# TOOLSTICK CAPTOUCHSENSE DAUGHTER CARD USER'S GUIDE

1. Handling Recommendations

To enable development, the ToolStick Base Adapter and daughter cards are distributed without any protective plastics. To prevent damage to the devices and/or the host PC, please take into consideration the following recommendations when using the ToolStick:

- Never connect or disconnect a daughter card to or from the ToolStick Base Adapter while the Base Adapter is connected to a PC.
- Always connect and disconnect the ToolStick Base Adapter from the PC by holding the edges of the boards.
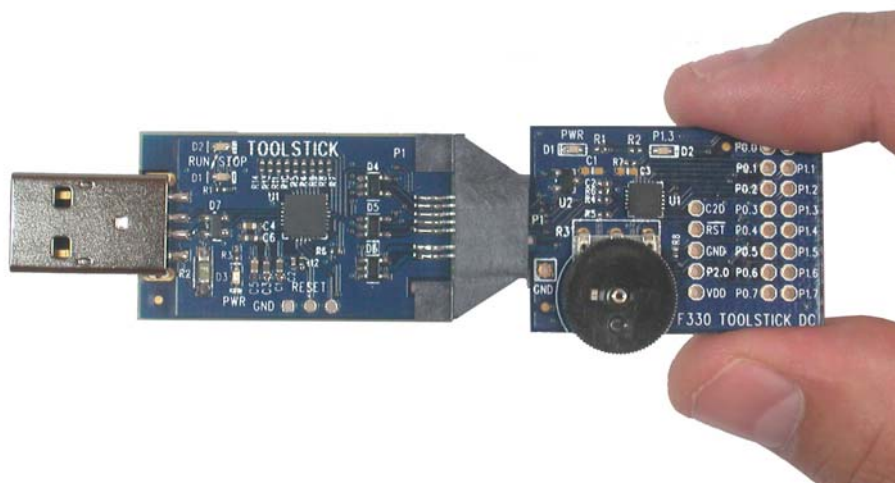
Figure 1. Proper Method of Holding the ToolStick

- Avoid directly touching any of the other components.
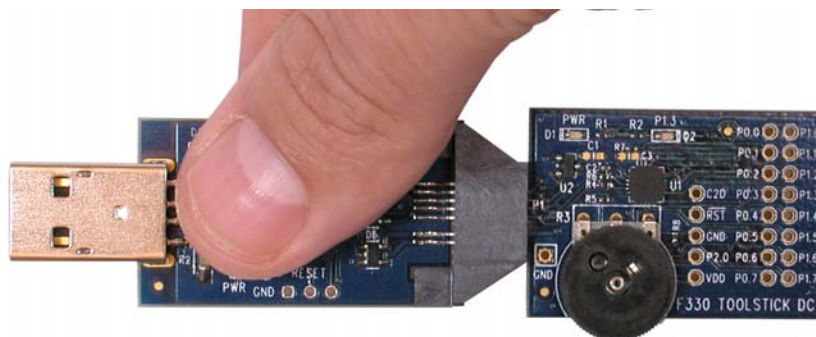
Figure 2. Improper Method of Holding the ToolStick

- Manipulate mechanical devices on the daughter cards, such as potentiometers, with care to prevent the Base Adapter or daughter card from accidentally dislodging from their sockets.

ToolStick-CapTouchSenseDC

2. Contents

The ToolStick-CapTouchSenseDC kit contains the following items:

- ToolStick CapTouchSense Daughter Card

- One A76 battery

A ToolStick daughter card requires a ToolStick Base Adapter to communicate with the PC. ToolStick Base Adapters can be purchased at www.silabs.com/toolstick. The ToolStick-CapTouchSenseDC is also available as part of a ToolStick Starter Kit (CapTouchSenseSK) that includes a CapTouchSenseDC, Toolstick Base Adapter, and USB Extension Cable and may be purchased from the same link.

3. ToolStick Overview

The purpose of the ToolStick is to provide a development and demonstration platform for Silicon Laboratories microcontrollers and to demonstrate the Silicon Laboratories software tools, including the Integrated Development Environment (IDE).

The ToolStick development platform consists of two components: the ToolStick Base Adapter and a daughter card. The ToolStick Base Adapter provides a USB debug interface and data communications path between a Windows PC and a target microcontroller.

The target microcontroller and application circuitry are located on the daughter card. Some daughter cards, such as the CapTouchSense Daughter Card, are used to demonstrate a specific feature or application and some are used as general-purpose development platforms for the target microcontrollers.

The CapTouchSense Daughter Card includes a C8051F931 MCU, four GPIO controlled LEDs, a switch connected to a GPIO, four capacitive touch sense switches, and a small prototyping area which provides access to all of the pins of the device. This prototyping area can be used to connect additional hardware to the microcontroller and use the daughter card as a development platform. The CapTouchSense Daughter Card also includes an A76 1.5 V alkaline battery which can be used to power the board when not connected to the Toolstick Base Adapter. The C8051F931 MCU on this daughter card will continue to operate from the single "button cell" battery until the supply voltage drops below 0.9 V.

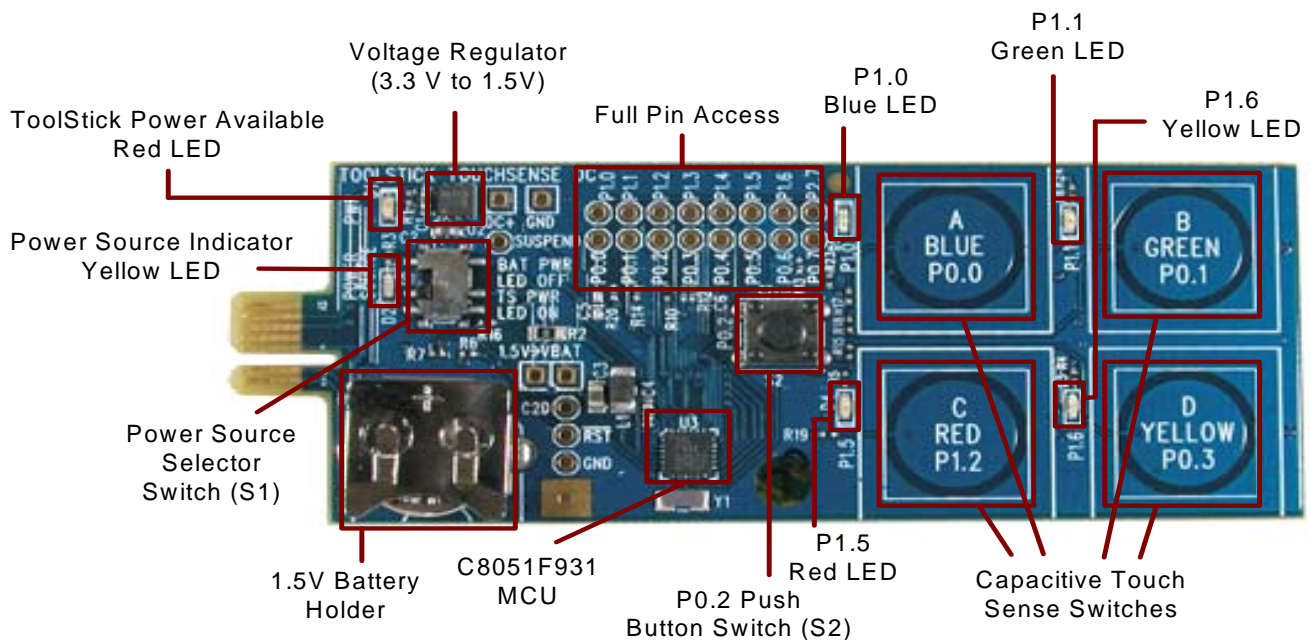Figure 3 shows the ToolStick CapTouchSense Daughter Card and identifies the various components.

Figure 3. ToolStick CapTouchSense Daughter Card

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4. Getting Started

The necessary software to download, debug and communicate with the target microcontroller must be downloaded from www.silabs.com/toolstick. The following software is necessary to build a project, download code to, and communicate with the target microcontroller:

- Silicon Laboratories Integrated Development Environment (IDE)
- Keil Demonstration Tools
- ToolStick Terminal application

The Keil Demo Tools include a compiler, assembler, and linker. See Section "5.2. Keil Demonstration Toolset" for more information about the evaluation version limitations. ToolStick Terminal communicates with the target microcontroller's UART through the ToolStick Base Adapter. It can also read/write the two GPIO pins available on the ToolStick Base Adapter.

Other useful software that is provided on the Silicon Labs Downloads (www.silabs.com/mcudownloads) website includes the following:

- Configuration Wizard 2
- Keil µVision2 and µVision3 Drivers

All of the above software is described in more detail in Section "5. Software Overview".

The software described above is provided in several download packages. The ToolStick Download package includes example code, documentation including user's guides and data sheets, and the ToolStick Terminal application. The IDE, Keil Demonstration Tools, Configuration Wizard 2, and the Keil µVision Drivers are available as separate downloads. After downloading and installing these packages, see the following sections for information regarding the software and running one of the demo applications.

5. Software Overview

5.1. Silicon Laboratories IDE

The Silicon Laboratories IDE integrates a source-code editor, source-level debugger, and an in-system Flash programmer. See Section "7. ToolStick CapTouchSense Daughter Card Example Code" for information on how to use the IDE. The Keil Demonstration Toolset includes a compiler, linker, and assembler and easily integrates into the IDE. The use of third-party compilers and assemblers is also supported.

5.1.1. IDE System Requirements

The Silicon Laboratories IDE requirements:

- Pentium-class host PC running Microsoft Windows 2000 or Windows XP.
- One available USB port.
- 64 MB RAM and 40 MB free HD space recommended.

5.1.2. 3rd Party Toolsets

The Silicon Laboratories IDE has native support for many 8051 compilers. The full list of natively supported tools is as follows:

- Keil
- IAR
- Raisonance
- Tasking
- Hi-Tech
- SDCC

The demo applications for the CapTouchSense Daughter Card are written for the Keil and SDCC toolsets.

5.2. Keil Demonstration Toolset

5.2.1. Keil Assembler and Linker

The Keil demonstration toolset assembler and linker place no restrictions on code size.

5.2.2. Keil Demonstration C51 C Compiler

The evaluation version of the C51 compiler is the same as the full version with the following limitations: (1) Maximum 4 kB code generation, (2) There is no floating point library included. When initially installed, the C51 compiler is limited to a code size of 2 kB, and programs start at code address 0x0800. Refer to "AN104: Integrating Keil Tools into the Silicon Labs IDE" for instructions to change the limitation to 4 kB and have the programs start at code address 0x0000.

5.3. Configuration Wizard 2

The Configuration Wizard 2 is a code generation tool for all of the Silicon Laboratories devices. Code is generated through the use of dialog boxes for each of the device's peripherals.
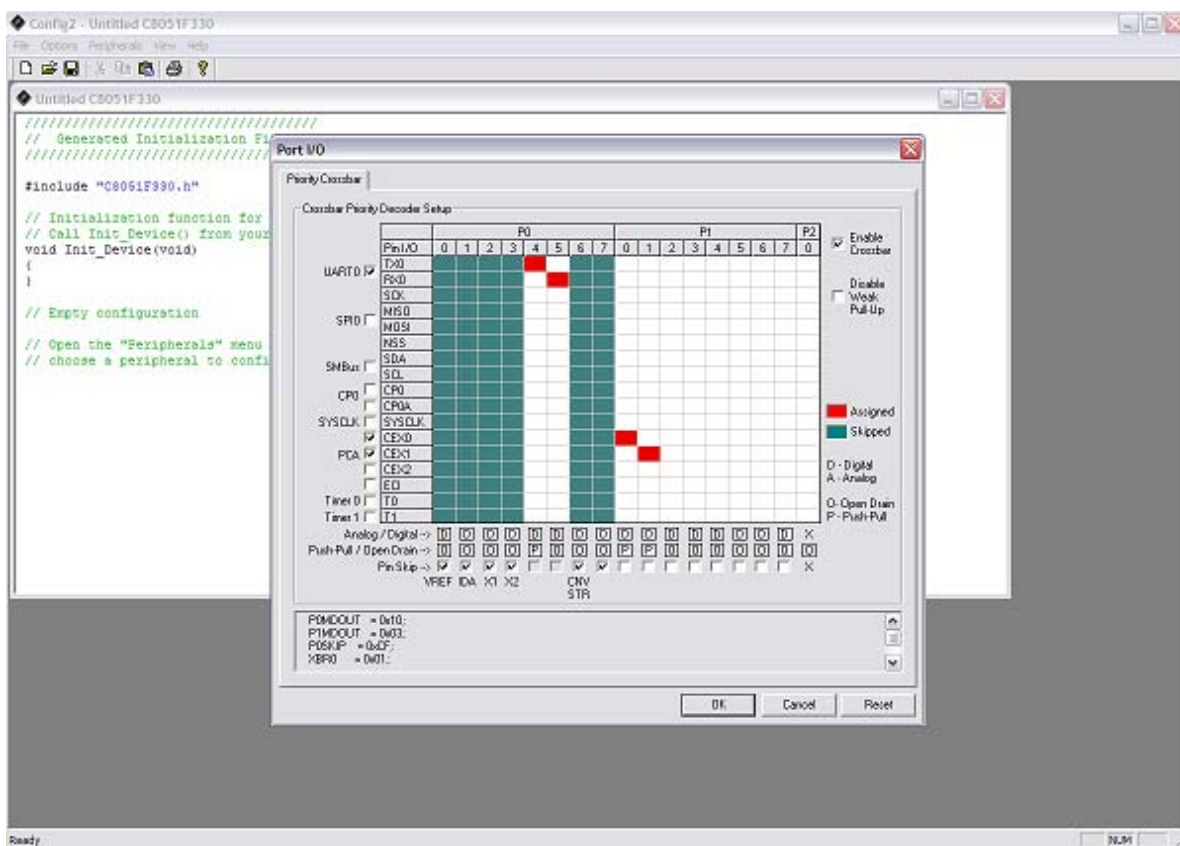

Figure 4. Configuration Wizard 2 Utility

The Configuration Wizard 2 utility helps accelerate development by automatically generating initialization source code to configure and enable the on-chip resources needed by most design projects. In just a few steps, the wizard creates complete startup code for a specific Silicon Laboratories MCU. The program is configurable to provide the output in C or assembly.

For more information, please refer to the Configuration Wizard 2 documentation. The documentation and software are available from the Downloads webpage (www.silabs.com/mcudownloads).

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5.4. Keil µVision2 and µVision3 Silicon Laboratories Drivers

As an alternative to the Silicon Laboratories IDE, the uVision debug driver allows the Keil µVision2 and µVision3 IDEs to communicate with Silicon Laboratories on-chip debug logic. In-system Flash memory programming integrated into the driver allows for rapidly updating target code. The µVision2 and µVision3 IDEs can be used to start and stop program execution, set breakpoints, check variables, inspect and modify memory contents, and single-step through programs running on the actual target hardware.

For more information, please refer to the µVision driver documentation. The documentation and software are available from the Downloads webpage (www.silabs.com/mcudownloads).

5.5. ToolStick Terminal

The ToolStick Terminal program provides the standard terminal interface to the target microcontroller's UART. However, instead of requiring the usual RS-232 and COM port connection, ToolStick Terminal uses the USB interface of the ToolStick Base Adapter to provide the same functionality.

In addition to the standard terminal functions (send file, receive file, change baud rate), two GPIO pins on the target microcontroller can be controlled using the Terminal for either RTS/CTS handshaking or software-configurable purposes (see the demo software for an example).

The software is available on the ToolStick webpage (www.silabs.com/toolstick).

6. ToolStick CapTouchSense Daughter Card Memory Game Demo

The ToolStick CapTouchSense Daughter Card is pre-loaded with a memory game firmware that can be played without connecting to the ToolStick Base Adapter. When disconnected from the ToolStick Base Adapter, the daughter card may be powered from the included A76 alkaline battery. When connected to a ToolStick Base Adapter, the daughter card can be powered from the USB port.

6.1. Hardware Setup

To use the CapTouchSense Daughter Card in standalone mode (battery powered) perform the following steps:

1. Insert the A76 alkaline "button cell" battery into the battery holder (BAT1) ensuring that the "+" terminal is on the top side as marked on the battery holder.
2. Set the Power Select Switch (S1) to select Battery Power (BAT PWR). The yellow power source indicator LED should be OFF.

To use the CapTouchSense Daughter Card with a ToolStick Base Adapter (USB powered) perform the following steps:

1. Connect the ToolStick Base Adapter to the ToolStick CapTouchSense Daughter Card taking note of the recommendations in Section 1.
2. If available, connect the USB extension cable to the ToolStick Base Adapter.
3. Set the Power Select Switch (S1) to select ToolStick Power (TS PWR). The yellow power source indicator LED should be ON.
4. Connect the ToolStick to a USB port on a PC.

See Figure 5 for an example hardware setup using the C8051F330 ToolStick Daughter Card.
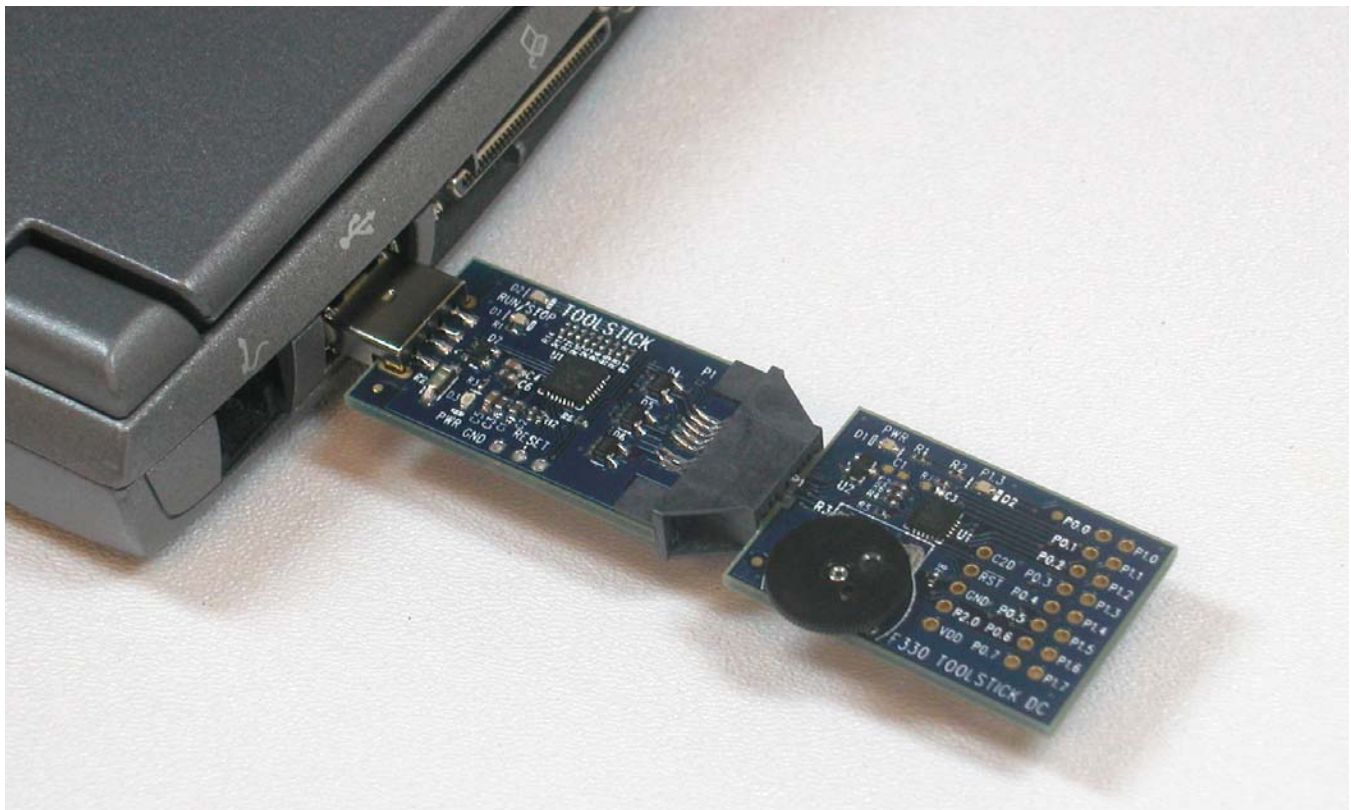

Figure 5. Hardware Setup Example

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6.2. Playing the Memory Game

This section describes how to play the memory game using the capacitive touch sense switches on the CapTouchSenseDC. The objective of the game is to remember a sequence of lights and press the corresponding switches. As the player correctly presses the sequence of switches and advances to the next level, the number of switch presses in a sequence increases. The player wins when the correct sequence at the last level is entered.

1. Press the S2 switch on the daughter card to enter the game. After pressing the S2 switch, all four LEDs will light up.

2. Press one of the capacitive touch sense switches to select the difficulty level and start the game. Switches A, B, C, and D select 4, 8, 16, and 32 levels, respectively.

3. The game begins at level 1. One LED will blink. Press the corresponding switch to advance to the next level.

4. In the second level, there will be a sequence of two blinks. Press the corresponding switches in the same sequence as the LED blinks to advance to the next level.

5. Continue the game until you complete all levels to win the game. A game win is indicated by the blue and green LEDs blinking alternately. If you press a switch in the wrong sequence, an error will be indicated by the red LED blinking four times. The game will then restart at the same level and you will have two such retries. The third error will end the game. This will be indicated by the red and yellow LED blinking alternately.

6. The game can be restarted by pressing the S2 switch.

6.3. Evaluating the Capacitive Touch Sense Switch Sensitivity

Holding the S2 switch for longer than 5 seconds places the device in a switch sensitivity test mode where the corresponding LED lights up each time a switch press is detected. If connected to the ToolStick Terminal, the raw codes corresponding to the relaxation oscillator period are displayed on the screen. When the switch capacitance increases (i.e., the switch is touched), the raw code from the switch should increase. By knowing the approximate value of "switch pressed" and "switch idle", the appropriate finger-detect threshold can be determined.

When ToolStick Terminal is connected, ensure that the GPIO0 and GPIO1 pins are configured as inputs so that they do not interfere with the MCU. While running this software, the GPIO pins should only be driven by the MCU. See the board schematic in "12. ToolStick CapTouchSense Daughter Card Schematic," on page 13 to see the connection between the GPIO pins and the MCU.

7. ToolStick CapTouchSense Daughter Card Example Code

The ToolStick kit includes two code examples. One of them is titled **CapTouchSenseDC_SwitchSensitivity**. This example can be used by a new user to learn the features and capabilities of the IDE and the microcontroller's on-chip debug capabilities. A ToolStick Base Adapter is required to be able to download code to the daughter card and perform debugging.

7.1. Hardware Setup

Connect the ToolStick hardware to the PC using the steps below while taking note of the recommendations in Section 1:

1. Connect the ToolStick Base Adapter to the ToolStick CapTouchSense Daughter Card.

2. If available, connect the USB extension cable to the ToolStick Base Adapter.

3. Set the Power Select Switch (S1) to select ToolStick Power (TS PWR).

4. Connect the ToolStick to a USB port on a PC.

See Figure 5 for an example hardware setup using the C8051F330 ToolStick Daughter Card.

7.2. Connecting to the Device and Downloading Firmware

This section describes how to open the IDE, open and build a project, connect to a device and download the firmware.

1. Open the Silicon Laboratories IDE from the **Start → Programs → Silicon Laboratories** menu.

2. In the IDE, go to **Project → Open Project**.

3. Browse to the default installation location *C:\SiLabs\MCU\ToolStick\CapTouchSenseDC\Firmware*.

4. Select **CapTouchSenseDC_SwitchSensitivity.wsp** and click OK.

5. In the IDE, select **Project → Rebuild Project**.

6. Go to **Options → Connection Options**.

7. Select "**USB Debug Adapter**" for the Serial Adapter and "**C2**" for the Debug Interface, and then click "OK". If you have other Silicon Labs debug adapters connected to the PC, ensure that the correct ToolStick is selected in the drop-down box.

8. Go to **Debug → Connect**.

9. Erase code space using the **Tools → Erase Code Space** command to remove configuration constants stored by the memory game in non-volatile Flash. It is not required when re-downloading the same software project.

10. Download the code using the **download button** on the menu bar or use alt-D.

Once these steps are completed, the firmware is built into an object file (step 5) and downloaded to the device (step 9). The device is now ready to begin executing code. If all of these steps were followed successfully, the "Go" option is enabled in the Debug menu. A green circle icon in the IDE toolbar also indicates that the device is ready to run. If one of the steps leads to an error, make sure that the ToolStick is properly inserted in a USB port and start again with step 6.

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7.3. Running and Stopping Code Execution

Once the IDE is connected to the device and the firmware is loaded, the IDE can start and stop the code execution. The following steps can be performed using the buttons on the toolbar or using the options in the Debug menu.

1. To start code execution, click the green "**Go**" button on the toolbar or use the **Debug → Go** menu option. The debug commands in the IDE (single-step, multiple-step, set breakpoint, and others) are disabled when the device is running. While the firmware is running, pressing any switch on the daughter card will turn on the corresponding LED. The less sensitive switches will require a firmer touch to turn on the LED, and the more sensitive switches will require only a light touch. The first time the firmware runs, it will enter the configuration mode described in Section 7.4.

2. To stop code execution, click the red "**Stop**" button on the toolbar or use the **Debug → Stop** menu option. The device will halt code execution and all of the registers and pins on the device will hold their state.

All debug windows and watch windows are refreshed when the device is stopped. If any of the values in these windows have changed since the last time the device was halted, the new value is shown in red text instead of black text.

7.4. Configuring the Capacitive Touch Sense Switches

The **CapTouchSenseDC_SwitchSensitivity** example includes code that allows the configuration of the capacitive touch sense switches. This code is executed the first time firmware is run or when the code constants are removed from Flash memory (e.g., using the Erase Code Space command).

1. Start code execution by clicking the green "**Go**" button on the toolbar or using the **Debug → Go** menu option. The blue LED will light up to indicate that no calibration values are present. If the blue LED is not on, press the mechanical switch (S2) to start configuration.

2. Put your finger on touch sensitive switch A and press and release the mechanical switch.

3. Repeat Step 2 for the remaining three switches. The LED will turn on to indicate which switch to put your finger on.

4. Touching each switch should now light up the corresponding LED.

7.5. Restoring the Memory Game Demo

The **CapTouchSenseDC_Memory_Game** can be restored in the CapTouchSense daughter card using the following steps.

1. Close the current project or open a new instance of the Silicon Laboratories IDE.

2. Connect to the target.

3. Click the **download button** on the menu bar or use alt-D.

4. Click **Erase All Code Space**. Click OK to erase all code and the configuration values stored in the scratchpad memory.

5. Browse for the HEX file named **CAPTOUCHSENSEDC_MEMORY_GAME.hex**.

6. Click **Download**.

7. Disconnect from the target to start executing code. The red and yellow will light up to indicate that no calibration values are present.

8. Press the S2 switch to begin configuration. Be careful not to touch the capacitive touch sense switches while

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pressing the S2 switch. The blue and green LEDs will blink a few times and switch off. This indicates configuration is complete.

9. Press each of the capacitive touch sense switches to test the configuration, and finally press the S2 switch to return to the game. All four LEDs will light up to indicate that the calibration is complete and the game is ready to be played.

8. Additional Demo Examples

In addition to the **CapTouchSenseDC_SwitchSensitivity** example firmware, the ToolStick download package also includes another example project named **CapTouchSenseDC_Memory_Game**. The instructions for running this example can be found at the top of the source file.

The project and source files for these examples can be found by default in the *C:\SiLabs\MCU\ToolStick\CapTouchSenseDC\Firmware* folder.

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9. Using the CapTouchSense Daughter Card as a Development Platform

The prototyping area on the ToolStick CapTouchSense Daughter Card makes it easy to interface to external hardware. All of the digital I/O pins of the C8051F931 MCU are available so it is possible to create a complete system.

9.1. C8051F931 Pin Connections

It is important to note that if external hardware is being added, some of the existing components on the board can interfere with the signaling. The following is a list of port pins on the C8051F931 that are connected to other components:

- P0.2—This pin is connected to the P0.2 switch. The switch and R10 can be safely removed from the daughter card if they are not needed.
- P0.0, P0.1, P0.3, P1.2—These pins are connected to capacitive touch sense switches. The 0 Ω resistors R15, R17, R18, and R19 be safely removed from the daughter card if the capacitive touch sense switches are not needed.
- P0.4, P0.5—These pins are connected directly to the ToolStick Base Adapter for UART communication.
- P1.0, P1.1—These pins are connected directly to the ToolStick Base Adapter's GPIO pins. By default, these GPIO pins on the Base Adapter are high-impedance pins so they will not affect any signaling. Configuring these pins on the Base Adapter to output pin or handshaking pins could affect signaling.
- P1.3—This pin is connected to the power source detect signal.
- P1.0—This pin is connected to the cathode (-) of the blue LED on the daughter card. The LED or R23 resistor can be removed to disconnect the LED from the pin.
- P1.1—This pin is connected to the cathode (-) of the green LED on the daughter card. The LED or R24 resistor can be removed to disconnect the LED from the pin.
- P1.5—This pin is connected to the cathode (-) of the red LED on the daughter card. The LED or R5 resistor can be removed to disconnect the LED from the pin.
- P1.6—This pin is connected to the cathode (-) of the yellow LED on the daughter card. The LED or R4 resistor can be removed to disconnect the LED from the pin.

See the daughter card schematic in Section 12 for more information.

9.2. VREF Capacitor

On the C8051F931 devices, if VREF is generated using the High-Speed Internal Reference, no output capacitor is required. If using the on-chip Precision Voltage Reference, it is highly recommended to place a capacitor on the VREF output pin. On the ToolStick CapTouchSense Daughter Card, there are pads on the board (C5) to populate a 0603 surface mount capacitor. There are also pads on the board (R14) to facilitate shorting P0.1 to the ground plane for use as an analog ground reference (AGND). The firmware examples for the daughter card use the High-Speed Internal Reference as VREF and the GND pin as a ground reference, so no external capacitor on P0.0 is necessary for proper operation. Also, P0.1 may be used for general purpose I/O.

9.3. C2 Pin Sharing

On the C8051F931, the debug pins, C2CK, and C2D, are shared with the pins /RST and P2.7 respectively. The daughter card includes the resistors necessary to enable pin sharing which allow the /RST and P2.7 pins to be used normally while simultaneously debugging the device. See Application Note "AN124: Pin Sharing Techniques for the C2 Interface" at www.silabs.com for more information regarding pin sharing.

10. Capacitive Touch Sense Switches

The capacitive touch sensitive switches on the CapTouchSenseDC are implemented as relaxation oscillators, with the PCB trace forming the touch-sensitive capacitive element. The relaxation oscillator is constructed using the on-chip analog comparator, on-chip resistors in the C8051F931 MCU. The on-chip analog multiplexer allows multiple switches to be operated using one comparator.

11. Information Locations

Example source code is installed by default in the "C:*SiLabs\MCU\ToolStick\CapTouchSenseDC\Firmware*" directory during the ToolStick installation.

Documentation for the ToolStick kit, including this User's Guide, can be found by default in the *C:\SiLabs\MCU\ToolStick\Documentation* and the *C:\SiLabs\MCU\ToolStick\CapTouchSenseDC\Documentation* directories.

The installer for the ToolStick software is available at www.silabs.com/toolstick.

All application notes are available at http://www.silabs.com/products/microcontroller/applications.asp.
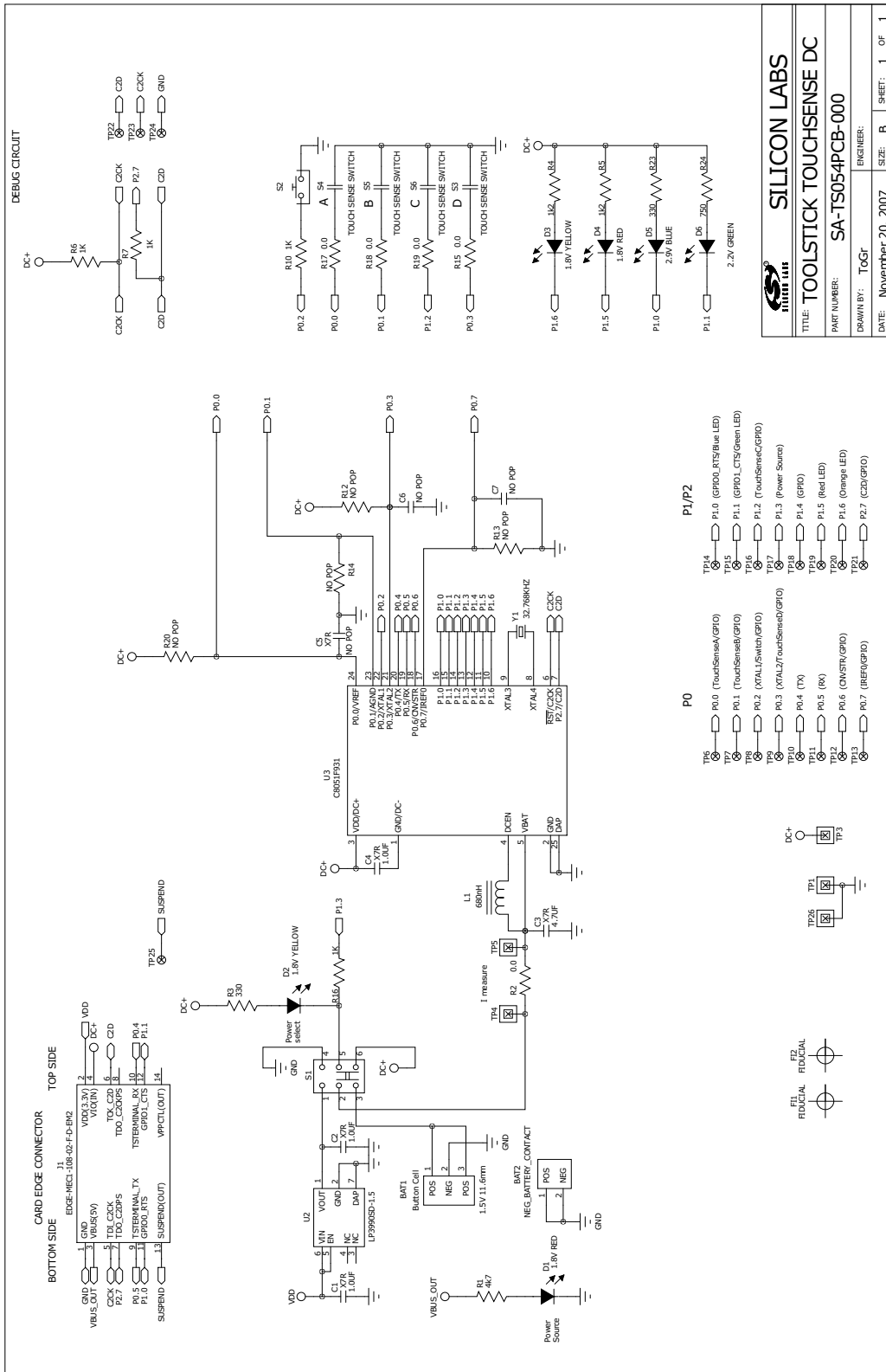
12. ToolStick CapTouchSense Daughter Card Schematic

ToolStick-CapTouchSenseDC

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