Application Brief

Improving Capacitive Touch Keypad Robustness in Extreme Weather Conditions

This application brief describes a capacitive touch keypad that can reliably detect key presses in a varied temperature range, even during winter when a user may be wearing thick winter gloves. This system is composed of a liquid-tolerant capacitive touch keypad, TI's CapTIvate™ touch-sensing microcontroller, and one or more piezo sensors.

An overview of the MSP430™ capacitive touch sensing, or CapTIvate, microcontrollers can be found at the MSP430 capacitive touch sensing microcontrollers overview. For a more detailed look at the CapTIvate peripheral, refer to the CapTIvate Technology Guide.

1 Introduction

When designing capacitive touch keypads for outdoor applications, several environmental conditions, such as temperature range and moisture presence, must be considered and accommodated in order to have a reliable user experience. The rate of false positives could increase due to excess moisture, which could negatively affect the end user's system operation. For example, in the case of a security e-lock, having the keypad detect too many false positives could seem as though someone is attempting to repeatedly gain entry, leading to the system locking down or sending false alarms. In low temperatures, users may wear thick gloves that insulate their finger from the capacitive sensors, effectively rendering the keypad unreliable to the end user. This application brief will focus on the reliability of capacitive touch keypads when the end user is wearing gloves since the system utilizes a moisture-tolerant keypad, which is further discussed in the Liquid Tolerant Capacitive Touch Keypad Reference Design.

As a designer, one could increase the capacitive touch sensitivity to detect a finger within a thick glove; however, this comes with some tradeoffs such as increased power consumption and sensitivity to noise. This can cause users to change out batteries more often or receive notifications of incorrect code inputs due to false touches.

A better solution is to increase the sensitivity only when needed. A typical user will press with more force on a keypad or button when wearing thick gloves. A piezo sensor that is mounted behind the keypad can measure this force. A comparator on the MCU can establish a force threshold from the voltage generated by the piezo sensor. Once that threshold is reached, then one can change the sensitivity of the capacitive sensors to detect the finger inside the glove.

2 Setup and Configuration

A liquid tolerant capacitive touch keypad, a design that integrates the MSP430FR2675 and a CapTIvate touch keypad, is placed over four piezo sensors in the configuration shown in Figure 1. A 2 mm overlay is placed on top of the keypad, providing ESD and environmental protections from moisture, liquids, and other contents that could damage the PCB.

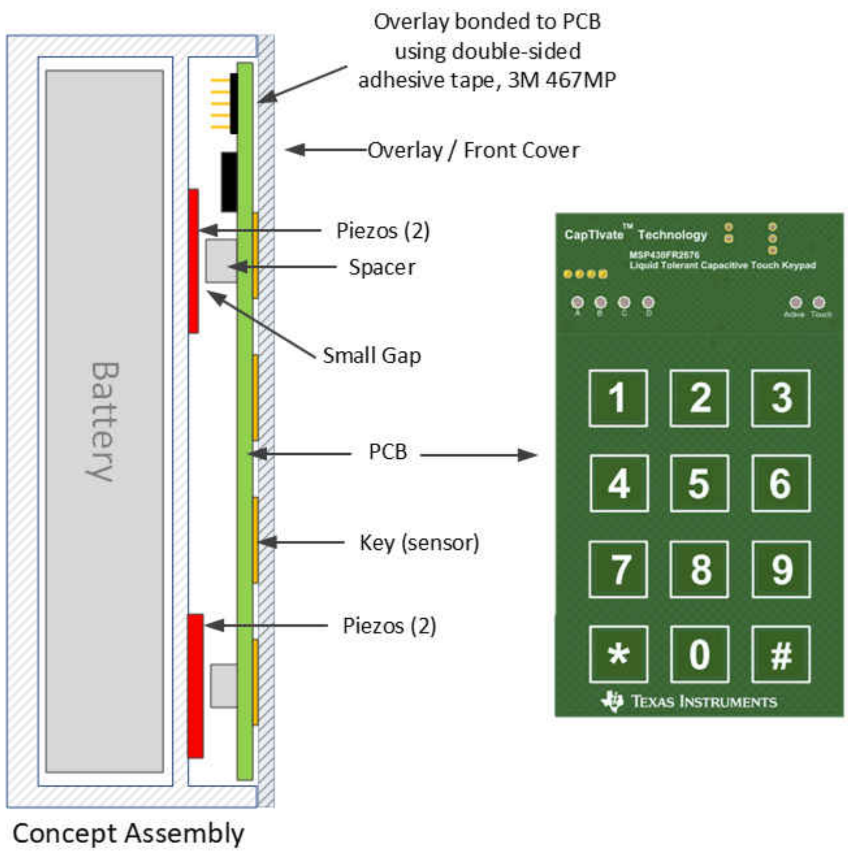

Figure 1. 12-Button Liquid-Tolerant Capacitive Keypad with Piezo Sensor Design Layout

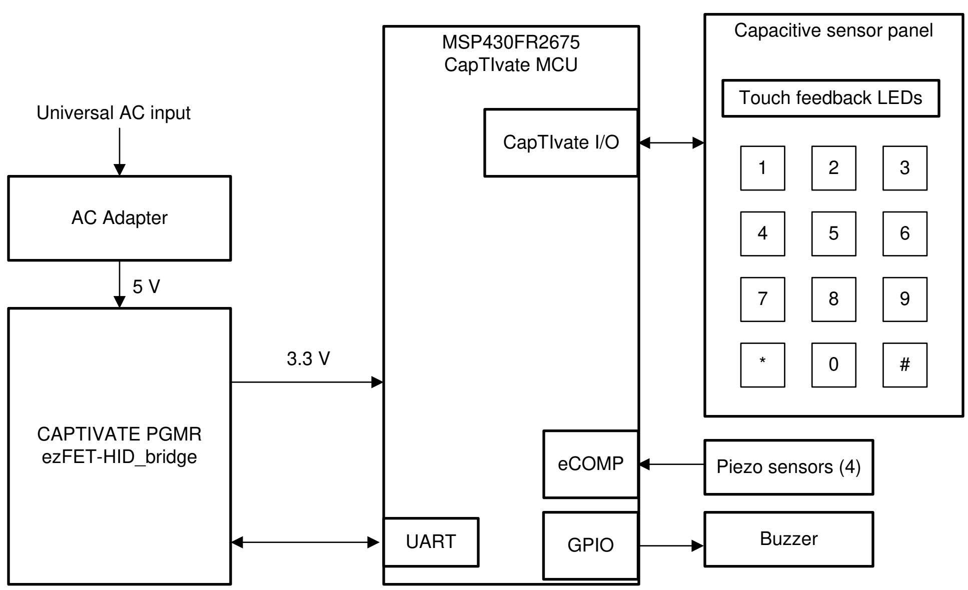

Figure 2. System Level Block Diagram

Figure 2 shows the components of the system. The programmer board is used to program the MSP430FR2675 on the integrated keypad. Using the programmer board, one can connect to the CapTIvate Design Center GUI to tune the sensors and collect measurement data.

The liquid capacitive touch keypad includes the following features:

- 12 mutual capacitance buttons
- 6 LEDs for touch indication feedback
- An audio buzzer for touch indication feedback
- A MSP430FR2675 microcontroller
- A 20-pin connector to the CapTIvate programmer board

The four piezo sensors are OR'd together and input to the comparator module on the MCU. An example of the piezo signal conditioning circuit is shown in Figure 3.

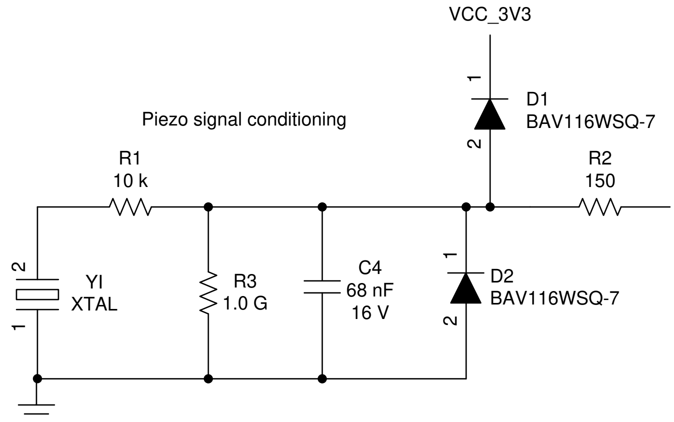

Figure 3. Single Piezo Network

When the generated voltage reaches the threshold specified in the comparator, the MCU signals CapTIvate to increase the sensitivity to detect gloved finger touches. Figure 4 shows that the comparator has its own 6-bit DAC that the software uses to adjust the detection threshold.

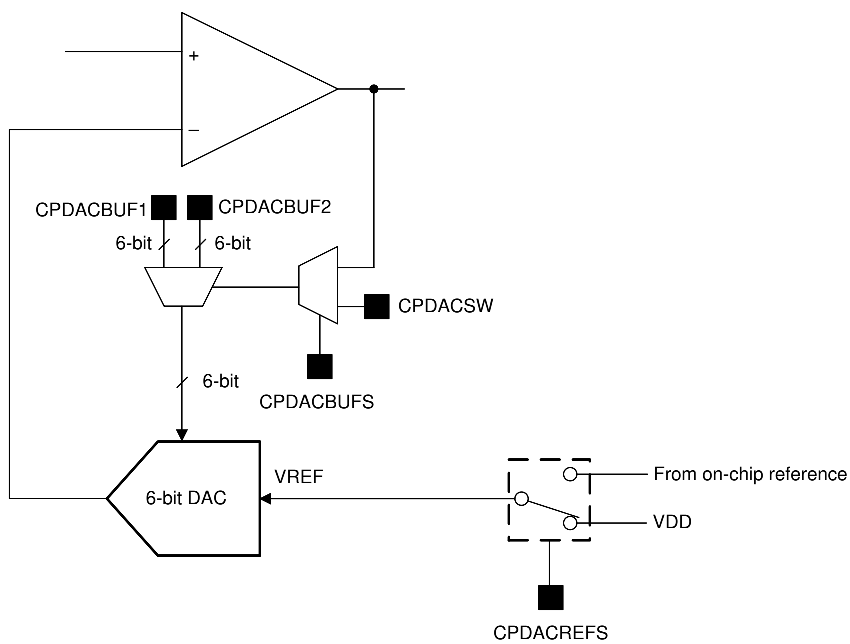

Figure 4. Comparator or eCOMP Module

2.1 Design Considerations

Some applications require the capacitive solution to work in various scenarios with different amounts of liquids and types of gloves. All of these cases impact the capacitance between the TX and RX electrodes. The presence of liquids on the keypad could result in false touch detections, and the presence of gloves could render the keypad unreliable. In addition, the glove material, thickness, and structure can also impact the capacitive touch detection. In all of these cases, the designer must consider the tradeoff between sensitivity to gloved finger touches and tolerance to liquids.

Another aspect to consider would be the number of piezo sensors. For simpler designs in which one only wants to know whether more force was applied, one piezo sensor could do. For designs requiring rough location data such as where more force was applied on the board, the designer may consider using multiple piezo sensors. In this design, the four piezo sensor outputs are OR'd together and connected to the comparator input, allowing for one or more sensors to signal the CPU of a "force" event through the comparator's interrupt. This allows for a fast detection of a gloved finger press. Each sensor's output is also connected to an ADC channel. Once the CPU receives the comparator's interrupt, the CPU can scan the ADC channels to see which sensor or sensors are active and based on the signal amplitude, which sensor received the largest force.

3 Software Solution

The design uses the CapTIvate software library and code generated by the CapTIvate Design Center to process capacitive measurements resulting from a finger press. The application callback function controls the touch indication feedback and handles transitioning between normal and high sensitivity. Figure 5 describes the callback function flow.

The callback function first checks if CapTIvate is operating in normal or high sensitivity mode. This check is to determine if a transition between sensitivity levels occurred and to properly handle that transition. In a transition, the callback function sets the appropriate sensitivity level LED, reseeds the long term average (LTA) filter since the baseline values differ between the sensitivity modes, and reloads the sensor tuning values.

Then, the callback function checks whether a button was pressed or not. If so, the callback function determines which particular button was pressed using CapTIvate's dominant button algorithm, makes the buzzer beep at a particular frequency based on the current sensitivity level, and outputs the binary representation of the button value on the binary-coded LEDs.

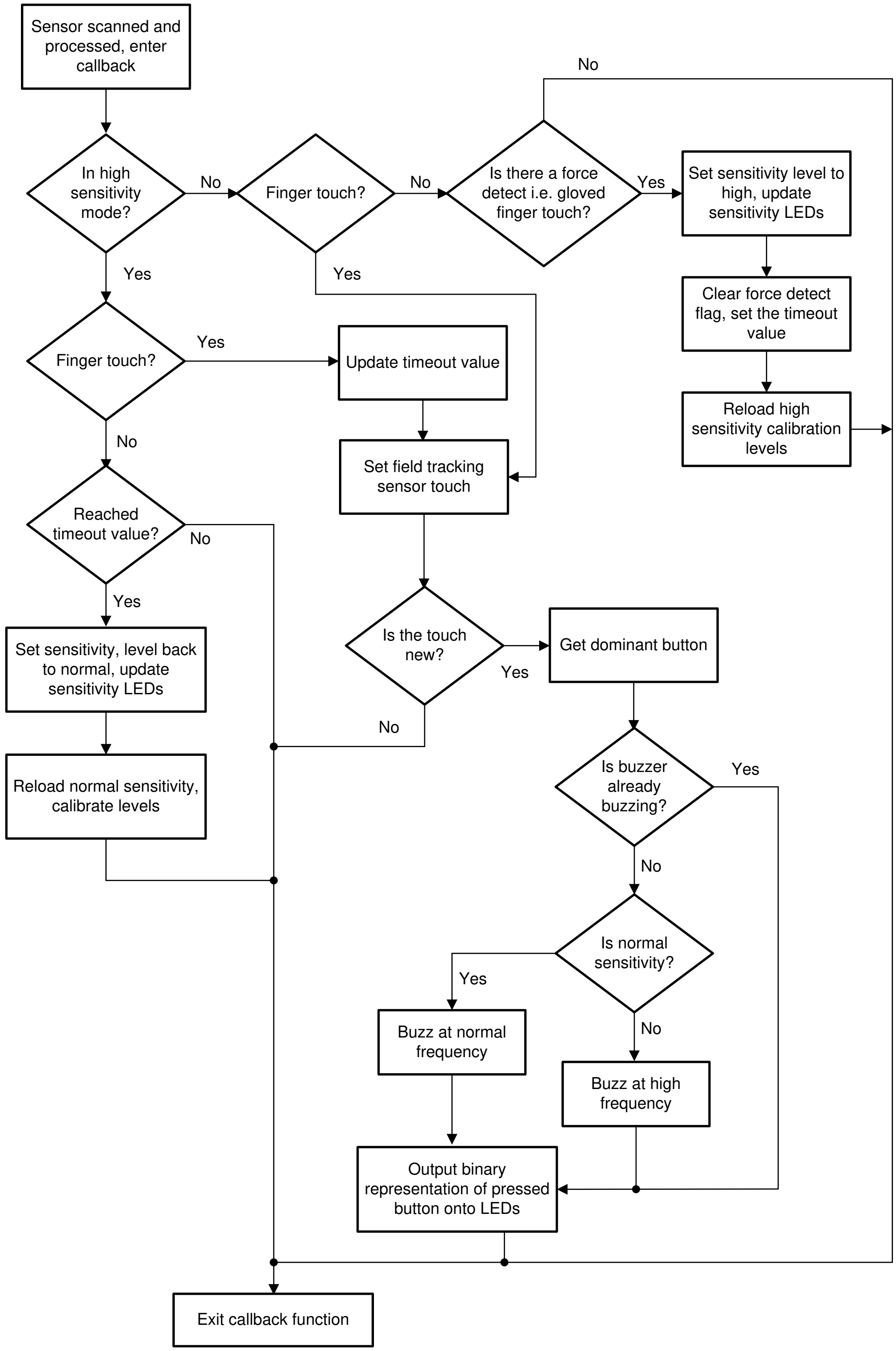

Figure 5. Callback Function Flowchart

4 Test and Results

4.1 Test Setup

Figure 6 shows the board containing the integrated keypad, CapTIvate programmer, and piezo sensors enclosed in an overlay. This setup allows for testing gloved and non-gloved touches in a dry or liquid environment (continuous water flow and water spray).

Figure 6. Test Setup

4.2 Test Results

Figures 7 and 8 show that CapTIvate detects both gloved and non-gloved finger touches in dry and liquid environments. The binary-coded LEDs show the value of the pressed button, and the sensitivity LEDs, LEDs 1 and 2, indicate whether CapTIvate is operating at normal or high sensitivity.

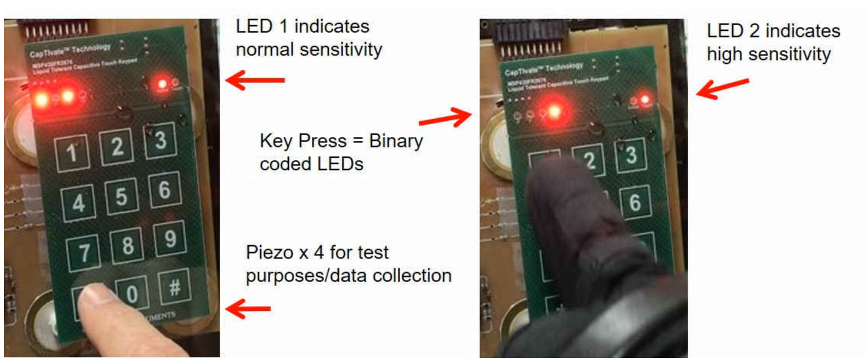

Figure 7. Dry Environment Finger Detection

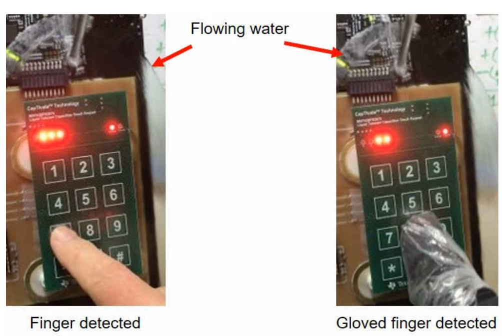

Figure 8. Flowing Water Environment Finger Detection

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265