RA Family
Using QE and FSP to Develop Capacitive Touch Applications

Introduction
This document will demonstrate the needed steps to create an application example that integrates capacitive touch sensing using Renesas RA Microcontrollers

Target Device
RA family with Capacitive Touch Sensing Unit (CTSU)

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1. Application Example Overview

This document will demonstrate how to implement capacitive touch sensing using Renesas RA Microcontrollers. Using these steps, the user will be shown the process of connecting the RA6M2 MCU board, using the RA Configurator for project creation, and QE for Capacitive Touch [RA] to create, tune and monitor a Capacitive Touch project.

2. Related Documents

This application example is intended to give a user a short introduction to creating a working RA capacitive touch project. A thorough review of all the applicable documentation for the e² studio IDE/RA Configurator, Flexible Software Package (FSP) drivers/middleware, Renesas Code Generator, and QE for Capacitive Touch plug-in help (contained within the e² studio IDE help index) is strongly suggested to answer any questions or for more details on usage of any of the tools utilized in this application example.

3. High Level Integration Steps

The following high-level steps will give the reader an overview of the steps required integrate touch detection into this project. These same steps should apply to any typical user development application.

- Create the initial project using the e² studio project creation wizard
- Use the RA Configurator to add the required modules to the created e² studio project
- Use the QE for Capacitive Touch [RA] e² studio plug-in to create the capacitive touch interface
- Use the QE for Capacitive Touch [RA] e² studio plug-in to tune the application project
- Add the needed FSP application code function calls to the user project to enable capacitive touch operations in the application project
- Monitor the application project using QE for Capacitive Touch [RA] e² studio plug-in to demonstrate capacitive touch detection

4. Required Development Tools and Software Components

The project utilizes the following development environment:

- EVALUATION Kit (EK-RA6M2)
- Renesas e² studio IDE, Version 7.8.0 or later
- GCC ARM Embedded compiler (9.2.1.20191025 or later) installed
- Renesas QE for Capacitive Touch [RA] e² studio plug-in, version: 1.1.0 or later
- Flexible Software Package (FSP) version: 1.0.0 or later and Renesas Code Generator

5. Application Example Overview

In the main loop of the application example, the following processing is performed:

- The global flag used to determine if the rm_touch middleware is ready to be processed is checked
  - If the flag is set (ready to process)
    - The global flag is reset to 0
    - A call to the rm_touch middleware processes data from the previous completed scan, updates needed data, then starts the next touch scan process
    - A call to the rm_touch middleware populates a user created global variable with the binary determination of a touch on the sensor board

A code listing of the completed application example is in Appendix A for review.
6. **Project Creation**

1. On the PC start the IDE using the Windows->Start menu or the icon on the desktop. When the dialog appears, create the Workspace at anywhere.

2. Start a new project by clicking File->New->RA C/C++ Project.

3. At the dialog box that opens, select Renesas RA and highlight with a single-click **Renesas RA C Executable Project**, then click Next.

4. In the next dialog box, enter a Project name-this can be any name desired. The example here uses **Capacitive_Touch_Project_Example**. When complete, click Next.

5. In the next dialog box, ensure the following is selected:
   - FSP version: 1.0.0 or later
   - Board: EK-RA6M2
   - Target Device: R7FA6M2AF3CFB
   - RTOS: No RTOS
   - Toolchain: GCC ARM Embedded
   - Toolchain Version: 9.2.1.20191025
   - Debugger: J-Link ARM
     
     **Note:** Use the ‘…’ to select the proper device using the menu that appears.

6. Once complete, click Next.

7. In the next dialog box that appears, select Bare Metal - Minimal, then click Finish.

Once complete, a default window will open for the IDE with the RA Configurator perspective open and ready for project configuration. This completes the project creation.
7. Using RA Configurator to Add Modules

1. Using the tabs in the lower-middle pane of the IDE, select the BSP tab to display the board support package configuration.

2. Set the power supply voltage with the property displayed at the bottom left of the screen. For this example, the MCU Vcc (mV) will be set to 3300mV.

3. Using the tabs in the lower-middle pane of the IDE, select the Clocks tab to display the clock tree.
4. For this example, the XTAL will be used as the system clock.

5. Next, Assigns the sensor port of the MCU to connect the button / wheel / slider board. Move to the Pins tab by selecting it at the bottom of the pane.

   Note: If you select the EK-RA6M2 board when creating a project, the sensor port is assigned TS2 Pin by default.
6. The pin to use must be selected. Expand the [Peripherals] tree, then expand the [Input: CTSU] entry and select the “CTSU0”.

7. Change the Operation Mode setting of the pin configuration from “Disable” to “Enabled”.

8. Enable the TS pins that you use. This application example will only assign TS2.
   - TSCAP Pin
   - TS2 Pin
9. Next, the touch sensor pins that are NOT being used by the application are recommended to be setup such that they are driven to "OUTPUT" and "LOW" at startup. Expand the [Ports] tree node. Expand the [P2] sub-node and select the "P206". Change the Mode setting of the pin configuration from "Disable" to "Output mode (Initial Low)".

**NOTE:** Only one port is setup here as an example of the usage.

10. Next, move to the Stacks tab by selecting it at the bottom of the pane

11. Select the [New Stack]->[Middleware]->[CapTouch]->[Touch Driver on rm_touch] to add the CTSU driver & middleware
12. HAL/Common Stack will appear as shown in the picture below:

13. Next, click [g_ctsu0 CTSU Driver on r_ctsu] to display properties

   NOTE: Sections 13 to 16 should be set only when using the Data transfer controller (DTC). Transfer data between memory and registers without going through CPU by DTC.

14. Set the DTC with the property displayed at the bottom left of the screen. Change the Support for using DTC setting from “Disable” to “Enable”.
15. Click [Add DTC Driver for Transmission] to select the [New]->[Transfer Driver on r_dtc] to add the DTC driver for Transmission

16. Click [Add DTC Driver for Reception] to select the [New]->[Transfer Driver on r_dtc] to add the DTC driver for Reception

17. At this point, all needed application modules for capacitive touch operations have been added. The final step is to generate the needed application code modules for the project. Do this by clicking the Generate Project Content icon in the upper-right of the Smart Configure pane as shown in the picture below.
8. Creating the Capacitive Touch Interface

1. From the e² studio IDE, use Renesas Views->Renesas QE->CapTouch Main / Sensor Tuner RA (QE) to open the main perspective for configuring capacitive touch to the project.

2. In the CapTouch Main / Sensor Tuner RA (QE) pane, select the project to configure the touch interface for by using the pull-down tab and selecting the Capacitive_Touch_Project_Example project as shown below.

3. Next, create a new touch configuration by using the lower pull-down and selecting Create a new configuration.
4. A new menu window will open with shows the default blank canvas for creating the touch interface

5. Add 1 buttons to the canvas by selecting the **Button** menu item from the right-hand side and adding one(1) button to the canvas. Press the **ESC** key to exit once one button is added. The canvas will look similar to below
6. To make this connection, double-click on Button00 and a dialog box will appear. In this case, using the pull-down, select TS02 as the MCU sensor to assign to this button. Note also, the indication of a configuration error will go away once all assignment are made properly and correspond to the enabled channels in the RA Configurator.

7. Click Create in the dialog box. This will setup the Touch Interface.

8. The CapTouch Main / Sensor Tuner RA (QE) window will now display the configuration of the touch interface in the main view pane.

9. Build the project using the hammer icon in the upper left-hand side of the IDE. The project should build without any errors or warnings.
9. **Modifying the e² studio Project Debug Session for Capacitive Touch Tuning**

1. The debug session needs to be modified slightly so that a special tuning kernel can be downloaded into the MCU RAM after the debug session starts. Enter the Debug Configuration by clicking the gear icon in the upper left-hand side of the IDE.

2. Select the **Startup** tab

3. Ensure the two check boxes **Set breakpoint at:** AND **Resume** are checked and look as follows. You may need to scroll down in the dialog box to see these check boxes

4. Click **Apply** then **Close** to use these modified settings. This completes the project configuration and debug setup for tuning
10. **Tuning the Capacitive Touch Interface Using QE for Capacitive Touch [RA] Plug-in**

1. To start the automatic tuning process, click the button **Start Tuning** in the **CapTouch Main / Sensor Tuner RA (QE)** e² studio IDE.

![Tuning interface screenshot](image)

2. At the start of the first debug session, e² studio **MAY** display a message indicating the Debug perspective will be switched to. Click the **Remember my decision** check box and **Yes** to continue the Debug process and the QE for Capacitive Touch [RA] automatic tuning.

![Confirm Perspective Switch](image)

3. QE for Capacitive Touch [RA] automatic tuning will now begin. Please carefully read the tuning dialog windows as they will guide you thru the tuning process. An example screen is shown below. Typically, no interaction is required during the initial tuning process steps.

![Automatic Tuning Processing](image)
4. After several automated steps, a dialog box with information similar to what is shown below will appear. This is the touch sensitivity measurement step of the tuning process. As the first ‘interactive’ step of the tuning process, press using normal touch pressure on the sensor being indicated in the dialog box (Button00/TS02). When pressing the bar graph will increase to the right and the touch counts go numerically UP. While holding that pressure, press any key on the PC keyboard to accept the measurement.

5. Once sensitivity measurement for the buttons is complete, you will see a screen like what is shown below. This is the detection threshold that is used by the middleware to determine if a touch event has occurred.

6. Click the Continue the Tuning Process button in the dialog box shown. This will exit the tuning process and disconnect from the Debug session on the target. You should return to the default Cap Touch Main / Sensor Tuner RA (QE) screen in the e² studio IDE.
7. In this example, all that is left is to output the tuning parameter files. Click the button **Output Parameter Files**

8. In the **Project Explorer** window and you will see that `qe_touch_config.c`, `qe_touch_config.h` and `qe_touch_define.h` files have been added. These contain the needed tuning information to enable touch detection using the module of FSP

9. Build the project using the hammer icon in the upper left-hand side of the IDE. The Console output showing build results should show no errors
11. Adding rm_touch FSP Function Calls to Application Example

1. To implement application code to scan and report the state of the touch sensor, click the button **Show Sample** in the **CapTouch Main / Sensor Tuner RA (QE) e² studio IDE**

2. A new menu window will open with shows the sample code in text. Click the button **Output to a File**
3. Created a new project file that describes the sample code. In the Project Explorer window and you will see that `qe_touch_sample.c` files have been added.

4. Open the declaration of `hal_entry()` function that is called within the `main()` function.

5. In the `hal_entry()`, call the `qe_touch_main()` with main program

6. This completes all the needed code modifications required for this simple application example. Building the code should result in no errors or warnings for this simplified application example.
12. Monitoring Touch Performance using e² studio Expressions Window and QE for Capacitive Touch [RA]

1. Start a Debug session by clicking the Bug icon in the upper left-hand corner of e² studio. A Debug session will commence.

2. The debugger will stop at the `hal_entry()` function call. This is the first code point in the `main()` function.

3. Open the declaration of `hal_entry()` function.

4. Open the declaration of `qe_touch_main()` function.

5. Scroll down in the `hal_entry.c` file to the `RM_TOUCH_DataGet()` function in the `while (true)` loop. Add the variable `button` to the expressions window.


7. Click the ‘Resume’ button located approximately in the middle of the e² studio menu bar to continue code execution.
8. Press TS2 on the board, which was configured as Button00 in Section 7 of this application guide. When pressed, a ‘1’ will appear for button in the Expression window, indicating a binary indication of touch.

9. Open the Monitoring view from Show Views of CapTouch Main / Sensor Tuner RA (QE)

10. It may be necessary to drag the pane up for better viewing, however you should see the CapTouch Board Monitor RA (QE) pane appear like the image below.
11. Click the **Enable Monitoring** button. The dialog text will change to **Monitoring: Enabled**

![Enable Monitoring button](image)

12. Touch the button **TS2** on the EK-RA6M2 board. The **CapTouch Board Monitor RA (QE)** will show a touch with a finger image on the button like the below image.

![Button 00](image)

13. To see a graphical representation of the 'touch counts' from the board, use the **CapTouch Status Chart RA (QE)**
14. Using the pulldown, select **Button00 @ config01**

15. The graph will begin to display running values. Touch **TS2** on the board and you should see the ‘touch counts’ show as a step change on the running graph. The **GREEN** line is the touch ‘Threshold’, which the middleware uses to determine whether a button is actuated/touched. The **RED BELT** at the bottom of the graph is a visual indication to the user that the ‘touch counts’ have crossed above the threshold and a touch is detected.
Note: Sections 16 to 19 should only be set when displaying and measuring standard deviation.

16. Next, measure standard deviation. Click the **Start Data Collection** button. Don’t touch the electrode as this will collect data of **touch-off** state. The green bar is the data collection rate. When the green bar goes all the way to the right, the data collection of **touch-off** state is complete.

17. Click the **Stop Data Collection** button, when the green bar goes all the way to the right.

18. Next, Touch the electrode as this will collect data of **touch-on** state. Click the **Start Data Collection** button while touching the electrode.
19. Click the **Stop Data Collection** button, when the green bar goes all the way to the right. The SNR is displayed when data collection is complete.
13. `qe_touch_sample.c` Listing AFTER Modifications

```c
#include "qe_touch_config.h"
#define TOUCH_SCAN_INTERVAL_EXAMPLE (20) /* milliseconds */

void qe_touch_main(void);

uint64_t button;

void qe_touch_main(void)
{
    fsp_err_t err;

    /* Open Touch middleware */
    RM_TOUCH_Open(g_qe_touch_instance_config01.p_ctrl,
                   g_qe_touch_instance_config01.p_cfg);

    /* Main loop */
    while (true)
    {
        /* for [CONFIG01] configuration */
        RM_TOUCH_ScanStart(g_qe_touch_instance_config01.p_ctrl);
        while (0 == g_qe_touch_flag) {}
        g_qe_touch_flag = 0;

        err = RM_TOUCH_DataGet(g_qe_touch_instance_config01.p_ctrl, &button, NULL, NULL);
        if (FSP_SUCCESS == err)
        {
            /* TODO: Add your own code here. */
        }
    }
}
```

} /* FIXME: Since this is a temporary process, so re-create a waiting process yourself. */

R_BSP_SoftwareDelay(TOUCH_SCAN_INTERVAL_EXAMPLE, BSP_DELAY_UNITS_MILLISECONDS);

} }
Website and Support

Renesas Electronics Website
http://www.renesas.com/

Capacitive Touch Sensing Unit related page
https://www.renesas.com/solutions/touch-key
https://www.renesas.com/fsp
https://www.renesas.com/qe-capacitive-touch

Inquiries
http://www.renesas.com/contact/
## Revision History

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2. Processing at power-on
   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

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   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

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