

## Terminal Voltage $\pm 5V$ , 32 Taps, Log Taper

# X9314

## E<sup>2</sup>POT™ Nonvolatile Digital Potentiometer

### FEATURES

- **Low Power CMOS**
  - $V_{CC} = 3V$  to  $5.5V$
  - Active Current,  $3mA$  Max
  - Standby Current,  $500\mu A$  Max
- **31 Resistive Elements**
  - Temperature Compensated
  - $\pm 20\%$  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**
- **X9314W =  $10K\Omega$**
- **Packages**
  - 8-Lead MSOP
  - 8-Lead PDIP
  - 8-Lead SOIC

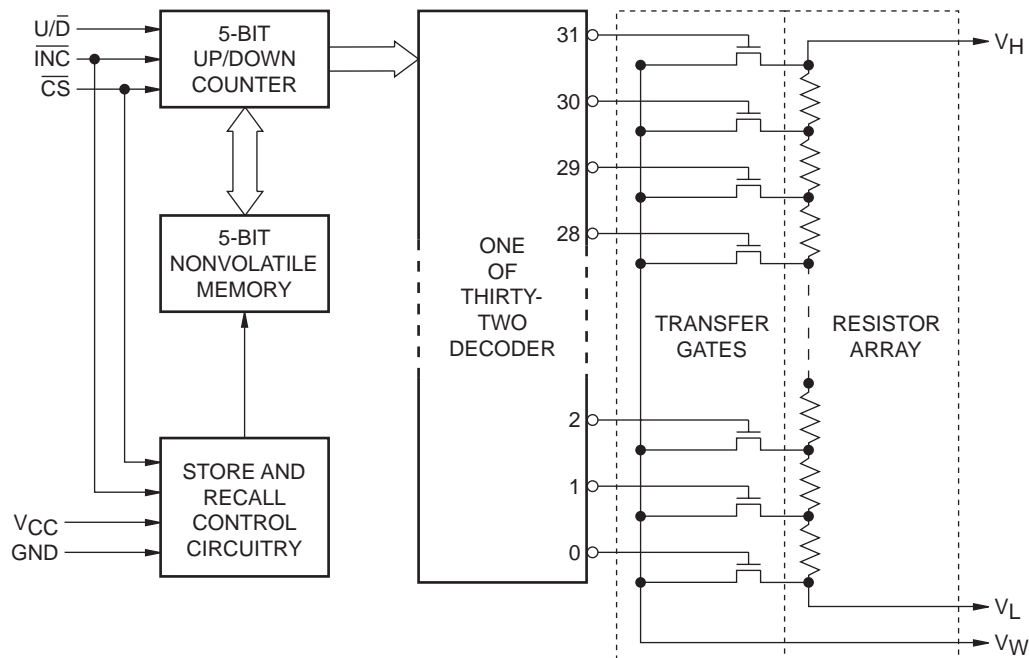
### DESCRIPTION

The Xicor X9314 is a solid state nonvolatile potentiometer and is ideal for digitally controlled resistance trimming.

The X9314 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.

All Xicor nonvolatile Digitally Controlled Potentiometers are designed and tested for applications requiring extended endurance and data retention.

### FUNCTIONAL DIAGRAM



6427 FHD F01

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# X9314

## PIN DESCRIPTIONS

### $V_H$ and $V_L$

The high ( $V_H$ ) and low ( $V_L$ ) terminals of the X9314 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  $U/\bar{D}$  input and not the voltage potential on the terminal.

### $V_W$

$V_W$  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  $40\Omega$ .

### Up/Down ( $U/\bar{D}$ )

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

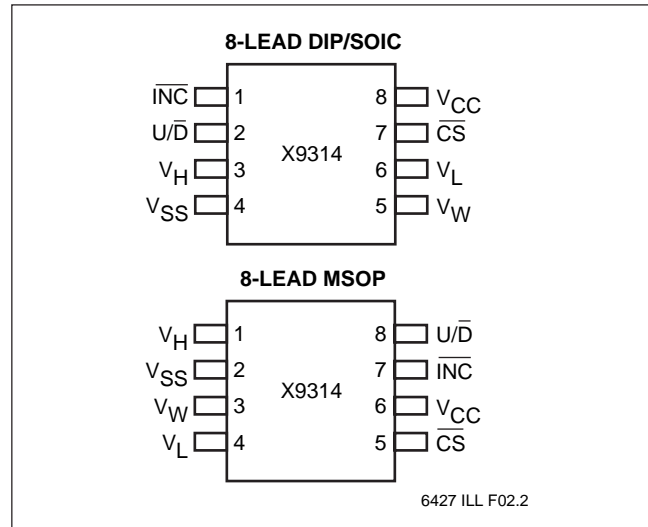
### Increment ( $\bar{INC}$ )

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

### Chip Select ( $\bar{CS}$ )

The device is selected when the  $\bar{CS}$  input is LOW. The current counter value is stored in nonvolatile memory when  $\bar{CS}$  is returned HIGH while the  $\bar{INC}$  input is also HIGH. After the store operation is complete the X9314 will be placed in the low power standby mode until the device is selected once again.

## PIN CONFIGURATION

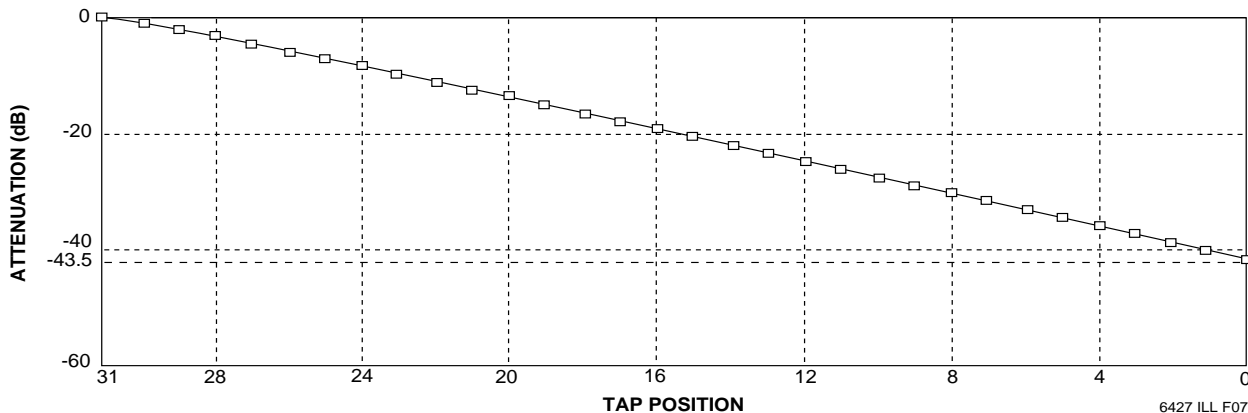


## PIN NAMES

Symbol	Description
$V_H$	High Terminal
$V_W$	Wiper Terminal
$V_L$	Low Terminal
$V_{SS}$	Ground
$V_{CC}$	Supply Voltage
$U/\bar{D}$	Up/Down Input
$\bar{INC}$	Increment Input
$\bar{CS}$	Chip Select Input

6427 PGM T01

## Typical Attenuation Characteristics (dB)



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# X9314

## DEVICE OPERATION

There are three sections of the X9314: 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.

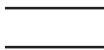




The  $\overline{INC}$ ,  $U/\overline{D}$  and  $\overline{CS}$  inputs control the movement of the wiper along the resistor array. With  $\overline{CS}$  set LOW the X9314 is selected and enabled to respond to the  $U/\overline{D}$  and  $\overline{INC}$  inputs. HIGH to LOW transitions on  $\overline{INC}$  will increment or decrement (depending on the state of the  $U/\overline{D}$  input) a five 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  $\overline{CS}$  transitions HIGH while the  $\overline{INC}$  input is also HIGH.

When the X9314 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.

## SYMBOL TABLE

WAVEFORM	INPUTS	OUTPUTS
	Must be steady	Will be steady
	May change from LOW to HIGH	Will change from LOW to HIGH
	May change from HIGH to LOW	Will change from HIGH to LOW
	Don't Care: Changes Allowed	Changing: State Not Known
	N/A	Center Line is High Impedance

## Operation Notes

The system may select the X9314, 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 keep the  $\overline{INC}$  LOW while taking  $\overline{CS}$  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 X9314 and then move the wiper up and down until the proper trim is attained.

## $T_{IW}/R_{TOTAL}$

The electronic switches on the X9314 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.

# X9314

## ABSOLUTE MAXIMUM RATINGS\*

Temperature under Bias ..... -65°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  $V_{SS}$  ..... -8V to +8V  
 $\Delta V = |V_H - V_L|$   
 X9314W ..... 10V  
 Lead Temperature (Soldering 10 seconds) ..... 300°C  
 Wiper Current .....  $\pm 1\text{mA}$

## \*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 .....  $\pm 20\%$   
 Power Rating at 25°C  
 X9314W ..... 10mW  
 Wiper Current .....  $\pm 1\text{mA Max.}$   
 Typical Wiper Resistance .....  $40\Omega$  at 1mA  
 Typical Noise .....  $< -120\text{dB}/\sqrt{\text{Hz}}$  Ref: 1V

### Relative Variation

Relative variation is a measure of the error in step size between taps =  $\log(V_{w(n)}) - \log(V_{w(n-1)}) = 0.07 \pm 0.003$  for tap  $n = 2 - 31$

### Temperature Coefficient

(-40°C to +85°C)  
 X9314W ..... +600 ppm/°C Typical  
 Ratiometric Temperature Coefficient .....  $\pm 20$  ppm

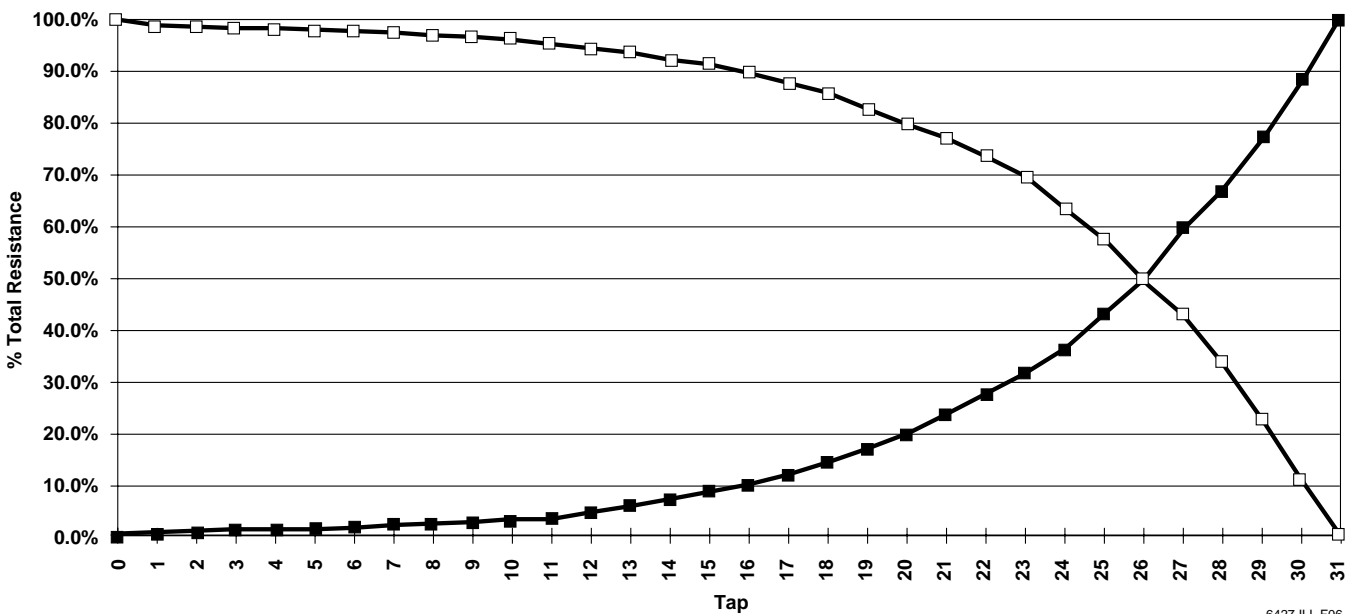
### Wiper Adjustability

Unlimited Wiper Adjustment (Non-Store operation)  
 Wiper Position Store Operations ..... 100,000  
 Data Changes

### Physical Characteristics

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

## Typical Electrical Taper



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# X9314

## RECOMMENDED OPERATING CONDITIONS

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

6427 PGM T03.1

Supply Voltage	Limits
X9314	5V ±10%
X9314-3	3V to 5.5V

6427 PGM T04.1

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

Symbol	Parameter	Limits			Units	Test Conditions
		Min.	Typ. <sup>(4)</sup>	Max.		
I <sub>CC</sub>	V <sub>CC</sub> Active Current		1	3	mA	$\overline{CS} = V_{IL}$ , $U/\overline{D} = V_{IL}$ or $V_{IH}$ and $\overline{INC} = 0.4V/2.4V$ @ max. $t_{CYC}$
I <sub>SB</sub>	Standby Supply Current			500	μA	$\overline{CS} = V_{CC} - 0.3V$ , $U/\overline{D}$ and $\overline{INC} = V_{SS}$ or $V_{CC} - 0.3V$
I <sub>LI</sub>	$\overline{CS}$ , $\overline{INC}$ , $U/\overline{D}$ Input Leakage Current			±10	μA	$V_{IN} = V_{SS}$ to $V_{CC}$
V <sub>IH</sub>	$\overline{CS}$ , $\overline{INC}$ , $U/\overline{D}$ Input HIGH Voltage	2		V <sub>CC</sub> + 1	V	
V <sub>IL</sub>	$\overline{CS}$ , $\overline{INC}$ , $U/\overline{D}$ Input LOW Voltage	-1		0.8	V	
R <sub>W</sub>	Wiper Resistance		40	100	Ω	Max. Wiper Current ±1mA
V <sub>VH</sub>	VH Terminal Voltage	-5		+5	V	
V <sub>VL</sub>	VL Terminal Voltage	-5		+5	V	
C <sub>IN</sub> <sup>(5)</sup>	$\overline{CS}$ , $\overline{INC}$ , $U/\overline{D}$ Input Capacitance			10	pF	$V_{CC} = 5V$ , $V_{IN} = V_{SS}$ , $T_A = 25^\circ C$ , $f = 1MHz$

6427 PGM T05.3

## STANDARD PARTS

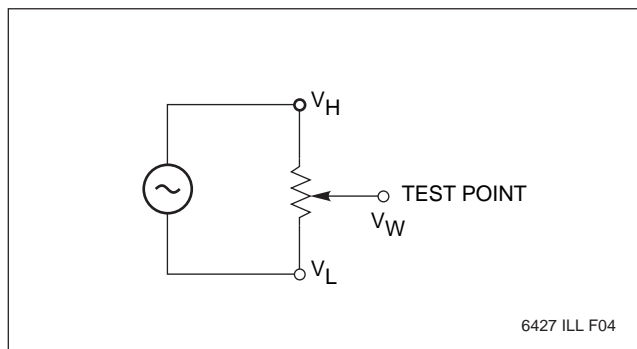
Part Number	Maximum Resistance	Wiper Increments	Minimum Resistance
X9314W	10KΩ	Log Taper	40Ω

6427 PGM T08.1

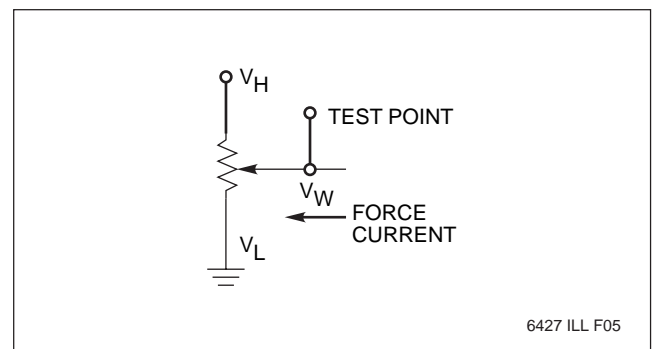
Notes: (4) Typical values are for  $T_A = 25^\circ C$  and nominal supply voltage.

(5) This parameter is periodically sampled and not 100% tested.

### Test Circuit #1



### Test Circuit #2



# X9314

## A.C. CONDITIONS OF TEST

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

6427 PGM T05.1

## MODE SELECTION

$\overline{CS}$	$\overline{INC}$	$U/\overline{D}$	Mode
L	$\lambda$	H	Wiper Up
L	$\lambda$	L	Wiper Down
f	H	X	Store Wiper Position
H	X	X	Standby
f	L	X	No Store, Return to Standby

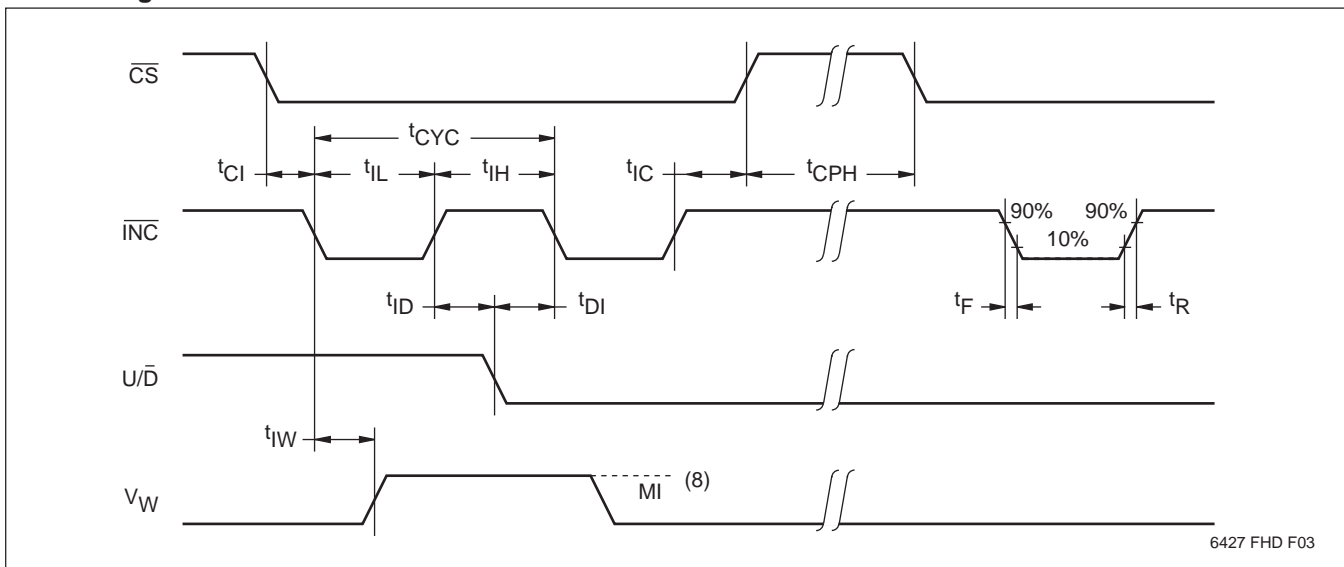
6427 PGM T06

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

Symbol	Parameter	Limits			Units
		Min.	Typ.(6)	Max.	
$t_{CI}$	$\overline{CS}$ to $\overline{INC}$ Setup	100			ns
$t_{ID}$	$\overline{INC}$ HIGH to $U/\overline{D}$ Change	100			ns
$t_{DI}$	$U/\overline{D}$ to $\overline{INC}$ Setup	2.9			$\mu$ s
$t_{IL}$	$\overline{INC}$ LOW Period	1			$\mu$ s
$t_{IH}$	$\overline{INC}$ HIGH Period	1			$\mu$ s
$t_{IC}$	$\overline{INC}$ Inactive to $\overline{CS}$ Inactive	1			$\mu$ s
$t_{CPH}$	$\overline{CS}$ Deselect Time	20			ms
$t_{IW}$	$\overline{INC}$ to $V_W$ Change		100	500	$\mu$ s
$t_{CYC}$	$\overline{INC}$ Cycle Time	4			$\mu$ s
$t_R, t_F^{(7)}$	$\overline{INC}$ Input Rise and Fall Time			500	$\mu$ s
$t_{PU}^{(7)}$	Power up to Wiper Stable			500	$\mu$ s
$t_R V_{CC}$	$V_{CC}$ Power-up Rate	0.2		50	mV/ $\mu$ s

6427 PGM T07.3

## A.C. Timing



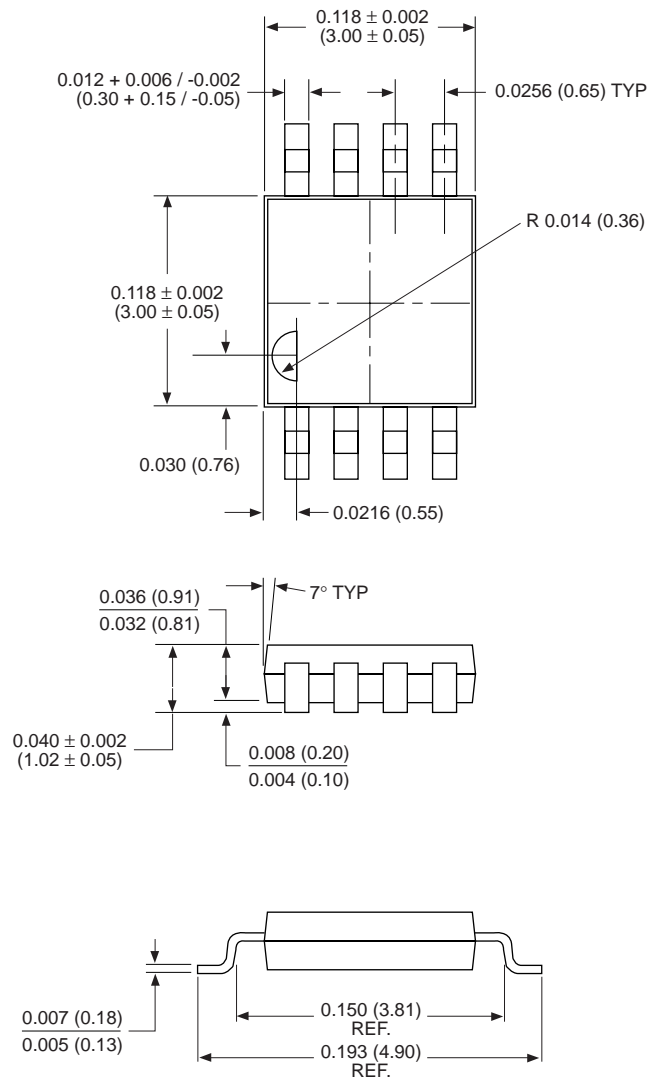
6427 FHD F03

- Notes:** (6) Typical values are for  $T_A = 25^\circ\text{C}$  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.

# X9314

## PACKAGING INFORMATION

### 8-LEAD MINIATURE SMALL OUTLINE GULL WING PACKAGE TYPE M



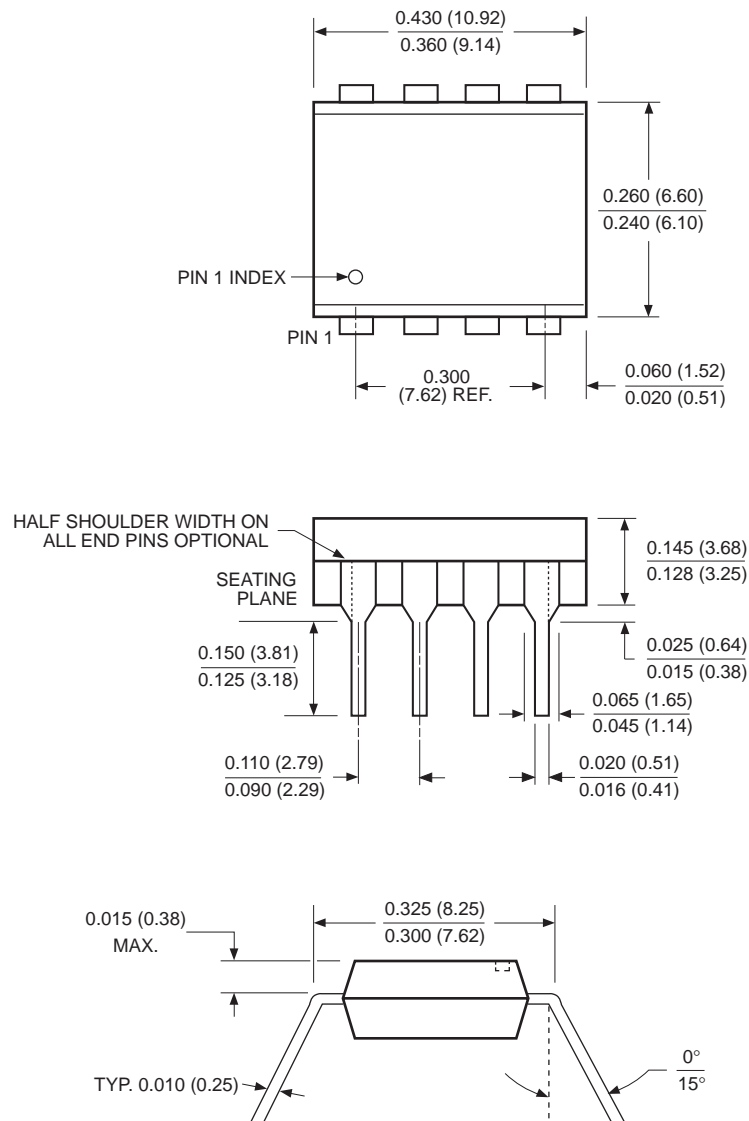
**NOTE:**  
1. ALL DIMENSIONS IN INCHES AND (MILLIMETERS)

3003 ILL 01

# X9314

## PACKAGING INFORMATION

### 8-LEAD PLASTIC DUAL IN-LINE PACKAGE TYPE P



**NOTE:**

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

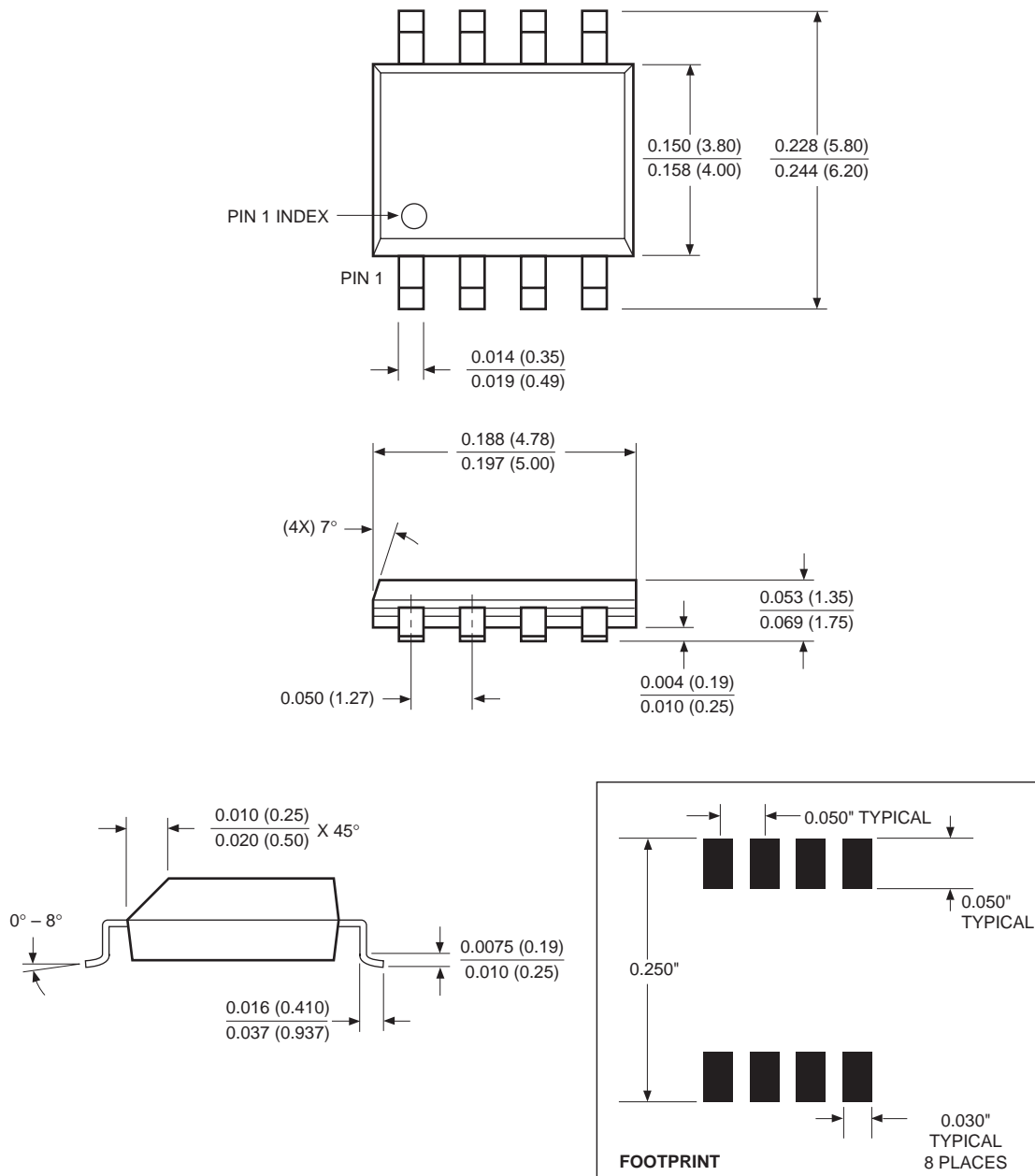
3926 FHD F01



# X9314

## PACKAGING INFORMATION

### 8-LEAD PLASTIC SMALL OUTLINE GULL WING PACKAGE TYPE S



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

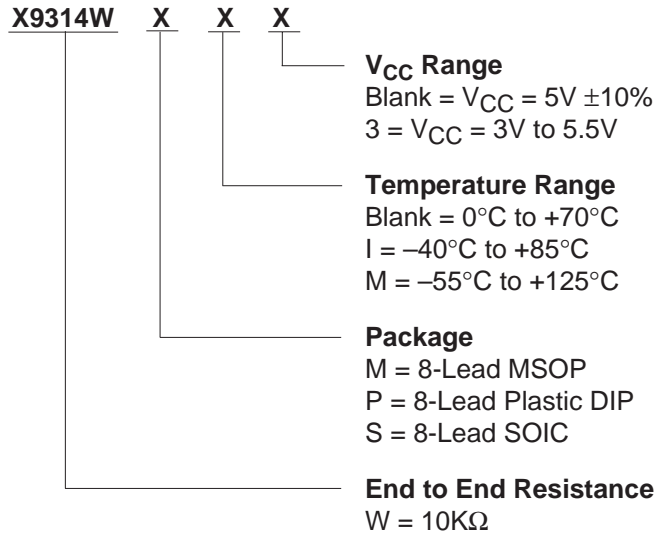
3926 FHD F22.1

# X9314

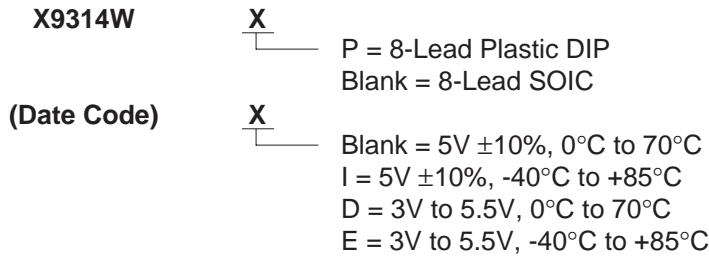
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## ORDERING INFORMATION

### X9314 E<sup>2</sup>POT 10K Ohms, Log Taper



### Part Mark Convention



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### LIMITED WARRANTY

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### LIFE RELATED POLICY

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 occurrence.

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.