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APPLICATION NOTE 4051

Using an Analog Voltage to Control a Digital Potentiometer

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Abstract: In some applications a digital potentiometer with an I²C interface must be controlled by a continuously varying analog signal. This application note addresses this requirement, and provides a simple design solution. The principle presented here is versatile and can be used in multiple applications.

A similar article appeared in the March 20, 2008 edition of *EDN* magazine.

Introduction

This application note describes a simple method that uses an external analog voltage to change the resistance of a digital potentiometer. The Microchip PIC12F683 microcontroller is used to make the conversion from an analog voltage to an I²C stream, which is then used to control the digital potentiometer. The DS1803 digital potentiometer serves as the example device and a minimum number of external components is used in this application. The ideas presented here can be applied to other control inputs and other digital potentiometers/resistors.

Hardware Configuration

Figure 1 shows the schematic for the control circuit that uses the PIC12F683. Four of the microcontroller's six GPIOs are used to control output signals on SDA, SCL, and a single LED, and to accept one analog input.

Output signals on SDA, SCL, and the LED are assigned to GP5, GP4, and GP0, respectively. SDA and SCL have 4.7kΩ pull-up resistors to V_{DD} and connect directly to the DS1803's SDA and SCL pins. The microcontroller's GP1 IO is assigned as the analog input pin. Jumpers are provided for selecting address pins, separating the shared V_{CC} (V_{DD}), and isolating SDA and SCL.

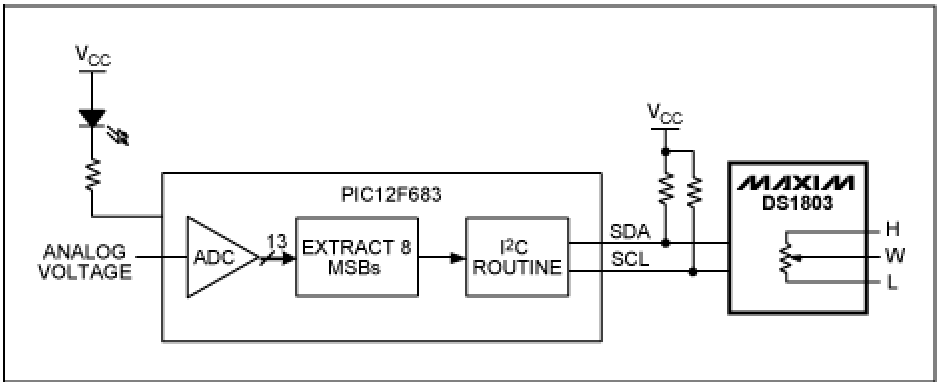


Figure 1. Schematic illustrated analog voltage control of a digital potentiometer.

Project Firmware

Firmware for this project was written in assembly language using the MPLAB IDE (version 7.40). This tool is currently available from Microchip at no cost. The entire program consists of fewer than 450 bytes in program space (Flash) and 8 bytes in data space (RAM).

The program first initializes the various configuration bits in the PIC, including the ADC and the internal oscillator. The program configures the ADC to accept input from GP1, and sets the conversion clock to use the internal oscillator at 125kHz.

The firmware runs in a loop with the ADC converting the voltage at the analog input continuously. Once a conversion is complete, the 8 MSBs of the 10-bit ADC output are used as the data byte to be sent over the I²C bus. This I²C signal is then used to control the DS1803. The program is set up to control both the potentiometers on the DS1803; by making a change in the firmware, however, the potentiometers can be controlled individually with two different analog inputs on the PIC12F683.

The firmware is available for download.

Versatile Functionality

The program allows the user to control the potentiometer by varying a voltage on the PIC12F683's GP1 input. A continuously varying input on GP1 will cause a corresponding change in the resistances of the potentiometers. The output resistance (R_{OUT}) can be calculated as a function of the input voltage:

End-to-end resistance of the DS1803 used in the design: 50kΩ
V_{CC} range allowable: 2.7V to 5V
Input voltage varies from 0V to V_{CC}

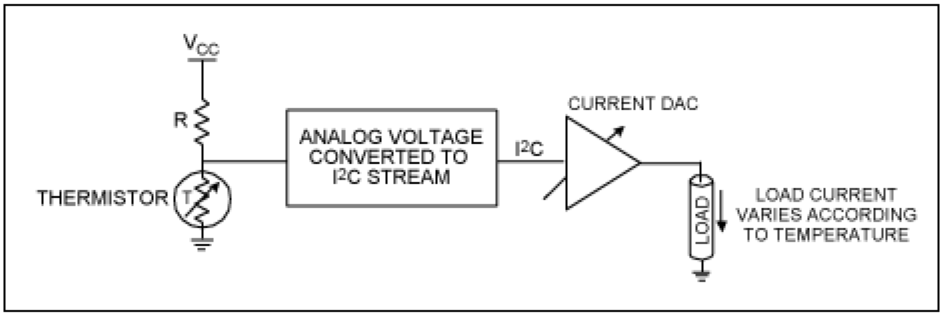
Output resistance observed will be:

R_{OUT} (kΩ) = (50 (kΩ)/V_{CC}) × Input Voltage

While the ADC is running, the LED blinks constantly. The LED remains on in case an I²C error occurs. Once the error is corrected, the LED resumes normal function. The designer can troubleshoot the application by checking that the device address is correct and that the I²C bus is connected.

This design is quite versatile, and a similar approach can be used for a variety of applications. Some examples include:

1. A nonlinear transfer function (e.g., gamma correction) can be implemented by using the DS3906 variable resistor with the correct transfer function implemented in the embedded lookup tables.
2. A thermistor can be connected at the input to vary the output of an I²C-controlled current DAC when there are changes in the ambient temperature (DS4402/DS4404).



Conclusion

This application note describes a simple and cost-effective mechanism for controlling a digital potentiometer by using an analog voltage. The application concept can be extended to use an analog voltage to control any device with an I²C interface.

Questions/comments/suggestions concerning this application note can be sent to: MixedSignal.Apps@maximintegrated.com.

Related Parts		
DS1803	Addressable Dual Digital Potentiometer	Free Samples
DS1805	Addressable Digital Potentiometer	Free Samples
DS1807	Addressable Dual Audio Taper Potentiometer	Free Samples
DS1808	Dual Log Digital Potentiometer	Free Samples
DS1844	Quad Digital Potentiometer	Free Samples
DS1845	Dual NV Potentiometer and Memory	Free Samples
DS1846	NV Tri-Potentiometer, Memory and MicroMonitor	Free Samples
DS1847	Dual Temperature-Controlled NV Variable Resistor	Free Samples
DS1848	Dual Temperature-Controlled NV Variable Resistor & Memory	Free Samples
DS1855	Dual Nonvolatile Digital Potentiometer and Secure Memory	Free Samples
DS1870	LDMOS RF Power-Amplifier Bias Controller	Free Samples
DS1881	Dual NV Audio Taper Digital Potentiometer	Free Samples
DS1882	Dual Log Audio Digital Potentiometer	Free Samples
DS3902	Dual, NV, Variable Resistors with User EEPROM	Free Samples

DS3903	Triple 128-Position Nonvolatile Digital Potentiometer	Free Samples
DS3904	Triple, 128-Position, Nonvolatile, Variable, Digital Resistor/Switch	Free Samples
DS3905	Triple, 128-Position, Nonvolatile, Variable, Digital Resistor/Switch	Free Samples
DS3906	Triple NV Low Step Size Variable Resistor Plus Memory	Free Samples
DS3930	Hex Nonvolatile Potentiometer with I/O and Memory	Free Samples
DS4302	2-Wire, 5-Bit DAC with Three Digital Outputs	Free Samples
MAX5417	256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5418	256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5419	256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5420	Digitally Programmable Precision Voltage Divider for PGAs	Free Samples
MAX5421	Digitally Programmable Precision Voltage Divider for PGAs	Free Samples
MAX5426	Precision Resistor Network for Programmable Instrumentation Amplifiers	Free Samples
MAX5427	32-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5428	32-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5429	32-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5430	±15V Digitally Programmable Precision Voltage-Dividers for PGAs	Free Samples
MAX5431	±15V Digitally Programmable Precision Voltage-Dividers for PGAs	Free Samples
MAX5432	32-Tap, Nonvolatile, I²C, Linear, Digital Potentiometers	Free Samples
MAX5433	32-Tap, Nonvolatile, I²C, Linear, Digital Potentiometers	Free Samples
MAX5434	32-Tap, Nonvolatile, I²C, Linear, Digital Potentiometers	Free Samples
MAX5435	32-Tap, Nonvolatile, I²C, Linear, Digital Potentiometers	Free Samples
MAX5460	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5461	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples

MAX5462	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5463	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5464	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5465	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5466	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5467	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5468	32-Tap FleaPoT™, 2-Wire Digital Potentiometers	Free Samples
MAX5477	Dual, 256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5478	Dual, 256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5479	Dual, 256-Tap, Nonvolatile, I²C-Interface, Digital Potentiometers	Free Samples
MAX5527	64-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5528	64-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples
MAX5529	64-Tap, One-Time Programmable, Linear-Taper Digital Potentiometers	Free Samples

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