Terminal Voltage ±5V, 32 Taps



X9313

E²**POT**[™] Nonvolatile Digital Potentiometer

FEATURES

- Low Power CMOS
 - $-V_{CC} = 3V \text{ to } 5.5V$
 - -Active Current, 3mA Max
 - —Standby Current, 500μA Max
- 31 Resistive Elements
 - —Temperature Compensated
 - -±20% End to End Resistance Range
 - -5V to +5V Range
- 32 Wiper Tap Points
 - -Wiper Positioned via Three-Wire Interface
 - -Similar to TTL Up/Down Counter
 - Wiper Position Stored in Nonvolatile Memory and Recalled on Power-Up
- 100 Year Wiper Position Data Retention
- $X9313Z = 1K\Omega$
- X9313W = $10K\Omega$
- Packages
 - -8-Lead MSOP
 - -8-Lead PDIP
 - -8-Lead SOIC

DESCRIPTION

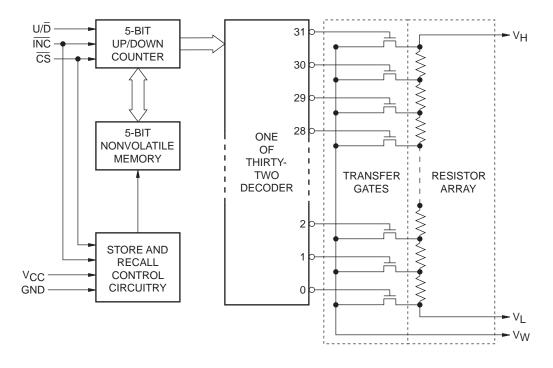
The Xicor X9313 is a solid state nonvolatile potentiometer and is ideal for digitally controlled resistance trimming.

The X9313 is a resistor array composed of 31 resistive elements. Between each element and at either end are tap points accessible to the wiper element. The position of the wiper element is controlled by the \overline{CS} , U/\overline{D} , and \overline{INC} inputs. The position of the wiper can be stored in nonvolatile memory and then be recalled upon a subsequent power-up operation.

The resolution of the X9313 is equal to the maximum resistance value divided by 31. As an example, for the X9313W (10K Ω) each tap point represents 323 Ω .

All Xicor nonvolatile memories are designed and tested for applications requiring extended endurance and data retention.

FUNCTIONAL DIAGRAM



3866 FHD F01

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PIN DESCRIPTIONS

V_H and V_L

The high (V_H) and low (V_L) terminals of the X9313 are equivalent to the fixed terminals of a mechanical potentiometer. The minimum voltage is –5V and the maximum is +5V. It should be noted that the terminology of V_L and V_H references the relative position of the terminal in relation to wiper movement direction selected by the U/ \overline{D} input and not the voltage potential on the terminal.

V_{W}

Vw is the wiper terminal, equivalent to the movable terminal of a mechanical potentiometer. The position of the wiper within the array is determined by the control inputs. The wiper terminal series resistance is typically 40Ω .

Up/Down (U/D)

The U/\overline{D} input controls the direction of the wiper movement and whether the counter is incremented or decremented.

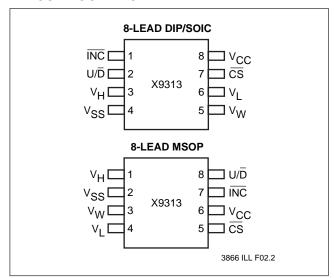
Increment (INC)

The $\overline{\text{INC}}$ input is negative-edge triggered. Toggling $\overline{\text{INC}}$ will move the wiper and either increment or decrement the counter in the direction indicated by the logic level on the U/\overline{D} input.

Chip Select (CS)

The device is selected when the $\overline{\text{CS}}$ input is LOW. The current counter value is stored in nonvolatile memory when $\overline{\text{CS}}$ is returned HIGH while the $\overline{\text{INC}}$ input is also HIGH. After the store operation is complete the X9313 will be placed in the low power standby mode until the device is selected once again.

PIN CONFIGURATION



PIN NAMES

Symbol	Description			
V _H	High Terminal			
V _W	Wiper Terminal			
V_L	Low Terminal			
V _{SS}	Ground			
V _{CC}	Supply Voltage			
U/D	Up/Down Input			
ĪNC	Increment Input			
CS	Chip Select Input			

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DEVICE OPERATION

There are three sections of the X9313: the input control, counter and decode section; the nonvolatile memory; and the resistor array. The input control section operates just like an up/down counter. The output of this counter is decoded to turn on a single electronic switch connecting a point on the resistor array to the wiper output. Under the proper conditions the contents of the counter can be stored in nonvolatile memory and retained for future use. The resistor array is comprised of 31 individual resistors connected in series. At either end of the array and between each resistor is an electronic switch that transfers the potential at that point to the wiper.

The $\overline{\text{INC}}$, U/D and $\overline{\text{CS}}$ inputs control the movement of the wiper along the resistor array. With $\overline{\text{CS}}$ set LOW the X9313 is selected and enabled to respond to the U/ $\overline{\text{D}}$ and $\overline{\text{INC}}$ inputs. HIGH to LOW transitions on $\overline{\text{INC}}$ will increment or decrement (depending on the state of the U/ $\overline{\text{D}}$ input) a seven bit counter. The output of this counter is decoded to select one of thirty two wiper positions along the resistive array.

The wiper, when at either fixed terminal, acts like its mechanical equivalent and does not move beyond the last position. That is, the counter does not wrap around when clocked to either extreme.

The value of the counter is stored in nonvolatile memory whenever $\overline{\text{CS}}$ transistions HIGH while the $\overline{\text{INC}}$ input is also HIGH.

When the X9313 is powered-down, the last counter position stored will be maintained in the nonvolatile memory. When power is restored, the contents of the memory are recalled and the counter is reset to the value last stored.

Operation Notes

The system may select the X9313, move the wiper and deselect the device without having to store the latest wiper position in nonvolatile memory. The wiper movement is performed as described above; once the new position is reached, the system would the keep $\overline{\text{INC}}$ LOW while taking $\overline{\text{CS}}$ HIGH. The new wiper position would be maintained until changed by the system or until a power-up/down cycle recalled the previously stored data.

This would allow the system to always power-up to a preset value stored in nonvolatile memory; then during system operation minor adjustments could be made. The adjustments might be based on user preference, system parameter changes due to temperature drift, etc...

The state of U/\overline{D} may be changed while \overline{CS} remains LOW. This allows the host system to enable the X9313 and then move the wiper up and down until the proper trim is attained.

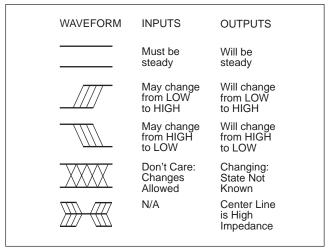
T_{IW}/R_{TOTAL}

The electronic switches on the X9313 operate in a "make before break" mode when the wiper changes tap positions. If the wiper is moved several positions multiple taps are connected to the wiper for t_{IW} (\overline{INC} to V_W change). The R_{TOTAL} value for the device can temporarily be reduced by a significant amount if the wiper is moved several positions.

R_{TOTAL} with V_{CC} Removed

The end to end resistance of the array will fluctuate once V_{CC} is removed.

SYMBOL TABLE



ABSOLUTE MAXIMUM RATINGS*

Temperature under Bias65°C to +135°C
Storage Temperature –65°C to +150°C
Voltage on \overline{CS} , \overline{INC} , U/\overline{D} and V_{CC}
with Respect to V _{SS} 1V to +7V
Voltage on V _H and V _L Referenced to V _{SS}
$\Delta V = V_H - V_L $
X9313Z4V
X9313W, X9313U, X9313T10V
Lead Temperature (Soldering 10 seconds) 300°C
Wiper Current±1mA

*COMMENT

Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and the functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ANALOG CHARACTERISTICS

Electrical Characteristics

End-to-End Resistance Tolerance	±20%
Power Rating at 25°C	
X9313Z	16mW
X9313W	10mW
Wiper Current	±1mA Max.
Typical Wiper Resistance	40Ω at 1mA
Typical Noise< -1	20dB/√Hz Ref: 1V

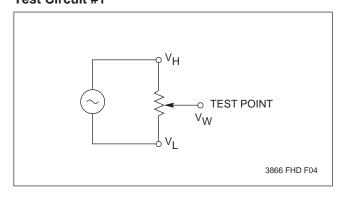
Resolution

Resistance	6
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Linearity

Absolute Linearity ⁽¹⁾	. ±1.0 MI ⁽²⁾
Relative Linearity ⁽³⁾	±0.2 MI ⁽²⁾

Test Circuit #1



Temperature Coefficient

(-40°C to +85°C)	
X9313Z	+600 ppm/°C Typical
X9313W, X9313U, X9313T	+300 ppm/°C Typical
Ratiometric Temperature Coef	fficient ±20 ppm

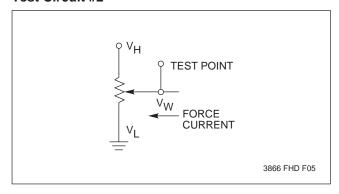
Wiper Adjustability

Unlimited Wiper Adjustment (Non-Store	e operation)
Wiper Position Store Operations	10,000
Dat	ta Changes

Physical Characteristics

Marking Includes
Manufacturer's Trademark
Resistance Value or Code
Date Code

Test Circuit #2



Notes: (1) Absolute Linearity is utilized to determine actual wiper voltage versus expected voltage = $(V_{w(n)}(actual) - V_{w(n)}(expected)) = \pm 1$ MI Maximum.

- (2) 1 MI = Minimum Increment = R_{TOT}/31.
- (3) Relative Linearity is a measure of the error in step size between taps = $V_{W(n+1)} [V_{w(n)} + MI] = +0.2 \text{ MI}.$

RECOMMENDED OPERATING CONDITIONS

Temperature	Min.	Max.
Commercial	0°C	+70°C
Industrial	−40°C	+85°C
Military	−55°C	+125°C

Supply Voltage	Limits
X9313	5V ±10%
X9313-3	3V to 5.5V
	3966 PCM TO 4

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D.C. OPERATING CHARACTERISTICS (Over recommended operating conditions unless otherwise specified.)

			Limits			
Symbol	Parameter	Min.	Typ.(4)	Max.	Units	Test Conditions
Icc	V _{CC} Active Current		1	3	mA	$\overline{\text{CS}} = \text{V}_{\text{IL}}, \text{ U/}\overline{\text{D}} = \text{V}_{\text{IL}} \text{ or V}_{\text{IH}} \text{ and } \overline{\text{INC}} = 0.4\text{V}/2.4\text{V @ max. t}_{\text{CYC}}$
I _{SB}	Standby Supply Current		200	500	μА	$\overline{\text{CS}} = \text{V}_{\text{CC}} - 0.3\text{V}, \text{U}/\overline{\text{D}} \text{ and } \overline{\text{INC}} = \text{V}_{\text{SS}} \text{ or } \text{V}_{\text{CC}} - 0.3\text{V}$
ILI	CS, INC, U/D Input Leakage Current			±10	μА	$V_{IN} = V_{SS}$ to V_{CC}
V _{IH}	CS, INC, U/D Input HIGH Voltage	2		V _{CC} + 1	V	
V _{IL}	CS, INC, U/D Input LOW Voltage	-1		0.8	V	
R _W	Wiper Resistence		40	100	Ω	Max. Wiper Current ±1mA
V_{VH}	VH Terminal Voltage	- 5		+5	V	
V_{VL}	VL Terminal Voltage	-5		+5	V	
C _{IN} ⁽⁵⁾	CS, INC, U/D Input Capacitance			10	pF	$V_{CC} = 5V$, $V_{IN} = V_{SS}$, $T_A = 25$ °C, $f = 1$ MHz

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STANDARD PARTS

Part Number	Number Maximum Resistance Wiper Increments		Minimum Resistance
X9313Z	1ΚΩ	32.3Ω	40Ω
X9313W	10ΚΩ	323Ω	40Ω
X9313U	50ΚΩ	2381Ω	40Ω
X9313T	100ΚΩ	3226Ω	40Ω

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Notes: (4) Typical values are for $T_A = 25^{\circ}C$ and nominal supply voltage. (5) This parameter is periodically sampled and not 100% tested.

A.C. CONDITIONS OF TEST

Input Pulse Levels	0V to 3V
Input Rise and Fall Times	10ns
Input Reference Levels	1.5V

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MODE SELECTION

CS	ĪNC	U/ D	Mode		
L	f	Н	Wiper Up		
L	f	L	Wiper Down		
f	Н	Х	Store Wiper Position		
Н	Х	Х	Standby		
f	L	Х	No Store, Return to Standby		

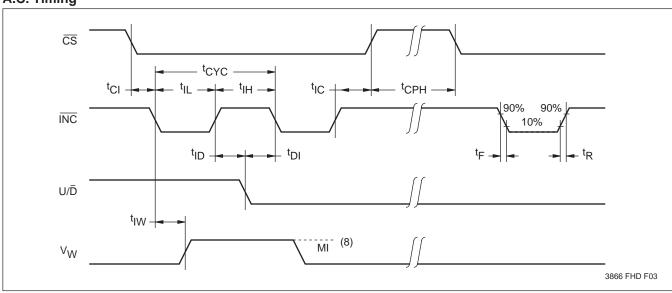
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A.C. OPERATING CHARACTERISTICS (Over recommended operating conditions unless otherwise specified)

			Limits		
Symbol	Parameter	Min.	Typ.(6)	Max.	Units
t _{Cl}	CS to INC Setup	100			ns
t _{ID}	INC HIGH to U/D Change	100			ns
t _{DI}	U/D to INC Setup	2.9			μs
t _{IL}	INC LOW Period	1			μs
t _{IH}	INC HIGH Period	1			μs
t _{IC}	INC Inactive to CS Inactive	1			μs
t _{CPH}	CS Deselect Time	20			ms
t _{IW}	ĪNC to Vw Change		100	500	μs
t _{CYC}	ĪNC Cycle Time	4			μs
t _R , t _F (7)	INC Input Rise and Fall Time			500	μs
t _{PU} (7)	Power up to Wiper Stable			500	μs
t _R V _{CC} ⁽⁷⁾	V _{CC} Power-up Rate	0.2		50	mV/μs

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A.C. Timing

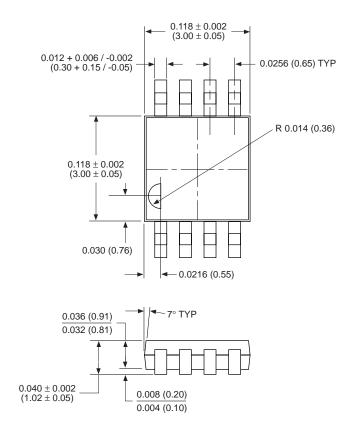


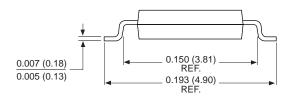
Notes: (6) Typical values are for $T_A = 25^{\circ}C$ and nominal supply voltage.

- (7) This parameter is periodically sampled and not 100% tested.
- (8) MI in the A.C. timing diagram refers to the minimum incremental change in the V_W output due to a change in the wiper position.

PACKAGING INFORMATION

8-LEAD MINIATURE SMALL OUTLINE GULL WING PACKAGE TYPE M





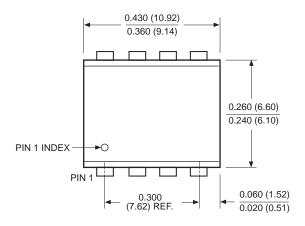
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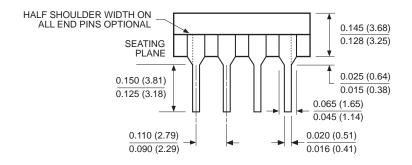
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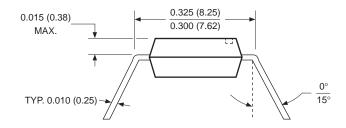
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PACKAGING INFORMATION

8-LEAD PLASTIC DUAL IN-LINE PACKAGE TYPE P







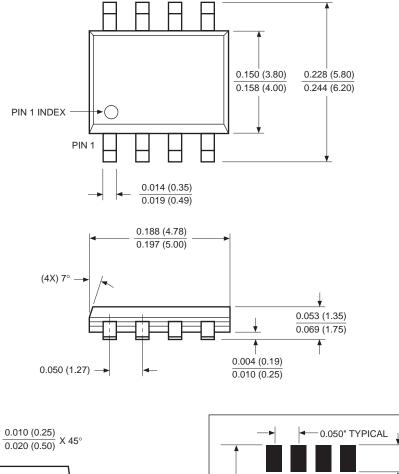
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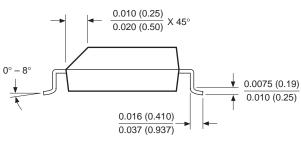
- 1. ALL DIMENSIONS IN INCHES (IN PARENTHESES IN MILLIMETERS)
- 2. PACKAGE DIMENSIONS EXCLUDE MOLDING FLASH

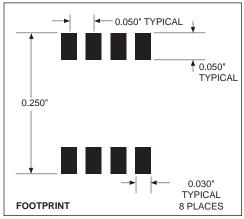
3926 FHD F01

PACKAGING INFORMATION

8-LEAD PLASTIC SMALL OUTLINE GULL WING PACKAGE TYPE S



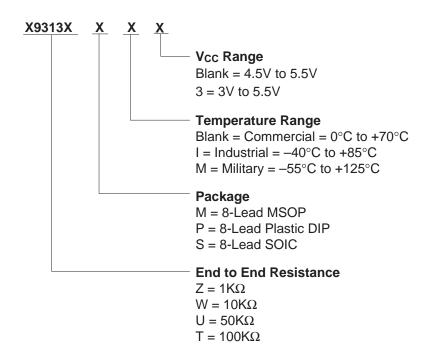




NOTE: ALL DIMENSIONS IN INCHES (IN PARENTHESES IN MILLIMETERS)

3926 FHD F22.1

ORDERING INFORMATION



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In situations where semiconductor component failure may endanger life, system designers using this product should design the system with appropriate error detection and correction, redundancy and back-up features to prevent such an occurence.

Xicor's products are not authorized for use in critical components in life support devices or systems.

- 1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
- 2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.