Description

The Atmel® SMART SAM D20 QTouch® Robustness Demo demonstrates the high performance capacitive touch support of the Peripheral Touch Controller (PTC) while achieving best-in-class conducted immunity and moisture tolerance. The demo implements a robustness solution that allows customers to easily incorporate the Atmel QTouch technology into designs that require high levels of noise immunity and moisture tolerance.

Features

- Six self-capacitance buttons with Philipp Spring
- Four mutual-capacitance buttons
- Individual LEDs for indicating button status
- One 8-channel mutual-capacitance slider
- Seven LEDs to indicate slider position
- Buzzer for audio feedback
- On-board Embedded Debugger module
- Connectivity with QTouch Analyzer
- On-board Embedded Debugger module for programming/debugging and QDebug data streaming
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1 Overview

This document describes the SAM D20 QTTouch Robustness demo kit. The demo kit showcases both self-capacitance (with springs) sensors and mutual-capacitance sensors running on the same Atmel SAM D20 microcontroller. The associated package for SAM D20 QTTouch Robustness Demo contains the schematic, Gerber, BoM, and firmware.

The demo kit consists of two different PCBs. The mutual capacitance sensors and LEDs are kept on the top PCB. The self capacitance sensors and other electronics are kept on the bottom PCB. The PCBs are electrically connected to each other by means of a flex cable. The PCBs are mechanically held by hex screw mount standoffs. The front panel is pasted over the top sensor PCB.

The demo kit is designed to be used as a standalone unit with its own on-board microcontroller to evaluate the noise immunity and moisture tolerance performance. The SAM D20 QTTouch Robustness demo kit running its associated firmware can pass Test Level 3 (10V_{RMS}) of IEC/EN 61000-4-6 specifications for conducted immunity.

Figure 1-1. Internal View of the Demo Kit
2 Hardware Description

2.1 Block Diagram

Figure 2-1 shows the various modules of the SAM D20 QTtouch Robustness Demo Kit.

Figure 2-1. Block Diagram of SAM D20 QTtouch Robustness Demo Kit
3 Pin Configuration

3.1 Mutual Capacitance Sensors

The demo kit has one slider and four buttons which are based on mutual-capacitance sensing technology. The slider is composed of eight channels. There are eight X-lines and two Y-lines.

Table 3-1. Pin Configuration of the Mutual Capacitance Sensors

<table>
<thead>
<tr>
<th>FUNCTIONALITY</th>
<th>MCU PIN #</th>
<th>MCU PIN NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>X0</td>
<td>17</td>
<td>PA08</td>
</tr>
<tr>
<td>X1</td>
<td>18</td>
<td>PA09</td>
</tr>
<tr>
<td>X2</td>
<td>19</td>
<td>PA10</td>
</tr>
<tr>
<td>X3</td>
<td>20</td>
<td>PA11</td>
</tr>
<tr>
<td>X12</td>
<td>25</td>
<td>PB12</td>
</tr>
<tr>
<td>X13</td>
<td>26</td>
<td>PB13</td>
</tr>
<tr>
<td>X14</td>
<td>27</td>
<td>PB14</td>
</tr>
<tr>
<td>X15</td>
<td>28</td>
<td>PB15</td>
</tr>
<tr>
<td>Y4</td>
<td>15</td>
<td>PA06</td>
</tr>
<tr>
<td>Y15</td>
<td>16</td>
<td>PA07</td>
</tr>
</tbody>
</table>

3.2 Self Capacitance Sensors

The demo kit has six buttons which are based on self capacitance sensing technology. Philipp Spring is used to bridge the air gap between the PCB and front panel. The Philipp Spring design is patented by Atmel. The design specification of the Philipp Spring can be obtained from Atmel.

Table 3-2. Pin Configuration of the Self Capacitance Sensors

<table>
<thead>
<tr>
<th>FUNCTIONALITY</th>
<th>MCU PIN #</th>
<th>MCU PIN NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>4</td>
<td>PA03</td>
</tr>
<tr>
<td>Y10</td>
<td>5</td>
<td>PB04</td>
</tr>
<tr>
<td>Y11</td>
<td>6</td>
<td>PB05</td>
</tr>
<tr>
<td>Y12</td>
<td>9</td>
<td>PB06</td>
</tr>
<tr>
<td>Y13</td>
<td>10</td>
<td>PB07</td>
</tr>
<tr>
<td>Y14</td>
<td>11</td>
<td>PB08</td>
</tr>
</tbody>
</table>
3.3 Indication

This demo kit has seventeen LEDs and a buzzer for audio visual indication of touch detection. Each button has its corresponding LED that glows as long as the button is in detect. The slider has seven LEDs to indicate the touch position on the slider.

The buzzer beeps when there is a valid touch detect.

Table 3-3. Pin Configuration for LEDs and Buzzer

<table>
<thead>
<tr>
<th>FUNCTIONALITY</th>
<th>MCU PIN #</th>
<th>MCU PIN NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>LED BUTTON MC 0</td>
<td>36</td>
<td>PA17</td>
</tr>
<tr>
<td>LED BUTTON MC 1</td>
<td>35</td>
<td>PA16</td>
</tr>
<tr>
<td>LED BUTTON MC 2</td>
<td>38</td>
<td>PA19</td>
</tr>
<tr>
<td>LED BUTTON MC 3</td>
<td>37</td>
<td>PA18</td>
</tr>
<tr>
<td>LED SLIDER 0</td>
<td>45</td>
<td>PA24</td>
</tr>
<tr>
<td>LED SLIDER 1</td>
<td>44</td>
<td>PA23</td>
</tr>
<tr>
<td>LED SLIDER 2</td>
<td>43</td>
<td>PA22</td>
</tr>
<tr>
<td>LED SLIDER 3</td>
<td>42</td>
<td>PA21</td>
</tr>
<tr>
<td>LED SLIDER 4</td>
<td>41</td>
<td>PA20</td>
</tr>
<tr>
<td>LED SLIDER 5</td>
<td>40</td>
<td>PB17</td>
</tr>
<tr>
<td>LED SLIDER 6</td>
<td>39</td>
<td>PB16</td>
</tr>
<tr>
<td>LED BUTTON SC 0</td>
<td>2</td>
<td>PA01</td>
</tr>
<tr>
<td>LED BUTTON SC 1</td>
<td>1</td>
<td>PA00</td>
</tr>
<tr>
<td>LED BUTTON SC 2</td>
<td>64</td>
<td>PB03</td>
</tr>
<tr>
<td>LED BUTTON SC 3</td>
<td>63</td>
<td>PB02</td>
</tr>
<tr>
<td>LED BUTTON SC 4</td>
<td>62</td>
<td>PB01</td>
</tr>
<tr>
<td>LED BUTTON SC 5</td>
<td>61</td>
<td>PB00</td>
</tr>
<tr>
<td>BUZZER</td>
<td>60</td>
<td>PB31</td>
</tr>
</tbody>
</table>

3.4 Communication Interface

The communication pins of the Touch MCU are connected to the Data Gateway Interface (DGI) of the Embedded Debugger (EDBG) module that acts as a bridge between PC and SAM D20 MCU. Touch data is sent using Bit Bang SPI mode.

Table 3-4. Pin Configuration for Bit Bang SPI Communication Interface

<table>
<thead>
<tr>
<th>FUNCTIONALITY</th>
<th>MCU PIN #</th>
<th>MCU PIN NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>BB-SS</td>
<td>31</td>
<td>PA14</td>
</tr>
<tr>
<td>BB-SCK</td>
<td>30</td>
<td>PA13</td>
</tr>
<tr>
<td>BB-MOSI</td>
<td>29</td>
<td>PA12</td>
</tr>
<tr>
<td>BB-MISO</td>
<td>32</td>
<td>PA15</td>
</tr>
</tbody>
</table>
4 Unit Assembly
There are three separate units for the demo kit:

- Acrylic Front Panel
- Sensor PCB
- Main MCU PCB

Figure 4-1. Board Stack-up
5 **Powering up the Kit**

There are multiple components in the kit which can handle different voltage ratings. The LEDs are driven at +3.3V by default to ensure optimum brightness. The maximum safe operating voltage of the SAM D20 is +3.6V. There is an on-board regulator in the kit to provide +3.3V supply to the SAM D20 MCU. There is provision in the board to bypass the on-board regulator.

LED brightness can be increased by moving the PWR-LED jumper from 3.3V LED to 5V LED.

There are two ways to provide power to the kit. There is a set of jumpers in the Main MCU PCB to allow use of different powering options.

### 5.1 USB Port

This is the default power option for the kit. The USB is connected to the EDBG module, which in turn connects to the SAM D20 MCU. The +5V USB VBUS is fed to the on-board regulator of the Main MCU PCB which converts it to +3.3V for the SAM D20 MCU.

![Default Jumper Configuration for USB as Power Supply](image)

### 5.2 External DC Power Supply

There are two ways in which power can be provided to the kit externally:

- **[Configuration – I]** The user can choose to use the on-board regulator and provide voltage from +5V to +12V
- **[Configuration – II]** The user can choose to bypass the regulator and provide +3.3V directly to the chip
6 Embedded Debugger (EDBG)

The demo kit features an on board Embedded Debugger (EDBG) module. This can be used for programming and debugging the firmware using Atmel Studio. Additionally, it allows to stream touch data between the Host PC and the kit using the Data Gateway Interface (DGI).

Figure 6-1. EDBG Board on SAM D20 QTorch Robustness Demo Kit

The EDBG is mounted on the kit as a separate module. Using the EDBG the user can connect to QTorch Analyzer and view the touch data. The EDBG has been pre-configured to support SAMD20J18 device using SWD interface for programming and debugging.

For streaming data to QTorch Analyzer it uses DGI which connects to SAM D20 over Bit Bang SPI.

Figure 6-2. Connecting with EDBG for Programming using Atmel Studio
7 **Connecting to QTouch Analyzer**

The kit can be connected to the QTouch Analyzer to view touch data.

A. Connect the kit to PC using a mini USB cable.
B. Open QTouch Analyzer in Atmel Studio 6.
C. Select QDEBUG_DGI from the drop down menu and click on **Connect**.

D. Click **OK** when the DGI Settings screen pops up.

E. Click **Start Reading**.
F. View touch signals in QTtouch Analyzer.
8 Switch Operation

There are two slide switches available on the board that can be used to enable or disable the countermeasures in the firmware. These switches are present in the top left corner of the board.

Figure 8-1. Switch Position in the Kit

Slide Up for OFF and Slide Down for ON

8.2 Noise Handling

The NOISE HANDLING switch is used to enable or disable the noise countermeasures in the firmware. The position of the switch should be kept at ON when the demo kit is subjected to Conducted Immunity noise testing or powered from a noisy power supply.

There is a beep sound whenever the switch is moved from ON to OFF or vice versa.

8.3 Moisture Tolerance

The MOISTURE TOLERANCE switch is provided to enable or disable the moisture tolerance countermeasures in the firmware. The firmware is designed to detect the presence of moisture and lock the sensors so as to prevent false detects.

There is a beep sound whenever the switch is moved from ON to OFF or vice versa.

Note: Touch on multiple sensors simultaneously is not supported when this switch is in ON position.
9 Board Operation

9.1 Product Layout

Figure 9-1 shows the product layout of the demo kit and the placement of both self capacitance and mutual capacitance sensors.

Figure 9-1. Layout of Sensors on the Kit

9.2 Button Description

9.2.1 Power Button

The power button is used to turn the panel ON or OFF.

The LED for power button will remain glowing to indicate the ON state of the touch panel. Touching the power button again, the touch panel will be put to OFF state, and the LED will stop glowing.

There is a long beep when the button in OFF state comes into detect and the touch panel is activated. A short beep is made when the button comes into detect in ON state and the touch panel is deactivated.

9.2.2 Lock Button

The Lock button is used to Enable or Disable all other touch sensors in the kit. While lock is enabled, the other sensors will not respond to touch.

The LED for the Lock button will remain glowing to indicate the locked state of the touch panel. Touching the Lock button in lock state will release the lock and the LED will turn OFF.

Every valid touch to the button is accompanied by a beep.
9.3 Operating Modes of the Kit

9.3.1 Application Flow

Figure 9-2. Top Level Application Flowchart of the SAM D20 QTtouch Robustness Demo Firmware

9.3.2 Normal Mode

In this mode all sensors are operational. Detect state of button and slider position is provided by the corresponding LEDs. For every valid touch there is a short beep.

This is the default mode of the touch panel.

9.3.3 Mode Change

To change the application mode, press and hold program buttons P3 and P4 for one second. This will change the mode to Settings mode if the current mode is Normal mode and vice versa.
Note: If the kit is left in Settings mode for more than ten seconds, it will automatically switch to Normal mode.

TIP

There is a buzzer beep and LED activity for buttons P3 and P4 to indicate mode change. If Moisture Tolerance is enabled, it will appear that both LEDs blink for a moment along with the buzzer beep. If Moisture Tolerance is disabled, it will appear that both LEDs turn off after the buzzer beep.

9.3.4 Settings Mode

The Settings Mode allows adjustment of the audio visual impact of the kit. The kit provides feedback in form of LED glow and buzzer beep for a valid touch. This mode can be used for the following:

- Adjust the brightness of the LEDs for the mutual capacitance sensors
- Adjust the volume of the buzzer

9.3.4.1 LED Brightness Adjustment

Following are the steps to adjust the brightness of the LEDs for mutual-capacitance sensors.

Ensure that you are in Settings Mode

- Select the mutual capacitance button for which LED brightness is to be adjusted
- Adjust the required brightness level using the slider
- Save the LED brightness level by double tapping corresponding program button (P1 ~ P4)
- Press and hold program buttons P1 and P2 for one second. This restores LEDs to default brightness

Note: The LED brightness settings are saved temporarily in the RAM. A power cycle to the kit will restore the LED brightness to default settings.

9.3.4.2 Buzzer Volume Adjustment

Following are the steps to adjust the volume of the buzzer.

Ensure that you are in Settings Mode

- Press and hold program buttons P2 and P3 for one second. A beep will indicate that you have entered into volume settings mode.
- The number of LEDs glowing on the slider indicates the current volume setting. Adjust the volume level using the slider. The buzzer sound is audible as long as the slider is touched.
- Press and hold program buttons P2 and P3 for one second. This will save the buzzer volume level.

Note: The buzzer volume is saved into the NVM. The volume setting is retained in the memory even after power cycle. Buzzer volume is to be manually set; there is no provision for automatic reset of buzzer volume.
Figure 9-3. Application Flow for the Settings Mode

1. **SETTINGS MODE**
   - **Mode Change (P3 + P4)**?
     - Yes: **NORMAL MODE**
     - No: **Clear Settings (P1 + P2)**?
       - Yes: **Reset LED Brightness**
       - No: **Mutual-Cap Button in Detect**?
         - Yes: **Adjust LED PWM with Slider Position**
         - No: **Slider in Detect**?
           - Yes: **Adjust LED PWM with Slider Position**
           - No: **Double Tap in Self Cap**?
             - Yes: **Save Brightness PWM Setting**
             - No: **Volume Settings (P2 + P3)**?
               - Yes: **Save Volume Setting**
               - No: **Adjust Volume with Slider Position**
     - No: **Volume Settings (P2 + P3)**?
       - Yes: **Save Volume Setting**
       - No: **NORMAL MODE**

10 Schematic

10.1 MCU and Sensor Configuration Section
10.2  LED, Buzzer, and Switch Section
10.3 Power Supply Section

10.4 Sensor Board
11 PCB Design

11.1 Main MCU PCB – Top Layer
11.2 Main MCU PCB – Bottom Layer
11.3 Sensor PCB – Top Layer
11.4 Sensor PCB – Bottom Layer
# Bill of Materials

## Table 12.1. Top Level Bill of Materials

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>QUANTITY</th>
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<tbody>
<tr>
<td>Acrylic Front Panel</td>
<td>1</td>
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<tr>
<td>SAM D20 QTouch Robustness Demo Main MCU Board – PCBA</td>
<td>1</td>
</tr>
<tr>
<td>SAM D20 QTouch Robustness Demo Main Sensor Board – PCBA</td>
<td>1</td>
</tr>
<tr>
<td>Atmel EDBG – PCBA</td>
<td>1</td>
</tr>
<tr>
<td>Flex Cable</td>
<td>1</td>
</tr>
<tr>
<td>Hex Standoff - 5mm M3</td>
<td>4</td>
</tr>
<tr>
<td>Screw M3</td>
<td>4</td>
</tr>
<tr>
<td>Washer</td>
<td>4</td>
</tr>
<tr>
<td>(Rubber Feet) Bump-on</td>
<td>4</td>
</tr>
<tr>
<td>3M Adhesive Sheet (3M767/768)</td>
<td>1</td>
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</tbody>
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## Table 12.2. Bill of Materials for the Sensor PCB

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>VALUE</th>
<th>QUANTITY</th>
<th>DESIGNATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FCC Connector</td>
<td>Molex 52435-2471</td>
<td>1</td>
<td>Flex-Connector</td>
</tr>
<tr>
<td>SMD LED White</td>
<td>LTW-C230DS (703-1174)</td>
<td>11</td>
<td>D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11</td>
</tr>
<tr>
<td>SMD Resistor 0603</td>
<td>330R</td>
<td>11</td>
<td>R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11</td>
</tr>
<tr>
<td>SMD Capacitor 0603</td>
<td>10nF</td>
<td>11</td>
<td>C1, C2, C3, C4, C5, C6, C7, C8, C9, C10, C11</td>
</tr>
<tr>
<td>Broaching Sockets</td>
<td>KFE-M3-4ET</td>
<td>4</td>
<td></td>
</tr>
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## Table 12.3. Bill of Materials for the Main MCU PCB

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>VALUE</th>
<th>QUANTITY</th>
<th>DESIGNATOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROBUSTNESS DEMO SPRING</td>
<td>AIREDALE(15020-B)</td>
<td>6</td>
<td>KEY 101, KEY 102, KEY 103, KEY 104, KEY 105, KEY 106</td>
</tr>
<tr>
<td>Jumper</td>
<td>SNT-100-BK-G</td>
<td>3</td>
<td>JS1, JS2, JS3</td>
</tr>
<tr>
<td>FCC Connector</td>
<td>Molex 52435-2471</td>
<td>1</td>
<td>J301</td>
</tr>
<tr>
<td>Right Angle Header 1x3</td>
<td>STL1-1470ATT-003</td>
<td>3</td>
<td>J104, J105, J106</td>
</tr>
<tr>
<td>Right Angle Header 2x5</td>
<td>TSW-105-08-F-D-NA</td>
<td>1</td>
<td>J102</td>
</tr>
<tr>
<td>Voltage Regulator</td>
<td>LMS8117AMP-3.3/NOPB</td>
<td>1</td>
<td>U101</td>
</tr>
<tr>
<td>SMT Side Actuator</td>
<td>KMS223GPLFG</td>
<td>1</td>
<td>SW101</td>
</tr>
<tr>
<td>Slide Switch</td>
<td>EAO 09.10201.02</td>
<td>2</td>
<td>SW1, SW2</td>
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<tr>
<td>MCU</td>
<td>SAMD20J18A-AU</td>
<td>1</td>
<td>U301</td>
</tr>
<tr>
<td>Buzzer</td>
<td>ABT-402-RC</td>
<td>1</td>
<td>LS1</td>
</tr>
<tr>
<td>SMD Inductor</td>
<td>BLM18PG471SN1</td>
<td>1</td>
<td>L1</td>
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13 References

The following documents can be used as reference for better understanding of the technology:

14 Revision History

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<thead>
<tr>
<th>Doc Rev.</th>
<th>Date</th>
<th>Comments</th>
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