RSSKRX23E-A

PC Tool Program Operation Manual

Introduction

This document is an operation manual of the PC tool program (called the PC tool below) that is connected to the Renesas Solution Starter kit for RX23E-A (called RSSKRX23E-A below) board for operation. For details on the MCU, refer to " RX23E-A Group User's Manual: Hardware ".

The PC tool is used in combination with the included firmware for RX23E-A.

Target Device

RSSKRX23E-A board

Contents

1. Overview

1.1 System Overview

This PC tool performs serial communication with the RSSKRX23E-A board (called the EVB below) by USB connection to set the registers of the AFE and DSADs of RX23E-A on the board, control operation of the AFE and DSADs, and obtain and display A/D conversion values for up to twelve channels. In addition, the PC tool obtains and displays measurement values of the sample programs in the measurement example application notes.

The main functions are listed below.

(1) Performs the following operations with serial communication through the EVB by USB connection.

・ Checks the connection with the EVB.

・ Obtains and sets RX23E-A register values.

・ Requests the EVB to start and stop A/D conversion.

・ Obtains A/D conversion values. (A/D conversion performs the continuous scan mode)

(2) Analyzes and displays the obtained A/D conversion values as follows.

・ Displays a waveform of the A/D conversion values.

・ Analyzes and displays a histogram of the A/D conversion values.

・ Displays various measurement results.

(3) Obtains and sets AFE and DSAD register setting values.

・ Selects and specifies register parameters in a block diagram.

・ Displays the register setting values for parameters.
   Displays a SINC4 filter frequency-gain characteristic graph based on register setting values.
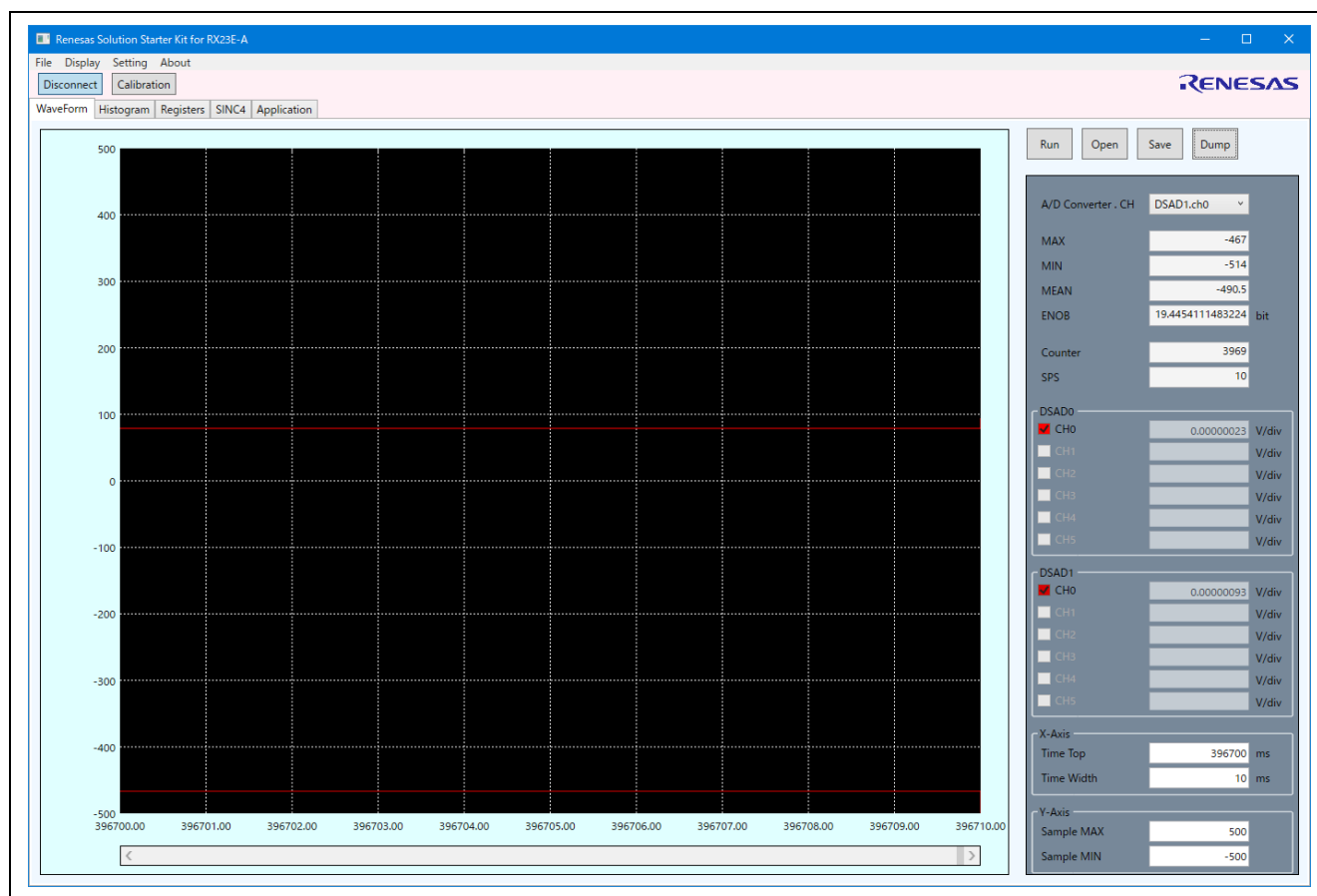

Figure 1-1 PC Tool Program

1.2   Operating Environment

- OS: Microsoft Windows 10 (32/64 bits)
- .NET Framework 4.7.2

1.3   Conditions for Operation Confirmation

The operation of this PC tool has been confirmed under the following conditions.

Table 1-1 Conditions for Operation Confirmation

Item		Details
Evaluation board		RSSKRX23E-A board RTK0ESXB10C00001BJ
PC	CPU	Intel Core i5-6300U @ 2.40 GHz
	Memory	8.00 GB
	OS	Microsoft Windows 10 64-bit 1083
		.NET Framework 4.7.2

1.4   File Configuration

The file configuration of this PC tool is as follows.

Table 1-2 File Configuration

File name	Explanation
RSSK23EA.exe	PC tool executable file
rx23ea_rssk_fw.mot	Firmware for RX23E-A (Motorola-S format)
r20an0540ej0201-rsskrx23e-a.pdf	This document

Note: The PC tool is used in combination with the included firmware for RX23E-A.

1.5   Installation and Uninstallation

1.5.1   Installation and Execution

To operate the PC tool, the following items may be required.

- USB Serial Port driver
  On the EVB, FTDI USB serial conversion IC FT232 is mounted. If the system requests the driver on connecting the EVB with USB, download the driver file from the FTDI website (http://www.ftdichip.com/) and install it.
- Microsoft .NET Framework
  If the PC tool does not start, download .NET Framework version 4.7.2 or later from the Microsoft website and install it.

No special procedure is required for installing the PC tool. Execute the executable file stored on the PC.

1.5.2   Uninstallation

Delete the executable file and configuration file (RSSK23EA.ini).

1.6   Modification from the previous version.

Major modification from Version 1.0 is listed below.

(1)   WaveForm Tab :   WaveForm Tab : Function enhancement to support the channel function.

・   Simultaneous display of multiple channel waveform

・   Channel selection display in Dump Dialog

・   The update of A/D conversion value file format and the readout of the previous version file.

(2)   Histogram Tab: Specification change to support the channel function

・   Addition of selection function for histogram display.

・   Change of Bin value in Dump Dialog to median of each Bin.

(3)   Registers Tab

・   Support the channel function.

・   Addition of the readout function for the built-in temperature sensor coefficient.

(4)   Application Tab: Function enhancement to support up to 12chs.

・   Simultaneous display of waveform for up to 12chs.

・   Support time axis which is the horizontal axis of the graph (depending on information from FW)

・   Display of channel selection of Dump Dialog

・   The update of the measurement value file format and the readout of the previous version file.

(5)   Others

・   Modification to the calibration per channel to support the channel function.

・   Addition of the register to support the register setting file.

・   Enhancement of the communication specifications

1.7   Reference Documents

- R20UT4542 RSSKRX23E-A User's Manual
- R01UH0801 RX23E-A Group User's Manual: Hardware
- R01AN4747 Application Note RX23E-A Group Example of Temperature Measurement using Thermocouple
- R01AN4788 Application Note RX23E-A Group Example of Temperature Measurement using Resistance Temperature Detector
- R01AN4789 Application Note RX23E-A Group Example of Weight Measurement using Load Cell

2. Explanation of Functions

The screen of the PC tool consists of three areas. Figure 2-1 and Table 2-1 show the screen configuration.
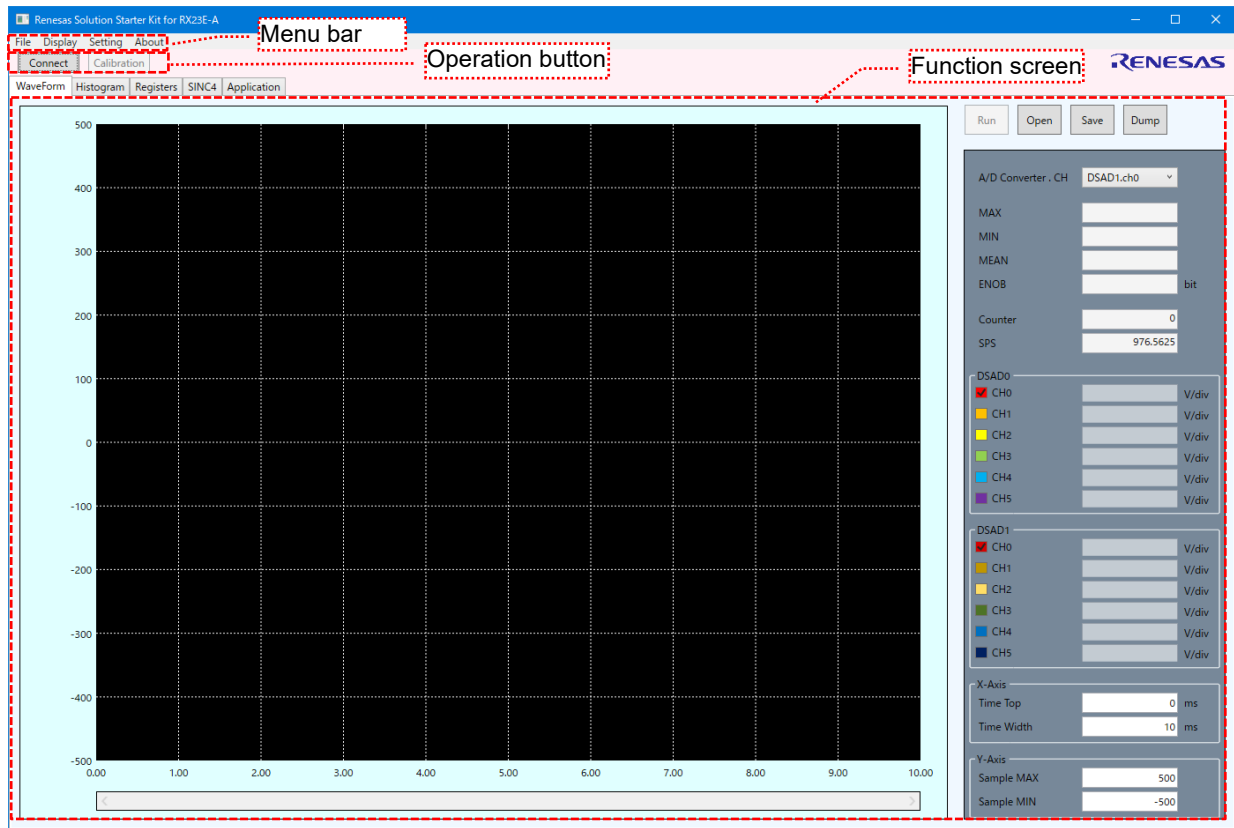
Figure 2-1 Screen Configuration

Table 2-1 Screen Items and Areas

Item/area name	Explanation
Menu bar	There are four menus: "File", "Display", "Setting", and "About".
Operation buttons	The "Connect/Disconnect" and "Calibration" buttons are provided, which are independent of the functions of each tab.
Function screen	Five function screens, "WaveForm", "Histogram", "Registers", "SINC4" and "Application", are available. To display a desired screen, click the corresponding tab.

2.1 Menu Bar

Select a menu item to manipulate a file, select a function, make settings, and display application information.

Table 2-2 explains menus and menu items.

Table 2-2 Items on the Menu Bar

Menu	Item	Explanation
File	Exit	Exits the application.
Display	WaveForm	Displays the WaveForm Tab.
	Histogram	Displays the Histogram Tab.
	Registers	Displays the Registers Tab.
	SINC4	Displays the SINC4 Tab.
	Application	Displays the Application Tab.
Setting	Connect/ Disconnect	Corresponds to the "Connect/Disconnect" button. Starts or ends serial communication according to the conditions set in the "Configure" menu.
	Calibration	Corresponds to the "Calibration" button. Performs calibration.
	Configure	Displays the dialog box for setting communication with the EVB (selecting a COM port and setting a baud rate).
About		Displays the version information in the dialog box.

2.2 Operation Buttons

Use the corresponding buttons to connect to the EVB and calibrate DSAD. Table 2-3 explains the buttons.

Table 2-3 Operation Buttons

Button	Explanation
Connect/ Disconnect	Connects or disconnects serial communication with the EVB according to the settings made in the "Configure" menu.
Calibration	Performs calibration of DSAD.

2.2.1 Connection

Follow the procedure below to establish a connection in order to operate the EVB from the PC Tool.

1. Connect the PC and EVB with a USB cable. Figure 2-2 shows a connection diagram. For details on the board setting, refer to "RSSKRX23E-A User's Manual: Board".
2. Execute RSSK23EA.exe.
3. Select "Setting" > "Configure" from the menu bar to display the "ConnectSetting" dialog box (Figure 2-3).
4. Set communication-related items in the "ConnectSetting" dialog box.
   "COM Port" combo box: Select a COM port used for communication.
   "BaudRate" input field: Enter 3000000.
5. Click the "OK" button to close the "ConnectSetting" dialog box.
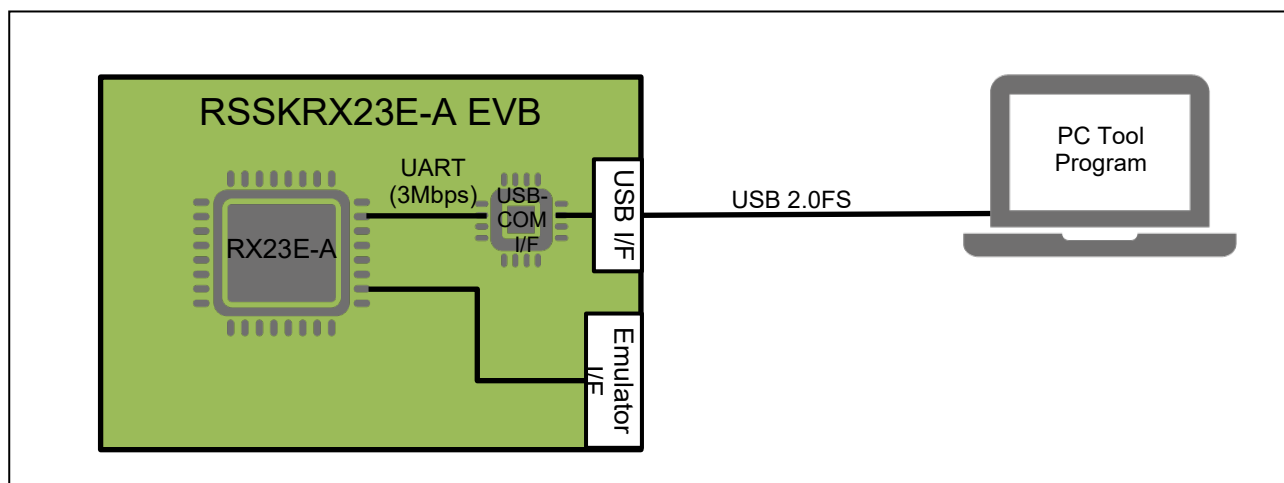6. Click the "Connect" operation button to establish the connection.
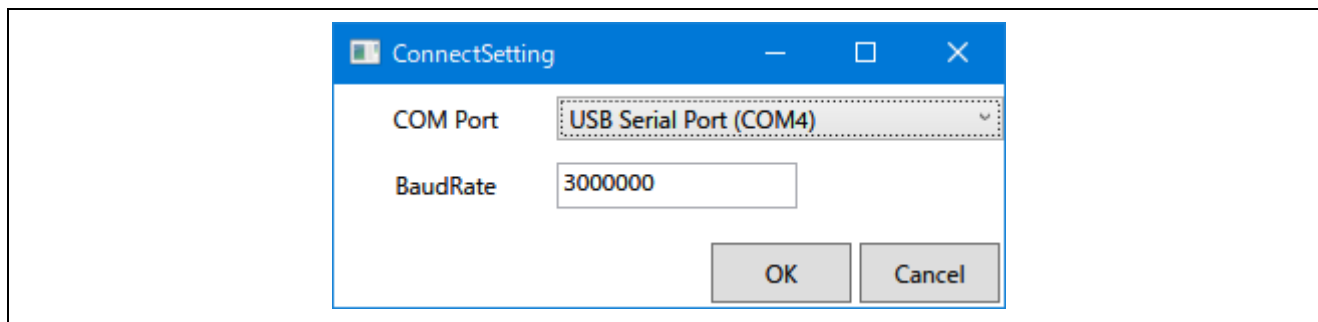

Figure 2-2 System Connection Diagram

Figure 2-3 ConnectSetting Dialog Box

2.2.2 Calibration

Use the "Calibration" button to calculate the values of the gain of the A/D conversion and offset correction registers based on the A/D conversion result of two types of input voltage. The gain correction of the calibration result contains the correction of digital filter gain depending on the SINC4 settings.

The Calibration performs for each channel of DSAD unit. Calibration can be performed interactively in the displayed dialog box as follows:

1. After establishing a connection with the EVB, specify the register setting on Registers and SINC4 Tabs according to the use conditions.

2. Click the "Calibration" operation button to start the calibration procedure.

3. In "Select channel, input and Fill in reference voltage 1", select a channel of DSAD unit for which to perform calibration, enter the reference voltage 1 which inputs to the pin, and click the "Next" button.

Calibration
Select channel, input and Fill in reference voltage 1
Channel — DSAD0.ch0
Reference Voltage 1 — 0
Cancel   Next

4. Following "A/D value acquisition", "input and Fill in reference voltage 2", enter the reference voltage 2 which inputs to the pin and click the "Next" button.

Calibration
input and Fill in reference voltage 2
Channel — DSAD0.ch0
Reference Voltage 2 — 2.5
Cancel   Next

5. Following "AD value acquisition / Calculation", the calibration result appears.
   Click the "OK" button to reflect the values in "Gain/Offset Correction" on the SINC4 Tab and "CGR and OFCR" on the Registers Tab.
   To apply the values to the device, check the checkboxes of GCR and OFCR, and click "Set" on the Registers Tab.
   Click the "Cancel" button to discard the calibration result and terminate calibration.

Calibration
Substitute the values to SINC4 TAB
Channel   DSAD0.ch0
GCR0   00405D29   4218153
OFCR0   FFFFFFFE   -2
Cancel   OK

   If an error occurs in the calibration procedure, "Calculation Error" appears.

Calibration
Calculation Error
OK

2.3 WaveForm Tab

WaveForm Tab obtains A/D conversion values from the EVB with serial communication and display a waveform graph. In addition, it is possible to save the obtained A/D conversion values in a file, and read saved A/D conversion values to display a graph.

A/D conversion values can be measured during up to 1 hour with the output data rate of 15625 SPS.

The WaveForm Tab consists of the following three areas as shown in Figure 2-4.

1. Graphical display area
2. Operation buttons
3. Setting area
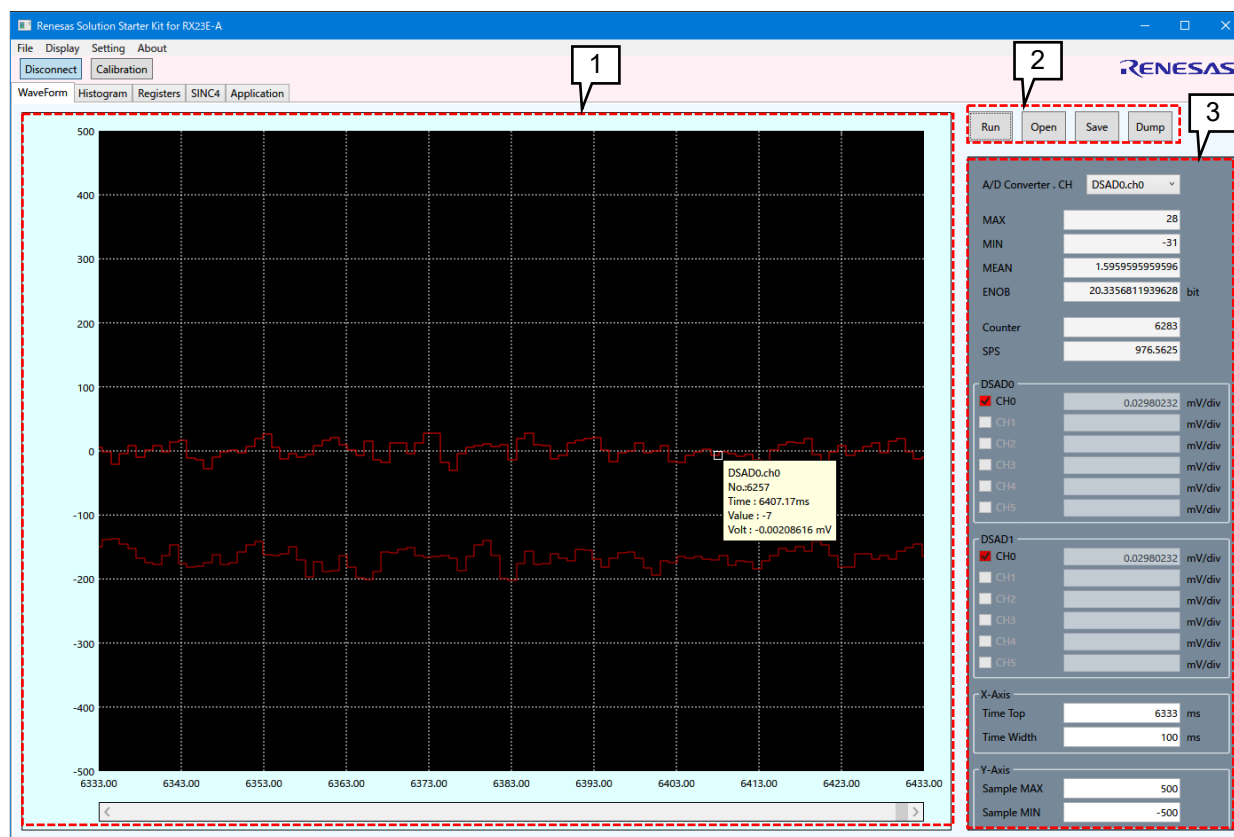
Figure 2-4 WaveForm Tab Screen

2.3.1 Graphical Display Area

In this area, A/D conversion values are displayed as a waveform. The horizontal axis indicates the time, the vertical axis indicates the conversion value. The value displayed on each axis depends on the settings in the "X-Axis" or "Y-Axis" group in the setting area.

The graph is updated to the latest values when the scroll bar is positioned at the right end while A/D conversion values are being obtained from the EVB.

Note: Display update may be suppressed to prioritize obtaining A/D conversion value. During suppression, the graph and measurement value are not updated. Suppression condition can be specified by "UpdateRestriction" parameter in the "WaveForm" section of the configuration file. Refer to "0 Configuration File" in detail.
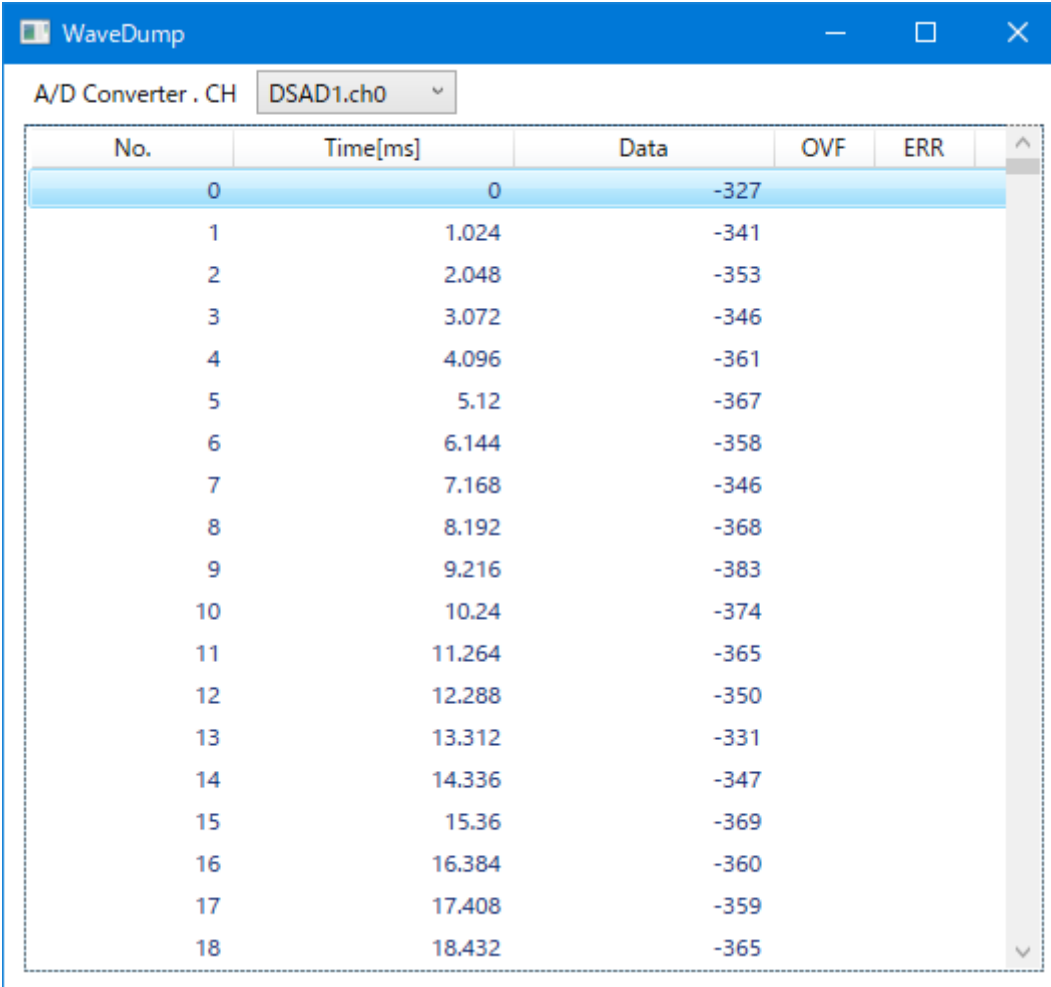
2.3.2 Operation Buttons

Use the operation buttons to start and stop A/D conversion, save and read A/D conversion values from a file, and display the conversion values in a list.

Table 2-4 explains the operation buttons.

Table 2-4 WaveForm Tab Operation Buttons

Button	Explanation
Run/Stop	Obtains or stops A/D conversion values when the connection with the EVB is established. When "Run" is displayed on the button, clicking the button will start A/D conversion and "Stop" button will be displayed. The obtained A/D conversion values are displayed in a graph. When "Stop" is displayed on the button, clicking the button will stop A/D conversion and the button"Run" will be displayed.
Open	Reads a saved A/D conversion value file. This button is disabled during A/D conversion. When a saved file is read, the A/D conversion values being held are discarded.
Save	Saves all A/D conversion values being held in a file. This button is disabled during A/D conversion.
Dump	Displays a list of A/D conversion values of the channel of DSAD unit in the "WaveDump" dialog box shown in Figure 2-5.The displayed channel of unit can be switched. The list can be copied in range selection as the CSV format by using CTRL+C. The dialog box cannot be opened during A/D conversion. When this dialog box is open, the tabs cannot be switched.

Figure 2-5 WaveDump Dialog Box

2.3.3 Setting Area

Use the setting area to set items related to the graphical display and display various measurement values of the A/D conversion values. Table 2-5 explains the items.

Table 2-5 WaveForm Tab Setting Area

Item		Explanation	
A/D Converter		Select the channel of DSAD unit for which to display A/D conversion values.	
MAX		Displays the maximum A/D conversion value of the selected channel of DSAD unit.	The display is stopped according to the condition during A/D conversion obtainment.
MIN		Displays the minimum A/D conversion value of the selected channel of DSAD unit.	
MEAN		Displays the average A/D conversion value of the selected channel of DSAD unit.	
ENOB		Displays the ENOB of the A/D conversion values of the selected channel of DSAD unit.	
Counter		Displays the number of all samples of A/D conversion values of the selected channel of DSAD unit	
SPS		Displays the data rate of the selected channel of DSAD unit.	
DSAD0 DSAD1	CHm (m=0 ~ 5)	Select the each DSAD channel which is displayed in the graph.	
	V/div	Displays the each DSAD channel voltage on the vertical axis with V/div. The voltage is calculated from each voltage which is set at "Voltages" on the Registers Tab.	
X-Axis	Time Top	Set the left limit of the horizontal axis of the displayed graph in milliseconds.	
	Time Width	Set the width of the horizontal axis of the displayed graph in milliseconds.	
Y-Axis	Sample MAX	Set the maximum value of the vertical axis of the displayed graph in decimal.	
	Sample MIN	Set the minimum value of the vertical axis of the displayed graph in decimal.	

2.4   Histogram Tab

Histogram Tab displays a histogram with the A/D conversion values displayed on the WaveForm Tab as a population.

The Histogram Tab consists of the following three areas as shown in Figure 2-6.

1.   Graphical display area
2.   Operation buttons
3.   Setting area
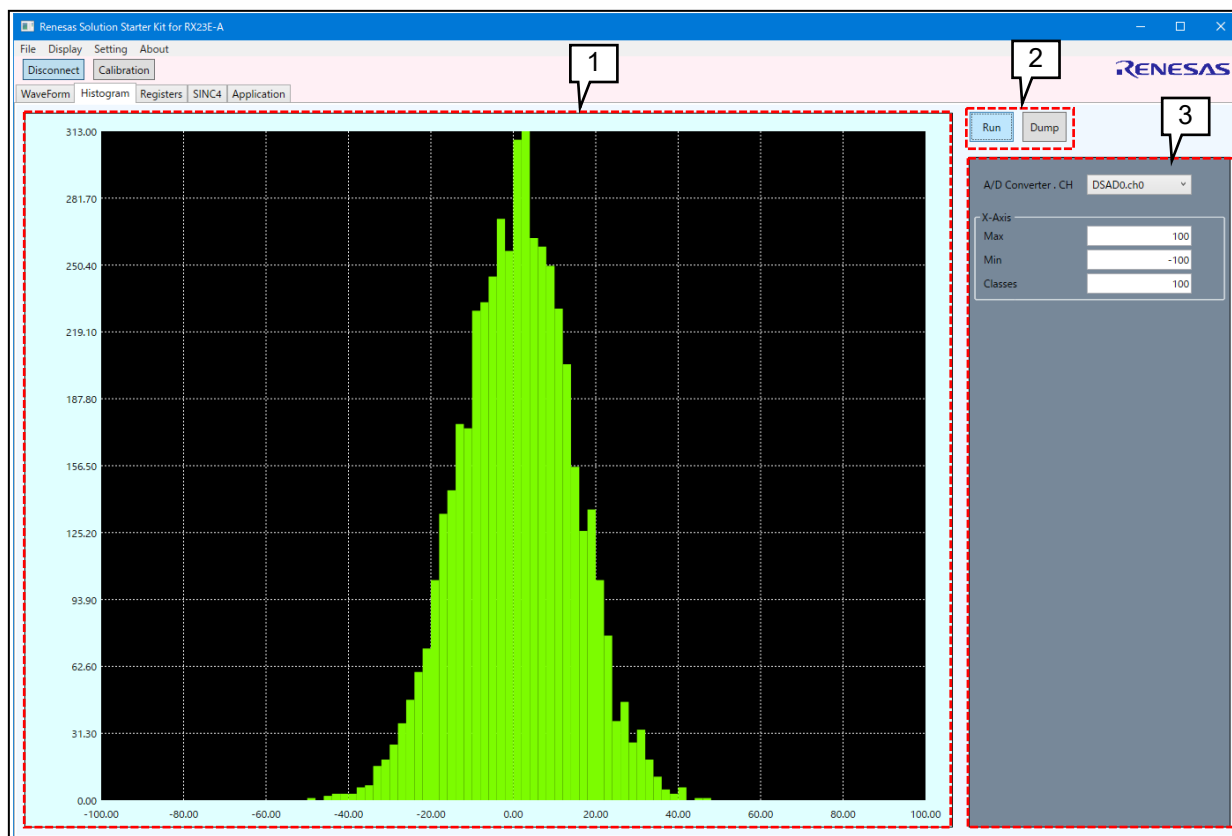
Figure 2-6 Histogram Tab Screen

2.4.1   Graphical Display Area

In this area, a histogram is displayed. The histogram is based on the A/D conversion values displayed on the WaveForm Tab for the selected channel of DSAD unit as a population

The horizontal axis indicates the A/D conversion values, and the vertical axis indicates the frequency. The value displayed on the horizontal axis depends on the settings in the "X-Axis" group in the setting area. The value displayed on the vertical axis is the range from zero to the maximum frequency.
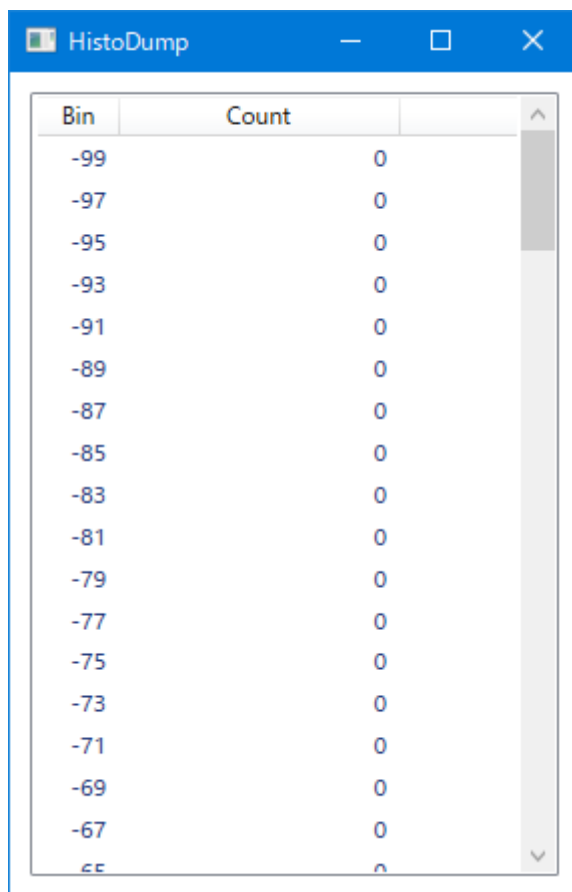
2.4.2 Operation Buttons

Use the operation buttons to start and stop A/D conversion, and display the histogram in a list.

Table 2-6 explains the operation buttons.

Table 2-6 Histogram Tab Operation Buttons

Button	Explanation
Run/Stop	Obtains or stops A/D conversion values when the connection with the EVB is established. When "Run" is displayed on the button, clicking the button will start A/D conversion and the button "Stop" will be displayed. The obtained A/D conversion values are displayed in a graph. When "Stop" is displayed on the button, clicking the button will stop A/D conversion and the button "Run" will be displayed.
Dump	Displays a list of frequency of each class in the current histogram in the "HistoDump" dialog box shown in Figure 2-7. Each class shows median. The list can be copied in range selection as the CSV format by using CTRL+C. The dialog box cannot be opened during A/D conversion. When this dialog box is open, the tabs cannot be switched.

Figure 2-7 HistoDump Dialog Box

2.4.3   Setting Area

Use the setting area to set items related to histogram display. Table 2-7 explains the items.

Table 2-7 Histogram Tab Setting Area

Item		Explanation
A/D Converter		Select a channel of DSAD unit as population in histogram.
X-Axis	Max	Set the maximum A/D conversion value in decimal. A/D conversion values more than the set value are not included in the histogram.
	Min	Set the minimum A/D conversion value in decimal. A/D conversion values less than the set value are not included in the histogram.
	Classes	Set the number of classes between Min and Max.

Assuming that the range of A/D conversion values in the population is [Min, Max] and the number of classes is "Classes", the width of A/D conversion values included in one class "ClassWidth" is calculated as the following equation.

$$ClassWidth = \frac{Max - Min + 1}{Classes}$$

2.5 Registers Tab

On the Registers Tab, a block diagram of the AFE and DSADs of RX23E-A and parameters of each function are displayed. The setting value of each register is also displayed based on the relevant parameter. Each parameter value in the block diagram can be selected and input. A changed value is reflected to RX23E-A on the EVB by clicking the "Set" button.

When the EVB is connected by clicking the "Connect" button, the current settings in RX23E-A on the EVB are displayed.

Each parameter setting can be saved to a file and applied by reading this file.

The Registers Tab screen consists of the three areas as shown in Figure 2-8.

1. Operation Buttons
2. AFE and DSAD block diagram
3. Register value display area
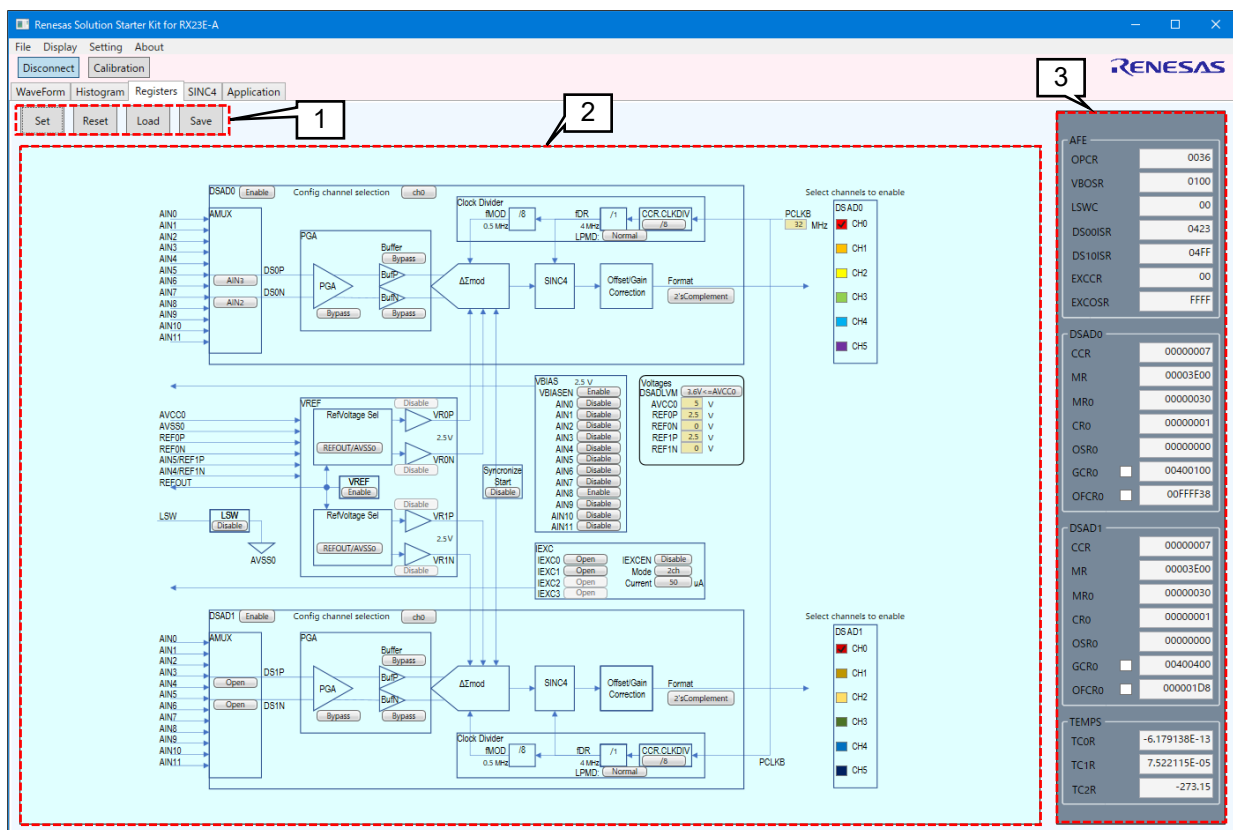
Figure 2-8 Registers Tab Screen

2.5.1 AFE and DSAD Block Diagram

A block diagram of the AFE and DSADs of RX23E-A and parameters of each function are displayed. Each parameter value in the block diagram which is shown in Figure 2-9 can be selected or input. The block diagram can be scaled up and down by mouse wheel. SINC4 and Offset/Gain correction is set with SINC4 Tab.

In "1" in the diagram, select each DSAD channel which is enabled. In "2", select each DSAD channel of which parameter is set. When selecting in "2", the target parameter is displayed with highlight.

The box in which the value is entered is confirmed with enter key. A prohibited setting is displayed in red.

At the start of the PC tool, each parameter displays the RX23E-A initial values.

After a connection with the EVB is established, the current RX23E-A values are displayed.

For details on each parameter, refer to "RX23E-A Group User's Manual: Hardware".
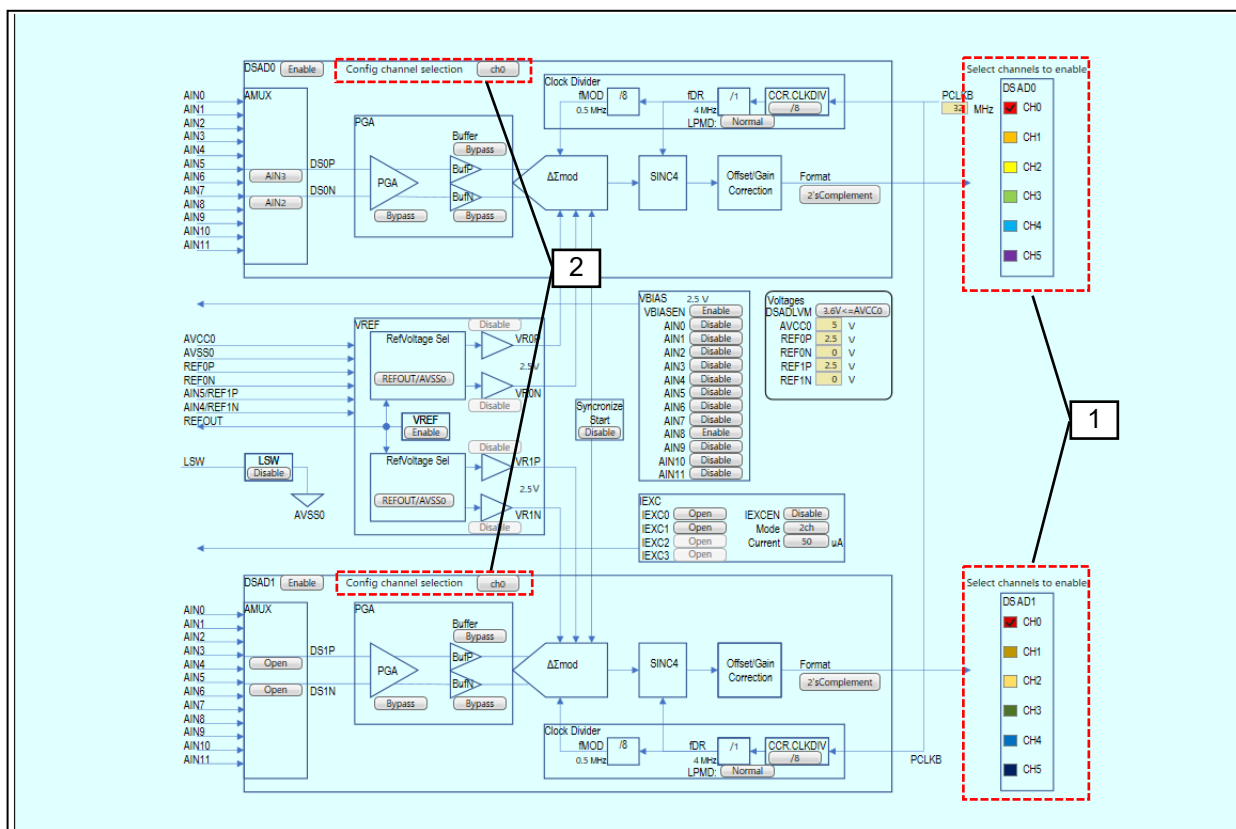
Figure 2-9 AFE and DSAD Block Diagram

2.5.2 Operation Buttons

Use the operation buttons to operate register set values. Table 2-8 explains the operation buttons.

Table 2-8 Registers Tab Operation Buttons

Button	Explanation
Set	Transmits the register setting values to the EVB.
	This button is enabled when communication with the EVB has been established and while A/D conversion values are not being obtained.
Reset	Restores the register values to the current EVB values.
	This button is enabled when communication with the EVB has been established and while A/D conversion values are not being obtained.
Load	Reads and applies register setting from a file.
	This button is disabled during A/D conversion.
Save	Writes the current register settings to a file.
	This button is disabled during A/D conversion.

2.5.3 Register Value Displaying Area

Each register value is displayed based on the relevant parameter set in the block diagram and applied SINC4 Tab settings. The display is switched depending on the channel selection of each DSAD for which the parameter is set in the block diagram.

Each value of GCRm and OFCRm in DSAD0 and DSAD1 group is transmitted by clicking the "Set" button only when each checkbox is checked.

For details on each register value, refer to "RX23E-A Group User's Manual: Hardware".

2.6   SINC4 Tab

The SINC4 Tab screen is provided to additionally set items related to the Registers Tab screen. This tab screen allows you to set SINC4 filter-related registers and displays a SINC4 filter frequency-gain characteristic graph based on the setting.

The SINC4 Tab consists of the following three areas as shown in Figure 2-10.

  1. Operation buttons
  2. SINC4 filter frequency-gain characteristic graph
  3. Setting area
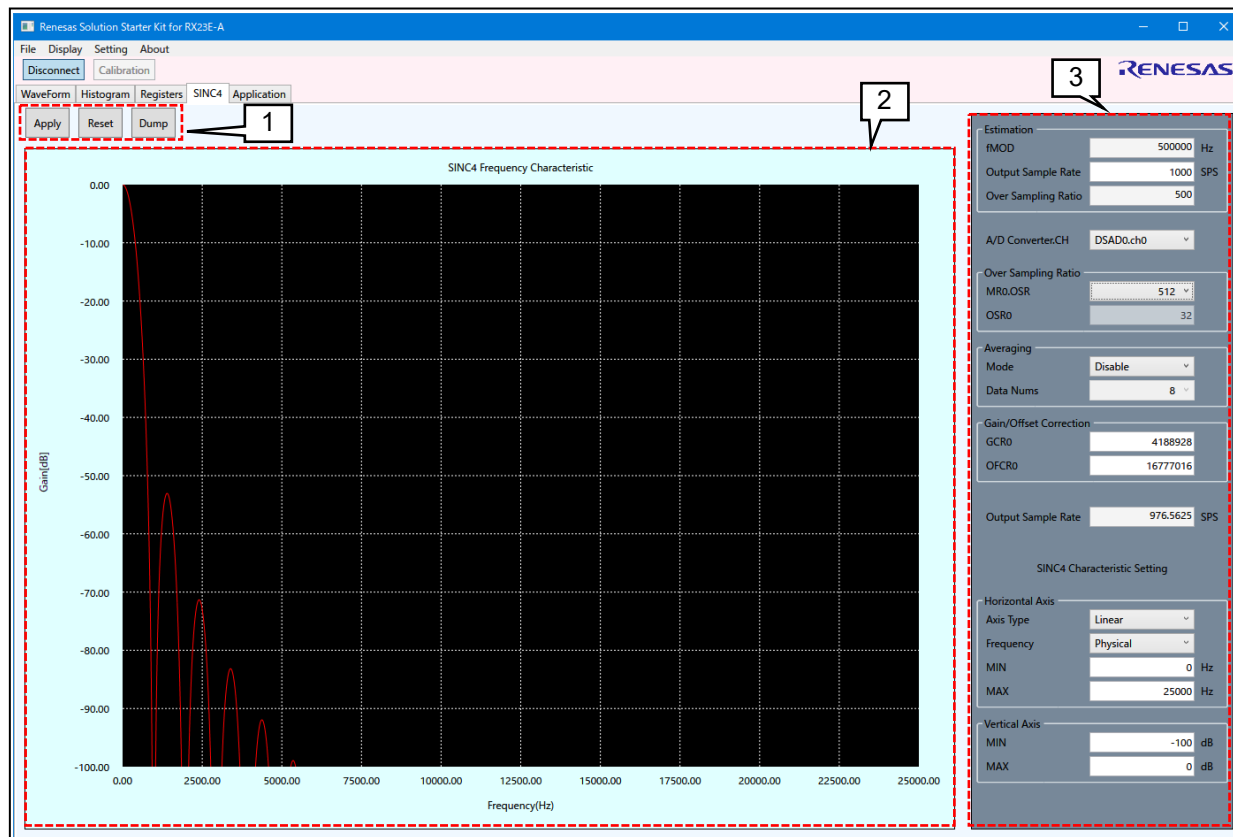
Figure 2-10 SINC4 Tab Screen

2.6.1   Operation Buttons

Use operation buttons to apply each parameter to the corresponding register value and display a list of SINC4 filter frequencies and corresponding gain characteristics.

Table 2-9 explains the operation buttons.

Table 2-9 SINC4 Tab Operation Buttons

Button	Explanation
Apply	Applies each parameter to the corresponding register value on the Registers Tab. This button is disabled during A/D conversion values obtainment.
Reset	Restores each parameter to the setting based on the corresponding register value on the Registers Tab. This button is disabled during A/D conversion values obtainment.
Dump	Displays the "SINC4 DUMP" dialog box shown in Figure 2-11, which displays a list of frequencies and corresponding gains. The list can be copied in range selection as the CSV format by using CTRL+C. When the "SINC4 DUMP" dialog box is open, the tabs cannot be switched.

SINC4 DUMP	
Frequency	**Gain[dB]**
0.000000e+000	0.000000e+000
2.500000e+000	-3.745433e-004
5.000000e+000	-1.498183e-003
7.500000e+000	-3.370948e-003
1.000000e+001	-5.992886e-003
1.250000e+001	-9.364066e-003
1.500000e+001	-1.348458e-002
1.750000e+001	-1.835452e-002
2.000000e+001	-2.397403e-002
2.250000e+001	-3.034324e-002
2.500000e+001	-3.746233e-002
2.750000e+001	-4.533147e-002
3.000000e+001	-5.395087e-002
3.250000e+001	-6.332076e-002
3.500000e+001	-7.344137e-002
3.750000e+001	-8.431297e-002
4.000000e+001	-9.593585e-002

Figure 2-11 SINC4 DUMP Dialog Box

2.6.2   SINC4 Filter Frequency-Gain Characteristic Graph

A SINC4 filter frequency-gain characteristic graph is displayed based on the current setting of channel of DSAD unit selected in the setting area.

The scale of each axis is based on the parameters in "SINC4 Characteristic Setting" in the setting area. You can select the normalized frequency based DSAD sampling frequency f_{MOD} or physical frequency as the frequency on the horizontal axis. You can also set the display range by specifying the maximum and minimum frequencies.

2.6.3   Setting Area

Use the setting area to set the output data rate (Sampling per second: SPS) and axes in the graph. For details on each parameter, refer to "RX23E-A Group User's Manual (Hardware)".

Table 2-10 explains items in the setting area.

Table 2-10 SINC4 Tab Setting Area

Item		Explanation
Estimation Calculates the over sampling ratio based on the output data rate.	fMOD	Displays the sampling frequency based on the settings on the Registers Tab.
	Output Sample Rate	Enter an expected DSAD output data rate.
	Over Sample Ratio	Displays the over sampling ratio calculated based on the above values.
A/D Converter.CH		Select a channel of DSAD unit to set.
Over Sampling Ratio Set the over sampling ratio.	MR0.OSR	Select an over sampling ratio.
	OSRm	If "OSR0" is selected in MR0.OSR, enter desired over sampling ratio. The input value is rounded to the nearest value that can be set.
Averaging Specify the averaging function settings.	Mode	Select whether to use the averaging function.
	Data Nums	Select the number of data items to be averaged.
Gain/Offset Correction Enter gain and offset correction values. Alternatively you can set these values by calibration.	GCRm	Enter a gain correction value.
	OFCRm	Enter an offset correction value.
Output Sample Rate		Displays the output data rate according to the parameter setting.
Horizontal Axis Specify the settings for the horizontal axis of the frequency-gain characteristic graph.	Axis Type	Select Linear or Log for the horizontal axis.
	Frequency	Select Physical or Normalized for the frequency displayed on the horizontal axis.
	MIN	Set the minimum value on the horizontal axis. The input value depends on the "Frequency" setting.
	MAX	Set the maximum value on the horizontal axis. The input value depends on the "Frequency" setting.
Vertical Axis Specify the settings for the vertical axis of the frequency-gain characteristic graph.	MIN	Set the minimum value on the vertical axis.
	MAX	Set the maximum value on the vertical axis.

Note: m = 0 ~ 5

2.7 Application Tab

Application Tab obtains the measurement values of sample programs in the measurement example application notes and displays as graph. In addition, it is possible to save the obtained measurement values in a file, and read saved measurement values to display a graph. The measurement results can be obtained for up to 12 channels.

The Application Tab consists of the following three areas as shown in Figure 2-12.

1. Graphical display area
2. Operation buttons
3. Setting area
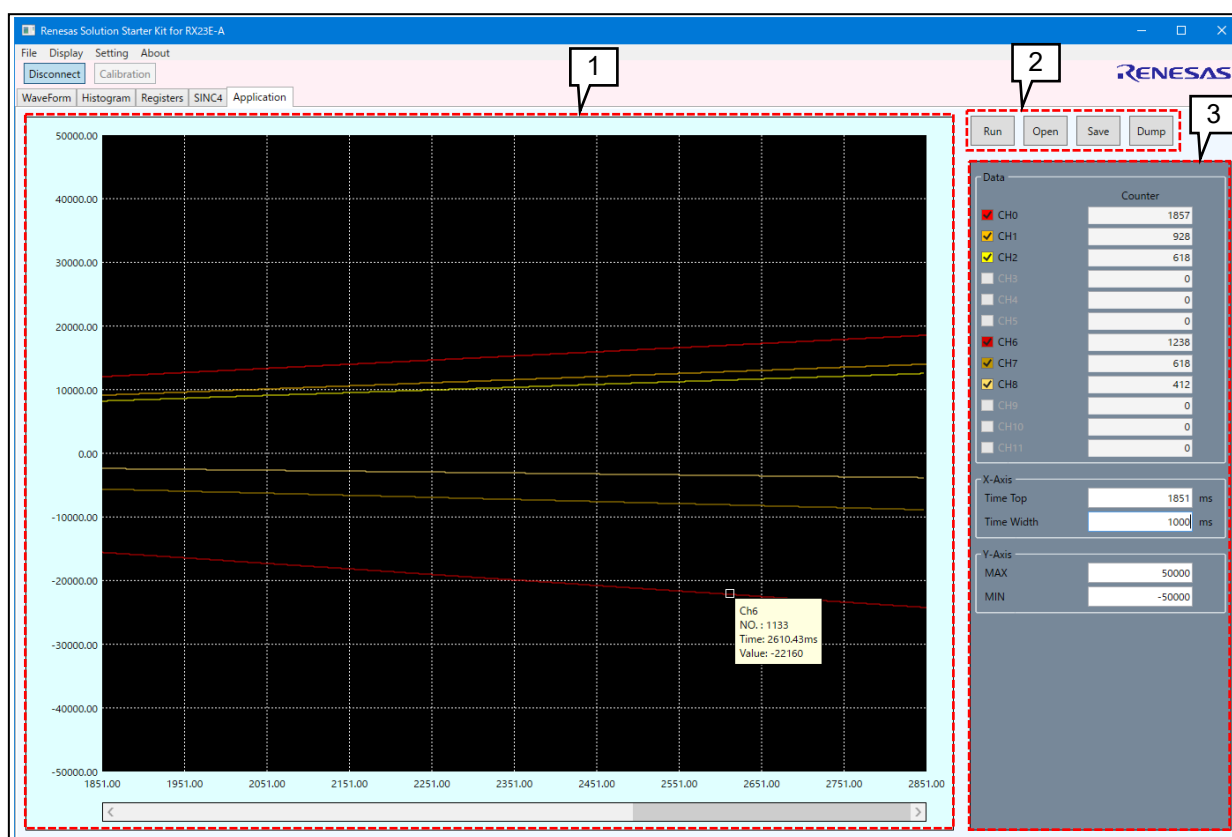
Figure 2-12 Application Tab Screen

Note: There is an option not to display this tab to reduce memory consumption. Setting option can be specified by "Enable" parameter in the "Application" section of the configuration file. Refer to "0 Configuration File" in detail.

2.7.1 Graphical Display Area

In this area, measurement values are displayed as a waveform. The horizontal axis indicates the time when data rate information is obtained from the EVB, and indicates the sampling number when the information is not obtained, and the vertical axis indicates the measurement value For the details of the data rate information of the vertical axis, refer to "4.4.7 Extra Information (Rev.2.0)" of communication specifications.

The value displayed on each axis depends on the settings in the "X-Axis" or "Y-Axis" group in the setting area.

The graph is updated to the latest values when the scroll bar is positioned at the right end while measurement values are being obtained from the EVB.

2.7.2 Operation Buttons

Use the operation buttons to start and stop measurement value obtainment, save and read A/D conversion values from a file, and display the conversion values in a list.

Table 2-11 explains the operation buttons.

Table 2-11 Application Tab Operation Buttons

Button	Explanation
Run/Stop	Obtains or stops measurement values when the connection with the EVB is established. When "Run" is displayed on the button, clicking the button will start obtaining measurement values and the button "Stop" will be displayed. The obtained measurement values are displayed in a graph. When "Stop" is displayed on the button, clicking the button will stop obtaining measurement values and the button "Run" will be displayed.
Open	Read a saved measurement value file. This button is disabled during measurement values obtainment. When a saved file is read, the measurement values being held are discarded.
Save	Saves all measurement values being held in a file. This button is disabled during measurement values obtainment.
Dump	Displays a list of measurement values of the channel currently selected for displaying the values in the "ApplicationDump" dialog box shown in Figure 2-13. The list can be copied in range selection as the CSV format by using CTRL+C. The dialog box cannot be opened during measurement values obtainment. When this dialog box is open, the tabs cannot be switched.

Figure 2-13 ApplicationDump Dialog Box
(Left: Without data rate information, Right: With data rate information)

2.7.3 Setting Area

Use the setting area to set items related to the graphical display. Table 2-12 explains the items.

Table 2-12 Application Tab Setting Area

Item		Explanation
Data	CHm (m=0 ~ 11)	Select the channel for measurement values which is displayed in the graph
	Counter	Displays the number of obtained samples of measurement values of each channel.
X-Axis	Top/Time Top	Set the value of left edge of the horizontal axis of the graph. Specify the sample No. when the display is "Top", and with msec when the display is Time Top.
	Width/Time Width	Set the width of the horizontal axis of the graph. Specify the number of samples when the display is "Width", and with msec when the display is "Time Width".
Y-Axis	MAX	Set the maximum value of the vertical axis of the graph.
	MIN	Set the minimum value of the vertical axis of the graph.

3. File Specification

The PC tool handles the files listed in Table 3-1.

Table 3-1 Files

File	Explanation
RSSK23EA.ini	Configuration file. Created in the same folder as the executable file at closing the PC tool.
*.dat	A/D conversion values file. This file can be saved and read in any folder.
*.3ea	Register setting file. This file can be saved and read in any folder.
*.mea	Measurement values file. This file can be saved and read in any folder.

3.1 Configuration File

The configuration file is automatically generated at the first termination of the PC tool. The PC tool updates the configuration file when finished, to record the specific setting values and status for next start-up setting.

The file name is fixed to RSSK23EA.ini. The file is generated in the same folder as for the PC tool executable file (RSSK23EA.exe).Table 3-2 explains the data in the configuration file. Figure 3-1 shows a sample configuration file.

Table 3-2 Explanation of the Configuration File

Section	Parameter	Format	Explanation
[Window] General PC tool setting	FullScreen	True/False	Whether to display the PC tool in full screen. When True is set, the following parameters are invalid.
	Top	Integer	Y position at the start of the PC tool
	Left	Integer	X position at the start of the PC tool
	Width	Integer	Window width at the start of the PC tool
	Height	Integer	Window height at the start of the PC tool
[Configure] Setting items in the Configure dialog box	Port	String	COM port name. Blank when no value is specified.
	BaudRate	Integer	Baud rate. Initial value: 3000000
[WaveForm]	X_TimeTop	Integer	Start time on the horizontal axis
	X_TimeWidth	Integer	Time width on the horizontal axis
	Y_MAX	Integer	Maximum A/D conversion value on the vertical axis
	Y_MIN	Integer	Minimum A/D conversion value on the vertical axis
	filename	String	Path to the A/D conversion result file
	UpdateRestriction	Integer	Graph update suppression parameter during data obtainment. This value is defined as the following equation. If it exceeded this value, update is suppressed. $$(SPS_{DSAD0} \times enabled\ channels \\ + SPS_{DSAD1} \times enabled\ channels) \\ \times Time\ Width\ of\ graph[sec]$$
[Histogram]	Bins	Integer	Number of bins
	StdDiv	True/False	Whether to display the standard deviation
	X_MIN	Integer	Minimum value on the horizontal axis
	Y_MAX	Integer	Maximum value on the horizontal axis
[Application]	X_Top	Integer	Value of left edge on horizontal axis
	X_Width	Integer	Value of display width on horizontal axis
	Y_MAX	Real number	Maximum measurement value on the vertical axis
	Y_MIN	Real number	Minimum measurement value on the vertical axis
	Enable	True/False	Whether Application Tab can be displayed

```
[Window]
FullScreen=True
Top=0
Left=0
Width=1408
Height=943
[Configure]
Port="COM4"
BaudRate=3000000
[WaveForm]
X_TimeTop=0
X_TimeWidth=100
Y_MAX=8388607
Y_MIN=-8388607
filename=""
UpdateRestriction=312500
[HistoGram]
X_MIN=0
Y_MAX=1
Bins=10
[Register]
filename=""
[Calibration]
channel=0
RefVoltage1=0
RefVoltage2=0
[Application]
Enable=True
X_Top=0
X_Width=10000
Y_MAX=10000
Y_MIN=-10000
filename=""
```

Figure 3-1 Configuration File Example

3.2 A/D Conversion Value File

An A/D conversion value file is used to record A/D conversion values obtained from EVB on the WaveForm Tab as binary data.

The file name is optional and can be saved and read at any folder. The default extension is "dat".

The following table shows the data structure of an A/D conversion value file.

Table 3-3 Explanation of an A/D Conversion Value File

offset [bytes]	Type	Item	Explanation	
0	uint8_t[16]	Identifier	File identifier	Required header
+16	uint32_t	File version	File version (= 2)	
+20	uint8_t[24]	Time of "RUN"	Run click time (UTC) in the RFC3339 format	
+44	uint8_t[24]	Time of "STOP"	Stop click time (UTC) in the RFC3339 format	
+68	uint32_t	Number of Channels	Number of channels	
+72	uint32_t	Channel No.	Channel No.	Upper16bit: DSAD Lower16bit: Channel
+76	double	SPS	Samples/sec	
+84	uint32_t	data format	data format 0: 2's complement 1: Straight binary	
+88	uint32_t	Number of Samples	Number of samples	
+92	uint32_t	Sample[0]	Sample0	
+96	uint32_t	Sample[1]	Sample1	
⋮				
+92+(Ch.NoS)*4	uint32_t	Channel No.	Channel No.	Upper16bit: DSAD Lower16bit: Channel
+96+(Ch.NoS)*4	double	SPS	Samples/sec	
+104+(Ch.NoS)*4	uint32_t	data format	data format 0: 2's complement 1: Straight binary	
+108+(Ch.NoS)*4	uint32_t	Number of Samples	Number of samples	
+112+(Ch.NoS)*4	uint32_t	Sample[0]	Sample0	
+116+(Ch.NoS)*4	uint32_t	Sample[1]	Sample1	
⋮				

3.3 Register Setting File

A register setting file is used to record setting data of the registers handled on the Registers Tab as text data.

The file name is optional and can be saved and read at any folder. The default extension is "3ea".

The following shows the data structure of a register setting file. Table 3-4 lists data items in a register setting value file. Figure 3-2 shows example of register setting file.

Table 3-4 Explanation of a Register Setting Value File

Block	Explanation	Parameter	Format	Explanation
[AFE]	AFE registers (m=0 ~ 5)	OPCR	16-bit HEX	AFE operation control register
		VBOSR	16-bit HEX	Bias voltage output select register
		LSWC	8-bit HEX	Low side switch control register
		EXCCR	8-bit HEX	Excitation current control register
		EXCOSR	16-bit HEX	Excitation current output select register
		DS0mISR	16-bit HEX	DSAD0 channel m input select register
		DS1mISR	16-bit HEX	DSAD1 channel m input select register
[DSAD0] [DSAD1]	DSAD0/DSAD1 registers (m=0 ~ 5)	CCR	8-bit HEX	Excitation current control register
		MR	32-bit HEX	DSAD operating mode register
		MRm	32-bit HEX	Channel m operating mode register
		CRm	32-bit HEX	Channel m control register
		OSRm	32-bit HEX	Channel m over sampling ratio setting register
		GCRm	32-bit HEX	Channel m gain correction register
		OFCRm	32-bit HEX	Channel m offset correction register
[VOLTAGE]	Voltage setting	AVCC0	Real Number	Analog power supply voltage
		REF0P		Positive DSAD0 reference voltage
		REF0N		Negative DSAD0 reference voltage
		REF1P		Positive DSAD1 reference voltage
		REF1N		Negative DSAD1 reference voltage

```
[AFE]
OPCR=0x0000
VBOSR=0x0000
LSWC=0x00
DS00ISR=0x00FF
DS01ISR=0x00FF
DS02ISR=0x00FF
DS03ISR=0x00FF
DS04ISR=0x00FF
DS05ISR=0x00FF
DS10ISR=0x00FF
DS11ISR=0x00FF
DS12ISR=0x00FF
DS13ISR=0x00FF
DS14ISR=0x00FF
DS15ISR=0x00FF
EXCCR=0x00
EXCOSR=0xFFFF
[DSAD0]
CCR=0x00000007
MR=0x00000000
MR0=0x00000020
MR1=0x00000020
MR2=0x00000020
MR3=0x00000020
MR4=0x00000020
MR5=0x00000020
CR0=0x00000001
CR1=0x00000001
CR2=0x00000001
CR3=0x00000001
CR4=0x00000001
CR5=0x00000001
OSR0=0x00000000
OSR1=0x00000000
OSR2=0x00000000
OSR3=0x00000000
OSR4=0x00000000
OSR5=0x00000000
GCR0=0x00000000
GCR1=0x00000000
GCR2=0x00000000
GCR3=0x00000000
GCR4=0x00000000
GCR5=0x00000000
```

```
OFCR0=0x00000000
OFCR1=0x00000000
OFCR2=0x00000000
OFCR3=0x00000000
OFCR4=0x00000000
OFCR5=0x00000000
[DSAD1]
CCR=0x00000007
MR=0x00000000
MR0=0x00000020
MR1=0x00000020
MR2=0x00000020
MR3=0x00000020
MR4=0x00000020
MR5=0x00000020
CR0=0x00000001
CR1=0x00000001
CR2=0x00000001
CR3=0x00000001
CR4=0x00000001
CR5=0x00000001
OSR0=0x00000000
OSR1=0x00000000
OSR2=0x00000000
OSR3=0x00000000
OSR4=0x00000000
OSR5=0x00000000
GCR0=0x00000000
GCR1=0x00000000
GCR2=0x00000000
GCR3=0x00000000
GCR4=0x00000000
GCR5=0x00000000
OFCR0=0x00000000
OFCR1=0x00000000
OFCR2=0x00000000
OFCR3=0x00000000
OFCR4=0x00000000
OFCR5=0x00000000
[VOLTAGE]
AVCC0=5
REF0P=2.5
REF0N=0
REF1P=2.5
REF1N=0
```

Figure 3-2 Register Setting File Example

3.4 Measurement Value File

A measurement is used to record measurement values obtained from EVB on the Application Tab as binary data.

The file name is optional and can be saved and read at any folder. The default extension is "mea".

Table 3-5 shows the data structure of a measurement value file.

Table 3-5 Explanation of a Measurement Value File

offset[byte]	Type	content	Explanation	
0	uint8_t[16]	Identifier	File identifier	Required header
+16	uint32_t	File version	File version (=2)	
+20	uint8_t[24]	Time of "RUN"	Run click time (UTC) in the RFC3339 format	
+44	uint8_t[24]	Time of "STOP"	Stop click time (UTC) in the RFC3339 format	
+68	uint32_t	Number of Channels	Number of channels	
+72	uint32_t	Channel No.	Channel No.N	N = 0 ~ 11
+76	float	SPS	Samples/sec	
+80	uint32_t	Number of Samples	Number of samples	
+84	float	Sample[0]	Sample0	
+88	float	Sample[1]	Sample1	
⋮				
+84+(Ch.NoS)*4	uint32_t	Channel No.	Channel No.N	N = 0 ~ 11
+88+(Ch.NoS)*4	float	SPS	Samples/sec	
+92+(Ch.NoS)*4	uint32_t	Number of Samples	Number of samples	
+96+(Ch.NoS)*4	float	Sample[0]	Sample0	
+100+(Ch.NoS)*4	float	Sample[1]	Sample1	
⋮				

4. Communication Specification

This section describes the communication specification between PC tool and firmware for RX23E-A (called FW below).

This revision supports the following functions by extending the specification.

- Transmission of A/D conversion values and measurement values for up to 12 channels.
- Acquisition of data rate information when measurement value is transmitted.

Where there is a difference between the previous and this revision, Rev.1.0 and Rev.2.0. are described for each.

Rev.1.0 and 2.0 cannot be used at the same time.

4.1 Serial Communication Settings

Table 4-1 Serial Communication Settings

Item	Settings
Transfer speed	3Mbps
Data length	8bit
Parity	none
Stop bit	1

4.2 Sequence

Communication sequence is that PC tool sends command, then FW sends the corresponding response. The FW response is ACK as supported command, or NACK as unsupported command.

PC tool sends the Negotiation Request at first, then receives FW response which contains supported functions. Following this, PC tool sends the commands which correspond to the FW supported function .

In addition, FW sends packets whether A/D conversion value or measurement value sequentially for the Run command.

Figure 4-1 shows the communication sequence.
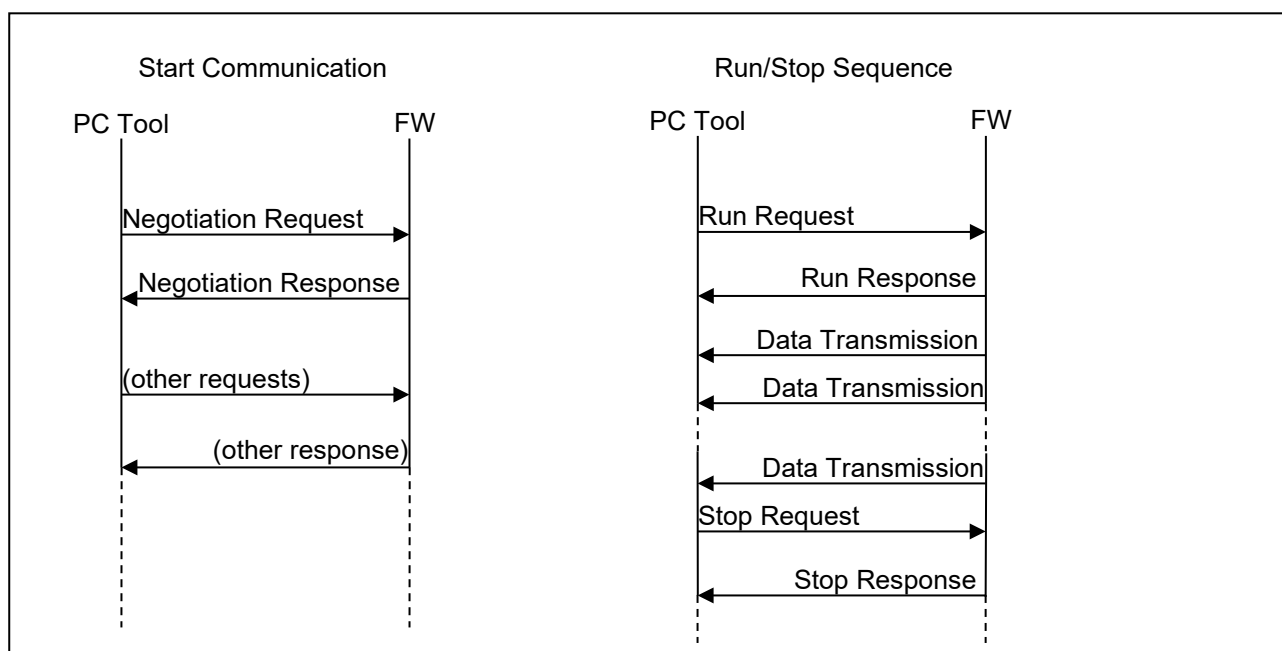
Figure 4-1 Communication Sequence

4.3   Packet Structure

Table 4-2 Packet Structure

offset [Byte]	Contents	Description
0	Header	Packet header, constitution is shown in Table 4-3
+1	Data Length	Attached data length, H'00 – H'FF
+2	Data	Attached data, 0 to 255 bytes, data is defined in each command

Table 4-3 Header Constitution

Header	bit	Name	Description
	b7-b6	Identifier	B'10
	b5	Type	0: Request, 1: Response
	b4	ACK/NACK	0: ACK, 1: NACK, for Response 0 if Type is Request
	b3-b0	Command	Command list is shown in Table 4-4

Table 4-4 Command List

Value	Command	Description
H'0	Negotiation	FW supported functions acquisition (Rev.1.0/2.0)
H'1	Read	Read registers
H'2	Write	Write registers
H'3	Run	Start data obtainment
H'4	Stop	Stop data obtainment
H'5	Data Transmission (Ch0)	Send Ch0 data (Rev.1.0)
H'6	Data Transmission (Ch1)	Send Ch1 data (Rev.1.0)
H'7-H'8	-	reserved
H'9	Data Transmission	Data transmission (Rev.2.0)
H'A	Extra Information	Acquisition of extended information (Rev.2.0)
H'B-H'F	-	reserved

4.4 Commands

Details of the Commands shown in Table 4-4 are explained below.

4.4.1 Negotiation

PC tool requests the FW supported functions. FW responds them. The packet structure is shown in Table 4-5 and constitution of supported functions is shown in Table 4-6.

Table 4-5 Negotiation Packet Structure

Type	Header	Data Length	Data
Request	H'80	H'00	None
Response	H'A0	(1byte)	Rev.1.0: Supported function1 (1byte) Rev.2.0: Supported function 1 ~ 5 (5byte)

Table 4-6 Constitution of Supported functions

Supported functions	bit	Name	Description
function 1 (Rev.1.0/2.0)	b7	Endian	MCU Endian[Note1] 0: Little, 1: Big
	b6-b5	Data Ch0	Transmission Data Type (Rev.1.0) [Note2]
	b4-b3	Data Ch1	B'00: None (Select "None" on Rev.2.0) B'10: A/D Conversion Value (uint32_t) B'11: Measurement Value (float)
	b2	Read	Supporting Registers Reading 0: Not Supported, 1: Supported
	b1	Write	Supporting Registers Writing 0: Not Supported, 1: Supported
	b0	-	reserved (0)
function 2 (Rev.2.0)	b7-b0	-	reserved (0)
function 3 (Rev.2.0)	b7-b6	Data Ch0	Transmission Data Type [Note2]
	b5-b4	Data Ch1	B'00: None
	b3-b2	Data Ch2	B'10: DSAD0 A/D Conversion Value (uint32_t) [Note3]
	b1-b0	Data Ch3	B'11: Measurement Value (float)
function 4 (Rev.2.0)	b7-b6	Data Ch4	
	b5-b4	Data Ch5	
	b3-b2	Data Ch6	Transmission Data Type [Note2]
	b1-b0	Data Ch7	B'00: None
function 5 (Rev.2.0)	b7-b6	Data Ch8	B'10: DSAD1 A/D Conversion Value (uint32_t) [Note3]
	b5-b4	Data Ch9	B'11: Measurement Value (float)
	b3-b2	Data Ch10	
	b1-b0	Data Ch11	

Notes: 1. PC tool supports only Little Endian.

2. A mismatch of Transmission Data Type among channels does not support except None.

3. A/D conversion value supports the DSAD channel number. In DSAD1 Ch6-Ch11 supports the channel 0-5 in order.

4.4.2 Read

PC tool reads register value in RX23E-A. PC tool specifies top address and number of registers to read. FW responds top address and values of read registers.

The packet structure is shown in Table 4-7.

Table 4-7 Read Packet Structure

Type	Header	Data Length	Data			
Request	H'81	H'05	Start Address (4byte)	Number of registers: N (0 < N < 32) (1byte)		
Response	H'A1	(1+N) * 4 (0 < N < 32)	Start Address (4byte)	Register 1 (4byte)	…	Register N (4byte)

4.4.3 Write

PC tool writes register in RX23E-A. PC tool specifies top address and register values to write. FW responds top address and written register values.

The packet structure is shown in Table 4-8.

Table 4-8 Write Packet Structure

Type	Header	Data Length	Data			
Request	H'82	(1+N) *4	Start Address	Register 1	…	Register N
Response	H'A2	(0 < N < 32)	(4byte)	(4byte)		(4byte)

4.4.4 Run

PC tool requires to send data transmission packets. FW responds it, then start sending data transmission packets.

The packet structure is shown in Table 4-9.

Table 4-9 Run Packet Structure

Type	Header	Data Length	Data
Request	H'83	H'00	none
Response	H'A3		

4.4.5 Stop

PC tool requires to stop sending data transmission packets. FW responds it, then stop sending data transmission packets.

The packet structure is shown in Table 4-10.

Table 4-10 Stop Packet Structure

Type	Header	Data Length	Data
Request	H'84	H'00	none
Response	H'A4		

4.4.6 Data Transmission

FW sends whether A/D conversion value or measurement value obtained from DSAD. The transmission data has the format of what is responded in Negotiation.

4.4.6.1 Rev.1.0

The packet structure is shown in Table 4-11.

Table 4-11 Data Transmission Packet Structure (Rev.1.0)

Type	Header	Data Length	Data			
Ch0	H'A5	N*4	Data1	Data 2	…	Data N
Ch1	H'A6	(1byte)	(4byte)	(4byte)		(4byte)

4.4.6.2 Rev.2.0

The packet structure is shown in Table 4-12, the data structure in Table 4-13.

Table 4-12 Data Transmission Packet Structure (Rev.2.0)

Header	Data Length	Data				
H'A9	N*4+1 (1byte)	Channel (1byte)	Data1 (4byte)	Data 2 (4byte)	…	Data N (4byte)

Table 4-13 Data Structure (Rev.2.0)

Name	bit	Description	
		DSAD A/D Conversion Value	**Measurement Value**
Channel	b7-b5	DSAD No. DSAD0: 0 DSAD1: 1 Others: reserved	0
	b4-b0	DSAD Channel No.: 0 - 5	Channel No.: 0 - 11
data1…dataN	b31-b0	Value	

4.4.7 Extra Information (Rev.2.0)

MCU obtains the extended information which can be provided.

The packet structure is shown in Table 4-14, the extended information in Table 4-15.

Table 4-14 Extra Information Packet Structure

Type	Header	Data Length	Data	
Request	H'8A	H'02	Class (2byte)	
Response	H'AA	Refer to Table 4-15	Class (2Byte)	Class Information Refer to Table 4-15

Table 4-15 Class Information

Data Length	Class		Class Information				Description
	Value	Name					
H'32	0x0001	SPS Information	Ch.0 (4byte)	ch.1 (4byte)	…	ch.11 (4byte)	If Data Ch is measurement value in Negotiation, return data rate in float format. Disabled ch is "NaN".
-	Others	-	reserved				

Revision History

Rev.	Date	Description		
		Page	**Summary**	
1.00	Nov. 11, 19	-	First edition	
1.10	Feb. 07, 20	1	Add text "The PC tool is used in combination with the included firmware for RX23E-A." along with the firmware for RX23E-A fix.	
		4		
		29	Corrected "program" to "firmware" to unify terms.	
2.00	July 20, 20	-	Revision due to the addition of software function.	
2.01	March 15, 21	19-20	Replaced Figure 2-10 and Figure 2-11 due to the correction of the SINC4 filter frequency-gain characteristic graph.	

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.

Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.

2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.

3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.

4. You shall be responsible for determining what licenses are required from any third parties, and obtaining such licenses for the lawful import, export, manufacture, sales, utilization, distribution or other disposal of any products incorporating Renesas Electronics products, if required.

5. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.

6. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.

     "Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.

     "High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.

     Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.

7. No semiconductor product is absolutely secure. Notwithstanding any security measures or features that may be implemented in Renesas Electronics hardware or software products, Renesas Electronics shall have absolutely no liability arising out of any vulnerability or security breach, including but not limited to any unauthorized access to or use of a Renesas Electronics product or a system that uses a Renesas Electronics product. RENESAS ELECTRONICS DOES NOT WARRANT OR GUARANTEE THAT RENESAS ELECTRONICS PRODUCTS, OR ANY SYSTEMS CREATED USING RENESAS ELECTRONICS PRODUCTS WILL BE INVULNERABLE OR FREE FROM CORRUPTION, ATTACK, VIRUSES, INTERFERENCE, HACKING, DATA LOSS OR THEFT, OR OTHER SECURITY INTRUSION ("Vulnerability Issues"). RENESAS ELECTRONICS DISCLAIMS ANY AND ALL RESPONSIBILITY OR LIABILITY ARISING FROM OR RELATED TO ANY VULNERABILITY ISSUES. FURTHERMORE, TO THE EXTENT PERMITTED BY APPLICABLE LAW, RENESAS ELECTRONICS DISCLAIMS ANY AND ALL WARRANTIES, EXPRESS OR IMPLIED, WITH RESPECT TO THIS DOCUMENT AND ANY RELATED OR ACCOMPANYING SOFTWARE OR HARDWARE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY, OR FITNESS FOR A PARTICULAR PURPOSE.

8. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.

9. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.

10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.

11. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.

12. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.

13. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.

14. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.

(Note1)   "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.

(Note2)   "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.5.0-1   October 2020)

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan

www.renesas.com

Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.

Contact information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:
www.renesas.com/contact/.