F65xx

Evaluation System (EVS)

The Renesas F65xx Evaluation System (EVS) includes a set of hardware components and software that when combined with additional Required User Supplied Equipment enables the full evaluation and validation of the electrical performance characteristics of the Renesas Electronics F65xx family of devices. The F65xx device is an 8-Channel Transmit Active Beamforming IC intended for use in electronically scanned phased array antenna systems. This document provides guidelines for installing and using the F65xx EVS to evaluate the F6513S, F6521S, and F6522S devices.

The F65xxEVS includes a custom software application, the Renesas Beamforming EVS Software, which controls the F65xx IC (mounted on the Evaluation Board) from a PC via the Digital Interface Board. The EVS Software wraps all controls into an intuitive, easy to use Graphical User Interface (GUI), thus requiring no pre-requisite programming experience. This document describes how to obtain and install the EVS Software, identify the various components of the Evaluation System, make connections to the Evaluation Board, and outlines the steps required to control and evaluate the F65xx device.

Evaluation System (EVS) Contents

Items shipped with the board/kit (also see Figure 1):

1. Evaluation Board
2. Digital Interface Board
3. USB Cable (USB-A to USB-B micro)
4. Power Supply Cable
5. Renesas Beamforming EVS Software v0.2.x.x (downloadable from Secure Portal)
6. FTDI Device Drivers (included with EVS Software Installer)
7. RF De-Embed Files (downloadable from Secure Portal)
8. Thru Reference Board (separate order required)

Required User-Supplied Equipment

- Desktop or Laptop PC with:
  - Microsoft Windows 7 or higher Operating System, 32- or 64-bit
  - .NET 4.5 framework
  - Minimum of 2GHz CPU, 4GB RAM, 100MB HDD space
- Powered USB Port (USB 2.0 or later)
- Power Supply capable of sourcing 2.5V / 0.5A (for example, Keysight N6705B with N6781A SMU)
- Vector Network Analyzer (VNA) (for example, Keysight PNA-X N5245B with Options 422, S93086B, S93087B)
- Remote Sense Leads (for example, Pomona Minigrabber Test Clip to Stacking Banana plug)
- 2 or more Coaxial Cables with 2.92mm (K) connectors
- Electronic Calibration Module (for example, Keysight N4692D)
- Up to seven 50Ω Load Terminations, 2.92mm (K) (for example, Hirose HK-TMP)

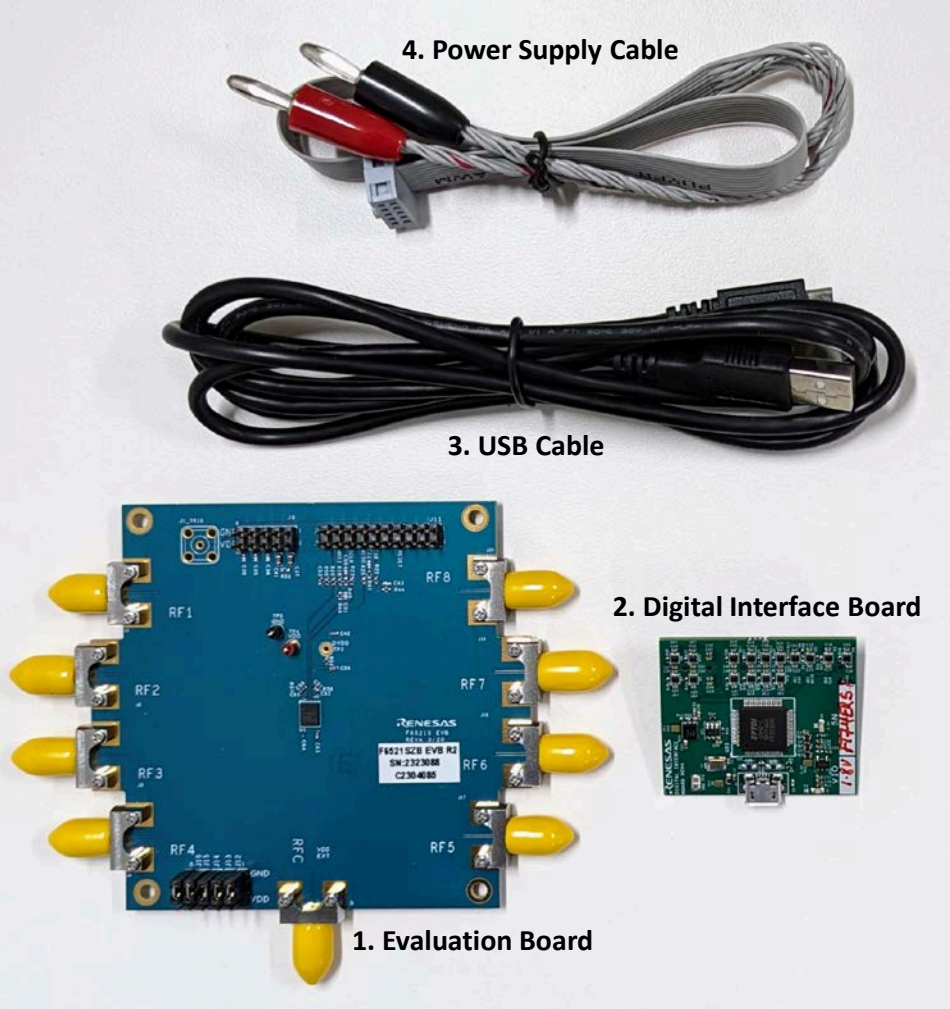


Figure 1. F6522S Evaluation System Included Components

Contents

Figures

Tables

1. Functional Description

The F65xx Evaluation System includes the Evaluation Board (EVB), Digital Interface Board, USB Cable, Power Supply Cable, EVS Software and RF De-Embed Files.

1.1 F65xxS Evaluation Board

The F65xxS Evaluation Board is designed to allow the user to thoroughly evaluate both the RF and DC performance of the device. The RF transmission lines are designed such that input and output transmission lines associated with all channels have similar electrical lengths. In particular, channels 1, 4, 5 and 8, as well as channels 2, 3, 6, and 7 have identical traces. This reduces the number of de-embedding configurations required to perform accurate RF measurements referenced to the IC pins.

Multiple terminals are used on the power supply connector to reduce voltage drop across the connections. Test Points are provided on the board, in close proximity to the IC pins, for voltage sensing to compensate for voltage drops and improve the measurement accuracy.

For identification and location information of power and digital headers, and RF I/O ports, see Figure 2 and Table 1. For the default jumper configuration, see Table 2. For information on SPI address configuration, see Table 3. For detailed test point information, see Table 4.

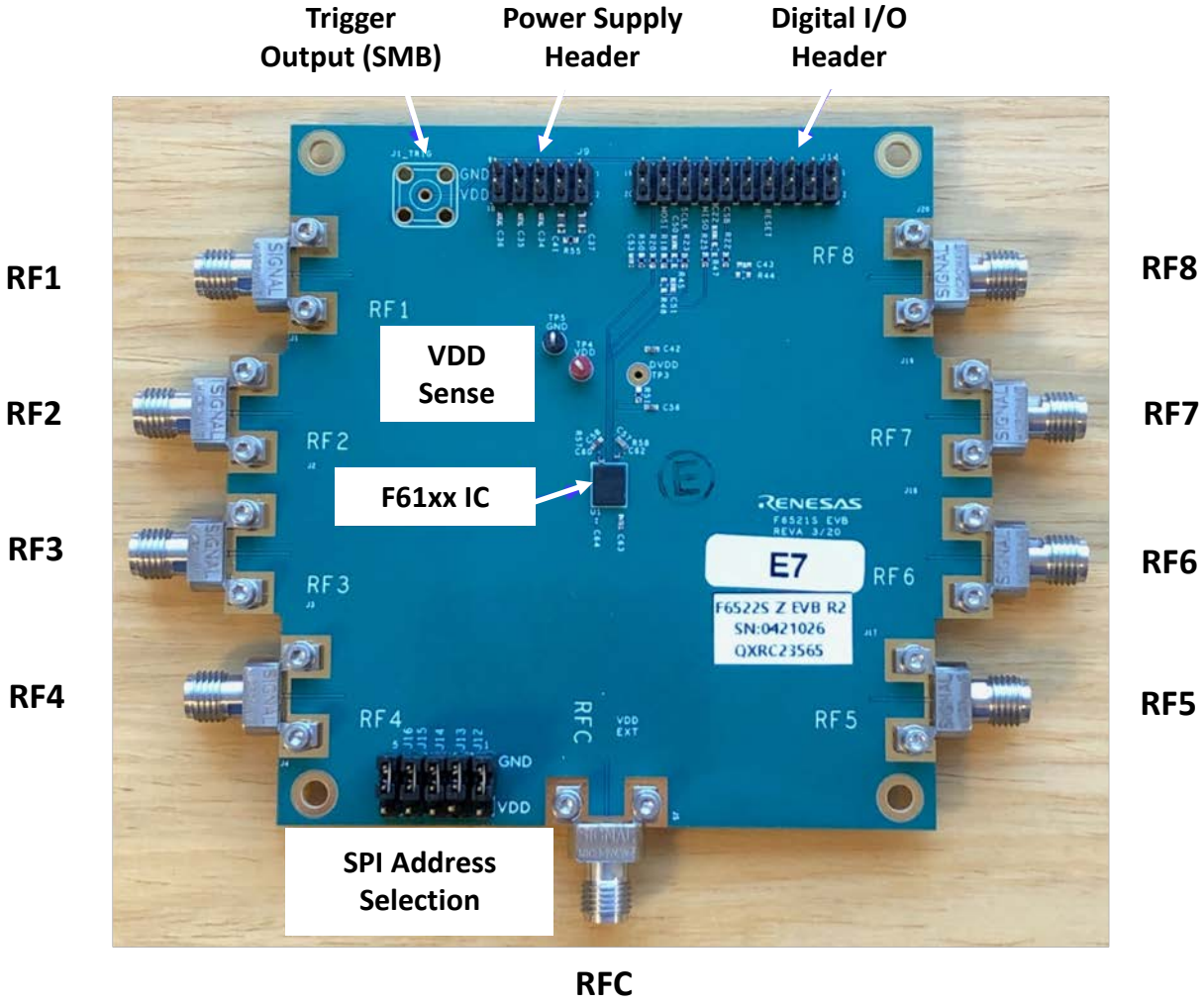


Figure 2. Evaluation Board

Table 1. Evaluation Board Connector Description

Connector	Description	
J9	External power supply header: 1, 3, 5, 7, 9 – GND 2, 4, 6, 8, 10 – VDD (Analog)	
J11	Digital control header: 1, 2, 3, 4, 5, 7, 8 – No connect 6 – Trigger Out 8 – RESET control 9, 11, 13, 15, 17, 19 – GND	10, 20 – GND 12 – CSB control 14 – SDO control 16 – SCLK control 18 – SDI control
J1 (RF1)	RF output port for channel 1.	
J2 (RF2)	RF output port for channel 2.	
J3 (RF3)	RF output port for channel 3.	
J4 (RF4)	RF output port for channel 4.	
J17 (RF5)	RF output port for channel 5.	
J18 (RF6)	RF output port for channel 6.	
J19 (RF7)	RF output port for channel 7.	
J20 (RF8)	RF output port for channel 8.	
J5 (RFC)	RF input common port.	
J1_TRIG	TRIG SMB port. Used to trigger external test equipment when combined with user created software. Not supported by GUI.	

Table 2. Evaluation Board Selector (Jumper) Descriptions

Selector Block	Description	Factory Setting
J12	ADD1 selection jumper. 1 – VDD (from J9) = Note: Do not connect jumper between pins 1-2. For Logic 1, remove the jumper. There is an internal pull up resistor. 2 – ADD1 to chip. 3 – Ground = Logic 0.	2 – 3
J13	ADD2 selection jumper. 1 – VDD (from J9) = Note: Do not connect jumper between pins 1-2. For Logic 1, remove the jumper. There is an internal pull up resistor. 2 – ADD2 to chip. 3 – Ground = Logic 0.	2 – 3
J14	ADD3 selection jumper. 1 – VDD (from J9) = Note: Do not connect jumper between pins 1-2. For Logic 1, remove the jumper. There is an internal pull up resistor. 2 – ADD3 to chip. 3 – Ground = Logic 0.	2 – 3

Selector Block	Description	Factory Setting
J15	ADD4 selection jumper. 1 – VDD (from J9) = Note: Do not connect jumper between pins 1-2. For Logic 1, remove the jumper. There is an internal pull up resistor. 2 – ADD4 to chip. 3 – Ground = Logic 0.	2 – 3
J16	ADD5 selection jumper. 1 – VDD (from J9) = Note: Do not connect jumper between pins 1-2. For Logic 1, remove the jumper. There is an internal pull up resistor. 2 – ADD5 to chip. 3 – Ground = Logic 0.	2 – 3

Table 3. Evaluation Board Selector (Jumper) Positions per SPI Address

SPI Address (hexadecimal)	SPI Address (decimal)	J12 (1)	J13 (2)	J14 (4)	J15 (8)	J16 (16)
0x0	0	2 – 3	2 – 3	2 – 3	2 – 3	2 – 3
0x1	1	OPEN	2 – 3	2 – 3	2 – 3	2 – 3
0x2	2	2 – 3	OPEN	2 – 3	2 – 3	2 – 3
0x3	3	OPEN	OPEN	2 – 3	2 – 3	2 – 3
0x4	4	2 – 3	2 – 3	OPEN	2 – 3	2 – 3
0x5	5	OPEN	2 – 3	OPEN	2 – 3	2 – 3
0x6	6	2 - 3	OPEN	OPEN	2 – 3	2 – 3
0x7	7	OPEN	OPEN	OPEN	2 – 3	2 – 3
0x8	8	2 – 3	2 – 3	2 – 3	OPEN	2 – 3
0x9	9	OPEN	2 – 3	2 – 3	OPEN	2 – 3
0xA	10	2 – 3	OPEN	2 – 3	OPEN	2 – 3
0xB	11	OPEN	OPEN	2 – 3	OPEN	2 – 3
0xC	12	2 – 3	2 – 3	OPEN	OPEN	2 – 3
0xD	13	OPEN	2 – 3	OPEN	OPEN	2 – 3
0xE	14	2 – 3	OPEN	OPEN	OPEN	2 – 3
0xF	15	OPEN	OPEN	OPEN	OPEN	2 – 3
0x10	16	2 – 3	2 – 3	2 – 3	2 – 3	OPEN
0x11	17	OPEN	2 – 3	2 – 3	2 – 3	OPEN
0x12	18	2 – 3	OPEN	2 – 3	2 – 3	OPEN
0x13	19	OPEN	OPEN	2 – 3	2 – 3	OPEN
0x14	20	2 – 3	2 – 3	OPEN	2 – 3	OPEN

SPI Address (hexadecimal)	SPI Address (decimal)	J12 (1)	J13 (2)	J14 (4)	J15 (8)	J16 (16)
0x15	21	OPEN	2 – 3	OPEN	2 – 3	OPEN
0x16	22	2 – 3	OPEN	OPEN	2 – 3	OPEN
0x17	23	OPEN	OPEN	OPEN	2 – 3	OPEN
0x18	24	2 – 3	2 – 3	2 – 3	OPEN	OPEN
0x19	25	OPEN	2 – 3	2 – 3	OPEN	OPEN
0x1A	26	2 – 3	OPEN	2 – 3	OPEN	OPEN
0x1B	27	OPEN	OPEN	2 – 3	OPEN	OPEN
0x1C	28	2 – 3	2 – 3	OPEN	OPEN	OPEN
0x1D	29	OPEN	2 – 3	OPEN	OPEN	OPEN
0x1E	30	2 – 3	OPEN	OPEN	OPEN	OPEN
0x1F	31	OPEN	OPEN	OPEN	OPEN	OPEN

Table 4. Evaluation Board Test Point Descriptions

Test Point	Description
TP3	DVDD/CREG test point.
TP4	VDD test point.
TP5	GND test point.

1.2 RF De-Embed Files

De-embed files derived from Automatic Fixture Removal (AFR) are downloadable from the Secure Customer Portal section of the Renesas website. The de-embedding translates the RF measurement reference plane from the evaluation board connector inputs to the pins (BGA balls) on the IC. Please contact your Renesas representative for Secure Portal access and download instructions.

These de-embed files were created using the Thru Reference Board (see section 1.3). The Thru Reference Board is an optional accessory and not included with the EVS.

1.3 Thru Reference Board

The Thru Reference Board replicates the transmission line traces that feed the IC on the evaluation board and is used to characterize these traces. Following characterization, Automatic Fixture Removal (AFR) software is used to generate de-embed files. The de-embed files allow for the translation of the RF measurement reference plane from the inputs of the connectors to the device pins. It is strongly recommended that customers use the Renesas supplied de-embed files to perform accurate measurements of the IC.

1.4 Digital Interface Board

The FT2232HL digital interface board connects your computer to the F65xx EVB through a USB-to-Micro USB cable. It is designed to directly attach to the EVB (see Figure 14).

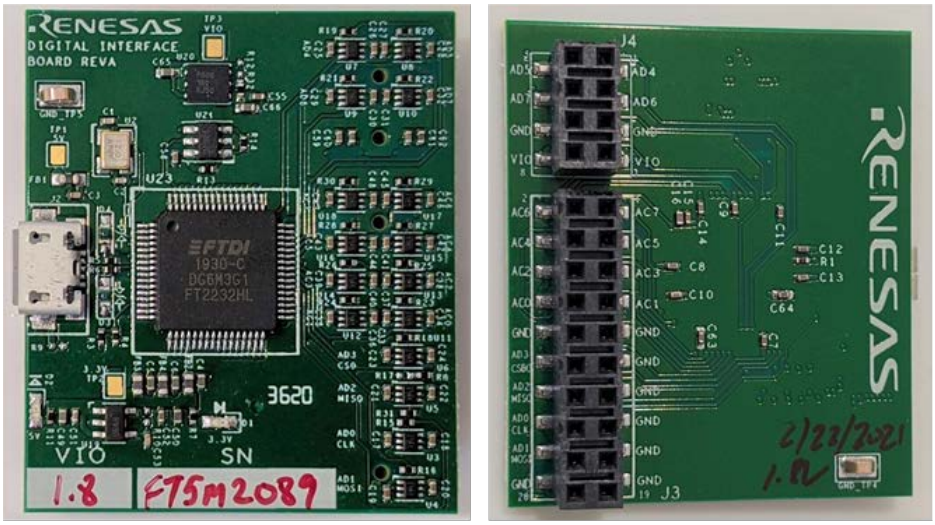


Figure 3. Digital Interface Board

2. Software Overview

Required software consists of the EVS Software Program and FTDI Device Drivers. The EVS Software is a custom program developed specifically for the F65xx Evaluation System. It enables the user to evaluate the F65xx IC without any pre-requisite programming knowledge. The installer package, consisting of single executable file, downloadable from the Secure Customer Portal is capable of installing both the software and the driver. Alternately, the user can download the driver from the internet using Windows Update.

2.1 Obtaining the Software

The Evaluation Software can be downloaded from the Renesas website. Use the log in feature of the web site to access the software from the Secure Portal section of the website. Please contact your Renesas representative for Secure Portal access and download instructions.

2.2 Installing the Software

1. Execute the application setup.exe by double clicking on the icon shown in Figure 4.
2. Follow the installer prompts as indicated below in Figure 5 to Figure 12.

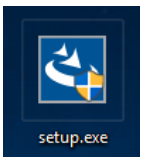
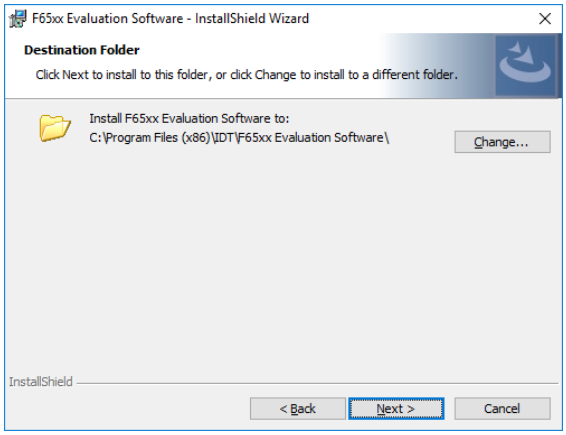
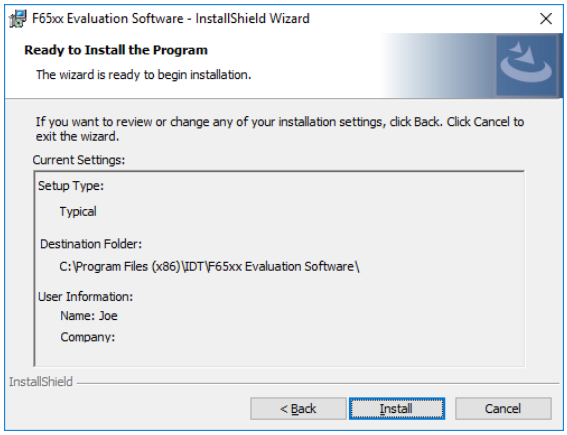


Figure 4. Evaluation Software Installer Application



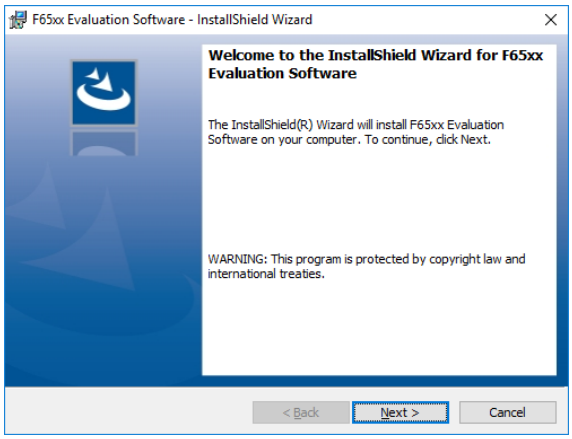
Confirm the desired location of the installation files and click "Next" to proceed.

Figure 5. Windows User Access Control



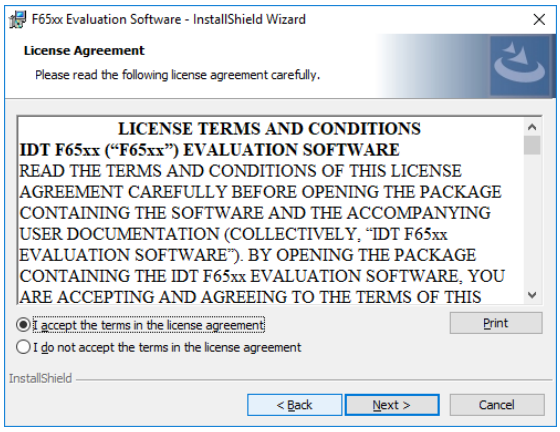
Review the installation summary and finalize the installation by clicking the "Install" button.

Figure 6. Installation Extracting Files



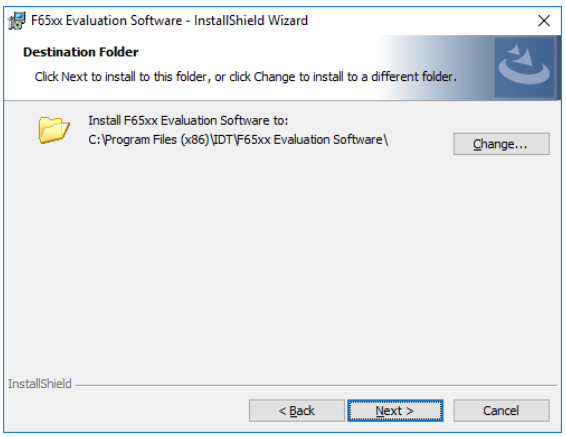
The installation is now ready to being. Click on the "Next" button to being the installation.

Figure 7. Installation Confirmation



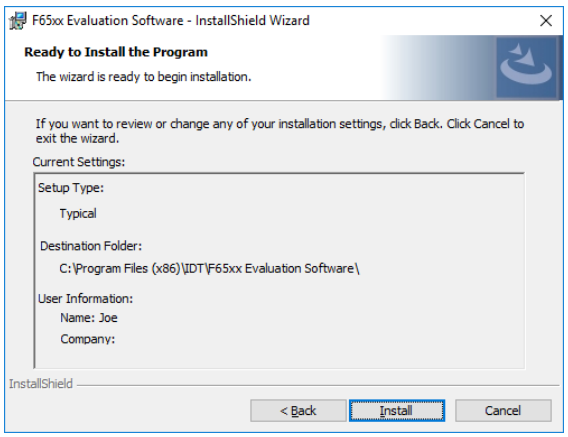
Review License Terms and Conditions, select Accept, and click "Next" to proceed.

Figure 8. License Terms and Conditions



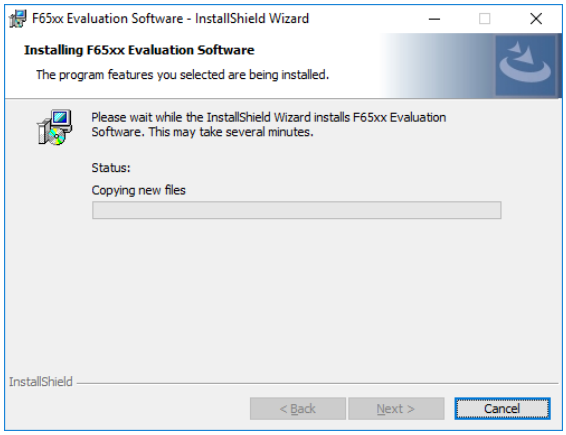
Confirm the desired location of the installation files and click “Next” to proceed.

Figure 9. Installation Location



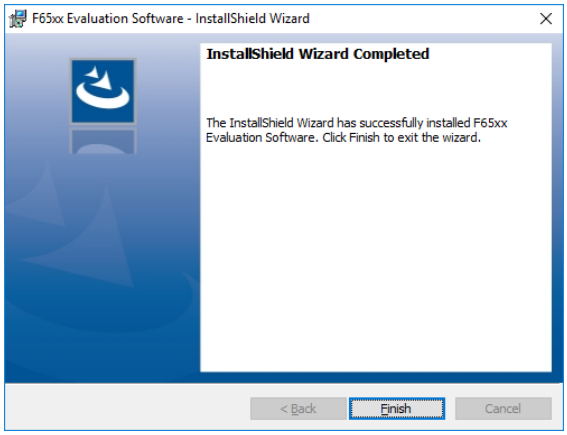
Review the installation summary and finalize the installation by clicking the “Install” button.

Figure 10. Installation Confirmation



The dialog will display the installation progress. This may take a few moments.

Figure 11. Installation Progress



The dialog confirms that installation has been completed successfully.

Figure 12. Installation Complete

2.3 Installing the FTDI Device Driver

The FTDI Device Driver is required for the PC to communicate with the Digital Interface Board via USB. If the PC does not contain the FTDI Device Drivers and is connected to the Internet, users can initiate the driver installation simply by connecting the Digital Interface Board to the PC (plugging the USB-A end of the cable into the PC and the USB-B Micro end into the Digital Interface Board). The driver installation should begin and proceed automatically through Windows Update. Wait for notification that the driver installation has completed successfully (see Figure 13) before proceeding.

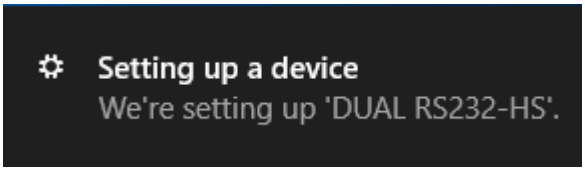


Figure 13. Digital Interface Board USB Driver Installation Windows Update Progress

3. Cable Connection Quick Start

It is recommended that components be connected in the following order (see Figure 14):

1. Attach the digital interface board to the EVB header.
2. Connect the digital interface board to the PC with the USB cable.
3. Connect the power supply cable to the evaluation board header.
4. Connect the power supply cable to the power supply.
5. Connect the remote sense Lead from the power supply (+) to TP4 (VDD) on the evaluation board.
6. Connect the remote sense Lead from the power supply (-) to TP5 (GND) on the evaluation board.
7. Connect the VNA Port 1 to the RFC (J5) coaxial connector on the evaluation board
8. Connect the VNA Port 2 to RF1 (J1) coaxial connector, or one of the other seven desired RF outputs, on the evaluation board.
9. Connect additional VNA ports to remaining RF outputs or terminate remaining outputs with 50Ω loads.

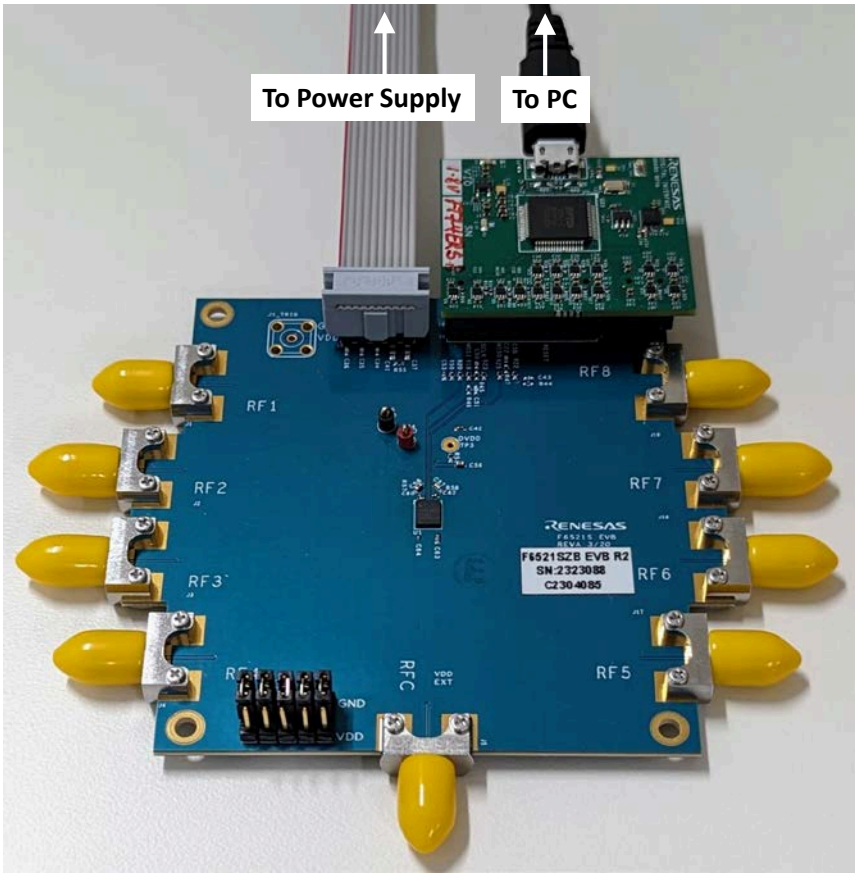


Figure 14. Evaluation Board Digital I/O and Power Connections

4. Evaluation Software Graphical User Interface (GUI)

The following section will describe the controls available to the user via the EVS Software GUI. An overview of each tab page in the software will be presented followed by detailed information for each control in the application describing the interaction with the device under test.

4.1 General Controls and Block Diagram Tab

Figure 15 shows the general controls available to the user in the F65xx Evaluation Software with the Block Diagram tab activated. The block diagram is a static (non-clickable) display that allows the user to visualize the RF signal flow within the device. Table 5 provides a description of all components in this window.

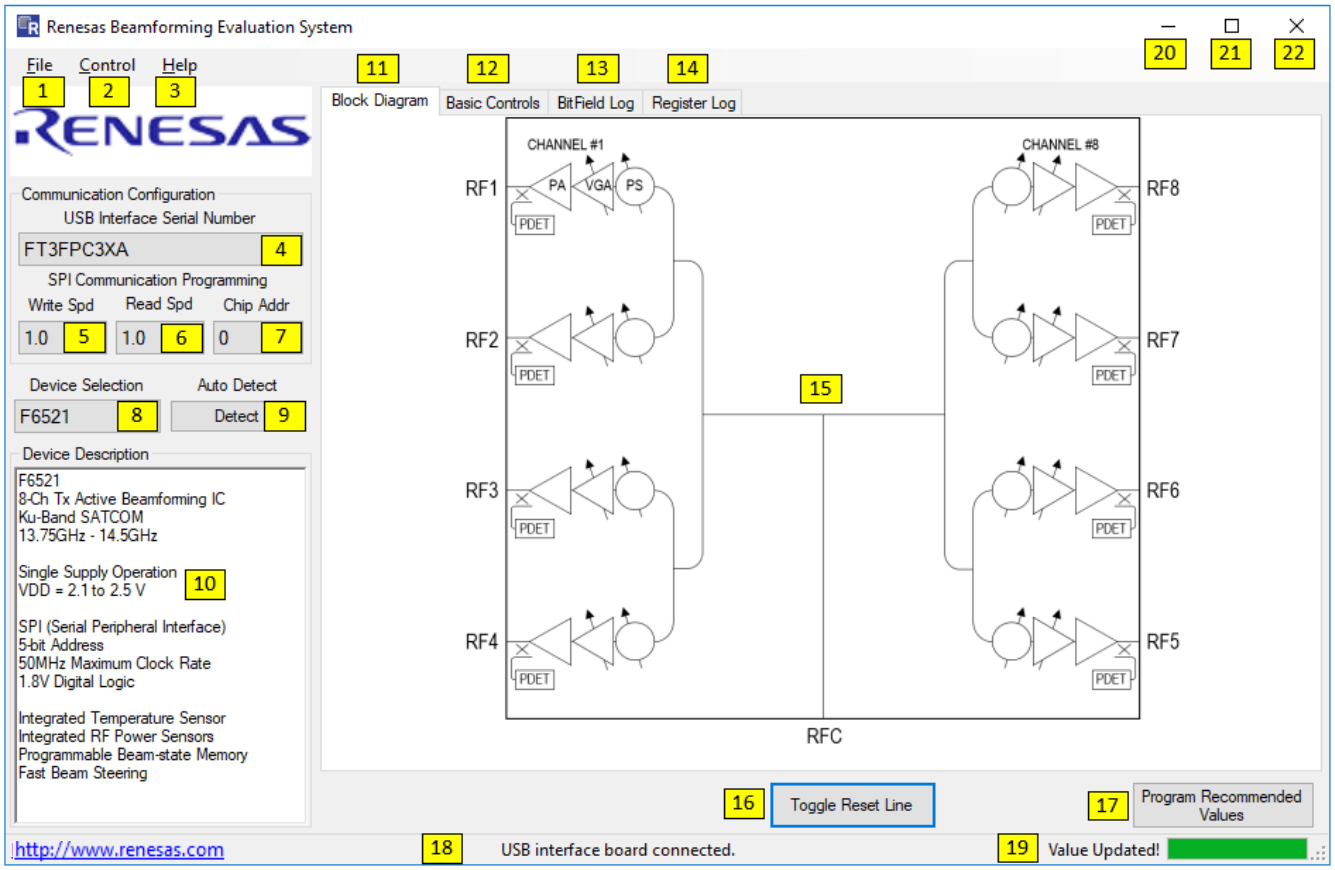


Figure 15. F65xx Evaluation Software – Block Diagram Tab View

Table 5. F65xx Evaluation Software – Description of General Controls and Window Components in Block Diagram Tab View

Item	Function	Description
1	File Menu	Options to save / recall device state file, save / recall a gain Mapping Table, and to exit the application.
2	Control Menu	Toggle ON/OFF SPI read & verify for every write operation.
3	Help Menu	Display software version information and help information.
4	Digital Interface Board Selection Menu	Identifies the serial number of the Digital Interface Board that is being programmed by the Evaluation Software.
5	Write Speed	Controls the clock rate used for all write SPI transactions (30MHz is the maximum of Digital Interface Board)

Item	Function	Description
6	Read Speed	Controls the clock rate used for all read SPI transactions (10MHz is the maximum of Digital Interface Board)
7	Chip Address	Address of the target SPI device being programmed by the Evaluation Software.
8	Device Selection	Selects the specific F65xx Beamformer device. F6513, F6521, and F6522 are supported.
9	Auto Detect Device	Attempts to auto detect the device on the EVB. F65xx must be powered on and connected.
10	Device Description	Information about the selected device such as frequency coverage, voltage range, and other information.
11	Block Diagram Tab	Displays static RF block diagram of the F65xx IC.
12	Basic Controls Tab	Contains controls that allow the most basic evaluation of the electrical functionality of the F65xx.
13	Bit Field Log Tab	Tab page that displays the SPI read and write transactions to the device control fields (register sub fields) when enabled by the checkbox. The ability to save the history to a log file is provided. A button to clear the log is available. The user can write the GUI settings to the device with a single click if the device loses sync. Can also sync the GUI to the device by reading the control values from the device.
14	Register Log Tab	Tab page that displays the SPI read and write transactions to the device registers when enabled by the checkbox. The ability to save the history to a log file is provided. A button to clear the log is available. The user can write the GUI settings to the device with a single click if the device loses sync. Can also sync the GUI to the device by reading the control values from the device.
15	Block Diagram	The block diagram is a graphical representation of the RF signal flow within the device. Static image (non-clickable).
16	Toggle Reset Line Button	Toggles RST pin from logic low→high→low, resulting in all registers being reset to a hardware default state. Different from programming the device with the recommended values.
17	Program Recommended Values Button	Programs the device with the recommended values.
18	Interface Board Status	Indicates if the USB drivers are loaded, and if a Digital Interface board is detected.
19	Programming Progress Indicator	Indicates the progress of programming the chip with new register values, momentarily displaying “Value Updated!”, each time that programming is completed following a new action.
20	Minimize Button	Minimizes the application window. Restore to normal size by selecting on the taskbar or using Alt-tab.
21	Maximize Button	Maximizes the application window to fill the screen. Restore to normal size by clicking the same maximize button again.
22	Exit Button	Closes the application.

4.2 Basic Controls Tab View

The Basic Controls tab contains several sub-pages that demonstrate the most basic control of the device, including powering down of the chip, individual channels, rudimentary gain and phase control, sensor readout, and fast beam steering control. These controls represent a fractional subset of all available device controls and settings. For example, the Gain & Phase tab allows the user to cycle through only 128 of the 512 total available gain states effectively reducing the number of gain control bits from 9 to 7. A Mapping Table, accessible from the GUI, is used for this purpose.

4.2.1 Basic Controls – Chip Control

Figure 16 shows the controls available to the user in the Chip Control tab under Basic Controls. The Chip Controls tab allows the user to control high level parameters such as standby and master RF channel enable. Table 6 provides a summary of the Basic Control tab functions.

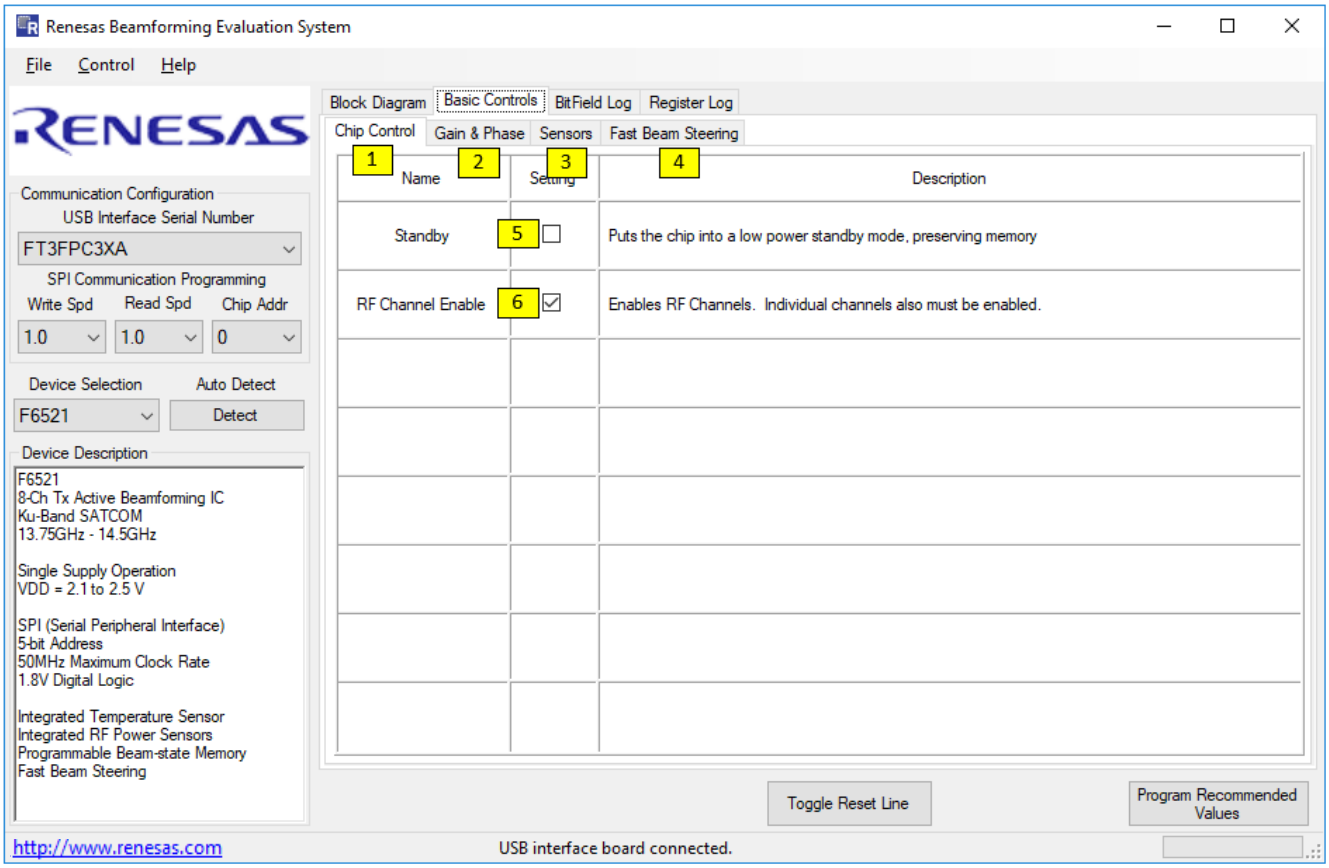


Figure 16. F65xx Evaluation Software – Basic Controls View – Chip Control

Table 6. F65xx Evaluation Software – Chip Control Descriptions

Item	Function	Description
1	Chip Control Tab	Contains high level power functions for the device.
2	Gain & Phase Tab	Contains individual channel enable/disable controls and gain and phase controls.
3	Sensors Tab	Contains sensor reading controls for the device.
4	Fast Beam Steering Tab	Contains fast beam steering controls for the device.
5	Shutdown Checkbox	Puts the device into a low power standby mode.
6	RF Channel Enable	Global enable/disable of active channels (channels that are enabled using the local individual channel controls).

4.2.2 Basic Controls – Gain and Phase

Figure 17 shows the controls available to the user for F65xx Evaluation Software in the Gain & Phase tab view of Basic Controls. The Gain & Phase tab controls allow the user to independently adjust channel-specific parameters, such as individual channel enables, gain, and phase. Table 7 provides a description of the Gain & Phase tab controls.

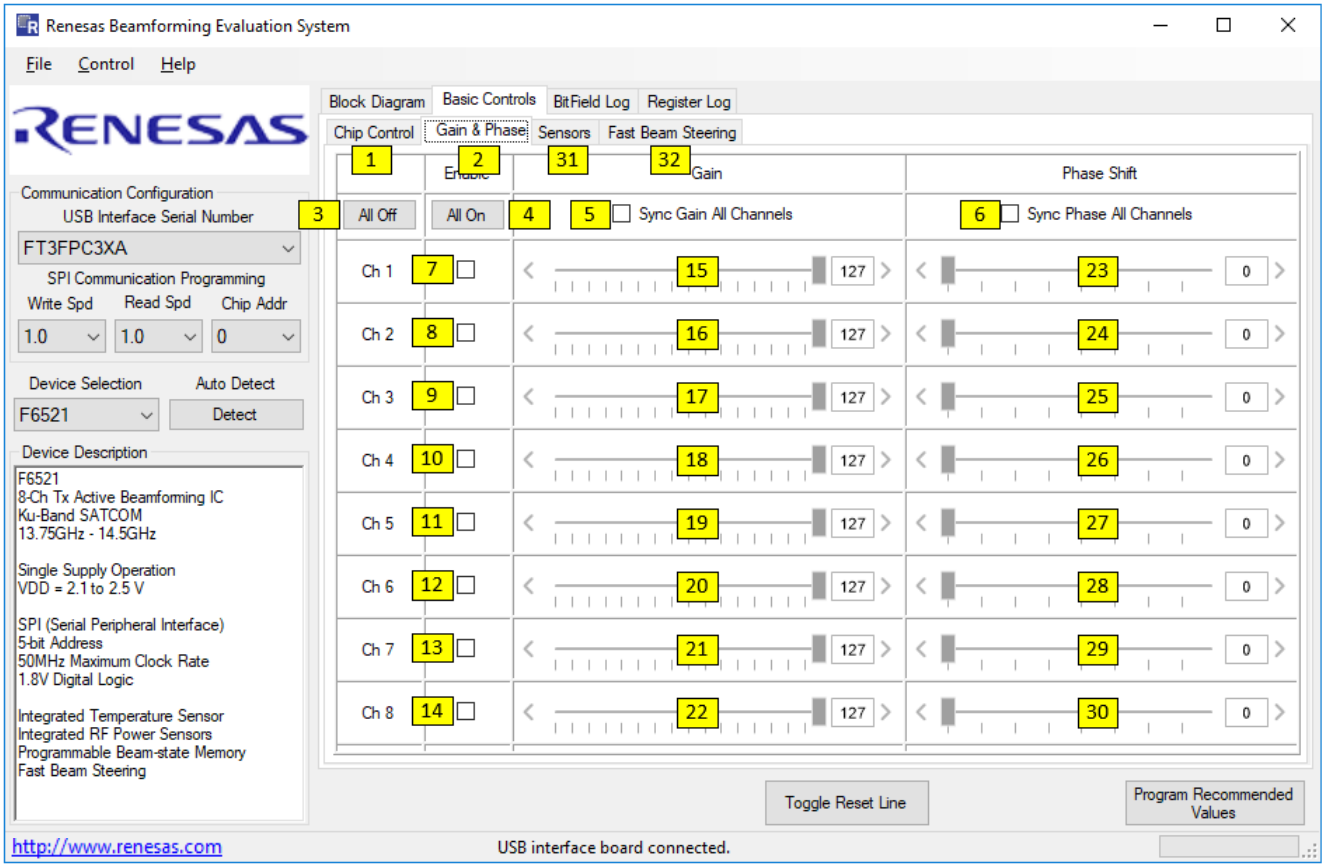


Figure 17. F65xx Evaluation Software – Basic Control View – Gain & Phase Control

Table 7. F65xx Evaluation Software – Basic Control View - Gain & Phase Control Descriptions

Item	Function	Description
1	Chip Control Tab	Contains high level power functions for the device.
2	Gain & Phase Tab	Contains individual channel enable/disable controls and gain & and phase controls.
3	All On Button	Checks all of the Ch En checkboxes, turning on all channels.
4	All Off Button	Unchecks all of the Ch En checkboxes, turning off all channels.
5	Sync Gain All Channels Checkbox	Syncs the gain values of all channels to that of channel 1 and locks the gain controls together.
6	Sync Phase All Channels Checkbox	Syncs the phase values of all channels to that of channel 1 and locks the phase controls together.
7–14	RF Channel 1-8 Enable Checkboxes	Individual channel enables for channels 1–8. A check mark indicates the channel is enabled. The device has a logic AND function with the RF Channel Enable control on the Chip Control Tab page. Both controls must be checked to enable the channel in the device.
15–22	RF Channels 1–8 7-bit Gain Control	Programs the values from the Mapping Table corresponding to the indicated gain decimal value to the VGA_SET_n and DR_SET_MSB_n register fields of the device, where n is the channel number.
23–30	Channels 1–8 6-bit Phase Control	Programs the indicated decimal value to the PS_SET_n register field of the device, where n is the channel number.
31	Sensors Tab	Contains sensor reading controls for the device.
32	Fast Beam Steering Tab	Contains fast beam steering controls for the device.

4.2.3 Basic Controls – Sensors

Figure 18 shows the controls available to the user for F65xx Evaluation Software in the Sensors tab view of Basic Controls. The Sensors tab controls allow the user to query the on-chip sensors and set the number of times each individual sensor is queried. The median value of the samples are displayed in the uncalibrated (x) text boxes. The slope (m) and offset (b) text boxes allow the user to enter individual sensor coefficients for the linear point slope equation y = mx + b. The Calibrated text boxes display the (y) result value from the equation. Table 8 provides a description of the Sensor tab controls.

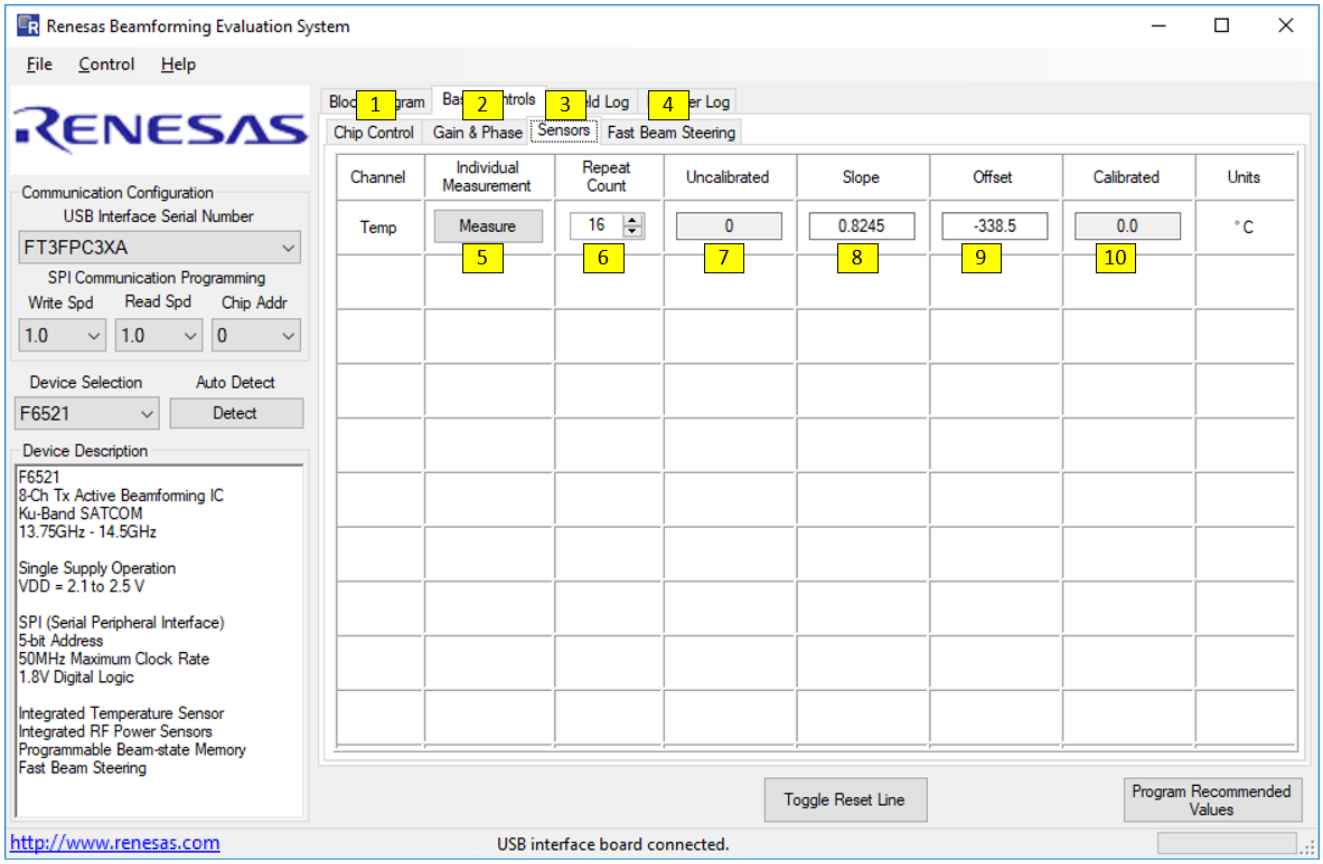


Figure 18. F65xx Evaluation Software – Basic Control View – Sensors Control

Table 8. F65xx Evaluation Software – Basic Control View – Sensor Descriptions

Item	Function	Description
1	Chip Control Tab	Contains high level power functions for the device.
2	Gain & Phase Tab	Contains individual channel enable/disable controls and gain & and phase controls.
3	Sensors Tab	Contains sensor reading controls for the device.
4	Fast Beam Steering Tab	Contains fast beam steering controls for the device.
5	Temp Sensor Measure Button	Initiates a group of sensor reads. The number of reads is set by the Repeat Count Entry Control.
6	Repeat Count Entry Control	Sets the number of sequential reads of the sensor. Minimum number of reads is set to 16.
7	Uncalibrated Text Box Control	Displays the median value of the sensor reads.
8	Slope Text Box Control	User-definable slope value used to in the y = mx + b formula to calculate the calibrated value.
9	Offset Control	User-definable offset value used to in the y = mx + b formula to calculate the calibrated value.

Item	Function	Description
10	Calibrated Control	Display box for the y calibrated result from the y = mx + b formula utilizing the data from the uncalibrated result, slope, and offset fields. Updated only when a measurement is taken by clicking the Measure button.

4.2.4 Basic Controls – Fast Beam Steering

Figure 19 shows the controls available to the user for F65xx Evaluation Software in the Fast Beam Steering tab view of Basic Controls. The Fast Beam Steering tab controls allow the user to set the active beam state in the device through a local or global SPI message, plus view and edit the contents of the Fast Beam Steering table stored in the device. Table 9 provides a description of the Fast Beam Steering tab controls.

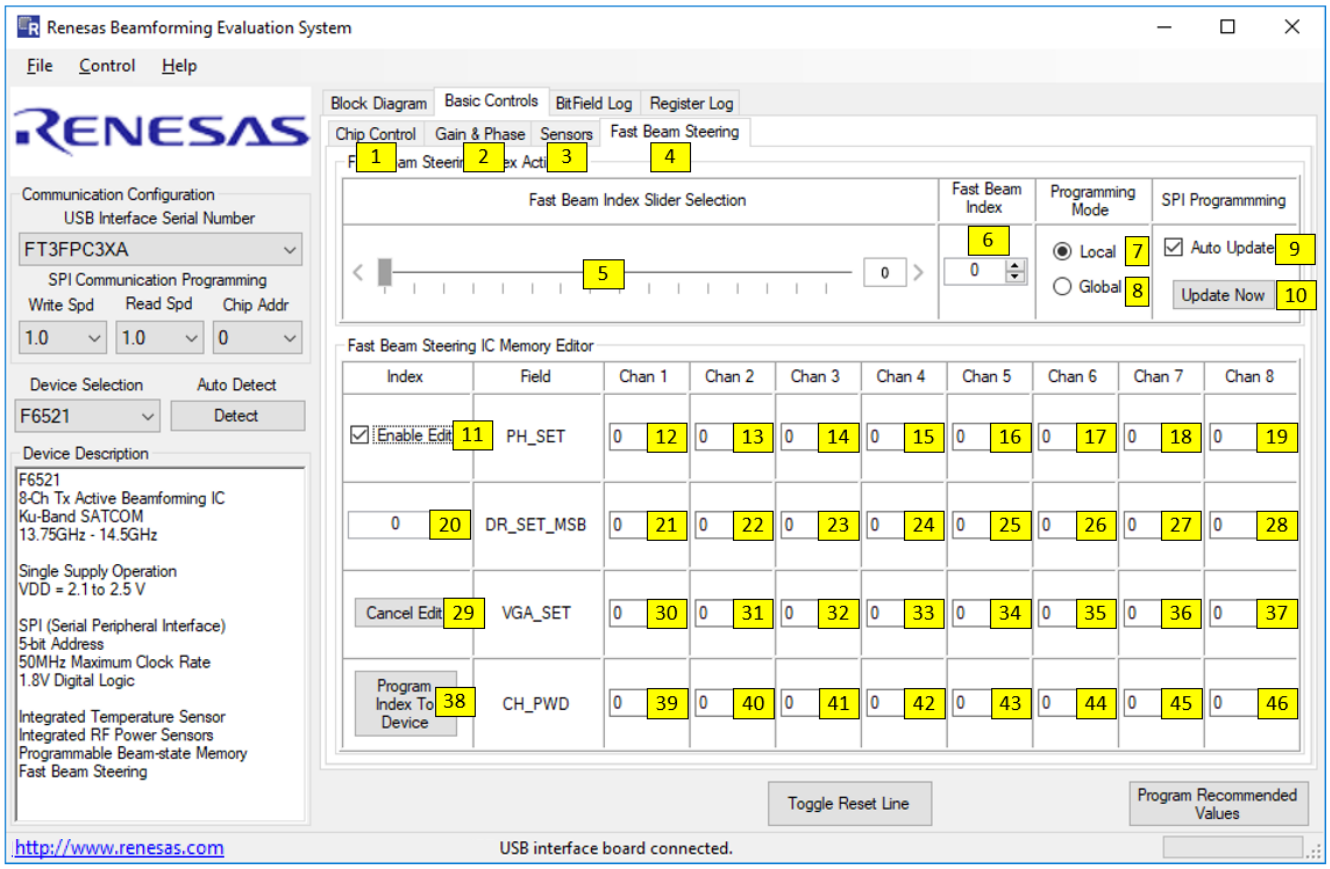


Figure 19. F65xx Evaluation Software – Basic Control View – Fast Beam Steering Control

Table 9. F65xx Evaluation Software – Basic Control View – Fast Beam Steering Descriptions

Item	Function	Description
1	Chip Control Tab	Contains high level power functions for the device.
2	Gain & Phase Tab	Contains individual channel enable/disable controls and gain & and phase controls.
3	Sensors Tab	Contains sensor reading controls for the device.
4	Fast Beam Steering Tab	Contains fast beam steering controls for the device.
5	Fast Beam Steering LUT Index Slider	Selects the active index of the fast beam steering lookup table in the device. The index is programmed into the device immediately when changed if the Auto Update control (Item 9) is checked.
6	Fast Beam Steering LUT Index Entry	Allows the user to directly enter the desired active index of the fast beam steering lookup table in the device. The index is programmed into the device immediately when changed if the Auto Update control (Item 9) is checked.
7	FBS Local Programming Mode	Fast Beam Steering index programming messages are sent to the local device that matches the SPI Chip Address selected on the main panel.
8	FBS Global Programming Mode	Fast Beam Steering index programming messages are sent to all devices on the SPI bus regardless of the SPI Chip Address selected on the main panel or hardware address.
9	Auto Update Checkbox	Checkbox control when checked automatically sends changes to FBS index (from item 5 and item 6) programming messages to the device without having to click on the Update Now button (item 10).
10	Update Now Button	Sends currently selected Fast Beam Steering index programming message to the device based on the selected local and global control.
11	Enable Edit Checkbox	Enables the edit controls to view and change the contents of the Fast Beam Steering lookup table.
12–19	RF Channels 1–8 Phase Entry Textboxes	Individual phase entry (PS_SET_n) for channels 1–8. Valid value range is 0-63.
20	Edit Index Selection Control	Select the index of the Fast Beam Steering lookup table to view / edit. The Edit Enable checkbox must be checked to use this control.
21–28	RF Channel 1-8 Driver Set MSB Entry Textboxes	Individual Driver Set MSB entry (DR_SET_MSB_n) for channels 1–8. Valid value range is 0-3.
29	Cancel Edit Button	This button cancels any in process edit of the fast beam steering index. Any changes to the entries will be lost.
30–37	RF Channels 1–8 VGA Entry Textboxes	Individual VGA entry (VGA_SET_n) for channels 1–8. Valid value range is 0-127.
38	Program Index to Device Button	This button sends the current contents of the PS_SET, DR_SET_MSB, VGA_SET, and CH_PWD controls for channels 1-8 to the device. These values will overwrite the current memory contents. This is a local message and will only update the device that matches the SPI Chip Address front panel control.
39–46	RF Channels 1–8 Power Down Entry Textboxes	Individual VGA entry (CH_PWD_n) for channels 1–8. Valid value range is 0-1.

4.3 Bit Field Log

Figure 31 shows the controls available to the user for F65xx Evaluation Software in the Bit Field Log tab. The Bit Field Log, when enabled, displays all SPI writes that are performed to the register fields. A check box at the bottom of the page (item 8) is used to enable the Bit Field Log. Table 10 provides a description of the Bit Field Log tab components.

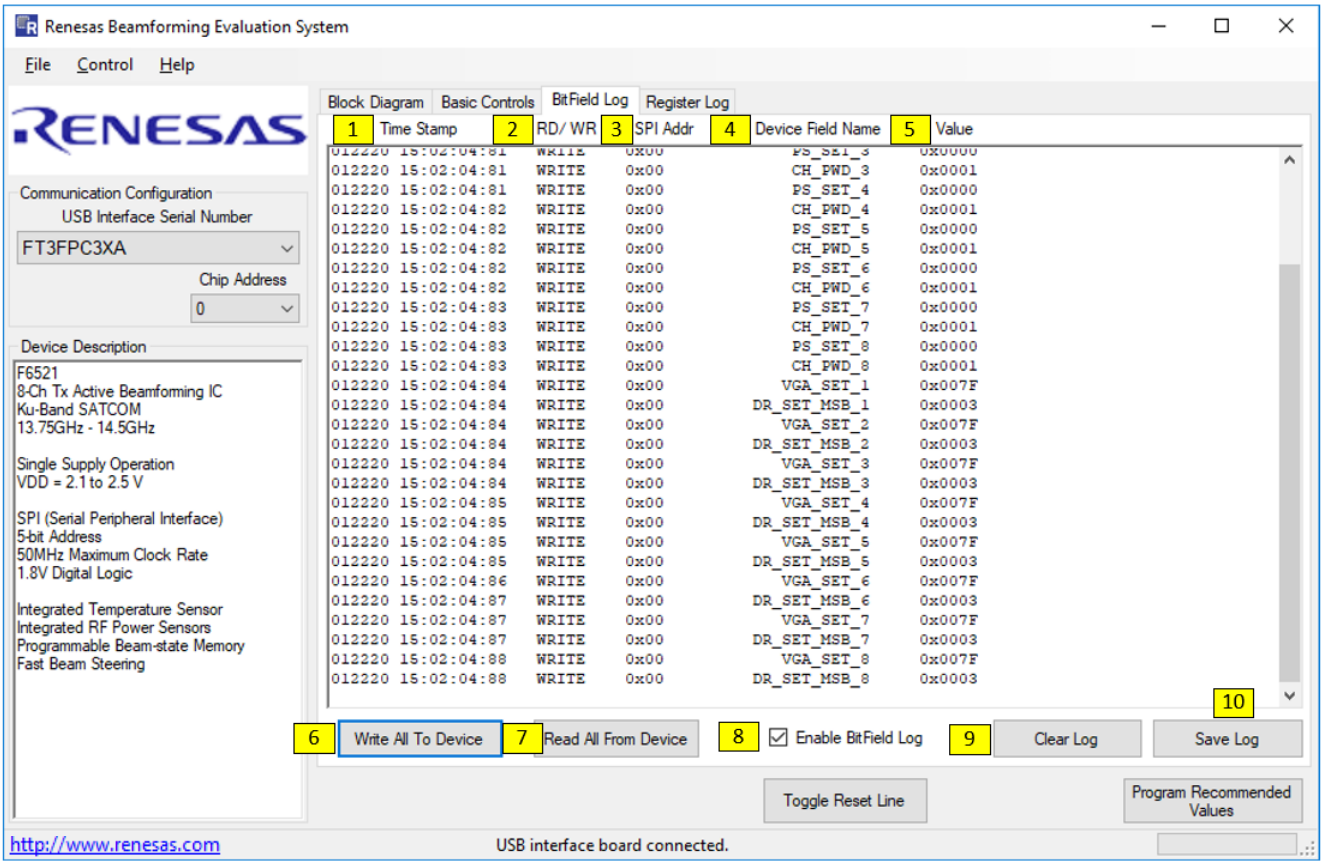


Figure 20. F65xx Evaluation Software – Bit Field Log

Table 10. F65xx Evaluation Software – Bit Field Log Control Descriptions

Item	Function	Description
1	Time Stamp Column	The format of the date column is MMDDYY. The format of the time column is HH:MM:SS:MS where MS is milliseconds.
2	RD / WR Column	WRITE indicates a SPI write command. READ indicates a query of the device register content.
3	SPI Address Column	The 5-bit address that the SPI command was addressed to.
4	Device Field Name Column	The name of the register field that was read or written. Field represents just the portion of a register that was written. Most registers contain multiple bit fields and require bitwise manipulation (bitand, bitor, bitshift) to write a single register. This individual bit field data is presented to aid the user in understanding the programming model.
5	Value Column	The 16-bit hexadecimal value that was written to the bit field. Note not all bit fields are 16-bits wide. The log displays all values in 16-bit hexadecimal format for formatting purposes.

Item	Function	Description
6	Write all to Device Button	Writes all GUI control values to the device and syncs the GUI controls to the programmed values. To write/sync factory recommended settings, use the Program recommended values button. To write/sync hardware default settings to the device, use the Toggle Reset Line button.
7	Read all from Device Button	Updates the GUI control values with the values currently stored in the device. This is only recommended to sync the evaluation software with device.
8	Enable Bit Field Log Checkbox	This control enables the SPI commands being sent to the device to appear in the log window.
9	Clear Log Button	Clears the contents of the log window.
10	Save Log Button	Saves the contents of the log window to a user selected file. Please choose a folder location that the user and scope of the application has permission to save files.

4.4 Register Log

Figure 21 shows the controls available to the user for F65xx Evaluation Software in the Register Log tab. The Register Log tab allows the user to see all SPI writes performed to the chip. Before the log will show any transactions, the log must be enabled with a check box at the bottom of the page (item 8). Table 11 provides a description of the Register Log tab window components.

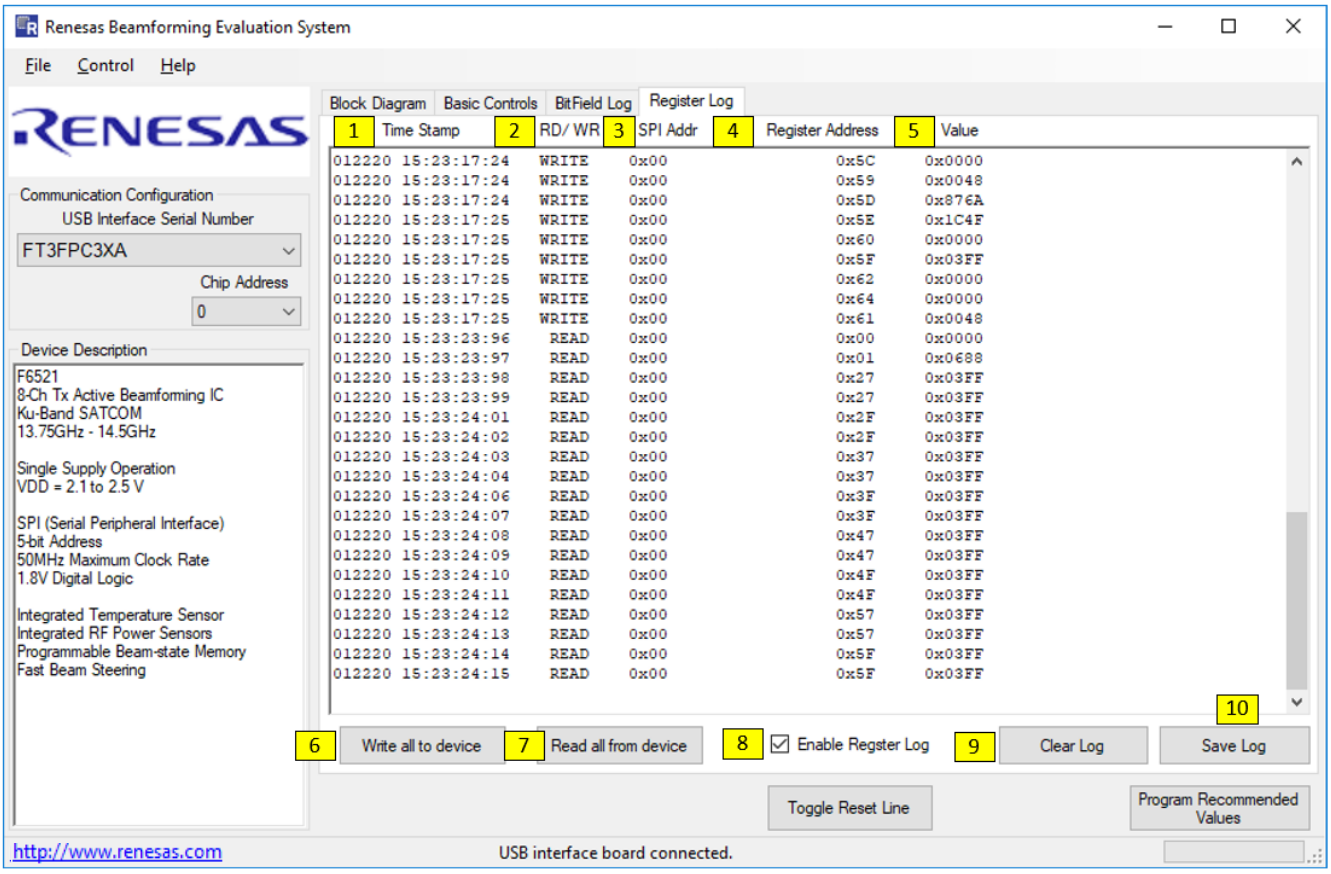


Figure 21. F65xx Evaluation Software – Register Log

Table 11. F65xx Evaluation Software – Register Log Tab Description

Item	Function	Description
1	Time Stamp Column	The format of the date column is MMDDYY. The format of the time column is HH:MM:SS:MS where MS is milliseconds.
2	RD / WR Column	WRITE indicates a SPI write command. READ indicates a query of the device register content.
3	SPI Address Column	The 5-bit address that the SPI command was addressed to.
4	Register Address Column	The hexadecimal address of the register that was read or written.
5	Value Column	The 16-bit hexadecimal value that was written to the register. The log displays all values in 16-bit hexadecimal format for formatting purposes.
6	Write all to Device Button	Writes all GUI control values to the device and syncs the GUI controls to the programmed values. To write/sync factory recommended settings, use the Program recommended values button. To write/sync hardware default settings to the device, use the Toggle Reset Line button.
7	Read all from Device Button	Updates the GUI control values with the values currently stored in the device. This is only recommended to sync the evaluation software with device.
8	Enable Bit Field Log Checkbox	This control enables the SPI commands being sent to the device to appear in the log window.
9	Clear Log Button	Clears the contents of the log window.
10	Save Log Button	Saves the contents of the log window to a file of the users choosing. Please choose a folder location that the user and scope of the application has permission to save files.

4.5 Menu Selections

4.5.1 File Menu

The Evaluation software File Menu offers several choices to load and save device settings files, load custom gain Mapping Tables, and to exit the software application. Refer to Figure 33 and Table 12 for detailed information on the use of the menu.

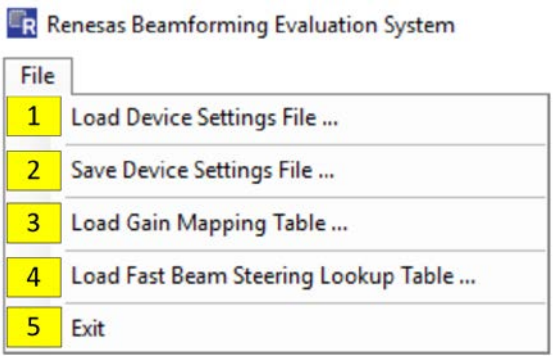


Figure 22. Evaluation Software File Menu

Table 12. Evaluation Software – File Menu Items

Item	Function	Description
1	Load Device Settings File …	Allows user to select and load a read-only settings file containing the device bit field values to program to the device under test. Refer to **Error! Reference source not found.** for a sample dialog box.
2	Save Device Settings File …	Allows the user to save all of the bit field values associated with the currently programmed state of the device to a user selected settings file (**Error! Reference source not found.**). This file is not editable by the user.
3	Load Gain Mapping Table …	Allows the user to load (**Error! Reference source not found.**) a Mapping Table file containing the gain control values 0-127 and the corresponding values of the DR_SET_MSB and VGA_SET register fields.
4	Load Fast Beam Steering Lookup Table …	Allows the user to load (**Error! Reference source not found.**) a Lookup Table file containing 128 indexes of PS_SET, DR_SET_MSB, VGA_SET, and CH_PWD for 8 channels to be used in a phased-array mode. These indexes are stored on chip for fast retrieval with a low bit count SPI message.
5	Exit	Closes the application. A confirmation dialog is presented.

4.5.1.1 Load Device Settings File

The Load Device Settings File menu option will open a file dialog that allows the user to select a device settings file that restores bit field values in the device under test. The evaluation software installs a default settings file for the F65xx. Refer to Figure 23 for the details of the dialog box.

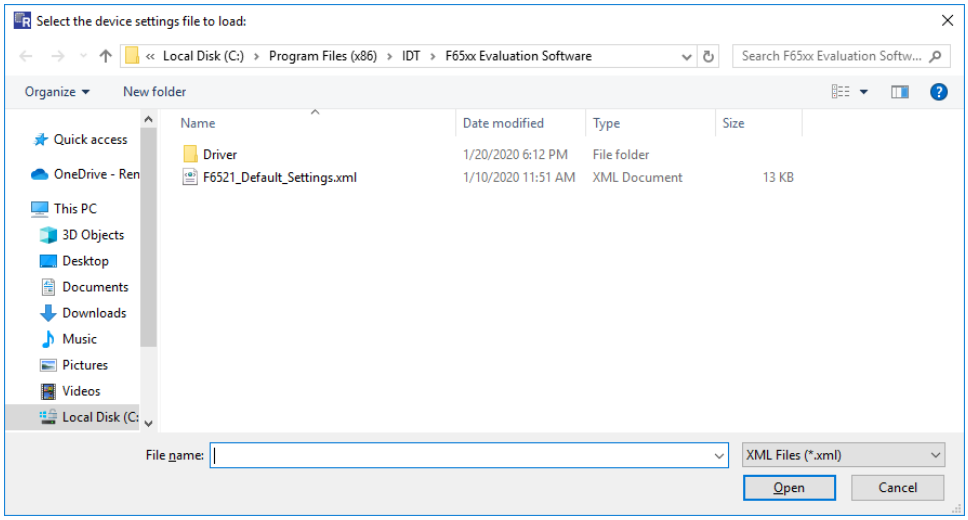


Figure 23. File Menu – Load Device Settings File Open Dialog

4.5.1.2 Save Device Settings

The save device settings file menu option will open a file dialog that allows the user to name a file an choose a directory for the settings file that can restore bit field values currently set in the device under test. Note the user must have write privileges in the directory selected. Refer to Figure 24 for the details of the dialog box.

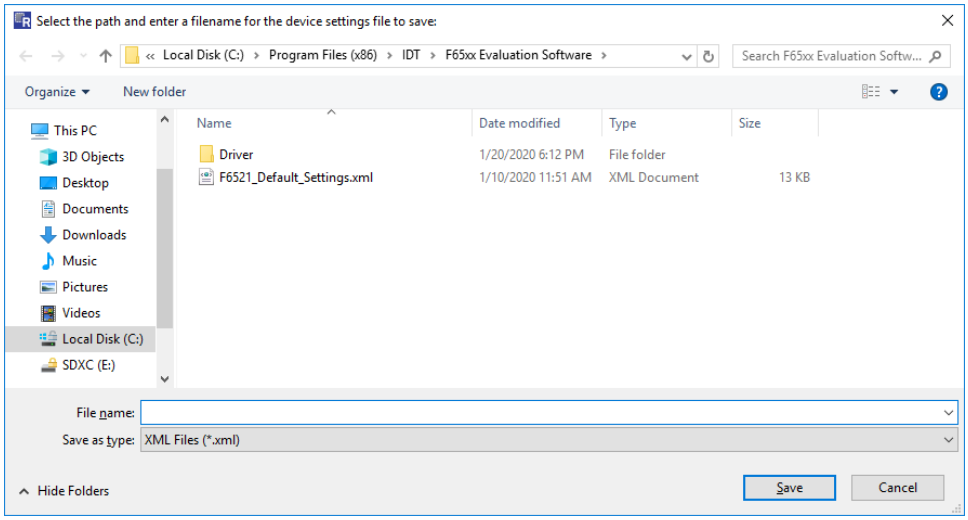


Figure 24. File Menu – Save Device Settings File Save Dialog

4.5.1.3 Load Gain Mapping Table

The Load Gain Mapping Table file menu option will open a file dialog that allows the user to select a Mapping Table file (.csv) that contains an ordered subset of the 512 available gain states that get associated with the 128-value Gain Control Sliders. Users are encouraged to examine these files to understand the programming model of the device. The evaluation software installs a default Gain Mapping Table file for each supported device – F6513, F6521, and F6522. Refer to Figure 25 for the details of the dialog box.

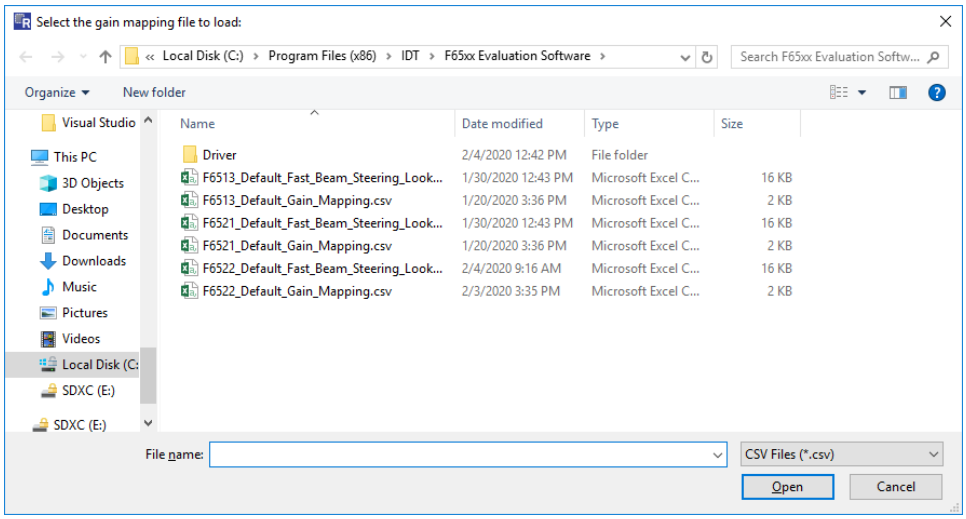


Figure 25. File Menu – Load Gain Mapping Table File Open Dialog

4.5.1.4 Load Fast Beam Steering Lookup Table

The Load Fast Beam Steering Lookup Table file menu option will open a file dialog that allows the user to select a lookup table file (.csv) that contains 128 sets of values for phase, driver MSB, VGA, and power down bits for 8 RF channels. Users are encouraged to examine these files to understand the programming model of the device. The evaluation software installs a default gain lookup table for the F6513, F6521, and the F6522. For the details of the dialog box, see Figure 26.

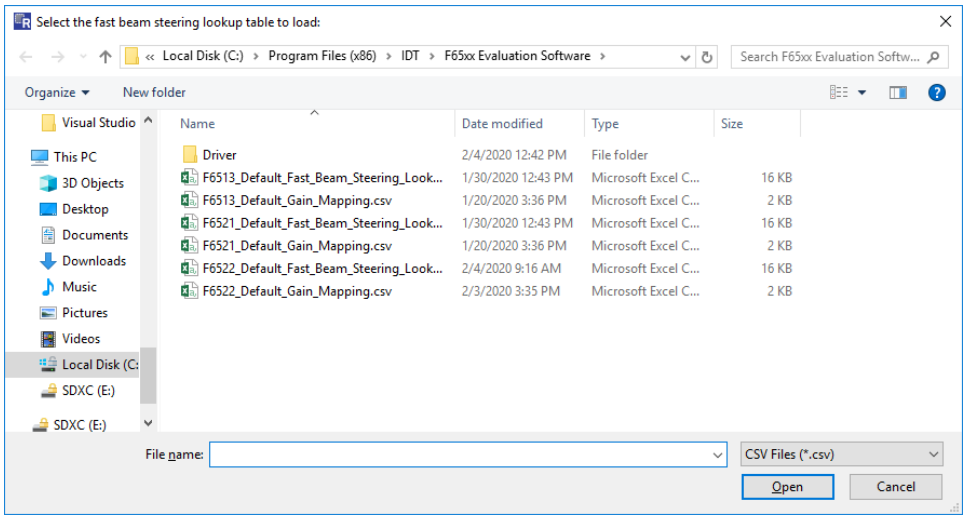


Figure 26. File Menu – Load Fast Beam Steering Lookup Table File Open Dialog

4.5.1.5 Exit

The Exit menu item allows the user to exit the software application.

4.5.2 Evaluation Software Control Menu

The Control menu shown in Figure 27 allows the user to change the behavior of the evaluation software SPI programming. Refer to Table 13 for details.

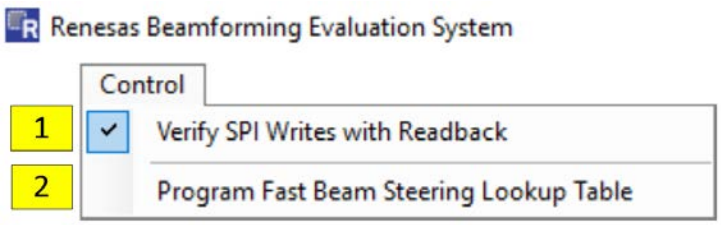


Figure 27. Control Menu – Verify SPI Writes

Table 13. F65xx Evaluation Software – Control Menu Items

Item	Function	Description
1	Verify SPI Writes with Readback Menu Item	Clicking on “Verify SPI Writes with Read back” will toggle the check mark to change states. SPI writes to device are verified by an immediate read when the check mark is shown. Mainly used or speed reasons.
2	Program Fast Beam Steering Lookup Table Menu Item	Clicking on “Program Fast Beam Steering Lookup Table” will program the Fast Beam Steering Lookup table to the device matching the SPI address selected on the front panel.

4.5.3 Help Menu

The Help menu shown in Figure 28 allows the user to see very basic help documentation embedded in the application itself. The help is not a replacement for this user guide, but useful when this guide is not available. Refer to Table 14 for details on each menu choice.

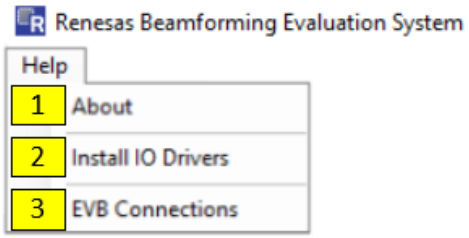


Figure 28. Evaluation Software Help Menu

Table 14. F65xx Evaluation Software – Help Menu Items

Item	Function	Description
1	About Menu Item …	Menu item that opens a message box showing the version of the evaluation software.
2	Install IO Drivers Menu Item	Menu item that opens a new window with abbreviated help to walk the user through installing the USB FTDI Drivers for the Digital Interface Board.
3	EVB Connections Menu Item	Menu item that opens a new window with abbreviated help to walk the user through making the connections to the evaluation board. However, please consult the latest user guide if available.

5. Evaluation Software Quick Start

The following procedure should be used to initialize the F65xx with the Evaluation Software in preparation for a measurement. This example will enable RF Channel 1.

1. Verify the power supply is set for 2.3V and disabled. It is recommended to measure the output voltage with a DMM prior to connecting the Evaluation System power supply cable.
2. Connect the evaluation board with the recommended connections. Refer to section 3.
3. Enable the power supply to begin sourcing 2.3V.
4. Launch the F65xx Evaluation Software. Refer to **Error! Reference source not found.**.
5. Verify the Digital Interface Board is detected. Refer to item 18.
6. Reset the F65xx by clicking on the “Toggle the Reset Line” Refer to item 16. Confirm that you want to reset the device with the hardware reset pin by clicking “Yes”.

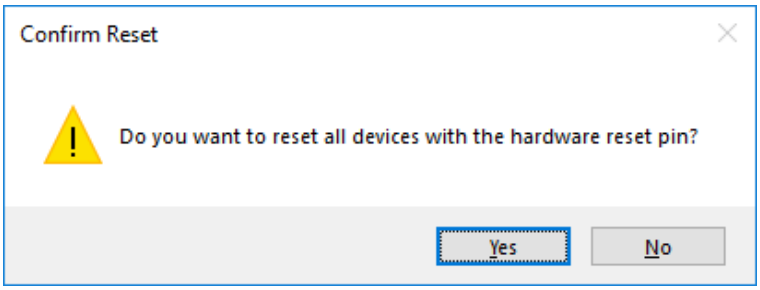


Figure 29. Evaluation Software Reset Confirmation Dialog Box

After the reset is complete, the GUI will ask if you would like to program the default values. Click “Yes”, then dismiss the programming complete dialog box. Alternatively, you can skip the programming via the reset button by clicking “No” then program the F65xx device by clicking the “Program the recommended values” button. Refer to item 17. Wait for the progress bar to indicate complete (refer to item 19).

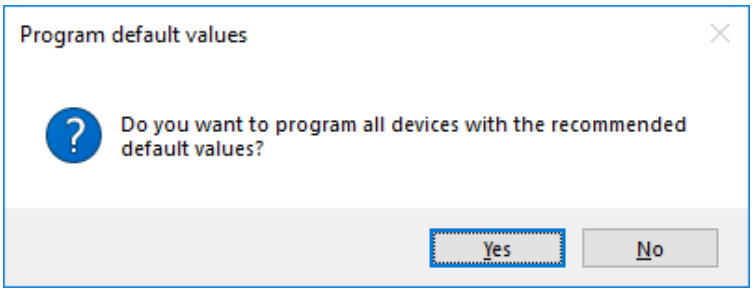


Figure 30. Evaluation Software Post Reset Programming Confirmation Dialog Box

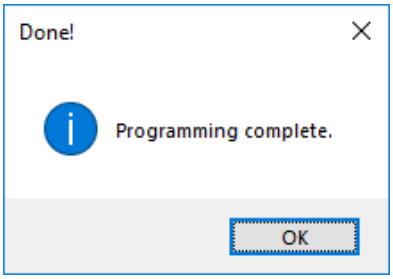


Figure 31. Evaluation Software Post Programming Notification

7. On the Basic Control tab page, the Chip Control sub tab page, verify that the shutdown control is disabled (no check mark). Refer to Figure 16, item 5.
8. On the Basic Control tab page, the Chip Control sub tab page, verify that the RF Channel Enable control is enabled (check mark visible). Refer to Figure 16, item 6.
9. On the Basic Control tab page, the Gain & Phase sub tab page, verify that the Channel 1 Enable control is enabled (check mark visible). Refer to Figure 17, item 7.
10. Verify the current drawn is ~27mA.
11. Proceed with measurements on the VNA.

6. Gain Mapping Table File Format

The Evaluation Software uses a .csv file format (comma separated values). The Mapping Table (Table 15) is designed to give monotonically increasing gain control versus increasing code value with a uniform step size. This is done by sorting and ordering a subset (128) of the 512 gain control states available.

The F65xx uses two bit fields for gain control: VGA_SET_n (7-bits) and DR_SET_MSB_n (2-bits), where n is the channel number (1–8), resulting in 512 (9-bits) of gain control. In performing array calibration, Mapping Tables can be created for different channels at select frequencies and temperatures to minimize RMS phase errors. Refer to Table 15 and Figure 32. Gain Mapping Table Example for details and a sample Mapping Table.

Any line beginning with “//” or “#” are considered comment lines and will be ignored by the import tool. A comma will separate the columns of the table per the .csv file specification.

The Evaluation software currently applies one Mapping Table to all channels of the F65xx. The entire table must be populated, partial tables are not permitted.

Table 15. Gain Mapping Table File Format

Column	Description
1	Table Index (0–127) used by the GUI Slider Control.
2	VGA_SET_n value (0–127) programmed to the F65xx register.
3	DR_SET_MSB_n value (0–3) programmed to the F65xx register.

	A	B	C
1	//Index	VGA_SET	DR_MSB_SET
2	0	0	0
3	1	2	0
4	2	3	0
5	3	6	0
6	4	7	0
7	5	9	0
8	6	11	0
9	7	12	0
10	8	14	0
11	9	15	0

Figure 32. Gain Mapping Table Example

7. Fast Beam Steering Lookup Table (LUT) File Format

The Evaluation Software uses a .csv file format (comma separated values). The Fast Beam Steering Lookup Table (Table 16) is designed to give the user the ability to generate a table offline that is then programmed to the on-chip memory for use with the Fast Beam Steering Mode of the device. This mode allows for rapid cycling through the 128 beam states.

The F65xx uses four fields for each lookup table index: PS_SET_n (6 bits), DR_SET_MSB_n (2-bits), VGA_SET_n (7-bits), and CH_PWD_n(1 bit), where n is the channel number (1–8). PS_SET controls the phase, DR_SET_MSB and VGA_SET control the gain, and CH_PWD enables or disables the channel.

The lookup table values are typically chosen to achieve the desired beam characteristics (pointing angle, shape, sidelobe level, etc.). These values should combine the theoretical phase and gain values required to steer a beam with the phase and gain offsets obtained from array calibration in order to compensate for channel-to-channel variation over temperature and frequency.

In the .csv file defining the LUT values to be programmed to the chip, any line beginning with “//” or “#” are considered comment lines and will be ignored by the import tool. A comma will separate the columns of the table per the .csv file specification. The Evaluation software currently applies the table to a single device. The entire table must be populated; partial tables are not permitted.

Table 16. Fast Beam Steering Lookup Table File Format

Column	Description
1	Table Index (0–127) used by the F65xx device lookup table.
2	RF Channel (1–8) used by the F65xx device lookup table.
3	PS_SET_n value (0–63) programmed to the F65xx re device lookup table.
4	DR_SET_MSB_n value (0–3) programmed to the F65xx device lookup table
5	VGA_SET_n value (0–127) programmed to the F65xx device lookup table.
6	CH_PWD_n value (0–1) programmed to the F65xx device lookup table.

	A	B	C	D	E	F
1	//Index	Channel	PS_SET	DR_MSB_S	VGA_SET	CH_PWD
2	0	1	0	0	0	0
3	1	1	0	0	2	0
4	2	1	0	0	3	0
5	3	1	0	0	6	0
6	4	1	0	0	7	0
7	5	1	0	0	9	0
8	6	1	0	0	11	0
9	7	1	0	0	12	0
10	8	1	0	0	14	0
11	9	1	0	0	15	0
12	10	1	0	0	17	0
13	11	1	0	0	19	0
14	12	1	0	0	21	0
15	13	1	0	0	23	0
16	14	1	0	0	24	0
17	15	1	0	0	26	0
18	16	1	0	0	27	0
19	17	1	0	0	29	0
20	18	1	0	0	33	0

Figure 33. Fast Beam Steering Lookup Table Example

8. Revision History

Revision	Date	Description
1.03	Oct 24, 2023	▪ Updated digital interface board and connections. ▪ Reformatted document to the latest template.
1.02	Mar 15, 2021	Updated to reflect F65xxS EVB hardware.
1.01	Feb 11, 2020	Updated for release targeting software release 0.2.0.0
1.00	Jan 27, 2020	Initial release.