DS250DF410EVM User's Guide

The DS250DF410 is a four-channel multi-rate retimer with integrated signal conditioning. It is used to extend the reach and robustness of long, lossy, crosstalk-impaired high-speed serial links while achieving a bit error rate (BER) of 10-15 or less. Each channel of the DS250DF410 independently locks to serial data rates in a continuous range from 20.6 Gbps to 25.8 Gbps or to any supported sub-rate (÷2 and ÷4), including key data rates such as 10.3125 Gbps and 12.5 Gbps. The DS250DF410 has a single power supply and minimal need for external components. These features reduce PCB routing complexity and BOM cost. The advanced equalization features of the DS250DF410 include a low-jitter 3-tap transmit finite impulse response (FIR) filter, an adaptive continuous-time linear equalizer (CTLE), and an adaptive decision feedback equalizer (DFE). This enables reach extension for lossy interconnect and backplanes with multiple connectors and crosstalk. The integrated CDR function is ideal for front-port optical module applications to reset the jitter budget and retime the high-speed serial data. The DS250DF410 implements 2x2 cross-point on each channel pair, providing the host with both lane crossing and fanout options.

The DS250DF410 can be configured via the default SMBus slave mode or with an external EEPROM. Up to 16 devices can share a single EEPROM. A non-disruptive on-chip eye monitor and PRBS generator and checker functions allow for in-system diagnostics. With this kit, users can quickly evaluate the DS250DF410 retimer performance.

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Trademarks

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1 Hardware Description and Setup

The general procedure for setting up and testing with the DS250DF410 Evaluation Module (DS250DF410EVM) hardware is as follows:

1. Check the EVM jumper settings to ensure they match Figure 1 below.
2. Connect the EVM to a PC using the provided USB cable.
3. Connect 3.3V power (2A max) as shown below. The EVM has an on-board 3.3V-to-2.5V regulator to supply the Retimer with the required 2.5V. Make sure multiple jumpers are used on header J10.

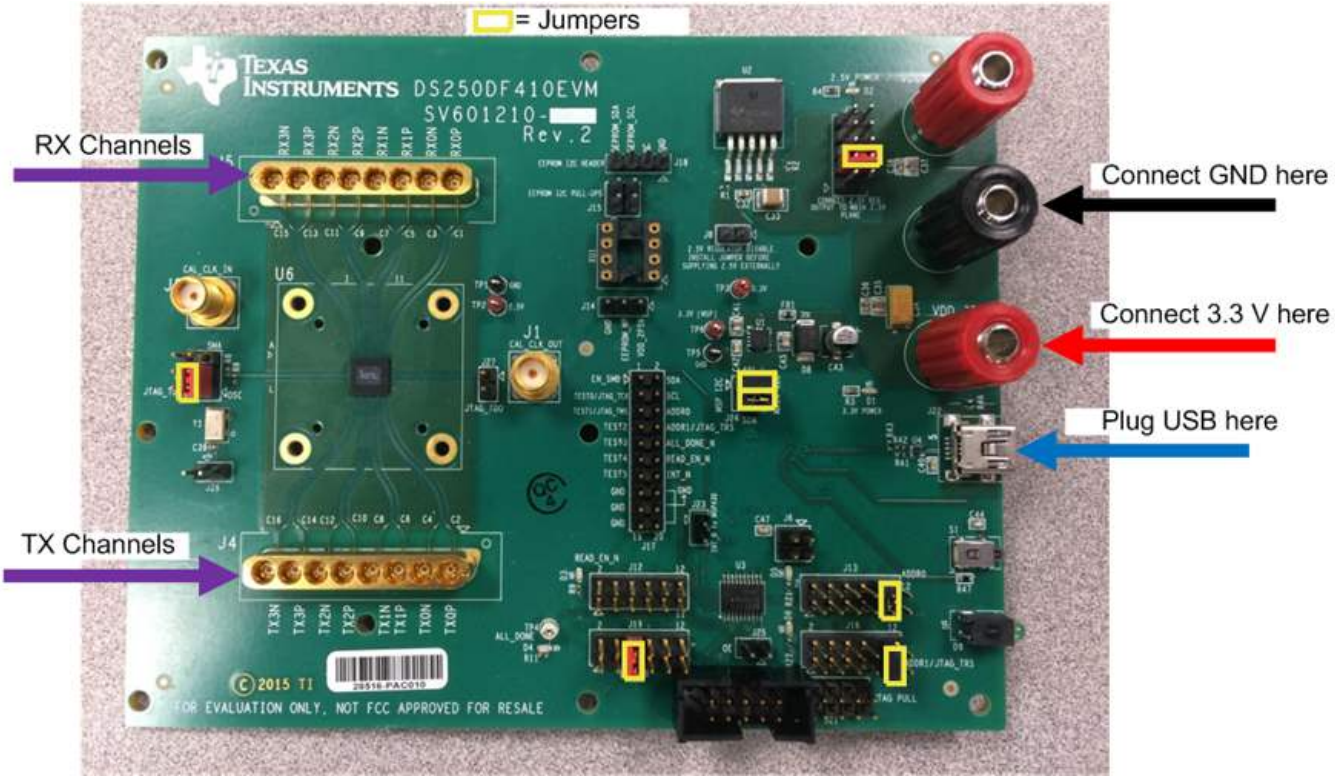


Figure 1. DS250DF410EVM, Showing Connections for Power, Signal, and USB Communications

4. Connect the EVM to the system under test.

The default EVM configuration has four differential RX inputs and four differential TX outputs accessible to the user. Connect the RX and TX signals to the test channel using Huber+Suhner 1x8 MXP cable assemblies (See Section 6 for ordering information).

NOTE: All TX and RX channels are AC coupled with physical 220 nF capacitors on the evaluation board, so external AC coupling capacitors are not needed when using this EVM.

2 Software Description

2.1 Setup

The **one-time** procedure for installing the GUI software is as follows:

1. Download and install the TI SigCon Architect GUI. The steps for installing the software are as follows:
    1. Go to www.ti.com/tool/sigconarchitect and download the latest version of SigCon Architect. At the time this document was written, the latest version of SigCon Architect is 2.0.0.4.

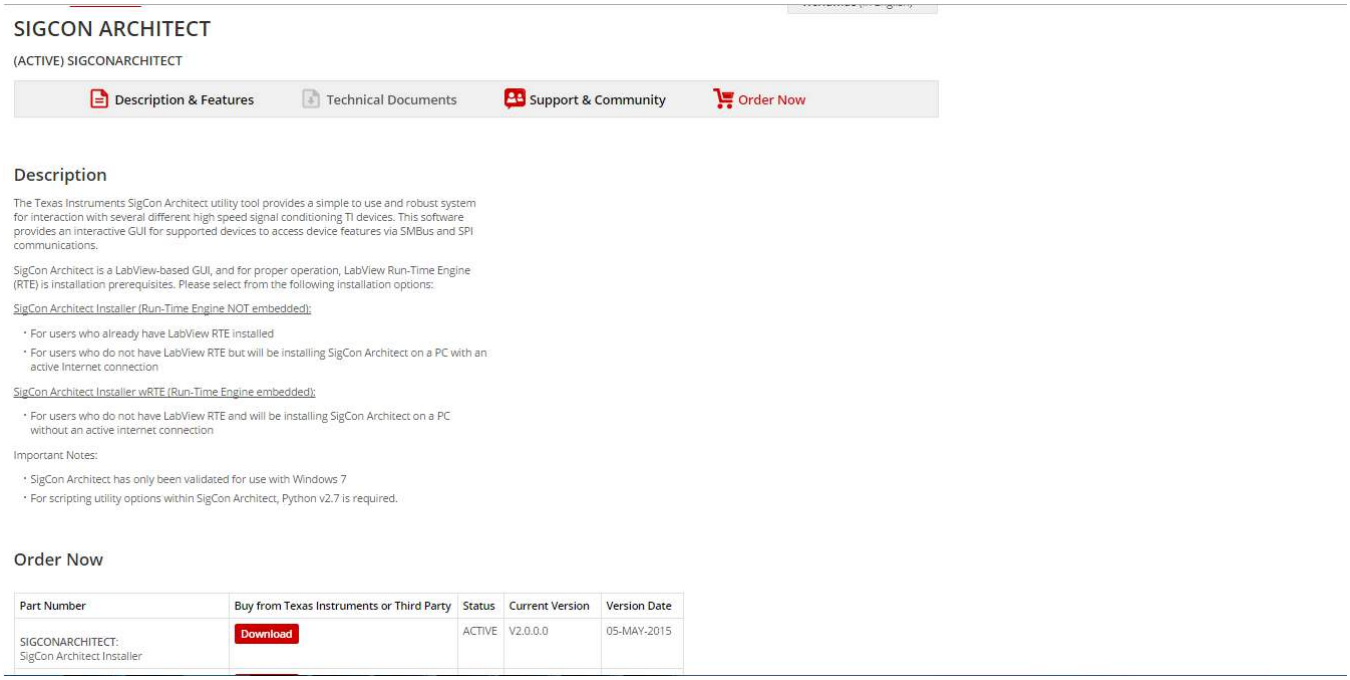


Figure 2. Download SigCon Architect from www.ti.com

2. Extract the executable file (.EXE) from the downloaded file and run the executable.
3. Follow the installation wizard's instructions to install SigCon Architect.
4. Request download link for the DS250DF410 profile file via "Special Note" link. Software access will be granted with TI MySecure software access.
5. Extract the executable file (.EXE) from the downloaded file and run the executable.

2. Run the SigCon Architect software.
    1. Start the software by double-clicking its icon on the desktop.
    2. On the “Selection” panel, the DS250DF410 should appear.
    3. If DS250DF410 is not listed:
        1. Go to “Device” tab and choose “Manage Devices”.
        2. Click on “+” icon and then select the “DS250DF410” device model.
        3. Fill in the “New Device Name" DS250DF410 is recommended.
        4. Select the slave address as configured on EVM (typical setting is 0x30).
        5. Click “OK”.
    4. Navigate to the “Configuration” page of DS250DF410 via the “Selection” panel. Choose “Slave Address” “0x30” from the drop down menu. Verify the “USB2ANY Details” specify “USB2ANY 0”, and click “Apply”. Successful connection is indicated by the green “CONNECTED” indicator on the bottom of the application.

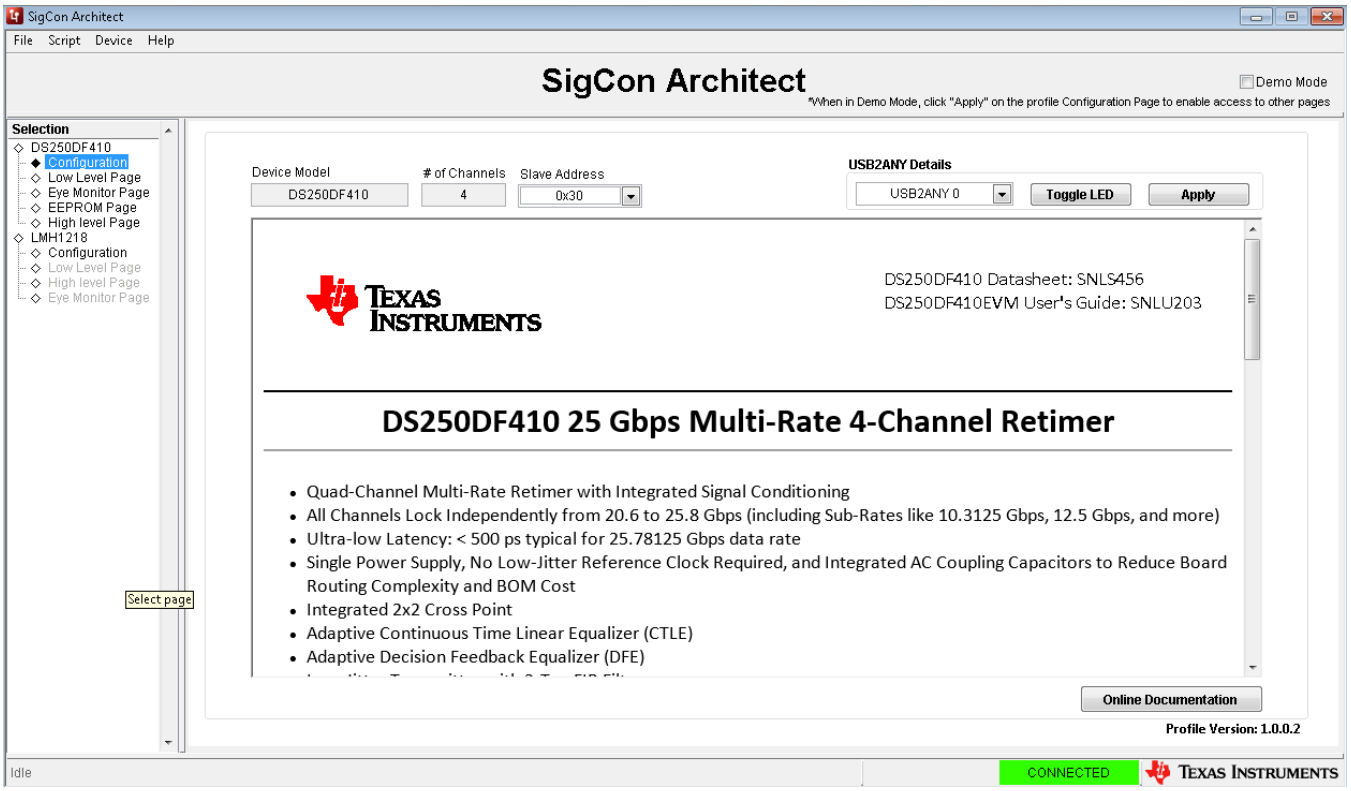


Figure 3. Sigcon Architect Start-Up Screen

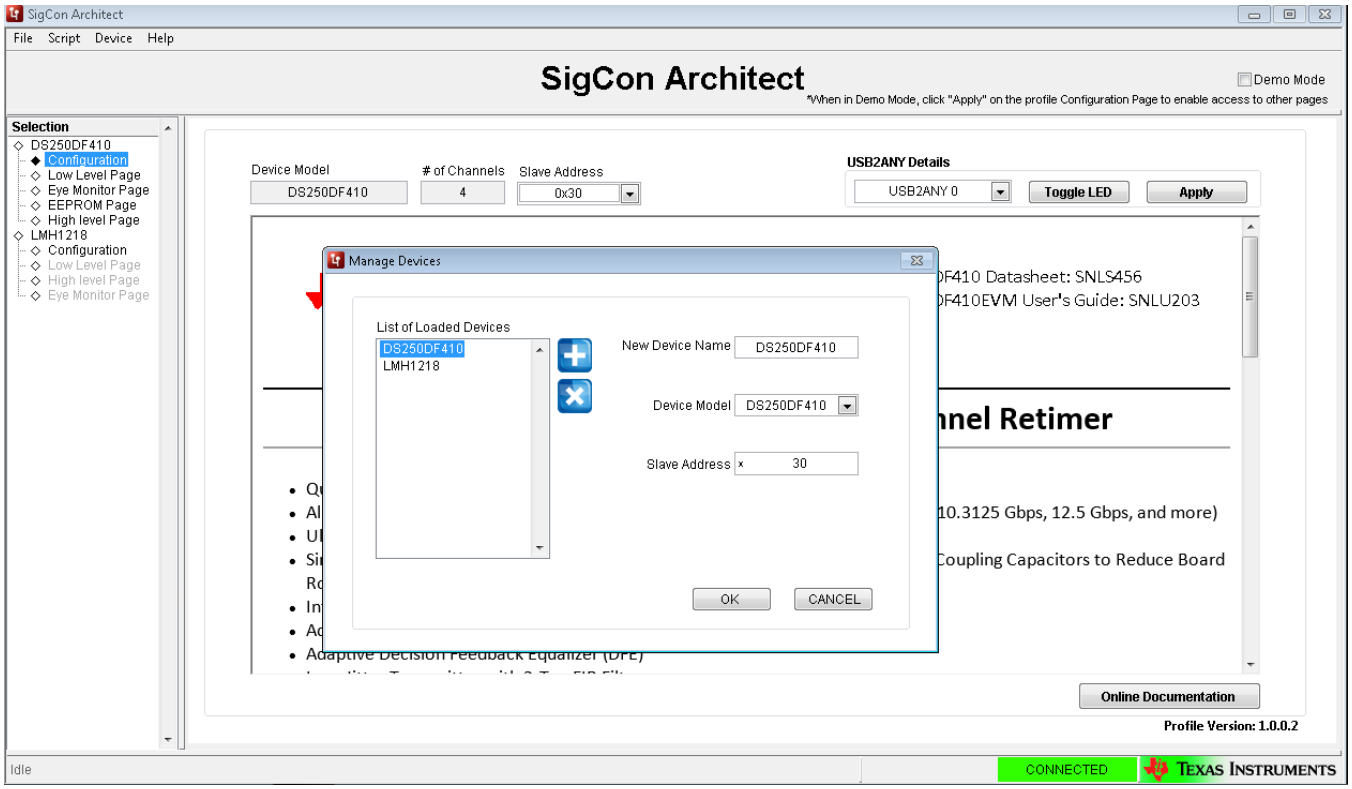


Figure 4. Capture Illustrating the "Manage Devices" Pop-Up Window for Adding New Part Numbers to the "Selection" Panel

3. Once connection is successfully established, users can read and write various settings to the device in real-time, using the functional pages.

2.2 Functional Pages

2.2.1 Low-Level Page

The low-level page allows the user to read and write to all registers on the DS250DF410. To access it, navigate to the "Low Level Page", as shown below.

- The user may click "Read All" to load the data in each register from the device to the "Register Map."
- The user may access the Shared, Global or Channel registers via "Block Select."
- To Read a register:
  - Type the readable address in the "Current Address" text box or select a register from the Register Map.
  - Click "Read Register". The data in this register will appear in the "Data" text box.
- To Write a register:
  - Type the writeable address in the "Current Address" text box or select a register from the Register Map.
  - The user may either type the data value (in HEX) to write to this address in the "Data" text box, or check/uncheck boxes as desired for individual bits within the register. Then click "Write Register."
  - If Broadcast is selected for channel register writes, the specified write will be performed to all channels in the device.

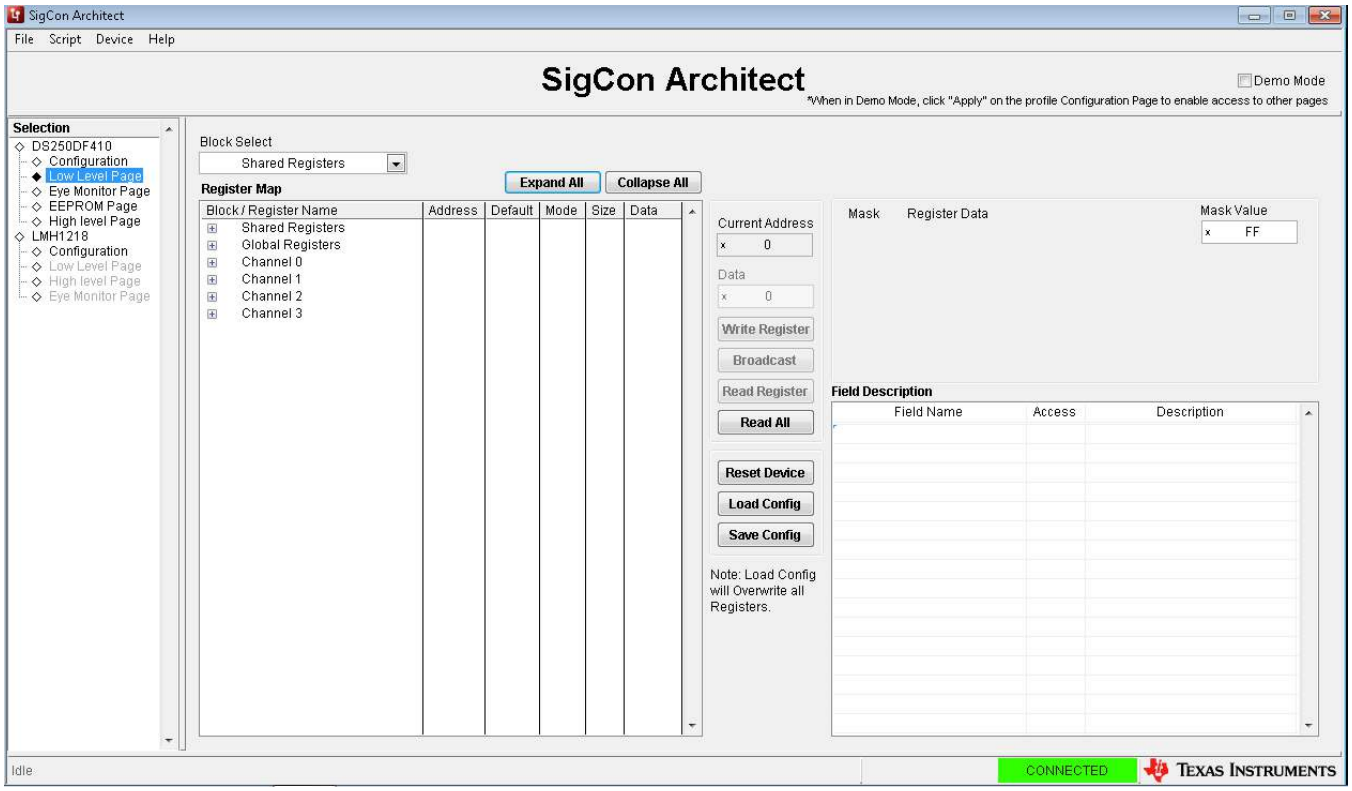


Figure 5. Low-Level Page Capture Illustrating the Different Block Select Options

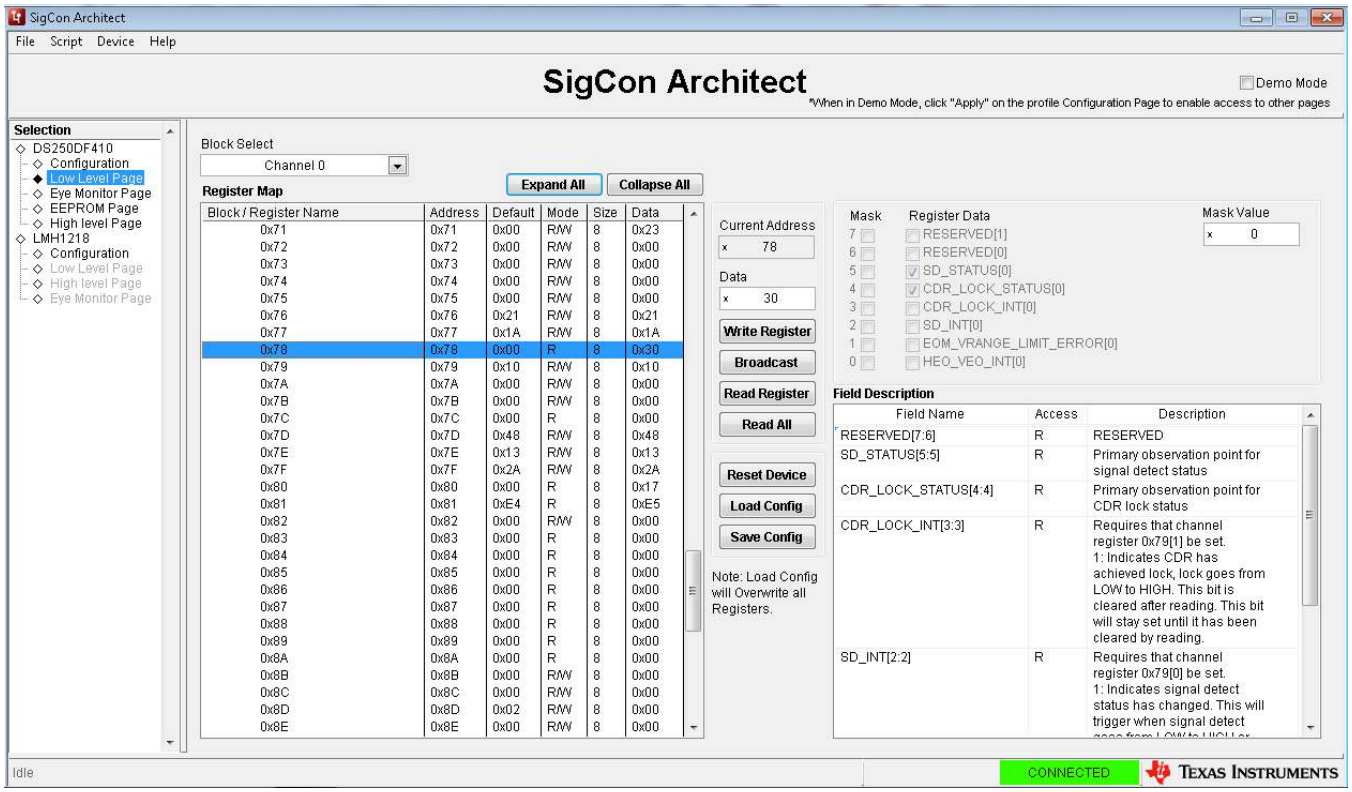


Figure 6. Low-Level Page Capture After Selecting Access to an Individual Register

2.2.2 Eye Opening Monitor (EOM) Page

The Eye monitor page allows the user to visualize DS250DF410 eye plots, a means of assessing received signal quality after equalization.

- Select the channel for eye plotting. Note that plots can only be generated for a given channel if “CDR Locked” is indicated.
- The EOM_SEL_VRANGE pull-down allows the user to adjust the vertical scale for eye plots.
- The user may perform a “Single Capture” of eye monitor plot, or select “Continuous Capture” to accumulate multiple plots over a period of time.
- The Horizontal Eye Opening (HEO) and Vertical Eye Opening (VEO) may be read on the Eye Monitor page.
- If the user desires to do their own analysis or post-processing of the EOM data, the “Export Raw Data” and “Export Density” buttons respectively generate an Excel spreadsheet containing the 63x63 eye monitor values matrix.

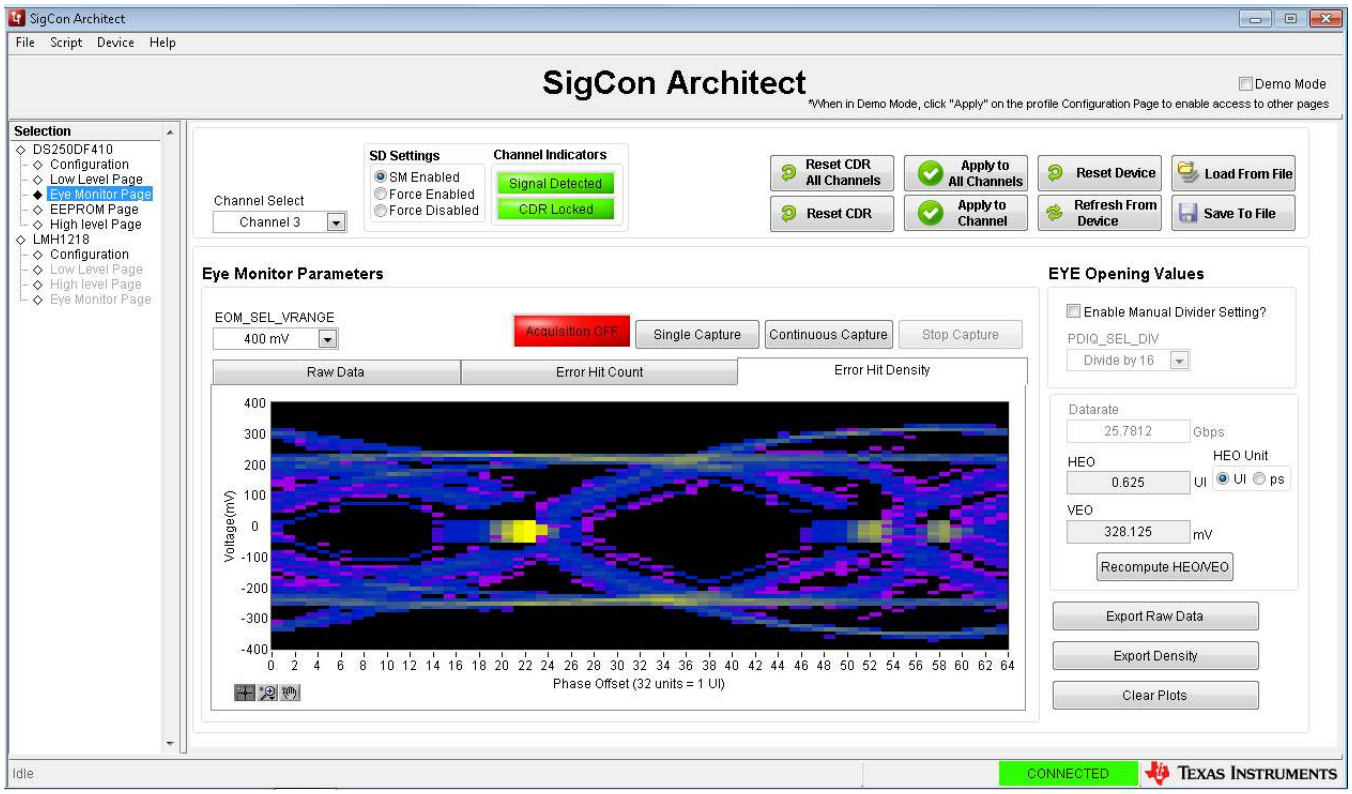


Figure 7. Eye Monitor Page for DS250DF410 Profile

2.2.3 EEPROM Page

The SigCon Architect EEPROM page allows the user to either create a DS250DF410 Hex file that is programmable to an EEPROM or configure a DS250DF410 device based on values from an existing DS250DF410 Hex file.

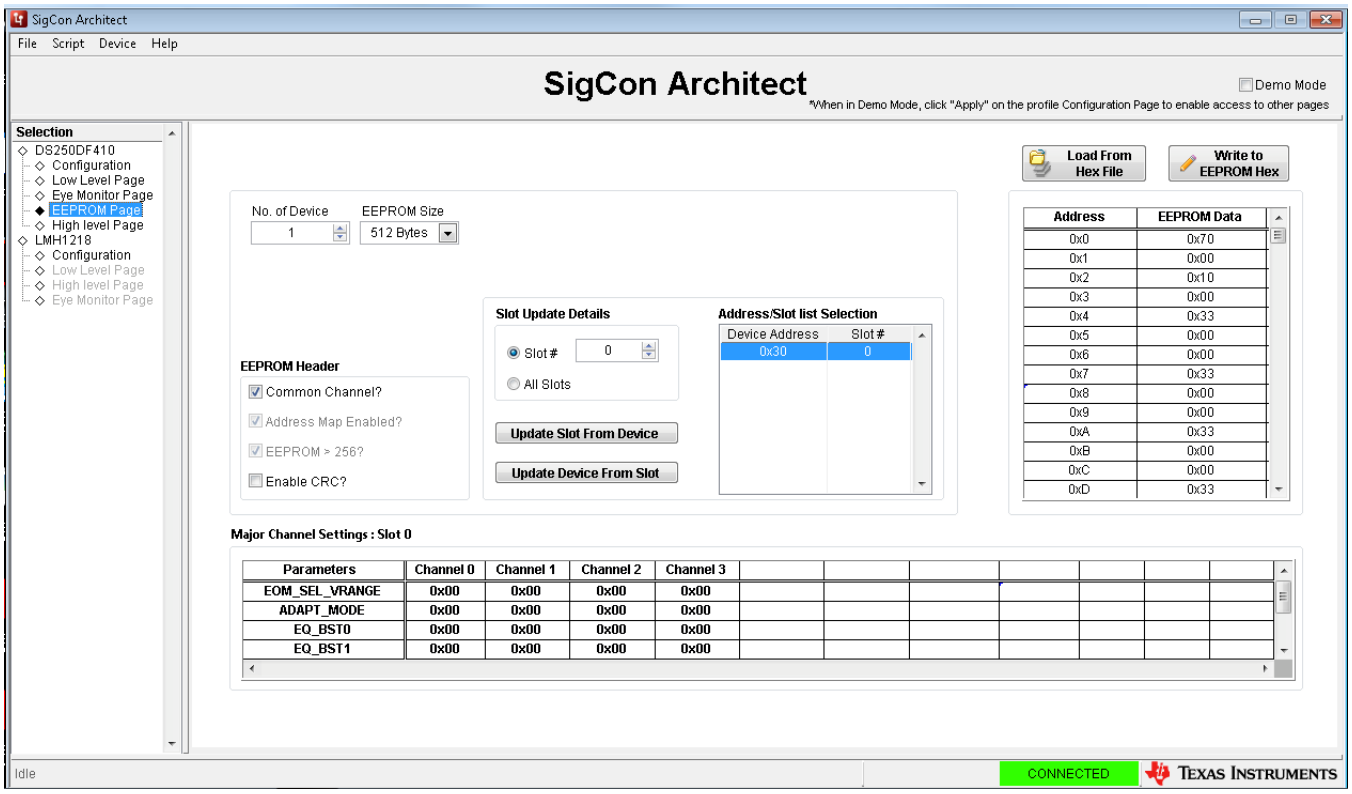


Figure 8. EEPROM Page for DS250DF410 Profile

The user may choose to update the EEPROM page settings based on values read from the DS250DF410 device by clicking “Update Slot from Device”. To create the programmable hex file, click “Write to EEPROM Hex”. Note that the evaluation module does not include an EEPROM, but there is a socket for a standard 6-pin EEPROM (XU1). SigCon Architect cannot directly program the EEPROM. The EEPROM Hex File can be burned on the EEPROM via I^2C communication (i.e. AARDVARK or equivalent interface adapter). The EEPROM control settings are described in greater detail below.

- Common Channel: If this box is checked, all channels receive the same configuration. Different devices can receive different configurations, but within one device, all channels will receive the same configuration. If this box is unchecked, then the EEPROM will store the configuration as unique channel configurations. Each of the four channels can receive a unique configuration.
- EEPROM>256:
  - This setting must be enabled if there are more than 4 EEPROM slots.
  - When this box is checked, the “EEPROM Size” drop down menu is automatically populated by 512 Bytes if previously populated by 256 Bytes.
  - When this box is unchecked, the “EEPROM Size” drop down menu is automatically populated by 256 Bytes. Up to 4 EEPROM slots can be programmed.
- Enable CRC: If enabled, each device will have a CRC value specific to the base header, address map header, and data. If disabled, the CRC is not computed.
- Slot Update Details: The number of slots refers to the total number of unique SMBus register settings to load from the EEPROM. The user can choose to update all slots, or which slot # to update the SigCon Architect EEPROM page from.

- EEPROM Size: The EEPROM size must be set to 256, 512, or 1024 bytes. A single external EEPROM can be used by up to 16 DS250DF410 devices.
  - The first 3 bytes of EEPROM data is the base header. The base header contains the CRC enabled, address map header enabled, EEPROM<256 bytes, device count, and maximum EEPROM burst size settings.
  - If multiple devices are programmed, an address map header is needed for each device. The address map header specifies the CRC value and the Device EEPROM Start Address.
  - EEPROM Size ≤ 256 Bytes:
    - EEPROM Size = 3 Bytes (Base Header) + # of devices * 8 Bytes/device (Address Header) + # of slots * 66 Bytes/slot (Data)
  - EEPROM Size > 256 Bytes:
    - EEPROM Size = 3 Bytes (Base Header) + # of devices * 12 Bytes/device (Address Header) + # of slots * 66 Bytes/slot (Data)

2.2.4 High-Level Page

2.2.4.1 Overview

The High-Level Page on the Selection Panel enables the user to easily configure and/or check the status of the DS250DF410 high-speed data path functional blocks: Clock and data recovery (CDR), Receiver equalization, Transmitter output driver, PRBS generator and checker, and cross-point. The Figure 9 below shows the landing page after uses selects “High-Level Page on the Selection Panel. The first button option is the “Block Diagram”, an illustrative page highlighting the DS250DF410’s functional stages. The configuration features for the additional tabs within the High-Level Page are described further in the next sub-sections.

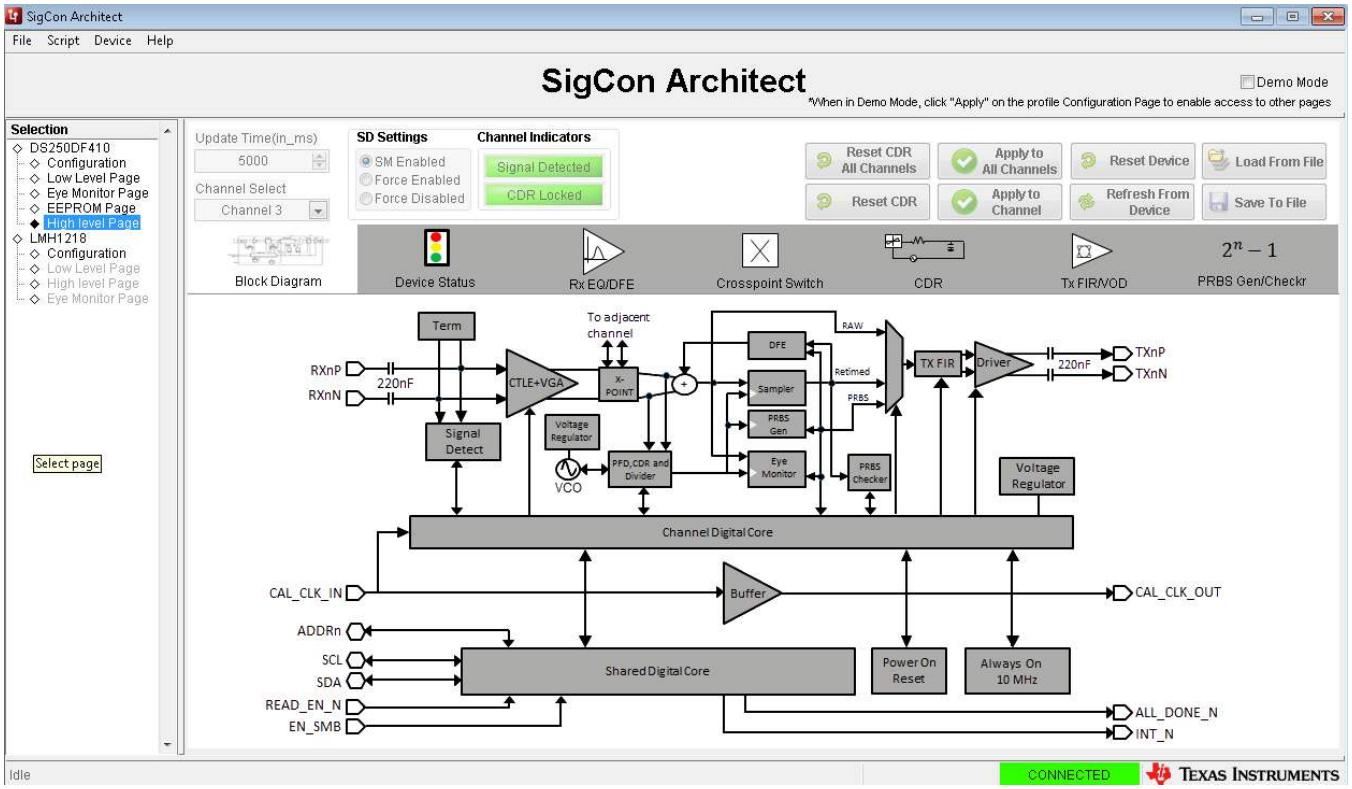


Figure 9. High-Level Page, with Block Diagram Tab Selected

2.2.4.2 Device Status

In order to view a real-time high-level summary of the current device status and control settings, navigate to the “High Level Page”, and choose the “Device Status” tab. Click “Refresh From Device” to ensure the settings shown are from the device. The settings on this page are not editable.

- Signal Detect Status: For each channel the device status is displayed as “Signal Not Detected” if there is no detectable signal present at the RX side of this channel or “Signal Detected” if there is a signal present at the RX side of this channel.
- CDR Locked: For each channel the CDR lock status is displayed. Note that each channel’s CDR status and configuration is independent from the others.
- EQ Boost: This field displays the Rx Continuous-Time Linear Equalizer (CTLE) boost value as a four digit figure. Each digit corresponds to one of the four CTLE stages, and each can have a value from 0 to 3.0 represents minimum boost and 3 represents maximum boost in each stage, so the maximum possible boost setting is "3333" and the minimum possible boost setting is "0000."
- DFE Taps: The boost values in mV for each of the five Decision Feedback Equalizer (DFE) taps are displayed here.
- HEO and VEO: The HEO and VEO values in mV are displayed for each of the retimer channels.
- Tx FIR filter taps: The Device Status tab displays the current decimal value and polarity for the FIR pre-cursor, main-cursor and post-cursor taps for each of the channels. The coefficient sum (i.e. absolute sum of the FIR tap values) is also displayed. Finally, the page displays approximate values for the effective post-cursor and pre-cursor de-emphasis based on the channel’s current FIR tap settings.

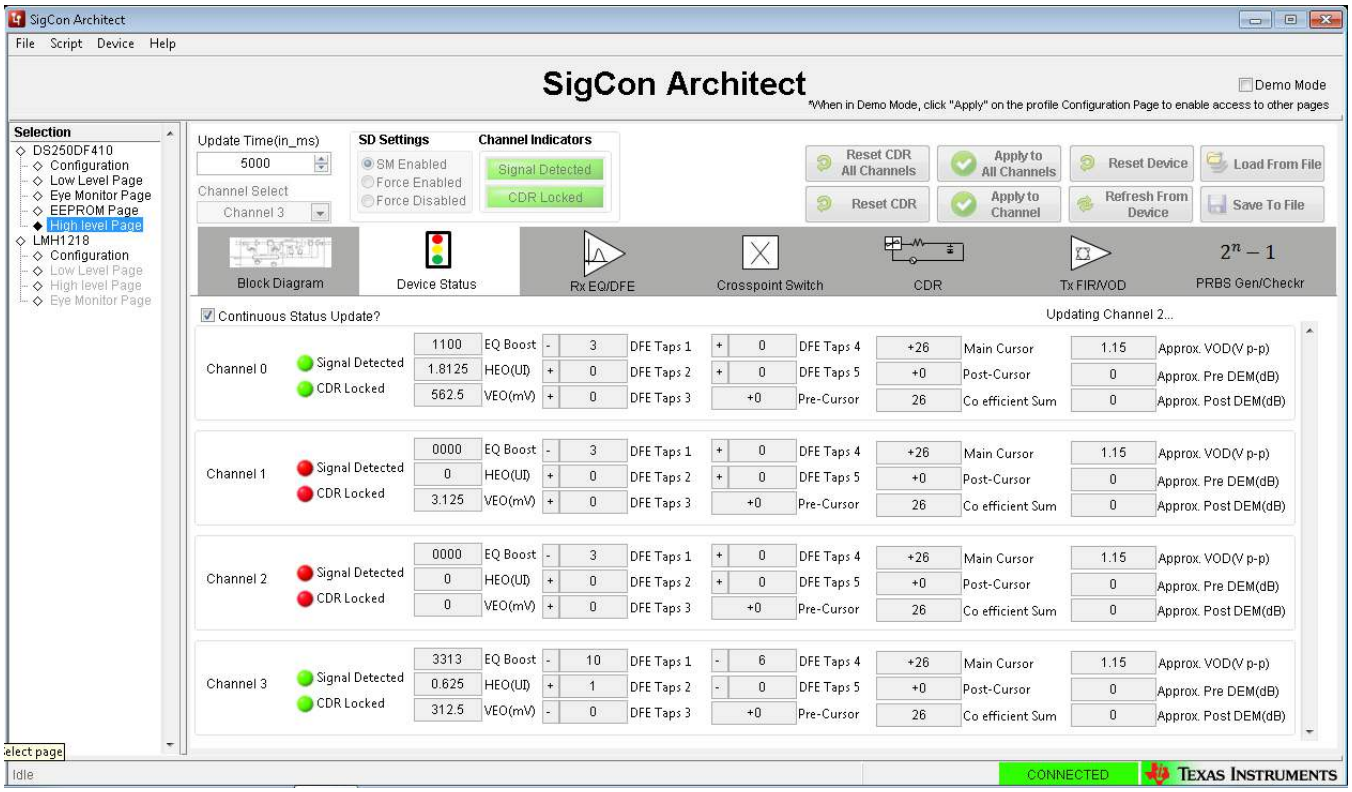


Figure 10. High-Level Page, with Device Status Tab Selected

2.2.4.3 Rx EQ/DFE

The Rx EQ/DFE tab provides the user with full status and control capability of the DS250DF410 Rx equalization functions. The Figure 11 below illustrates the Rx EQ page functions, which are described below in more detail.

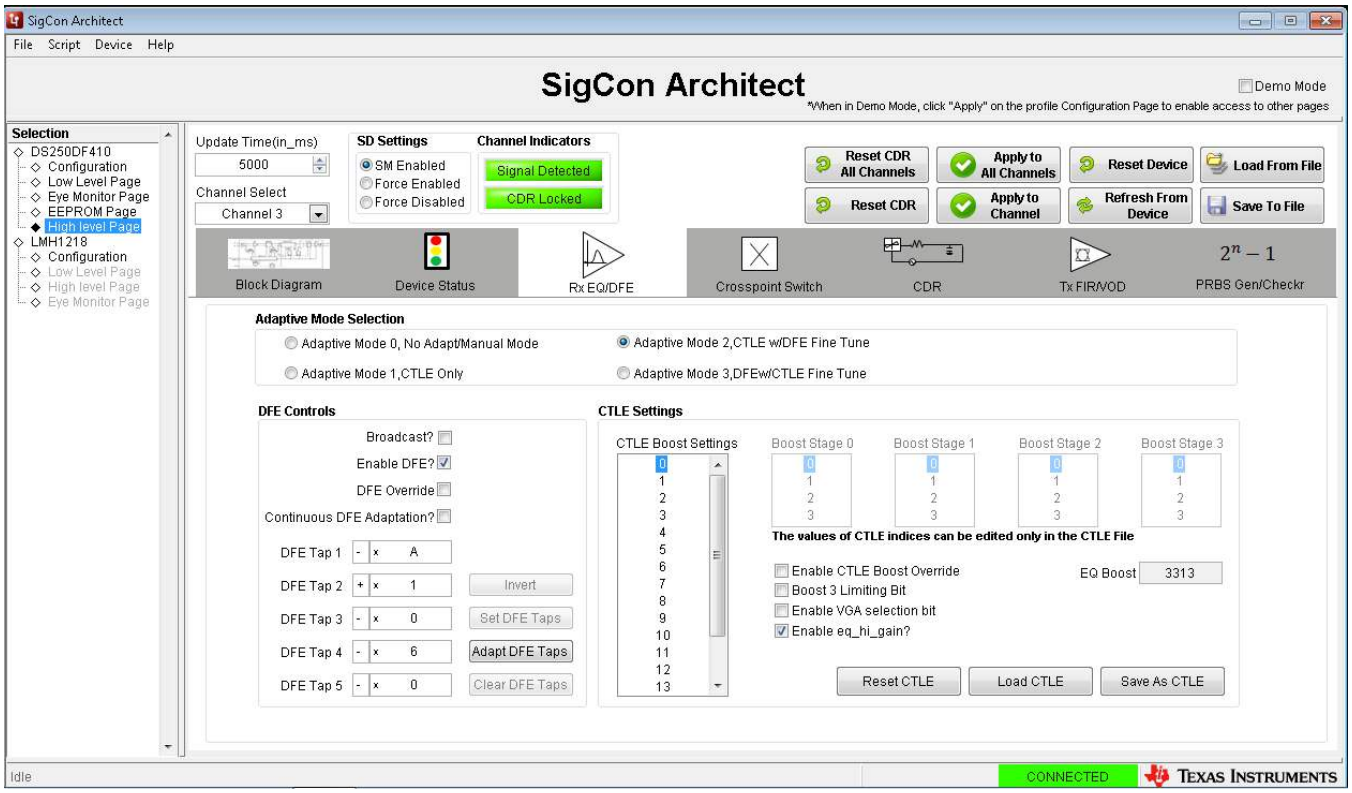


Figure 11. Rx EQ/DFE Tab

- Adapt Mode
  - Upon landing on the Rx EQ page, the GUI will display the current status for the retimer adapt mode for the channel selected in the Channel Select pull-down.
  - The Rx EQ page allows the user to set the DS250DF410 device to any of the four available adapt modes. To do so, the user should click on the desired adapt mode then click “Apply to Channel” to configure a specific retimer channel. Alternatively the user may broadcast the new adapt mode setting by clicking on “Apply to all channels.”
- CTLE Settings
  - Select the desired channel on Channel Select pull-down.
  - The GUI will display the current CTLE boost value on the EQ Boost field of the CTLE Settings section.
  - If the user wishes to manually set the EQ value:
    - Adapt Mode 0 may be selected (i.e. no adaption mode).
    - Check the “Enable CTLE Boost Override” option.
    - Click on “Reset CDR” button on the top right of page.
  - Boost 3 Limiting bit
    - When checked, this option configures the last CTLE boost stage to have a limiting output.
  - VGA (Variable Gain Amplifier) gain bit
    - When checked, it enables the Rx VGA block.

- EQ Hi gain mode bit
  - When checked, the EQ is set to the high-gain mode of operation. This bit is enabled by default.
- EQ boost table - If the user wishes to customize the sixteen value CTLE boost table:
  - The user can enter the desired values individually on the “CTLE Boost Settings”.
  - After entering all of the CTLE table values, the user should click on “Save as CTLE” button to save the file.
  - This CTLE table file can be loaded for use with new devices by clicking “Load CTLE” and selecting the file from its location.
- DFE Controls
  - Upon landing on the “Rx EQ” tab, the” DFE Controls” section will display the current weight values and polarities for the five DFE taps for the selected channel.
  - The user may check the “DFE Override” box to manually configure the DFE tap values.
  - The user may enable continuous DFE adaption by checking the corresponding box on the “DFE Controls” section.

2.2.4.4 Cross-Point Switch

The cross-point tab allows the user to easily configure the 2x2 cross-point implemented for each of the adjacent channel pairs of the DS250DF410 retimer.

- With the “Pair Select” pull-down, the user can choose which cross-point pair to configure (0-1, or 2-3.)
- The cross-point mode is selected using the “Crosspoint Configuration” pull-down.
- The cross-point channels mappings are illustrated on the “Crosspoint Settings” table on the page, and the displayed color matches the current cross-point mode.

There are three cross-point configuration modes selectable via the “Crosspoint Configuration” pull-down:

- Default
  - The transmitter for a given channel obtains data from its own receiver.
- Fanout
  - Upon selecting the “Fanout” option on the pull-down, the user will be asked to select a channel on the “Broadcast Channel” pull-down.
  - After the user selects the broadcast channel and clicks on “Broadcast”, the received data for the selected channel will be output both on its Tx output and also on the Tx output of its cross-point pair channel.
- Lane Crossing
  - Upon selecting the “Lane Crossing” option, the GUI will automatically configure the cross-point pair in question such that the Tx output of a given channel obtains its data from the Rx of its adjacent cross-point pair channel

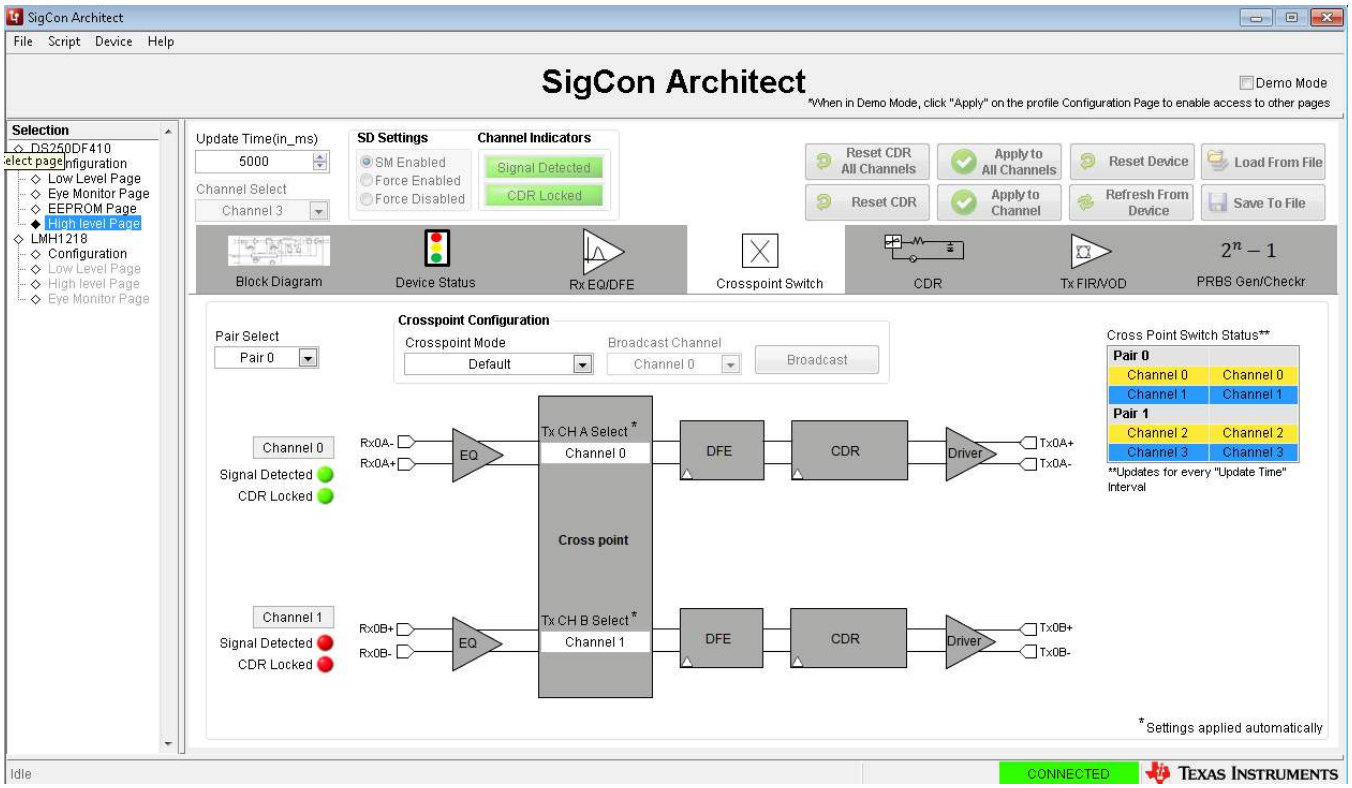


Figure 12. Cross-Point Tab, Default Mode Selected

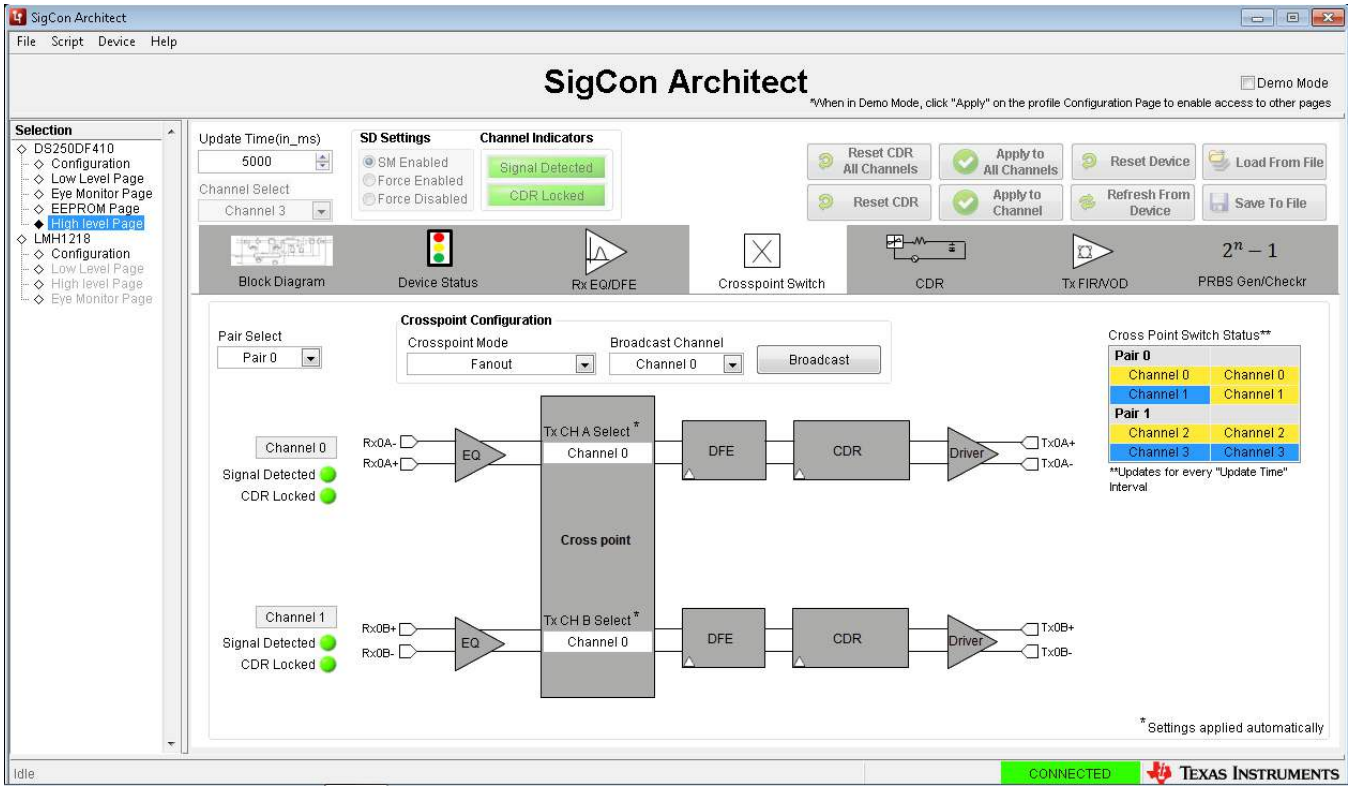


Figure 13. Cross-Point Tab, Fanout Mode Selected

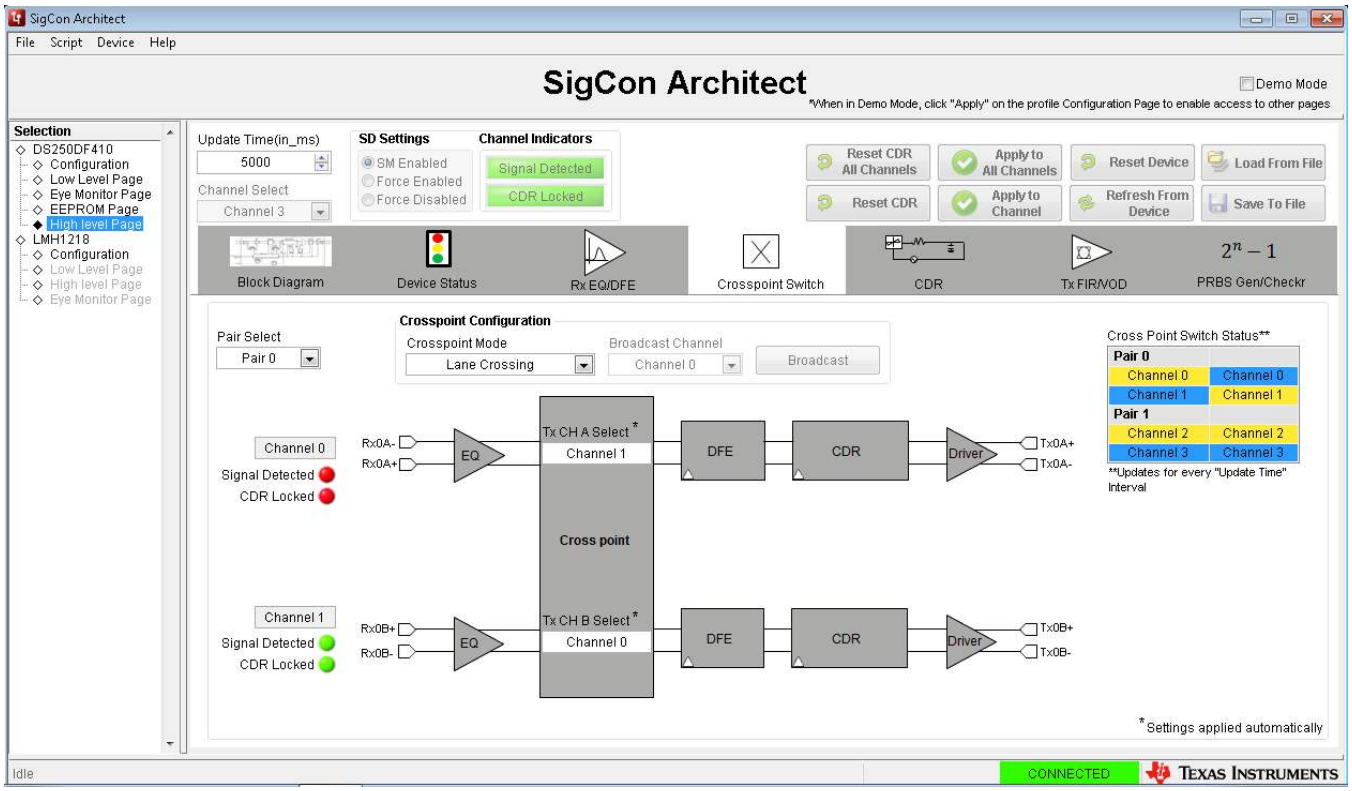


Figure 14. Cross-Point Tab, Lane Crossing Mode Selected

2.2.4.5 CDR (Clock and Data Recovery)

The CDR tab provides a quick way to configure the DS250DF410 retimer to operate at the desired data rates and sub-rates. The DS250DF410 channels must each be pre-programmed for the expected data rate(s) to ensure CDR lock. On the CDR tab the user can select between the Standard and Manual modes of CDR lock configuration.

- Upon landing on the CDR tab, the page will automatically display the mode that the retimer is currently set to, along with the data rate setting and also the divider setting (in the case of Manual Mode.)
- Standard Mode allows the user to program the retimer rate/sub-rate to one of within a set of pre-defined standard values.
  - Select the desired channel on Channel Select pull-down.
  - The user first clicks on the “Standard Mode” option on the page.
  - The user then selects the desired rate within the “Standard Data Rate Selection” Options.

NOTE: The default settings for the DS250DF410 are “Standard Mode”, and “100Gb Ethernet” (i.e 25.78125 Gb/s data rate per channel).

- Manual Mode allows the user to manually program a retimer channel to CDR lock to a specific data rate. This function is intended for applications requiring a data rate that exists within the VCO range, but that are not listed within the “Standard Data Rate Selection” options.

- To configure a channel via “Manual Mode”:
  - Select the desired channel on Channel Select pull-down.
  - Select “Manual Mode” option on the page; the user will then see the manual mode input fields become adjustable.
  - Select the desired divider setting from the “Divider Configuration” pull-down.
    - Select “divide-by-1” when data rate > 13 Gbps.
    - Select “divide-by-2” when 13 Gbps ≥ data rate > 6.5 Gbps.
    - Select “divide-by-4” for data rate ≤ 6.5 Gbps.
  - Enter desired Data Rate for group 0 then click “Write Rate Regs”. The GUI defaults to max PPM tolerance.
  - Enter desired Data Rate for for group 1 then click “Write Rate Regs”. The GUI defaults to max PPM tolerance.
  - Click “Reset CDR”.

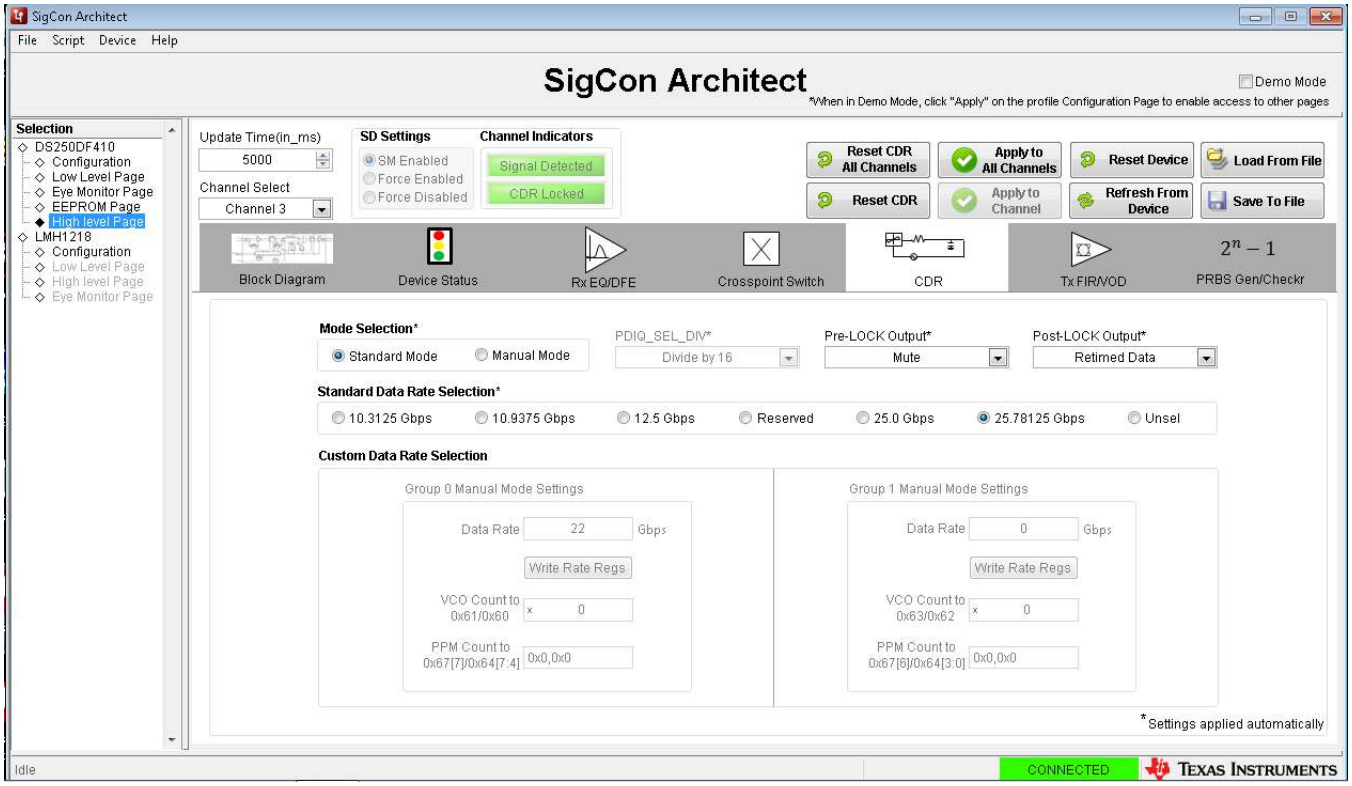


Figure 15. CDR Tab, Standard Mode Selected

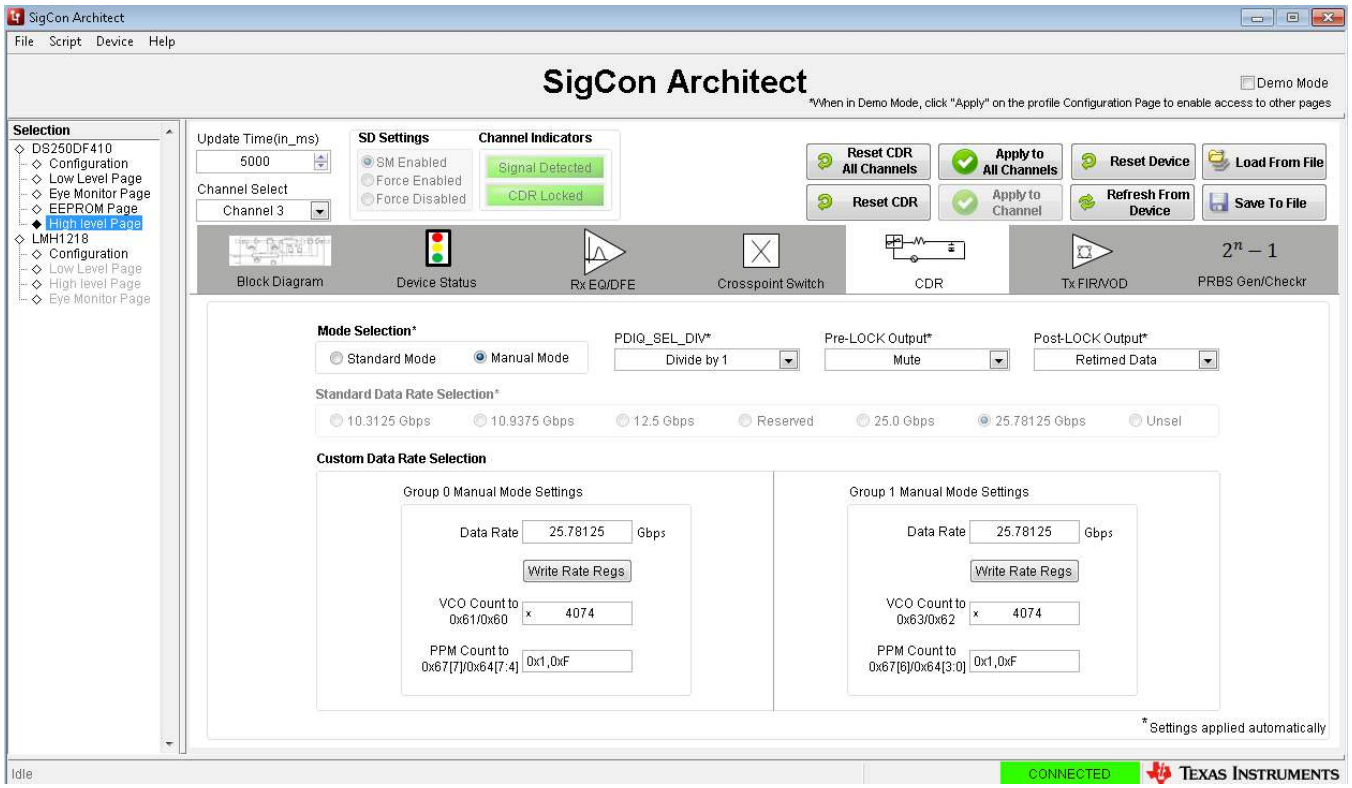


Figure 16. CDR Tab, Manual Mode Selected

2.2.4.6 TX FIR/VOD

The TX FIR tab allows the user to configure the FIR tap settings for each of the retimer channels, to set the output to specific voltage amplitude and/or realize specific transmit pre-cursor and post-cursor equalization ratios.

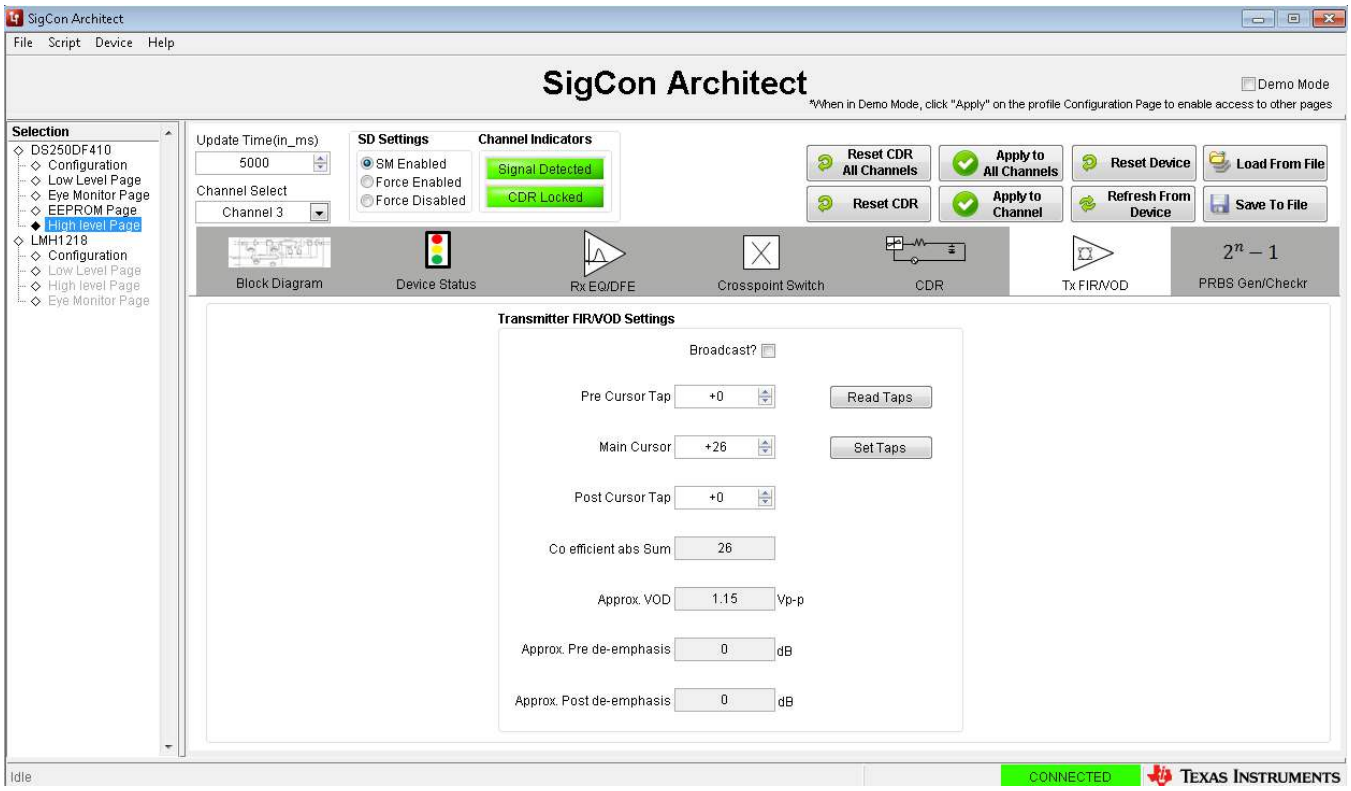


Figure 17. TX FIR Tab

- Upon landing on the TX FIR tab, the page will display the current decimal values and polarity for the main-cursor, post-cursor and pre-cursor FIR taps.
- In addition, the page also displays approximate values for the voltage output differential (VOD) and the de-emphasis for both pre-cursor and post-cursor.
- The user may adjust the FIR tap values, by clicking on the up/down arrows for each field. After entering the desired value(s), the user can click on “Set Taps” to make the entries effective.
- At any point the user can click on “Read Taps”.

2.2.4.7 PRBS Tab

The PRBS tab within the High-Level page allows the user to configure the PRBS generator or Checker functions on any of the channels of the DS250DF410 retimer.

- To enable PRBS Generator on a channel:
  - Select the desired channel using the “Channel Select” pull-down.
  - Select the desired pattern using the “Pattern Type” pull-down.
  - Set desired Polarity via pull-down, Non-Invert or Invert.
  - Click “Enable” button.

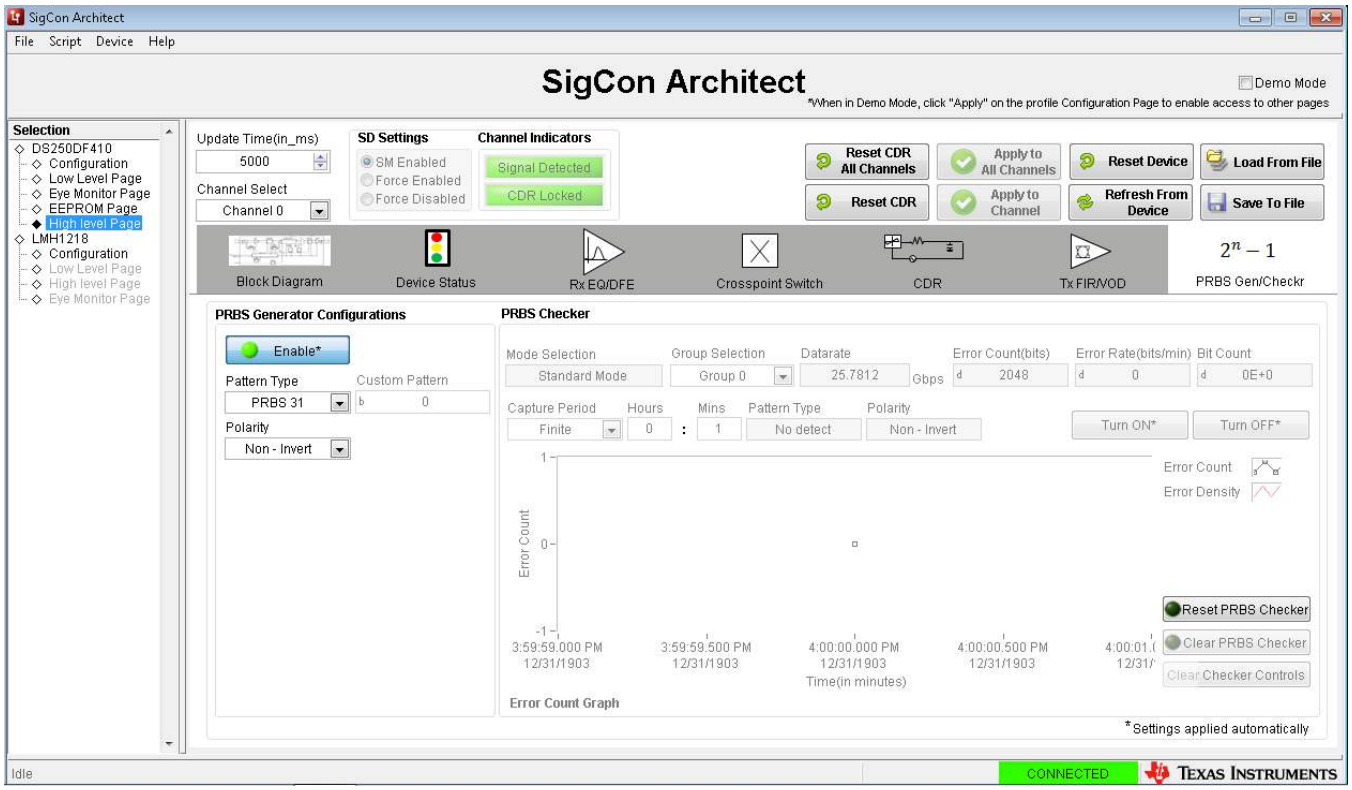


Figure 18. PRBS Tab, PRBS Generator Configuration

- To enable PRBS Checker on a channel:
  - Select the desired channel using the “Channel Select” pull-down.
  - Set the “Capture Period”.
    - Set pull-down to “Infinite” if it desired to run extended duration test without time limit.
    - If “Finite” period is desired, set the pull-down to “Finite” and enter the desired test duration via the “Hours” and/or the “Mins(Minutes)” input fields.
    - Click “Turn ON”.
    - The user may clear the counter fields by clicking “Clear Checker,” or reset the PRBS checker settings by clicking “Reset Checker”.
    - To turn off the checker and return to default settings, click on “Turn OFF”.

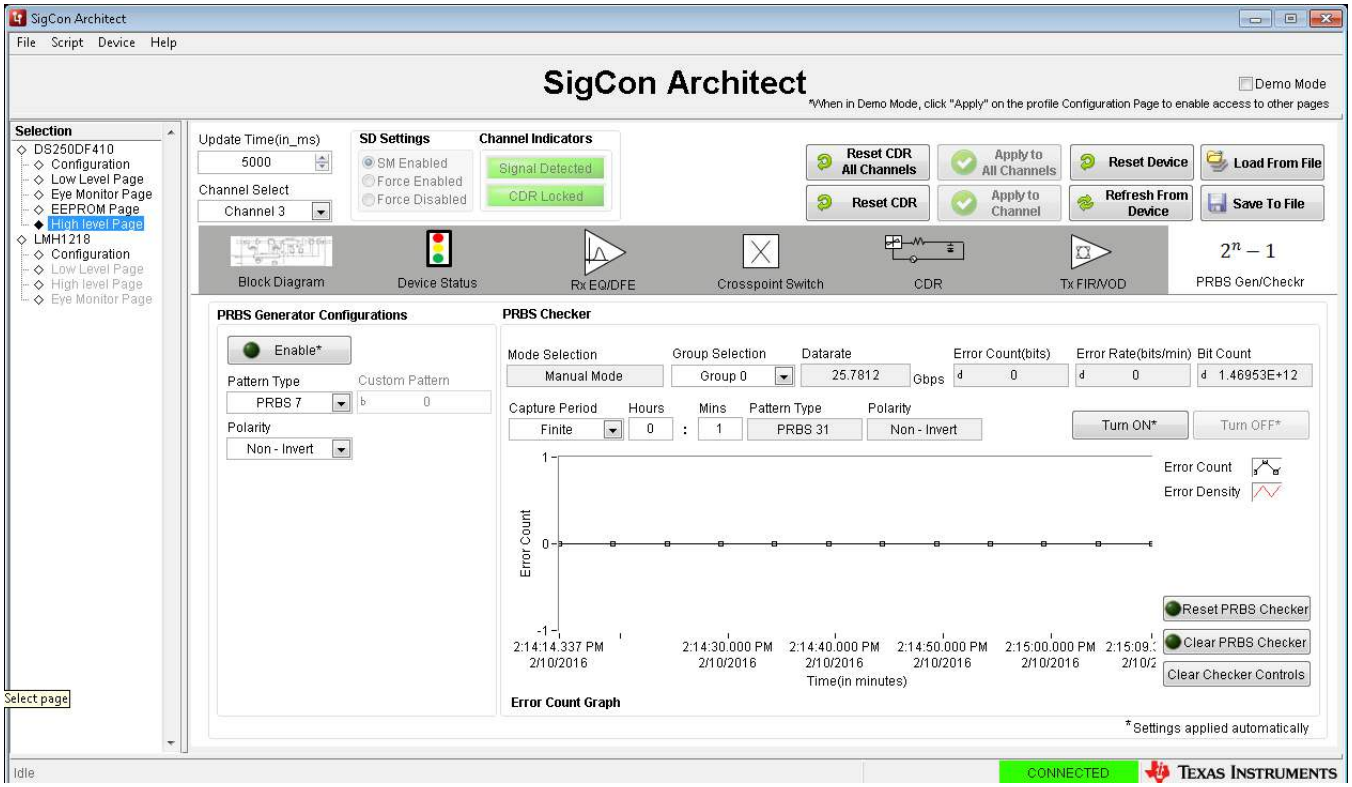


Figure 19. PRBS Tab, PRBS Checker Configuration

3 Best Practices and Usage Tips

The following is a general procedure that should be followed when using the DS250DF410EVM in a system.

1. Set up your data source (either BERT TX or ASIC TX) to generate a PRBS pattern of the desired data rate.
    1. Not all BERT TX sources have FIR capabilities. The DS250DF410 receiver usually does not need much de-emphasis applied by the link partner transmitter (i.e. the BERT TX or ASIC TX). Typically 3dB of de-emphasis or 0-15% post-cursor will be adequate. If the BERT/ASIC TX has pre-cursor capabilities, then 0-15% pre-cursor should be adequate. Most links should be operable without any TX de-emphasis.
2. Connect the EVM in to the system. Typically this will consist of the following topology: BERT TX or ASIC TX → SMA cables → channel_1 → Huber+Suhner cables → DS250DF410 EVM RXn → DS250DF410 EVM TXn → Huber+Suhner cables → channel_2 → SMA cables → BERT RX or ASIC RX
    1. After making your data rate selection, push the “RESET CDR” button on the CDR tab. You only need to press this once, provided you do not change data rate or adapt mode.
    2. Check the Signal Detect and CDR lock status indicators to see if the link is established.
    3. If the CDR is in locked, the CDR lock indicator on the page will turn green and display "CDR locked."
3. Check the Horizontal Eye Opening (HEO) and Vertical Eye Opening (VEO), displayed on the Device Status tab. The user may also go the Eye Monitor Page to plot a full eye diagram.
4. Check the Retimer Receiver’s bits received and errors by clicking "Turn ON" in the PRBS pattern checker section of the PRBS Gen/Checker" tab. If necessary, tune the link partner transmitter’s FIR settings to achieve the target BER.
5. Tune the Retimer TX FIR settings on the TX FIR/VOD tab. It is best to demonstrate that the return path (Retimer TX to BERT/ASIC RX) is working first before trying to optimize the Retimer RX parameters. One way to do this would be to test over a simple channel_1 first to prove that the Retimer can drive data error-free into the BERT/ASIC (optimizing the Retimer TX FIR as needed) then switch to the more difficult channel_1 while keeping channel_2 unchanged.

Things to watch for:

1. At 25-28Gbps data rates, small imperfections in the channel can be problematic. Ensure that cables are properly torqued (not over-torqued), paddle cards are properly mated with backplane connectors, and the BERT RX is properly aligned to the incoming data stream.
2. When adding up the total channel loss, do not forget to include the loss of the test fixture and cables. For example, the DS250DF410 EVM board plus Huber+Suhner cables have ~4dB of insertion loss from the device output to the Huber+Suhner cable end; and another ~4dB from the Huber+Suhner cable end to the device input.

4 Test Case Examples

The following is an example test case with results collected using this EVM.

- **Data Rate**: 25.78125Gbps
- **Data pattern**: PRBS31
- **Backplane insertion loss**: -35dB @ 12.9GHz
- **Crosstalk at victim RX**: 4.1 mV RMS (24.1 mVppd)
- **Victim TX amplitude**: 1200mVppd
- **Victim TX FIR**: C(-1)=-4, C(0)=24, C(+1)=-3
- **Adapt mode**: 2
- **Adapted RX CTLE**: [3,0,0,0]
- **Adapted DFE**: [-0x14, +0x2, +0x1, -0x2, 0x0]

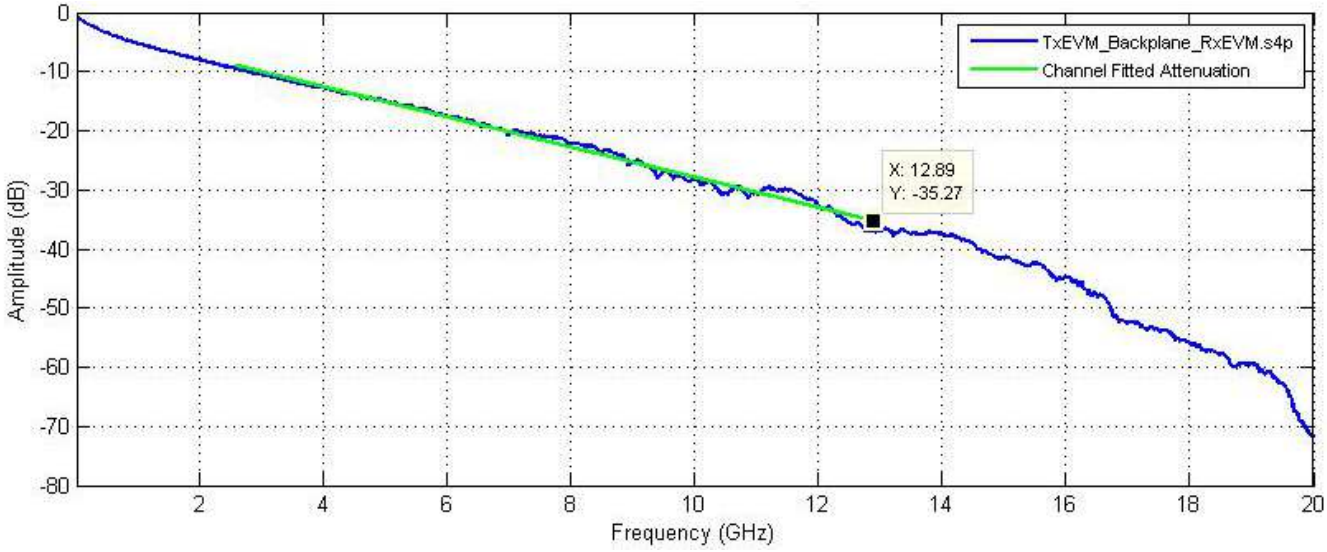


Figure 20. SDD21 Loss Characteristic of Example Test Case

Results:

- Error count = 0, BER < 1E-13
- Horizontal eye opening (HEO): 0.44UI @ 1.5E-5
- Vertical eye opening (VEO): 190mV @ 1.5E-5

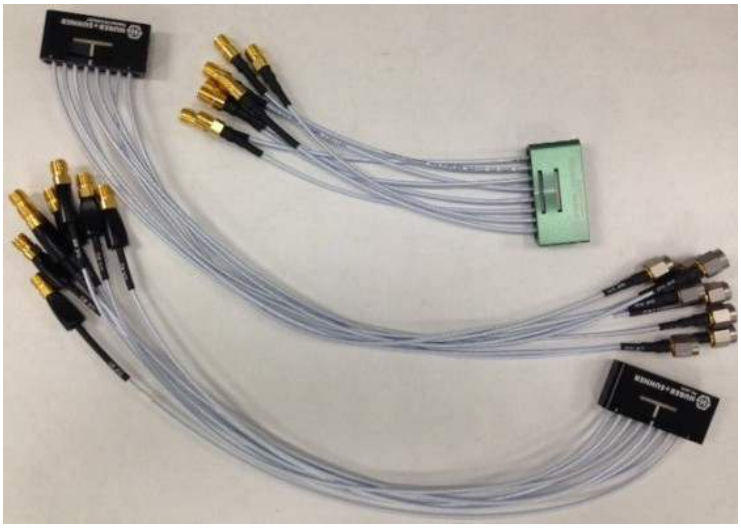
5 Supplemental Documents

All the EVM design, layout, and other files which are relevant to this EVM are listed below:

File description	File name
Schematic PDF	PDF_DS280DF410EVM_Rev2_06-17-15.pdf
Board layout file	DS250DF410EVM_R2_PD-15-0380_PCB_06172015.brd
Board Gerbers	DS250DF410EVM_R2_PD-15-0380_GRB_06172015.zip
Board s-parameters folder	EVM/s_parameters/

6 EVM Cable Assemblies

The DS250DF410EVM uses Huber+Suhner 1x8 MXP cable assemblies.



To inquire about purchasing cable assemblies from Huber+Suhner, contact:

Info.us@hubersuhner.com

HUBER+SUHNER Inc.

8530 Steele Creek Place Drive, Suite H

Charlotte-NC- 28273

+1 704-790-7300

There are three part numbers that TI suggests using with this EVM:

1. 85014420, MF53/1x8A_21MXP/21SMA/152: “MXP-15 cable assembly”. This is a lower cost cable assembly compared to the MXP-40, but the SI performance is very good and more than adequate for 25Gbps operation.
2. 84099607, MF53/1x8A_21MXP/11SK/305: “MXP-40 cable assembly”. This cable assembly is designed specifically for 40+ GHz. It features a male cable end and longer cable length options.
3. 84098900, MF53/1x8A_21MXP/21SK_ergo/305: “MXP-40 cable assembly”. This cable assembly is designed specifically for 40+ GHz. It features a female cable end and longer cable length options.

Huber+Suhner brochure available here.

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (February 2016) to A Revision	Page
• First public release.	3

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