# RX200, RX100 Series

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## Guidelines for Tuning a RX Based Capacitive Touch Project

## Introduction

Workbench produces tuning values that optimize performance of the Capacitive Touch Sensing Unit (CTSU) ensuring quick response and operation. However, if robustness to environmental factors such as conducted noise is desired the user-- upon completing the tuning process-- has the ability to further modify the values workbench produces. These calibration parameters, which result from the Workbench tuning process results in the possibility of further customization that includes switch debounces, thresholds and hysteresis, and filter values. This document will outline and discuss the tunable parameters offered.

## Target Device

RX230, RX231, RX130, and RX113.

## Contents

## 1. Overview of touch specific parameters

After using Renesas' workbench to create an example project to begin working with the capacitive touch solution a set of software parameters are produced that allow the user to tune the performance to their application. These software parameters are initially tuned for performance that when, in the presence of environmental factors such as injected electrical noise, or water, may need to be adjusted to prevent false touches. While a majority of the values can be found in the generated TouchAPI project, the tunable parameters contained in this document will only describe how to fine-tune the generated Base_Project_RXxxx (xxx stands for the MCU); from this point on this project will be referred to as the Base Project. It is recommended that after going through the tuning process that the user spends time inside of Workbench, which will allow them to gauge the relative magnitude of the various adjustments allotted to them. The calibration that workbench allows the user to interact with that apply the all of the buttons via the 'Touch Parameters' window are

- Drift correction and frequency
- Continual touch limiting
- Delay time to touch
- Delay time to non-touch (release)

These individual calibrations apply specifically to each touch sensor:

- Count Threshold
- Count Hysteresis

There are additional calibration parameters that that Workbench doesn't interact with, that can only be modified in software, is the filter length, which controls the length of a low pass filter that smooths the touch counts. Figure 1 describes the files where the tunable parameters are held; these values can be modified inside their appropriate files as shown below in Figure 1 in addition to Workbench.

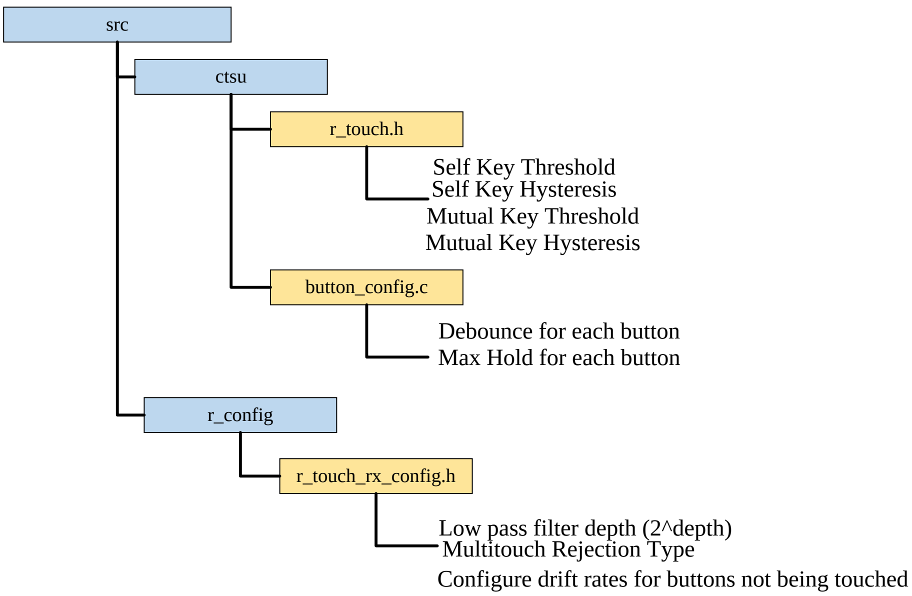


**Figure 1: File structure of the Base_Project_RX**

The second option is to tune them directly in Workbench by interacting with the Touch Parameters tab found under the 'Capacitive touch' pull down as described by Figure 2.

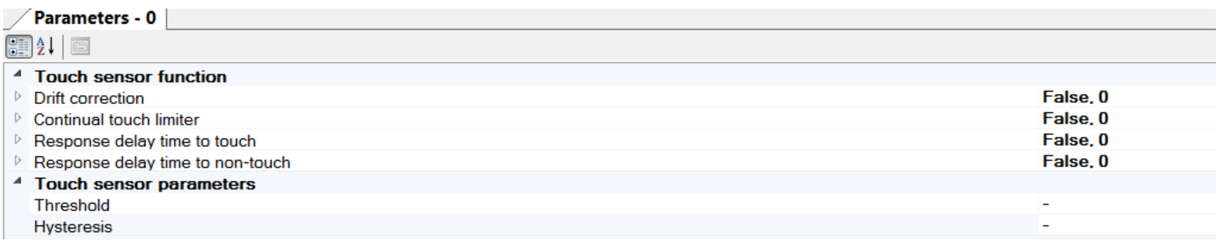


**Figure 2: Parameter window showing the values Workbench is able to tune**

## 2. Touch Limit Levels

There are two limits that the software has that determine a touch vs. a non-touch and these should be the first variables tuned to be more robust in harsher environments as they are the primary discriminator against noise. In the capacitive touch tuning projects that work bench generates, the threshold and hysteresis levels are set conservatively to ensure performance. In Figure 3 below, there is an example of the thresholds and hysteresis values overlaid on an example count chart in the self-capacitance method.

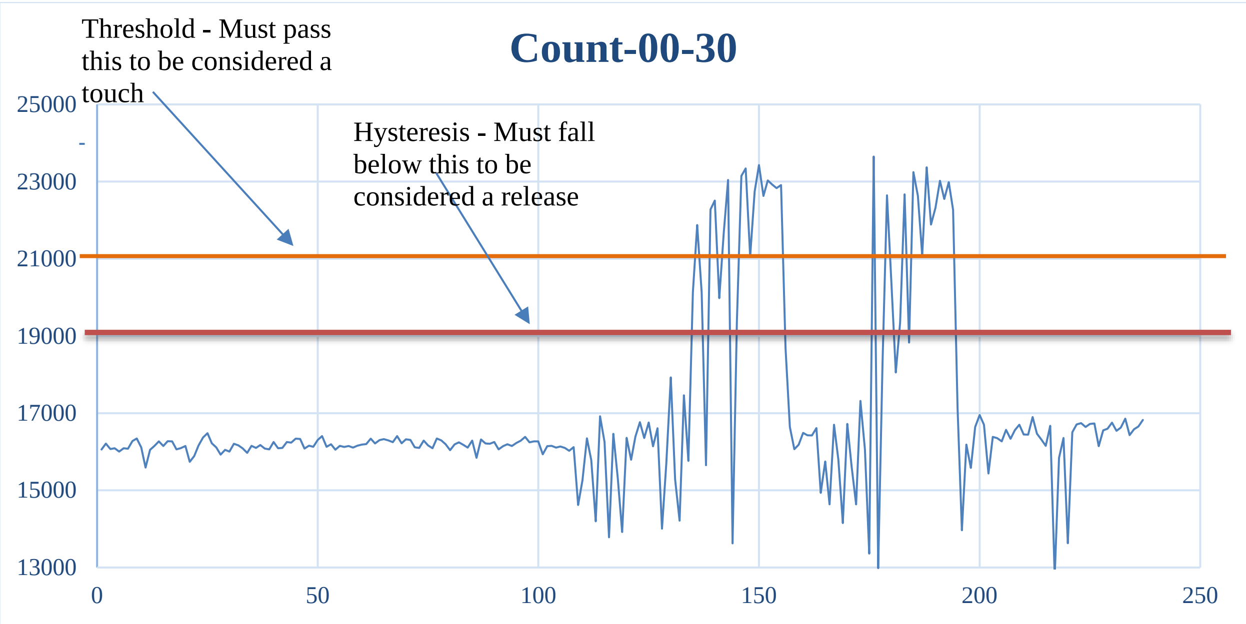


**Figure 3: Example graph showing threshold lines (in orange) and the hysteresis threshold (in red)**

An often-used strategy to tune these thresholds in the presence of external factors such as injected RF noise or with close proximity buttons is to touch the intended button and view the surrounding button responses.

### 2.1 Threshold

Testing should be done on buttons to understand the maximum threshold that will allow reliable detection of the smallest test finger. For buttons that are exhibiting noise sensitivity the threshold of that button should be increased as high as needed without exceeding the reliability threshold. To make the thresholds relative to any bias that might present itself on the touch measurements due to water, or something capacitive on the board they are based on the reference count, which is a moving average of counts. Therefore, if the reference changes from 10000 to 13000, the threshold is based on that value. The value that controls these thresholds are:

- **SELF_TSxx_THR** – Where the xx stands for the touch channel in which you would like to modify the threshold for. For the touch layer to trigger a touch, the counts must exceed the reference by a magnitude specified by the threshold.
- **MUTUALy_KEYxx_THR** – Where the xx represents the key touched and the y is the mutual group the key belongs to. For the touch layer to trigger a touch, the counts must decrease below the reference in addition to this threshold.

### 2.2 Hysteresis

Hysteresis ensures the touch signal must return to a “released” state before the touch is considered released. In the presence of noise, an actual touch may have transients below the threshold so increasing the hysteresis value can help with touches that ‘flicker.’ A value of 30% of threshold value is reasonable; the values that Workbench provides can be much lower than that. Lastly, the hysteresis referred here is the difference from the threshold e.g. if there is a threshold of 10000 and hysteresis is set to 3000 the value must fall below 7000 before a touch event is released.

- **SELF_TSxx_HYS** – Where the xx stands for the touch channel in which you would like to modify the hysteresis for.
- **MUTUALy_KEYxx_HYS -** Where the xx represents the key touched and the y is the mutual group the key is apart of.

## 3. Debounces

After tuning the thresholds and hysteresis to suitable numbers, Workbench allows for debounce tuning in the form of a delay. This delay can either be on the rising edge of a touch, and is referred to as a delay to touch or on the falling edge of a touch event and is referred to as a delay to release. These two values are commonly set low by workbench to increase touch response, but often in situations where the touch signal becomes 'noisy,' it needs to be increased to allow for more robustness. By increasing these values, within a certain amount the system responsiveness still remains suitable thereby preventing erratic behavior from adversely affecting touch decisions.

In addition, with the addition of the button layer contained inside of the Base Project there is also a debounce there as well.

### 3.1 Delay to touch

The delay to touch value determines how many consecutive scans must show a touch before the system accepts it as a valid touch. Increases this value can help with false touches. The value should typically be at least three (which is the value that Workbench tunes it to). The issue with increasing it too much is the response time to for the MCU to signal a touch increases. In addition, if this number is very high then a valid touch may never be detected in the presence of noise.

- **SELF_TOUCH_ON** – Cumulative number of counts to be determined as 'on,' or touched.

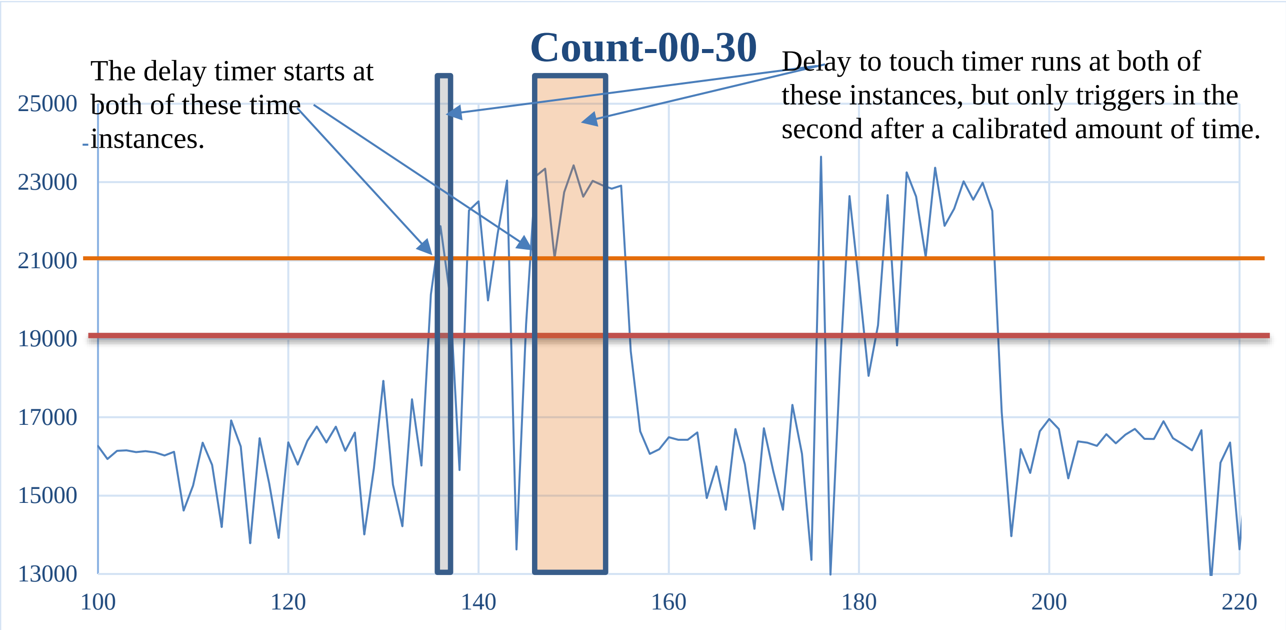


**Figure 4: Example graph showing the regions where debouncing is performed (gray and orange) and successful (orange)**

### 3.2 Delay to release

The delay to release value determines how many consecutive scans must show a release event before the system accepts it as a valid release. Increases this value can help with false releases in noisy conditions. The value should typically be at least three (which is the value that Workbench tunes it to). The issue with increasing it too far is the response time for the MCU to release a touch becomes too long.

- **SELF_TOUCH_OFF** – Cumulative number of counts to be determined as 'off,' or not touched.

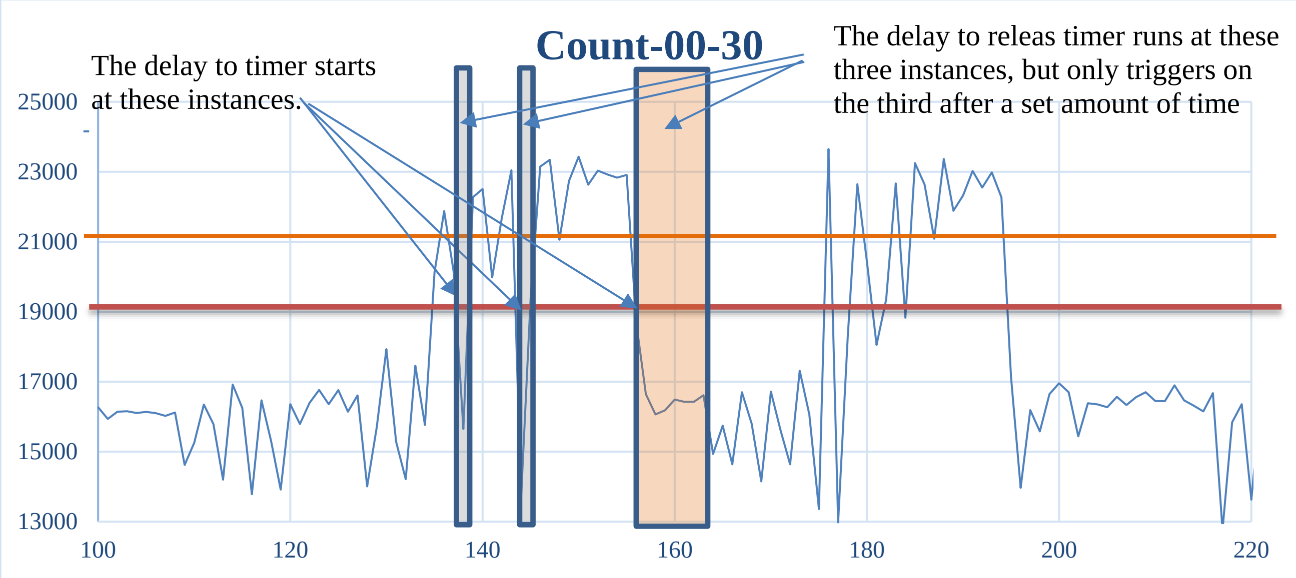


**Figure 5: Example graph showing the regions where debouncing is performed (gray and orange) and successful (orange)**

## 4. Maximum continuous on time

Depending upon the environmental situation, the buttons could be erroneously stuck to an on position. An example of this situation would be a self-capacitive pad with water sitting on top of it with drift correction turned off. To the MCU this would appear as if the button is 'stuck' on the on position. This function limits the total length of time the button can be triggered.

- **SELF_MSA** – Maximum Continuous On time, setting it to zero means this function is disabled.

## 5. Drift Correction

Drift compensation is designed to track slow moving changes to the capacitance values of the system due to environmental effects (age, humidity, temperature, power supply). Drift compensation can also help if there are DC offsets caused by continuous noise, or an external capacitive object resting on the sensor. Care must be taken in the configuration of this value, setting this value to too quickly of a compensation value results in the reference starting to track the noise. Too slow, or off, and the reference value does not readjust to environmental effects in a timely manner or at all. A standard value for drift compensation is 5 seconds.

- **SELF_DRIFT_ENABLE** – Enables the drift tracking function.
- **SELF_DRIFT_FREQUENCY** – How frequently will the drift function will be run.

## 6. Low Pass Filter Value

Lastly, the 'Touch_Api' project includes a low pass filter, which smooths the touch value in software. It operates on the signal every time the function is called, which means if increase too far depending upon how often the function is called could cause a delay in the system. A larger value will provide some additional noise filtering but also creates a touch delay. Since the target touch response is 100 - 200 mSec making this filter have a depth of more than 8-16 samples, a depth of 3-4, can be a problem with response when the scan time of the CTSU is 10 mSec. Care must be taken when lengthening this value, as the total response time depends on how often the touch function is called. For example, a filter depth of four, but running at 100 mSec, would result in a response time of 400 msec.

- **TOUCH_CFG_FILTER_DEPTH** – This is the length of the filter in $2^{\text{TOUCH\_CFG\_FILTER\_DEPTH}}$ terms. This is not a tunable value in Workbench, and pertains to all touch channels, not the individual ones.

## 7. Button Specific Values

The generated Base Project structure brings into use a button layer which interprets binary touch events from the touch layer and creates events that treat them more like a button (e.g. depending upon the driver version, a button can be long held, short held, rising edge, falling edge, etc. The enumerations can be found in the *touch_button_event_t* definition. An example of the touch structure for each button is:

```
touch_button_cfg_t const Button_RX27_TX21_on_g_touch_cfg_on_g_ctsu_cfg_mutual0
= {
     .button.rx = 27,
     .button.tx = 21,
     .debounce = 20,
     .hold_max = 1000,
     .p_callback = App_TOUCH_Button_Notification,
     .enable.press = true,
     .enable.release = true,
     .enable.hold =false,
     .p_touch_cfg = &g_touch_cfg_on_g_ctsu_cfg_mutual0,
};
```

With this structure, the project gains two parameters associated with the button layer.

- A debounce on a per button basis, instead of a global debounce associated with every touch event.
- A time to maximum hold, which allows the driver to switch from a touch event to a hold event (e.g. a timer needs to be held for a length of time to begin setting it).

## 8. Multitouch Rejection

The Base Project also brings in a parameter that allows for rejection of multi touch. This gives the user the option to release all touched sensors based on the number of other touched sensors in relation with the maximum amount of sensors touched allotted. The macro definition is MULTITOUCH_REJECTION_TYPE and can be set the following ways:

- 0 – Disables multitouch rejection, and the value in max_touched_sensors is ignored.
- 1 **–** The driver will release all touched sensors if number of non-debounced touch sensors is greater than the maximum amount of touched sensors.
- 2 **-** The driver will release all touched sensors if number of debounced touch sensors is greater than the maximum amount of touched sensors.
- 3 **-** The driver will release all touched sensors if the current number of debounced sensors subtracted from the previous number of debounced sensors is greater than the maximum amount of touched sensors. This condition tests for the condition of when the number of debouced sensors is growing from iteration to iteration.

## 9. Tuning through workbench

Workbench allows you to visualize threshold values in real time as you tune them to your application's environment. The measurement window allows you to view the status, counts, and thresholds of each TS channel at a glance. By rearranging the parameters and measurements window to be side by side, you are able to view- real time- your changes have on the CTSU processing. .

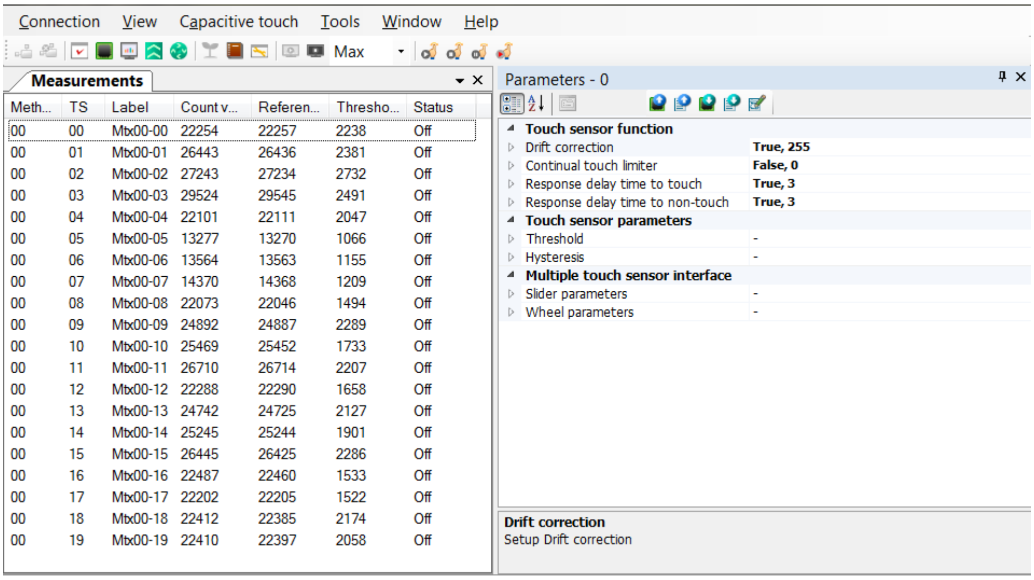


**Figure 6: Workbench showing the measurement and parameter window**

If the real time tuning values of just a few channels are desired, the user can right click on those channels and then switch to the status monitor. Below in Figure 7, are two buttons next to each other with the parameter window to the right, the green line represents the threshold and the blue line is the reference value in which the hysteresis and threshold values are calculated from.

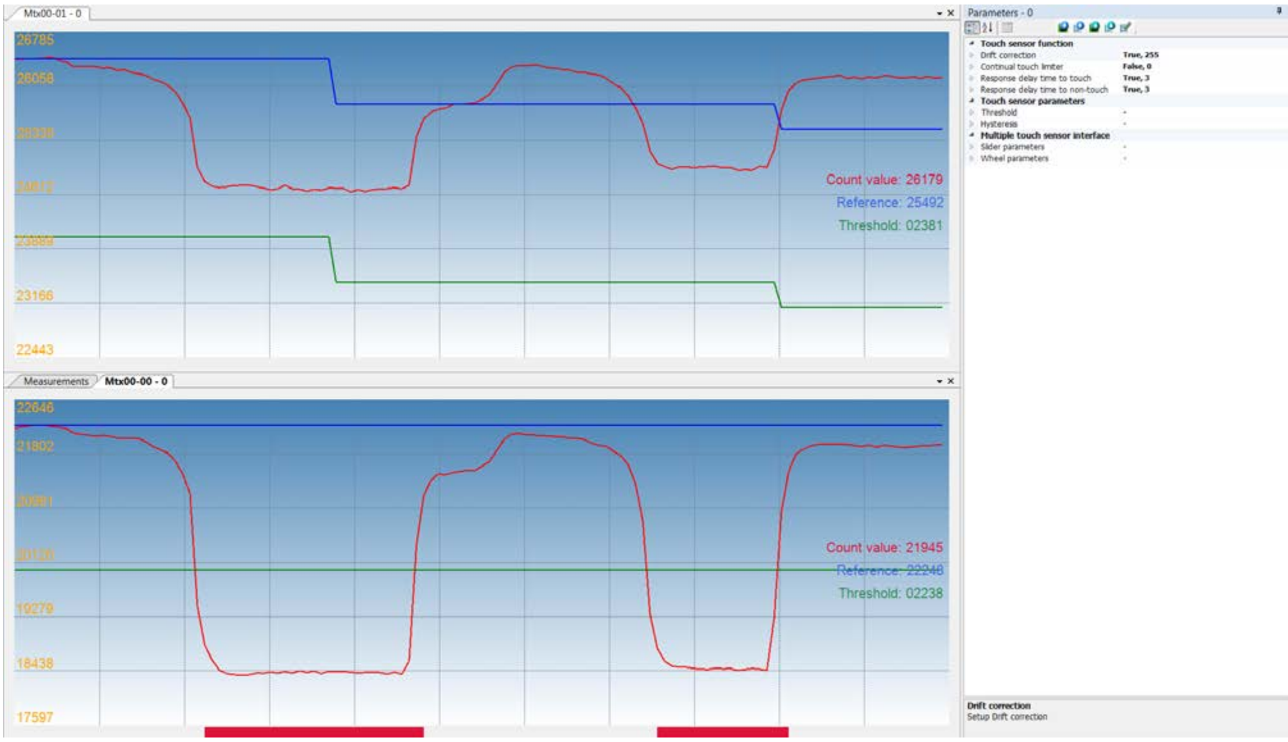


**Figure 7: Workbench picture describing how you can overlay the real time charts with the parameter window**

## 9.1 Recording data

To be able to save and view data later, Workbench also gives the user the option to save the data into a comma separated value file (.csv) that saves not only the touch and reference counts, but also the touch difference as well of all the configured channels. This function is useful when sending data between users.

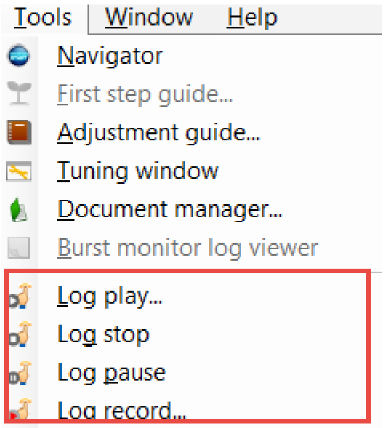


**Figure 8: Describing how to use Workbench to record data**

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## Revision History

| Rev. | Date | Description | |
|---|---|---|---|
| | | Page | Summary |
| 1.00 | May 11, 2017 | - | Initial Version Released |

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