Terminal Voltages ±5V, 100 Taps

X9C102/103/104/503

Digitally Controlled Potentiometer (XDCP™)

FEATURES

- **Solid-state potentiometer**
- **3-wire serial interface**
- **100 wiper tap points**
  - **—Wiper position stored in nonvolatile memory and recalled on power-up**
- **99 resistive elements**
  - **—Temperature compensated**
  - **—End to end resistance, ±20%**
  - **—Terminal voltages, ±5V**
- **Low power CMOS**
  - **—V_{CC} = 5V**
  - **—Active current, 3mA max.**
  - **—Standby current, 750µA max.**
- **High reliability**
  - **—Endurance, 100,000 data changes per bit**
  - **—Register data retention, 100 years**
- **X9C102 = 1 kΩ**
- **X9C103 = 10 kΩ**
- **X9C503 = 50 kΩ**
- **X9C104 = 100 kΩ**
- **Packages**
  - **—8-lead SOIC and DIP**

DESCRIPTION

The X9Cxxx are Xicor digitally controlled (XDCP) potentiometers. The device consists of a resistor array, wiper switches, a control section, and nonvolatile memory. The wiper position is controlled by a three-wire interface.

The potentiometer is implemented by a resistor array composed of 99 resistive elements and a wiper switching network. Between each element and at either end are tap points accessible to the wiper terminal. 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.

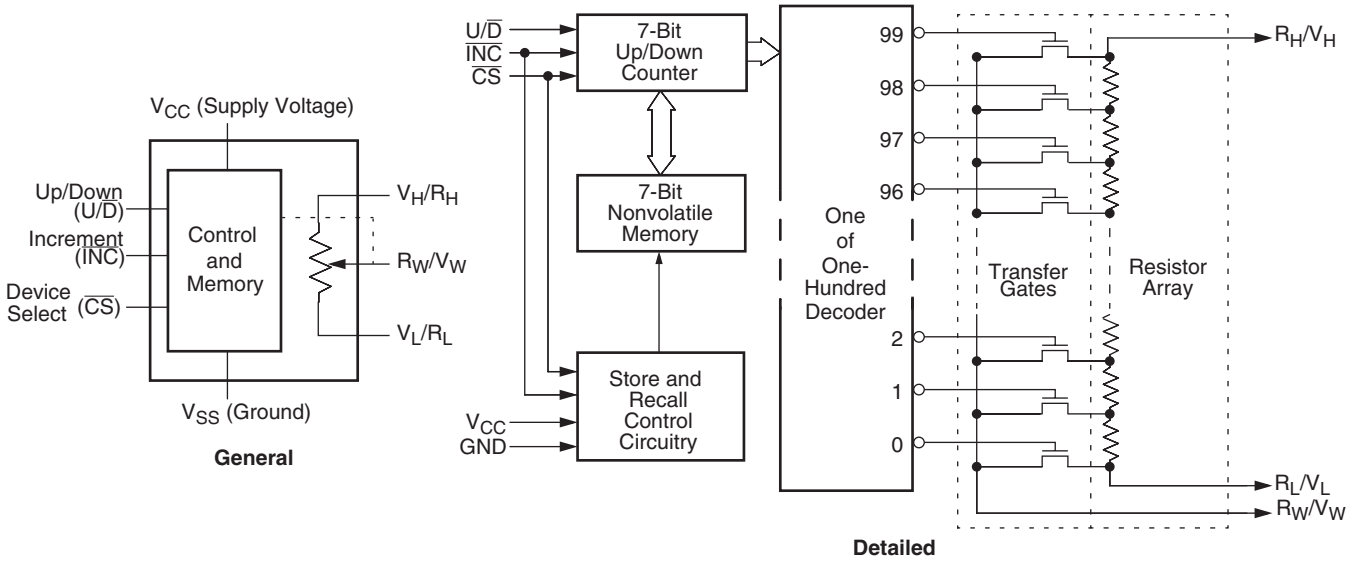
The device can be used as a three-terminal potentiometer or as a two-terminal variable resistor in a wide variety of applications including:

– control

– parameter adjustments

– signal processing

BLOCK DIAGRAM



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PIN DESCRIPTIONS

R_H/V_H and R_L/V_L

The high (V_H/R_H) and low (V_L/R_L) terminals of the X9C102/103/104/503 are equivalent to the fixed terminals of a mechanical potentiometer. The minimum voltage is –5V and the maximum is +5V. The terminology of V_H/R_H and V_L/R_L 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.

R_W/V_W

V_W/R_W is the wiper terminal, and is 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/$\overline{D}$)

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

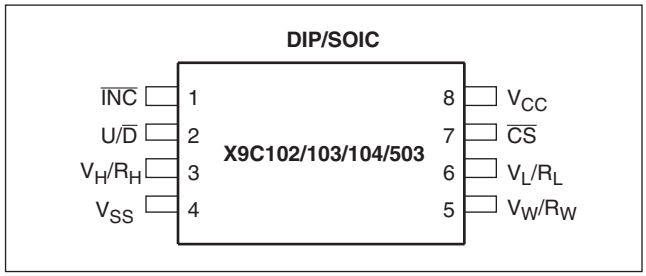
Increment ($\overline{INC}$)

The $\overline{INC}$ input is negative-edge triggered. Toggling $\overline{INC}$ 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 ($\overline{CS}$)

The device is selected when the $\overline{CS}$ input is LOW. The current counter value is stored in nonvolatile memory when $\overline{CS}$ is returned HIGH while the $\overline{INC}$ input is also HIGH. After the store operation is complete the X9C102/103/104/503 device will be placed in the low power standby mode until the device is selected once again.

PIN CONFIGURATION



PIN NAMES

Symbol	Description
V_H/R_H	High Terminal
V_W/R_W	Wiper Terminal
V_L/R_L	Low Terminal
V_{SS}	Ground
V_{CC}	Supply Voltage
U/$\overline{D}$	Up/Down Control Input
$\overline{INC}$	Increment Control Input
$\overline{CS}$	Chip Select Control Input
NC	No Connection

PRINCIPLES OF OPERATION

There are three sections of the X9Cxxx: 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 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 electronic switches on the device 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/R_W change). The R_{TOTAL} value for the device can temporarily be reduced by a significant amount if the wiper is moved several positions.

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

INSTRUCTIONS AND PROGRAMMING

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 device 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 seven-bit counter. The output of this counter is decoded to select one of one-hundred wiper positions along the resistive array.

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

The system may select the X9Cxxx, move the wiper, and deselect the device without having to store the latest wiper position in nonvolatile memory. After the wiper movement is performed as described above and once the new position is reached, the system must keep $\overline{INC}$ LOW while taking $\overline{CS}$ HIGH. The new wiper position will be maintained until changed by the system or until a power-down/up cycle recalled the previously stored data.

This procedure allows 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 device and then move the wiper up and down until the proper trim is attained.

MODE SELECTION

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

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
XXX	Don't Care: Changes Allowed	Changing: State Not Known
><<	N/A	Center Line is High Impedance