

RX23E-B Group

QE for AFE: Analog Front End Tuning Guide

Introduction

This document explains how to operate the “QE for AFE” PC tool, which is for connection to the RX23E-B board to control the operation of the board. For details on the MCU, refer to the “RX23E-B Group User’s Manual: Hardware”.

The QE for AFE is used in combination with the RSSKRX23E-B board control program (which comes with the R01AN6364 application note).

Target Device

RX23E-B (R5F523E6LDFP)

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1. Overview

1.1 System Overview

The QE for AFE is a development assistance tool that supports the development of embedded systems which perform highly accurate sensing with the use of microcontrollers that have a built-in analog front end (AFE). The QE for AFE handles serial communications with the RSSKRX23E-B board (hereafter referred to as the target board) via a USB connection to set the AFE registers of the RX23E-B mounted on the target board, control the operation of the AFE, and obtain values from A/D conversion or voltage values and display them as a graph. The QE for AFE also sets the operation of sample programs that run on the target board, and obtains the results of measurement and displays them as a graph.

The main functions are listed below.

(1) Evaluating the AFE, DSAD, and R16DA.

- a. Graphical setting of the operating conditions
 - Select and specify the register parameters on the block-diagram level.
 - Display the frequency-gain characteristic graph of an on-chip digital filter based on register settings.
- b. Directing the starting and stopping of A/D conversion, and obtaining and displaying the results.
 - Dump the values from A/D conversion.
 - Display the waveform of the values from A/D conversion.
 - Analyze and display a histogram of the values from A/D conversion.
 - Display the average, maximum, and minimum values of the values obtained from A/D conversion.

(2) Controlling sample programs and user programs, and obtaining and displaying the measured values.

- Set numerical parameters.
- Select functions.
- Obtain the measured values.
- Display the values obtained from measurement (waveform or raw data).

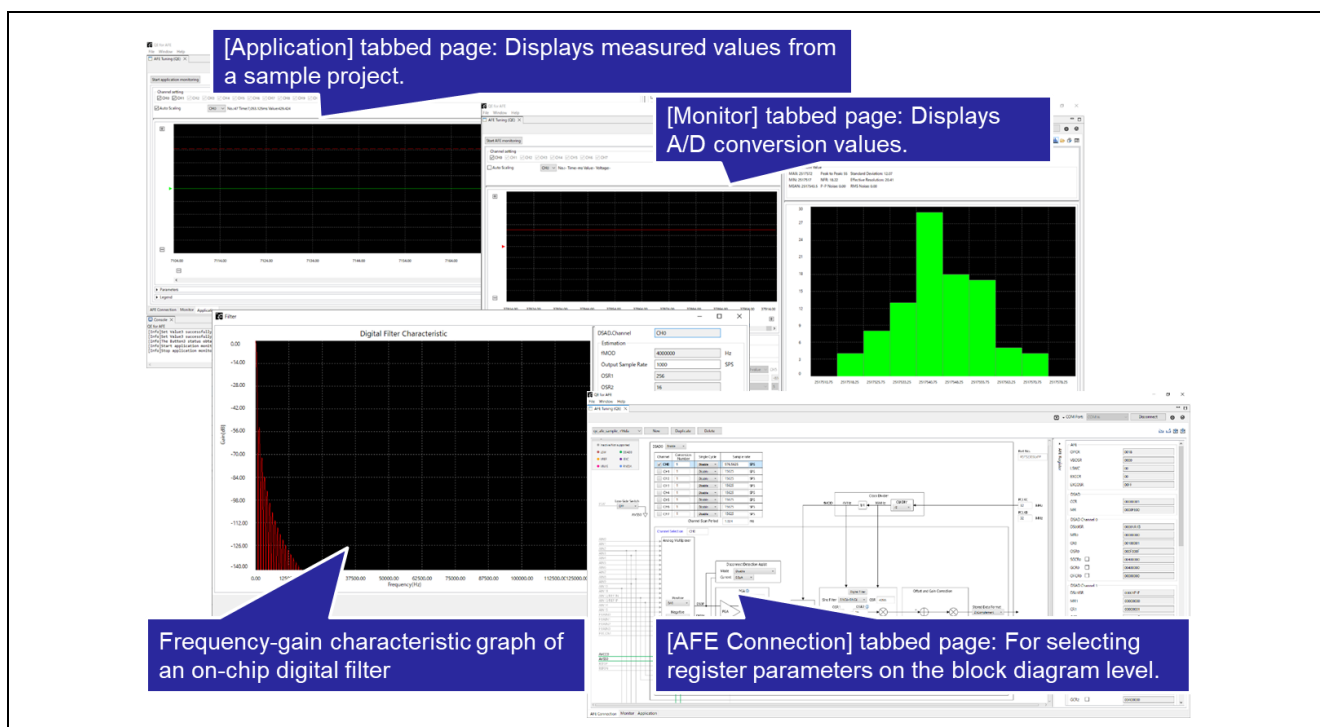


Figure 1-1 Main Functions of the QE for AFE

1.2 Operating Environment

The operating environment of the QE for AFE is as shown in the table below.

Table 1-1 Operating Environment

Item	Details	Remarks
OS of host PC	Windows 10 (64-bit version), Windows 11 (64-bit version)	—
Target board	RSSKRX23E-B	—
QE for AFE	QE for AFE V2.1.1	—
Board control program for the QE for AFE	RSSKRX23E-B board control program	Sample project provided with the RX23E-B Group RSSKRX23E-B Board Control Program Application Note (R01AN6364)

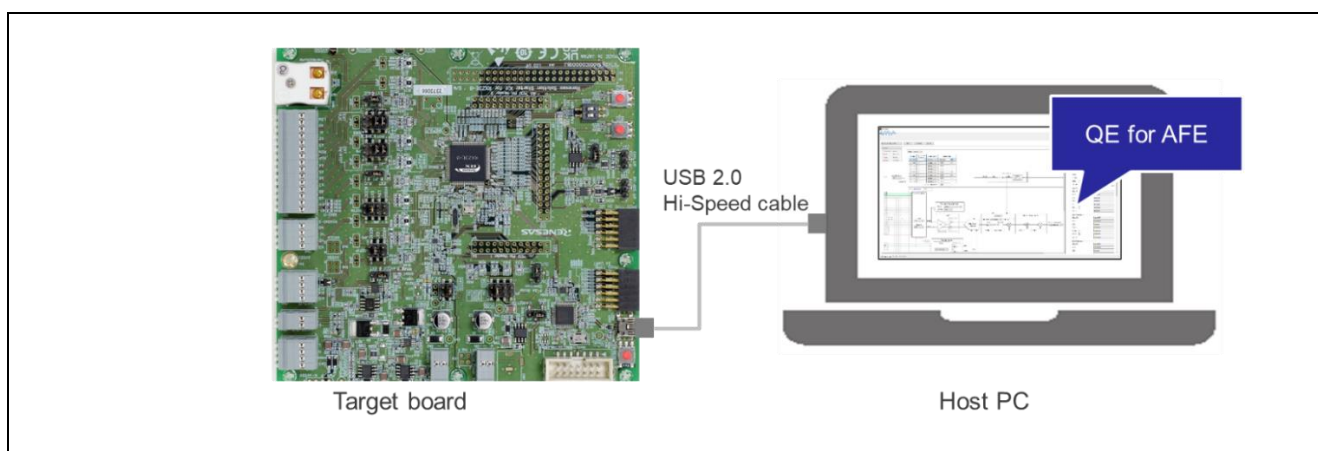


Figure 1-2 Operating Environment of the QE for AFE

1.3 References

- R01UH0972: RX23E-B Group User's Manual: Hardware
- R20UZ0108: RSSKRX23E-B User's Manual
- R20QS0044: RSSKRX23E-B Renesas Solution Starter Kit for RX23E-B Quick Start Guide
- R01AN6364: RX23E-B Group RSSKRX23E-B Board Control Program Application Note
(The package for the application note includes the board control program binary file and QE for AFE communications module.)

2. Preparations

Using the QE for AFE requires the following preparations.

- Installing and executing the USB serial port driver
- Installing the QE for AFE
- Programming the board control program for the QE for AFE
- Setting up the target board

2.1 Installing and Executing the USB Serial Port Driver

The target board is equipped with an FT232H USB-to-serial conversion IC, made by Future Technology Devices International, Ltd. If you will need this driver at the time of USB connection, download and install the driver file from the FTDI Web page (<http://www.ftdichip.com/>).

2.2 Installing and Launching the QE for AFE

The QE for AFE is provided in a zip package. To install the QE for AFE, take the following steps.

- (1) Unzip the zip file at a desired location on your PC.
However, select a shallow layer in the folder hierarchy for this purpose.
Note: Do not place it under the OS program folder (C:\Program Files).
- (2) Double-click on “¥QE-AFE¥eclipse¥qe-afe.exe” to start the QE for AFE.

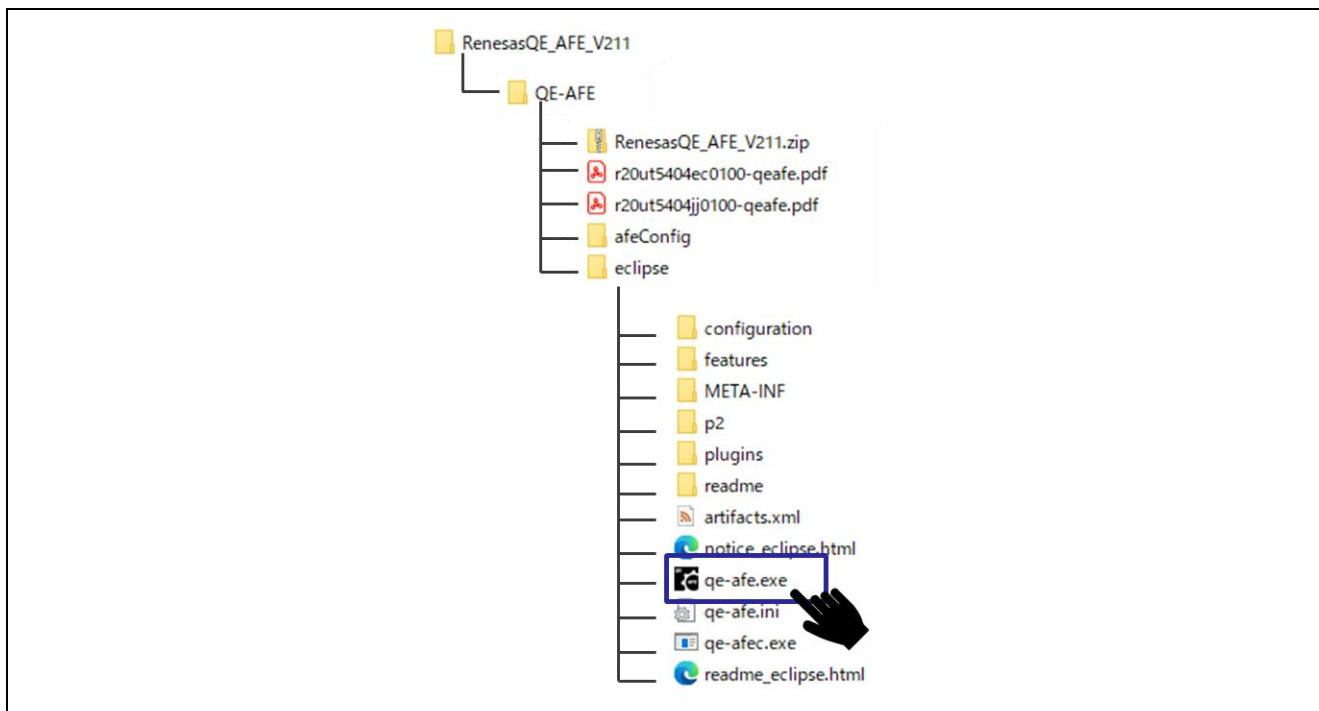


Figure 2-1 Executable File of the QE for AFE

- (3) The license agreement dialog box is displayed when you start the QE for AFE for the first time. Confirm the contents of the license agreement and select [Agree] or [Disagree].
If you select [Agree] in the above step, the QE for AFE will be launched and ready to use.
If you select [Disagree] in the above step, the QE for AFE will not start and you will not be able to use it.

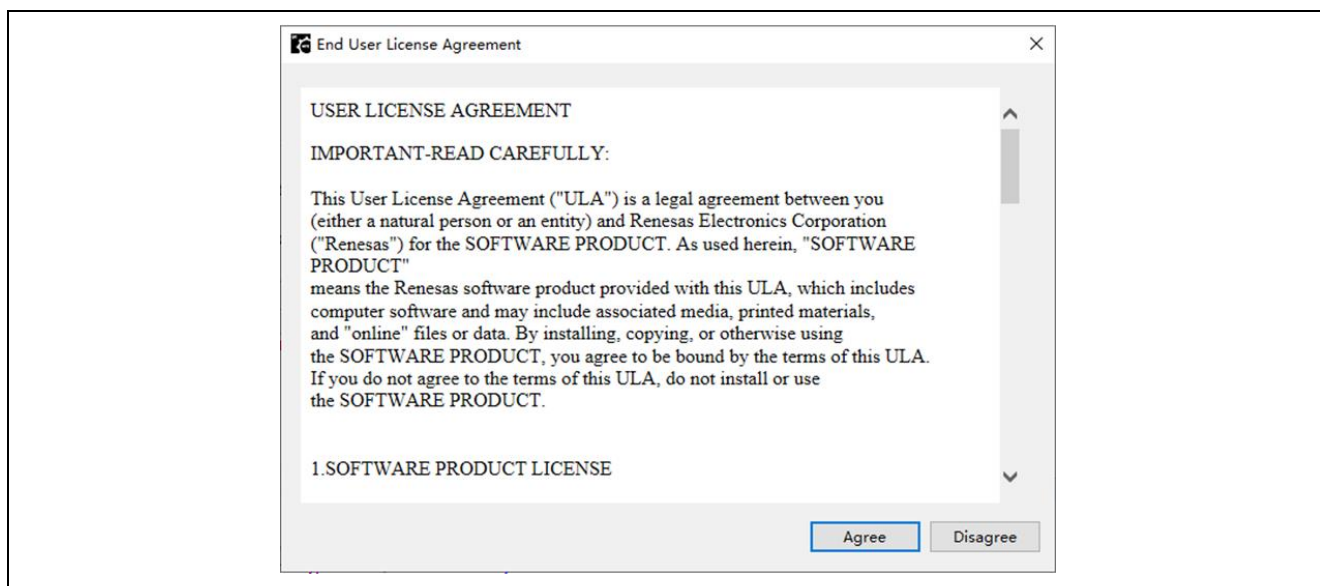


Figure 2-2 License Agreement Dialog Box

2.2.1 Updating the QE for AFE

If you want to update the QE for AFE, obtain the updated version of the package and perform updating by following the same procedure as for installation.

2.2.2 Uninstalling the QE for AFE

If you want to uninstall the QE for AFE, simply delete the folder where you unzipped the zip file.

2.3 Programming the Board Control Program for the QE for AFE

The board control program is already written to the RX23E-B on the RSSKRX23E-B board as shipped. If the program for the RX23E-B requires re-writing during software development, write the board control program included in the RX23E-B Group RSSKRX23E-B Board Control Program Application Note (R01AN6364). For details, refer to "RSSKRX23E-B Renesas Solution Starter Kit for RX23E-B Quick Start Guide (R20QS0044)".

3. Examples of Evaluation

This application note provides register setting files that can be imported into the QE for AFE. This section describes the procedure for importing the register setting files and evaluating the operation. Table 3-1 lists the register setting files.

The detailed evaluation procedure is explained in “3.1 Evaluation Procedure”, and a setting example is shown in “3.2 Example of Evaluating DSAD0”.

Table 3-1 List of Register Setting Files

Register Setting File Name	Description	Reference
qe_afe_sample_r16da.3eb	The output of R16DA is input to the AMUX where A/D conversion is performed. This register setting file is for checking the operation of the QE for AFE. The operation can be checked without using analog signals input from an external module.	3.1
qe_afe_sample_dsad0.3eb	DSAD0 A/D-converts the analog signals input from the AIN0 and AIN1 pins.	3.2

3.1 Evaluation Procedure

This section describes the procedure of evaluation when the output of R16DA is input to the AMUX and A/D conversion is performed, as shown in Figure 3-1.

- Register setting file: qe_afe_sample_r16da.3eb

In this example, a reference voltage and input signal do not have to be supplied from outside the target board. This makes it easy to check how to use the QE for AFE.

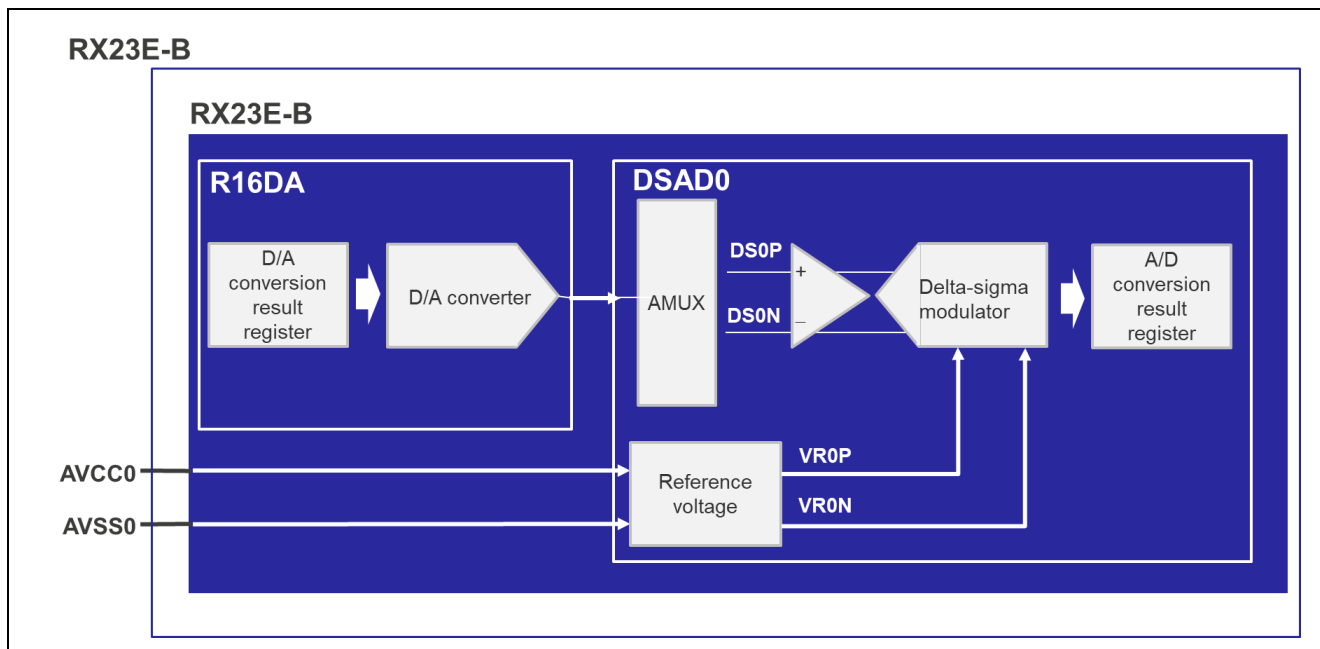


Figure 3-1 Evaluation Procedure: Connection

3.1.1 Preparations

Make the preparations for using the QE for AFE by following the instructions in “2.Preparations”.

- Install the QE for AFE.
- Write the board control program for the QE for AFE.
- Set up the target board.
 - Set the JP1 jumper pin on the target board to “Vbus”.
 - Set the JP11 jumper pin on the target board to “Single Chip”.

3.1.2 Connecting the Host PC to the Target Board

Connect the host PC to the target board in the manner shown below.

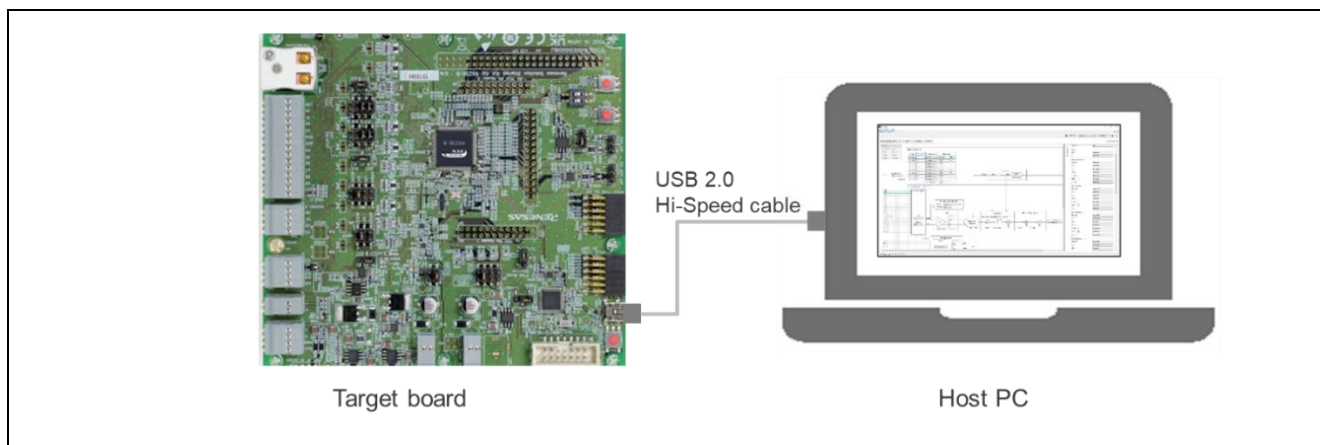


Figure 3-2 Evaluation Procedure: Connecting the Host PC to the Target Board

3.1.3 Starting the QE for AFE and Selecting the Device

Start the QE for AFE.

In the QE for AFE, select the device to be used in AFE tuning. Select “RX” for [Series] and “RX23E-B” for [Device], then click on the [OK] button.

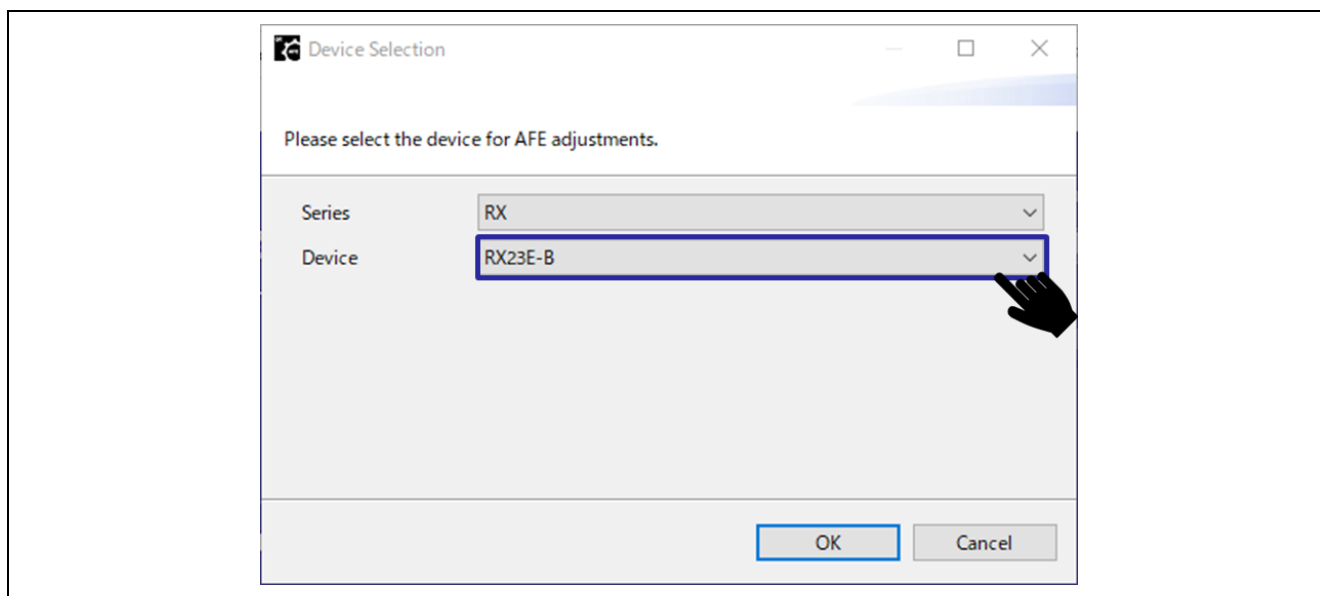


Figure 3-3 Selecting the Device

3.1.4 Connecting the Target Board

In the QE for AFE, select the COM port and click on the [Connect] button.

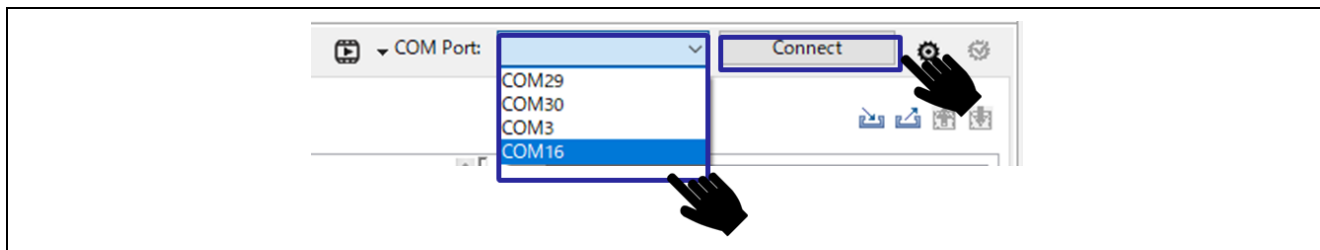


Figure 3-4 Evaluation Procedure: Selecting the COM Port and Making the Connection

In the QE for AFE console, confirm that connection was successful. If connection was successful, the register settings for the target board will be loaded.

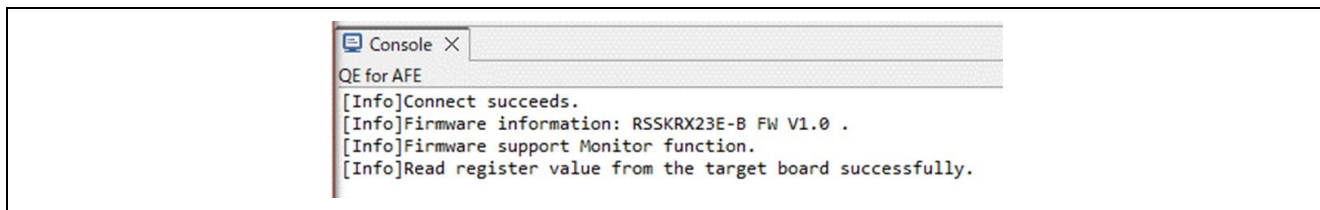


Figure 3-5 Evaluation Procedure: Successful Connection

3.1.5 Importing the Register Setting File

Select the [AFE Connection] tab to display the setting dialog box.

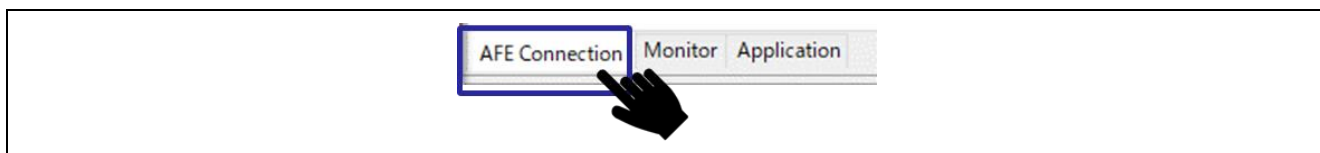


Figure 3-6 Evaluation Procedure: [AFE Connection] Tab

Click on the icon indicated below and import the register setting file.

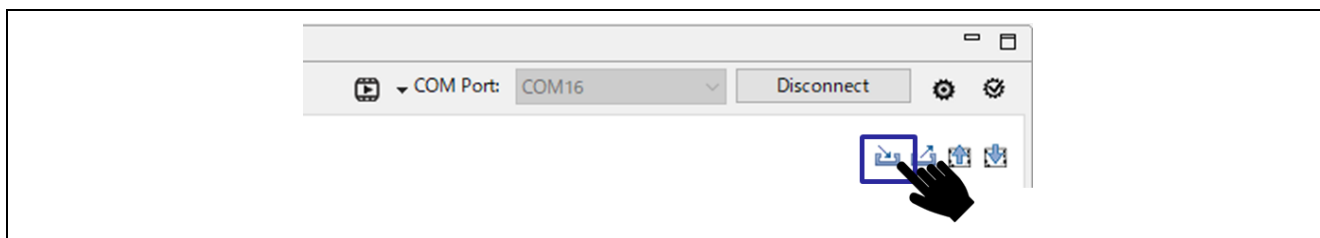


Figure 3-7 Evaluation Procedure: Selecting the Icon to Run Importing

After the register setting file has been selected, the following window appears. Click on the [OK] button.

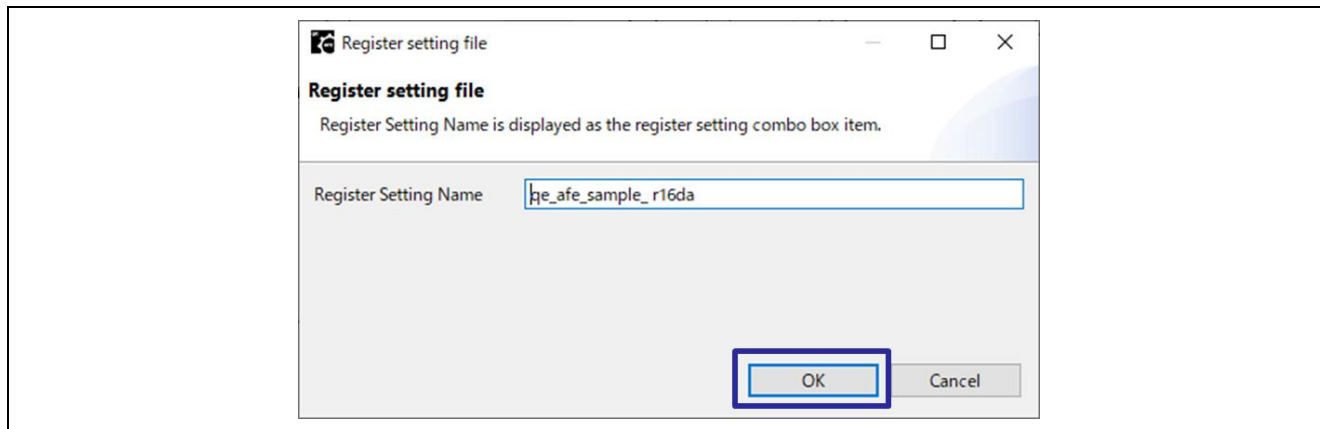


Figure 3-8 Evaluation Procedure: Selecting the Register Setting File

3.1.6 Setting R16DA

With the selected register setting file, R16DA is used to generate a 1.5-V signal.

R16DA is set as shown in the figure below.

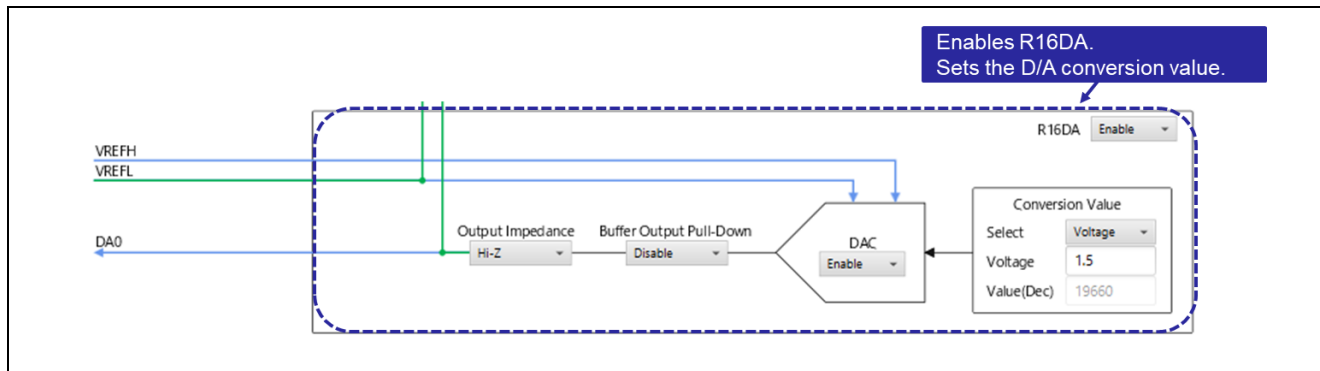


Figure 3-9 Evaluation Procedure: Setting R16DA

3.1.7 Setting DSAD0

With the register setting file, DSAD0 is used to set the output of DA0 and DAC GND as input signals.

DSAD0 is set as shown in the figure below.

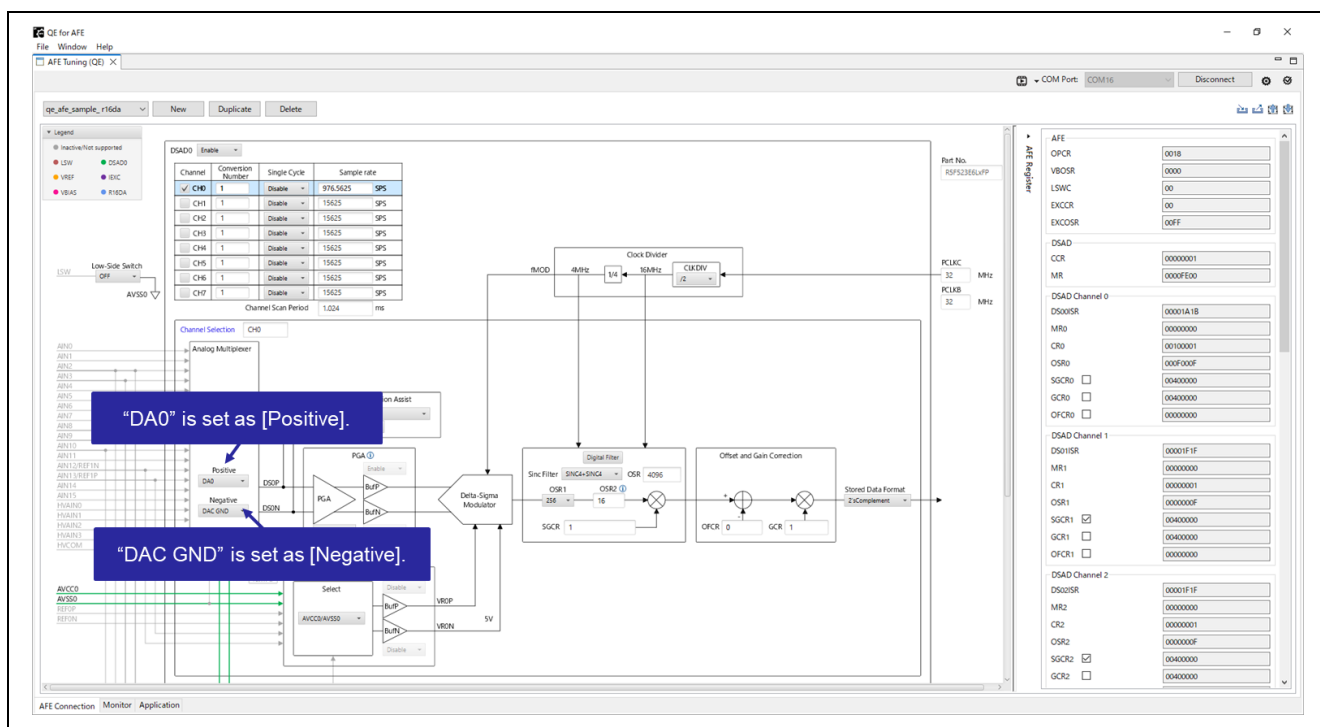


Figure 3-10 Evaluation Procedure: Setting DSAD0

3.1.8 Writing to the RX23E-B

Click on the icon shown below to write the register values to the RX23E-B on the target board.

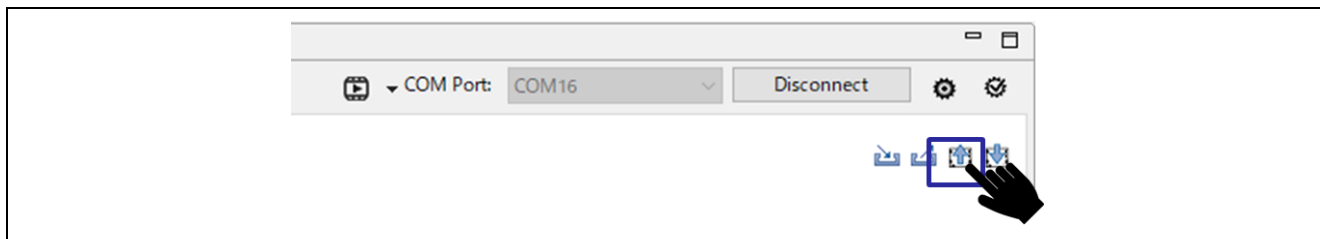


Figure 3-11 Evaluation Procedure: Writing the Register Values

In the QE for AFE console, confirm that all settings for the target functions have been written to the RX23E-B on the target board.

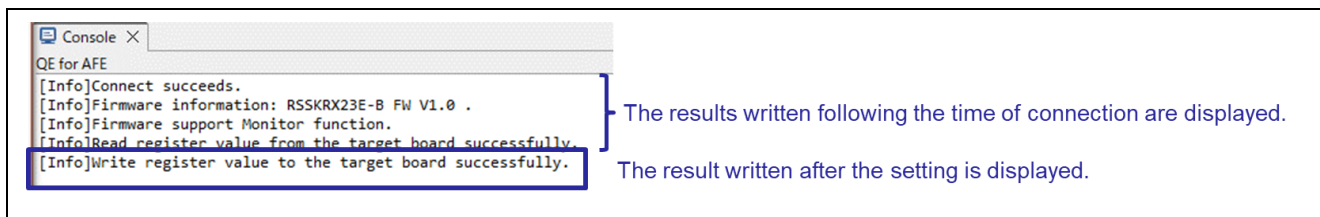


Figure 3-12 Evaluation Procedure: Successfully Written

3.1.9 Starting Monitoring

Select the [Monitor] tab to switch to the monitor display.

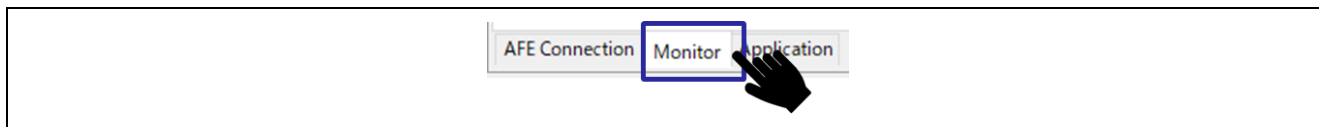


Figure 3-13 Evaluation Procedure: Selecting the [Monitor] Tab

Click on the [Start AFE monitoring] button to start AFE monitoring.

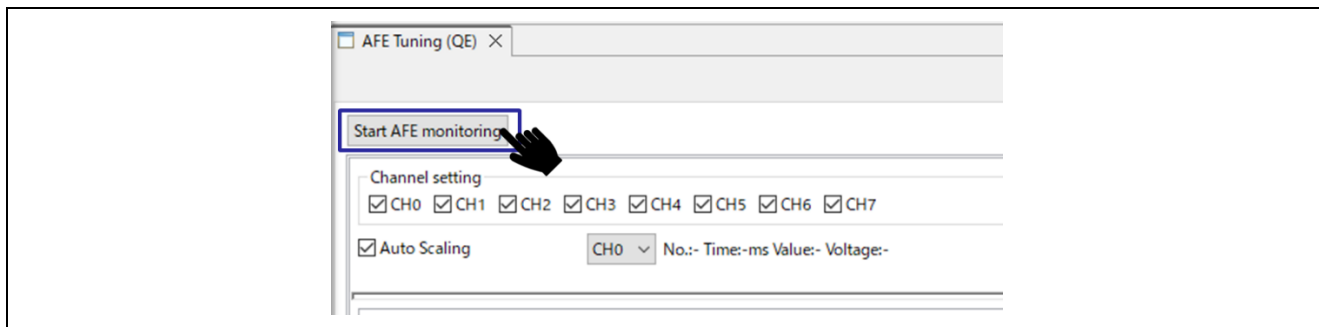


Figure 3-14 Evaluation Procedure: Starting AFE Monitoring

In the QE for AFE console, confirm that AFE monitoring has started.

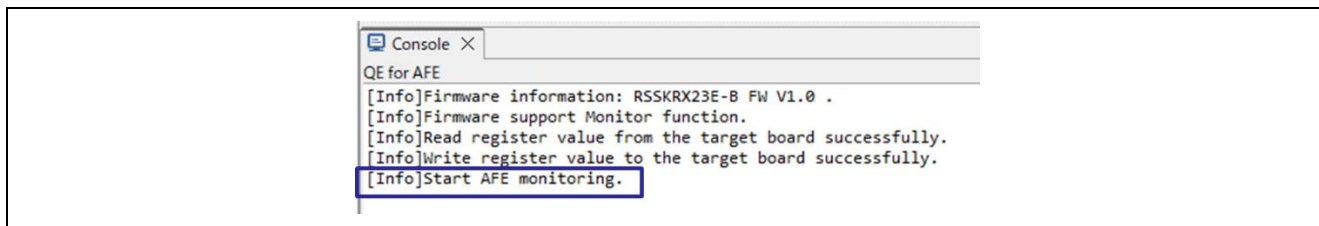


Figure 3-15 Evaluation Procedure: Successful Start of Monitoring

3.1.10 Displaying a Graph

In the initial state, a waveform is displayed on the left side of the window and a histogram is displayed on the right side. If the waveform is not displayed, click on the icon indicated below to display the waveform.

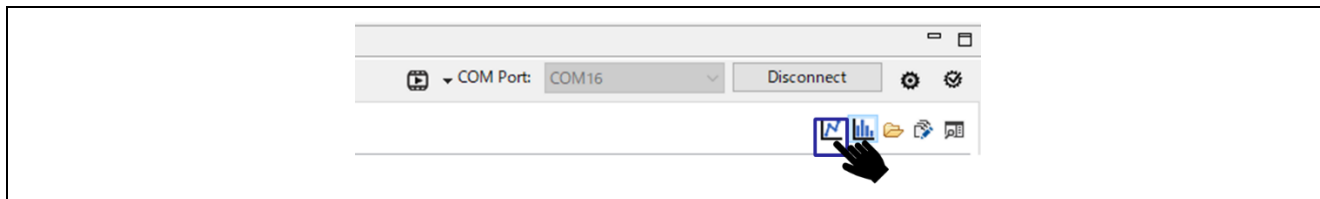


Figure 3-16 Evaluation Procedure: Icon for Displaying the Waveform

If the histogram is not displayed, click on the icon indicated below to display the histogram.

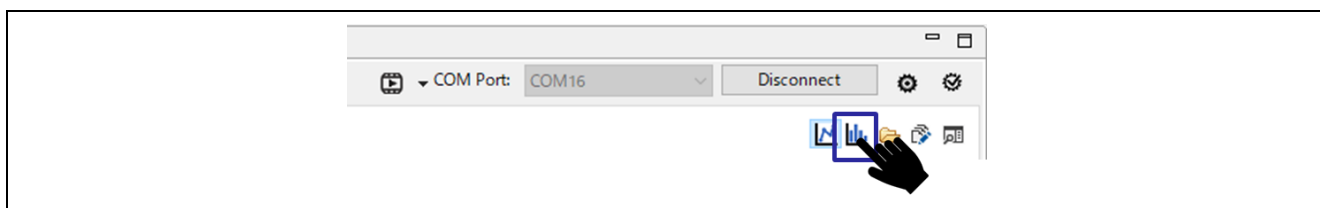


Figure 3-17 Evaluation Procedure: Icon for Displaying the Histogram

The values of the A/D conversion result registers are displayed graphically. Both the X-axis and Y-axis ranges of the graph can be adjusted for easier viewing.

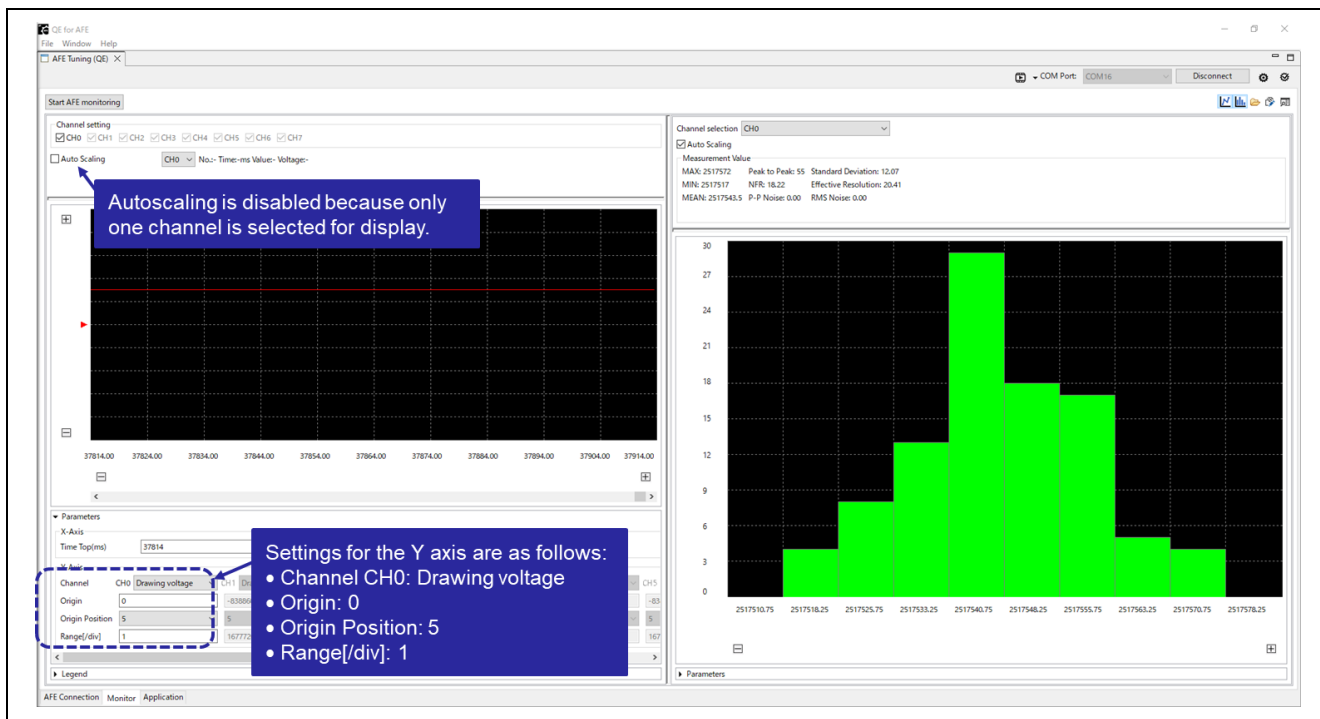


Figure 3-18 Evaluation Procedure: Graph Settings

3.2 Example of Evaluating DSAD0

This section shows an example of acquiring the result of A/D conversion of the input signals from the AIN0 and AIN1 pins by DSAD0, as shown in Figure 3-19. For details on the procedure of evaluation, refer to “3.1 Evaluation Procedure”.

- Register setting file: `qe_afe_sample_dsad0.3eb`

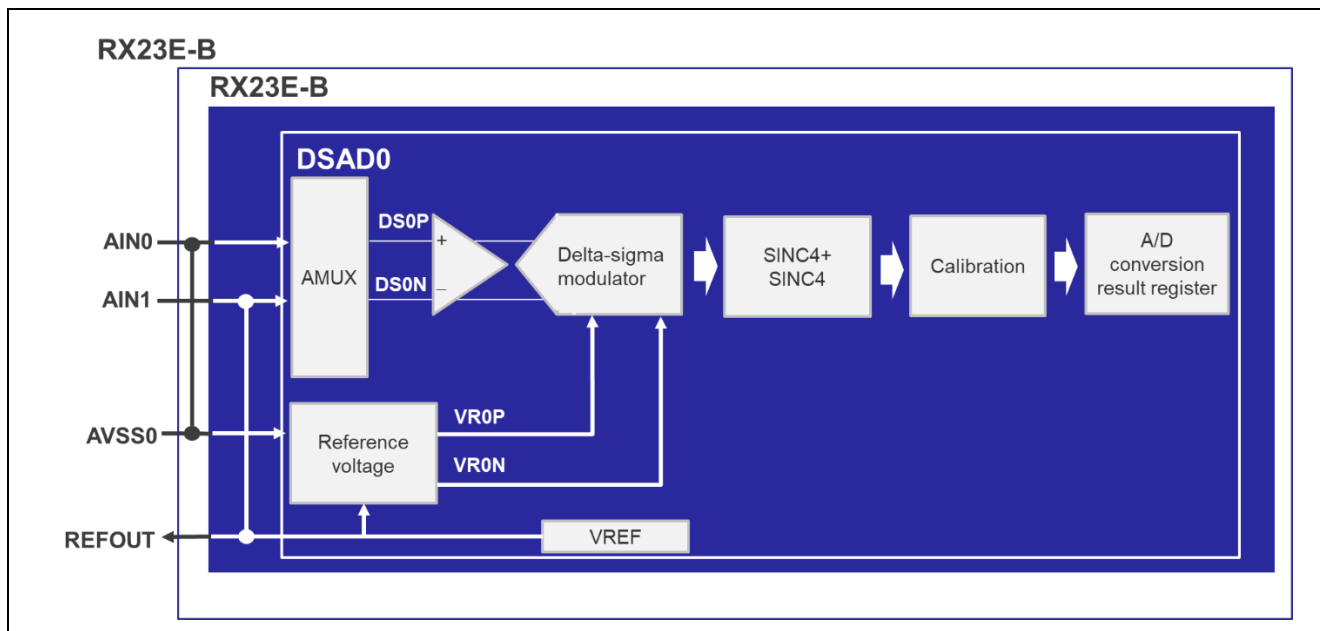


Figure 3-19 Example of Evaluating DSAD0: Connection

Once the register setting file is imported, the settings will become as shown in Figure 3-20 and Figure 3-21.

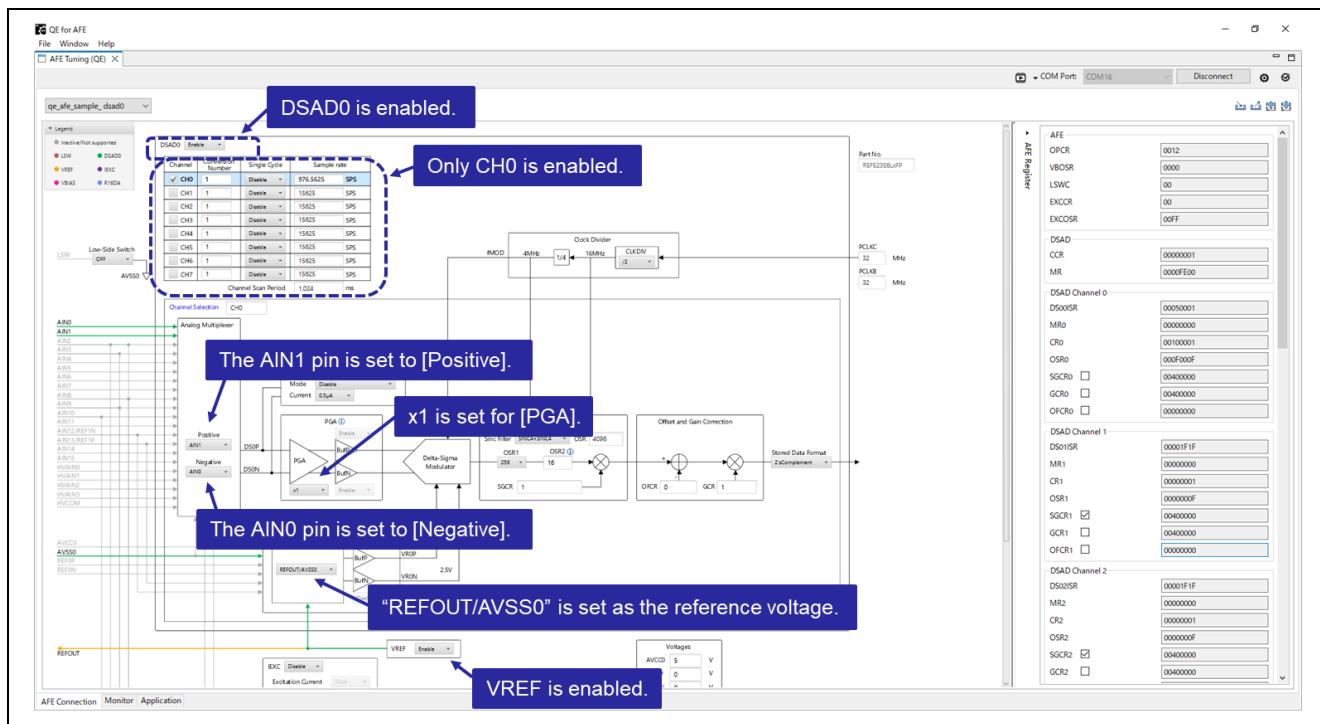


Figure 3-20 Example of Evaluating DSAD0: Setting DSAD0



3.2.1 Calibration

After the QE for AFE is connected to the target board, clicking on the icon indicated below allows making the settings for calibration of the analog characteristics.

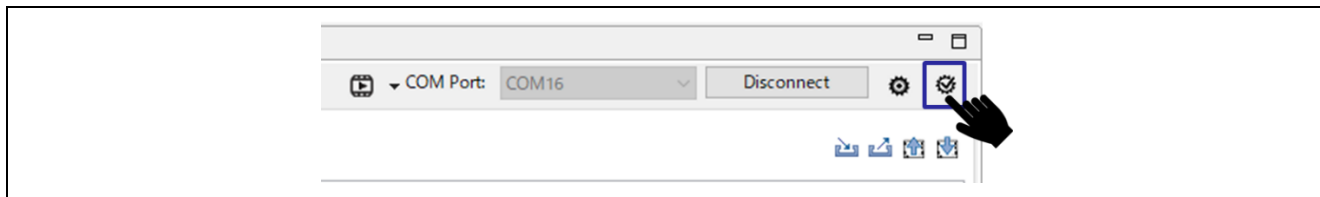


Figure 3-22 Calibration Icon

Calibration can be performed for each channel. After selecting the channel for calibration, enter the voltage being input to the pin and click on the [Next] button to display the result of calibration.

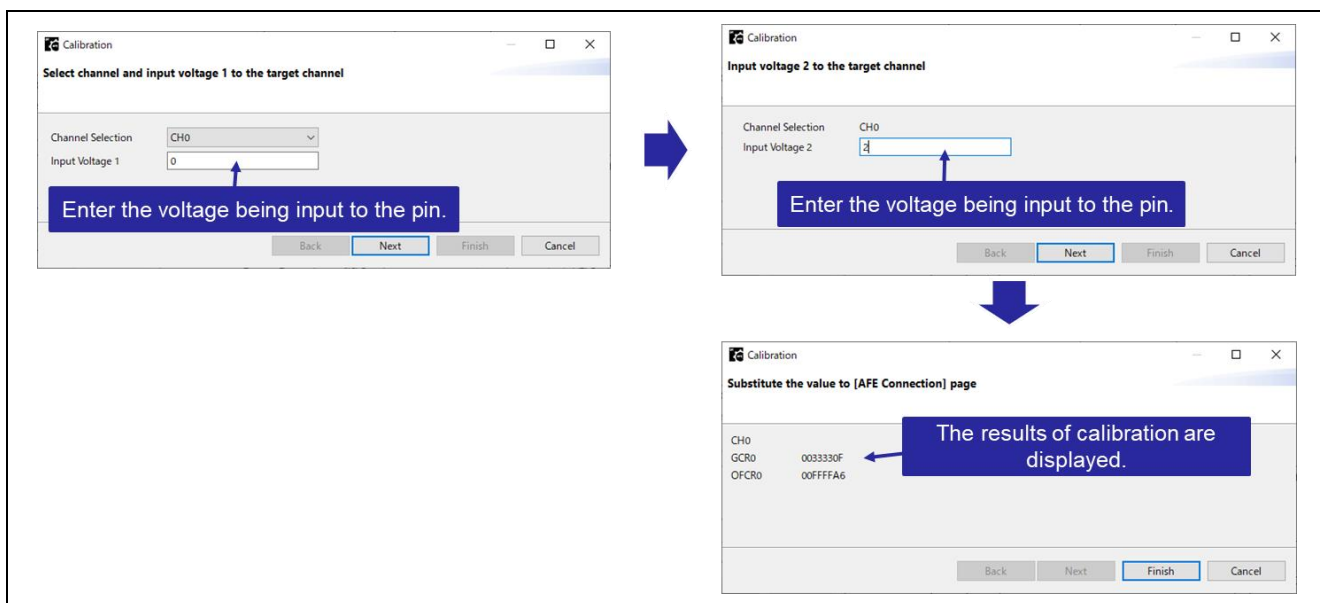


Figure 3-23 Displaying the Results of Calibration

Click on the [Finish] button to reflect the results of calibration in the register values for the filter and on the [AFE Connection] tabbed page.

To reflect the results of calibration in the RX23E-B registers, tick the checkboxes for the registers to be calibrated on the [AFE Connection] tabbed page, and be sure to write them to the RX23E-B on the target board.

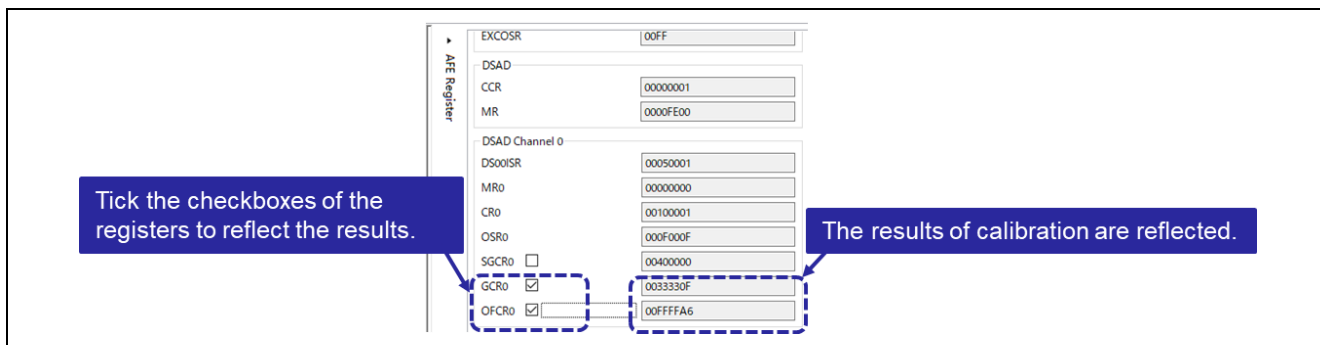


Figure 3-24 Reflecting the Results of Calibration in Register Values on the [AFE Connection] Tabbed Page

The results of A/D conversion when the analog signals are input from the AIN0 and AIN1 pins are displayed as a graph as shown below in Figure 3-25, which only shows the waveform.

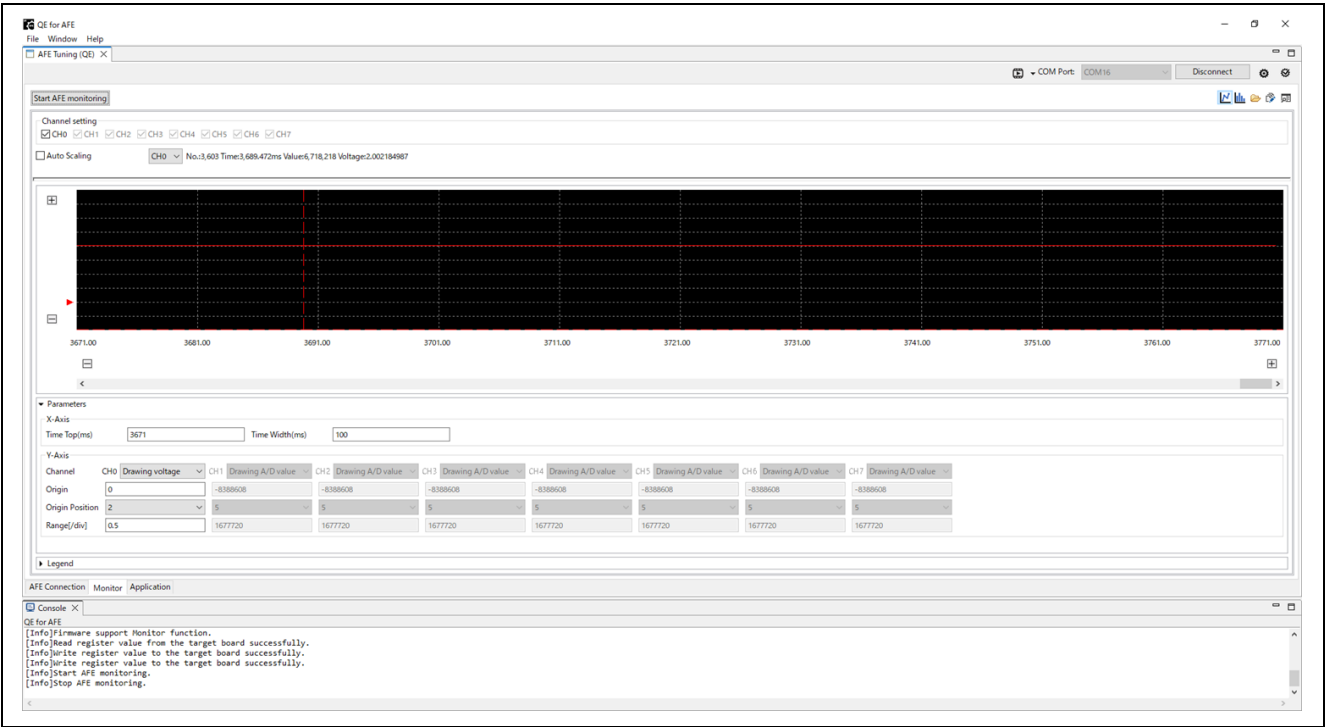


Figure 3-25 Example of Evaluating DSAD0: Displaying a Graph

4. Explanation of Functions

The QE for AFE has three main functions. Each of the functions can be selected by using the tabs at the bottom of the QE for AFE.

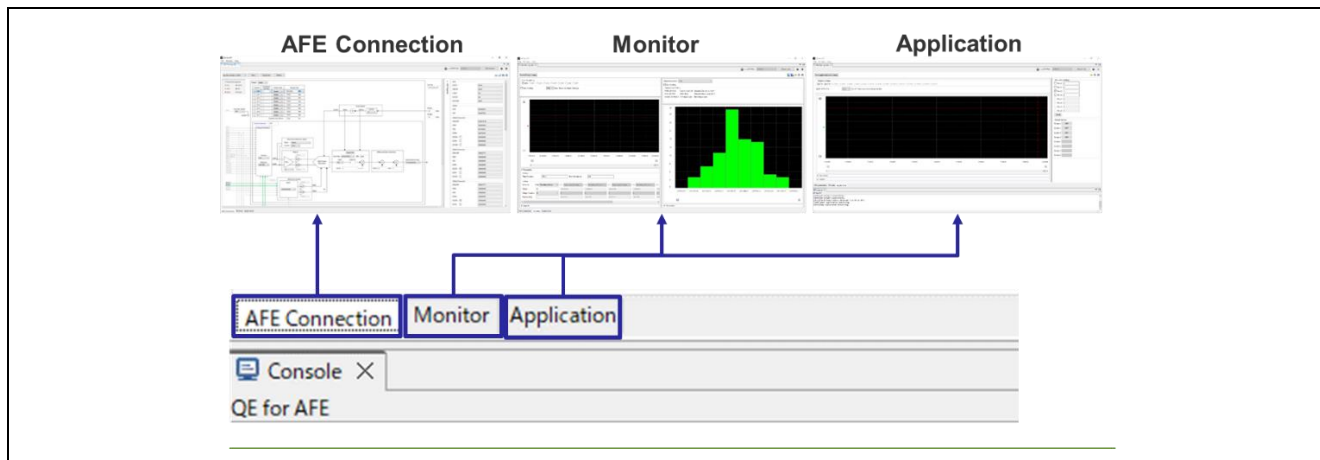


Figure 4-1 Functions of the QE for AFE

Table 4-1 Function Tabs of the QE for AFE

Tab Name	Description
AFE Connection	Displays a block diagram of the analog functions, and setting for each of the analog functions can be made on the block diagram. The register values based on these settings are reflected in the registers of the RX23E-B.
Monitor	Obtains the A/D-converted values from the RX23E-B, and displays a waveform and histogram of them.
Application	Obtains the application monitoring data from the RX23E-B, and displays a waveform. An interface for setting values or triggers in the user program is also provided.

4.1 UART Connection

The default bit rate is 4,000,000 bps. The rate can be changed by clicking on the icon indicated below.

The board control program for the RSSKRX23E-B included as part of the RX23E-B Group RSSKRX23E-B Board Control Program Application Note (R01AN6364) communicates at a bit rate of 4,000,000 bps.

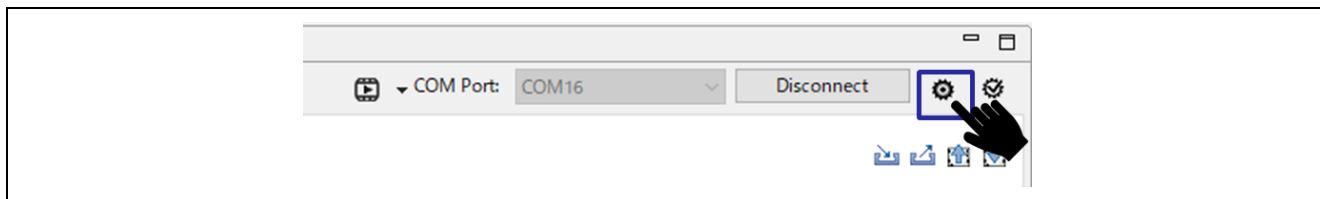


Figure 4-2 Setting the UART Bit Rate

The bit rate can be selected from the pull-down menu or entered directly.

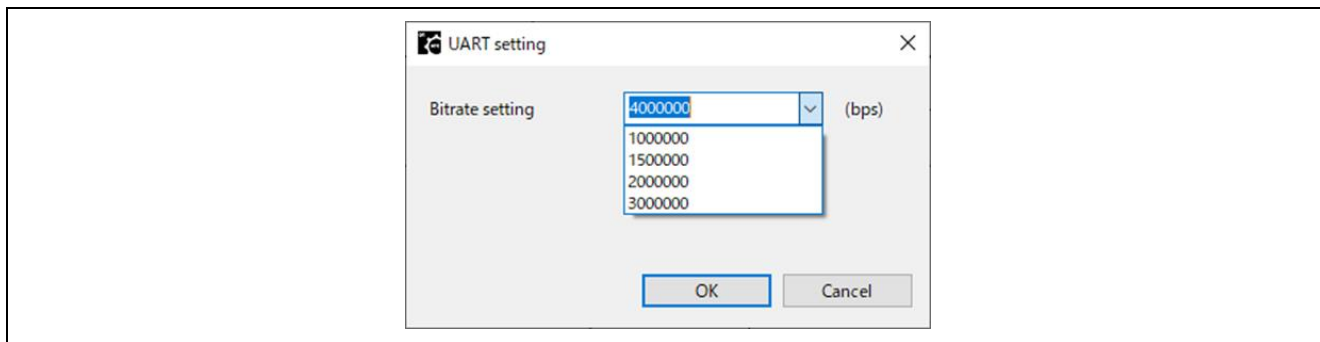


Figure 4-3 Selecting the UART Bit Rate

The bit rate values that can be entered directly are between 9,600 and 4,000,000 bps.

4.2 “AFE Connection” Function

By selecting the [AFE Connection] tab, the settings for the analog functions can be made on a block diagram.

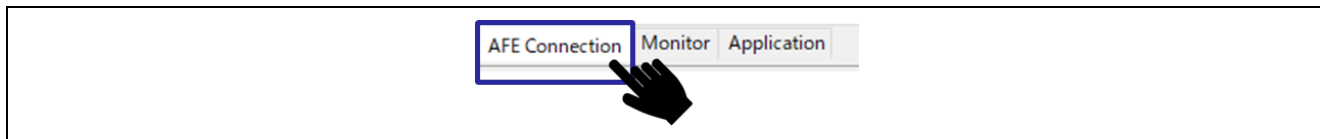


Figure 4-4 Selecting the [AFE Connection] Tab

The register values based on these settings can be reflected in the RX23E-B registers.

All of the settings can be exported to or imported from a register setting file, and the imported settings can be reflected in the QE for AFE.

For details on each function and register value, refer to the “RX23E-B Group User’s Manual: Hardware”.

4.2.1 Common Functions

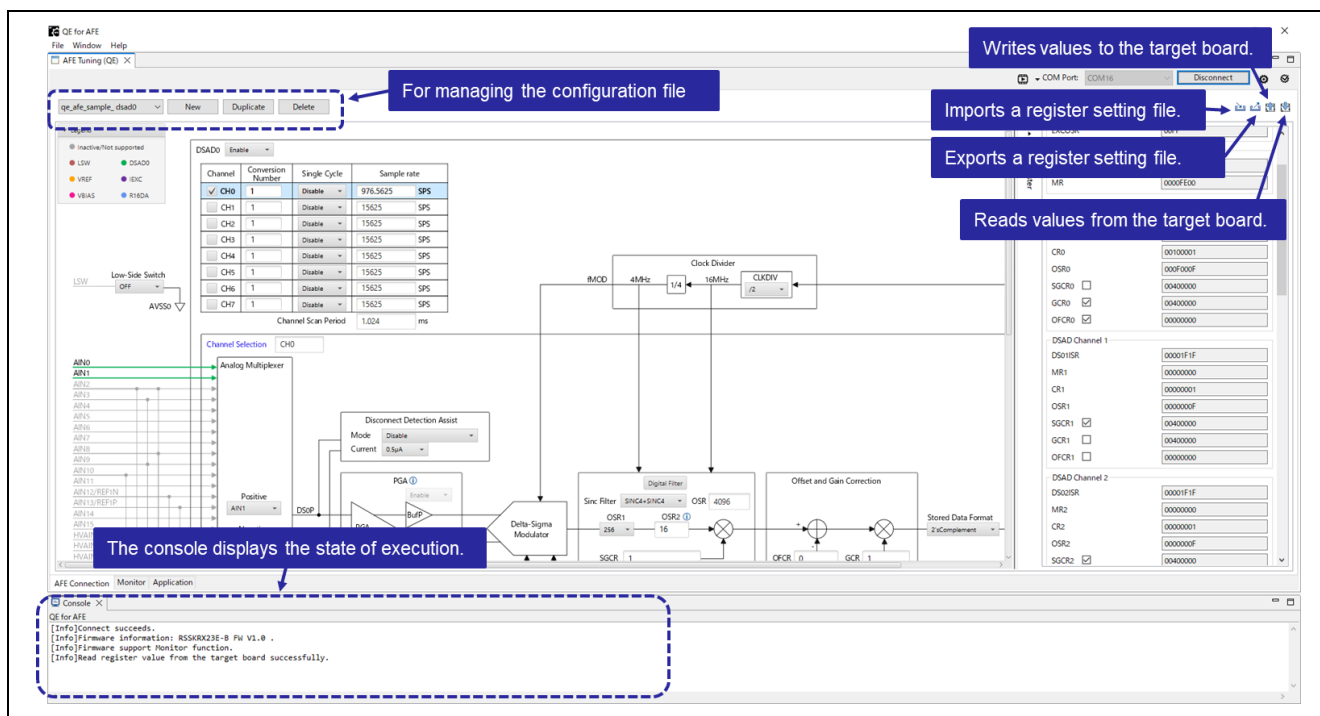




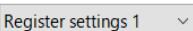
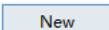
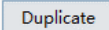
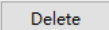


Figure 4-5 [AFE Connection]: Common Functions

Table 4-2 [AFE Connection]: List of Common Functions

Icon	Description	Settable State		
		Before Connection	After Connection ^{Note}	
			Stopped	Running
	Imports a register setting file and reflects its contents in the QE for AFE. The filename extension is “.3eb”, and the file can be saved at any desired location.	√	√	√
	Exports the current register values of the QE for AFE to a register setting file. The filename extension is “.3eb”, and the file can be saved at any desired location.	√	√	√
	Reflects the register values of the QE for AFE in the RX23E-B.		√	
	Reflects the register values of the RX23E-B in the QE for AFE.		√	
	Displays the name of the currently selected configuration file. The configuration file can be changed to another configuration file by selecting the name of the latter from the pull-down menu. If the configuration file is changed, the configuration file in its state before the change will be automatically saved. The configuration file is saved in the “afeConfig” folder under the folder where the QE for AFE was unzipped. The filename extension is “.cn”.	√	√	
	The register settings of the QE for AFE will be reset to the initial values for the RX23E-B, and another configuration file with a different name will be created. The register settings before resetting to the initial values will be automatically saved in the corresponding configuration file.	√	√	
	The configuration file will be duplicated in a file with a different name.	√	√	
	The selected configuration file will be deleted.	√	√	

Note: After the QE for AFE and target board have been connected, the condition when AFE monitoring is stopped differs in some cases from the condition when AFE monitoring is running.

4.2.2 Filter

Selecting the following button allows configuration of filter settings for the AFE connection.

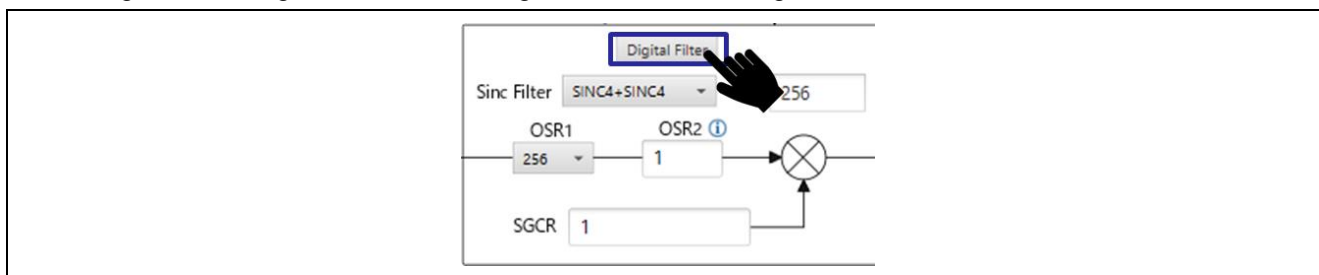


Figure 4-6 Selecting the Filter Button

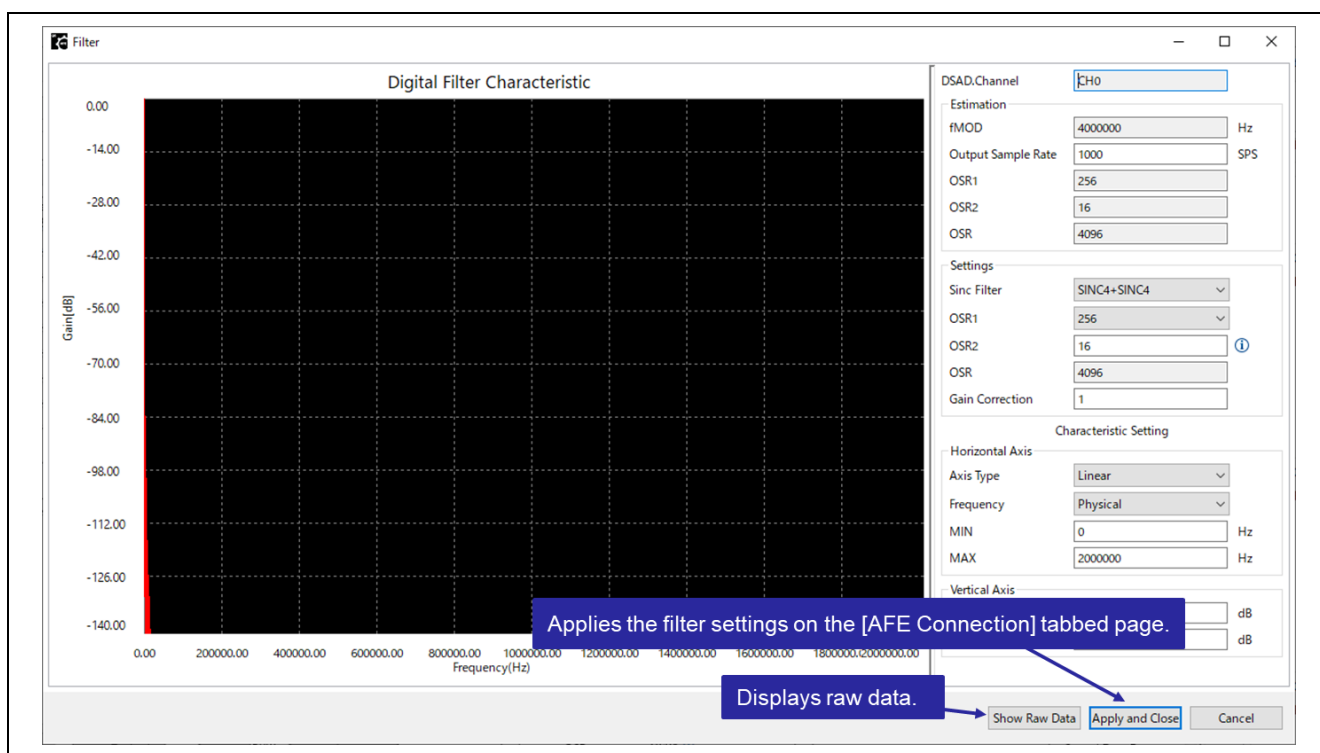


Figure 4-7 Display Window for the Filter

4.2.2.1 Frequency Characteristics of the Digital Filter

Setting the registers related to the digital filter and displaying the frequency-gain characteristic graph based on the settings are possible.

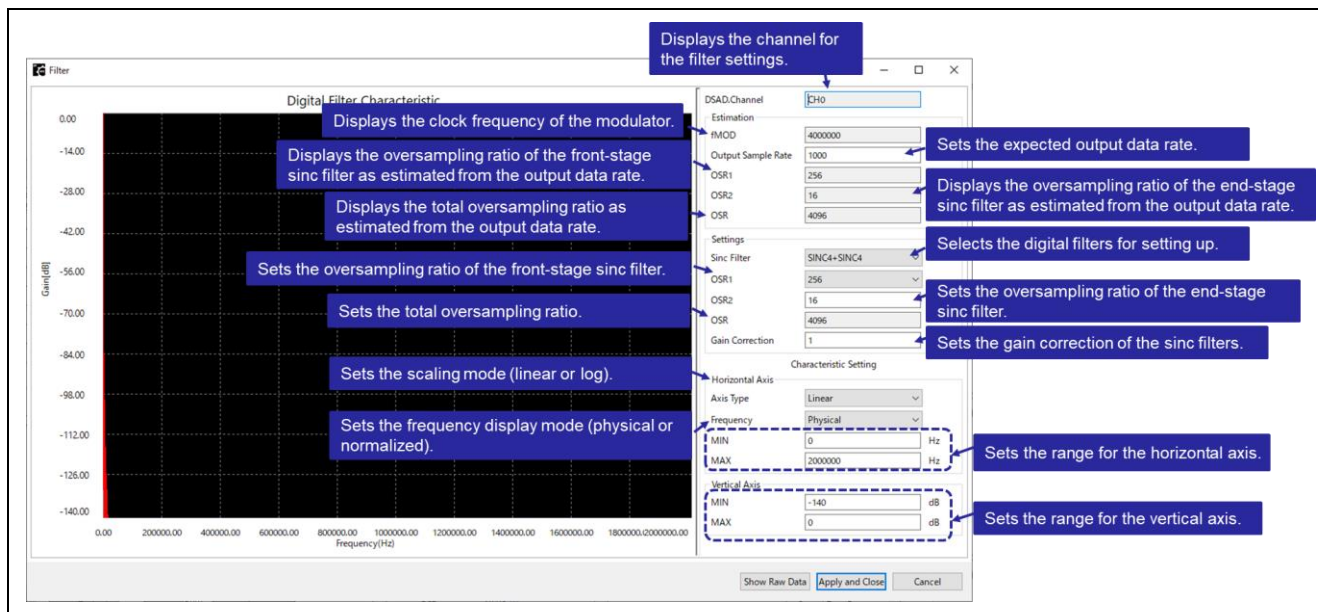


Figure 4-8 Frequency Characteristics of the Digital Filter

4.3 “Monitor” Function

By selecting the [Monitor] tab, the values from A/D conversion can be obtained and displayed as a waveform and histogram.

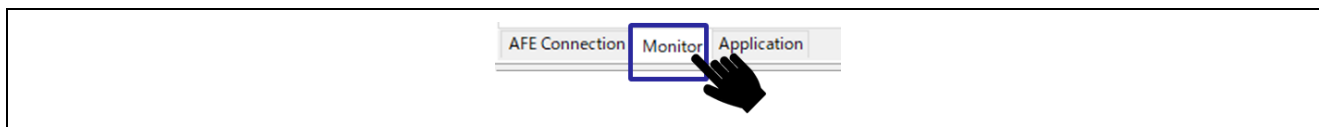


Figure 4-9 Selecting the [Monitor] Tab

4.3.1 Common Functions

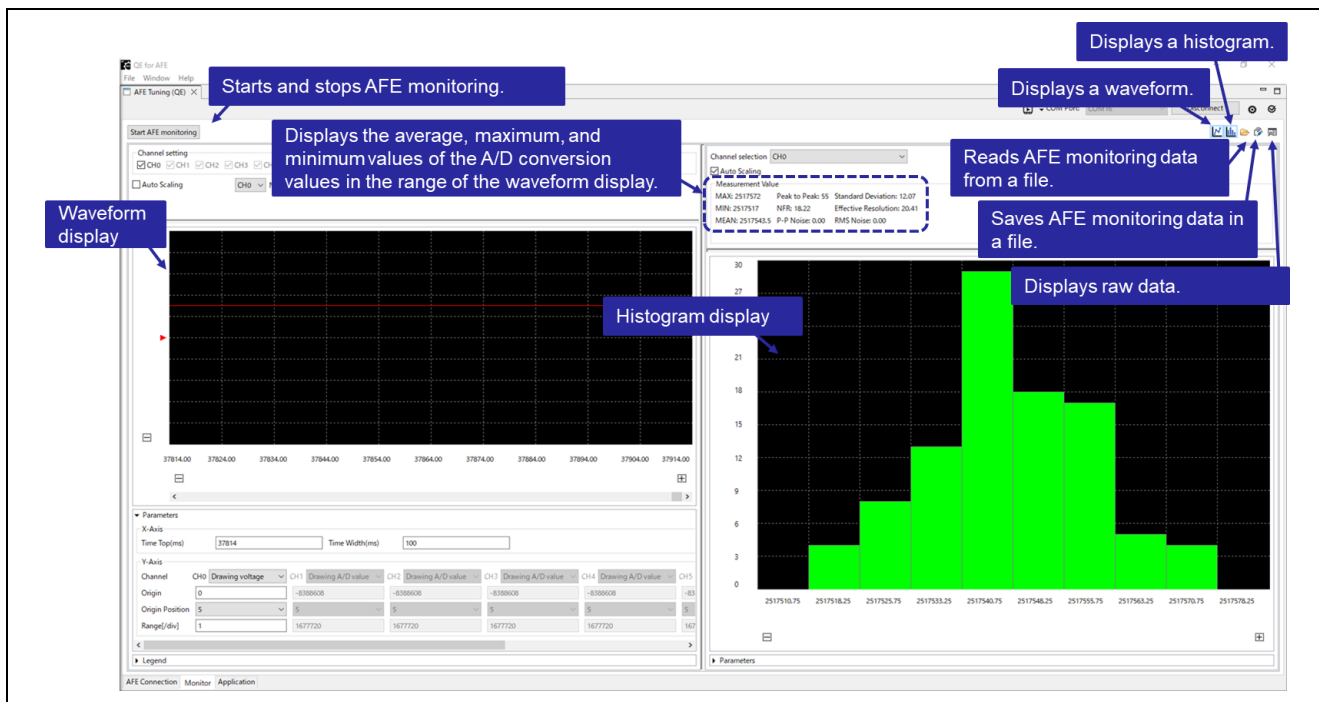







Figure 4-10 [Monitor]: Common Functions

Table 4-3 [Monitor]: List of Common Functions

Icon	Description	Settable State		
		Before Connection	After Connection	
			Stopped	Running
Start AFE monitoring	Starts AFE monitoring.		√	
Stop AFE monitoring	Stops AFE monitoring.			√
	Obtains the result of AFE monitoring from the RX23E-B and displays a waveform. To stop the waveform display, click on this icon again. For the waveform display, refer to “4.3.2 Displaying a Waveform”.	√	√	√
	Obtains the result of AFE monitoring from the RX23E-B and displays a histogram with the values from A/D conversion as the population. To stop the histogram display, click on this icon again. For the histogram display, refer to “4.3.3 Displaying a Histogram”.	√	√	√
	Reads the saved AFE monitoring data from a file. This operation discards the saved AFE monitoring data. The filename extension is “.dat”, and the file can be saved at any desired location.	√	√	
	Saves the retained AFE monitoring data in a file. The filename extension is “.dat”, and the file can be saved at any desired location.	√	√	
	Displays the raw data as a list. The channel to be displayed in the list can be switched. To stop the list display, click on “x” at the top right of the window. For the list display, refer to “4.3.4 Displaying the Raw Data”.	√	√	

4.3.2 Displaying a Waveform

By clicking on the icon indicated below, the values from A/D conversion can be displayed as a waveform.

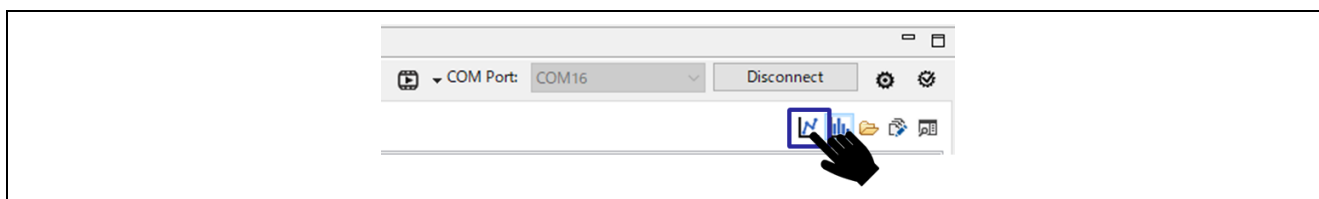


Figure 4-11 [Monitor]: Icon for Displaying a Waveform

The X-axis shows the time and the Y-axis shows the values from A/D conversion. The display ranges of both axes can be set with parameters.

The values from A/D conversion and voltage values can be displayed as raw data. For the display of raw data, refer to “4.3.4 Displaying the Raw Data”.

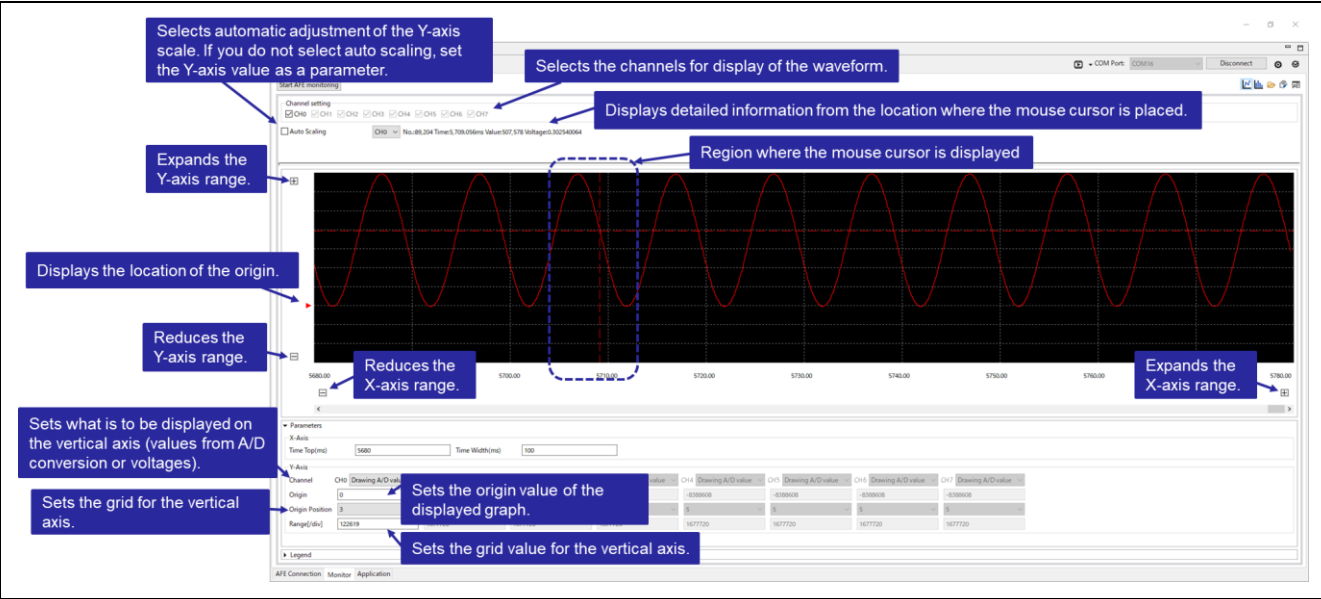


Figure 4-12 [Monitor]: Displaying the Waveform

4.3.3 Displaying a Histogram

By clicking on the icon indicated below, a histogram with the values from A/D conversion on the selected channel as the population can be displayed.

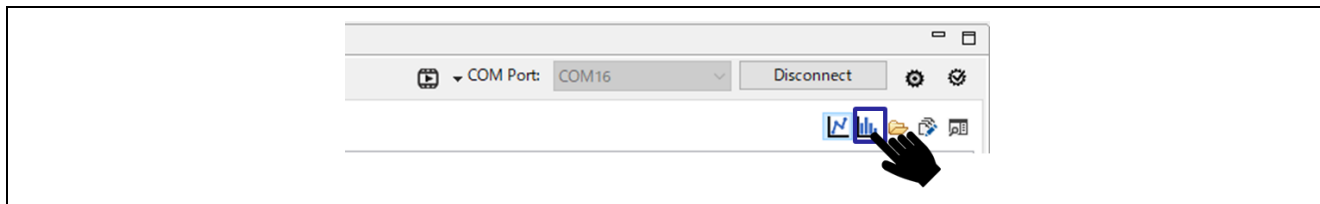


Figure 4-13 [Monitor]: Icon for Displaying a Histogram

The X-axis shows the values from A/D conversion and the Y-axis shows their frequencies. The display range of the X-axis can be set by parameters. The Y-axis is displayed in the range from 0 to the value with the maximum frequency.

The values for each ranking can be shown as raw data. For the display of raw data, refer to “4.3.4 Displaying the Raw Data”.

By clicking on the icons for both waveform display and histogram display, the waveform and histogram can be simultaneously displayed in two regions of the window. For an image of such a display, see Figure 4-10.

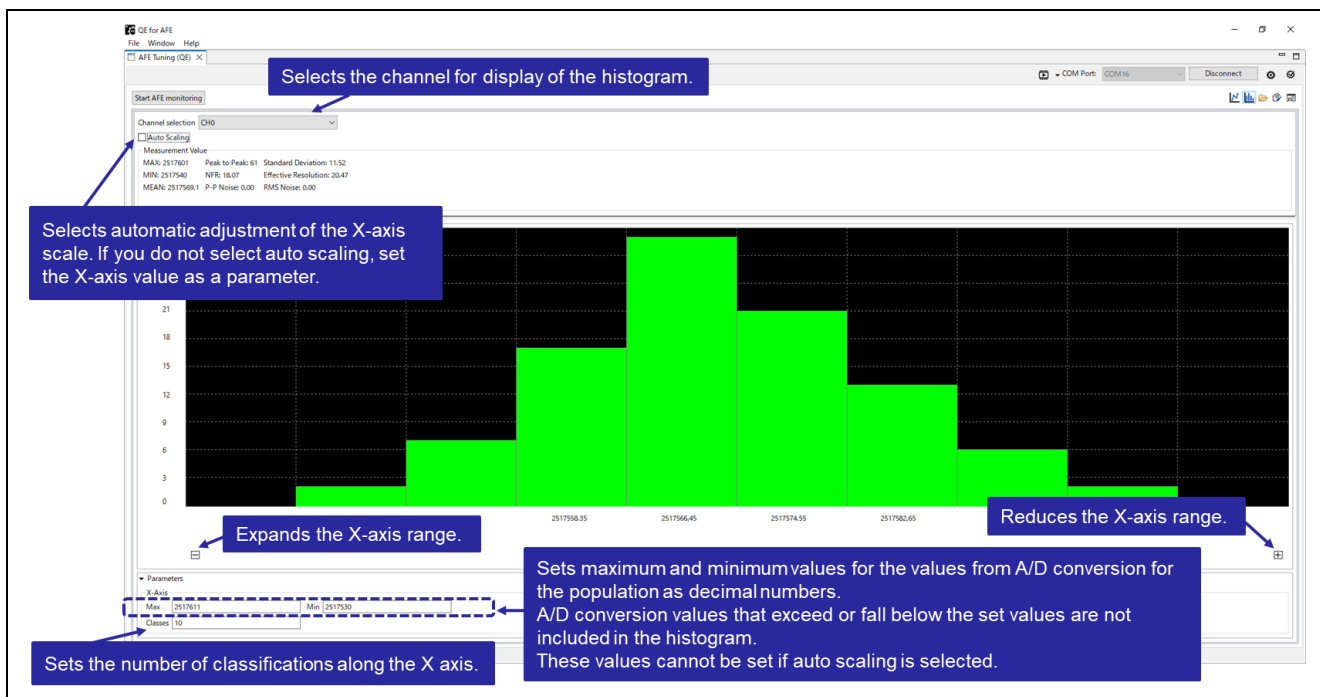


Figure 4-14 [Monitor]: Displaying the Histogram

4.3.4 Displaying the Raw Data

By clicking on the icon indicated below, the raw data can be displayed.

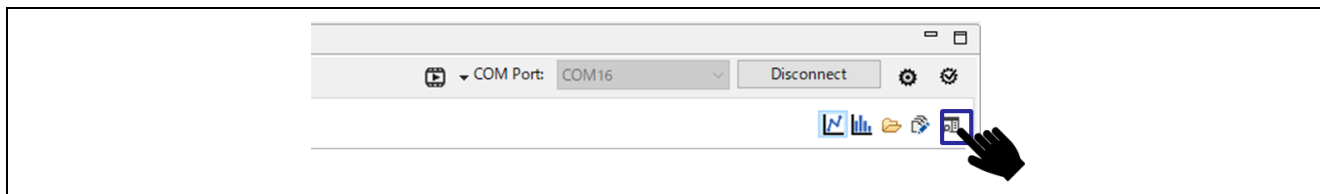


Figure 4-15 [Monitor]: Icon for Displaying the Raw Data

The raw data from a range can be selected and copied in the CSV format. Copying can be performed by pressing the [Ctrl] + [C] keys.

The raw data can also be exported to a .csv file by clicking on the [Export] button.

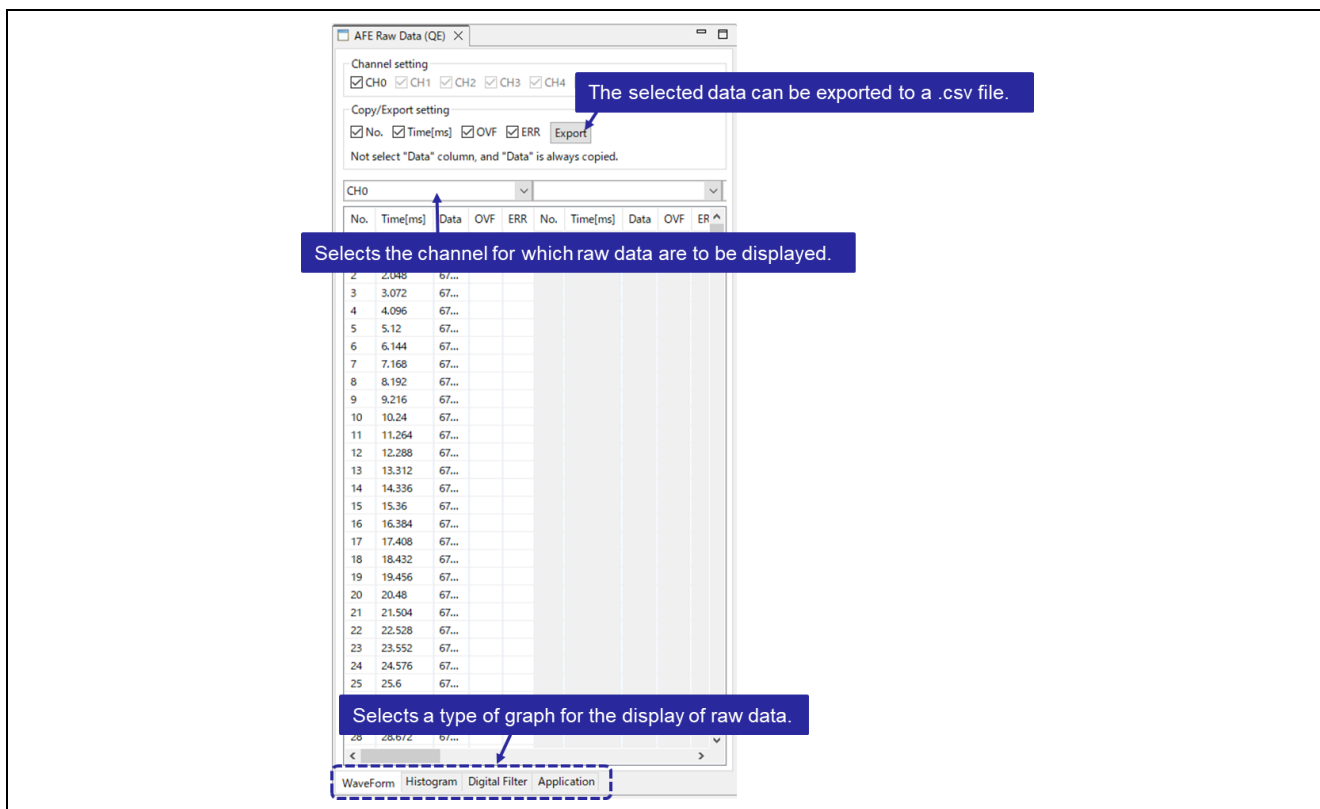


Figure 4-16 [Monitor]: Displaying the Raw Data

4.4 “Application” Function

By selecting the [Application] tab, the application monitoring data can be obtained and displayed as a waveform. This tabbed page can be used for making the settings for running the sample programs for application examples and obtaining the results of measurement. The communications module of the QE for AFE is included with the RX23E-B Group RSSKRX23E-B Board Control Program Application Note (R01AN6364).

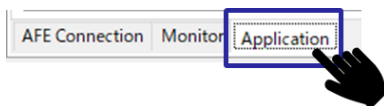


Figure 4-17 Selecting the [Application] Tab

4.4.1 Common Functions

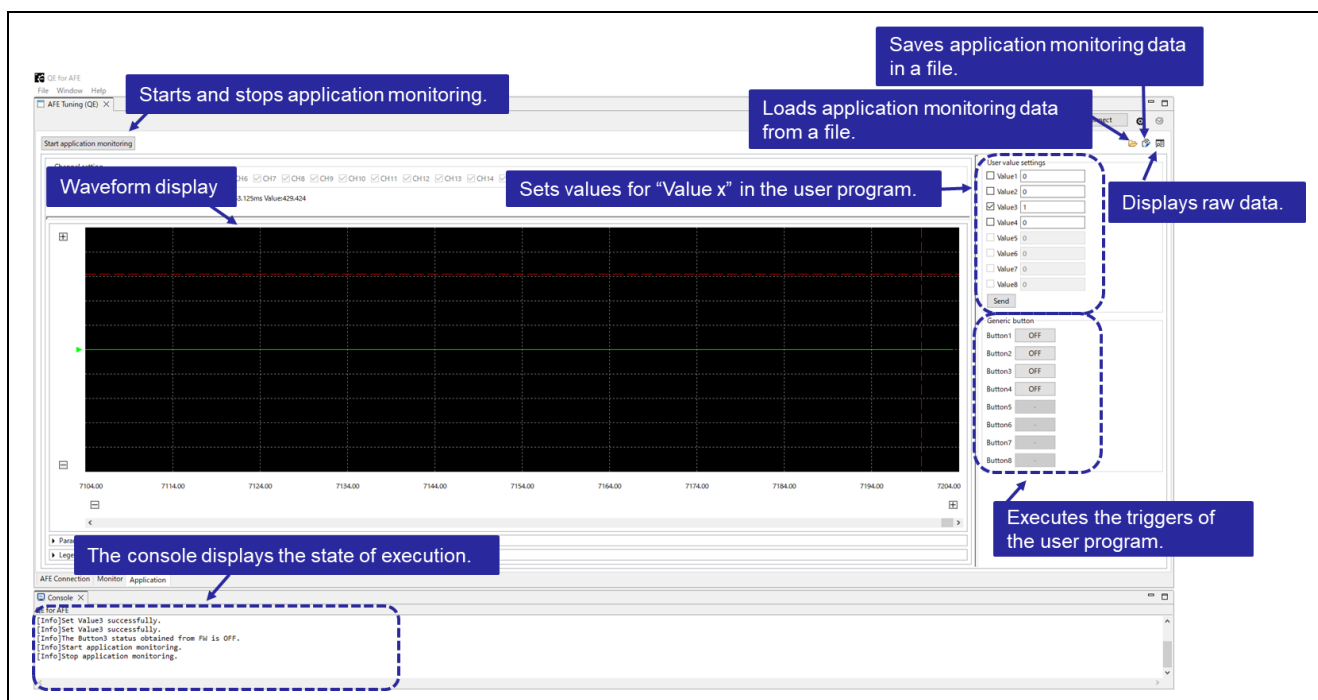
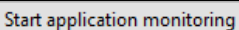
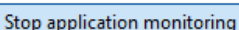





Figure 4-18 [Application]: Common Functions

Table 4-4 [Application]: List of Common Functions

Icon	Description	Settable State		
		Before Connection	After Connection Stopped	Running
	Starts application monitoring.		√	
	Stops application monitoring.			√
	Reads the saved application monitoring result from a file. This operation discards the saved application monitoring result. The filename extension is “.dat”, and the saved file can be at any desired location.	√	√	
	Saves the retained application monitoring result in a file. The filename extension is “.dat”, and the file can be saved at any desired location.	√	√	
	Displays the raw data as a list. The channel to be displayed in the list can be switched. To stop the list display, click on “x” at the top right of the window. For the list display, refer to “4.3.4 Displaying the Raw Data”.	√	√	

4.4.2 Displaying a Waveform

The X-axis shows the time and the Y-axis shows the values from A/D conversion. The display ranges of both axes can be set with parameters.

The application monitoring data can be obtained from the target board and displayed as a waveform. An interface for setting values or triggers in the user program is also provided. For the display of raw data, refer to “4.3.4 Displaying the Raw Data”.

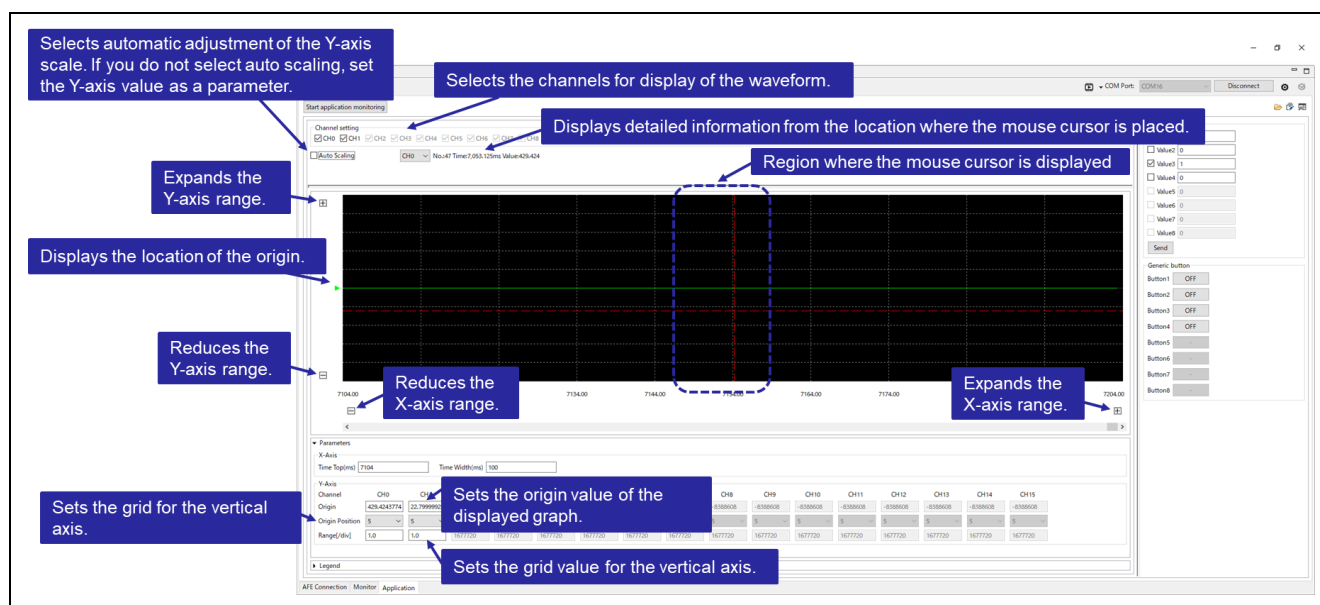


Figure 4-19 [Application]: Displaying the Waveform

4.4.3 Application Examples

The “Application” function is also used in the programs for the following application notes.

- R01AN7153EJ0101: RX23E-B Group Example of weight measurement using AC excited load cell
- R01AN6518: RX23E-B Group Example of 4-20mA transmitter using built-in D/A converter
- R01AN6512: RX23E-B Group Design and weight measurement of tiny board for digital load cell
- R01AN6513: RX23E-B Group Design and measurement of small board for 6-axis force sensor

Revision History

Rev.	Date	Description	
		Page	Summary
1.01	Feb.16.24	—	First Edition issued

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

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.

3. Input of signal during power-off state

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.

4. Handling of unused pins

Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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