**DESCRIPTION**

The Xicor X9312 is a solid state nonvolatile potentiometer and is ideal for digitally controlled resistance trimming.

The X9312 is a resistor array composed of 99 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 CS, U/D, and 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 X9312 is equal to the maximum resistance value divided by 99. As an example, for the X9312U (50KΩ) each tap point represents 505Ω.

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

**FEATURES**

- Compatible with X9C102/103/104/503
- Low Power CMOS
  - Active Current, 3mA Max
  - Standby Current, 1mA Max
- 99 Resistive Elements
  - Temperature Compensated
  - ±20% End to End Resistance Range
  - 0 to +15V Range
- 100 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
- X9312Z = 1KΩ
- X9312W = 10KΩ
- X9312U = 50KΩ
- X9312T = 100KΩ

**FUNCTIONAL DIAGRAM**
PIN DESCRIPTIONS

$V_H$ and $V_L$

The high ($V_H$) and low ($V_L$) terminals of the X9312 are equivalent to the fixed terminals of a mechanical potentiometer. The minimum voltage is 0V and the maximum is +15V. 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/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/D)

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

Increment (INC)

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

Chip Select (CS)

The device is selected when the CS input is LOW. The current counter value is stored in nonvolatile memory when CS is returned HIGH while the INC input is also HIGH. After the store operation is complete the X9312 will be placed in the low power standby mode until the device is selected once again.

PIN CONFIGURATION

PIN NAMES

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_H$</td>
<td>High Terminal</td>
</tr>
<tr>
<td>$V_W$</td>
<td>Wiper Terminal</td>
</tr>
<tr>
<td>$V_L$</td>
<td>Low Terminal</td>
</tr>
<tr>
<td>$V_{SS}$</td>
<td>Ground</td>
</tr>
<tr>
<td>$V_{CC}$</td>
<td>Supply Voltage</td>
</tr>
<tr>
<td>U/D</td>
<td>Up/Down Input</td>
</tr>
<tr>
<td>INC</td>
<td>Increment Input</td>
</tr>
<tr>
<td>CS</td>
<td>Chip Select Input</td>
</tr>
</tbody>
</table>
DEVICE OPERATION

There are three sections of the X9312: 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 99 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 INC, U/D and CS inputs control the movement of the wiper along the resistor array. With CS set LOW the X9312 is selected and enabled to respond to the U/D and INC inputs. HIGH to LOW transitions on INC will increment or decrement (depending on the state of the U/D input) a seven bit counter. The output of this counter is decoded to select one of one-hundred 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 CS transitions HIGH while the INC input is also HIGH.

When the X9312 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 X9312, 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 INC LOW while taking 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/D may be changed while CS remains LOW. This allows the host system to enable the X9312 and then move the wiper up and down until the proper trim is attained.

**T\text{IW}/R\text{TOTAL}**

The electronic switches on the X9312 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\text{IW} (INC to VW change). The R\text{TOTAL} value for the device can temporarily be reduced by a significant amount if the wiper is moved several positions.

**R\text{TOTAL} with V\text{CC} Removed**

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

**SYMBOL TABLE**

<table>
<thead>
<tr>
<th>WAVEFORM</th>
<th>INPUTS</th>
<th>OUTPUTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Must be steady</td>
<td>Will be steady</td>
</tr>
<tr>
<td></td>
<td>May change from LOW to HIGH</td>
<td>Will change from LOW to HIGH</td>
</tr>
<tr>
<td></td>
<td>May change from HIGH to LOW</td>
<td>Will change from HIGH to LOW</td>
</tr>
<tr>
<td></td>
<td>Don’t Care; Changes Allowed</td>
<td>Changing; State Not Known</td>
</tr>
<tr>
<td></td>
<td>N/A</td>
<td>Center Line is High Impedance</td>
</tr>
</tbody>
</table>
**ABSOLUTE MAXIMUM RATINGS**

Temperature under Bias -65°C to +135°C
Storage Temperature -65°C to +150°C
Voltage on CS, INC, U/D and VCC with Respect to VSS -1V to +7V
Voltage on VH and VL Referenced to VSS \( \Delta V = |V_{H} - V_{L}| \)
X9312Z, X9312W, X9312U, and X9312T .... 15V
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
X9312Z ........................................ 225mW
X9312W, X9312U, and X9312T ............... 25mW
Wiper Current ........................................ ±1mA Max.
Typical Wiper Resistance .......... 40Ω at 1mA
Typical Noise ...................... < −120dB/√Hz Ref: 1V

Resolution
Resistance ............................................................. 1%

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

**Temperature Coefficient**

(−40°C to +85°C)
X9312W, X9312U and X9312T ......................... +300 ppm/°C Typical
Ratiometric Temperature Coefficient ............ ±20 ppm

**Wiper Adjustability**

Unlimited Wiper Adjustment (Non-Store operation)
Wiper Position Store Operations .......... 10,000 Data Changes

**Physical Characteristics**

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

**Test Circuit #1**

![Test Circuit #1 diagram]

**Test Circuit #2**

![Test Circuit #2 diagram]

**Notes:**
(1) Absolute Linearity is utilized to determine actual wiper voltage versus expected voltage
\( = (V_{W(n)}(actual) - V_{W(n)}(expected)) = ±1\) Ml Maximum.
(2) 1 Ml = Minimum Increment = \( R_{TOT}/99 \).
(3) Relative Linearity is a measure of the error in step size between taps = \( V_{W(n+1)} - [V_{W(n)} + Ml] = ±0.2\) Ml.
### RECOMMENDED OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Min.</th>
<th>Max.</th>
<th>Supply Voltage</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>0°C</td>
<td>+70°C</td>
<td>X9312</td>
<td>5V ±10%</td>
</tr>
<tr>
<td>Industrial</td>
<td>−40°C</td>
<td>+85°C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Military</td>
<td>−55°C</td>
<td>+125°C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### D.C. OPERATING CHARACTERISTICS

(Over recommended operating conditions unless otherwise specified.)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Limits</th>
<th>Test Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Min.</td>
<td>Typ.(4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I\textsubscript{CC}</td>
<td>V\textsubscript{CC} Active Current</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>I\textsubscript{SB}</td>
<td>Standby Supply Current</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>I\textsubscript{IL}</td>
<td>CS, INC, U/\textbar D Input Leakage Current</td>
<td>±10</td>
<td>µA</td>
</tr>
<tr>
<td>V\textsubscript{IH}</td>
<td>CS, INC, U/\textbar D Input HIGH Voltage</td>
<td>2</td>
<td>V\textsubscript{CC} + 1</td>
</tr>
<tr>
<td>V\textsubscript{IL}</td>
<td>CS, INC, U/\textbar D Input LOW Voltage</td>
<td>−1</td>
<td>0.8</td>
</tr>
<tr>
<td>R\textsubscript{W}</td>
<td>Wiper Resistance</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td>V\textsubscript{VH}</td>
<td>VH Terminal Voltage</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>V\textsubscript{VL}</td>
<td>VL Terminal Voltage</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>C\textsubscript{IN}(5)</td>
<td>CS, INC, U/\textbar D Input Capacitance</td>
<td>10</td>
<td>pF</td>
</tr>
</tbody>
</table>

### STANDARD PARTS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Maximum Resistance</th>
<th>Wiper Increments</th>
<th>Minimum Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>X9312Z</td>
<td>1KΩ</td>
<td>10.1Ω</td>
<td>40Ω</td>
</tr>
<tr>
<td>X9312W</td>
<td>10KΩ</td>
<td>101Ω</td>
<td>40Ω</td>
</tr>
<tr>
<td>X9312U</td>
<td>50KΩ</td>
<td>505Ω</td>
<td>40Ω</td>
</tr>
<tr>
<td>X9312T</td>
<td>100KΩ</td>
<td>1010Ω</td>
<td>40Ω</td>
</tr>
</tbody>
</table>

**Notes:**
(4) Typical values are for T\textsubscript{A} = 25°C and nominal supply voltage.
(5) This parameter is periodically sampled and not 100% tested.
A.C. CONDITIONS OF TEST

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input Pulse Levels</td>
<td>0V</td>
<td>3V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Rise and Fall Times</td>
<td>10ns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Reference Levels</td>
<td>1.5V</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MODE SELECTION

<table>
<thead>
<tr>
<th>CS</th>
<th>INC</th>
<th>U/D</th>
<th>Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>L</td>
<td>H</td>
<td>Wiper Up</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
<td>L</td>
<td>Wiper Down</td>
</tr>
<tr>
<td>f</td>
<td>H</td>
<td>X</td>
<td>Store Wiper Position</td>
</tr>
<tr>
<td>H</td>
<td>X</td>
<td>X</td>
<td>Standby</td>
</tr>
<tr>
<td>f</td>
<td>L</td>
<td>X</td>
<td>No Store, Return to Standby</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>tCI</td>
<td>CS to INC Setup</td>
<td>ns</td>
</tr>
<tr>
<td>tID</td>
<td>INC HIGH to U/D Change</td>
<td>ns</td>
</tr>
<tr>
<td>tDI</td>
<td>U/D to INC Setup</td>
<td>µs</td>
</tr>
<tr>
<td>tIL</td>
<td>INC LOW Period</td>
<td>µs</td>
</tr>
<tr>
<td>tIH</td>
<td>INC HIGH Period</td>
<td>µs</td>
</tr>
<tr>
<td>tIC</td>
<td>INC Inactive to CS Inactive</td>
<td>µs</td>
</tr>
<tr>
<td>tCPH</td>
<td>CS Deselect Time</td>
<td>ms</td>
</tr>
<tr>
<td>tIW</td>
<td>INC to Vw Change</td>
<td>µs</td>
</tr>
<tr>
<td>tCYC</td>
<td>INC Cycle Time</td>
<td>µs</td>
</tr>
<tr>
<td>tR, tF(7)</td>
<td>INC Input Rise and Fall Time</td>
<td>µs</td>
</tr>
<tr>
<td>tPU(7)</td>
<td>Power up to Wiper Stable</td>
<td>µs</td>
</tr>
<tr>
<td>tR VCC(7)</td>
<td>VCC Power-up Rate</td>
<td>mV/µs</td>
</tr>
</tbody>
</table>

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 Vw output due to a change in the wiper position.
PACKAGING INFORMATION

8-LEAD PLASTIC DUAL IN-LINE PACKAGE TYPE P

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

8-LEAD PLASTIC SMALL OUTLINE GULL WING PACKAGE TYPE S

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