURES
True 12-Bit Accuracy
Guaranteed Monotonicity Over Full Temperature Range
Hermetic 24-Pin DIP
TTL/DTL and CMOS Compatibility
Positive True Logic
MIL-STD-883-Compliant Versions Available

PIN CONFIGURATIONS

Pin	AD562 TOP VIEW (Not to Scale)	Pin
1	Vcc +5V/+15V IN (15mA)	24 BIT 1 (MSB) IN
2	CMOS/TTL LOGIC THRESHOLD	23 BIT 2 IN
3	REF. V LO IN	22 BIT 3 IN
4	AMP SUMMING JUNCTION	21 BIT 4 IN
5	REF. V HI IN	20 BIT 5 IN
6	VEE -15V IN (20mA)	19 BIT 6 IN
7	BIPOLAR OFFSET R IN	18 BIT 7 IN
8	BIPOLAR OFFSET R OUT	17 BIT 8 IN
9	DAC OUT (-2mA F.S.)	16 BIT 9 IN
10	10V SPAN R	15 BIT 10 IN
11	20V SPAN R	14 BIT 11 IN
12	GND	13 BIT 12 (LSB) IN

| Pin	AD563 TOP VIEW (Not to Scale)	Pin
1	Vcc +5V/+15V IN	24 BIT 1 (MSB) IN
2	CMOS/TTL LOGIC THRESHOLD	23 BIT 2 IN
3	REFERENCE SUPPLY IN	22 BIT 3 IN
4	REFERENCE OUT (+2.5V ±3%)	21 BIT 4 IN
5	REF GND	20 BIT 5 IN
6	REFERENCE IN	19 BIT 6 IN
7	VEE -15V	18 BIT 7 IN
8	BIPOLAR OFFSET IN	17 BIT 8 IN
9	DAC OUT (-2mA F.S.)	16 BIT 9 IN
10	10V SPAN R	15 BIT 10 IN
11	20V SPAN R	14 BIT 11 IN
12	GND	13 BIT 12 (LSB) IN

PRODUCT DESCRIPTION
The AD562/AD563 are monolithic 12-bit digital-to-analog converters consisting of especially designed precision bipolar switches and control amplifiers and compatible high stability silicon chromium thin film resistors. The AD563 also includes its own internal voltage reference.

A unique combination of advanced circuit design, high stability SiCr thin film resistor processing and laser trimming technology provide the AD562/AD563 with true 12-bit accuracy. The maximum error at +25°C is limited to ±½LSB on all versions and monotonicity is guaranteed over the full operating temperature range.

The AD562 and AD563 are recommended for high accuracy 12-bit D/A converter applications where true 12-bit performance is required, but low cost and small size are considerations. Both devices are also ideal for use in constructing A/D conversion systems and as building blocks for higher resolution D/A systems. J and K versions are specified for operation over the 0 to +70°C temperature range, the S and T for operation over the extended temperature range, –55°C to +125°C.
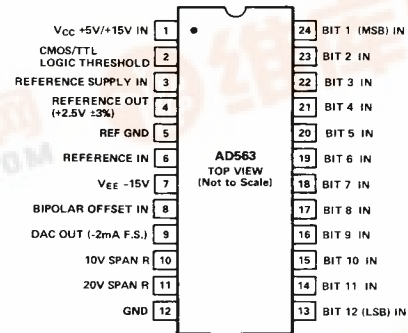
PRODUCT HIGHLIGHTS
1. The AD562 multiplies in two quadrants when a varying reference voltage is applied. When multiplication is not required, the AD563 is recommended with its internal low drift voltage reference.

2. True 12-bit resolution is achieved with guaranteed monotonicity over the full operating temperature range. Voltage outputs are easily implemented by using an external operational amplifier and tne AD562/AD563s internally provided feedback resistors.

3. The devices incorporate a newly developed and fully differential, non-saturating precision current switching cell structure which provides increased immunity to supply voltage variation and also reduces nonlinearities due to thermal transients as the various bits are switched; nearly all critical components operate at constant power dissipation.

4. The thin film resistor network contains gain, range, and bipolar offset resistors so that various output voltage ranges can be programmed by changing connections to the device terminal leads. Thin film resistors are laser trimmed while the device is powered to accurately calibrate all scale factors. The scale factors are dependent upon the tracking coefficient (<±2ppm/°C) of these resistors, rather than upon their absolute temperature coefficients.

5. TTL or CMOS inputs can be accommodated for supply voltages from +5V to +15V.

6. Positive true logic eliminates the need for additional inverter components.

7. The AD562 and AD563 are available in versions compliant with MIL-STD-883. Refer to the Analog Devices Military Products Databook or current /883B data sheet for detailed specifications.

REV. A

AD562/AD563 — SPECIFICATIONS (T_A = +25°C, otherwise specified.)

MODEL	AD562KD/BIN AD562KD/BCD	AD562AD/BIN AD562AD/BCD	AD562SD/BIN AD562SD/BCD
DATA INPUTS (positive True, Binary (BCD)) and Offset Binary (BCD)) TTL, V_{CC} = +5V, Pin 2			
Open Circuit			
Bit ON Logic "1"	+2.0V	•	•
Bit OFF Logic "0"	+0.8V max	•	•
CMOS, 4.75 ≤ V_{CC} ≤ 15.8, Pin 2 Tied to Pin 1			
Bit ON Logic "1"	70%V_{CC} min	•	•
Bit OFF Logic "0"	30%V_{CC} max	•	•
Logic Current (Each Bit)			
Bit ON Logic "1"	+20nA typ, +100nA max	•	•
Bit OFF Logic "0"	–50µA typ, –100µA max	•	•
OUTPUT			
Current			
Unipolar	–1.6mA min, –2.0mA typ, –2.4mA max	•	•
Bipolar	±0.8mA min, ±1.0mA typ, ±1.2mA max	•	•
Resistance (Exclusive of Span Resistors)	5.3kΩ min, 6.6kΩ typ, 7.9kΩ max	•	•
Unipolar Zero (All Bits OFF)	0.01% of F.S. typ, 0.05% of F.S. max	•	•
Capacitance	33pF typ	•	•
Compliance Voltage	–1.5V to +10V typ	•	•
RESOLUTION			
Binary	12 Bits	•	•
BCD	3 Digits	•	•
ACCURACY (Error Relative to Full Scale)			
Binary	±1/2LSB max	•	±1/4LSB max
BCD	±1/2LSB max	•	±1/10LSB max
DIFFERENTIAL NONLINEARITY	±1/2LSB max	• • •	• •
SETTLING TIME TO 1/2LSB			
All Bits ON-to-OFF or OFF-to-ON	1.5µs typ	•	•
POWER REQUIREMENTS			
V_{CC}, +4.75 to +15.8V dc	15mA typ, 18mA max	•	•
V_{EE}, –15V dc ±5%	20mA typ, 25mA max	•	•
POWER SUPPLY GAIN SENSITIVITY			
V_{CC} @ +5V dc	2ppm of F.S./% max	•	•
V_{CC} @ +15V dc	2ppm of F.S./% max	•	•
V_{EE} @ –15V dc	6ppm of F.S./% max	•	•
TEMPERATURE RANGE			
Operating	0 to +70°C typ	–25°C to +85°C	–55°C to +125°C
Storage	–65°C to +150°C typ	•	•
TEMPERATURE COEFFICIENT			
Unipolar Zero	2ppm of F.S./°C max	•	•
Bipolar Zero	4ppm of F.S./°C max	•	•
Gain	5ppm of F.S./°C max	•	•
Differential Nonlinearity	2ppm of F.S./°C	•	1ppm of F.S./°C
MONOTONICITY	Guaranteed Over Full Operating Temperature Range	• • •	• •
EXTERNAL ADJUSTMENTS[1]			
Gain Error with Fixed 50Ω Resistor	±0.2% of F.S. typ	•	•
Bipolar Zero Error with Fixed 50Ω Resistor	±0.1% of F.S. typ	•	•
Gain Adjustment Range	±0.25% of F.S. typ	•	•
Binary Bipolar Zero Adjustments Range	±0.25% of F.S. typ	•	•
BCD Bipolar Offset Adjustment Range	±0.17% of F.S. typ	•	•
PROGRAMMABLE OUTPUT			
RANGES	0 to +5V typ	•	•
	–2.5V to +2.5V typ	•	•
	0V to +10V typ	•	•
	–5V to +5V typ	•	•
	–10V to +10V typ	•	•
REFERENCE INPUT			
Input Impedance	20kΩ typ	•	•

•Specifications same as AD562KD. ••Specifications same as AD563KD. •••Specifications same as AD563JD. [1]Device calibrated with internal reference.
Specifications subject to change without notice.

AD563JD/BIN AD563JD/BCD	AD563KD/BIN AD563KD/BCD	AD563SD/BIN AD563SD/BCD	AD563TD/BIN AD563TD/BCD
• •	• •	• •	• •
• •	• •	• •	• •
• •	• •	• •	• •
• •	• •	• •	• •
• • • •	• • • •	• • • •	• • • •
• •	• •	• •	• •
• •	±1/4LSB ±1/4LSB	• • • •	• • • •
•	•	•	•
•	•	•	•
15mA typ, 20mA max •	• • • •	• • • •	• • • •
3ppm of F.S./% typ, 10ppm of F.S./% max 3ppm of F.S./% typ, 10ppm of F.S./% max 14ppm of F.S./% typ, 25ppm of F.S./% max	• • • • • • • • •	• • • • • • • • •	• • • • • • • • •
• •	• •	–55°C to +125°C •	–55°C to +125°C •
With Internal Reference 1ppm of F.S./°C typ, 2ppm of F.S./°C max 10ppm of F.S./°C max 50ppm of F.S./°C max •	• • • • • • 20ppm of F.S./°C max •	• • • • • • 30ppm of F.S./°C max •	• • • • • • 10ppm of F.S./°C max •
•	•	•	•
With Fixed 10Ω Resistor ±0.2% of F.S. typ	• • •	• • •	• • •
• •	• •	• •	• •
• •	• •	• •	• •
• • • •	• • • •	• • • •	• • • •
5kΩ typ	• • •	• • •	• • •

AD562/AD563

THE AD562/AD563 OFFERS TRUE 12-BIT RESOLUTION OVER FULL TEMPERATURE RANGE

Accuracy: Analog Devices defines accuracy as the maximum deviation of the actual DAC output from the ideal analog output (a straight line drawn from 0 to F.S. − 1LSB) *for any bit combination.* The AD563, for example, is laser trimmed to ¼LSB (0.006% of F.S.) maximum error at +25°C for K, S and T versions . . . ½LSB for the J version.

Monotonicity: A DAC is said to be monotonic if the output either increases or remains constant for increasing digital inputs such that the output will always be a single-valued function of the input. All versions of the AD562/AD563 are monotonic over their full operating temperature range.

Differential Nonlinearity: Monotonic behavior requires that the differential nonlinearity error be <1LSB both at 25°C and over the temperature range of interest. Differential nonlinearity is the measure of the variation in analog value, normalized to full scale, associated with a one LSB change in digital input code. For example, for a 10V full-scale output, a change of one LSB in the digital input code should result in a 2.4mV change in the analog output (10V x 1/4096 = 2.4mV). If in actual use, however, a one LSB change in the input code results in a change of 1.3mV in analog output, the differential nonlinearity would be 1.1mV, or 0.011% of F.S. The differential nonlinearity temperature coefficient must also be considered if the device is to remain monotonic over its full operating temperature range. A differential nonlinearity temperature coefficient of 1ppm/°C could, under worst case conditions for a temperature change of +25°C to +125°C, add 0.01% (100°C x 1ppm/°C) of error. The resulting error could then be as much as 0.006% + 0.01% = 0.016% of F.S. (1LSB represents 0.024% of F.S.). All versions of the AD563 are 100% tested to be monotonic over the full operating temperature range.

UNIPOLAR DAC's

STEP I . . . OUTPUT RANGE
Determine the output range required. For +10V F.S., connect the external operational amplifier output to Pin 10 and leave Pin 11 unconnected. For +5V F.S., connect the external op amp output to Pin 10 and short Pin 11 to Pin 9.

STEP II . . . ZERO ADJUST
Turn all bits OFF and adjust R_1 until op amp output is 0 volts.

STEP III . . . GAIN ADJUST
Turn all bits ON for binary DAC's (bits 1, 4, 5, 8, 9 and 12 ON for BCD DAC's). Adjust R_2 until op amp output is:

BINARY	BCD
4.9988V for +5V Range	4.9950 for +5V Range
9.9976 for +10V Range	9.9900 for +10V Range

BIPOLAR DAC's

Figure 1b is a typical connection scheme for the AD563 used in bipolar operation.

STEP I . . . OUTPUT RANGE
Determine the output range required. For ±10V F.S., connect the external op amp output to Pin 11 and leave Pin 10 unconnected. For ±5V F.S., connect the external op amp output to Pin 10 and leave Pin 11 unconnected. For ±2.5V F.S., connect the external op amp output to Pin 10 and short Pin 11 to Pin 9.

STEP II . . . OFFSET ADJUST
Turn all bits OFF and adjust R_3 until op amp output is:
   −2.5000V for ±2.5V Range
   −5.0000V for ±5V Range
   −10.0000V for ±10V Range

STEP III . . . GAIN ADJUST (Bipolar Zero)
Turn bit 1 ON for Binary DAC's (bits 2 and 4 ON for BCD DAC's). Adjust R_2 until op amp output is 0 volts.

ORDERING GUIDE

MODEL[1]	INPUT CODE	TEMP. RANGE	ACCURACY @ +25°C	GAIN T.C. (of F.S./°C)	PACKAGE OPTION[2]
AD562KD/BIN	Binary	0 to +70°C	±1/2LSB max	5ppm max	D-24A
AD562KD/BCD	Binary Coded Decimal	0 to +70°C	±1/2LSB max	5ppm max	D-24A
AD562AD/BIN	Binary	−25°C to +85°C	±1/2LSBmax	5ppm max	D-24A
AD562AD/BCD	Binary Coded Decimal	−25°C to +85°C	±1/2LSB max	5ppm max	D-24A
AD562SD/BIN	Binary	−55°C to +125°C	±1/4LSB max	5ppm max	D-24A
AD562SD/BCD	Binary Coded Decimal	−55°C to +125°C	±1/10LSB max	5ppm max	D-24A
AD563JD/BIN	Binary	0 to +70°C	±1/2LSB max	50ppm max	D-24A
AD563JD/BCD	Binary Coded Decimal	0 to +70°C	±1/2LSB max	50ppm max	D-24A
AD563KD/BIN	Binary	0 to +70°C	±1/4LSB max	20ppm max	D-24A
AD563KD/BCD	Binary Coded Decimal	0 to +70°C	±1/4LSB max	20ppm max	D-24A
AD563SD/BIN	Binary	−55°C to +125°C	±1/4LSB max	30ppm max	D-24A
AD563SD/BCD	Binary Coded Decimal	−55°C to +125°C	±1/4LSB max	30ppm max	D-24A
AD563TD/BIN	Binary	−55°C to +125°C	±1/4LSB max	10ppm max	D-24A
AD563TD/BCD	Binary Coded Decimal	−55°C to +125°C	±1/4LSB max	10ppm max	D-24A

NOTES
[1] For details on grade and package offerings screened in accordance with MIL-STD-883, refer to the Analog Devices Military Products Databook or current /883B data sheet.
[2] D = Ceramic DIP. For outline information see Package Information section.