QUICK START GUIDE

SV6E-X

Mid-Frequency Digital Test Module

E SERIES

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Table of Contents

Introduction

OVERVIEW

The SV6E-X is an all-inclusive solution for mid-frequency digital interface development and test. Capable of supporting popular protocols such as I2C, I3C, SPI, SoundWire, and RFFE, this module replaces racks of equipment that are typically required for I/O testing. For any given protocol, the SV6E-X contains three instruments in one: a protocol exerciser, a protocol analyzer with fine-resolution timing analysis, and a real-time oscilloscope, currently with a suite of conformance test capability for I3C.

All three categories of instrumentation features are accessible simultaneously using the award-winning Pinetree software.

QUICK START DOCUMENTATION

This Quick Start Guide will provide the information required for a user to get up and running with the SV6E-X Mid-Frequency Digital Test Module. Basic hardware and software installation instructions are included followed by a step-by-step procedure to start sending and manipulating MIPI I3C commands using Pinetree. Note that the I3C PurVue Analyzer is not covered in this guide.

Quick Start Hardware Description

REQUIREMENTS

The full list of hardware required for this Quick Start Guide is provided below:

- 1 x SV6E-X Mid-Frequency Digital Test Module
- 1 x 12V, 5A DC power supply (Manufacturer: CUI, Part # SDI65-12-UDC-P5)
- 2 x Male to male jumper wires
- 1 x Personal computer connected to the SV6E-X through a USB 2.0 cable and USB 3.0 cable

HARDWARE DESCRIPTION

The following figure shows a diagram of the physical ports of the SV6E-X module.

Figure 1: Ports of the SV6E-X module.

If you have previously used Introspect's SV4E-I3C Test and Debug Module which included an external adapter, note that the SV6E-X does not have an adapter. Instead, the adapter has been replaced with two (2) voltage banks: Bank A and Bank B. Bank A ranges from 0.8V to 2V, and Bank B ranges from 2V to 3.6V.

The module supports four (4) devices which you may either allocate on Bank A or Bank B, depending on the selected I3C bus voltage. Every device core has 2 pins: SCL (clock line) and SDA (data line). The SV6E-X Operates with USB 2.0 and USB 3.0 for analog capture and data capture (faster transmission with USB 3.0) – plugged in simultaneously.

Next, there are two sets of GPIOs. The first GPIO set is powered by the same voltage as Bank A, and the second set is powered by the same voltage as Bank B.

If you want to use two internal devices on Bank A, you could instantiate a controller on Port 1 and a target on Port 2. Then connect both devices by connecting SCL1 to SCL2 and SDA1 to SDA2. This Quick Start Guide will take you through this sequence, under the 'SV6E-X Demonstration' section below.

Figure 2: Illustration of the connection between controller device on Port 1 to target device on Port 2.

Pinetree Installation

SYSTEM REQUIREMENTS

Introspect's software, Pinetree, provides an easy-to-use environment for device characterization and test plan development. To run the software, the following components are required:

- A PC installed with Windows 10 or later
- The Pinetree install executable
- USB device drivers (refer to the driver installation instructions)

INSTALLING PINETREE

1. PREPARE FOR INSTALLATION

Quit any Pinetree sessions before starting the installation.

2. INSTALL SOFTWARE

a) From the directory containing the installation files, double-click on the icon for "IntrospectESP_Installer.exe" and follow the instructions on the screen.

b) The installer will install a local Python environment, and it has no dependence on any Python installation that already exists on your PC.

c) When prompted, specify the location where you want to install the Pinetree application. (Note that this must be a new location, not a location of a previous installation). The default location is the "Introspect" folder under the Windows "Program Files" folder. The application will be installed into a sub-folder with a name that includes the version number. The application will also create a folder called "Introspect" under the "My Documents" folder of your account. This folder is where test procedures are typically stored.

3. INSTALL LICENSE FILE

a) Towards the end of the installation, you will be asked to provide either an activation key or a license file for the software.

b) If you have a valid activation key, simply select the "Use Activation Key" option, and continue with the installation. You will be asked to enter the Activation Key code later when you start the GUI for the first time.

c) If you were provided with a license file instead, or if you have valid license files from a previous installation, select the "Use Existing License" option, and the installer will help you copy the license file into the new installation folder.

d) If you do not have any of the above, select the "Get a New License" option, and the installer will provide you with information that needs to be sent to Introspect Technology customer support. Before continuing, you will need to send this information to license_support@introspect.ca to request a license. Then, upon receipt of the valid license files, place them into the following directory:

```
C:\[Your Introspect Installation Folder]\Licenses
```

NOTE

The installer creates a folder called "Introspect" under the "My Documents" folder of your Windows account. This folder is where test procedures are saved by default.

4. RUN PINETREE

a) Double-click on the "Pinetree" shortcut on your desktop and you should see the first "welcome" window of the GUI.
Specify the hardware as "SV6E_I3C_EXERCISER" and Press "Next" to continue.

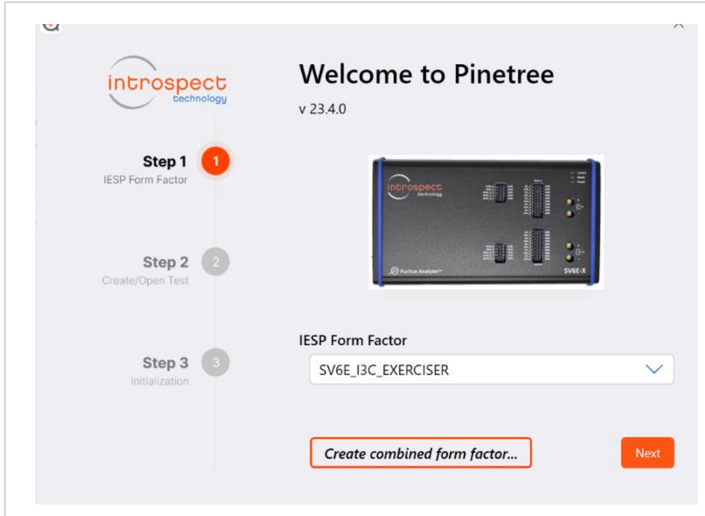


Figure 3: Pinetree welcome window.

b) Select the option "Create a new Test" and click the "Next" button.

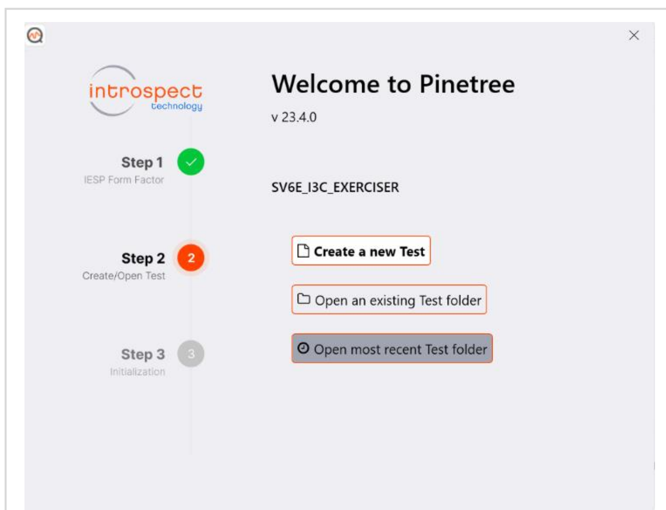


Figure 4: Prompt for creating a new test.

c) With a valid license in the “Licenses” directory, the following GUI screen should come up, which indicates that Pinetree has been successfully installed.

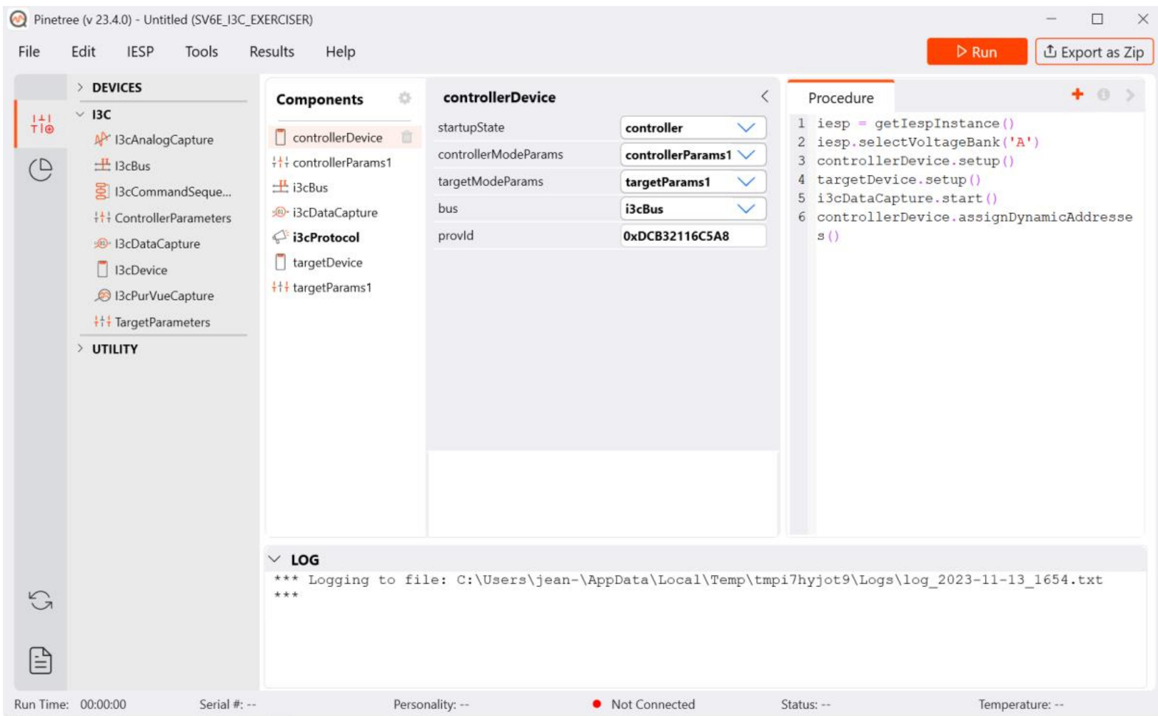


Figure 5: SV6E_I3C_EXERCISER window in Pinetree.

FURTHER DOCUMENTATION

The “[IntrospectESP_install_dir]\Doc” folder contains the following information on the software:

“IntrospectESP_UserManual.pdf” is the user manual for Pinetree and is recommended reading for all users.

“svt.html” and “iesp.html” provide documentation on the Python component classes and lower-level functions specific to the selected form factor. Both files can be found in

"<iESP_inst_dir>\Doc\FormFactors\SV6E_I3C_EXERCISER". These are intended for intermediate and advanced users.

NOTE

Both the user manual and the above html files are also conveniently available from the "Help" drop down menu located on the top right corner of the main Pinetree window.

"Application Notes" can also be found in the "[IntrospectESP_install_dir]\Doc" sub-folder and have more advanced features, often in the form of tutorials.

USB Driver Installation

The following procedure will allow for automated driver installation.

HARDWARE SETUP

For this procedure, connect the SV6E-X to the PC via the USB cables as shown in the figure below, and power on the module. To allow for driver installation, the PC should be connected to the internet as well.

Figure 6: Diagram of the SV6E-X and PC setup.

WAIT FOR THE PC TO DETECT THE NEW HARDWARE

The PC should display the message “New drivers successfully installed” once the installation process is complete. If this does not occur, see the troubleshooting notes at the end of this section.

VERIFY DRIVER INSTALLATION

a) If it is not yet open, launch Pinetree and select the “SV6E_I3C_EXERCISER” form factor. From the main GUI window, click the “IESP” drop down menu and click “Connect”, as shown in Figure 7. Establishing the connection should take a couple of seconds.

b) To verify the connection, click the “IESP” drop down menu and select “ConnectionConfig”. A dialog window should confirm that the SV6E-X module is connected.

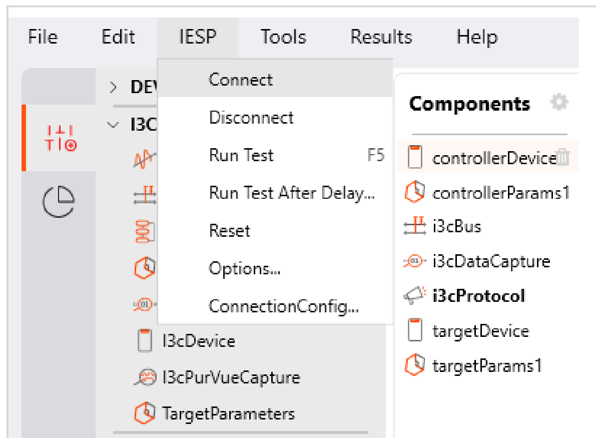


Figure 7: Selecting ConnectionConfig from the IESP drop down menu.

TROUBLESHOOTING

If the connection cannot be established, or if the drivers cannot be found or automatically installed, please refer to the “FTDI Driver Manual Installation” Appendix at the end of this document to install the required drivers.

SV6E-X Demonstration

STEP-BY-STEP GUIDE: ASSIGNING DYNAMIC ADDRESSES AND SENDING DIRECT READS

The following step-by-step guide will allow the user to assign a dynamic address to an I3C target device and send it a direct read command from a controller device inside the SV6E-X. It will also demonstrate how to visualize the response from the target and the I3C bus activity, using the mipiI3cDataCapture functionality of the SV6E-X module. The following procedure is intended to provide an overview of how to use the Pinetree GUI and highlight several of the GUI's features.

1. CONNECT THE HARDWARE COMPONENTS

For this procedure, select the voltage bank of interest, depending on the required I3C bus voltage. In this test, we are going to be running at 1.2V, so connecting devices on Bank A. Connect the controller device on SV6E-X Port 1 to the target device on Port 2 by connecting SCL1 to SCL2 and SDA1 to SDA2, as well as connecting the ground wire.

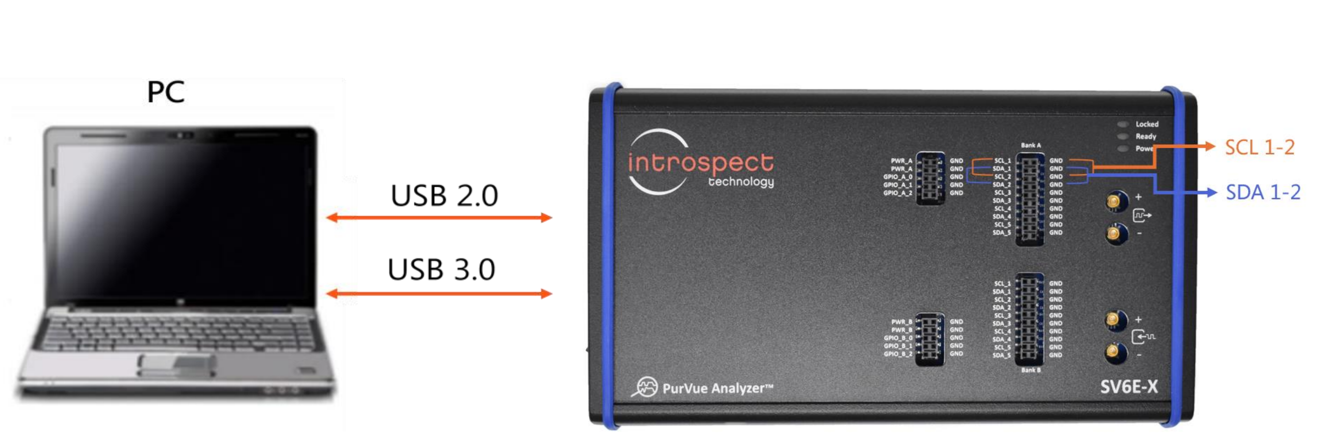


Figure 8: SV6E-X connecting to a PC.

2. FAMILIARIZE YOURSELF WITH THE PINETREE GUI

a) Double click on “Introspect.ESP” located in the Pinetree GUI installation folder and select form factor “SV6E_I3C_EXERCISER”. At this point, connect the SV6E-X Mid-Frequency Digital Test Module to your PC via the USB cable if this is not already done.

b) Select the “IESP” pull-down menu and click on the “Connect” option if you have not done so already in the previous USB driver installation procedure. Establishing connection should require a couple of seconds.

c) At the very bottom of the GUI, you should be able to verify the connection to the SV6E-X unit by observing the connection status, serial number of the connected unit, and the firmware version on the unit. See Figure 9. Note that the firmware version may differ from what is shown below.

Figure 9: Bottom of Pinetree GUI showing serial number, firmware version, and connected status.

d) When started in the SV6E_I3C_EXERCISER form factor, the GUI contains a default script in the test procedure window and seven pre-populated components in the “Components” windowpane of the “Params” tab, as shown in the screenshots on the following page. As shown in Figure 10, the procedure must start by specifying the selected voltage bank, by using method iesp.selectVoltageBank(‘A’). By default, the voltage bank A is set to Bank A, but you could change it to Bank B, if needed. When the default script is executed, the controllerDevice.setup() and targetDevice.stetup() methods configure a controller device and a target device onto the I3C bus. Additionally, the i3cDataCapture.start() will start a bus capture.

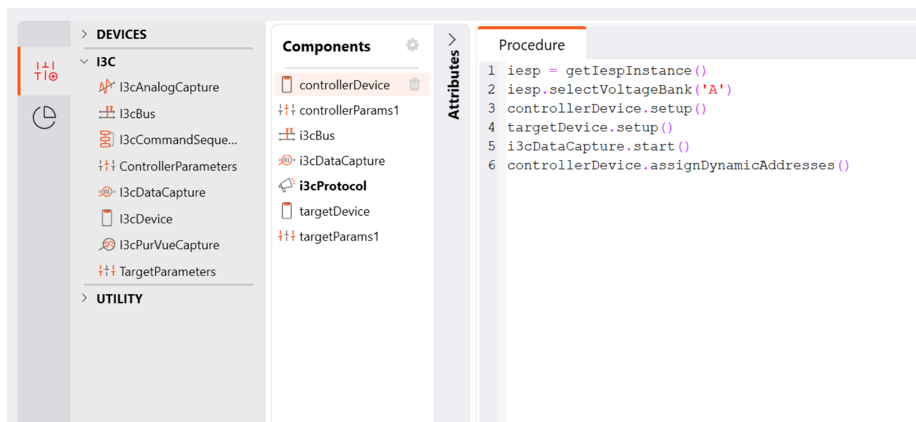


Figure 10: testProcedure commands.

e) By default, the "Components" windowpane contains a controller device (controllerDevice), and a target device (targetDevice). Note that each device can act as either a target, a controller, or be offline on start-up, and this is specified by the 'startupState' attribute under the device component. The SV6E-X can support up to four devices that can be connected in a multi-bus configuration, which means you may connect each device on either a different bus or the same bus. Since I3C is a multi-controller topology, it is possible to have multiple controllers on the same bus, but each bus must have only one 'active' controller at a time that manages the bus.

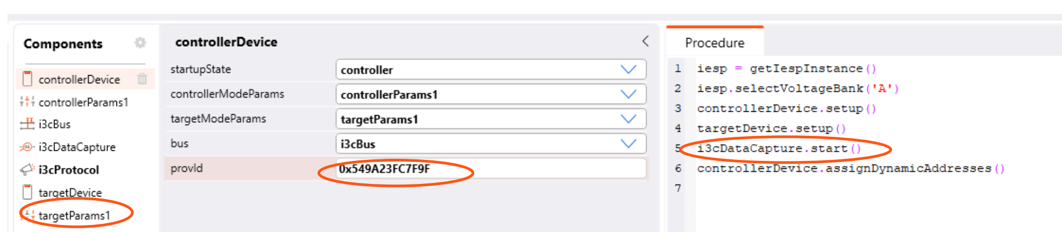


Figure 11: Provisional ID of the target device.

f) Figure 11 shows an example on the target device component. Every device is associated with a unique 6-byte provisional ID, which is set using the provId attribute on the I3C device component. The provisional ID may be edited, however, in this demo it is set to 0x549A23FC7F9F as below. To use this device as a target device on start-up, select the new component from the "Component" windowpane and ensure the startupState value is set to "target".

g) The behavior of the controller will be configured using the "controllerParams1" and the behavior of the target device will be configured using the values defined in "targetModeParams1". Each device parameter can either be manually changed under the 'param' window or within the test procedure. An update() method must be called on the device, if modified in the script, for the new parameter to take effect. Every device, whether a controller or a target, can have both "controllerParams1" and "targetParams1". Since the SV6E-X supports controllership role requests, this feature facilitates a seamless controllership role exchange between a controller and a target device.

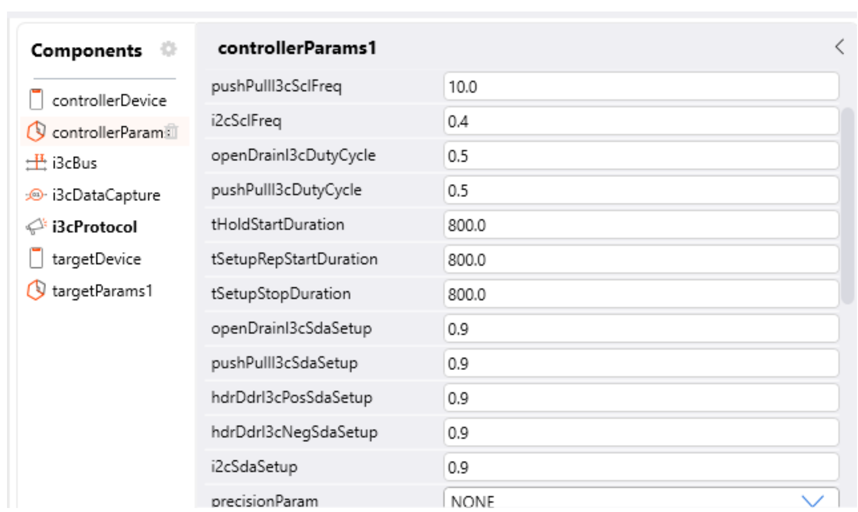


Figure 12: ControllerParams1 attributes.

h) Observe also the i3cBus component. This component specifies the list of ports which may be connected to the named bus. An assignment of a port on a bus occurs when a device is set up within a test (when either a “controllerDevice.setup()” or “targetDevice.setup()” is executed, as later in this document). The device port assignment happens in sequence depending on which device gets setup first. In this example, the “controllerDevice” gets the first port on the bus.

The i3cBus component also specifies the highVoltage level for SCL and SDA. This voltage is a global setting and affects all ports on the i3cBus component.

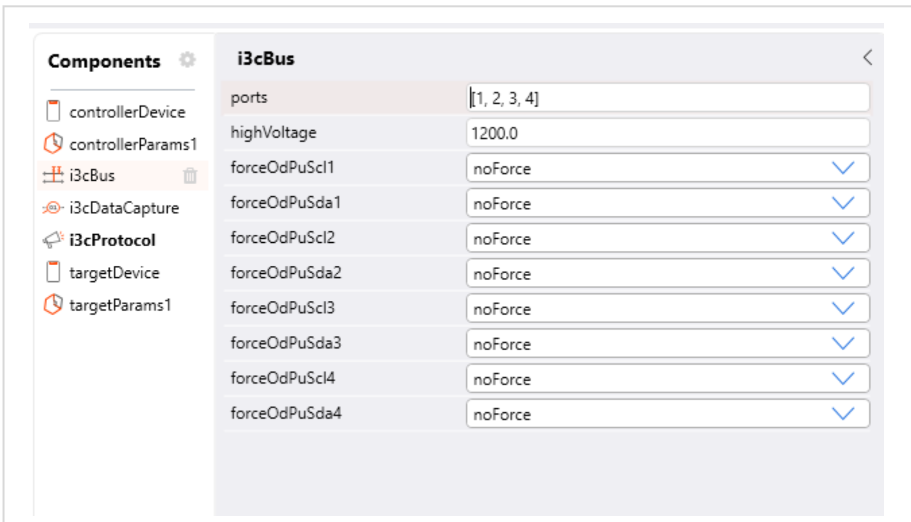
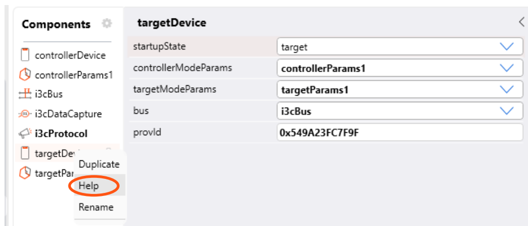


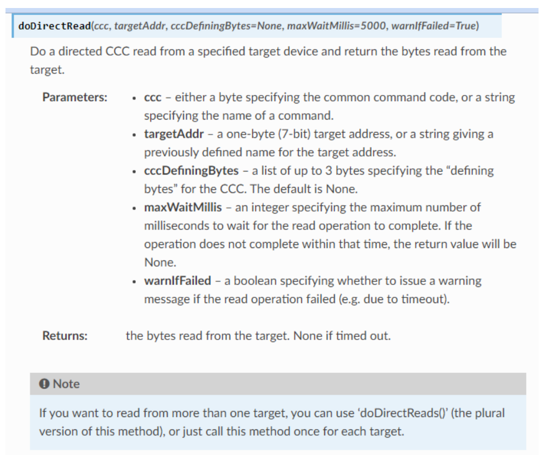
Figure 13: i3cBus attributes.

i) The best way to find further information on components and formats is to "**right click**" on the component and open the pop-up help file. Figure 14 below shows how to obtain help for a "doDirectRead" from the I3C controller device.



(a)

(b)



(c)

Figure 14: (a) Pinetree's help command (b) doDirectRead() method shown in Help page (c) doDirectRead() description in Help.

The example which follows implements a direct read, as documented above.

3. EDITING THE TEST PROCEDURE

Now that all the necessary components have been added to the test procedure, you are ready to send your first I3C commands using the SV6E-X module. The example below will demonstrate how to set a dynamic address to a target device, read back the address, and then perform a direct read of the target's provisional ID.

a) First, navigate to the bottom of the "Test Procedure" pane and notice that there are already three commands in the editor (as shown in Figure 10). The first one, controllerDevice.setup(), is used to initialize the controller device, which is already in the script by default. The second one, targetDevice.setup(), is used to initialize the target device we added in the previous section. Finally, the third one, i3cDataCapture.start(), is used to start the capture of the I3C bus waveform and its analysis.

b) The procedure starts by assigning a dynamic address, then targetDevice.getDynamicAddress() could be added to return the dynamic address that has been assigned to the Target. Simply add the following lines to the "Test Procedure" editor pane situated at the bottom of the main GUI window:

```
#Get the target's newly assigned dynamic address through software
print("Reading addresses of individual devices on bus...")
myTarget = targetDevice.getDynamicAddress()
print("targetAddr: 0x%02X " % (myTarget))
```

For more details on how to use these and other available methods, please consult the "Help" pull-down menu entry from the main Pinetree GUI window, or **"right click"** on the component in question in the component window to open the pop-up help file, as described previously.

If you click the “Run” button at the bottom of the GUI window, Pinetree will execute the script. Switch to the “Log” tab, where you will see the messages from your test procedure, as shown in the image below. Here, the target device was assigned address 0x08.

```
LOG
--------------------------------------------------------------------------------
*** Starting Test 'Untitled'
2024-06-03_1440_04
--------------------------------------------------------------------------------
controllerDevice assigned to port 1
targetDevice assigned to port 2
i3cDataCapture: Starting Data Capture on bus 'i3cBus'
Reading addresses of individual devices on bus...
targetAddr: 0x08
i3cDataCapture: Doing auto-stop at end of Test Procedure
Test finished
Test took 4.2 seconds
--------------------------------------------------------------------------------
```

Figure 15: testProcedure Log.

c) Since you have previously enabled the data capture component, you can visualize the I3C commands sent to the target device to assign a dynamic address to it. To do so, navigate to the “Results” tab at the top of the GUI window, select the most recent run result and double click the “i3cDataCapture” data capture icon. The data capture viewer is divided in three tabs: “PHY”, “I3C States” and “Transactions” and will allow you to see and visualize all of the bus activity.

d) The **“PHY”** tab shows the different physical states of the I3C bus during the run. A new entry will be added to this tab every time the I3C bus changes PHY states. Note that you can visualize the waveform over several PHY states by selecting a start PHY state, pressing and holding the SHIFT key on your keyboard, and selecting a second end PHY state, as shown in the image on the following page.

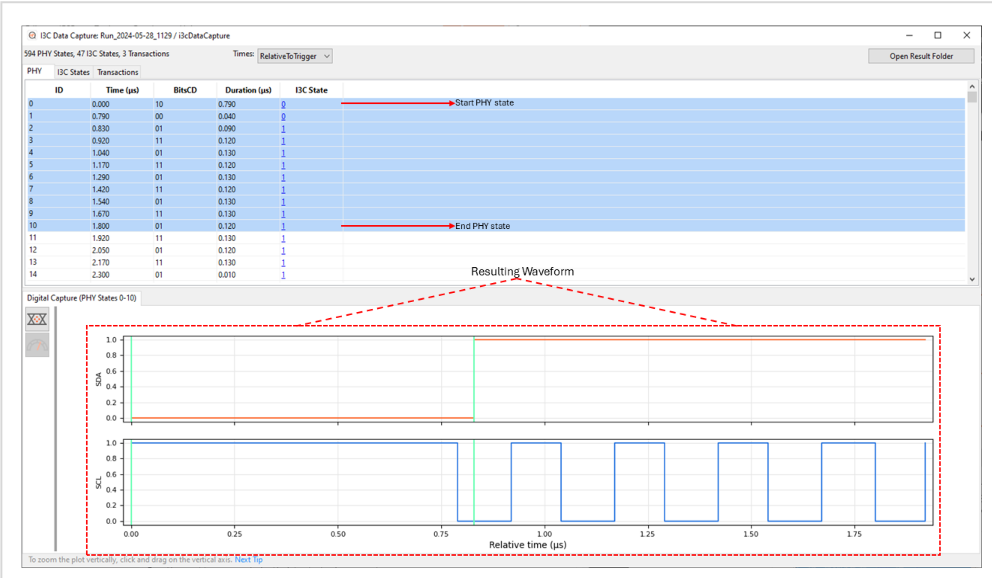


Figure 16: Phy window from "Result" tab.

Note that the top waveform is for the SDA line and the bottom is for the SCL line.

e) The **"I3C States"** tab allows you to visualize the different I3C packets that were transmitted on the bus during the run. Just like in the previous tab, you can visualize the waveform of one or multiple I3C commands by selecting it from the list.

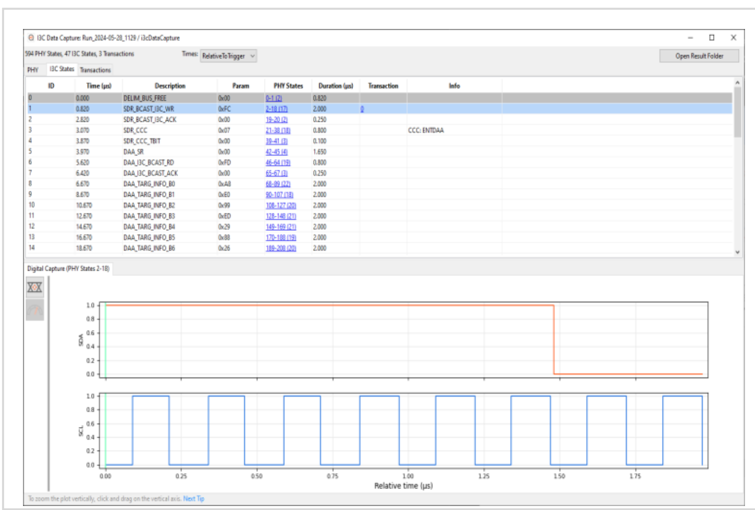


Figure 17: I3C States window from "Result" tab.

f) The third and final tab, **"Transactions"**, is a summary of all I3C transactions as defined by the specification. In the current example, only one message is presented. We see the DAA event we executed, listed as DAA for Dynamic Address Assignment.

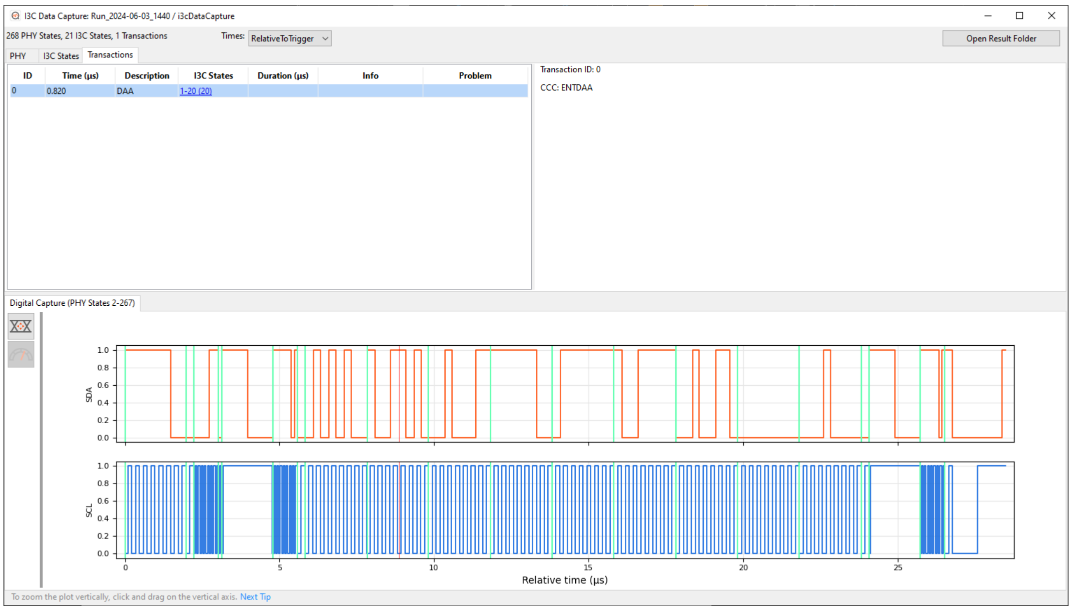


Figure 18: Transactions window from "Result" tab.

g) Now that the target has been assigned a dynamic address, we can start communicating with the target using I3C commands. For example, to read the provisional ID of the target device (previously programmed through the targetDevice.setup() operation), you will need to send a direct read command to the target device with the direct command code "GETPID".

To do so, navigate back to the “Params” tab at the top of the GUI window and add the following code to your test procedure:

```
#This demonstrates a direct read CCC
print("Reading provisional IDs of target devices on the bus...")
targetAddrs = [myTarget]
resultsByTargetAddr = controllerDevice.doDirectReads('GETPID', targetAddrs)
for targetAddr in targetAddrs:
    bytesFromTarget = resultsByTargetAddr[targetAddr]
    hexBytesFromTarget = [hex(byte) for byte in bytesFromTarget]
    print("targetAddr: 0x%02X bytesFromTarget: %s" % (targetAddr, hexBytesFromTarget))
```

For more details on the different types of commands supported by Pinetree and how to use them, please refer to the “Help” manual, available by right clicking a component and selecting the “Help” option, as shown previously. Now, your final test procedure is ready to be run.

4. EXECUTE THE FINAL TEST

a) You have run some partial tests in the previous section. Here, it is useful to execute the final test, and we do so by clicking "Run" again at the top right of Pinetree. Alternatively, use the shortcut key F5 to rapidly run a test procedure.

Figure 19: Clicking the run button at the top right of Pinetree.

Pinetree will execute the script. Switch to the "Log" tab, where you will see the resulting messages from your test procedure, as shown in the image on the next page. Observe that the provisional ID read back is six bytes long, matching the six hex bytes set previously in the target parameters.

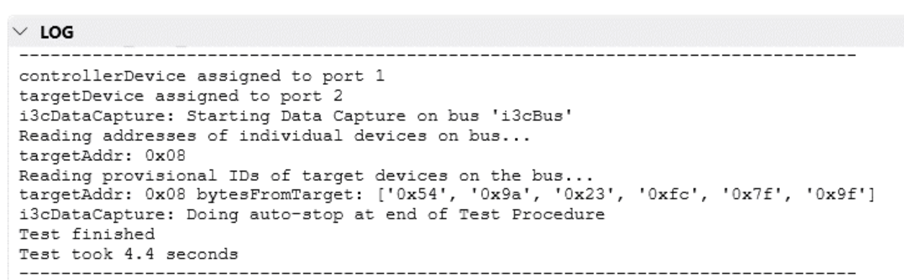


Figure 20: testProcedure Log.

b) Once the test has finished, switch to the "Results" tab where you can visualize the waveform of the I3C communications that have occurred during the test run.

Double click the "i3cDataCapture1" file in the "Results" window. There, navigate to the "I3C States" tab and scroll down until you see 6 "SDR_DIR_RD_DATA" states. As shown below, the "Param" column of each of them indicates the value that was transmitted during the direct read command. Each "SDR_DIR_RD_DATA" will be associated with 1 byte of the target PID. Observe the expected PID value that was set in the target parameters.

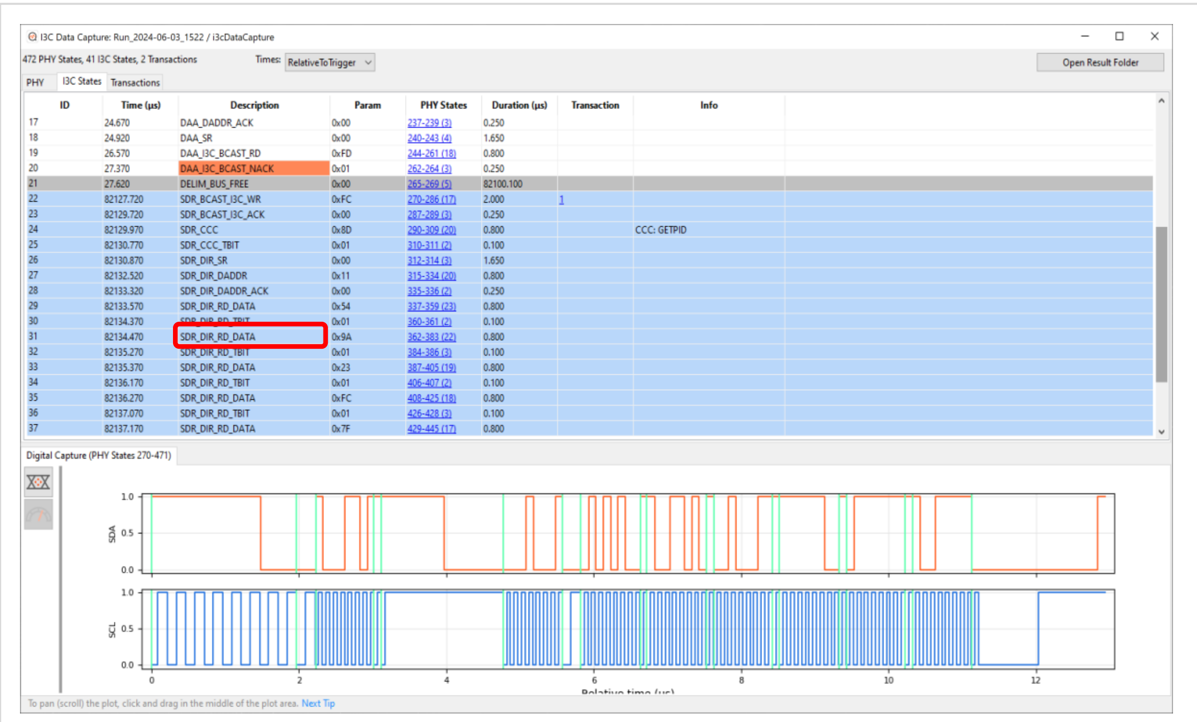


Figure 21: "I3C States" window.

This concludes the SV6E-X demonstration. For further information, note that the user manual is available from the "Help -> User Manual" pull-down menu entry from the main Pinetree window.

Appendix

FTDI DRIVER MANUAL INSTALLATION

Pinetree communicates with the SPI Controller via an FTDI device (connected via USB). If you don't already have required FTDI drivers installed on your Windows computer, or if the automated driver detection presented earlier in this document was unsuccessful, you will need to download them from the FTDI web site. To do this, follow the instructions from the link below:

- http://www.ftdichip.com/Documents/InstallGuides.htm

The latest drivers can be found at:

- http://www.ftdichip.com/Drivers/D2XX.htm

Note that the driver version used in our product development is 2.12.

You may wish to use the "usbview" utility program linked to on the following FTDI page:

- http://www.ftdichip.com/Resources/Utilities.htm

This program will allow you to check that your computer can "see" the FTDI device over USB.

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