Analog Decoder for Single Wire Multi-Key Detection

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Introduction

This application note will explain how to build a multi-level comparator for single wire, multi-key detection using three components in GreenPAK4: the ADC block, the digital comparator (DCMP) and the analog comparator (ACMP). This concept is useful when trying to decode an analog input voltage that varies with external circumstances. For this application note, this analog voltage will be varied using three input buttons as shown in Figure 1.

Key Detection Schematic

Figure 1 shows the button pressing schematic for this design. By pressing KEY1 (or KEY2/KEY3), R1 (or R2/R3) forms a resistive divider with R_{mic} and produces an analog voltage at KEY_IN. This single wire design reduces the number of hardware connections between the KEYs and KEY_IN. In order to choose resistor values, one needs to determine the desired KEY_IN voltages for each button press. In this particular design, R_{mic} has been set to 10 kΩ. Table 1 shows the desired voltages for single key button presses.

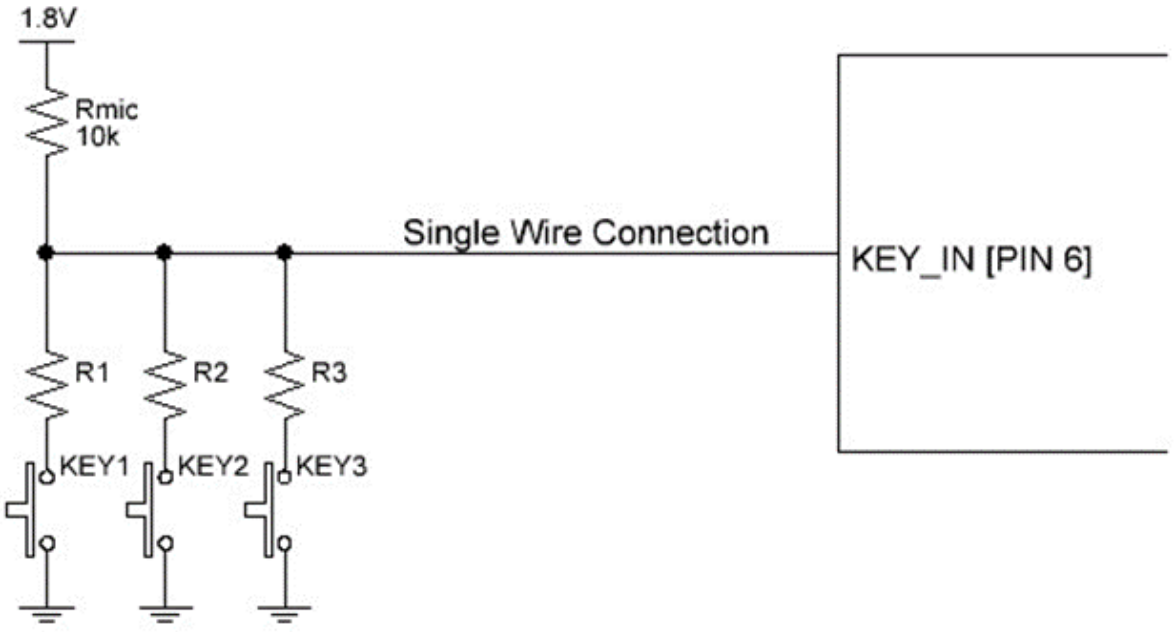

Figure 1. Key Detection Schematic

	KEY_IN Voltage [mV]
VKEY1_DEC	950
VKEY2_DEC	770
VKEY1_DEC	630

Table 1. Single Key Press Voltages

Using the equation below, the resistance values in Table 2 can be calculated.

$$R_{\#} = R_{mic} * \frac{V_{KEY\#\_DEC}}{1.8V - V_{KEY\#\_DEC}}$$

	Resistance [kΩ]
R1	11.18
R2	7.48
R3	5.38

Table 2. Calculated Resistor Values

Factory Mode Detection

By pressing two keys at the same time, additional KEY_IN voltages can be generated. When two buttons are pressed simultaneously, the effective resistive divider ratios change and generate the KEY_IN voltages shown in Table . These values were calculated using the equations below.

$$V_{KEY\_IN} = \frac{R12}{R12 + R_{mic}} * 1.8;\ where\ R12 = \frac{R1 * R2}{R1 + R2}$$

$$V_{KEY\_IN} = \frac{R23}{R23 + R_{mic}} * 1.8;\ where\ R23 = \frac{R2 * R3}{R2 + R3}$$

$$V_{KEY\_IN} = \frac{R13}{R13 + R_{mic}} * 1.8;\ where\ R13 = \frac{R1 * R3}{R1 + R3}$$

	Equivalent Resistance (kΩ)	KEY_IN Voltage [mV]
VKEY12_DEC	4.48	560
VKEY13_DEC	3.63	480
VKEY23_DEC	3.13	430

Table 3. Double Key Press Voltages

Functionality Diagram of Key detection

Figure 2 shows a functionality diagram for the desired key press combinations and the resulting three digital output pins.

GreenPAK Logic Block Set-up

Figure 3 shows the GreenPAK configuration for decoding theses input button presses. In order to generate this multi-level comparator design, both the ACMPs and DCMPs need to be used to create the comparator window voltages shown in Figure 2 and Table 4.

The 450 mV and 600 mV voltage levels in Table 4 are obtained using ACMP0 and ACMP1. The specific block settings are shown in Figure 4 and Figure 5 respectively. To avoid increased response time, these analog comparators should have hysteresis disabled.

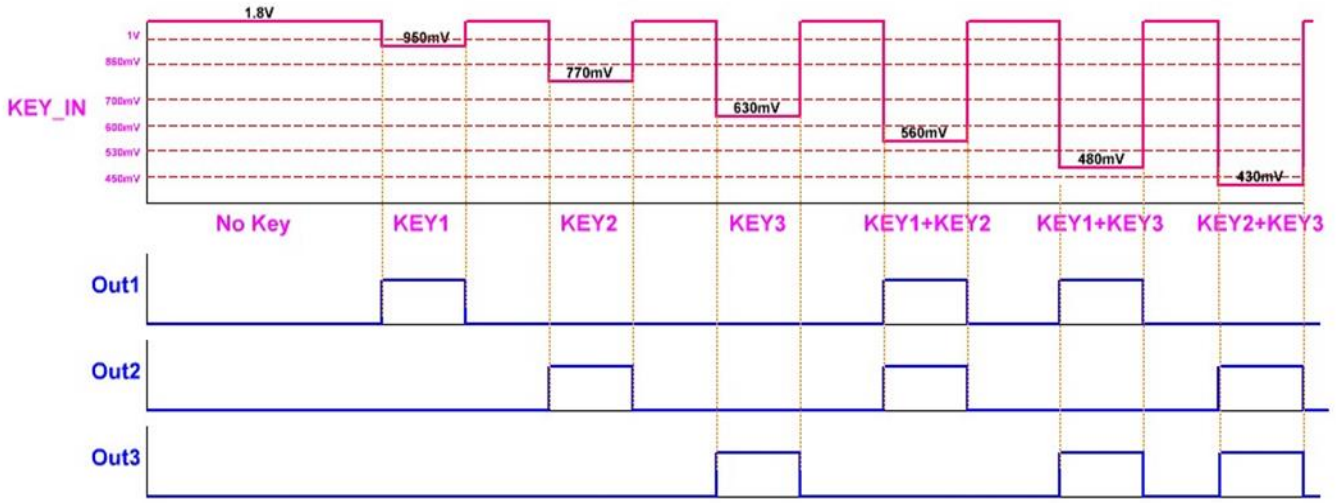

Figure 2. Key Press Functionality Diagram

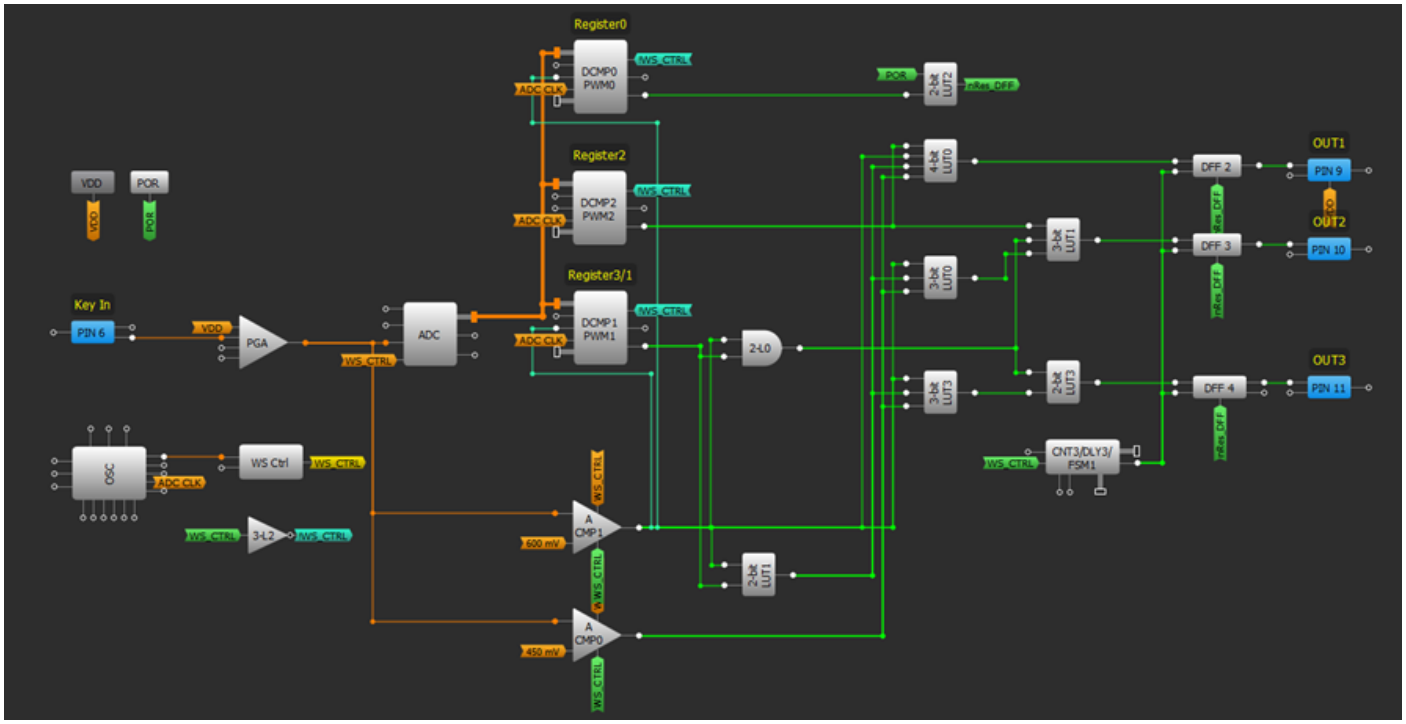

Figure 3. Key detection GreenPAK Configuration

Window	KEY Combination	Lower Voltage (mV)	Upper Voltage (mV)
1	KEY2+KEY3	0	450
2	KEY1+KEY3	450	530
3	KEY1+KEY2	530	600
4	KEY3	600	700
5	KEY2	700	860
6	KEY1	860	1000
7	No KEY	1000	--

Table 4. Comparator Windows

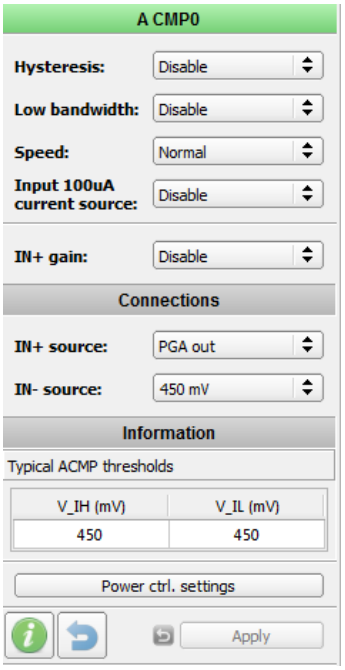

Figure 4. ACMP0 setting

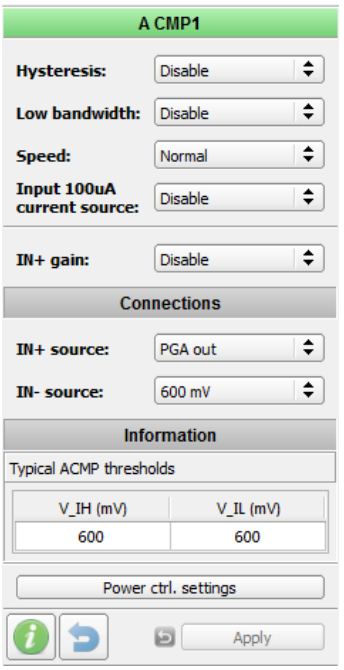

Figure 5. ACMP1 setting

For the remaining voltage levels, the DCMPs need to be used. These blocks compare two digital bytes of information on the IN+ and IN- inputs of the logic block. To pass an input signal to the DCMPs, the input signal has to pass through the programmable gain amplifier (PGA) to get to the ADC. The ADC changes the analog input voltage into a digital byte and passes these values into the DCMPs. Figure 6 shows the PGA settings. Figure 7 shows the DCMP settings. When this byte of data is passed into the DCMP's IN+ terminal, it can be compared to the registers shown in Figure 8. The equation below can translate these register values into analog voltages.

$$Analog\ Voltage = \frac{Register}{256} + 0.03$$

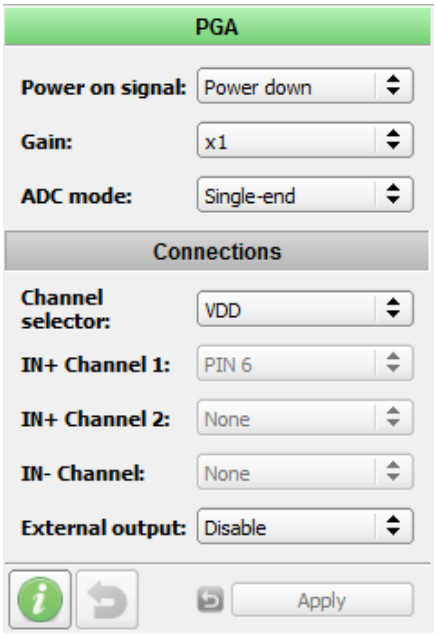

Figure 6. PGA Settings

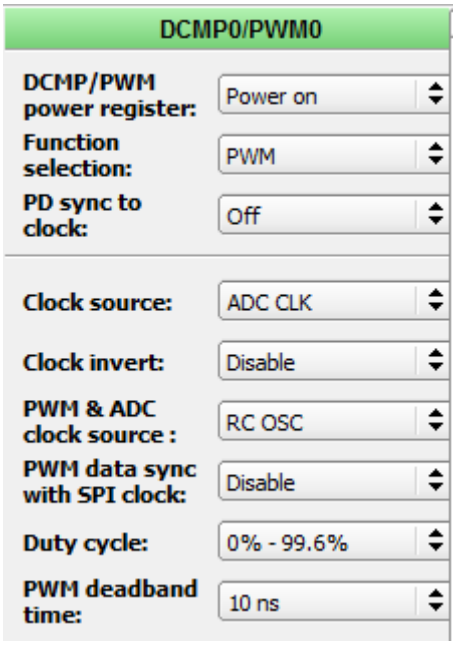

Figure 7. DCMP setting

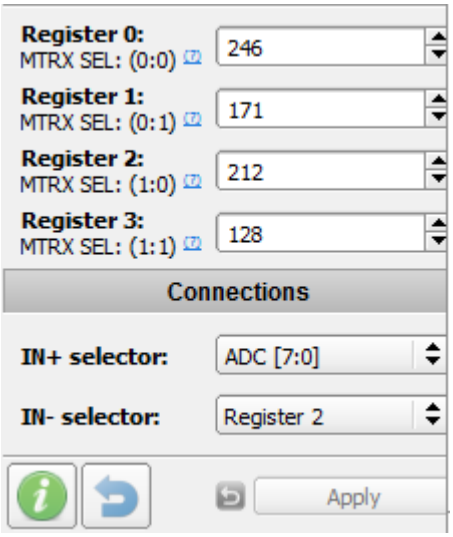

Figure 8. DCMP Register Settings

Minimizing Current Consumption

In order to minimize current consumption, the ADC, DCMP's, and ACMP's can be power cycled by using Wake/Sleep mode. Without using this feature, the current consumption is approximately 170 uA with KEY_IN pulled high to the 1.8 V supply. In the example, supply current is lowered to 34 uA by applying the settings as shown in Figure 9, which sets the total cycle period to 45 ms. Lower current consumption can be achieved with longer cycles at the expense of sample rate. Note the wake time is determined by the clock source, and it is important to wake up the analog blocks for a sufficient amount of time. In this example, we set the clock source to LF Osc / 16 in order to ensure sufficient wake to time across full 1.7 to 5.5V voltage range and -40 to 85C temperature. For more information, please see the Wake / Sleep Timing Generator application note on Dialog's website (**AN-1076**).

Example Application: Bluetooth Headsets

An example Bluetooth (BT) headset has 3 keys (Play, FF, and RFF) on the left side and 3 keys (Talk, Volume Up, and Volume Down) on the right side of the headset. Without this design, three wires would have to run from each side of the headset to a central node where all six buttons would be decoded. This design reduces the number of wires to two: one single wire connection from Figure 1 on each side of the headset.

BT headsets often have a common manufacturing issue centered around mechanical button wiring done by hand. The single wire decoding methods described in this application note help decrease the production failure rate by minimizing the number of wire connections between the left and right sides of the BT headset.

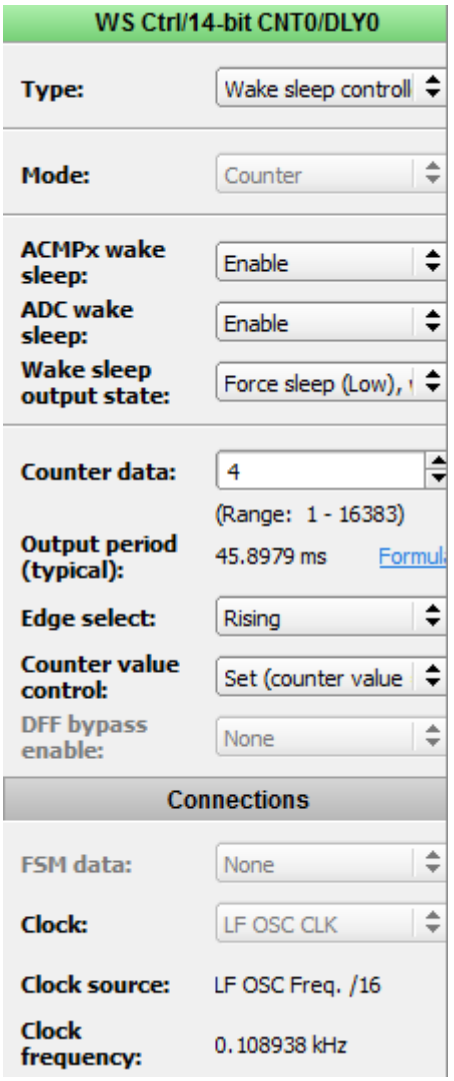

Figure 9. WS Ctrl Settings

Conclusion

By using the DCMP and ACMP blocks in the GreenPAK4, we were able to create a 7 window multi-level comparator for single wire, multi-key detection. In addition to the button pressing application described in this application note, this design can be altered to decode any analog input voltages provided to the Dialog's GreenPAK4.

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