

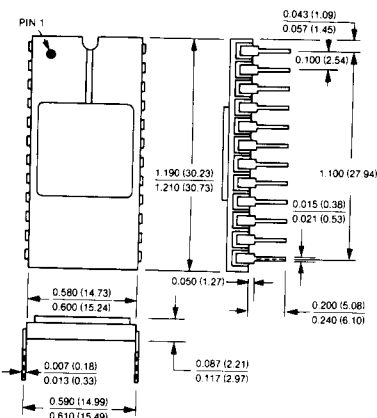
# MN565A

HIGH-SPEED, MONOLITHIC  
 12-BIT D/A CONVERTER  
 with REFERENCE

## FEATURES

- **Single-Chip Construction:**  
 Current Steering Switches  
 Thin-Film Resistor Network  
 Buried-Zener Reference  
 Output Feedback Resistors
- **250nsec Max Settling Time**  
 (2mA Step to  $\pm 1/2$  LSB)
- **Linearity and Monotonicity**  
 Guaranteed Over Temperature
- $\pm 12V$  to  $\pm 15V$  Supplies
- **24-Pin DIP**
- **345mW Max Power**  
 Consumption
- **Pin Compatible**  
 AD563, AD565, AD565A
- **Full Mil Operation**  
 $-55^{\circ}C$  to  $+125^{\circ}C$
- **MIL-STD-883 Screening**  
 Optional

## 24 PIN DIP



## DESCRIPTION

MN565A is a monolithic, 12-bit, current-output D/A converter with on-chip, buried-zener voltage reference. This single-chip device includes 12 high-speed, bipolar, current-steering switches; a precision buried-zener reference; a reference control amplifier; and a thin-film, silicon-chrome (SiCr) resistor network that includes R-2R ladder network, bipolar-offset resistor, feedback resistors and reference bias resistors. Active laser trimming of the thin-film resistors is used to set device integral linearity error to less than  $\pm 1/4$  LSB (K and T models); to set the reference for minimum Q point drift; to set the gain of the reference control amplifier to bring the reference output voltage to  $+10V$  ( $\pm 1\%$ ); and to set the values of the feedback resistors for the precise generation of 0 to  $+5V$ , 0 to  $+10V$ ,  $\pm 2.5V$ ,  $\pm 5V$  and  $\pm 10V$  output voltage ranges when the MN565A is used with an external output amplifier.

MN565A has output current ranges of 0 to  $-2mA$  and  $\pm 1mA$ . The very fast switching times of its fully differential, nonsaturating current switches result in output 10%-90% transition times of 50nsec (maximum) and full-scale settling times (to  $\pm 1/2$  LSB) of 250nsec (maximum).

MN565A is packaged in a standard, 24-pin, side-brazed, ceramic dual-in-line, and units are available in four performance grades for both commercial and military applications. J and K models are specified for  $0^{\circ}C$  to  $+70^{\circ}C$  operation. S and T models are specified for  $-55^{\circ}C$  to  $+125^{\circ}C$  operation and are available 100% screened to MIL-STD-883. MN565A is fully pin and function compatible with 563, 565 and 565A type 12-bit D/A converters made by other manufacturers.

Model Number	Temperature Range	Max Linearity Error ( $+25^{\circ}C$ )	Max Gain Drift (ppm/ $^{\circ}C$ )
MN565AJ	$0^{\circ}C$ to $+70^{\circ}C$	$\pm 1/2$ LSB	$\pm 50$
MN565AK	$0^{\circ}C$ to $+70^{\circ}C$	$\pm 1/4$ LSB	$\pm 20$
MN565AS	$-55^{\circ}C$ to $+125^{\circ}C$	$\pm 1/2$ LSB	$\pm 30$
MN565AS/B*	$-55^{\circ}C$ to $+125^{\circ}C$	$\pm 1/2$ LSB	$\pm 30$
MN565AT	$-55^{\circ}C$ to $+125^{\circ}C$	$\pm 1/4$ LSB	$\pm 15$
MN565AT/B*	$-55^{\circ}C$ to $+125^{\circ}C$	$\pm 1/4$ LSB	$\pm 15$

\*Includes MIL-STD-883 Screening. Contact factory for details.

# MN565A HIGH-SPEED, MONOLITHIC, 12-Bit, D/A CONVERTER with REFERENCE

## ABSOLUTE MAXIMUM RATINGS

Operating Temperature Range	-55°C to +125°C
Specified Temperature Range:	
MN565AJ, MN565AK	0°C to +70°C
MN565AS, S/B, T, T/B	-55°C to +125°C
Storage Temperature Range	-65°C to +150°C
+V <sub>cc</sub> Supply Voltage (Pin 3)	0 to +18 Volts
-V <sub>cc</sub> Supply Voltage (Pin 7)	0 to -18 Volts
Voltage on D/A Output (Pin 9)	-3 to +12 Volts
Voltage to Bipolar Offset Resistor (Pin 8)	±12 Volts
Voltage to 10V Span Resistor (Pin 10)	±12 Volts
Voltage to 20V Span Resistor (Pin 11)	±24 Volts
Reference Input (Pin 6)	±12Volts
Reference Output (Pin 4)	(Note 1)
Digital Inputs (Pins 13-24)	-1 to +7 Volts

## ORDERING INFORMATION

PART NUMBER \_\_\_\_\_ **MN565AX/B**

Select part number suffix (J, K, S or T) for performance level and specified temperature range.

Add "/B" suffix to S or T models for 100% screening according to MIL-STD-883. Contact factory for details.

## SPECIFICATIONS (T<sub>A</sub> = +25°C, ±V<sub>cc</sub> = ±15V unless otherwise indicated) (Note 2)

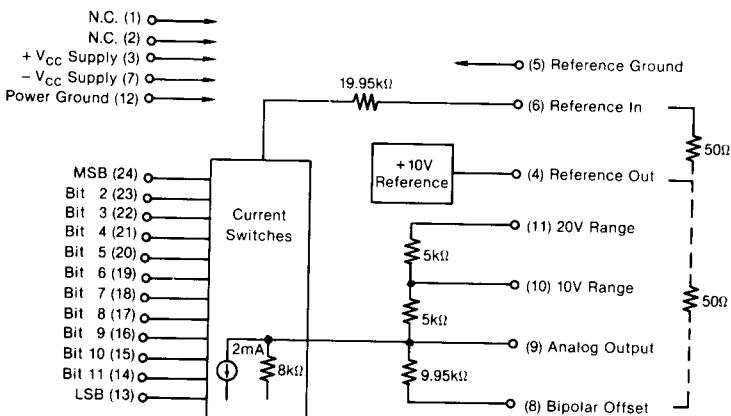
DIGITAL INPUTS	MIN.	TYP.	MAX.	UNITS
Logic Levels: Logic "1" Logic "0"	+2.0		+0.8	Volts Volts
Logic Currents: Logic "1" (V <sub>IH</sub> = +2.4) Logic "0" (V <sub>IL</sub> = +0.4)		+120 +35	+300 +100	μA μA
Logic Coding (Note 3): Current Output: Unipolar Bipolar Voltage Output (Note 4): Unipolar Bipolar	Complementary Binary Complementary Offset Binary Straight Binary Offset Binary			
<b>ANALOG OUTPUTS</b>				
Output Ranges: Current Output: Unipolar Bipolar Voltage Output (Note 4): Unipolar Bipolar	-1.6 ±0.8	-2 ±1	-2.4 ±1.2	mA mA Volts Volts
Output Impedance: Resistance Capacitance (Note 14)	6	8 25	10	kΩ pF
Compliance Voltage	-1.5		+10	Volts
<b>TRANSFER CHARACTERISTICS (Note 6)</b>				
Integral Linearity Error (Note 7): MN565AJ, MN565AS MN565AK, MN565AT		± ¼ ± ⅛	± ½ ± ¼	LSB LSB
Integral Linearity Over Temperature (Note 5): MN565AJ, MN565AS MN565AK, MN565AT		± ½ ± ¼	± ¾ ± ½	LSB LSB
Differential Linearity Error: MN565AJ, MN565AS MN565AK, MN565AT		± ½ ± ¼	± ¾ ± ½	LSB LSB
Monotonicity	Guaranteed Over Temperature			
Unipolar Offset Error (Notes 9,10): Initial (+25°C) Drift (Note 8)		±0.01 ±1	±0.05 ±2	%FSR ppm of FSR/°C
Bipolar Offset Error (Notes 9,11): Initial (+25°C): MN565AJ, MN565AS MN565AK, MN565AT Drift (Note 8): All Units		±0.05 ±0.05 ±5	±0.15 ±0.1 ±10	%FSR %FSR ppm of FSR/°C
Gain Error (Notes 9,12): Initial (+25°C) Drift (Note 8): MN565AJ MN565AK MN565AS MN565AT		±0.1 ±15 ±10 ±15 ±10	±0.25 ±50 ±20 ±30 ±15	% ppm/°C ppm/°C ppm/°C ppm/°C
<b>DYNAMIC CHARACTERISTICS</b>				
Settling Time (Full Scale Step to ±½LSB)		150	250	nsec
Full Scale Transition (10% to 90%) (Note 14): Delay Plus Rise Time Delay Plus Fall Time		15 30	30 50	nsec nsec

INTERNAL REFERENCE	MIN.	TYP.	MAX.	UNITS
Reference Input (Pin 6) Resistance	15	20	25	k $\Omega$
Reference Output (Pin 4): Voltage	+ 9.9	+ 10	+ 10.1	Volts
External Current (Notes 13,14)	1.5	2.5		mA
POWER SUPPLY REQUIREMENTS				
Power Supply Range	$\pm 11.4$	$\pm 15$	$\pm 16.5$	Volts
Power Supply Rejection: + 11.4V < + V <sub>CC</sub> < + 16.5V - 16.5V < - V <sub>CC</sub> < - 11.4V		$\pm 3$ $\pm 15$	$\pm 10$ $\pm 25$	ppm of FSR/% Supply ppm of FSR/% Supply
Current Drains: + V <sub>CC</sub> Supply - V <sub>CC</sub> Supply		+ 3 - 12	+ 5 - 18	mA mA
Power Consumption		225	345	mW

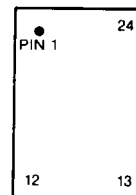
#### SPECIFICATION NOTES:

- Reference output (pin 4) can withstand a sustained short to ground and a momentary short to either supply.
- Listed specifications apply for all models of the MN565A unless otherwise indicated.
- See section labeled Digital Input Coding for additional details.
- Voltage output ranges are implemented using an external output op amp with the MN565A's internal feedback (span) resistors.
- Listed specification applies over each unit's full specified temperature range. MN565AJ and MN565AK are fully specified for 0°C to +70°C operation. MN565AS, AS/B and MN565AT, AT/B are fully specified for -55°C to +125°C operation.
- FSR stands for Full Scale Range and is equivalent to 2mA.
- Integral Linearity Error is equivalent to other manufacturers' "Accuracy Relative to Full Scale" specification. For a 12-bit converter, 1 LSB = 0.024% FSR.
- Specified using internal reference.
- Adjustable to zero with external potentiometers.
- Unipolar offset error is defined as the difference between the ideal and actual output voltage when 0000 0000 0000 is applied to the digital inputs. Listed specification assumes the device is in a unipolar configuration with a fixed 50 $\Omega$  resistor connected from Reference Output (pin 4) to Reference Input (pin 6) and Bipolar Offset (pin 8) is connected to Ground. Unipolar offset is specified and tested while MN565A is wired in a voltage out configuration using an external op amp in conjunction with the internal offset and range resistors. This specification does not include the offset of the external output op amp. See Unipolar Operation and Calibration section for further details.
- Bipolar offset error is defined as the difference between the ideal and actual output voltage when 1111 1111 1111 is applied to the digital inputs. Listed specification assumes the device is in a bipolar configuration with fixed 50 $\Omega$  resistors connected from Reference Output (pin 4) to Reference Input (pin 6) and between Reference Output (pin 4) and Bipolar Offset (pin 8). Bipolar offset is specified and tested while MN565A is wired in a voltage out configuration using an external op amp in conjunction with the internal offset and range resistors. This specification does not include the offset of the external output op amp. See Bipolar Operation and Calibration section for further details.
- Gain error is defined as the error in the slope of the converter transfer function. It is expressed as a percentage and is equivalent to the deviation (divided by the ideal value) between the actual and ideal value for the full output span from the 1111 1111 1111 output to the 0000 0000 0000 output. Listed specification assumes the MN565A is configured using an external op amp in the desired range and that the fixed 50 $\Omega$  resistors are connected as required. Gain error for all output ranges is specified and tested while MN565A is wired in a voltage output configuration using an external op amp in conjunction with the internal offset and range resistors.
- For operation at elevated temperatures, the reference cannot supply current for external loads and should be buffered.
- These parameters are listed for reference only and are not tested.

## BLOCK DIAGRAM



## PIN DESIGNATIONS



- |                            |                 |
|----------------------------|-----------------|
| 1 N.C.                     | 24 Bit 1 (MSB)  |
| 2 N.C.                     | 23 Bit 2        |
| 3 + V <sub>CC</sub> Supply | 22 Bit 3        |
| 4 Ref Out (+ 10V)          | 21 Bit 4        |
| 5 Reference Ground         | 20 Bit 5        |
| 6 Reference In             | 19 Bit 6        |
| 7 - V <sub>CC</sub> Supply | 18 Bit 7        |
| 8 Bipolar Offset           | 17 Bit 8        |
| 9 Analog Output            | 16 Bit 9        |
| 10 10V Range Resistor      | 15 Bit 10       |
| 11 20V Range Resistor      | 14 Bit 11       |
| 12 Power Ground            | 13 Bit 12 (LSB) |

# ORDERING INFORMATION

Part Number	Temperature Range	Max. Linearity Error (+25°C)	Max. Gain Error (+25°C)	Max. Gain Drift (ppm/°C)	Max. Settling Time (2)	Max. Power
MN565AJ	0°C to +70°C	± ½ LSB	± 0.25%	± 50	250nsec	345mW
MN565AK	0°C to +70°C	± ¼ LSB	± 0.25%	± 20	250nsec	345mW
MN565AS	-55°C to +125°C	± ½ LSB	± 0.25%	± 30	250nsec	345mW
MN565AS/B (1)	-55°C to +125°C	± ½ LSB	± 0.25%	± 30	250nsec	345mW
MN565AT	-55°C to +125°C	± ¼ LSB	± 0.25%	± 15	250nsec	345mW
MN565AT/B (1)	-55°C to +125°C	± ¼ LSB	± 0.25%	± 15	250nsec	345mW

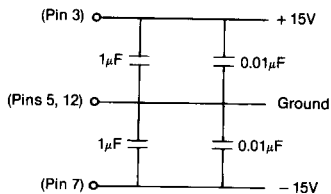
Notes: 1. Includes 100% screening to MIL-STD-883.  
2. Full scale step to ± ½ LSB.

## APPLICATIONS INFORMATION

**LAYOUT CONSIDERATIONS AND GROUNDING**—Proper attention to layout and decoupling is necessary to obtain specified accuracy from the MN565A. It is critically important that the device's power supplies be filtered, well-regulated and free from high-frequency noise. Use of noisy supplies may cause unstable and noisy output signals to be generated. Switching power supplies are not recommended for circuits attempting to achieve 12-bit accuracy unless great care is used in filtering any switching spikes present in the output.

MN565A's two ground systems (Power Ground, pin 12; Reference Ground, pin 5) are not connected to each other internal to the package. It is important that these pins are connected together and tied to system analog ground as close to the unit as possible, preferably through a large ground plane beneath the package.

Decoupling capacitors should be used on all power-supply pins; the supply decoupling capacitors should be connected directly from +Vcc (pin 3) and -Vcc (pin 7) to Power Ground (pin 12). Suitable decoupling capacitors are 1μF tantalum types in parallel with 0.01μF ceramic discs. See diagram below.



Coupling between analog signals and digital signals should be minimized to avoid noise pickup. Analog runs should be well separated from digital clock lines and other noise sources. The use of wire-wrap circuit construction is not recommended. Careful printed-circuit construction is preferred. If external offset and gain adjust potentiometers are used, the pots and associated series resistors should be located as close to the device as possible. If external gain adjustment is not used, replace the 100Ω potentiometer connected from Reference Output to Reference Input with a 50Ω ± 1% metal-film, fixed-value resistor. If unipolar offset adjustment is not used (0 to +5V, 0 to +10V ranges), connect Bipolar Offset (pin 8) to ground. If bipolar offset adjustment is not used (± 2.5V, ± 5V, ± 10V ranges), replace the 100Ω potentiometer connected from Reference Output (pin 4) to Reference Input (pin 6) with a 50Ω ± 1% metal-film, fixed-value resistor.

**OFFSET AND GAIN CALIBRATION** — Standard current-to-voltage conversion connections using an external operational amplifier are shown here with the suggested calibration circuits. If a low-offset amplifier (similar in performance to an OP-07) is used, excellent electrical performance can be obtained from MN565A in many applications without the use of external calibration circuits. If calibration is not required while operating MN565A in a unipolar configuration (0 to +5V or 0 to +10V ranges), the offset adjust network connected to Bipolar Offset (pin 8) should be omitted and Bipolar Offset (pin 8) should be connected to system analog ground. Also, the 100Ω potentiometer connected between Reference Output (pin 4) and Reference Input (pin 6) should be replaced with a 50Ω ± 1% metal-film, fixed-value resistor. If calibration is not required while operating MN565A in a bipolar configuration (± 2.5V, ± 5V or ± 10V ranges), both 100Ω potentiometers should be replaced with 50Ω ± 1% metal-film, fixed-value resistors.

**UNIPOLAR OPERATION AND CALIBRATION**—MN565A is shown here configured in the 0 to +10V range with optional offset and gain adjust circuits connected. If unipolar offset adjustment is not used, connect Bipolar Offset (pin 8) directly to Reference Ground (pin 5). (Note: As discussed earlier, Power Ground (pin 12) and Reference Ground (pin 5) are not connected internally and normally are tied together as close to the unit as possible and connected to system analog ground. See Layout Considerations for details). If gain adjustment is not used, replace the 100Ω potentiometer connected between Reference Output (pin 4) and Reference Input (pin 6) with a fixed-value, 50Ω ± 1%, metal-film resistor.

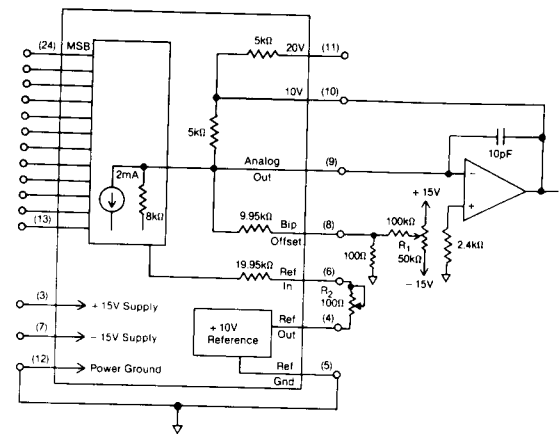
Unipolar offset and gain errors are specified and tested using an external op amp in conjunction with MN565A's internal bipolar offset and range resistors. Bipolar Offset (pin 8) is connected to ground and a 50Ω ± 1%, metal-film, fixed-value resistor is connected between Reference Output (pin 4) and Reference Input (pin 6). The offset of the external op amp is excluded from the unipolar offset error measurement.

Unipolar offset error refers to the accuracy of the voltage measured at the op amp's analog output when 0000 0000 0000 is applied to the digital inputs of the MN565A. MN565A's offset error, in combination with the offset of the external op amp, can be adjusted to zero with the use of the suggested calibration circuit. To offset adjust, apply 0000 0000 0000 to the digital inputs and adjust R<sub>1</sub> (50kΩ potentiometer) until the op amp output voltage equals 0.0000 Volts.

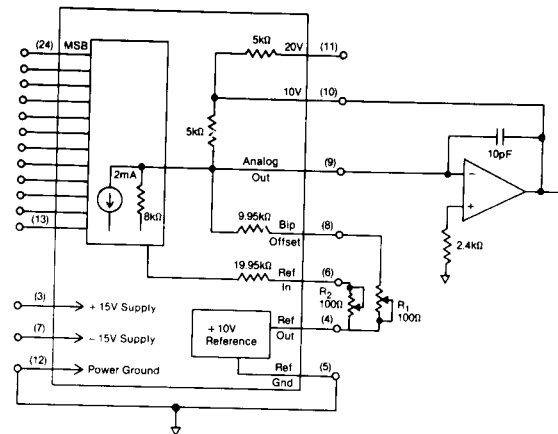
Unipolar gain error can be defined as the accuracy of the analog output voltage measured at the op amp's output after unipolar offset adjustment has been made. Gain adjustment is accomplished by applying 1111 1111 1111 to the digital inputs and adjusting R<sub>2</sub> (100Ω potentiometer) until the output voltage equals +9.9976 Volts.

If this device is configured in the 0 to +5V range, unipolar offset and gain adjustments are performed in the same manner as described above except that when gain adjusting, adjust R<sub>2</sub> until the op amp's output voltage is equal to +4.9988 Volts.

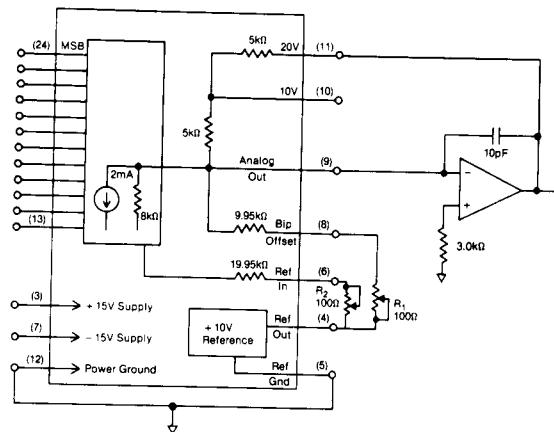
0 to +10V Unipolar Voltage Output



± 5V Bipolar Voltage Output



± 10V Bipolar Voltage Output



**BIPOLAR OPERATION AND CALIBRATION** — MN565A is shown here configured in the ± 5V and ± 10V ranges with optional offset and gain adjust circuits connected. If either bipolar offset or bipolar gain adjustments are not used, the 100Ω potentiometers (R<sub>1</sub> and R<sub>2</sub>) should be replaced with 50Ω metal-film, fixed-value resistors.

Bipolar offset error refers to the accuracy of the external op amp's analog output voltage when 0000 0000 0000 is applied to the digital inputs of MN565A. Bipolar offset and gain errors are specified and tested using an external op amp in conjunction with MN565A's internal bipolar offset and range resistors. Additionally, 50Ω ± 1%, metal-film, fixed-value resistors are connected between Reference Output (pin 4) and Reference Input (pin 6) and from Reference Output (pin 4) to Bipolar Offset (pin 8). The offset of the external op amp is excluded from the bipolar offset error measurement. To bipolar offset adjust, when configured in the ± 5V range, apply all "0"s to the digital inputs and adjust R<sub>1</sub> (100Ω potentiometer) until the op amp output voltage equals -5.0000 Volts. Bipolar gain error is defined as the accuracy of the external op amp's analog output voltage after bipolar offset adjustment has been made. To gain adjust, when configured in the ± 5V range, apply all "1"s to the digital inputs and adjust R<sub>2</sub> (100Ω potentiometer) until the op amp's output voltage is equal to +4.9976 Volts.

Offset and gain adjustment for the  $\pm 2.5V$  and  $\pm 10V$  ranges are performed in the same manner as described above except that when offset adjusting, adjust  $R_1$  until the op amp's output equals  $-2.5000$  Volts ( $\pm 2.5V$  range) or

$-10.0000$  Volts ( $\pm 10V$  range). When gain adjusting, adjust  $R_2$  until the op amp's output equals  $+2.4988$  Volts ( $\pm 2.5V$  range) or  $+9.9951$  Volts ( $\pm 10V$  range).

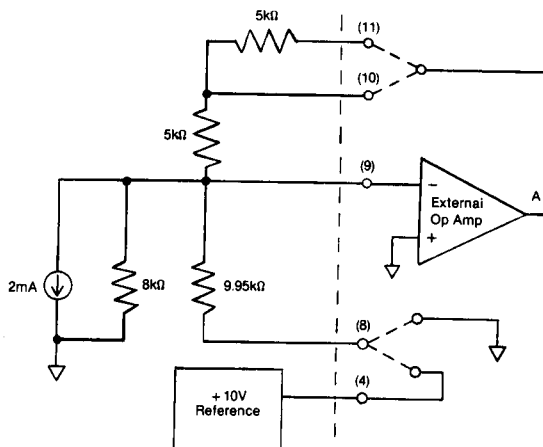
## OUTPUT RANGE SELECTION

Output Range	Connect A to	Connect Pin 8 to	Connect Pin 11 to	Connect Pin 10 to
$\pm 10V$	11	4	A	Open
$\pm 5V$	10	4	Open	A
$\pm 2.5V$	10	4	9	A
0 to +10V	10	5, 12	Open	A
0 to +5V	10	5, 12	9	A

### NOTES:

To achieve specified accuracies when configured in unipolar ranges, pin 8 should be connected directly to ground and a  $50\Omega \pm 1\%$  metal-film, fixed-value resistor inserted between pins 4 and 6.

To achieve specified accuracies when configured in bipolar ranges,  $50\Omega \pm 1\%$  metal-film, fixed-value resistors should be inserted between pins 4 and 8 and between pins 4 and 6.



## DIGITAL INPUT CODING

Digital Input		Voltage Output				Current Output		
MSB	LSB	0 to +5V	0 to +10V	$\pm 2.5V$	$\pm 5V$	$\pm 10V$	0 to -2mA	$\pm 1mA$
1111	1111 1111	+4.9988	+9.9976	+2.4988	+4.9976	+9.9951	-1.9995	-0.9995
1111	1111 1110	+4.9976	+9.9951	+2.4976	+4.9951	+9.9902	-1.9990	-0.9990
1000	0000 0000	+2.5000	+5.0000	0.0000	0.0000	0.0000	-1.0000	0.0000
0111	1111 1111	+2.4988	+4.9976	-0.0012	-0.0024	-0.0049	-0.9995	+0.0005
0000	0000 0001	+0.0012	+0.0024	-2.4988	-4.9976	-9.9951	-0.0005	+0.9995
0000	0000 0000	0.0000	0.0000	-2.5000	-5.0000	-10.0000	0.0000	+1.0000

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