AN1809
APPLICATION NOTE

STR71x ADC
DRIVING AN ANALOG KEYBOARD

INTRODUCTION

This application note gives an example of how to use the STR71x Analog to Digital Converter (ADC) to read input from an analog keyboard. The purpose is to decode a number of keys through only one analog I/O port pin, this has the advantage of reducing the number of pins used compared to a traditional matrix keyboard which requires a large number of I/O port pins.

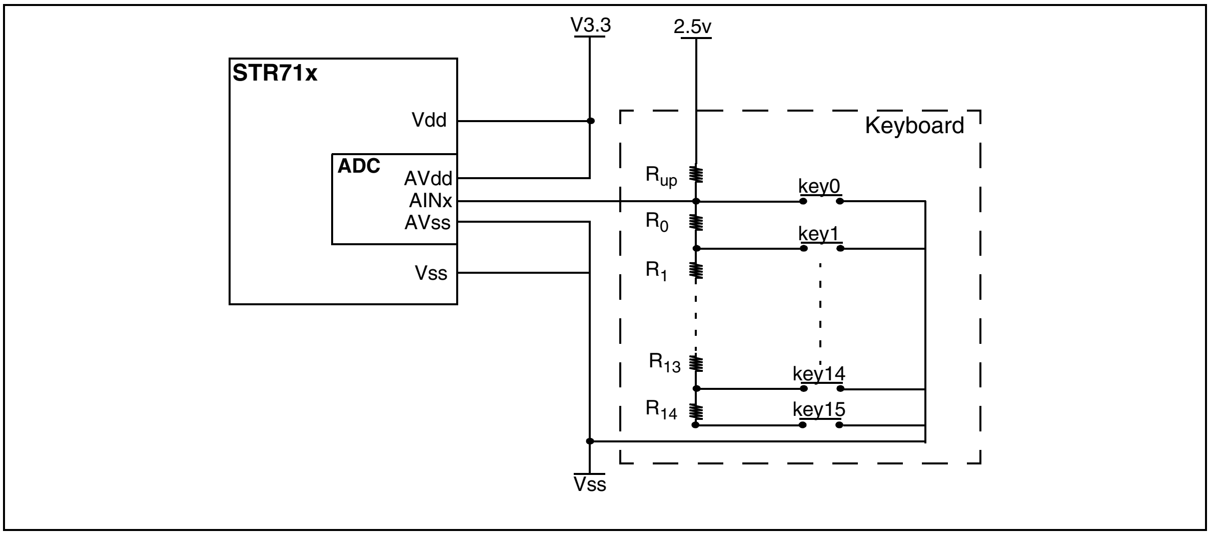
Rev. 2

1 HARDWARE CONFIGURATION

To reach the goal of this application note we need to connect an analog keyboard to one of the analog inputs of the STR71x ADC.

When a key is pressed, the voltage at the ADC input is given by the activated voltage divider. This analog voltage is converted by the ADC and the digital value is used to determine which switch is closed.

Figure 1. STR71x ADC and analog keyboard configuration



1.1 STR71X ADC

The STR71x Analog to Digital converter is a 12-bit Sigma-Delta converter with an input range between 0 and 2.5V. It has up to 4 multiplexed analog input channels.

It offers two conversion modes:

- **Round-robin**: this repeats the conversion process for each of the four channels continuously in turn.
- **Single channel**: this converts only the selected analog input.

Enabling or disabling the converter is done by setting or clearing the ADC_EN bit in the PCU_BOOTCR register.

The STR71x ADC provides four 16-bit data registers to store the conversion result for each channel. The availability of the conversion result in the data register is shown by the four DA[3:0] flags in the Control/ Status Register (ADC_CSR).

An **interrupt** is generated depending on the conversion mode, to confirm the end of conversion. In Single channel mode, an interrupt is generated if the interrupt bit and Data Available flag in the ADC_CSR are set, corresponding to the selected channel. In Round robin mode, an interrupt will be generated if all interrupt bits and all Data Available flags in the ADC_CSR are set.

The **clock configuration** of the STR71x converter is used to define the oversampling frequency which clocks the modulator of the Sigma-Delta converter. This frequency is programmed basing on the f_{PCLK2} frequency and the Sampling frequency. The oversampling rate is obtained by configuring the 12-bit value of the prescaler register.

The value to write in the Converter prescaler register is:

ADC_CPR = (RCCU_FrequencyValue(RCCU_PCLK)/(Adc12_clk*512*8))

The real factor, by which the input frequency will be multiplied to produce the oversampling frequency, is twice the prescaler register value.

1.2 I/O CONFIGURATION

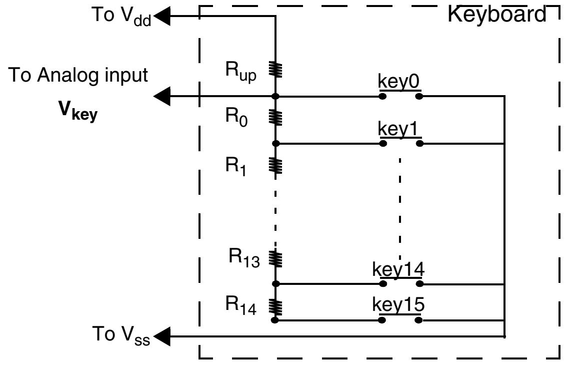
The STR71x Analog to Digital Converter provides four analog input pins for connecting different analog signals. These pins are internally multiplexed to use the same Sigma-Delta logic.

Depending on the conversion mode (Continuous or Single Channel), you can use either the four analog inputs or only one selected pin. If you are using the Single Channel mode, you can select a pin by writing the channel number in the A[1:0] bits in the Control Status Register(ADC_CSR). These pins are mapped on the pins of GPIO port 1(P1.1, P1.2, P1.3, P1.4).

To use the port pins as analog inputs, you must configure them as High impedance-Analog Inputs by writing the appropriate values in to the PC0, PC1 and PC2 registers of GPIO Port 1.

1.3 ANALOG KEYBOARD

The analog keyboard is formed by a number of keys connected to resistive dividers; with a pull-up resistor. In the analog keyboard each key is associated with a voltage.



R0-->R14: serial resistors through which keys will be connected to the analog input.

R_{up}: The pull-up resistor by which the v_{key} is maintained to Vdd when no key is pressed.

The associated voltage of the pressed key is given by:

$$v_{Key_i} = \frac{(V_{dd} - V_{ss}) \sum_{j=0}^{i-1} R_j}{R_{up} + \sum_{j=0}^{i-1} R_j}$$

If more than one key is pressed at the same time, the key detected will be the next key in the chain closest to the ADC input. This means that the key recognition is managed by priority.

1.3.1 Key recognition

The number of keys which can be detected depends on the tolerance of the resistors used. This mean that we must take a voltage range corresponding to each key when we convert the result.

The resistor value and the equivalent voltage of each key are given by the following table.

R_{up} =1200 Ω

Table 1. Key decision

Key	Resistor (Ω)	Voltage (mV)	Key	Resistor (Ω)	Voltage (mV)
0	0	0	**8**	220	1121
1	56	111	**9**	270	1273
2	68	234	**A**	390	1442
3	82	366	**B**	560	1616
4	100	507	**C**	820	1788
5	120	654	**D**	1200	1946
6	150	810	**E**	1800	2084
7	180	966	**F**	2800	2200

2 SOFTWARE CONFIGURATION

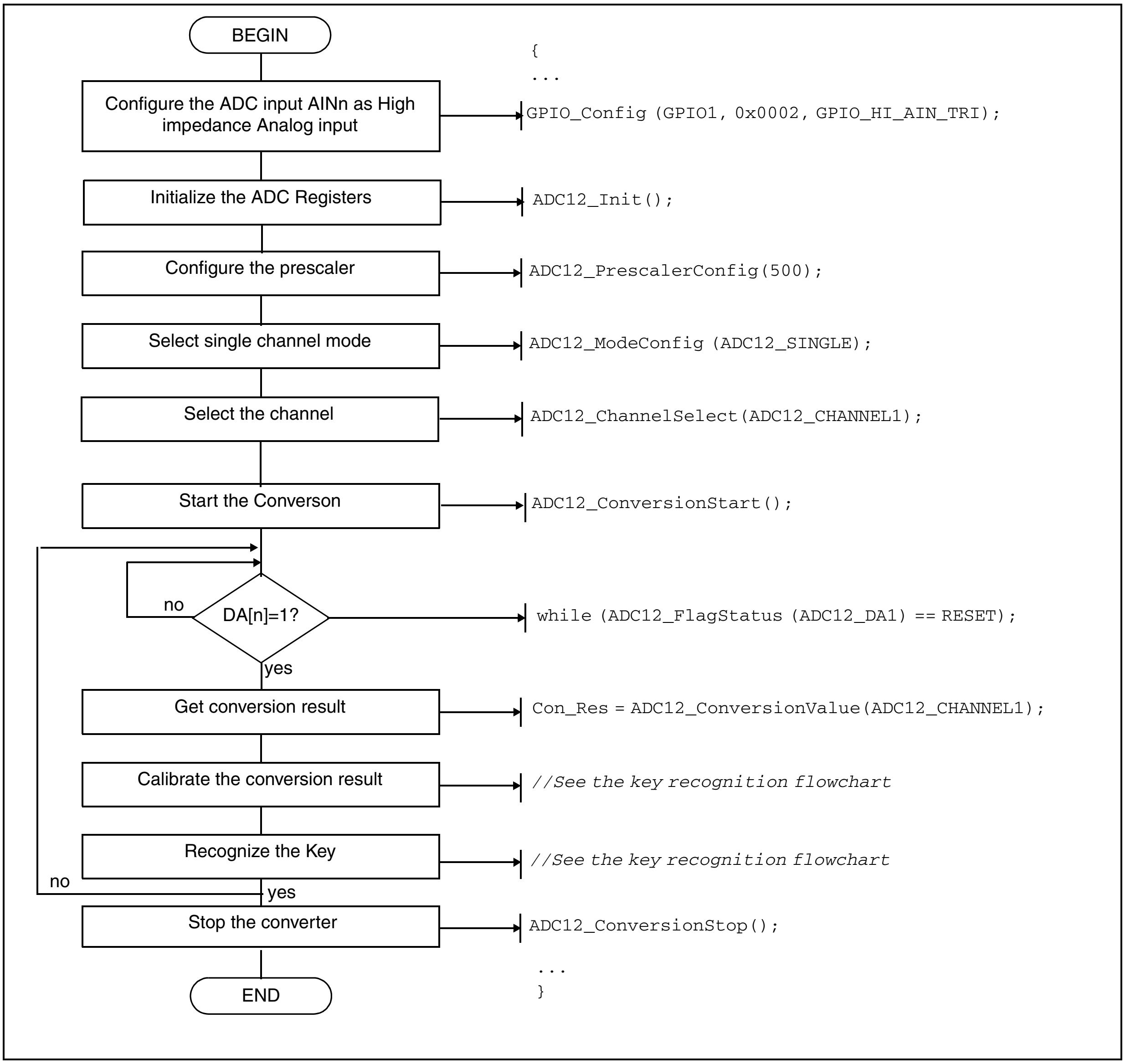
This software example manages the STR71x ADC configuration, and the key recognition using the ADC software library.

After configuring the analog input as a high impedance analog input, the STR71x ADC has to be enabled by setting the ADC_EN bit in the PCU_BOOTCR register. This action is followed by selecting the Single Channel conversion mode and the Channel to be converted by setting the AXT bit and writing the channel number in the A[1:0] bits in the Control Status Register (ADC_CSR). Next, the prescaler has to be configured. Waiting for the availability of data in the corresponding DATA register is done by looping on the Data Available flag (DAn) in ADC_CSR register. After that, we can get the conversion result which will be calibrated.

The next step is the key recognition. This part of the software consists of testing if the conversion result belongs to the range of the value of each key voltage. This range is defined by the lower voltage (min [key]) and the higher voltage (max [key]) that are considered as corresponding to the typical voltage of the key (Val [key]). This range is due to the resistor tolerance. Once the pressed key is recognized, its number is shown on four leds connected to GPIO port 0 pins.

The main program is given by the next flowchart.

Figure 2. Main program flowchart using ADC software library


BEGIN
Configure the ADC input AINn as High impedance Analog input
Initialize the ADC Registers
Configure the prescaler
Select single channel mode
Select the channel
Start the Converson
no
DA[n]=1?
yes
Get conversion result
Calibrate the conversion result
Recognize the Key
no
yes
Stop the converter
END

```
{
...
GPIO_Config (GPIO1, 0x0002, GPIO_HI_AIN_TRI);
ADC12_Init();
ADC12_PrescalerConfig(500);
ADC12_ModeConfig (ADC12_SINGLE);
ADC12_ChannelSelect(ADC12_CHANNEL1);
ADC12_ConversionStart();
while (ADC12_FlagStatus (ADC12_DA1) == RESET);
Con_Res = ADC12_ConversionValue(ADC12_CHANNEL1);
//See the key recognition flowchart
//See the key recognition flowchart
ADC12_ConversionStop();
 ...
 }
```

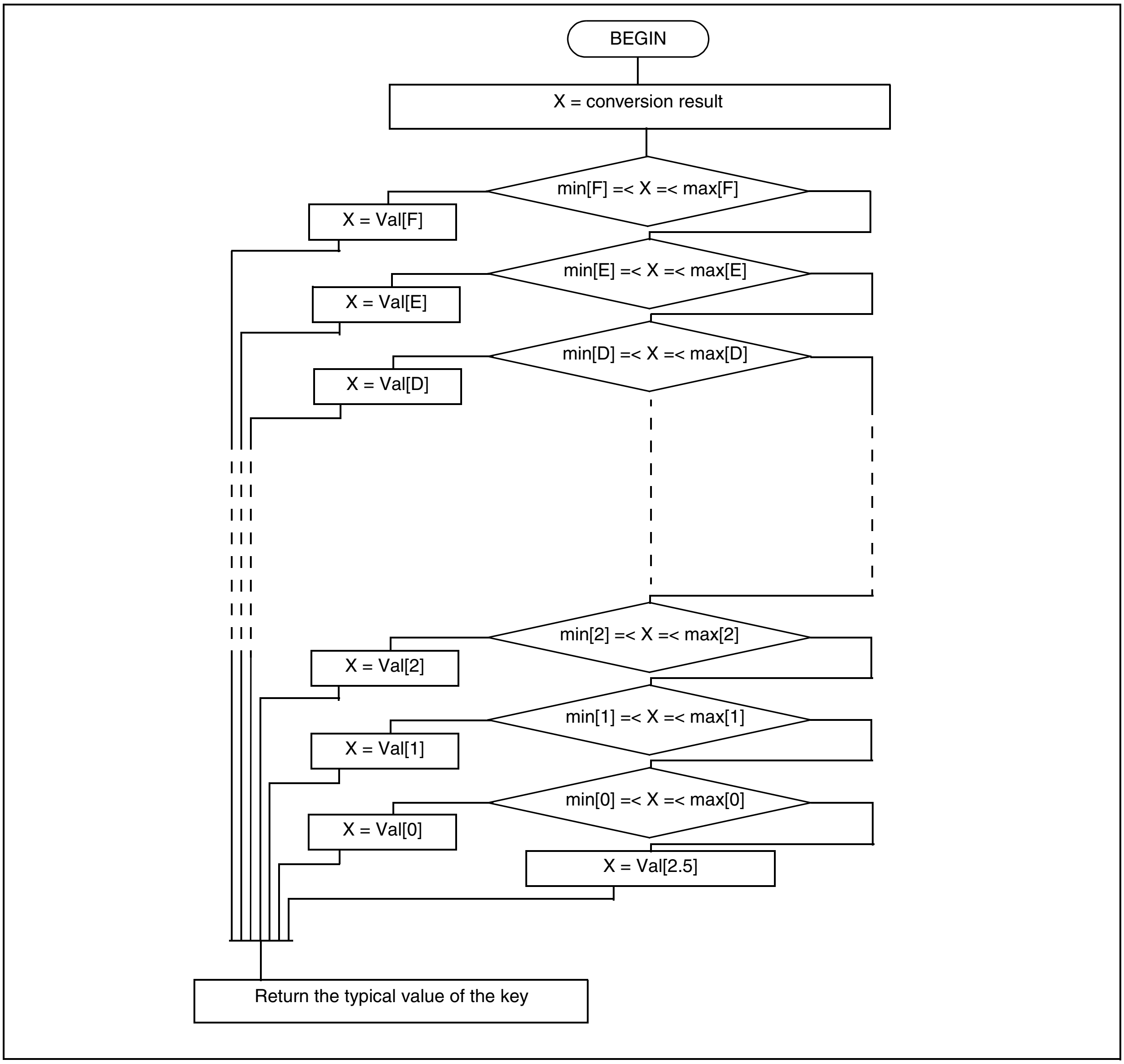
The key recognition routine is shown in the next flowchart with:

max[key]: Higher voltage of the range corresponding to the typical voltage of the key.

min[key]: Lower voltage of the range corresponding to the typical voltage of the key.

val [key]: Typical voltage.

Figure 3. Key recognition



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