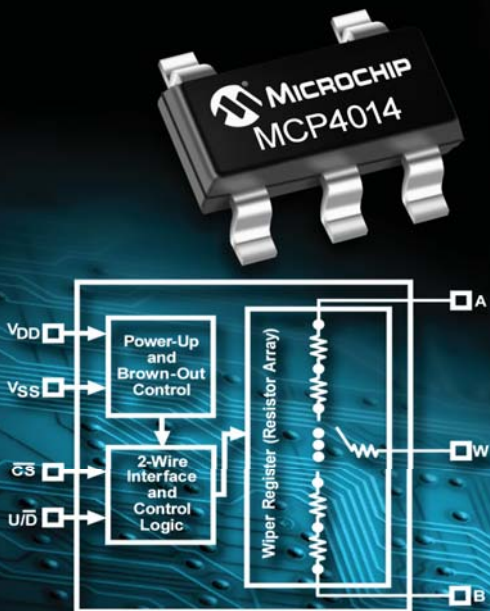




## Digital Potentiometers Design Guide

Supporting digital potentiometer applications, including: mechanical potentiometer replacement, amplifiers with offset and trimming, band pass filtering with offset and gain trimming, programmable filter, Wheatstone bridge trimming and general embedded system design techniques.

**Small Package**  
**Low Power**  
**Low Cost**



Design ideas in this guide use the following devices. A complete device list and corresponding data sheets for these products can be found at [www.microchip.com](http://www.microchip.com).

6-bit		7-bit			8-bit			
Single		Single	Dual	Quad		Single	Dual	Quad
MCP401X		MCP401X	MCP423X	MCP433X		MCP415X	MCP425X	MCP435X
MCP402X		MCP40D1X	MCP424X	MCP434X		MCP416X	MCP426X	MCP436X
		MCP413X	MCP463X	MCP443X		MCP455X	MCP465X	MCP445X
		MCP414X	MCP464X	MCP444X		MCP456X	MCP466X	MCP446X
		MCP453X						

# Digital Potentiometer Solutions

## Microchip's Family of Digital Potentiometers

Microchip offers a range of devices that allow the customer to select a device that is a best fit for their application. Some of the selection options include:

- A wide range of resistor values
  - $R_{AB}$  resistance (typical) from 2.1 k $\Omega$  to 100 k $\Omega$
- Step resolution
  - 6-bit
  - 7-bit
  - 8-bit
- Serial interfaces
  - Up/Down
  - SPI
  - I<sup>2</sup>C™
- Memory types
  - Volatile
  - Non-volatile
- Resistor network configurations
  - Potentiometer (resistor divider)
  - Rheostat (variable resistor)
- Single, dual and quad potentiometer options
- Package options
- Special features
  - Shutdown mode
  - WiperLock™ technology
- Low voltage, Low power options

Resistor sizes and resolutions allow the designer to select the step resistance and number of steps. For the device with the resistance ( $R_{AB}$ ) equal to 2.1 k $\Omega$ , there are 64 steps (63 resistors), so the step resistance ( $R_s$ ) equals  $R_{AB}/63$  (or 33.33 $\Omega$ ). For a 5 k $\Omega$  device with 257 steps (256 resistors), a step resistance ( $R_s$ ) equals  $R_{AB}/256 = 19.53\Omega$ . Now at the other end of the spectrum, for the device with the resistance ( $R_{AB}$ ) equal to 50 k $\Omega$ , there are 64 steps (63 resistors), so the step resistance ( $R_s$ ) equals  $R_{AB}/63$  (or 793.65 $\Omega$ ).

The serial interface options allow the designer to easily integrate the device into the application. For some applications the simple Up/Down interface will be adequate. For devices with higher resolution (7-bit, 8-bit) being able to directly write/read the wiper register is desirable. This is supported with SPI and I<sup>2</sup>C interfaces. SPI is simpler to implement, but I<sup>2</sup>C uses only 2 signals (pins) and supports multiple devices on the serial bus without additional pins.

The availability of both volatile and non-volatile devices allows the designer flexibility in optimizing the application. Some applications may use the digital potentiometer as a replacement for a mechanical potentiometer. In this case, a non-volatile device with the serial interface connecting to the test hardware interface allows a low cost device with low cost manufacturing.

Resistor network configurations allow the package size/cost to be minimized for the desired functionality. If a variable resistor (rheostat) with one terminal tied to ground is desired, then only one resistor terminal (the wiper) needs to be implemented. In the MCP4017/18/19 family, this configuration is shown in the MCP4019 and allows the functionality to be achieved in a low-cost SC70-5 package.

Dual and quad digital potentiometer resistor networks are closely matched, due to residing on the same silicon. Matched components allow customers to achieve better system performance in some applications

Packaging options allow customers to address their system requirement trade-offs including device cost, board area, and manufacturing sites (surface mount vs. thru-hole). Packages include 3x3 mm SOT-23 and DFN packages, 3x2 mm DFN package and tiny SC70 packages.

# Digital Potentiometer Solutions

## Low Power Applications

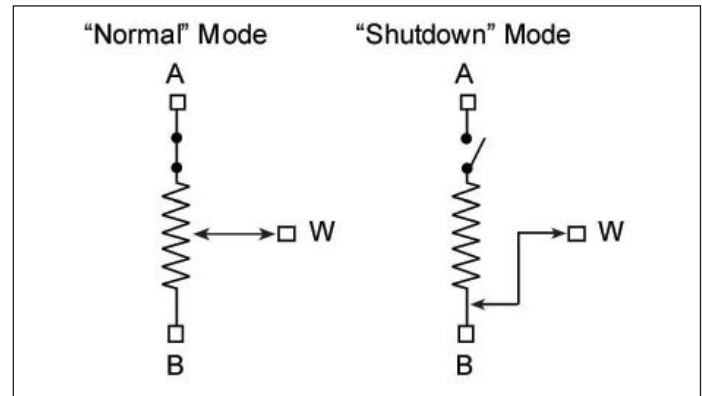
Many applications are power sensitive. This is because they are battery powered or design goals on the power supply. Microchip Technology's digital potentiometer families are low power, with the maximum  $I_{DD}$  as low as 1  $\mu\text{A}$  in some devices. This current is when the serial interface is inactive and a non-volatile memory write cycle is not active. This current does not include any current through the resistor network (the A, B and W pins).

The 1  $\mu\text{A}$  max  $I_{DD}$  devices include the MCP4011, MCP4012, MCP4013, MCP4014, MCP4021, MCP4022, MCP4023, MCP4024, MCP41010, MCP41050, MCP41100, MCP42010, MCP42050 and MCP42100. Currently all other devices have a max  $I_{DD}$  of 5  $\mu\text{A}$ .

A capability is given in many of the devices to shut down the resistor network, that is disconnect the resistor network from the circuit. This can substantially reduce the current of the system. This shut down mode may be achieved by a hardware pin (SHDN) or via software through the Terminal Control register(s). The software shutdown allows devices to retain this capability while being packaged in the smallest package since the SHDN pin is not present.

The hardware shutdown forces the resistor network into a defined condition where the resistor network is disconnected from the Terminal A pin and the Wiper value is forced to 00h (Wiper connected to Terminal B). The Wiper register retains its value so that when shutdown is exited the wiper returns to its previous position.

## Normal vs. Shutdown Mode



The software shutdown allows control to each of the resistor network terminal pins. Each resistor network has 4-bit in a TCON register. A bit for each terminal pin (A, B and W) and one bit that mimics the hardware shutdown state (the resistor network is disconnected from the Terminal A pin and the Wiper value is forced to 00h). This allows the application to completely control the currents through the digital potentiometers resistor network(s).

The software shutdown is more flexible than the hardware shutdown pin, and is available on devices where due to package selection a hardware shutdown pin was not implemented.

## Devices with Low Power Operation

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	$R_s \Omega$ (typ.)	Zero-Scale/Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	$I_{DD}$ max ( $\mu\text{A}$ ) <sup>(5)</sup>
MCP4011 <sup>(4)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot	1.8V to 5.5V <sup>(6)</sup>	8	SOIC, MSOP, DFN	1
MCP4012 <sup>(4)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SOT-23	1
MCP4013 <sup>(4)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SOT-23	1
MCP4014 <sup>(4)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SOT-23	1
MCP4021 <sup>(4)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot	2.7V to 5.5V	8	SOIC, MSOP, DFN	1
MCP4022 <sup>(4)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo	2.7V to 5.5V	6	SOT-23	1
MCP4023 <sup>(4)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot <sup>(7)</sup>	2.7V to 5.5V	6	SOT-23	1
MCP4024 <sup>(4)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo <sup>(7)</sup>	2.7V to 5.5V	5	SOT-23	1
MCP41010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP42010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1

1. Resistor options are: -202 (2.1 k $\Omega$ ), -502 (5.0 k $\Omega$ ), -103 (10.0 k $\Omega$ ), and -503 (50.0 k $\Omega$ ).

2. Resistor options are: -502 (5.0 k $\Omega$ ), -103 (10.0 k $\Omega$ ), 503 (50.0 k $\Omega$ ), and -104 (100.0 k $\Omega$ ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one  $R_s$  resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Low Voltage Applications

Some applications require a low operating voltage. Microchip offers most of their volatile memory devices specified down to 1.8V for their digital operation. The analog performance at this low voltage is not specified, but is characterized. For many applications this may be acceptable.

1.8V operational devices are all volatile devices except for the MCP41010, MCP41050, MCP41100, MCP42010, MCP42050 and MCP42100 devices.

## Devices that Support Low Voltage (1.8V) Operation

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs $\Omega$ (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(5)</sup>
MCP4011 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot	1.8V to 5.5V <sup>(6)</sup>	8	SOIC, MSOP, DFN	1
MCP4012 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SOT-23	1
MCP4013 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SOT-23	1
MCP4014 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SOT-23	1
MCP4017 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4018 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4019 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP40D17 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D18 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D19 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP4131 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4132 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4151 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4152 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4231 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4232 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4251 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4252 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4331 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4332 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4351 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4352 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4431 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4432 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4451 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4452 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4531 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4532 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4551 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4552 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4631 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4632 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4651 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4652 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5

1. Resistor options are: -202 (2.1 k $\Omega$ ), -502 (5.0 k $\Omega$ ), -103 (10.0 k $\Omega$ ), and -503 (50.0 k $\Omega$ ).

2. Resistor options are: -502 (5.0 k $\Omega$ ), -103 (10.0 k $\Omega$ ), 503 (50.0 k $\Omega$ ), and -104 (100.0 k $\Omega$ ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

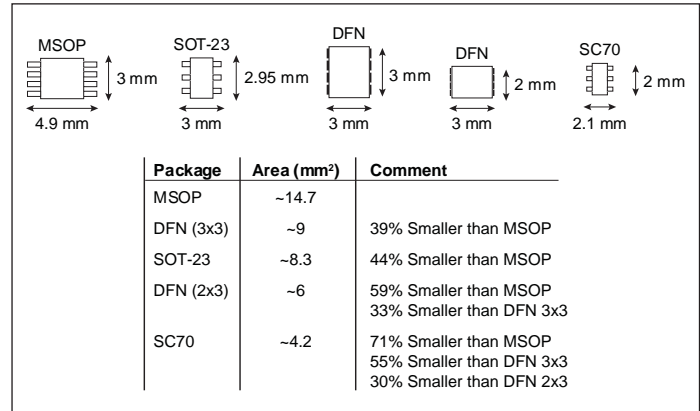
9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Small Footprint Applications

Some applications have package size limitations and require devices with the smallest footprint possible. Microchip offers several devices in small footprint packages. These packages include 8-pin DFN (3x3 mm and 2x3 mm), 5 and 6-pin SOT-23 and 5 and 6-pin SC70 packages.

## Small Footprint Devices



## Devices with Small Footprints

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	R <sub>s</sub> Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (µA) <sup>(5)</sup>
MCP4011 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 2x3	1
MCP4012 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4013 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4014 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SOT	1
MCP4021 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot	2.7V to 5.5V	8	DFN 2x3	1
MCP4022 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo	2.7V to 5.5V	6	SOT	1
MCP4023 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot <sup>(7)</sup>	2.7V to 5.5V	6	SOT	1
MCP4024 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo <sup>(7)</sup>	2.7V to 5.5V	5	SOT	1
MCP4017 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4018 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4019 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP40D17 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D18 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D19 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP4131 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4132 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4141 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	DFN 3x3	5
MCP4142 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	DFN 3x3	5
MCP4151 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4152 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4161 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	DFN 3x3	5
MCP4162 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	DFN 3x3	5
MCP4531 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4532 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4541 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	DFN 3x3	5
MCP4542 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	DFN 3x3	5
MCP4551 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4552 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	DFN 3x3	5
MCP4561 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	DFN 3x3	5
MCP4562 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	DFN 3x3	5

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).  
 2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).  
 3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.  
 4. There is one R<sub>s</sub> resistor between the maximum wiper value and Terminal A.  
 5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).  
 6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.  
 7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.  
 8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.  
 9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Non-Volatile Applications

Non-volatile devices allow the desired wiper position to be saved through a device power down or brown-out condition. When the device power is restored, the wiper value is loaded with the wiper value stored in the non-volatile register.

This is useful for both applications where the wiper value is programmed once and never changed (system calibration) as well as applications where the last user setting is saved on system powerdown (such as a volume setting).

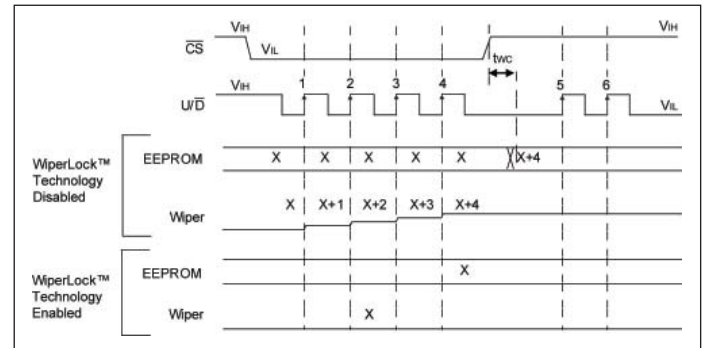
Mechanical trim pots have been used for device calibration to optimize the system performance. Digital potentiometers can now be a better solution due to reliability and total cost. Non-volatile memory versions allow the device to power on to the desired wiper setting. Non-volatile devices have a feature which can be used to ensure that this wiper value is not changed in the system.

WiperLock Technology is the method that allows Microchips non-volatile devices to ensure that once the non-volatile wiper is “locked” the wiper setting (volatile and non-volatile) can not be modified except with “High Voltage” commands.

This inhibits accidental modification of the wiper setting, as long as the high voltage is not present to the digital potentiometer during normal operation.

Many of the non-volatile devices also have some bytes of general purpose EEPROM memory available. This could be used to store system information, such as calibration codes, manufacture date, serial number or user information.

## WiperLock™ Technology Operation Example (Up/Down Interface)



## Devices with Non-Volatile Memory

Device	Serial Interface	Volatile (Vo) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology/ HV Commands	General Purpose EEPROM (bytes)	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(5)</sup>
MCP4021 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	-	N	Pot	2.7V to 5.5V	8	SOIC, MSOP, DFN	1
MCP4022 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	-	N	Rheo	2.7V to 5.5V	6	SOT-23	1
MCP4023 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	-	N	Pot <sup>(7)</sup>	2.7V to 5.5V	6	SOT-23	1
MCP4024 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	-	N	Rheo <sup>(7)</sup>	2.7V to 5.5V	5	SOT-23	1
MCP4141 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4142 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4161 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4162 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4241 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4242 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4261 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4262 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4341 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	5	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4342 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	5	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4361 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	5	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4362 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	5	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4441 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	5	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4442 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	5	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4461 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	5	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4462 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	5	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4541 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4542 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4561 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4562 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4641 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4642 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4661 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	10	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4662 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	10	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to “directly” connect to Terminal B, while full-scale allows the wiper to “directly” connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device’s analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device’s characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Serial Interfaces

Microchip currently offers devices with one of the following three serial interfaces:

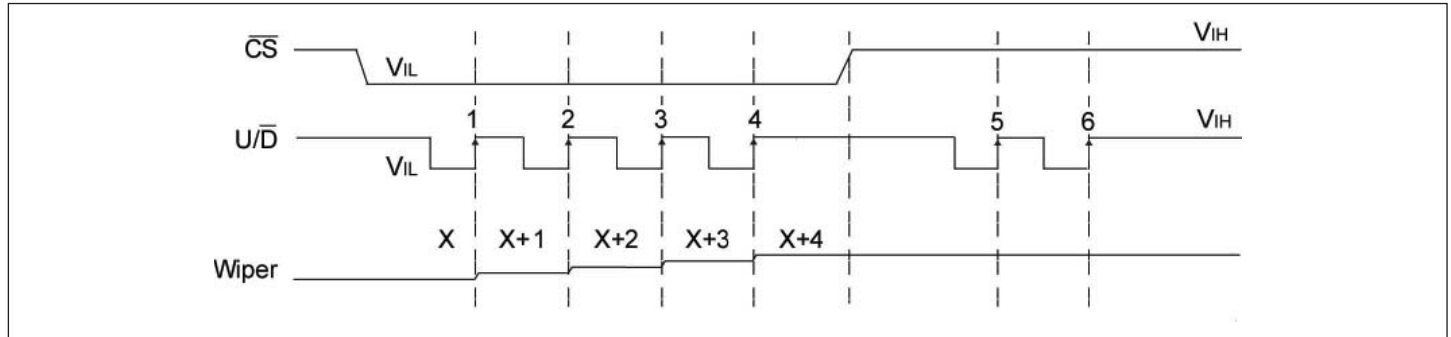
- An Up/Down interface
- An SPI interface
- An I<sup>2</sup>C interface

## Up/Down Interface

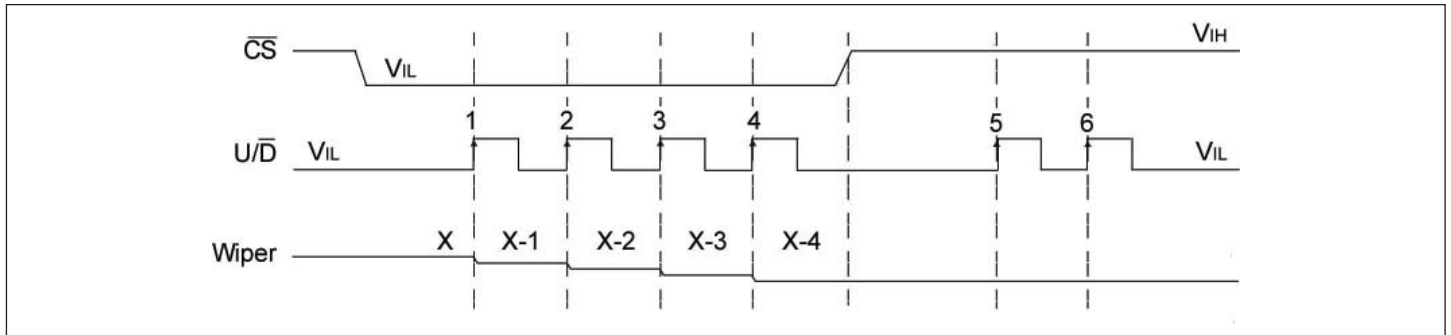
This is an easy to implement interface that requires two pins and can be implemented with minimal software overhead. This interface is also easy for test systems when using the non-volatile devices as replacements for mechanical potentiometers.

High voltage commands require the CS pin forced to the V<sub>IHH</sub> voltage, instead of the V<sub>IL</sub> voltage. In this state, the WiperLock Technology bit can be enabled and disabled.

### Increment



### Decrement



## Devices with Up/Down Interface

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	R <sub>s</sub> Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(5)</sup>
MCP4011 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 2x3	1
MCP4012 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4013 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4014 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SOT	1
MCP4021 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot	2.7V to 5.5V	8	SC70	1
MCP4022 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo	2.7V to 5.5V	6	SC70	1
MCP4023 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot <sup>(7)</sup>	2.7V to 5.5V	6	SC70	1
MCP4024 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo <sup>(7)</sup>	2.7V to 5.5V	5	SC70	1

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one R<sub>s</sub> resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

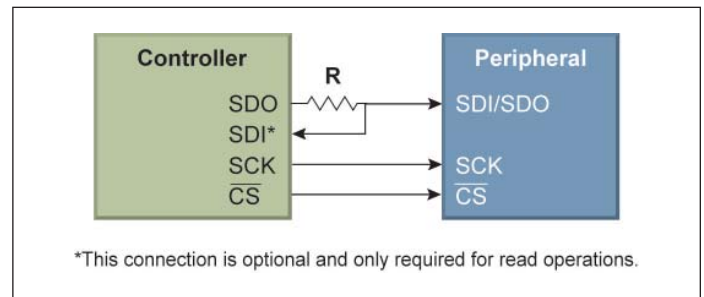
## SPI Interface

This is also an easy to implement interface, that requires three or four I/O pins. The additional pins allow data to be read back from the device or to allow device daisy chaining. Daisy chaining allows the SPI interface to update all devices in that chain at the same time.

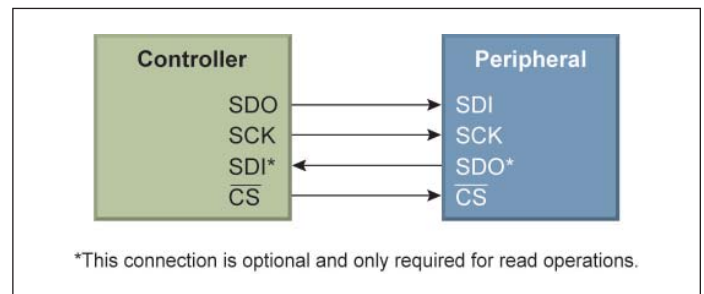
Many microcontrollers offer this interface as a hardware module, further simplifying the code development.

High voltage commands require the CS pin forced to the  $V_{IH}$  voltage, instead of the  $V_{IL}$  voltage. In this state, the WiperLock Technology bit can be enabled and disabled.

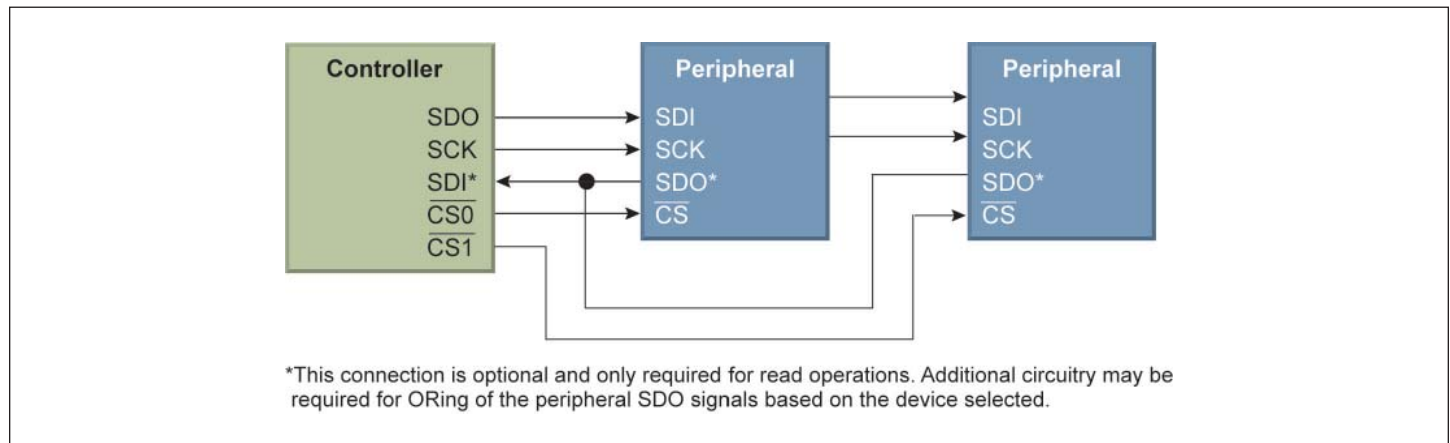
### Controller to Single Peripheral with Multiplexed SDI and SDO Pins



### Controller to Single Peripheral



### Controller to Multiple Peripherals (Multiple Chip Selects)





# Digital Potentiometer Solutions

## Devices with SPI Interface

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (µA) <sup>(5)</sup>
MCP4131 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4132 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4141 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4142 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4151 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4152 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	PDIP, SOIC, MSOP, DFN	5
MCP4161 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4162 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	PDIP, SOIC, MSOP, DFN	5
MCP4231 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4232 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4241 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4242 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4251 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4252 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4261 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4262 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4331 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4332 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4341 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4342 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4351 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4352 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4361 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4362 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP41010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP42010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

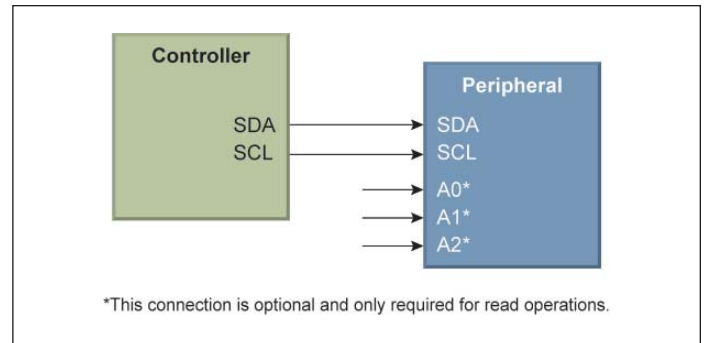
## I<sup>2</sup>C™ Interface

The I<sup>2</sup>C interface is a two wire interface, where the output drivers are open drain. This protocol supports reads and writes using only the interface's two wires. The I<sup>2</sup>C protocol allows multiple devices on the I<sup>2</sup>C bus, where each device has a unique device address. The I<sup>2</sup>C protocol requires more host controller firmware overhead than the SPI protocol, but requires less hardware resources (2 pins vs. 3 or 4 pins). The I<sup>2</sup>C protocol allows many devices on the I<sup>2</sup>C bus without the need to increase the number of I/O pins dedicated by the master controller. The typical I<sup>2</sup>C interface is shown. Several of the Microchip digital potentiometer devices support high voltage commands. This function requires an additional host controller output pin.

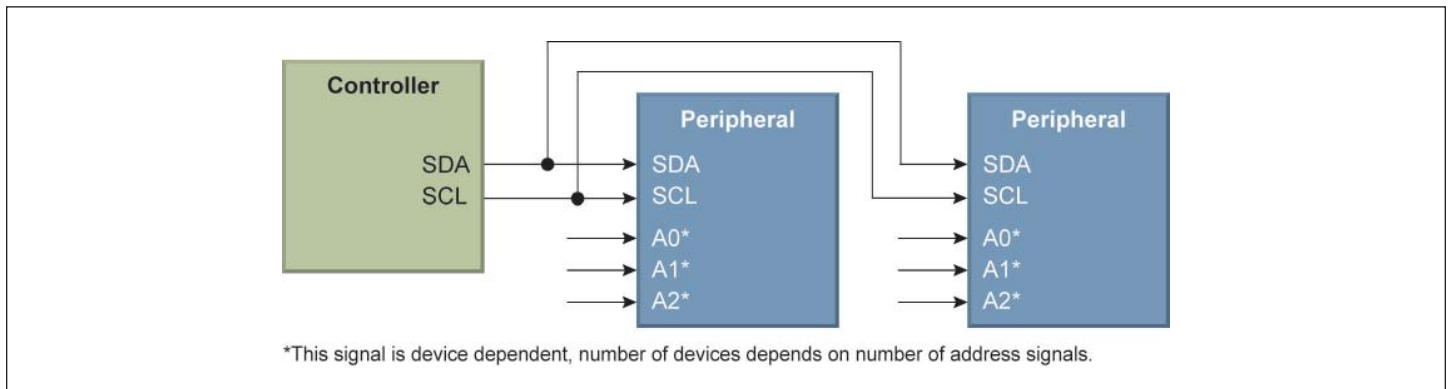
Many microcontrollers offer this interface as a dedicated hardware module, which eases the software requirement of the protocol.

High voltage commands require the HVC/A0 pin forced to the V<sub>IHH</sub> voltage, instead of the V<sub>IL</sub> voltage. In this state, the WiperLock Technology bit can be enabled and disabled.

## Controller to Single Peripheral



## Controller to Multiple Peripherals (Multiple Chip Selects)



# Digital Potentiometer Solutions

## Devices with I<sup>2</sup>C Interface

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLoc <sup>®</sup> ™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(5)</sup>
MCP4017 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4018 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4019 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP40D17 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D18 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D19 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP4531 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4532 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4541 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4542 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4551 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4552 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4561 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4562 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4631 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4632 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4641 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4642 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4651 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4652 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4661 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4662 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4431 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4432 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4441 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4442 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4451 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4452 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4461 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4462 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Single, Dual and Quad Potentiometer Options

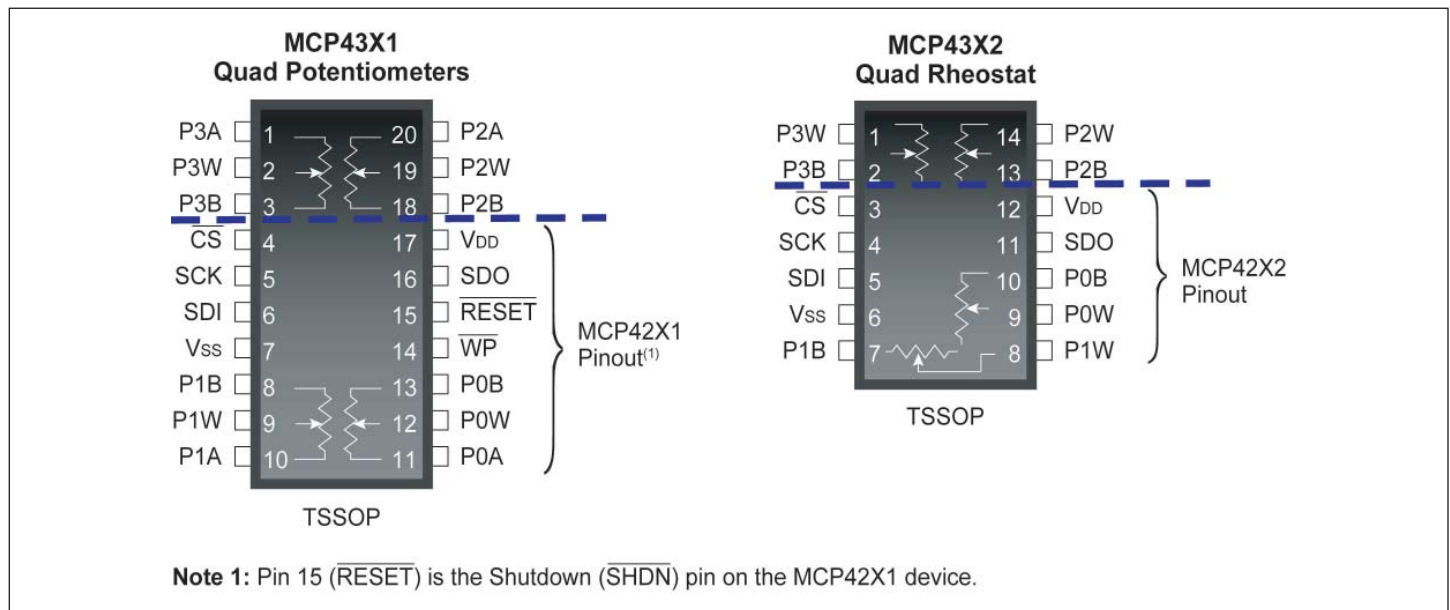
Some devices offer multiple resistor networks on the same device. Currently up to 4 resistor networks are available on a single device. These resistor networks are referred to as Pot 0 (Potentiometer 0), Pot 1, Pot 2 and Pot 3. Having multiple potentiometers on the same device offers several advantages, including:

- Cost per potentiometer
- PCB layout area per potentiometer
- Variation between potentiometers

In some applications, the  $R_{AB}$  resistance variation between potentiometer is important for the application circuit. When these potentiometers are on the same silicon, the  $R_{AB}$  resistance is small compared to the possible variation of the  $R_{AB}$  resistance on different devices. The data sheets for devices with multiple resistor networks have  $R_{AB}$  matching specifications as well as additional information in the characterization graph section.

The quad potentiometer devices are defined so that the for the same leaded package type (such as TSSOP) the Quad and Dual devices have a compatible footprint. The following figure shows footprint compatibility for both the MCP4261 → MCP4361 and the MCP4262 → MCP4362.

## Quad Pinout vs. Dual Pinout (TSSOP Package)



# Digital Potentiometer Solutions

## Single Potentiometer Devices

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(6)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(9)</sup>
MCP4011 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot	1.8V to 5.5V <sup>(6)</sup>	8	DFN 2x3	1
MCP4012 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4013 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SOT	1
MCP4014 <sup>(1)</sup>	U/D	Vol	63	33.3/79.4/158.7/793.7	Y/Y	1	N	Y <sup>(9)</sup>	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SOT	1
MCP4021 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot	2.7V to 5.5V	8	SC70	1
MCP4022 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo	2.7V to 5.5V	6	SC70	1
MCP4023 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Pot <sup>(7)</sup>	2.7V to 5.5V	6	SC70	1
MCP4024 <sup>(1)</sup>	U/D	NV	63	33.3/79.4/158.7/793.7	Y/Y	1	Y	Y	N	Rheo <sup>(7)</sup>	2.7V to 5.5V	5	SC70	1
MCP4017 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4018 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP4019 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP40D17 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D18 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Pot <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	6	SC70	5
MCP40D19 <sup>(2)</sup>	I <sup>2</sup> C	Vol	127	39.4/78.7/393.7/787.4	Y/Y	1	N	N	N	Rheo <sup>(7)</sup>	1.8V to 5.5V <sup>(6)</sup>	5	SC70	5
MCP4531 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4532 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4541 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4542 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4551 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4552 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4561 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4562 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4531 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4532 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4541 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4542 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP4551 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4552 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	1	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	8	MSOP, DFN	5
MCP4561 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	8	MSOP, DFN	5
MCP4562 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	1	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	8	MSOP, DFN	5
MCP41010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1
MCP41100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	1	N	N	N	Pot	2.7V to 5.5V	8	PDIP, SOIC	1

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Dual Potentiometer Devices

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (µA) <sup>(5)</sup>
MCP4231 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4232 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4241 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4242 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4251 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4252 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4261 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	PDIP, SOIC, TSSOP, QFN	5
MCP4262 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4631 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4632 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4641 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4642 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP4651 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	14, 16	TSSOP, QFN	5
MCP4652 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	2	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	10	MSOP, DFN	5
MCP4661 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	14, 16	TSSOP, QFN	5
MCP4662 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	2	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	10	MSOP, DFN	5
MCP42010	SPI	Vol	256	39.1	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42050	SPI	Vol	256	195.3	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1
MCP42100	SPI	Vol	256	390.6	Y/N <sup>(4)</sup>	2	N	N	Y	Pot	2.7V to 5.5V	14	PDIP, SOIC, TSSOP	1

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to "directly" connect to Terminal B, while full-scale allows the wiper to "directly" connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device's analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device's characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Quad Potentiometer Devices

Device	Serial Interface	Volatile (Vol) Non-Volatile (NV)	# RS Resistors	Rs Ω (typ.)	Zero-Scale/ Full-Scale <sup>(3)</sup>	# of Channels	WiperLock™ Technology	HV Commands	Shutdown Mode	Configuration	Voltage Range	# of Pins	Packages	I <sub>DD</sub> max (μA) <sup>(5)</sup>
MCP4331 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4332 <sup>(2)</sup>	SPI	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4341 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4342 <sup>(2)</sup>	SPI	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4351 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4352 <sup>(2)</sup>	SPI	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4361 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4362 <sup>(2)</sup>	SPI	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4431 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4432 <sup>(2)</sup>	I <sup>2</sup> C	Vol	128	39.1/78.1/390.6/781.3	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4441 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4442 <sup>(2)</sup>	I <sup>2</sup> C	NV	128	39.1/78.1/390.6/781.3	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5
MCP4451 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Pot	1.8V to 5.5V <sup>(6)</sup>	20	TSSOP, QFN	5
MCP4452 <sup>(2)</sup>	I <sup>2</sup> C	Vol	256	19.5/39.1/195.3/390.6	Y/Y	4	N	Y <sup>(9)</sup>	Y <sup>(8)</sup>	Rheo	1.8V to 5.5V <sup>(6)</sup>	14	TSSOP	5
MCP4461 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Pot	2.7V to 5.5V	20	TSSOP, QFN	5
MCP4462 <sup>(2)</sup>	I <sup>2</sup> C	NV	256	19.5/39.1/195.3/390.6	Y/Y	4	Y	Y	Y <sup>(8)</sup>	Rheo	2.7V to 5.5V	14	TSSOP	5

1. Resistor options are: -202 (2.1 kΩ), -502 (5.0 kΩ), -103 (10.0 kΩ), and -503 (50.0 kΩ).

2. Resistor options are: -502 (5.0 kΩ), -103 (10.0 kΩ), 503 (50.0 kΩ), and -104 (100.0 kΩ).

3. Zero-scale allows the wiper to “directly” connect to Terminal B, while full-scale allows the wiper to “directly” connect to Terminal A.

4. There is one Rs resistor between the maximum wiper value and Terminal A.

5. This current is with the serial interface inactive, and not during an EEPROM write cycle (for non-volatile devices).

6. The serial interface has been tested to 1.8V, the device’s analog characteristics (resistor) have been tested from 2.7V to 5.5V. Review the device’s characterization graphs for information on analog performance between 1.8V and 2.7V.

7. One of the terminal pins (A or B) is internally connected to ground, due to the limitation of the number of pins on the package.

8. Shutdown support via software (TCON register(s)). If device has SHDN pin, software shutdown also functions.

9. High voltage command support is for compatibility with the corresponding non-volatile version of the device.

# Digital Potentiometer Solutions

## Resistance Options and Resolutions

Microchip offers Digital Potentiometer devices with typical  $R_{AB}$  resistances of 2.1 K $\Omega$ , 5 K $\Omega$ , 10 K $\Omega$ , 50 K $\Omega$  and 100 K $\Omega$ . The devices offer either 6-, 7- or 8-bits of resolution.

The step resistance ( $R_s$ ) is the  $R_{AB}$  resistances divided by the number of  $R_s$  resistors in the  $R_{AB}$  ladder.

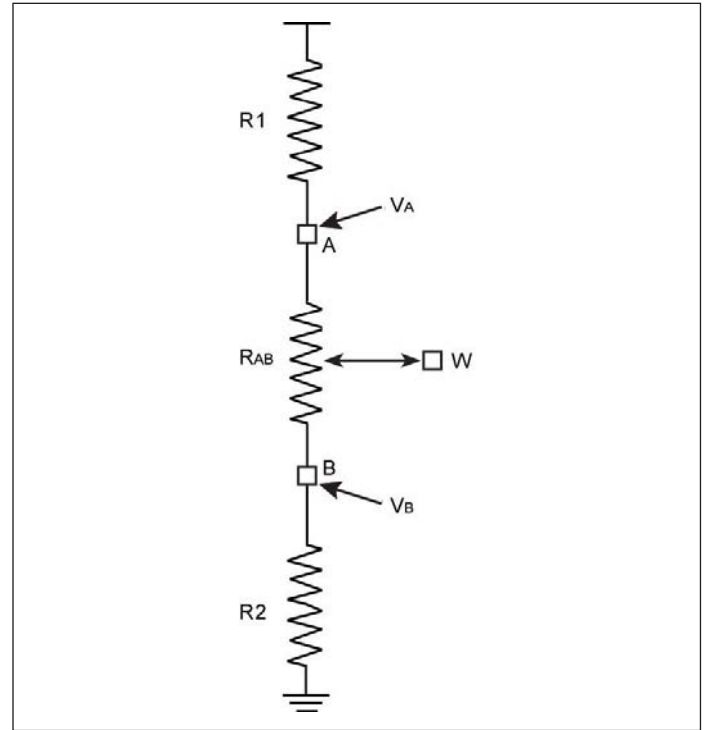
The step resistance is important to understand when you are using the device in a rheostat mode, or the potentiometer is being windowed by resistors on the Terminal A and/or on the Terminal B.

## Voltage Windowing

Terminal A and Terminal B may for example be any voltage within the device specification limits. Lets call the voltages at these nodes  $V_A$  and  $V_B$ . So the voltage across the resistor  $R_{AB}$  ( $V_{AB}$ ) is  $|V_A - V_B|$ . The  $V_{AB}$  voltage is determined by the values of the  $R_1$ ,  $R_2$  and  $R_{AB}$  resistors. As the  $V_{AB}$  voltage becomes smaller relative to the voltage range, the effective resolution of the device increase, though the resolution is limited to between the  $V_A$  and  $V_B$  voltages.

This allows a less precise device to be used for more precise circuit tuning over a narrower range. When replacing a mechanical potentiometer, this configuration can be used and  $R_1$  and  $R_2$  may be any resistance (including 0).

## Voltage Windowing



## Resistance Options

$R_{AB}$	6-bit (63)	7-bit (127)	7-bit (128)	8-bit (256)
2100	33.33333333	-	-	-
5000	79.36507937	39.37007874	39.0625	19.53125
10000	158.7301587	78.74015748	78.125	39.0625
50000	793.6507937	393.7007874	390.625	195.3125
100000	-	787.4015748	781.25	390.625

## How the $V_{AB}$ Voltage Effects the Effective Resolution

$V_{AB}$	mV per Step				Effective $V_{AB}$ Resolution vs. Fixed $V_{DD}$				Comment
	6-bit (63)	7-bit (127)	7-bit (128)	8-bit (256)	6-bit (63)	7-bit (127)	7-bit (128)	8-bit (256)	
5.00	79.4E	39.4E	39.1E	19.5E	6-bit	7-bit	7-bit	8-bit	$V_{AB} = V_{DD}$
2.50	39.7E	19.7E	19.5E	9.8E	7-bit	8-bit	8-bit	9-bit	$V_{DD} = 5.0V$
1.25	19.8E	9.8E	9.8E	4.9E	8-bit	9-bit	9-bit	10-bit	$V_{DD} = 5.0V$



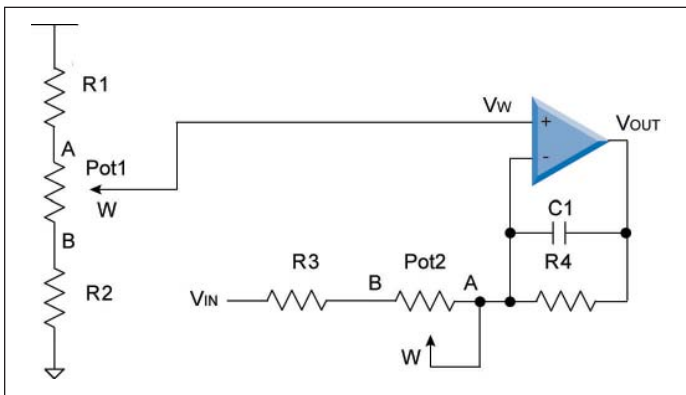
# Digital Potentiometer Solutions

## Application Circuits and Techniques

Digital potentiometers are a good fit for applications to trim offset and gain in amplifier circuits. In this following circuit, a resistor ladder is used to create a voltage window where Pot1 is used to trim the desired offset for the inverting amplifier. A second potentiometer (Pot2) is used in a rheostat mode along with resistor R3 to control the gain of the amplifier. The step resistance of Pot2 relative to resistor R3 determines if the gain trimming is a fine adjustment or a course adjustment. Capacitor C1 is for compensation of the op amp and to inhibit the output from oscillating.

In this circuit, there is no interaction between the offset trimming and the gain trimming, but the input signal ( $V_{IN}$ ) is loaded by the resistance of R3 plus Pot2's  $R_{BW}$  value.

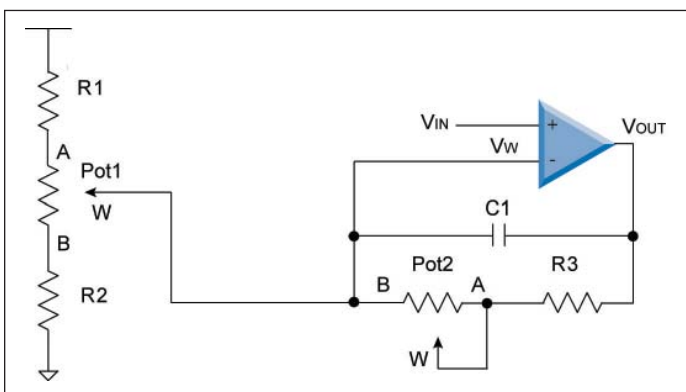
### Inverting Amplifier with Offset and Gain Trimming



In the following circuit, a resistor ladder is used to create a voltage window where Pot1 is used to trim the desired offset for the non-inverting amplifier. A second potentiometer is used in a rheostat mode to control the gain of the amplifier. The step resistance of Pot2 relative to resistor R3 determines if the gain trimming is a fine adjustment or a course adjustment. Capacitor C1 is for compensation of the op amp and to inhibit the output from oscillating.

In this circuit, there is an interaction between the offset trimming and the gain trimming. To minimize this interaction, Pot2 should be small compared to resistor R3 and Pot1 should be small relative to the sum of R1 and R2. But the input signal ( $V_{IN}$ ) is not loaded.

### Non-Inverting Amplifier with Offset and Gain Trimming



Additional information can be found in application note AN1316.

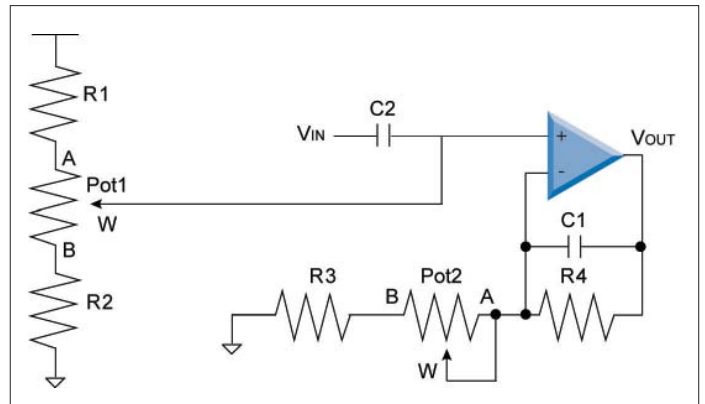
In the following circuit, a resistor ladder is used to create a voltage window where Pot1 is used to trim the desired offset for the band pass filter. This resistor ladder setting also works with capacitor C2 to set the high pass filter frequency.

A second potentiometer (Pot2) is used in a rheostat mode along with resistor R3 to control the gain of the amplifier. The step resistance of Pot2 relative to resistors R3 and R4 determines if the gain trimming is a fine adjustment or a course adjustment. Capacitor C1 along with Pot2, R3 and R4 is used to set the low pass filter.

Capacitor C1 is also used for compensation of the Op Amp and to inhibit the output from oscillating.

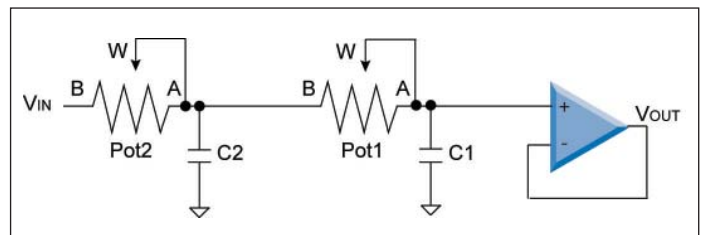
If capacitor C1 is not present, then the circuit is a high pass filter, while if capacitor C2 is not present then the circuit is a low pass filter.

### Band Pass Filter with Offset and Gain Trimming



The following circuit will use the use of an RC filter (Potx and Cx) will filter at the selected frequency. that frequency is determined by the rheostat value ( $R_{BW}$ ) of the Pot and the capacitor value ( $C_x$ ). each additional stage of the RC filter is used to enhance the roll-off characteristics for the filter. The capacitors  $C_x$  should be the same, while the wiper values of the Pots should be similar. The differences would be to compensate for the slight variations of the  $R_{AB}$  values of each Pot and the variations of the capacitors.

### Programmable Filter



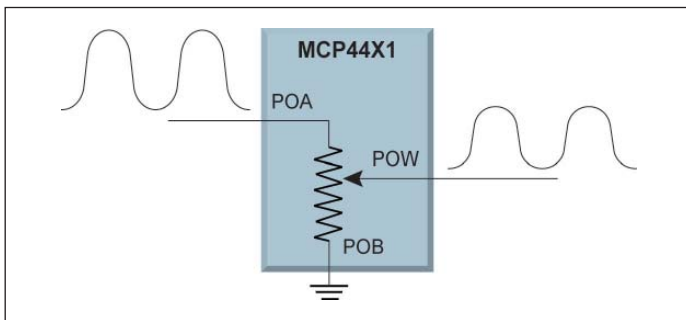
# Digital Potentiometer Solutions

## Logarithmic Steps

Logarithmic steps are desirable since the human ear hears in a logarithmic manner. The use of a linear potentiometer can approximate a log potentiometer, but with fewer steps. An 8-bit potentiometer can achieve fourteen 3 dB log steps plus a 100% (0 dB) and a mute setting.

The figure below shows a block diagram of one of the MCP44X1 resistor networks being used to attenuate an input signal. In this case, the attenuation will be ground referenced. Terminal B can be connected to a common mode voltage, but the voltages on the A, B and Wiper terminals must not exceed the MCP44X1 device's  $V_{DD}/V_{SS}$  voltage limits.

Signal Attenuation Block Diagram - Ground Referenced



The following equation shows how to calculate voltage dB gain ratios for the digital potentiometer.

### dB Calculations (Voltage)

$$L = 20 * \log_{10} (V_{OUT}/V_{IN})$$

$$L = 20 * \log_{10} (R_{BW}/R_{AB})$$

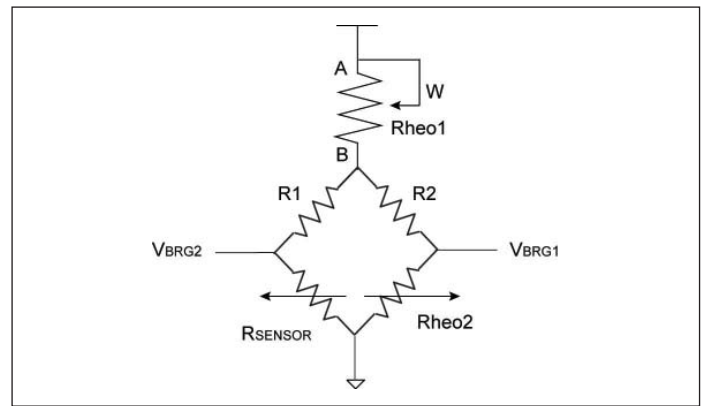
dB	$V_{OUT}/V_{IN}$ Ratio
-3	0.70795
-2	0.79433
-1	0.89125

More detail on this can be found in Section 8.5 of the MCP444X/446X Data Sheet (DS22265).

The following circuit shows a Wheatstone Bridge with current limiting. In a Wheatstone Bridge, there are four resistive elements. In this example, two are fixed value ( $R_1$  and  $R_2$ ), there is a resistive sensor ( $R_{SENSOR}$ ) and then there is the digital potentiometer in rheostat configuration to calibrate the circuit due to variations of the resistive sensor. This sensor could be for temperature or weight measurement.

At a default condition the sensor should be a given value, but this value will change from device to device. To compensate for the resistive changes in the  $R_1$  plus  $R_{SENSOR}$  leg of the bridge, the Rheo2 would be modified for the  $R_2$  plus Rheo2 leg of the bridge. This would be done so that the voltages of  $V_{BRG1}$  and  $V_{BRG2}$  are at their desired levels. Many times this is  $V_{BRG1} = V_{BRG2}$ .

Wheatstone Bridge Trimming



Now as the conditions on the sensor change, the resistance of the sensor will change, causing the  $V_{BRG2}$  voltage to change. The delta voltage between  $V_{BRG1}$  and  $V_{BRG2}$  can then be used to determine the state of the system (temperature, weight, etc.).

Rheo 1 is used in a rheostat mode to limit the current or trim the current through the Wheatstone Bridge.

### Implementing a More Precise Rheostat

The  $R_{AB}$  value of a typical digital potentiometer can vary as much as  $\pm 20\%$ , so a device with a 10 k $\Omega$   $R_{AB}$  value could have an  $R_{AB}$  value as small as 8 k $\Omega$ , as large as 12 k $\Omega$ . In a system, this variation for the rheostat value may not be desirable. This variation can be calibrated out to make a precise rheostat, at a cost of the resolution of the device.

If we design the application circuit where this rheostat only operates from 0 $\Omega$  to 8 k $\Omega$ , all digital potentiometer devices (over process) will meet this requirement. Now with calibration, we will need to ensure that the wiper value is limited to a value where the rheostat value is the closest resistance value to the desired rheostat target value of 8 k $\Omega$ . The worst case (lowest) wiper value occurs when the  $R_{AB}$  value is 12 k $\Omega$ . In this case, a wiper value of 171. results in a resistance of 8016 $\Omega$ . This results in a resolution of approximately 7.4 bits, or 0.58%.

In potentiometer mode, the process variation of the  $R_{AB}$  value may not be an application issue since the device is operating as a voltage divider.

# Digital Potentiometer Solutions

## Demo/Evaluation Support

Microchip Technology offers several boards that support the demonstration and evaluation of the digital potentiometer devices. These boards fall into two categories:

- Populated boards to demonstrate/evaluate the specific device(s)
- Blank printed circuit boards (PCBs)

The blank PCBs allow customers to populate the device and supporting circuit to best evaluate the performance and characteristics of the desired device configuration.

The following boards are available on the Microchip web site at: [www.microchip.com/analogtools](http://www.microchip.com/analogtools).

Name	Part Number	Package Supported	
		# Pins	Device/Pkg Type
MCP401X Evaluation Board	MCP401XEV	–	MCP401X
MCP402X Non-Volatile Digital Potentiometer Evaluation Board	MCP402XEV	–	MCP40X1 (SOT-23)
MCP42X1 Evaluation Board	MCP42X1EV	–	MCP42X1
MCP43X1 Evaluation Board	MCP43X1EV	–	MCP43X1
MCP46X1 Evaluation Board	MCP46X1EV	–	MCP46X1
MCP4XXX Digital Potentiometer Daughter Board	MCP4XXXDM-DB	–	MCP42XXX (DIP) and MCP40X1 (SOIC)
MCP42XX PICtail™ Plus Daughter Board	MCP42XXDM-PTPLS	–	MCP42XX
MCP46XX PICtail Plus Daughter Board	MCP46XXDM-PTPLS	–	MCP46XX
SOT-23-5/6 Voltage Supervisor Evaluation Board	VSUPEV2	5 & 6	SOT-23
8-pin SOIC/MSOP/TSSOP/DIP Evaluation Board	SOIC8EV	8	DIP, MSOP, SOIC and TSSOP
14-pin SOIC/TSSOP/DIP Evaluation Board	SOIC14EV	14	DIP, SOIC and TSSOP
20-pin TSSOP/SSOP Evaluation Board	TSSOP20EV	20	TSSOP and SSOP

### MCP401X Evaluation Board (MCP401XEV)



The MCP401XEV Evaluation Board allows the system designer to quickly evaluate the operation of Microchip Technology's MCP40D18 Digital Potentiometer device. The board uses the SC70EV Generic PCB and has been populated for the MCP40D18. The 6-pin header (PICKit Serial) has been jumpered to the appropriate pins on the MCP40D18 device, allowing the PICKit Serial to communicate with the device. The User's Guide includes demonstrations of the PICKit Serial controlling the MCP40D18 device.

### MCP402X Non-Volatile Digital Potentiometer Evaluation Board (MCP402XEV)



This low-cost board enables user's to exercise all of the features of the MCP401X and MCP402X devices. Kit includes one populated and one unpopulated PCB. The populated board has an MCP4021-103E/SN digital potentiometer configured as a "windowed" potentiometer using a 2.5 kΩ pull-up and a 2.5 kΩ pull-down resistor. The PCB supports the 8-pin SOIC, SOT-23-6 and SOT-23-5 package variations. The unpopulated PCB allows user's to build the exact combination of components their application requires.

### MCP42X1 Evaluation Board (MCP42X1EV)



The MCP42XXEV Evaluation Board allows the system designer to quickly evaluate the operation of Microchip Technology's MCP4261 Digital Potentiometer device. The board uses the TSSOP20EV Generic PCB and has been populated for the MCP4261. The 6-pin header (PICKit Serial) has been jumpered to the appropriate pins on the MCP4261 device, allowing the PICKit Serial to communicate with the device.

### MCP43X1 Evaluation Board (MCP43X1EV)



The MCP43XXEV Evaluation Board allows the system designer to quickly evaluate the operation of Microchip Technology's MCP4361 Digital Potentiometer device. The board uses the TSSOP20EV Generic PCB and has been populated for the MCP4361. The 6-pin header (PICKit Serial) has been jumpered to the appropriate pins on the MCP4361 device, allowing the PICKit Serial to communicate with the device.

### MCP46X1 Evaluation Board (MCP46X1EV)



The MCP46XXEV Evaluation Board allows the system designer to quickly evaluate the operation of Microchip Technology's MCP4661 Digital Potentiometer device. The board uses the TSSOP20EV Generic PCB and has been populated for the MCP4661. The 6-pin header (PICKit Serial) has been jumpered to the appropriate pins on the MCP4661 device, allowing the PICKit Serial to communicate with the device.

### MCP4XXX Digital Potentiometer Daughter Board (MCP4XXXDM-DB)



This board allows evaluation of the MCP42XXX and MCP402X Digital Potentiometers. The MCP42XXX are dual digital potentiometer devices that have the same characteristics as the single digital potentiometer devices (MCP41XXX). The MCP402X devices are non-volatile and have similar characteristics to their volatile memory versions (MCP401X). The board supports two MCP42XXX devices to allow the resistor networks to be "stacked" and form a programmable windowed digital potentiometer. The board also has a voltage doubler device (TC1240A), which can be used to show the WiperLock Technology feature of the MCP4021.

# Digital Potentiometer Solutions

## MCP42XX PICtail Plus Daughter Board (MCP42XXDM-PTPLS)



This daughter board is used to demonstrate the operation of Microchip's MCP42XX or MCP41XX digital potentiometers. This board is designed to be used in conjunction with either the PIC24 Explorer 16 Demo Board or the PICKit™ Serial Analyzer.

## MCP46XX PICtail Plus Daughter Board (MCP46XXDM-PTPLS)



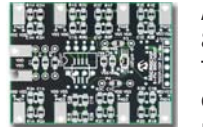
This daughter board demonstrates the features and abilities of Microchip's MCP45XX and MCP46XX Digital Potentiometers. This board is designed to exclusively use the MCP46X1 devices. The MCP4661 uses an I<sup>2</sup>C interface and can be controlled via the PICKit Serial Analyzer interface or via the PICtail Plus interface.

## SOT-23-5/6 Voltage Supervisor Evaluation Board (VSUPEV2)



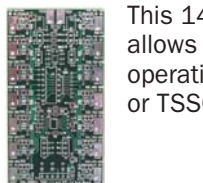
This blank PCB allows quick evaluation of voltage supervisors and voltage detectors in the SOT-23-5 and SOT-23-6 packages. This PCB supports many Microchip devices, including the non-volatile Digital Potentiometer and PIC10F2XX devices.

## SOIC 8-lead Evaluation Board (SOIC8EV)



A blank PCB to easily evaluate Microchip's 8-pin devices (in SOIC, DIP, MSOP and TSSOP packages). Each device pin is connected to a pull-up resistor, a pull-down resistor, an in-line resistor and a loading capacitor. The PCB pads allow through hole or surface mount connectors to be installed to ease connection to the board. Additional passive component footprints are on the board, to allow simple circuits to be implemented.

## 14-pin SOIC/TSSOP/DIP Evaluation Board (SOIC14EV)



This 14-lead SOIC/TSSOP/DIP evaluation board allows system designers to quickly evaluate the operation of Microchip devices in either SOIC, DIP or TSSOP packages.

## 20-pin TSSOP/SSOP Evaluation Board (TSSOP20EV)



This 20-pin TSSOP and SSOP evaluation board allows system designers to quickly evaluate the operation of Microchip devices in any of the following 20-pin packages: TSSOP-20/16/14/8 or SSOP-20. The board has a 6-pin header (PICKit Serial, ICSP™, etc.) that can be easily jumpered to the device's desired pins to communicate with the device (using PICKit Serial) or in the case of PIC microcontrollers or EEPROM, programmed (using ICSP).

The following literature is available on the Microchip web site: [www.microchip.com/appnotes](http://www.microchip.com/appnotes). There are additional application notes that may be useful.

### AN219: Comparing Digital Potentiometers to Mechanical Potentiometers

This application note compares two types of potentiometers – the mechanical potentiometer (also called a trimmer potentiometer) and the digital potentiometer. Resistor potentiometers can be found in electronic circuits across a wide spectrum of applications. Most typically, they function in a voltage divider configuration in order to execute various types of tasks, such as offset or gain adjust.

### AN691: Optimizing Digital Potentiometer Circuits to Reduce Absolute Temperature Variations

Circuit ideas are presented that use the necessary design techniques to mitigate errors, consequently optimizing the performance of the digital potentiometer.

### AN692: Using Digital Potentiometers to Optimize a Precision Single-Supply Photo Detect Circuit

This application note shows how the adjustability of the digital potentiometer can be used to an advantage in photosensing circuits.

### AN737: Using Digital Potentiometers to Design Low-Pass Adjustable Filters

A programmable, second-order, low-pass filter is presented in four different scenarios. The first three scenarios will illustrate how a dual digital potentiometer and a single amplifier can be configured for low-pass second-order Butterworth, Bessel and Chebyshev responses with a programmable corner frequency range of 1:100. An example of the digital potentiometer setting for these designs is summarized. The fourth scenario will show the same circuit design, where all three approximation methods (Butterworth, Bessel and Chebyshev) can coexist with a programmable corner frequency range of 1:10.

### AN746: Interfacing Microchip's MCP41XXX/MCP4XXX Digital Potentiometer to a PIC® Microcontroller

Communications between the MCP41XXX and MCP42XXX family of digital potentiometers and a PIC16F876 microcontroller is discussed. These devices communicate using a standard 3-wire SPI compatible interface. The code supplied with this application note will include both absolute and relocatable assembly code, written for both hardware SPI and firmware SPI implementations.

# Digital Potentiometer Solutions

## AN747: Communicating with Daisy Chained MCP42XXX Digital Potentiometers

The MCP41XXX and MCP42XXX family of digital potentiometers allow for daisy chaining of multiple devices on a single SPI bus. It is possible to communicate to multiple devices using one 3-wire data bus (CS, CLK and DATA), by connecting the SO pin on one device to the SI pin of the next device in the chain. This application note details one example of source code that is used to communicate with eight daisy chained devices.

## AN757: Interfacing Microchip's MCP41XXX/MCP4XXX Digital Potentiometer to the Motorola 68HC12 Microcontroller

Communication between the MCP41XXX and MCP42XXX family of digital potentiometers and the Motorola 68HC12 family of microcontrollers is discussed. These devices communicate using a standard 3-wire SPI compatible interface. Specifically, the MC68HC912B32 evaluation board was used.

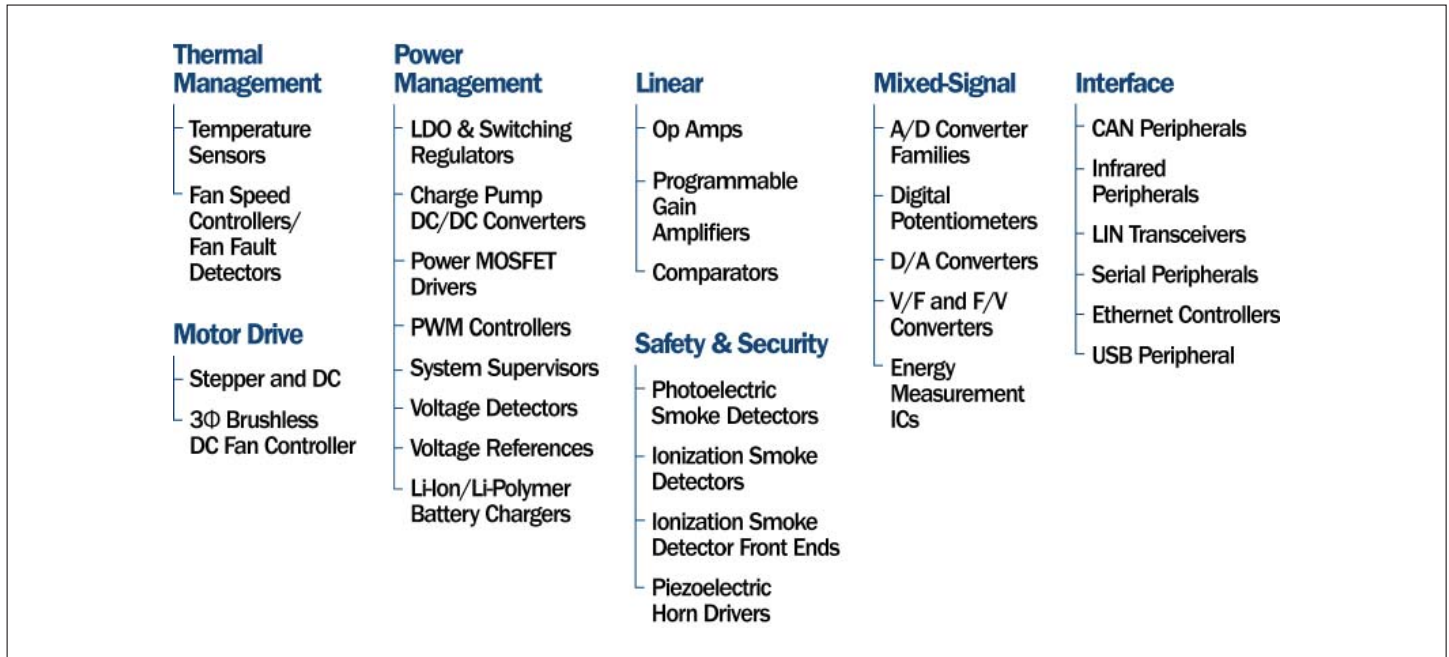
## AN1080: Understanding Digital Potentiometer Resistance Variations

This application note discusses how process, voltage and temperature effect the resistor network's characteristics, specifications and techniques to improve system performance.

## AN1316: Using Digital Potentiometers for Programmable Amplifier Gain

This Application Note will discuss implementations of programmable gain circuits using an op amp and a digital potentiometer. This discussion will include implementation details for the digital potentiometer's resistor network. It is important to understand these details to understand the effects on the application.

## Stand-Alone Analog and Interface Products



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