AN1775

Expanding Digital Input with an A/D Converter

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Introduction

This application note documents a method of extending digital input using the analog-to-digital converter (ADC) of a microcontroller unit (MCU).

Many MCU applications require digital input and arbitration. For example, determining which key of a keypad was pressed. This is commonly done by arranging switches in a matrix configuration, connecting to a series of digital input pins, and reading a digital input data register to determine which key was pressed. While this method is easily implemented, it does require the use of an MCU's parallel port pins.

Some applications require all available bidirectional or input-only pins for other purposes. In such a case, an alternate method of arbitrating keypresses is desired. By using the ADC of an MCU connected to a resistor ladder, user input can be more efficiently processed.

Background

Dedicated Input

A microcontroller typically receives user input through digital input pins. The simplest implementation is a single switch directly connected to a digital input pin. This is easy to realize, but is not the most efficient use of resources, with one pin dedicated to one input. One port data bit represents the state of one switch.

Matrix Input

Another method uses a keypad, a common element in embedded systems. These are ordinarily arranged in a matrix, as shown in Figure 1. In this case, the byte value of an entire port data register can be polled to determine which key was pressed. This is more efficient, as a 4 x 4 keypad can interface 16 keys with eight input pins.

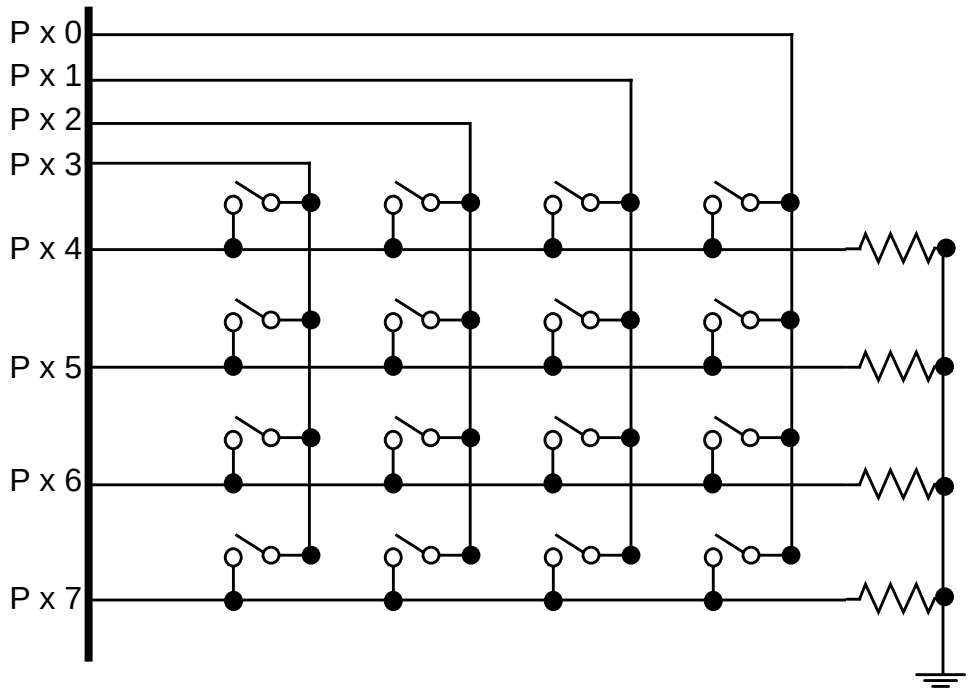

Figure 1. Resistor Matrix Keypad Using Parallel Port Pins

ADC Alternative

In many cases, input pins are at a premium. One can't always freely assign input pins to the function of user input. A more efficient use of microcontroller resources can be devised. One common feature of many Freescale MCUs is the analog-to-digital converter, or ADC.

The ADC of a Freesca;e MCU usually features four to eight channels of analog input, which is compared with a reference voltage and converted to an 8-bit digital value. When a resistor ladder is connected to an analog input through switches in each segment, the conversion result can be used to arbitrate an input. This allows many keys to be interfaced with one input pin, with only a little more software overhead. **Figure 2** shows such an implementation.

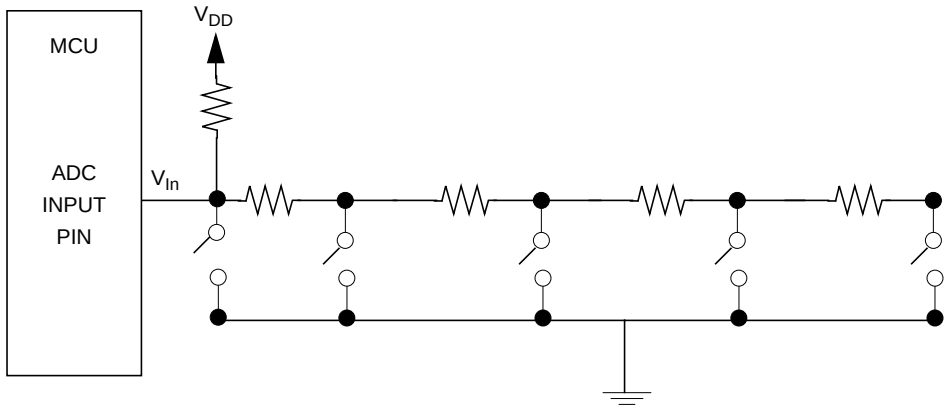

Figure 2. Resistor Ladder Keys Using an Analog Input Pin

Implementation

ADC Operation

An MCU ADC typically has 8-bit *precision*. This means there are 2^8, or 256, distinguishable A/D inputs, including 0. The analog inputs are converted to a binary number, which represents the magnitude of the input voltage in relation to a reference voltage.

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