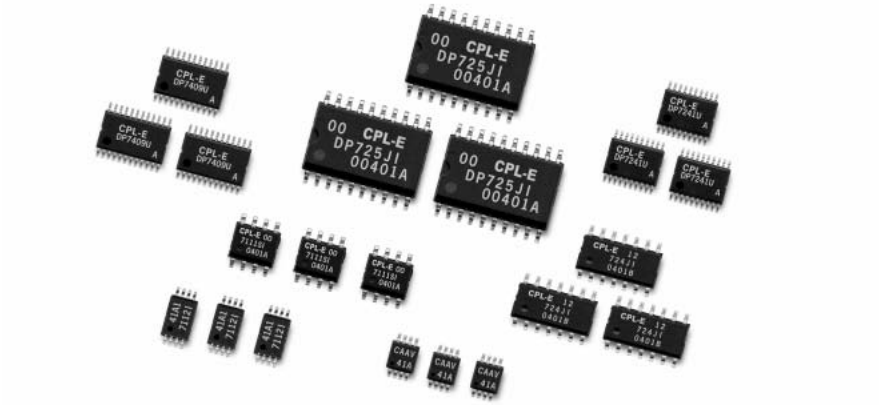
# DIGITAL POTENTIOMETERS

# DP7114



## FEATURES

- 32-position, linear-curved potentiometer
- Nonvolatile memory wiper storage
- Low-power CMOS technology
- Single-power operation: 2.5 V ~ 6.0 V
- Increment up/down serial interface
- Total resistance: 10 kΩ, 50 kΩ, 100 kΩ
- SOIC, TSSOP, MSOP and TDFN packages

## APPLICATIONS

- Auto calibration
- Remote control adjustment
- Offset, gain and zero controls
- Rewritable calibration
- Contrast, brightness and volume controls
- Motor-controlled, feedback system
- Programmable analog function



Sep., 2009

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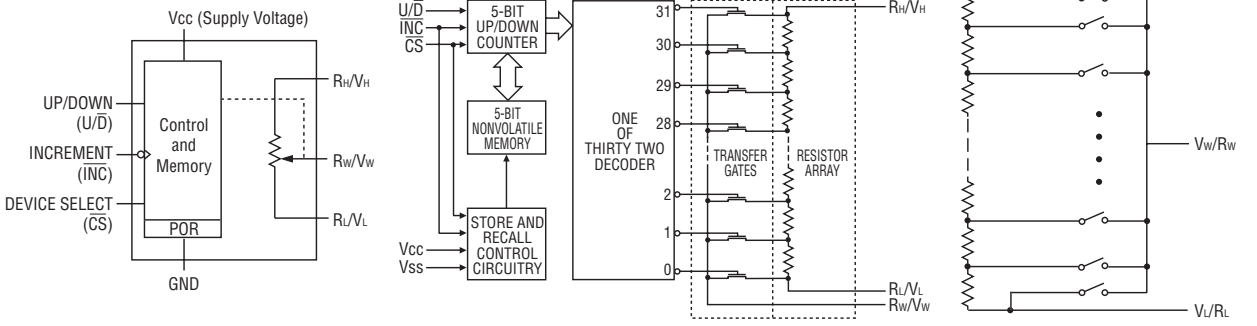
## SUMMARY

The DP7114 is a programmable digital potentiometer designed to replace mechanical potentiometers and variable resistors. Automated adjustment by product automation line is ideal. The DP7114 makes this possible and is suitable for applications where it is difficult to operate when machines require constant adjustment or in case of danger or at remote locations.

The DP7114 has a 32-tap resistance array between two terminals, RH and RL. The up/down counter and decoder controlled by 3 input terminals determines the tap connected to wiper resistance RW. Wiper settings stored in nonvolatile memory can not be lost even at power shutoff and will be automatically restored when power returns. Not affected by stored settings, the wiper can test new setting of the system.

The wiper control of the DP7114 is made by three input terminals, $\overline{CS}$, U/$\overline{D}$ and $\overline{INC}$. The $\overline{INC}$ input increments wiper to direction determined in U/$\overline{D}$ input logic condition. The $\overline{CS}$ input terminal is for device-select use and used when wiper position is stored before power shutoff. The digital potentiometer can be used as a voltage partial pressure device or 2-terminal variable resistor. The DP7114 offers valuable capabilities and programmability to a wide variety of applications such as parameter adjustment and signal processing.

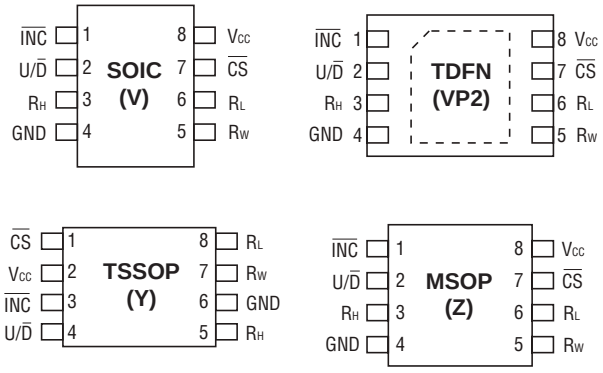
## CONFIGURATION




Circuit block diagram

Electricity-equivalent circuit of POT section

## CONTACT LAYOUT



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## ■TERMINAL FUNCTIONS

| Terminal name | Functions |
|---|---|
| $\overline{INC}$ | Increment control input |
| U/$\overline{D}$ | Up/Down control input |
| $R_H$ | High-end potentiometer terminal |
| GND | Ground |
| $R_W$ | Wiper terminal |
| $R_L$ | Low-end potentiometer terminal |
| $\overline{CS}$ | Chip select |
| $V_{CC}$ | Power voltage |

## ■FUNCTIONS OF EACH TERMINAL

$\overline{INC}$: Increment control input
This $\overline{INC}$ input moves wiper to the up and down direction selected by conditions of U/$\overline{D}$ input at the VIL edge.

U/$\overline{D}$: Up/down control input
U/$\overline{D}$ input controls moving direction of wiper. When U/$\overline{D}$ is in H state and $\overline{CS}$ is in L state, this input moves the wiper to $R_H$ from transition state of H - L of the INC. When U/$\overline{D}$ and $\overline{CS}$ are in L state, it moves the wiper to $R_L$ direction in the transition of H to L of the $\overline{INC}$.

$R_H$: High-end potentiometer terminal
$R_H$ is a high-end potentiometer terminal. This terminal does not require higher voltage than $R_L$ terminal. But, $R_H$ voltage should not be over $V_{CC}$ nor under GND.

$R_W$: Wiper terminal
$R_W$ is a wiper terminal of potentiometer. The position within resistance arrays are controlled by control input terminals of $\overline{INC}$, U/$\overline{D}$ and $\overline{CS}$.

$R_L$: Low-end potentiometer terminal
$R_L$ is a low-end potentiometer terminal. This terminal does not need to connect lower voltage than $R_H$ terminal. But, $R_L$ voltage should not be over $V_{CC}$ nor under GND. $R_H$ and $R_L$ can be changed electrically.

$\overline{CS}$: Chip select
Chip select input is used to make a DP7114 control input effective and becomes effective in the L state. When $\overline{CS}$ is in the H state, inputs of $\overline{INC}$ and U/$\overline{D}$ does not give effect or change to wiper position.

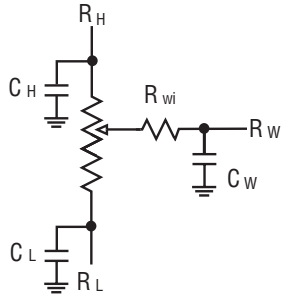
## ■OPERATION EXPLANATION

The $R_H$ and $R_L$ terminals of the DP7114 are equivalent to high and low terminals of mechanical potentiometers. The DP7114 is a digital potentiometer of which $R_W$ terminal operates as a wiper. The model has 32 taps including terminators of $R_H$ and $R_L$. There are 31 resistance arrays linearly connected between terminal $R_H$ and $R_L$. This wiper terminal is connected to one of 32 taps and controlled by 3 inputs of $\overline{INC}$, U/$\overline{D}$ and $\overline{CS}$. This input controls the 5-bit up/down counter which can decode to select wiper position. Selected wiper position data is stored into nonvolatile memories by $\overline{INC}$ and $\overline{CS}$ inputs.

When $\overline{CS}$ is in the L state, DP7114 is selected and responds to U/$\overline{D}$ and $\overline{INC}$ inputs. In transition from H of $\overline{INC}$ to L, wiper will be incremented or decremented. The wipe acts like mechanical and does not move from the last position. Counter values will be saved in nonvolatile memories by transition from H of the $\overline{INC}$ input to H of the $\overline{CS}$. When DP7114 power is shut down, counter position saved in the last will be kept in nonvolatile memories. When DP7114 power returns, contents within memories will be renewed and counter values are set on the counter. When $\overline{INC}$ is in L state, DP7114 will not be selected and shut down without saving the current wiper position in nonvolatile memories, thereby the system will recall preset values always stored in nonvolatile memories.

## ■OPERATION MODE

| $\overline{INC}$ | $\overline{CS}$ | U/$\overline{D}$ | Operation |
|---|---|---|---|
| High to Low | Low | High | Wiper toward H |
| High to Low | Low | Low | Wiper toward L |
| High | Low to High | X | Store Wiper Position |
| Low | Low to High | X | No Store, Return to Standby |
| X | High | X | Standby |




Equivalent circuit of potentiometer

# DP 7114
## DIGITAL POTENTIOMETERS

## ■ABSOLUTE MAXIMUM RATINGS

Supply voltage
Vcc to GND ・・・・・・・・・・・・・・・・・・・・・・ – 0.5 V ～ + 7 V

Inputs
$\overline{CS}$ to GND ・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V
$\overline{INC}$ to GND ・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V
U/$\overline{D}$ to GND ・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V
$R_H$ to GND ・・・・・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V
$R_L$ to GND ・・・・・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V
$R_W$ to GND ・・・・・・・・・・・・・・・・・・・・・・ – 0.5 V ～ Vcc + 0.5 V

* Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. Absolute Maximum Ratings are limited values applied individually while other parameters are within specified operating conditions, and functional operation at any of these conditions is NOT implied. Device performance and reliability may be impaired by exposure to absolute rating conditions for extended periods of time.

## ■RELIABILITY CHARACTRISTICS

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{ZAP}$ (1) | ESD Susceptibility | MIL-STD-883, Test Method 3015 | 2000 | — | — | Volts |
| $I_{LTH}$ (1)(2) | Latch-Up | JEDEC Standard 17 | 100 | — | — | mA |
| $T_{DR}$ | Data Retention | MIL-STD-883, Test Method 1008 | 100 | — | — | Years |
| $N_{END}$ | Endurance | MIL-STD-883, Test Method 1003 | 1,000,000 | — | — | Stores |

## ■DC ELECTRICAL CHARACTERISTICS

Unless otherwise specified, the specs are defined at
Vcc = +2.5 V to +6.0 V.

### ● Power supply

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $V_{CC}$ | Operating Voltage Range | — | 2.5 | — | 6.0 | V |
| $I_{CC1}$ | Supply Current (Increment) | $V_{CC}$ = 6 V, f = 1 MHz, $I_W$ = 0<br>$V_{CC}$ = 6 V, f = 250 kHz, $I_W$ = 0 | —<br>— | —<br>— | 100<br>50 | µA |
| $I_{CC2}$ | Supply Current (Write) | Programming, $V_{CC}$ = 6 V<br>$V_{CC}$ = 3 V | —<br>— | —<br>— | 1<br>500 | mA<br>µA |
| $ISB_1$ (2) | Supply Current (Standby) | $\overline{CS}$ = Vcc – 0.3 V<br>U/$\overline{D}$, $\overline{INC}$ = Vcc – 0.3 V or GND | —<br>— | 0.01 | 1 | µA |

### ● Logic inputs

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $I_{IH}$ | Input Leakage Current | $V_{IN}$ = $V_{CC}$ | — | — | 10 | µA |
| $I_{IL}$ | Input Leakage Current | $V_{IN}$ = 0 V | — | — | –10 | µA |
| $V_{IH2}$ | CMOS High Level input Voltage | 2.5 V ≦ $V_{CC}$ ≦ 6 V | Vcc × 0.7 | — | $V_{CC}$ + 0.3 | V |
| $V_{IL2}$ | CMOS Low Level input Voltage | | –0.3 | — | $V_{CC}$ × 0.2 | V |

Notes : (1) This parameter is tested initially and after a design or process change that affects the parameter.
(2) Latch-up protection is provided for stresses up to 100 mA on address and data pins from –1 V to Vcc +1 V.
(3) Iw = source or sink current.
(4) The value is for reference.

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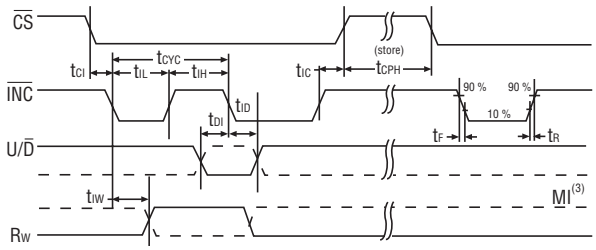
## ■POTENTIOMETER PARAMETERS

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| $R_{POT}$ | Potentiometer Resistance | –10 Device | — | 10 | — | kΩ |
| | | –50 Device | — | 50 | — | |
| | | –00 Device | — | 100 | — | |
| $R_{TOL}$ | Pot Resistance Tolerance | — | — | — | ±20 | % |
| $V_{RH}$ | Voltage on $R_H$ pin | — | 0 | — | $V_{CC}$ | V |
| $V_{RL}$ | Voltage on $R_L$ pin | — | 0 | — | $V_{CC}$ | V |
| RES | Resolution | — | — | 3.2 | — | % |
| INL | Integral Linearity Error | $I_W \leqq 2$ µA | — | 0.5 | 1 | LSB |
| DNL | Differential Linearity Error | $I_W \leqq 2$ µA | — | 0.25 | 0.5 | LSB |
| $R_{WI}$ | Wiper Resistance | $V_{CC}$ = 5 V, $I_W$ = 1 mA | — | 70 | 200 | Ω |
| | | $V_{CC}$ = 2.5 V, $I_W$ = 1 mA | — | 150 | 400 | kΩ |
| $I_{WI}$ | Wiper Current | — | −4.4 | — | 4.4 | mA |
| $TC_{RPOT}$ | TC of Pot Resistance | — | — | 300 | — | ppm/°C |
| $TC_{RATIO}$ | Ratiometric TC | — | — | — | 20 | ppm/°C |
| $V_N$ | Noise | 100 kHz / 1 kHz | — | 8/24 | — | nV/√Hz |
| $C_H/C_L/C_W$ | Potentiometer Capacitances | — | — | 8/8/25 | — | pF |
| fc | Frequency Response | Passive Attenuator, 10 kΩ | — | 1.7 | — | MHz |

## ■AC TEST CONDITIONS

| | |
|---|---|
| $V_{CC}$ Range | 2.5 V ≦ Vcc ≦ 6V |
| Input Pulse Levels | 0.2 $V_{CC}$ to 0.7 $V_{CC}$ |
| Input Rise and Fall Times | 10 ns |
| Input Reference Levels | 0.5 $V_{CC}$ |

## ■AC TIMING DIAGRAM




(1) The value is measured at temperature 25 °C and at the above defined power supply voltage.
(2) The value is for reference.
(3) MI shows minimum change unit of wiper output by changing wiper position.

## ■AC ELECTRICAL CHARACTERISTICS

Vcc = +2.5 V to +6.0 V, $V_H$ = Vcc, $V_L$ = 0 V

| Symbol | Parameter | Min | Typ | Max | Units |
|---|---|---|---|---|---|
| $t_{CI}$ | $\overline{CS}$ to $\overline{INC}$ Setup | 100 | — | — | ns |
| $t_{DI}$ | U/$\overline{D}$ to $\overline{INC}$ Setup | 50 | — | — | ns |
| $t_{ID}$ | U/$\overline{D}$ to $\overline{INC}$ Hold | 100 | — | — | ns |
| $t_{IL}$ | $\overline{INC}$ LOW Period | 250 | — | — | ns |
| $t_{IH}$ | $\overline{INC}$ HIGH Period | 250 | — | — | ns |
| $t_{IC}$ | $\overline{INC}$ Inactive to $\overline{CS}$ Inactive | 1 | — | — | µs |
| $t_{CPH}$ | $\overline{CS}$ Deselect Time (NO STORE) | 100 | — | — | ns |
| $t_{CPH}$ | $\overline{CS}$ Deselect Time (STORE) | 10 | — | — | ms |
| $t_{IW}$ | $\overline{INC}$ to $V_{OUT}$ Change | — | 1 | 5 | µs |
| $t_{CYC}$ | $\overline{INC}$ Cycle Time | 1 | — | — | µs |
| $t_R$, $t_F$(2) | $\overline{INC}$ Input Rise and Fall Time | — | — | 500 | µs |
| $t_{PU}$(2) | Power-up to Wiper Stable | — | — | 1 | ms |
| $t_{WR}$ | Store Cycle | — | 5 | 10 | ms |

■ Specifications are subject to change without notice. Specifications in this catalog are for reference. The formal specification sheets will be submitted upon request.