TX7316EVM Ultrasound Transmitter Evaluation Module

User's Guide

Literature Number: SBOU224A
March 2019–Revised May 2019

Contents

General Texas Instruments High Voltage Evaluation (TI HV EMV) User Safety Guidelines

Always follow TI's set-up and application instructions, including use of all interface components within their recommended electrical rated voltage and power limits. Always use electrical safety precautions to help ensure your personal safety and those working around you. Contact TI's Product Information Center http://ti.com/customer support for further information.

Save all warnings and instructions for future reference.

WARNING

Failure to follow warnings and instructions may result in personal injury, property damage or death due to electrical shock and burn hazards.

The term TI HV EVM refers to an electronic device typically provided as an open framed, unenclosed printed circuit board assembly. It is *intended strictly for use in development laboratory environments, solely for qualified professional users having training, expertise and knowledge of electrical safety risks in development and application of high voltage electrical circuits. Any other use and/or application are strictly prohibited by Texas Instruments.* If you are not suitable qualified, you should immediately stop from further use of the HV EVM.

1. Work Area Safety:
   a. Keep work area clean and orderly.
   b. Qualified observer(s) must be present anytime circuits are energized.
   c. Effective barriers and signage must be present in the area where the TI HV EVM and its interface electronics are energized, indicating operation of accessible high voltages may be present, for the purpose of protecting inadvertent access.
   d. All interface circuits, power supplies, evaluation modules, instruments, meters, scopes, and other related apparatus used in a development environment exceeding 50Vrms/75VDC must be electrically located within a protected Emergency Power Off EPO protected power strip.
   e. Use stable and non-conductive work surface.
   f. Use adequately insulated clamps and wires to attach measurement probes and instruments. No freehand testing whenever possible.
2. Electrical Safety:

   As a precautionary measure, it is always good engineering practice to assume that the entire EVM may have fully accessible and active high voltages.
   a. De-energize the TI HV EVM and all its inputs, outputs and electrical loads before performing any electrical or other diagnostic measurements. Revalidate that TI HV EVM power has been safely de-energized.
   b. With the EVM confirmed de-energized, proceed with required electrical circuit configurations, wiring, measurement equipment hook-ups and other application needs, while still assuming the EVM circuit and measuring instruments are electrically live.
   c. Once EVM readiness is complete, energize the EVM as intended.

WARNING

While the EVM is energized, never touch the EVM or its electrical circuits, as they could be at high voltages capable of causing electrical shock hazard.

3. Personal Safety
   a. Wear personal protective equipment e.g. latex gloves or safety glasses with side shields or protect EVM in an adequate lucent plastic box with interlocks from accidental touch.

Limitation for safe use:

EVMs are not to be used as all or part of a production unit.

TX7316EVM Evaluation Module

This user's guide gives a general overview of the TX7316EVM evaluation module (EVM) and provides a general description of the features and functions to be considered while using this module. The TX7316EVM provides a platform for evaluating the transmitter under various drive strength, different voltage levels and different modes of the device.

This user's guide refers to software TX7316EVM GUI v.1.0.0 or higher and requires the Microsoft® Windows 7® operating system or above to function.

For any further questions regarding the EVM, GUI or device, contact TI support.

WARNING

The TX7316EVM evaluation module has high voltage DC supply connected to it. Hence do not leave EVM powered when unattended as it can result in potential injury.

The TX7316EVM evaluation module is intended strictly for simulating ultrasound transducer interface development in electrical instrumentation/laboratory development environment. To minimize risk of possible electrical shock and/or radiation hazards, attachment of actual ultrasonic transducers/receivers is prohibited.

1 Trademarks

Microsoft, Windows 7 are registered trademarks of Microsoft.
National Instruments is a registered trademark of National Instruments.
Python is a registered trademark of Python.
All other trademarks are the property of their respective owners.

2 EVM Hardware Overview

The EVM received should resemble Figure 1. For more hardware details, refer to *Appendix D*.

The TX7316EVM kit contains the following items:

1. TX7316EVM
2. 1 mini-USB cable

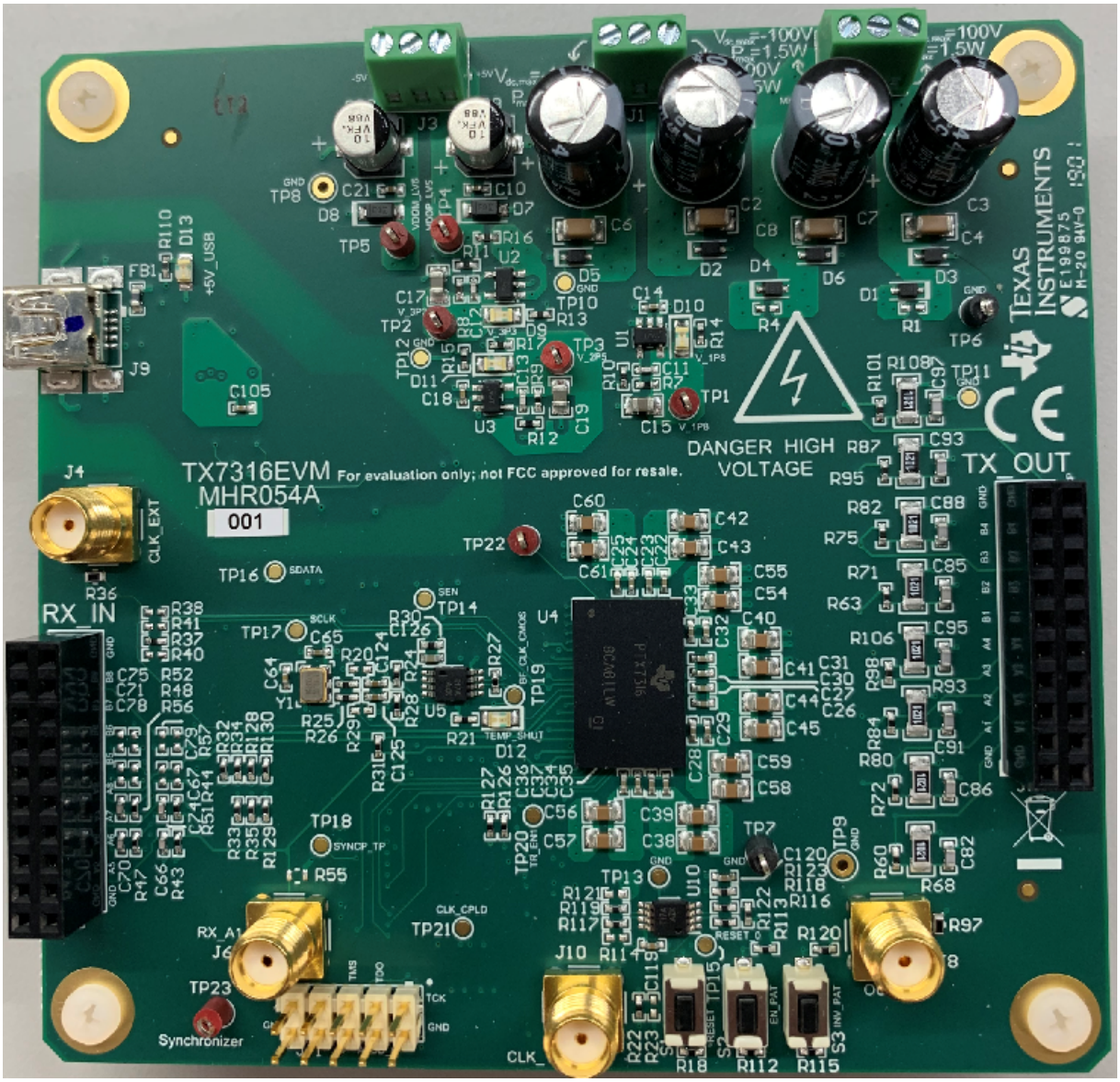


Figure 1. TX7316EVM

3 GUI Software Installation

The TX7316EVM requires a software to be installed to check the on-chip features of the device. Ensure that no USB connection is made to the EVM until after the installation is complete. This user's guide refers to software TX7316EVM GUI V 1.0.0. For information on the installation of the TX7316EVM software GUI, see Appendix A.

4 Equipment Setup Overview

Figure 2 and Figure 3 show the equipment setup required to test the TX7316EVM in off-chip and on-chip mode, respectively.

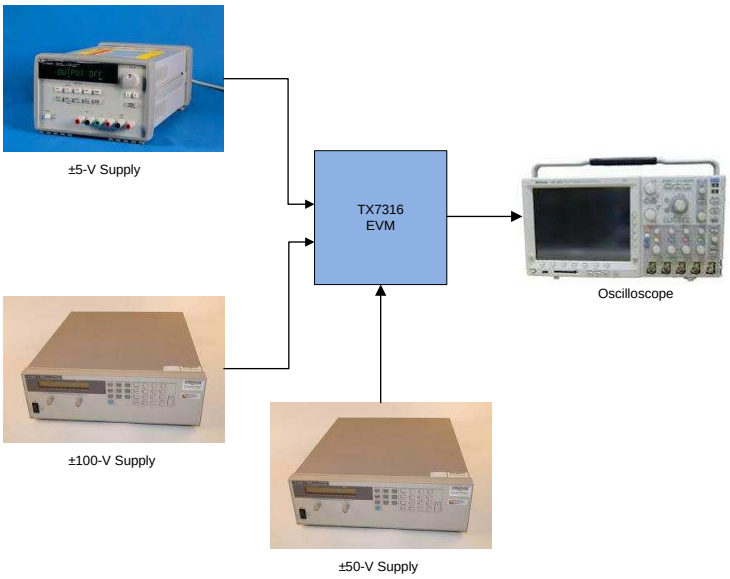


Figure 2. Off-chip Beamforming Setup

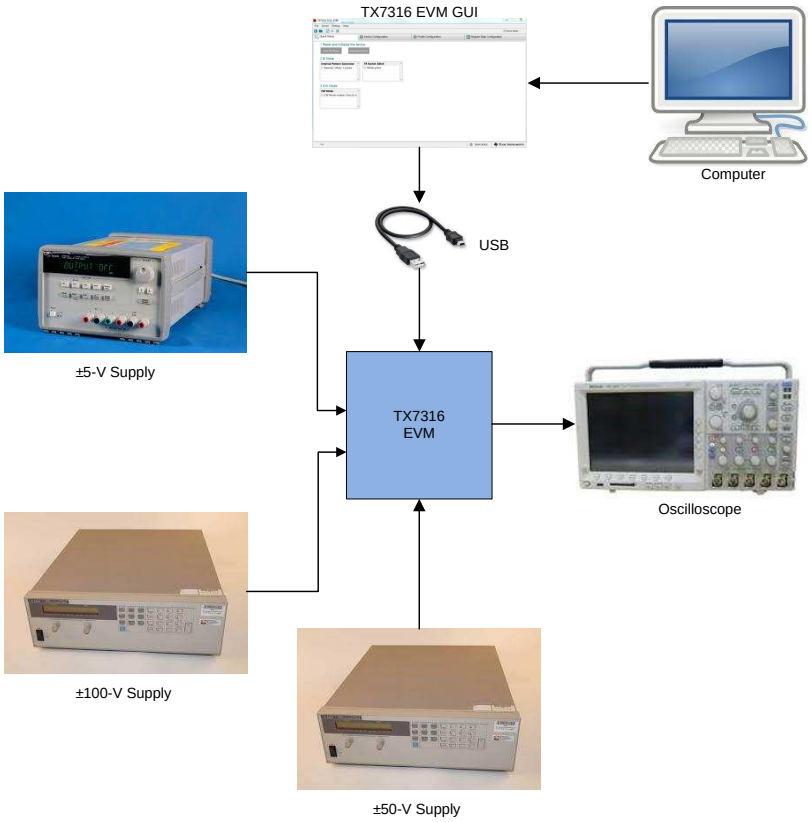


Figure 3. On-chip Beamforming Setup

4.1 Power Supply

The EVM uses a screw-based connector for power supply ports. The EVM requires a ±5-V supply and two high voltage ±100-V supply each with a 500-mA current range.

4.2 USB Interface to PC

USB connection from the TX7316EVM to the PC is used for communication between the GUI and the EVM. Both USB 2.0 and 3.0 ports are supported.

5 Testing the EVM

1. **Power Supply:** Ensure that the power supplies are turned off before connecting to the board. Apply ±5 V to connector J3 (set the current limit of both the supplies to 200 mA). Apply ±50 V to connecter J1 and ±100V to connector J2 (supply on both the connectors can be any value between ±1.5 to ±100 V; however, J2 supplies must be higher than that of J1). Set the current limit to 30 mA.
2. **Hardware reset:** Press switch S1 to hardware reset the device. After hardware reset, the CPLD on board starts emitting 1-kHz TR_BF_SYNC and TR_EN signals.

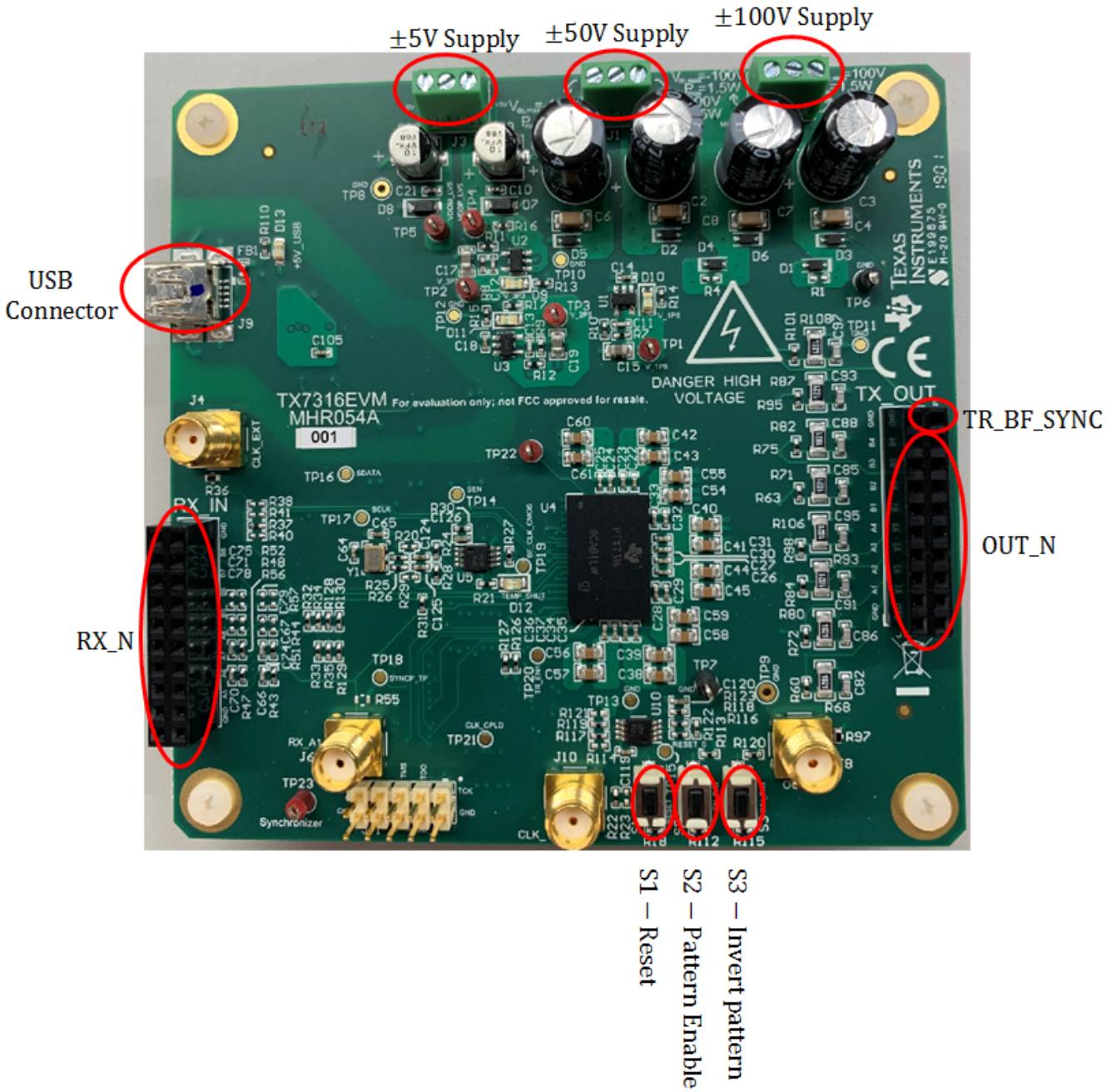
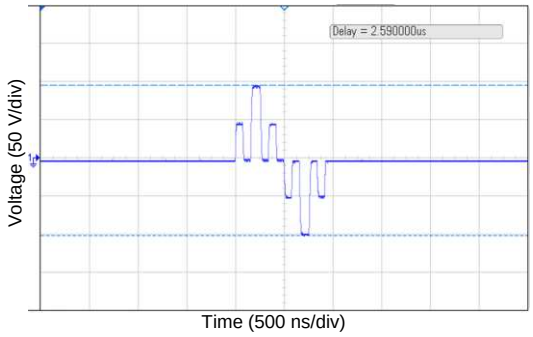


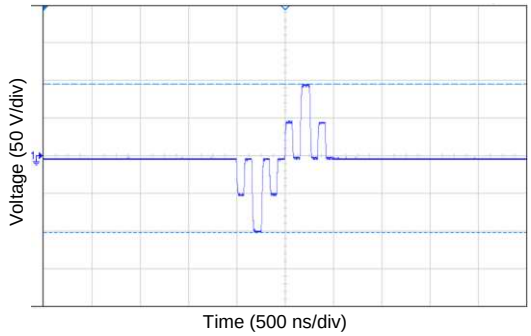
Figure 4. Connectors and Switches of the EVM

3. **Off-chip beamforming:** To enable the off-chip beamforming mode of the device, press switch S2. The switch triggers the CPLD on the board to start sending the input control signals required by the device. After the switch is pressed, the device starts emitting pattern. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Outputs can be observed on pins 3 to 10 of J7 connector. The output pattern can be inverted by pressing switch S3.



Frequency = 1.08 MHz; Peak-to-Peak = 196.5 mV

Figure 5. Output Pattern When Switch S2 is Pressed



Frequency = 1.08 MHz; Peak-to-Peak = 196.5 mV

Figure 6. Output Pattern When Switch S3 (invert) is Pressed

4. **On-chip beamforming:** To check on-chip functionality, first ensure that the power supplies are powered off. Then, connect the USB cable to the board and open the GUI. Select 5-level mode in the *Select a Device Mode* pop-up window.(See Figure 7). Turn on the power supplies once the GUI is loaded. Click *DUT HW Reset* button on the *Quick Setup* tab (See Figure 8) to hardware reset the device and then click *Reset Memory to 0* button to initialize the memory.

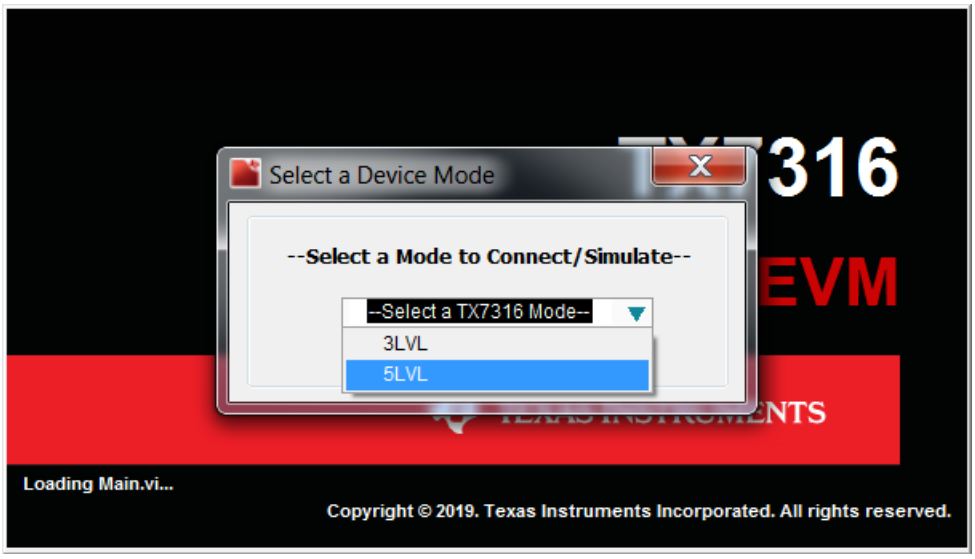


Figure 7. Select a Device Pop-up Window

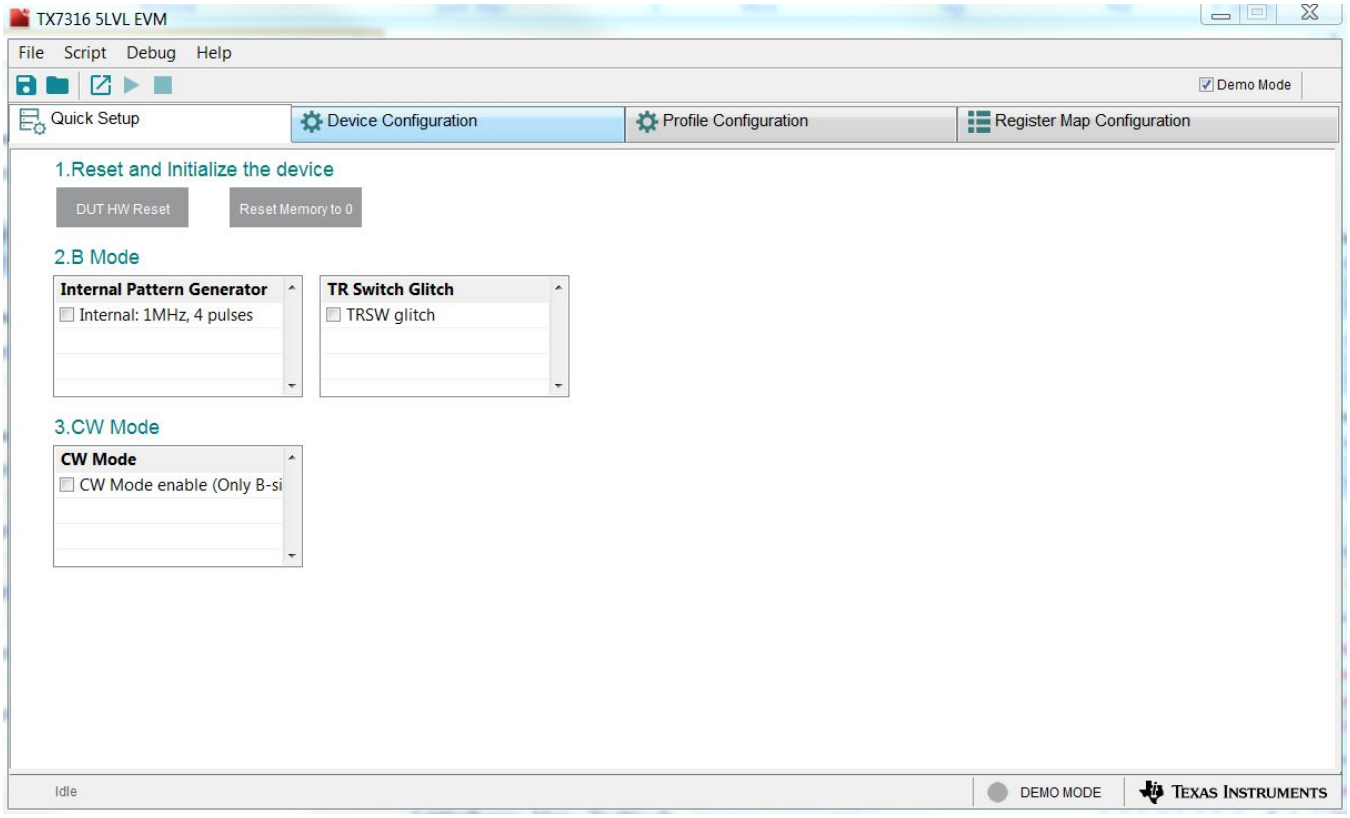
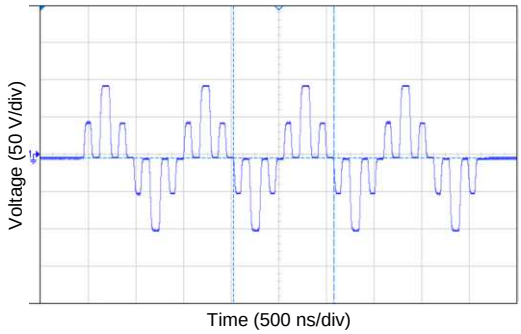


Figure 8. Quick Setup Page

a. **Testing the B mode of device:**

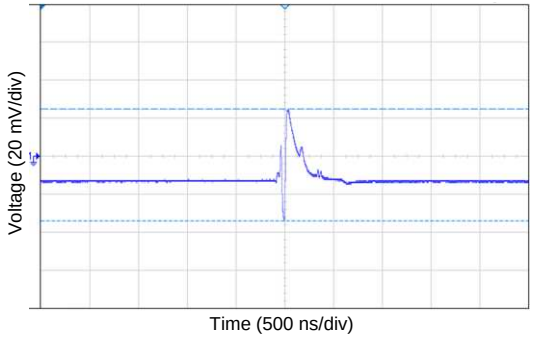
   i. Pulser output of the device can be checked by selecting the *Internal: 1 MHz, 4 pulses* option under B-Mode. The CPLD on board generates the TR_BF_SYNC and TR_EN signals (1-kHz pulse repetition frequency) control signals for the device. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Pulser outputs can be observed on pins 3 to 10 of J7 connector.



Frequency = 952.4 kHz; Peak-to-Peak = 196.5 mV

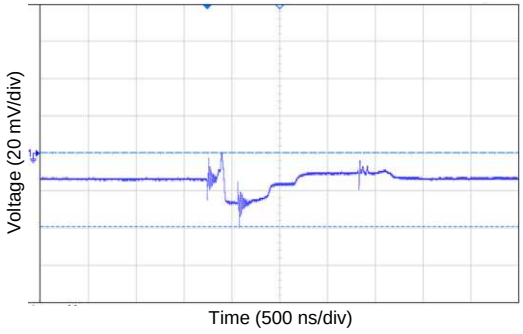
Figure 9. Internal: 1 MHz, 4 Pulses

ii. TW switch glitch can be checked by enabling the TRSW glitch mode on the quick setup tab. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). TRSW glitch can be observed on pins 3 to 10 of J5 connector (labelled as RX_IN).



Peak-to-Peak = 58.7 mV

Figure 10. TR Switch On Glitch



Peak-to-Peak = 39.6 mV

Figure 11. TR Switch Off Glitch

b. **Testing the CW mode of the device:**

i. To check the CW mode of the device, reduce the ±50-V supply (connected to J1 connector) to ±5 V. Current limit of all ±5-V supplies must be increased to 500 mA. The CW mode of the device can be enabled by clicking the *CW mode enable* on the GUI (clicking on this mode gives a pop-up warning asking the user to ensure that the supply voltage is ±5 V as shown in Figure 12; Click *Continue* button after reducing the supply voltage). Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Pulser CW outputs can be observed on pins 11 to 18 of J7 connector.

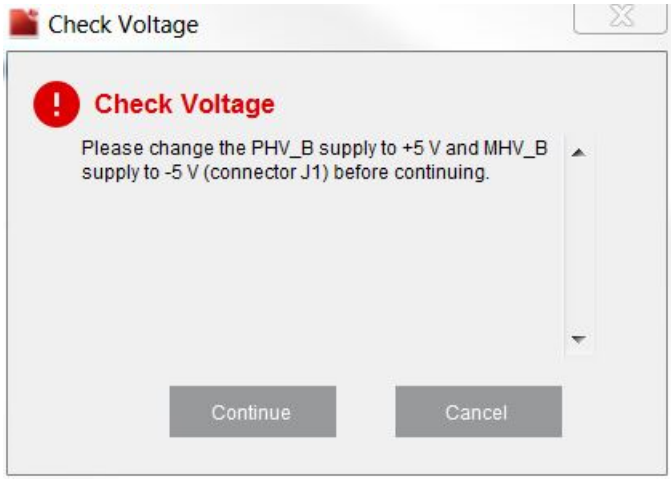
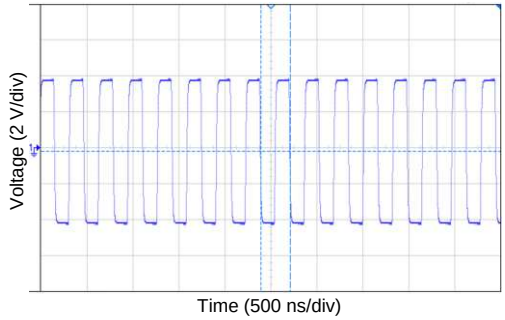


Figure 12. Pop-up Warning Given by the GUI When the CW Mode is Selected



Frequency = 3.125 MHz; Peak-to-Peak = 8.08 V

Figure 13. CW-Mode Output of the Device

A.1 TX7316EVM GUI Installation

Download the TX7316EVM GUI from the mySecureSoftware folder at https://www.ti.com/securesoftware/docs/securesoftwarehome.tsp

1. Unzip the saved file and run the installer executable as administrator by right clicking on the file and selecting *Run as Administrator*. In *TX7322 Installer* window, press the *Next* > button

Figure 14. TX7316EVM GUI Install (Begin Installation)

2. Read the Texas Instruments *License Agreement*. Select the *I accept the agreement* radio button, and then press the *Next* > button.

Figure 15. TX7316EVM GUI Install (TI License Agreement)

3. Read the National Instruments® *License Agreement*. Select the *I accept the agreement* radio button, and then press the *Next* > button.

Figure 16. TX7316EVM GUI Install (National Instruments® License Agreement)

4. Read the PSF *License Agreement* for Python®. Select the *I accept the agreement* radio button, and then press the *Next* > button

Figure 17. TX7316EVM GUI Install (Python® License Agreement)

5. In the *Installation Directory* screen, press the *Next* > button to allow the software to be installed in the default location or browse to the desired location and then press the *Next* > button

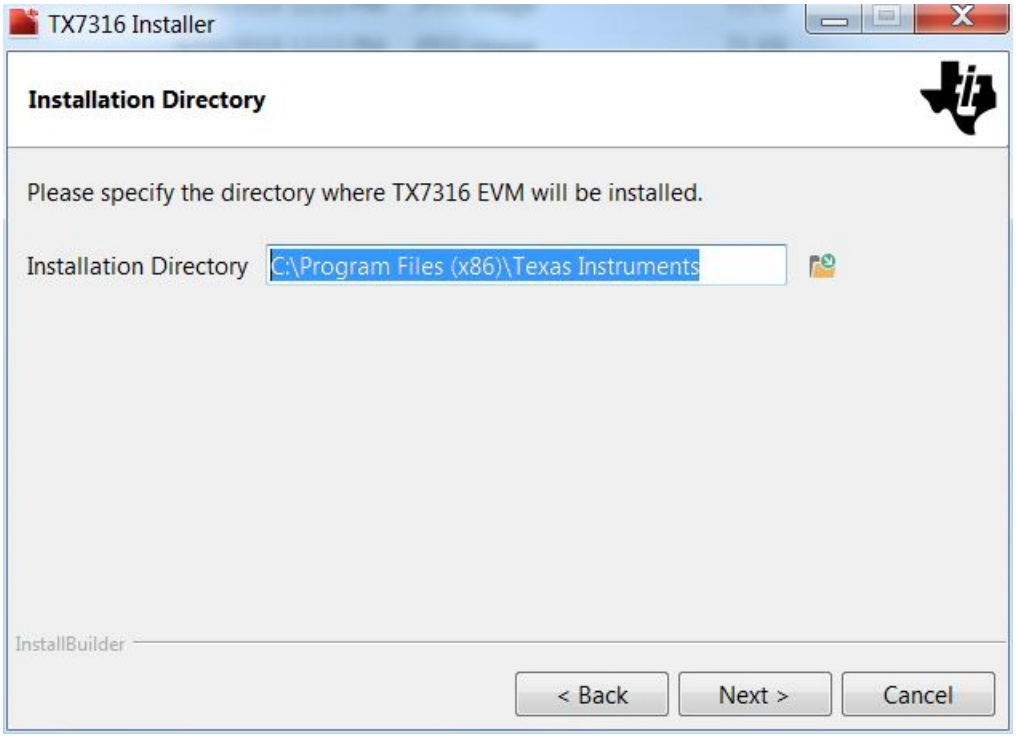


Figure 18. TX7316EVM GUI Install (Install Directory)

6. In the *Select Components* screen, keep the default selections unchanged and click the *Next* > button.

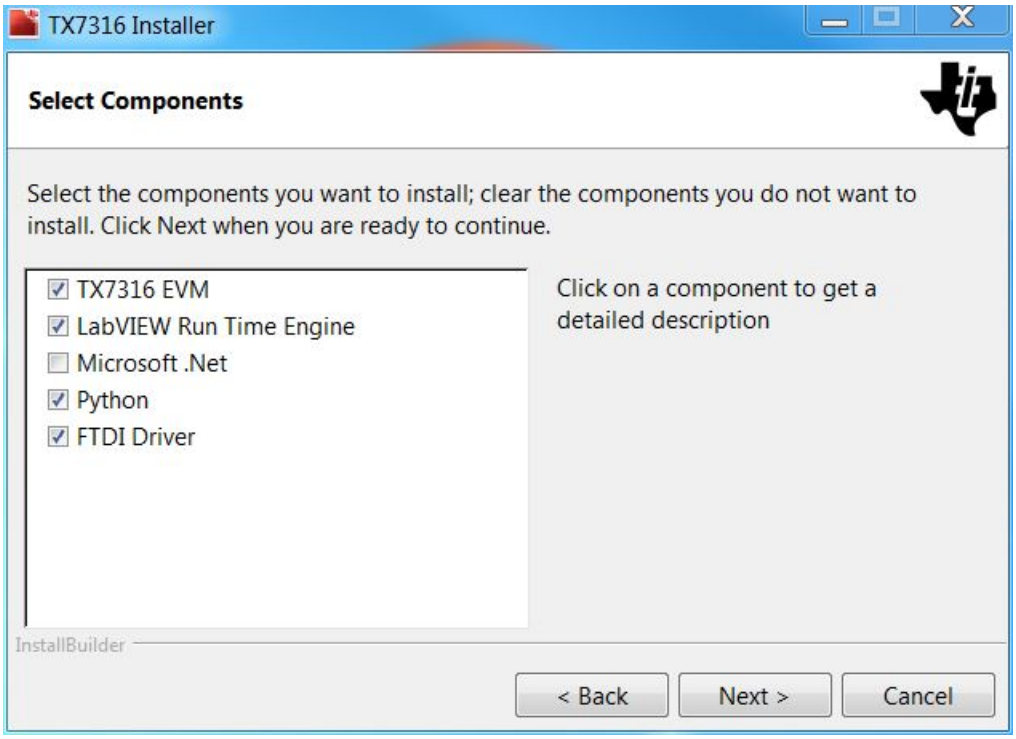


Figure 19. TX7316EVM GUI Install (Select Components)

7. In the *Ready to Install* screen, click the *Next* > button to allow the software to be installed:

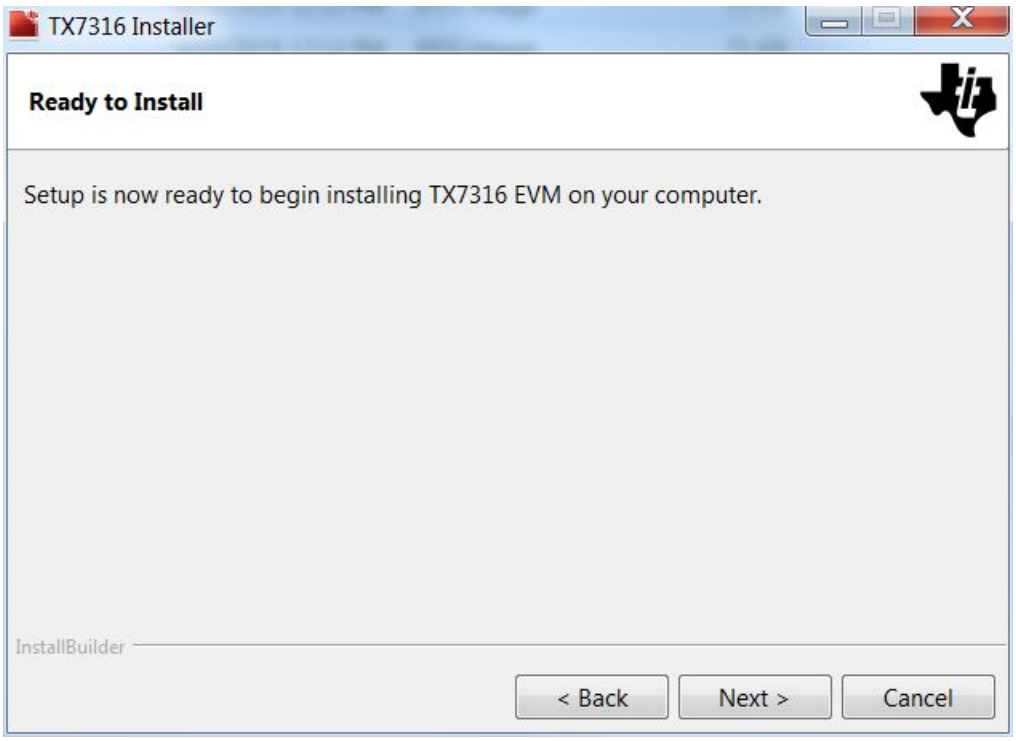


Figure 20. TX7316EVM GUI Install (Installation Ready)

8. The *Installation is in progress...* screen appears showing that the installation is in progress.

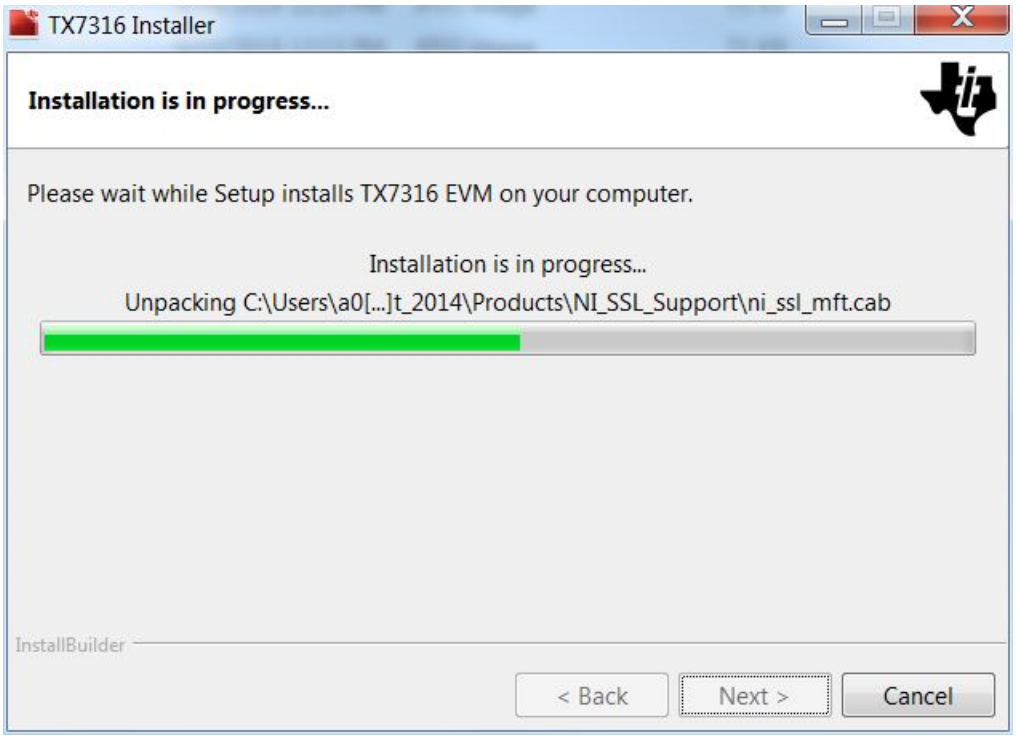


Figure 21. TX7316EVM GUI Install (Installation Progress)

9. *Python 2.7 Setup* window displays. Select the *Install for all users* radio button and then click the *Next >* button.

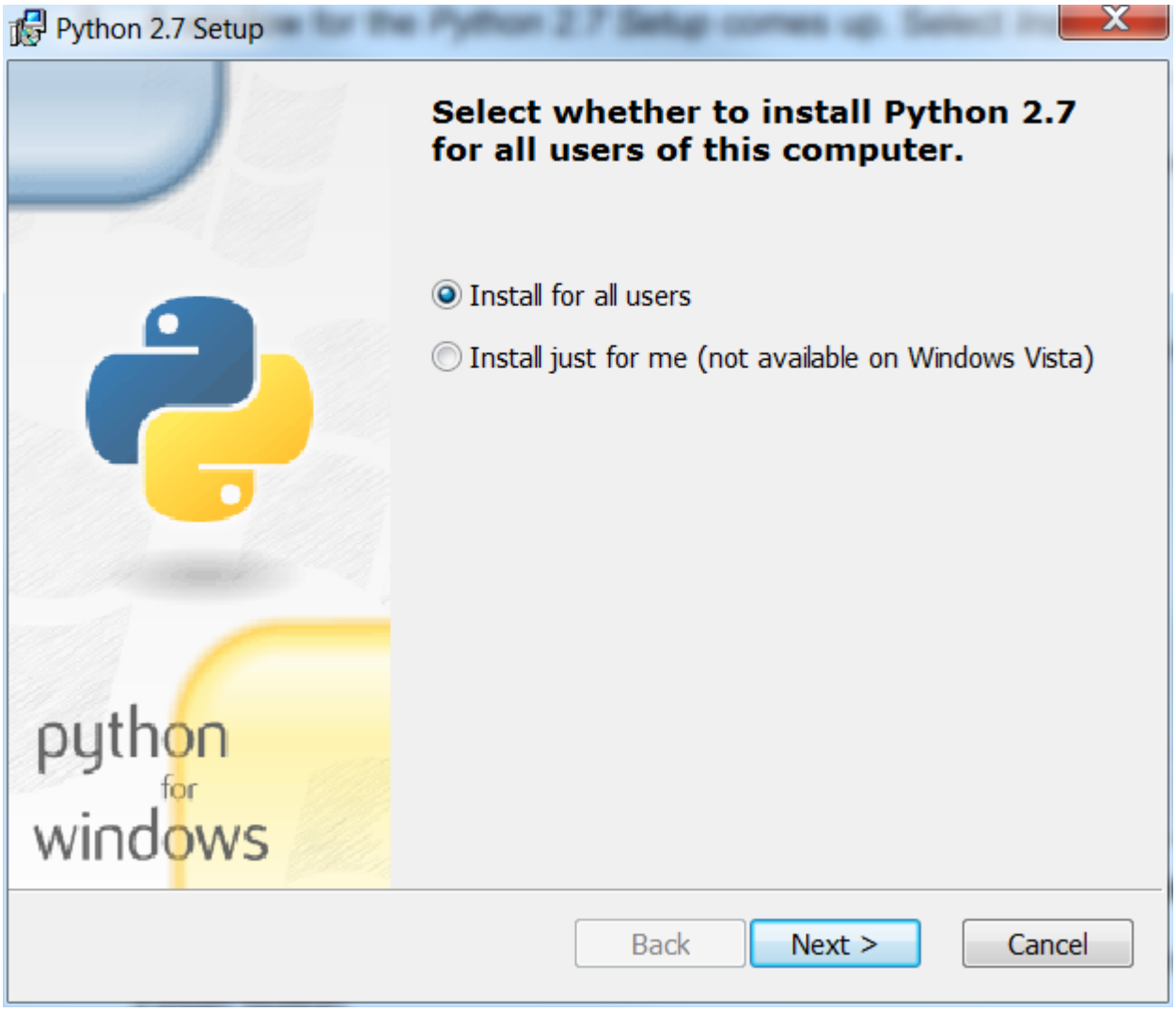


Figure 22. TX7316EVM GUI Install (Installation for Users)

10. *Select Destination Directory* window displays. Select the default path and click *Next* > button.

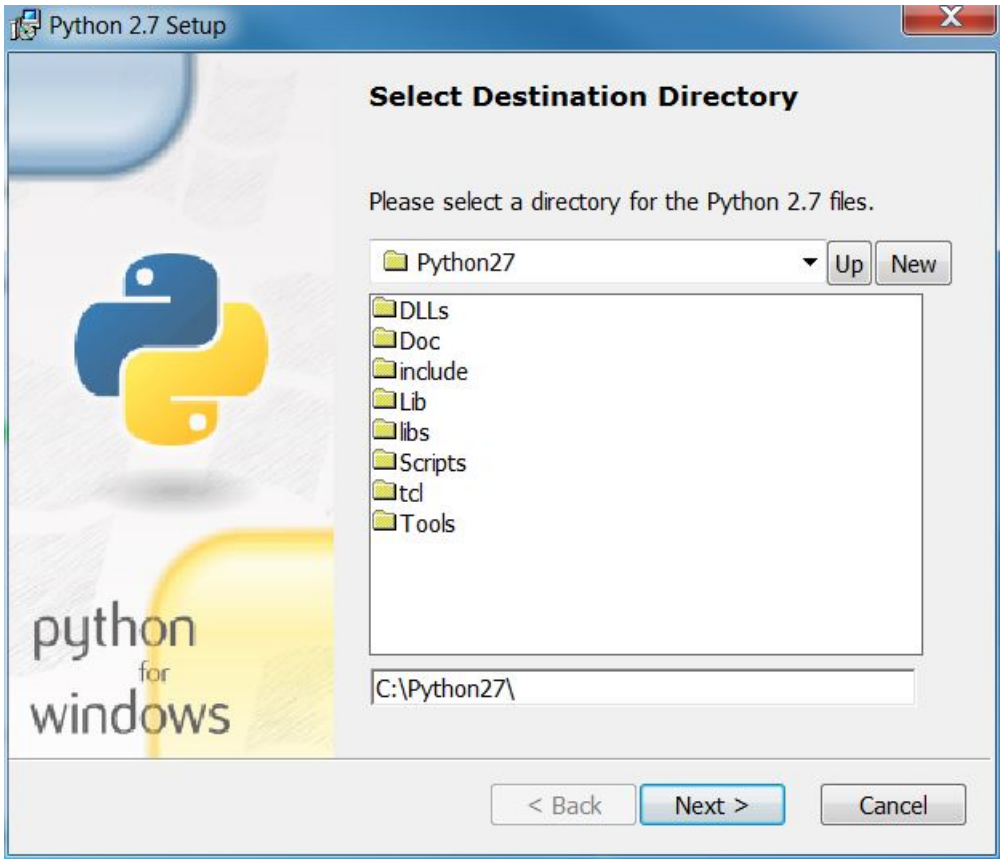


Figure 23. TX7316EVM GUI Install (Select Destination Directory)

11.

A. If Python 2.7 is already installed:

i. *Python 2.7* setup window appears. Click *No* button to prevent the existing files from getting overwritten.

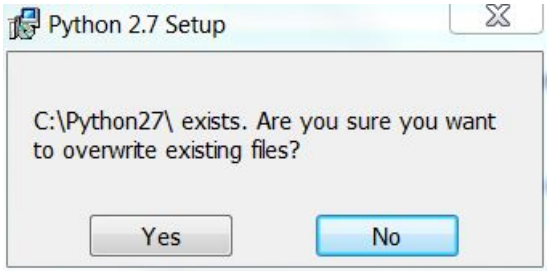


Figure 24. TX7316EVM GUI Install (Python® is Already Installed)

ii. Click *Yes* button to cancel the Python 2.7 installation.

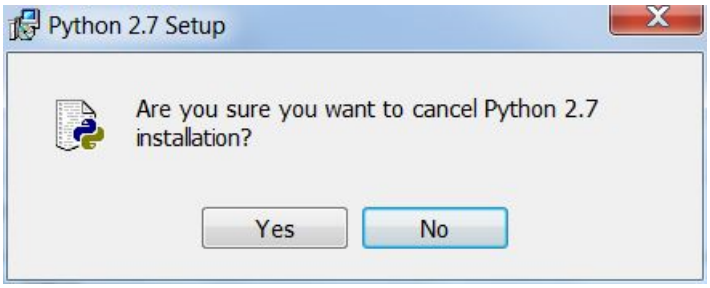


Figure 25. TX7316EVM GUI Install (Cancel Python® Installation)

B. If Python 2.7 is not installed:

i. In the *Customize Python 2.7* Screen, select the desired customization and click *Next* > button.

Figure 26. TX7316EVM GUI Install (Customize Python®)

ii. The Install Python 2.7 Screen appears.

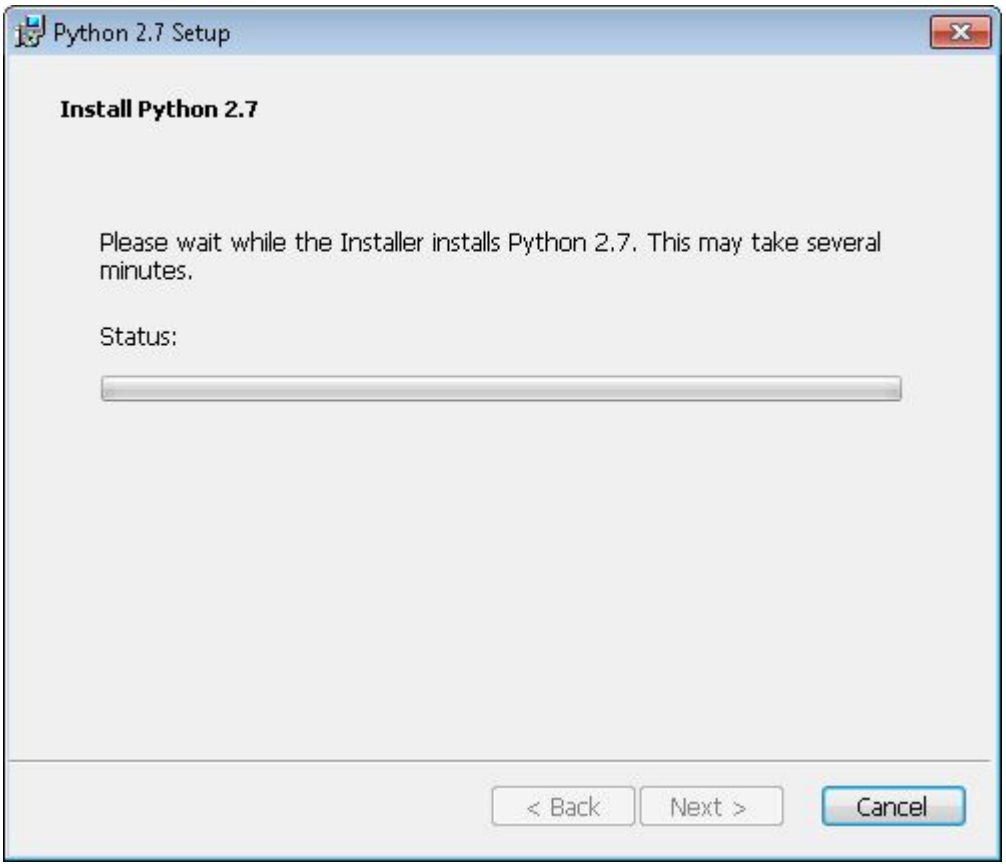


Figure 27. TX7316EVM GUI Install (Python® Installation Progress)

iii. After the installation is complete, *Completing the Python 2.7 Installer* screen appears. Click the *Finish* button to complete the installation.

12. In the *Completing the TX7316EVM Setup* Wizard screen, Click the Finish button to complete the installation.

Figure 28. TX7316EVM GUI Install (Finished)

TX7316EVM GUI Features

B.1 Overview of the TX7316EVM GUI Features

This section provides a quick overview of the features and functions of the TX7316EVM GUI. The GUI allows the user to easily configure the various functions of the transmitter such as Pulser drive strength, output waveform and so on.

Operations in the GUI should only be performed after the status at the bottom left-hand corner of the GUI reads Idle.

Furthermore, hovering over a control within any of the GUI sub-tabs displays the function of that control along with the register fields updated using that control. For example, as shown in Figure 29, in the *Quick Setup* tab, if you hoover over *DUT HW RESET* button, a light yellow box, describing the function of *DUT HW RESET* button is displayed.

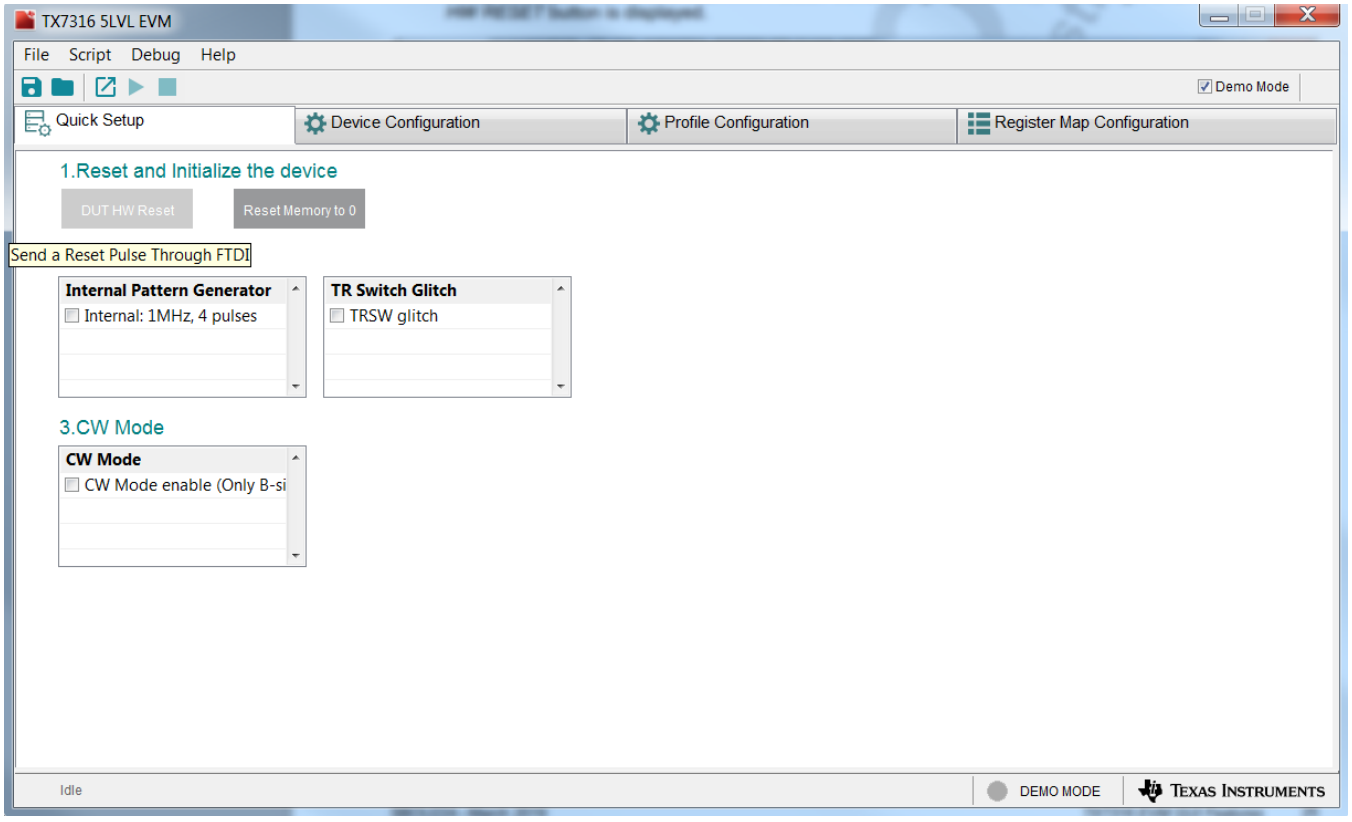


Figure 29. TX7316EVM GUI

The 4 main tabs, their sub-tabs and fields are as follows:

- Quick Setup
  - Reset and Initialize the device
    - DUT HW Reset
    - Reset Memory to 0

  - B Mode
    - Internal Pattern Generator
    - TR Switch glitch
  - CW mode
- Device Configuration
  - General Settings
    - Reset Device
    - Device Settings
      - Pattern Settings
      - Global Power Settings
      - Delay Profile Select
      - CW Mode Settings
      - Pattern Profile Select
  - Power Down Settings
    - Channel Power Down
    - TR Switch Control Using Device Pin / Registers
- Profile Configuration
  - Pattern Profile
  - Delay Profile
- Register Map Configuration

B.1.1 Quick Setup Tab

The *Quick Setup* tab has the following options:

1. Reset and initialize the device using the buttons *DUT HW Reset* and *Reset Memory to 0*.
2. Select Transmit mode or TR Switch glitch mode using the *B Mode* check-box menus.
3. Enable or disable CW mode using *CW Mode enable* checkbox.

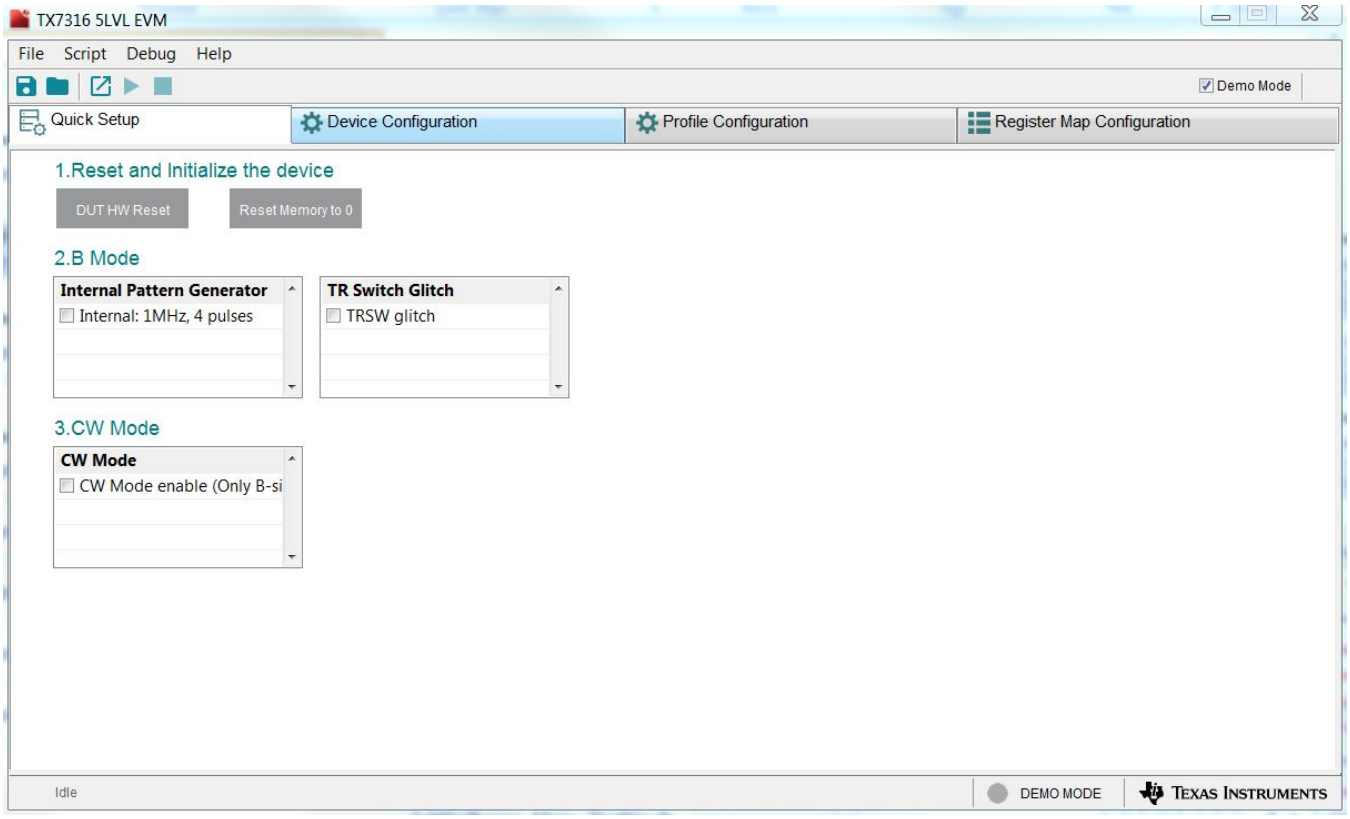


Figure 30. TX7316 Quick Setup Tab

B.1.2 Device Configuration Tab

This tab contains two sub-tabs: *General Settings* and *Power Down Settings*

B.1.2.1 General Settings

The *General Settings* sub-tab has the following options:

1. Reset the device using the *Software Reset* button.
2. Enable TX_BF_MODE, set the clock division factor and select the pattern invert for on-chip beamforming using the options under *PATTERN SETTING* field.
3. Select the global power settings using the check boxes under *GLOBAL POWER SETTINGS* field.
4. Select and configure Delay and pattern profile using the options under *DELAY PROFILE SELECT* and *PATTERN PROFILE SELECT* fields, respectively.
5. Enable and configure CW mode using the check boxes and options listed under *CW MODE SETTINGS* field.
6. Configure the TR switch delay mode and delay value using the options under *TR SWITCH* field.

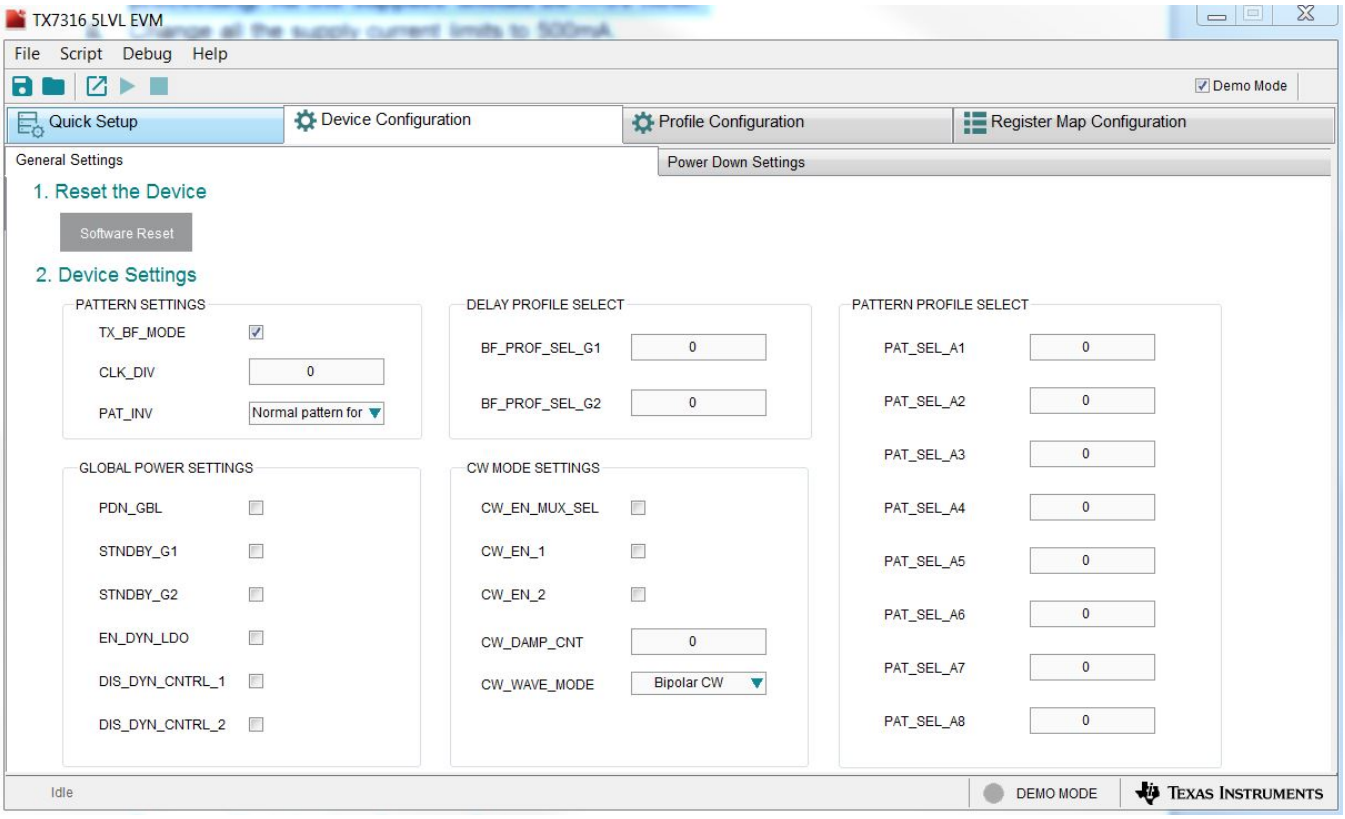


Figure 31. Device Configuration - General Setting

B.1.2.2 Power Down Settings

The *Power Down Settings* sub-tab for the TX7316 has the following options:

1. Power down individual channels using *CHANNEL POWER DOWN* options.
2. Power down individual TR switch using *T/R SWITCH CONTROL USING DEVICE PIN/REGISTERS*.

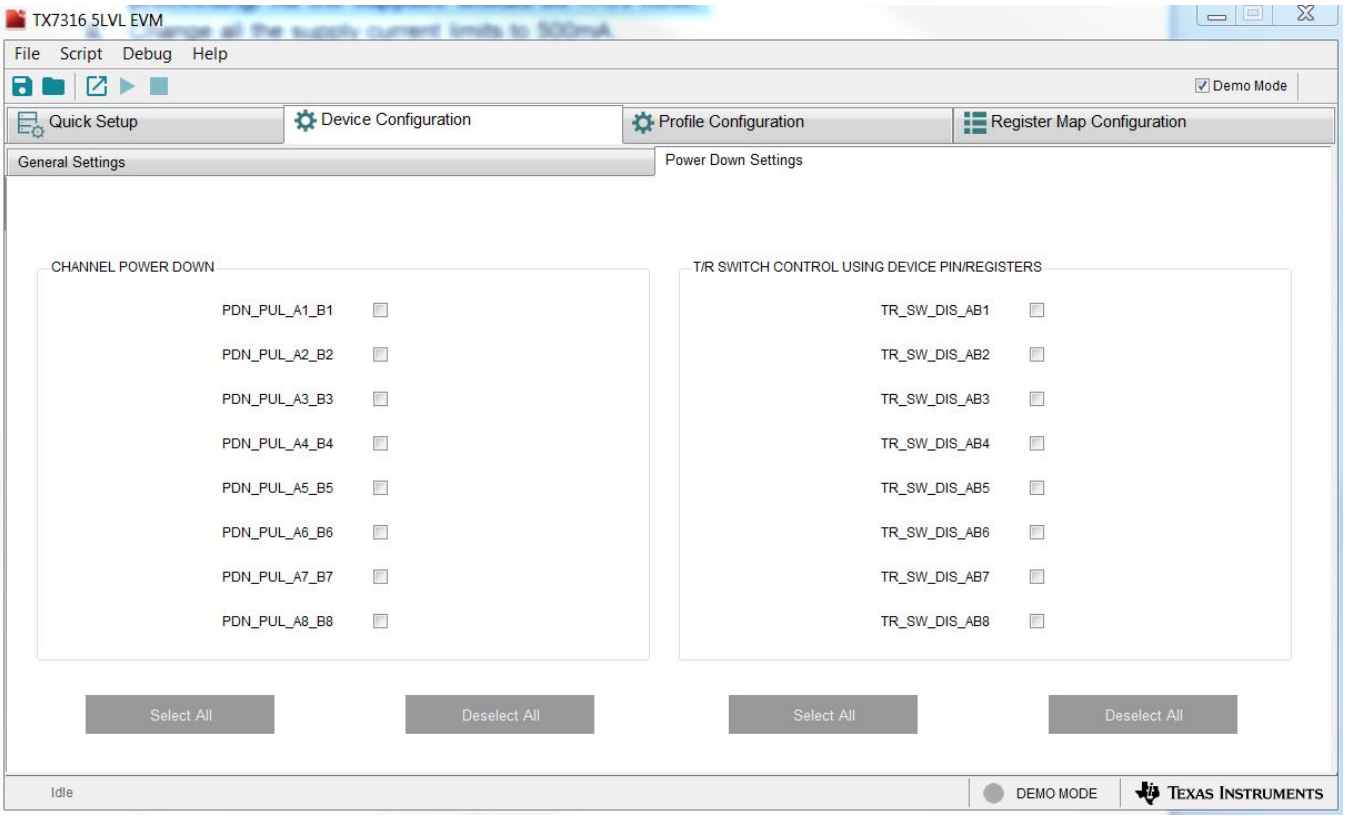


Figure 32. Device Configuration - Power Down Setting

B.1.3 Profile Configuration Tab

This tab contains two sub-tabs: *Pattern Profile* and *Delay Profile*.

B.1.3.1 Pattern Profile

The *Pattern Profile* sub-tab for the TX7316 has the following options:

1. Program the pattern profile of the device without caring about the exact register values.
2. Select the profile number and number of transition needed in the final waveform using the options under *PATTERN PROFILE CONFIGURATION* field.
3. Set the required level and period for each transition in the table. You can verify the waveform in the GUI plot.
4. Set the repeat and tail counts using the options under *COMMON PATTERN SETTINGS* field.
5. After all the settings are complete, you can use *Write to Device* button to configure the selected profile of the device.

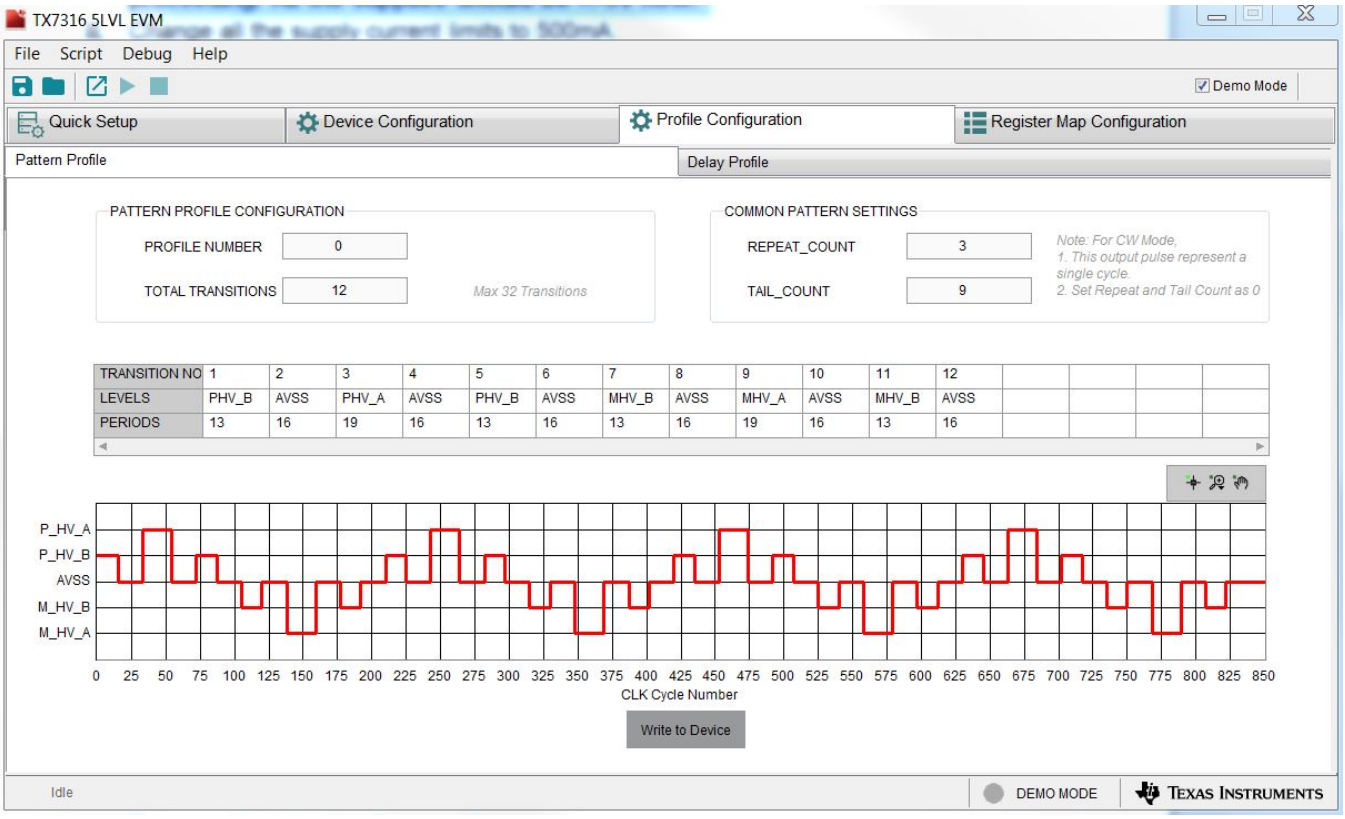


Figure 33. Profile Configuration - Pattern Profile

B.1.3.2 Delay Profile

The *Delay Profile* sub-tab for the TX7316 has the following options:

1. Select the delay profile using the *PROFILE NUMBER* field.
2. Enter the individual channel delay using the field listed under *DELAY PROFILE* field.

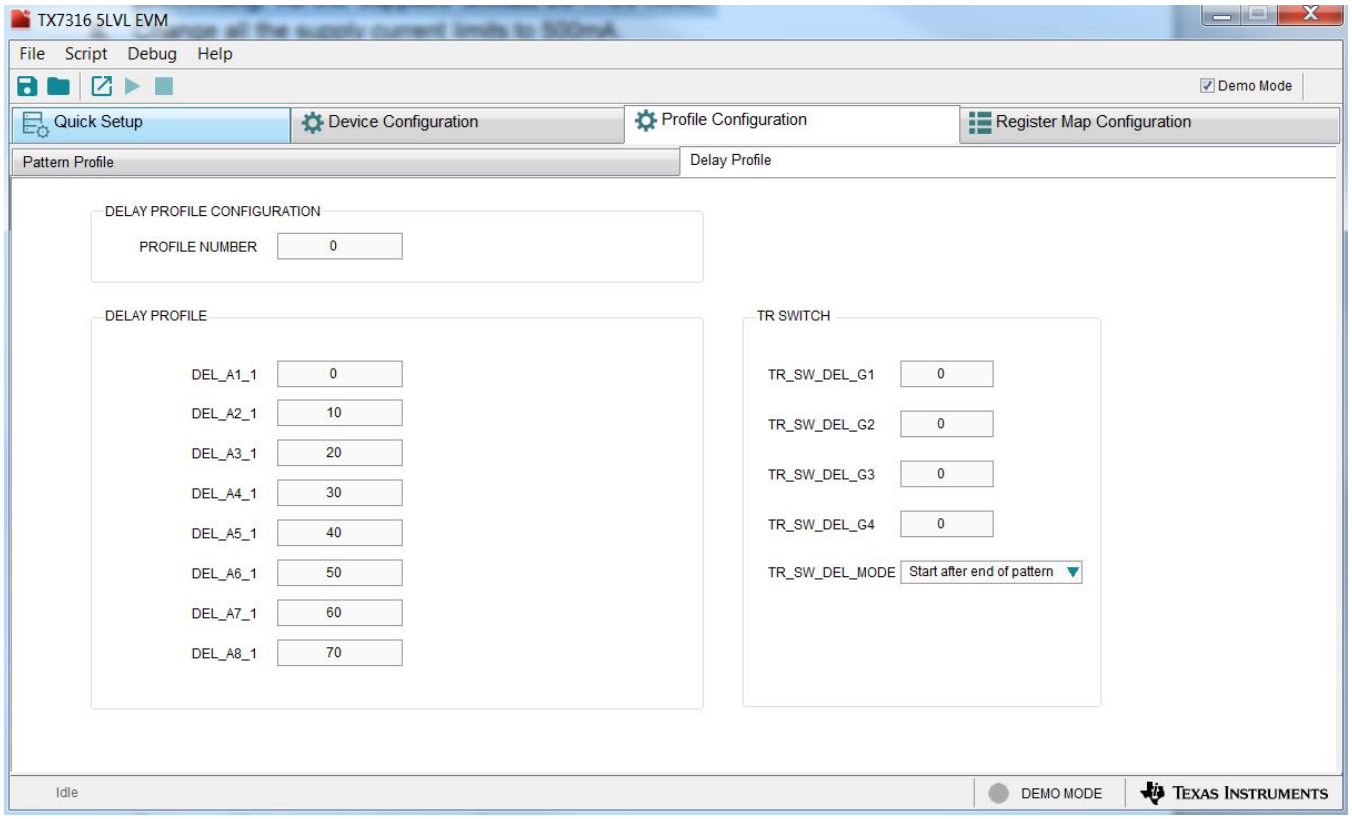


Figure 34. Profile Configuration - Delay Profile

B.1.4 Register Map Configuration Tab

The *Register Map Configuration* tab is a used to write and read specific registers using the SPI. The tab contains multiple fields that allow you to configure the register map, select the update modes, and also to update register values.

The *Register Map Configuration* tab has the following fields:

1. Register Map: Displays the details of all registers in the device such as the register name, address, default value, etc.
2. Field View: Displays the field names and field values of the register selected in the *Register Map* field.
3. Register Description: Describes the functions and the settings of the register selected in the *Register Map* field.
4. Update Mode: Allows you to update the contents of the registers in Immediate mode or Deferred mode.

B.1.4.1 Register Map Setting

Clicking on a register name gives a list of the fields within that specific register. Clicking on a field name highlights the bits within the register that correspond to that field. In Figure 35, Register 12 has been clicked. All the fields within Register 12 come up in the *Field View* on the right-hand side of the GUI.

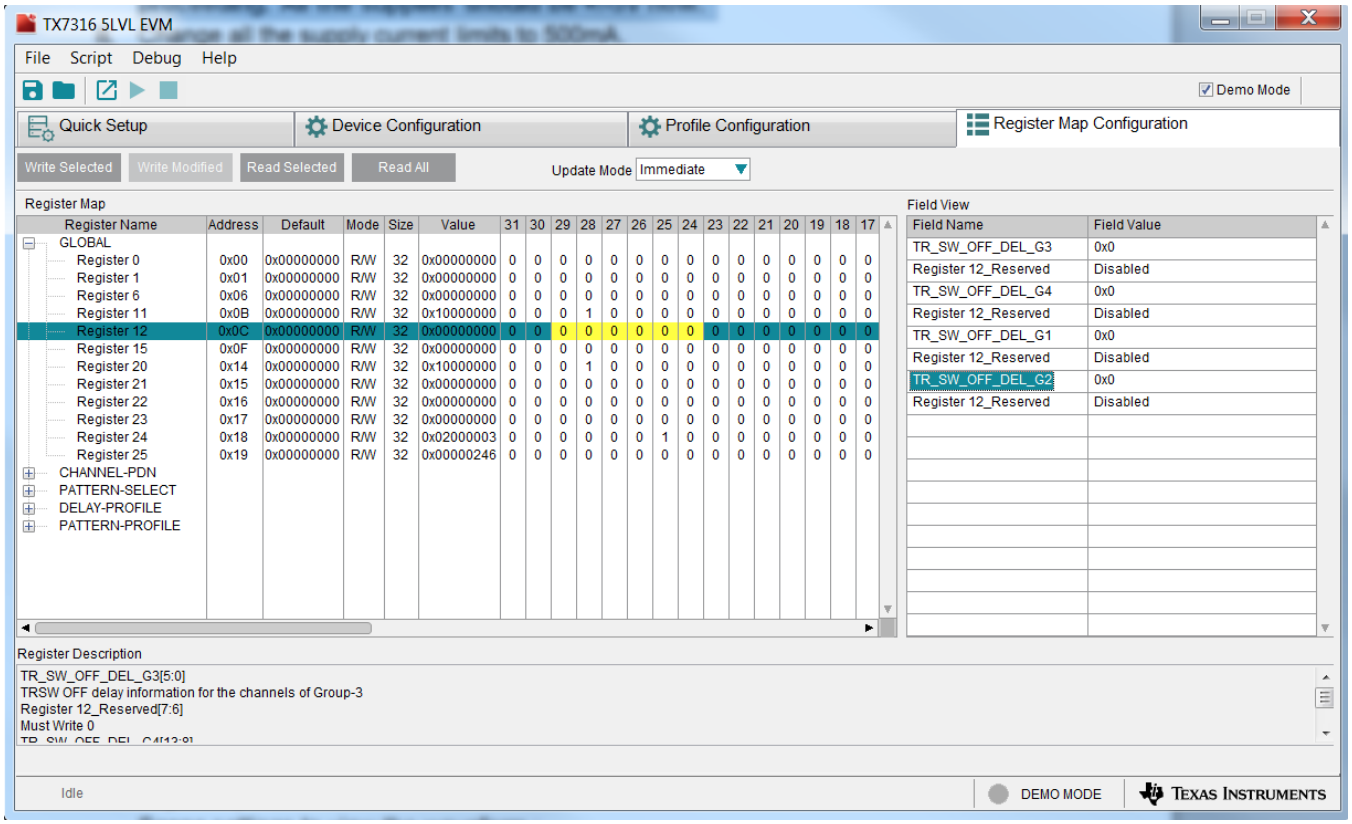


Figure 35. Register Map Configuration – Field View

B.1.4.2 Update Modes

You can make register updates using the two options listed in the *Update Mode* drop-down, as shown in Figure 36: (a) Immediate and (b) Deferred.

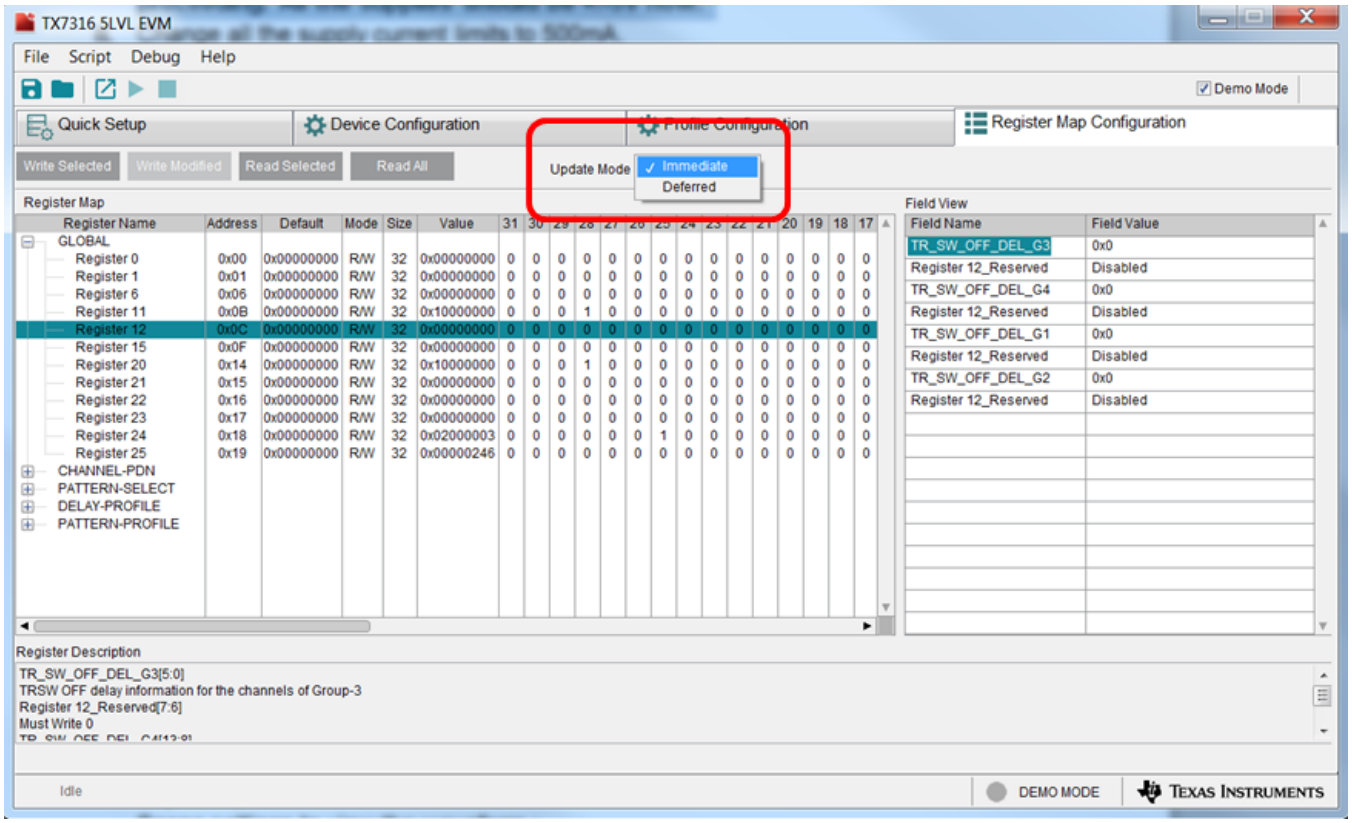


Figure 36. Register Map Configuration – Update Mode

1. Immediate: The Immediate update mode allows user to change the values of any number of bits or fields within the registers, and these changes are immediately written to the device. When using Immediate update mode, there are three options such as:
   a. Read Selected: Use this option to read from a selected register. In order to select a particular register, click on any register under *Register Name* and then use *Read Selected* button to read from the selected register. The *Address* field displays the address of the selected register, and the *Value* field displays the value contained in that register as shown in Figure 36.
   b. Write Selected: Use this option to write to a selected register. In order to select a particular register, click on any register under *Register Name* and then use *Write Selected* button to write to the selected register.
   c. Read All: Use this option to read data from all the registers in the device. This option lets user read all the registers irrespective of which register is selected in the *Register Map* field.

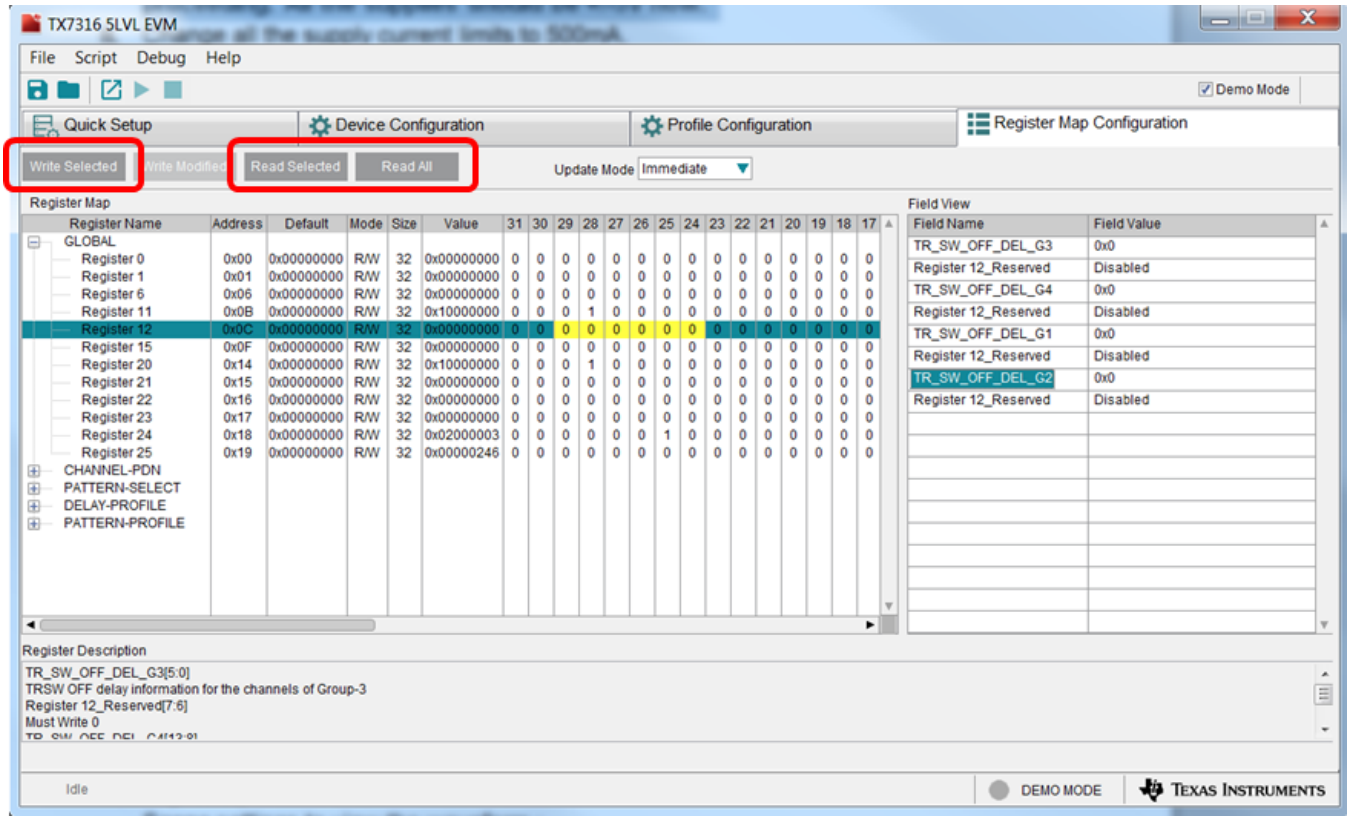


Figure 37. Register Map Configuration – Update Mode (Immediate)

2. The Deferred update mode allows user to change the values of any the of bits or fields within the registers, but these changes are not written to the device instantly. When a user changes the contents of a register in Deferred mode, the GUI turns the changed register font a blue color. These blue-font registers indicate that a change has been made but not yet implemented. Note that unless the changes are implemented, data cannot be read from the registers either. When using Deferred update mode, there are three options such as:
   a. Read Selected: Use this option to read from a selected register. In order to select a particular register, click on any register under *Register Name* and then use *Read Selected* button to read from the selected register. The *Address* field displays the address of the selected register, and the *Value* field displays the value contained in that register as shown in Figure 38
   b. Write Selected: Use this option to write the for a selected register. In order to select a particular register, click on any register under *Register Name* and then use *Write Selected* button to write to the selected register.
   c. Write Modified: If you have made changes to multiple registers in the register map, this option allows user to write the changes within all modified registers to the device. After all changes are written, there are no longer any blue-font registers, indicating that all the changes are implemented.
   d. Read All: Use this option to read data from all the registers in the device. This option lets you read all the registers irrespective of which register is selected in the *Register Map* field.

NOTE: If any registers contains modified values that are not yet written, none of the Read options can be used. User is prompted to either write the modified fields to the device or to discard the changes.

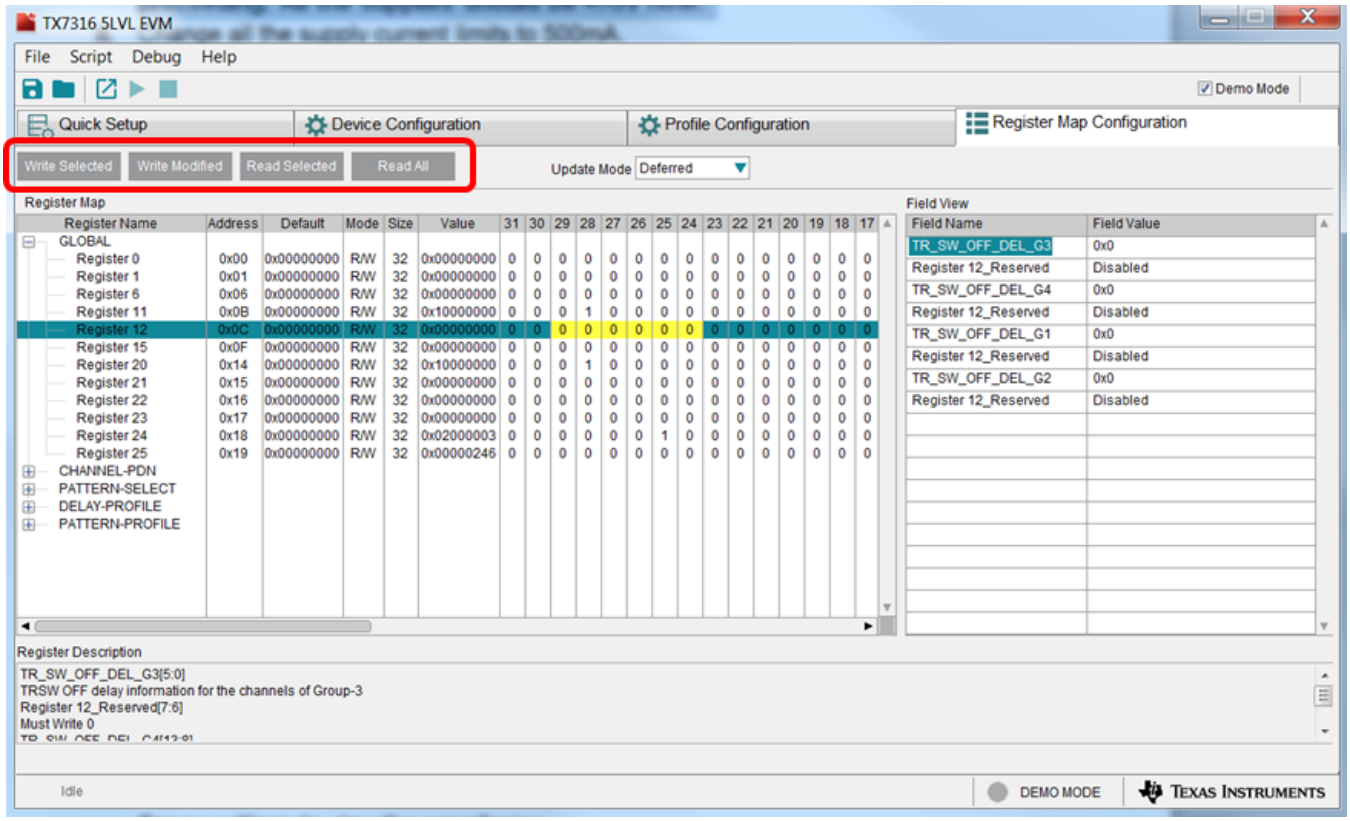


Figure 38. Register Map Configuration – Update Mode (Deferred)

B.1.4.3 Changing Register Values

As shown in Figure 39, user can use the *Field View* menu options to write to or to change the existing value in a register. After selecting the register in the *Register Map* field, use the *Field Value* drop-down to list the available options for the corresponding entry in the *Field Name*. User can select the desired option to write to or change and the change shows up in the register map. The value for a specific bit can also be changed by clicking on the corresponding bit in the register map.

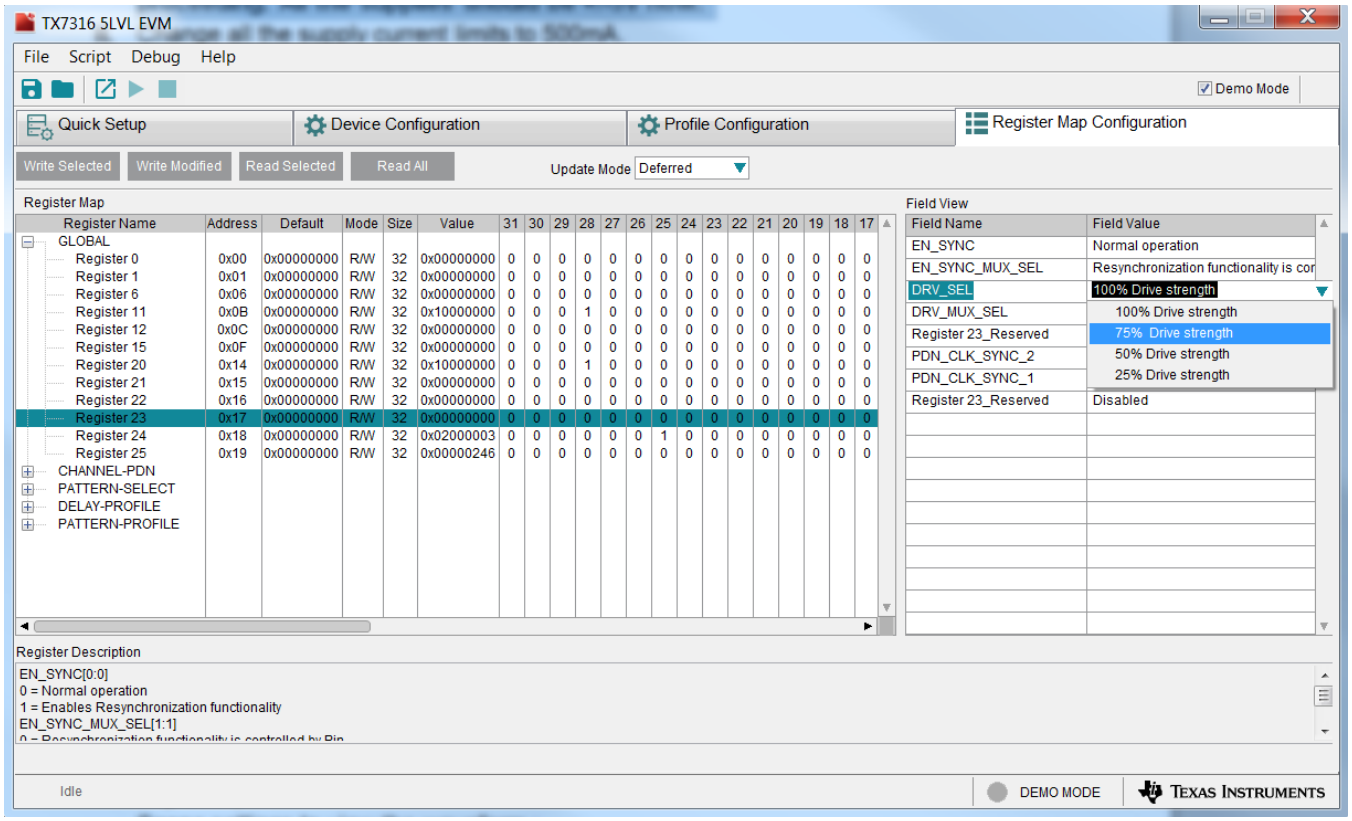


Figure 39. Register Map Configuration – Changing Register Value

Testing the EVM in 3-Level Mode

The TX7316 EVM can be reconfigured to be used in the 3-level mode of the device. Table 1 lists the hardware changes required to configure the EVM to 3-level mode.

Table 1. Hardware changes to configure EVM to 3-level mode

Purpose	Components to be removed	Components to be added	Part number to be used	Value
Short A and B supply		R1, R4	ERJ-2GE0R00X	0 Ω
LVL_3Z_5 change	R22	R23	ERJ-2GE0R00X	0 Ω
Removing the TX shorts and placing loads on B side	R66, R67, R78, R79, R91, R92, R104, R105	R61, R64, R73, R76, R85, R88, R99, R102	ERJ-2GE0R00X	0 Ω
Removing the RX shorts and placing loads on B side	R31, R32, R33, R34, R35, R128, R129, R130	R44, R46, R48, R50, R52, R54, R57, R59	FC0402E50R0BST1	50 Ω
		C67, C69, C71, C73, C75, C77, C79, C81	GRM1555C1E200JA01D	20 pF

C.1 Testing the EVM

1. **Power Supply:** Ensure that the power supplies are turned off before connecting to the board. Apply ±5 V to connector J3 (set the current limit of both the supplies to 200 mA). Apply ±100 V to connecter J1 (supply can be any value between ±1.5 to ±100 V) and set the current limit to 30 mA.
2. **Hardware reset:** Press switch S1 to hardware reset the device. After hardware reset, the CPLD on board starts emitting 1-kHz TR_BF_SYNC and TR_EN signals.

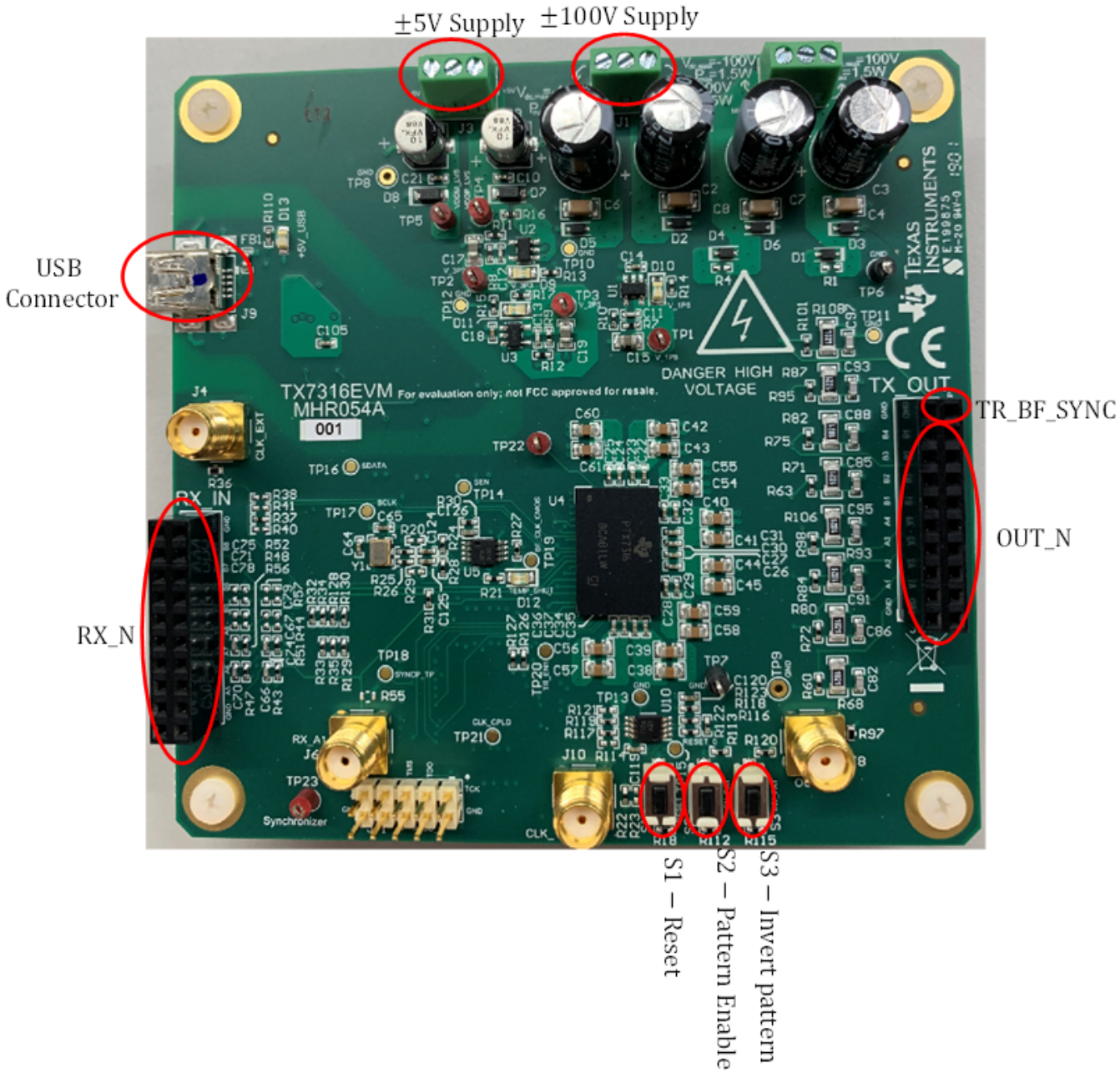
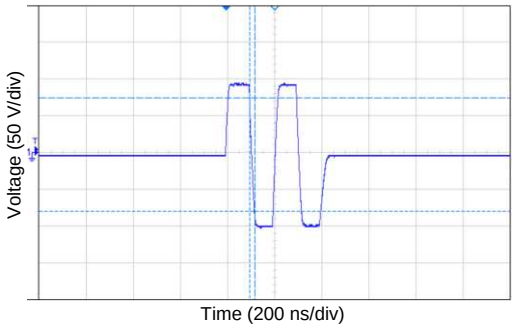


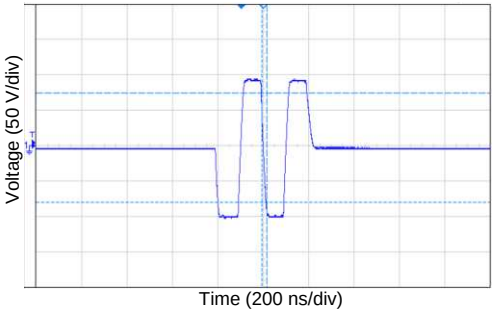
Figure 40. Connectors and Switches of the EVM

3. **Off-chip beamforming:** To enable the off-chip beamforming mode of the device, press switch S2. The switch triggers the CPLD on the board to start sending the input control signals required by the device. After the switch is pressed, the device starts emitting pattern. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Outputs can be observed on pins 3 to 18 of J7 connector. The output pattern can be inverted by pressing switch S3.



Frequency = 5 MHz; Peak-to-Peak = 196.5 mV, Rise Time = 20.8 ns; Fall Time = 21 ns

Figure 41. Output Pattern When Switch S2 is Pressed



Frequency = 5 MHz; Peak to peak = 196.6 mV, Rise Time = 20.8 ns; Fall Time = 20.8 ns

Figure 42. Output Pattern When Switch S3 (invert) is Pressed

4. **On-chip beamforming:** To check on-chip functionality, first ensure that the power supplies are powered off. Then, connect the USB cable to the board and open the GUI. Select 3-level mode in the *Select a Device Mode* pop-up window(See Figure 43). Turn on the power supplies once the GUI is loaded. Click *DUT HW Reset* button on the *Quick Setup* page (See Figure 44) to hardware reset the device and then click *Reset Memory to 0* button to initialize the memory.

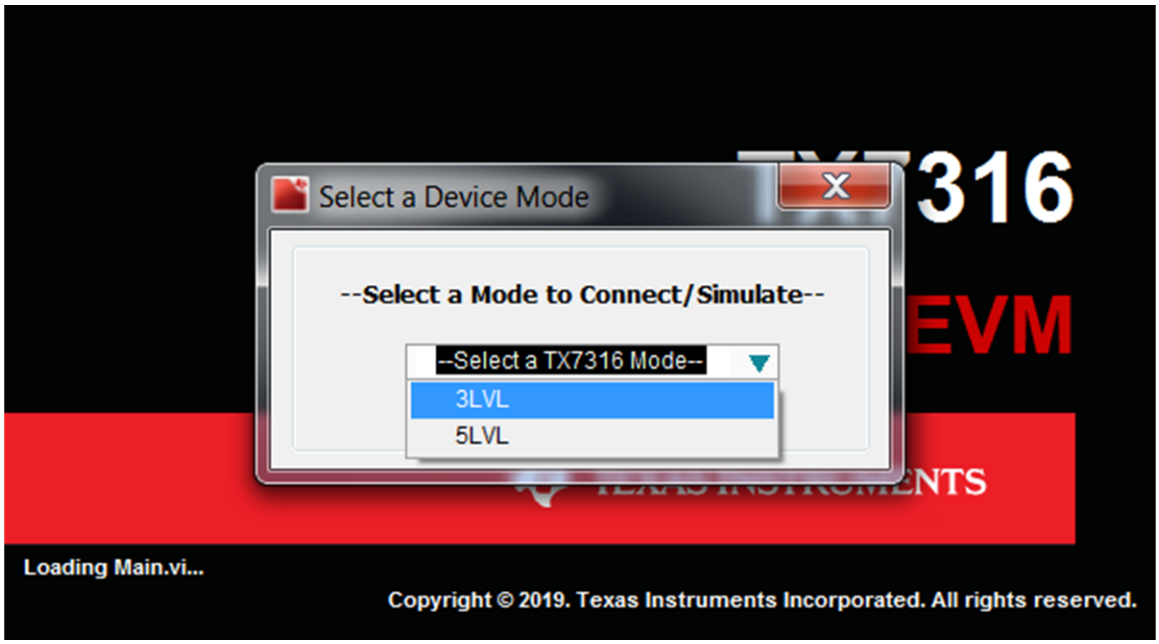


Figure 43. Select a Device Mode Pop-up Window

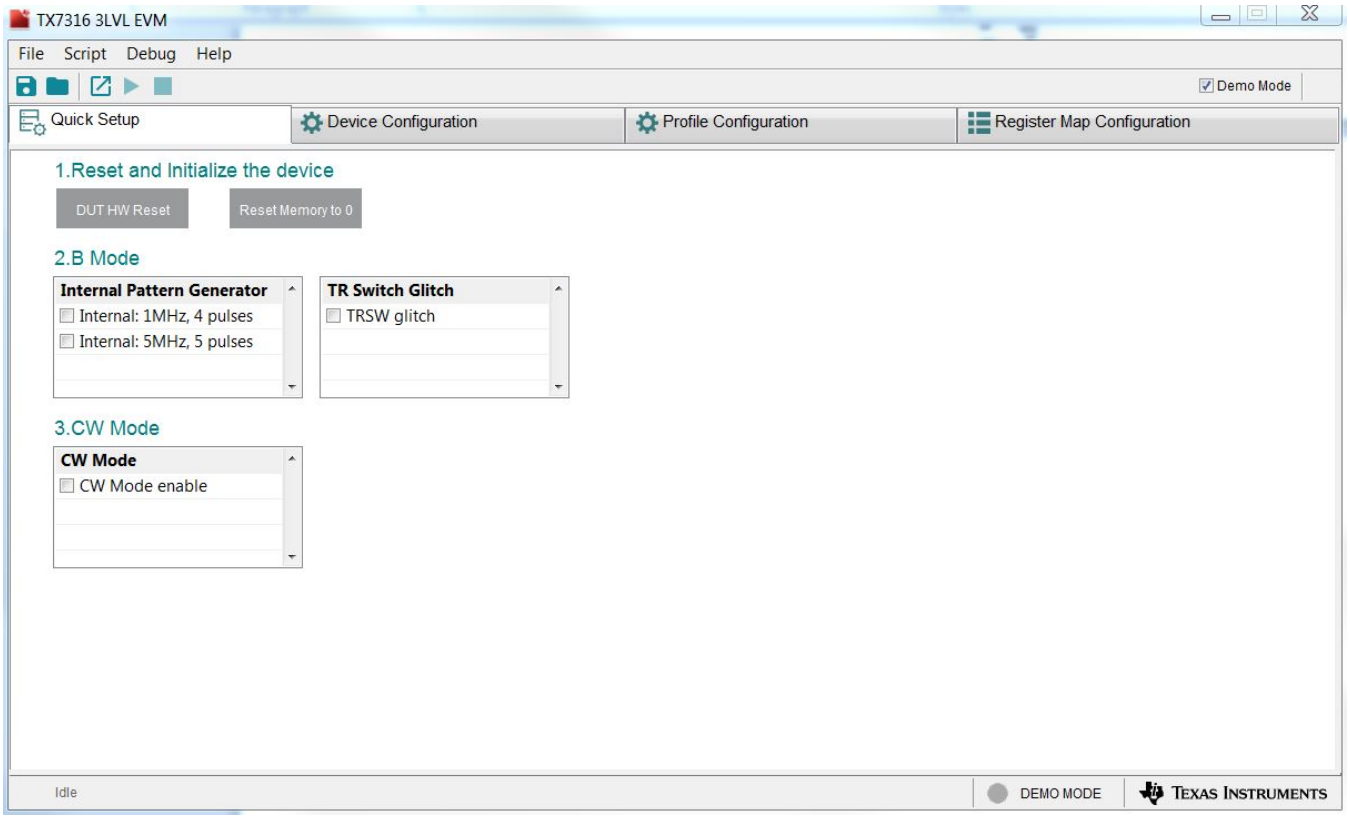


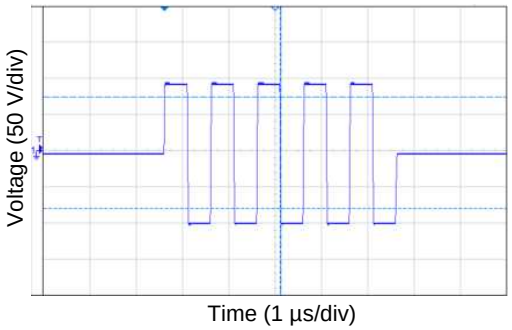
Figure 44. Quick Setup Page

a. **Testing the B mode of device:**

i. Pulser output of the device can be checked for the following two cases.

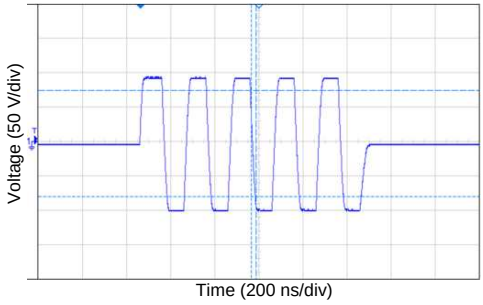
1. Internal: 1 MHz, 4 pulses
2. Internal: 5 MHz, 5 pulses

These modes can be enabled by selecting the respective mode in the Quick Setup tab of the GUI. The CPLD on board generates the TR_BF_SYNC and TR_EN (1-kHz pulse repetition frequency) control signals for the device. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Pulser outputs can be observed on pins 3 to 18 of J7 connector.



Frequency = 1 MHz; Peak-to-Peak = 196 V, Rise Time = 21.9 ns; Fall Time = 21.9 ns

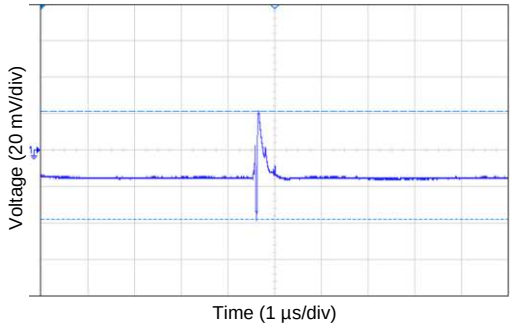
Figure 45. Internal: 1 MHz, 4 Pulses



Frequency = 5 MHz; Peak-to-Peak = 195.5 V, Rise Time = 22.5 ns; Fall Time = 21.8 ns

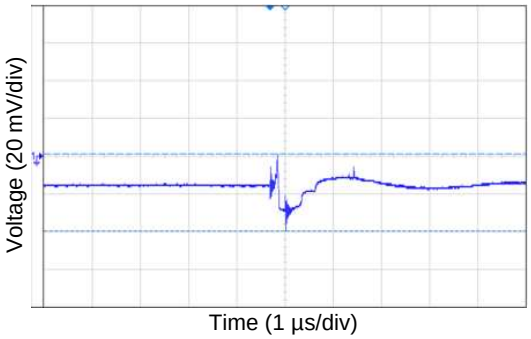
Figure 46. Internal: 5 MHz, 5 Pulses

ii. TW switch glitch can be checked by enabling the TRSW glitch mode on the quick setup tab. Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). TRSW glitch can be observed on pins 3 to 18 of J5 connector (labelled as RX_IN).



Peak-to-Peak = 40.8 mV

Figure 47. TR Switch On Glitch



Peak-to-Peak = 59.3 mV

Figure 48. TR Switch Off Glitch

b. **Testing the CW mode of the device:**

i. To check the CW mode of the device, reduce the ±100-V supply (connected to J1 connector) to ±5 V. Current limit of all ±5-V supplies must be increased to 500 mA. The CW mode of the device can be enabled by clicking *CW mode enable* on the GUI (clicking on this mode gives a pop-up warning asking the user to ensure that the supply voltage is ±5 V as shown in Figure 49; Click *Continue* button after reducing the supply voltage). Trigger the oscilloscope by probing pin 2 of J7 connector (TR_BF_SYNC). Pulser CW outputs can be observed on pins 3 to 18 of J7 connector.

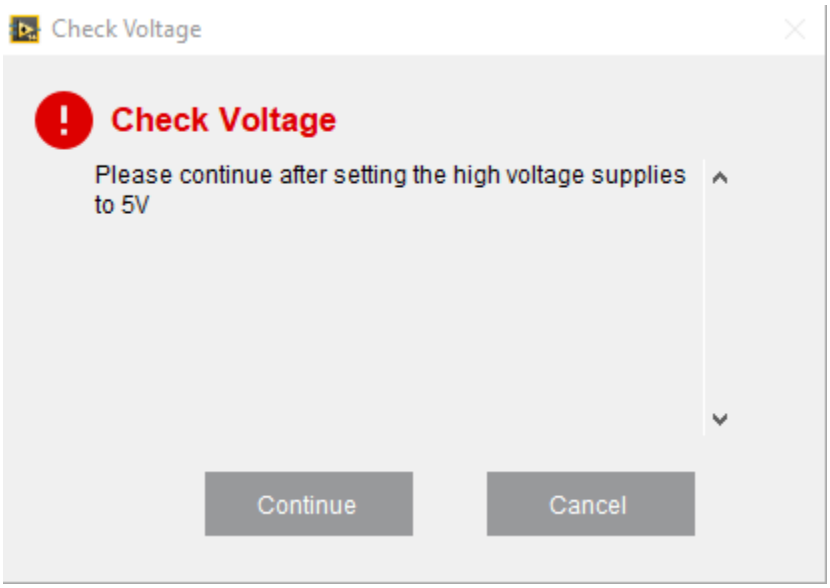
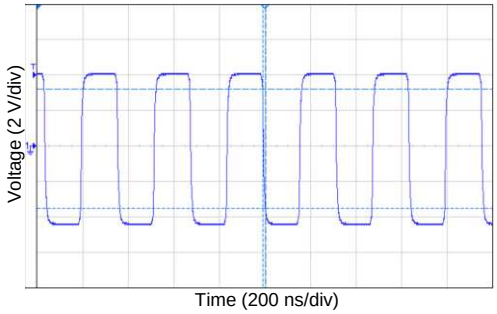


Figure 49. Pop-up Warning Given by the GUI When the CW Mode is Selected



Frequency = 3.125 MHz; Peak to peak = 8.57 V, Rise Time = 12.0 ns; Fall Time = 12.5 ns

Figure 50. CW-mode output of the device

D.1 TX7316EVM Hardware Overview

Figure 51 shows an overview of the EVM hardware

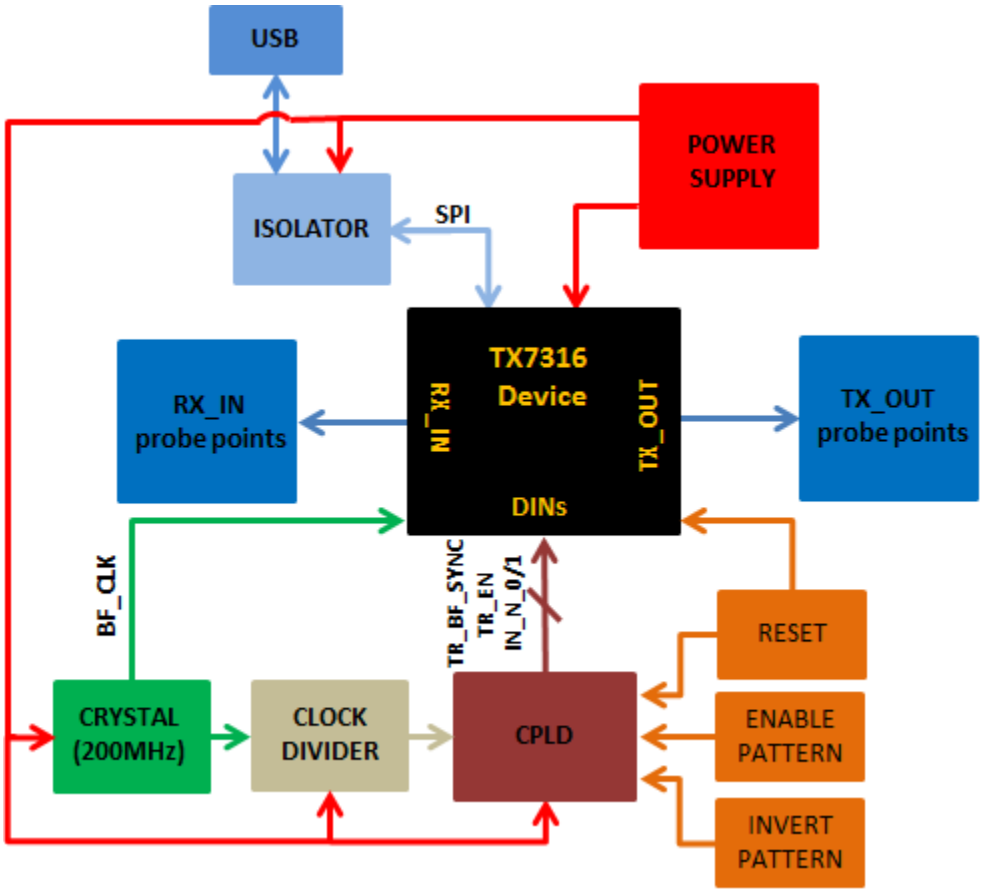


Figure 51. EVM Hardware Block Diagram

D.2 TX7316EVM Testpoints

Table 2 lists the test points present on TX7316EVM.

Table 2. TX7316EVM Test Points

TEST POINT	CIRCUIT	LABEL	TEST-POINT DESCRIPTION
TP1	Power supplies	V_1P8	1.8-V LDO output
TP2	Power supplies	V_3P3	3.3-V LDO output
TP3	Power supplies	V_2P5	2.5-V LDO output
TP4	Power supplies	VDDP_LV5	+5-V supply input
TP5	Power supplies	VDDM_LV5	–5-V supply input
TP6-13	Power supplies	GND	Ground test points
TP14	Device	SEN	SPI enable signal
TP15	Device	Reset_0	Reset signal from USB port
TP16	Device	SDATA	SPI data signal
TP17	Device	SCLK	SPI clock signal
TP18	CPLD	SYNC_TP	Sync signal generated by CPLD
TP19	Device	BF_CLK_CMOS	Beamformer clock
TP20	CPLD	TR_EN1	TREN signal generated by CPLD
TP21	CPLD	CPLD_CLK	Clock given to CPLD
TP22	Device	BIAS_2P5	Internal bandgap voltage

D.3 TX7316EVM Schematics

Figure 52 through Figure 59 show the EVM schematics.

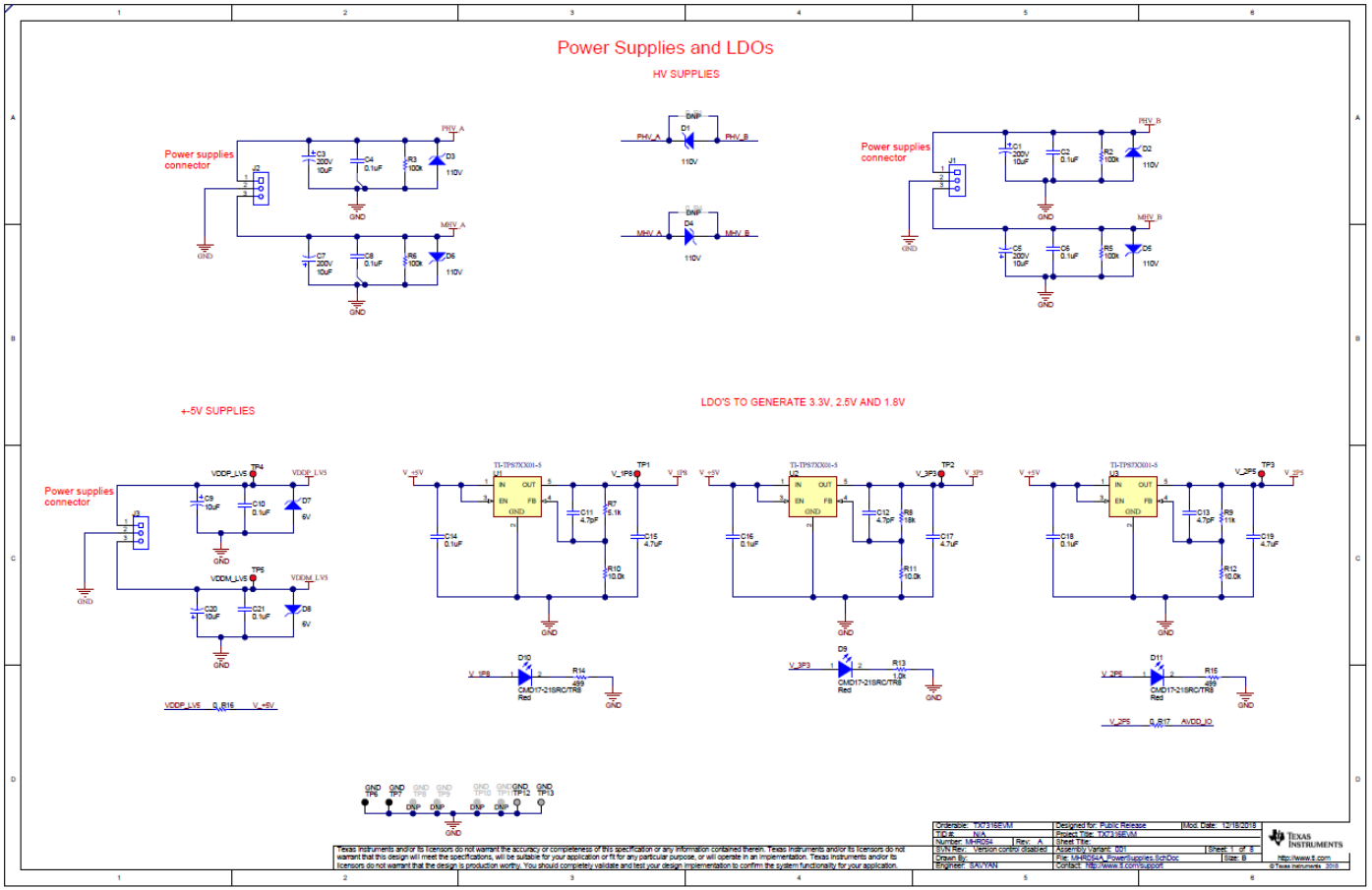


Figure 52. TX7316EVM Schematic 1 of 8

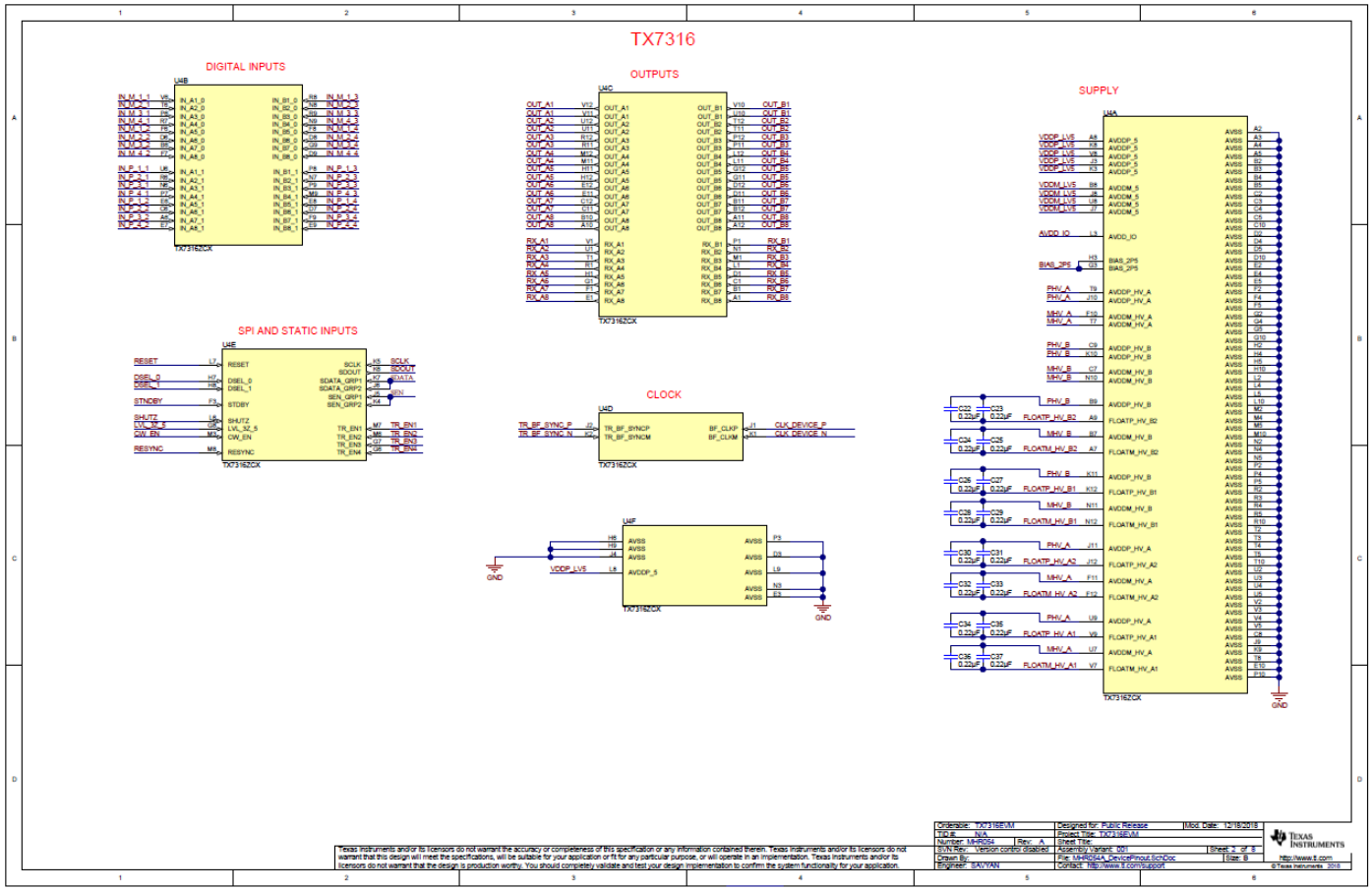


Figure 53. TX7316EVM Schematic 2 of 8

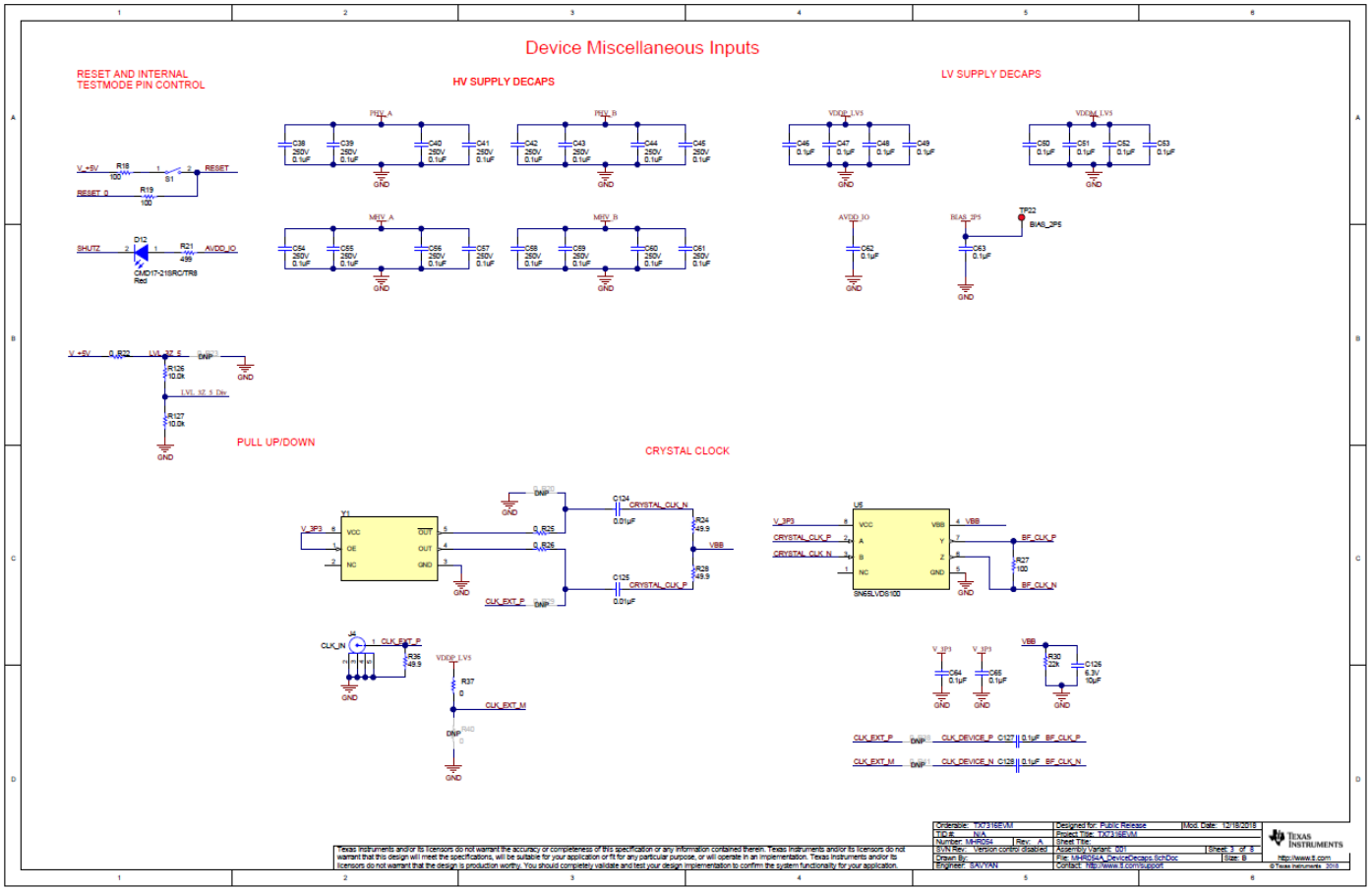


Figure 54. TX7316EVM Schematic 3 of 8

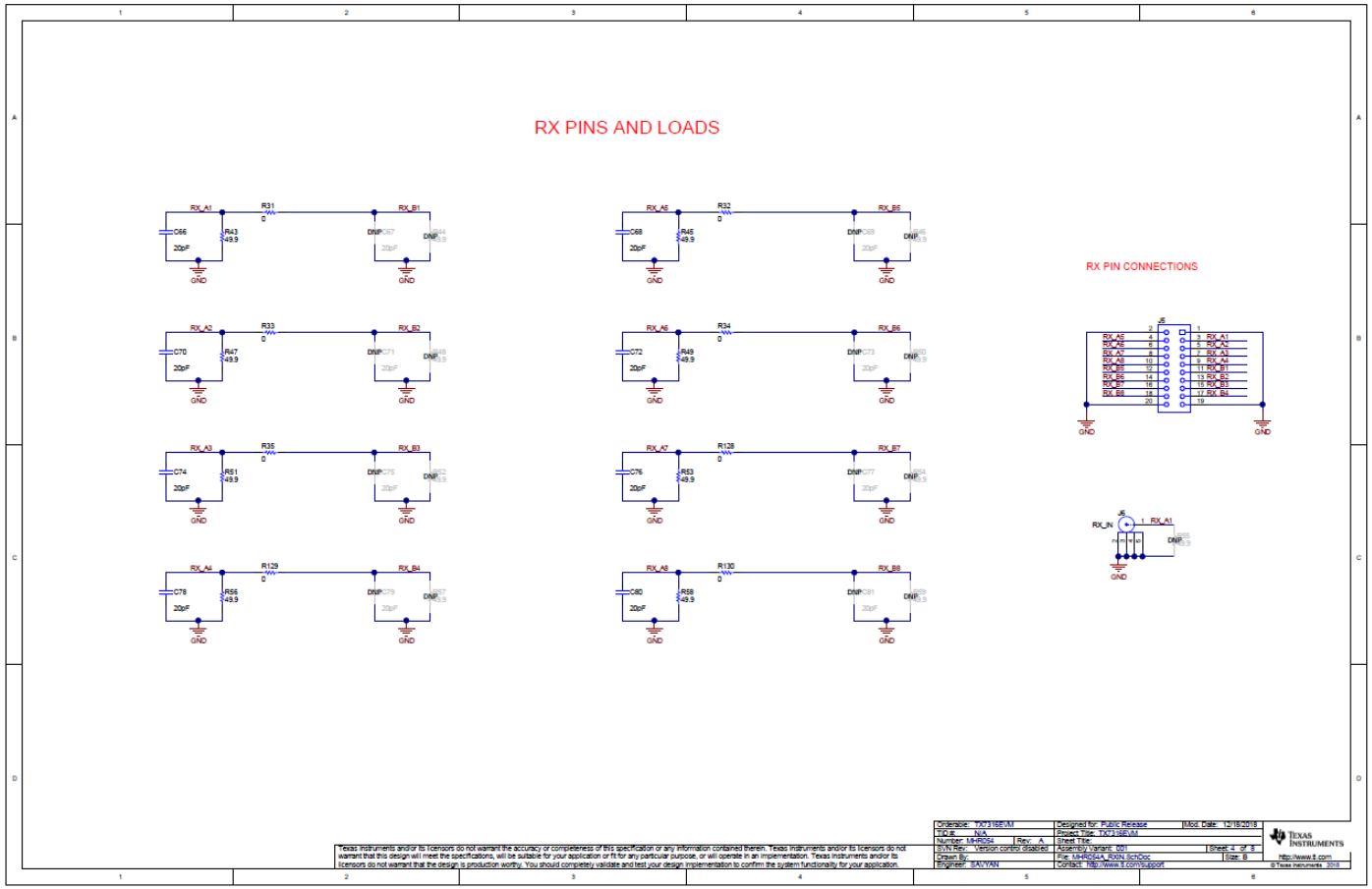


Figure 55. TX7316EVM Schematic 4 of 8

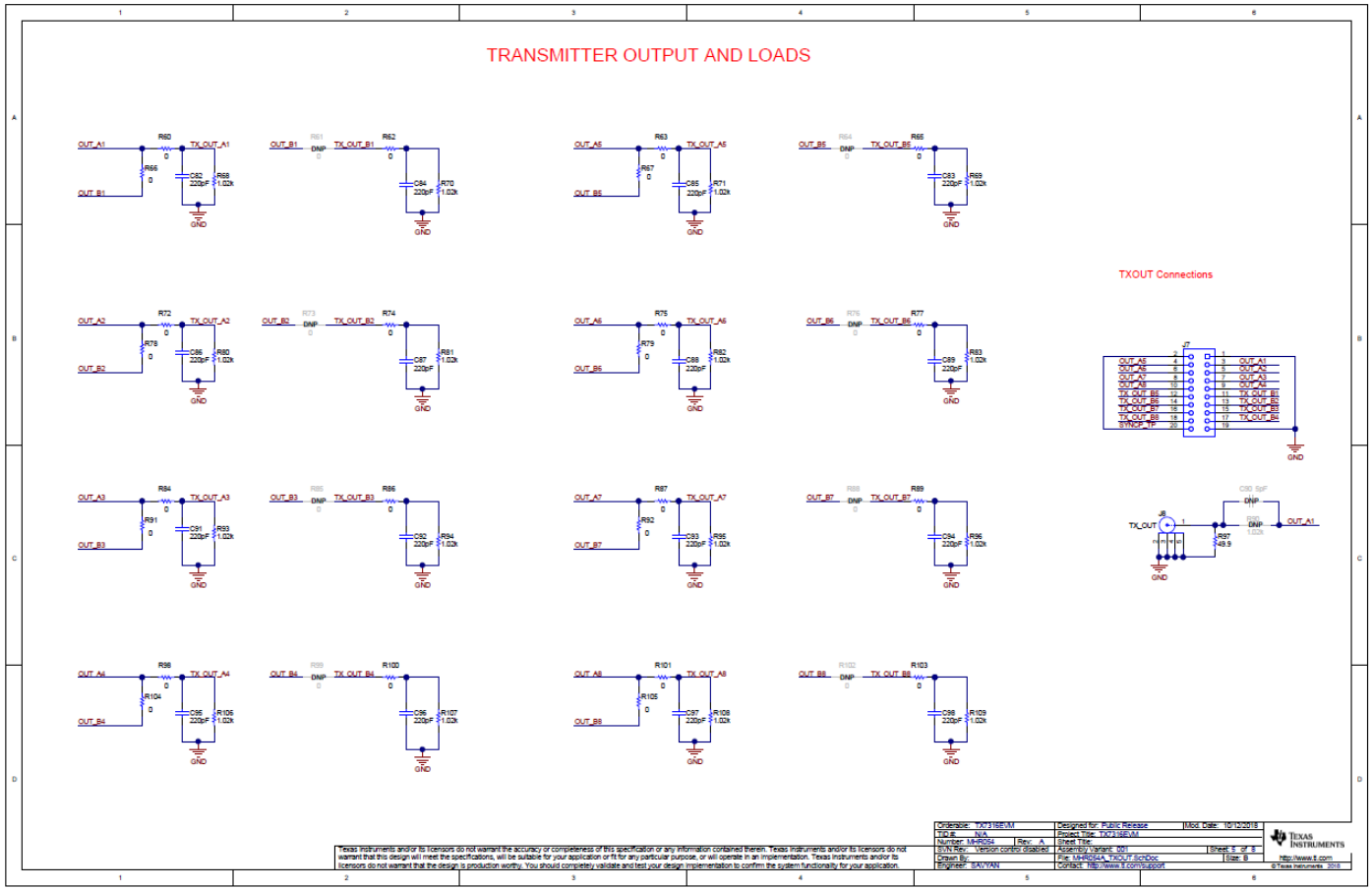


Figure 56. TX7316EVM Schematic 5 of 8

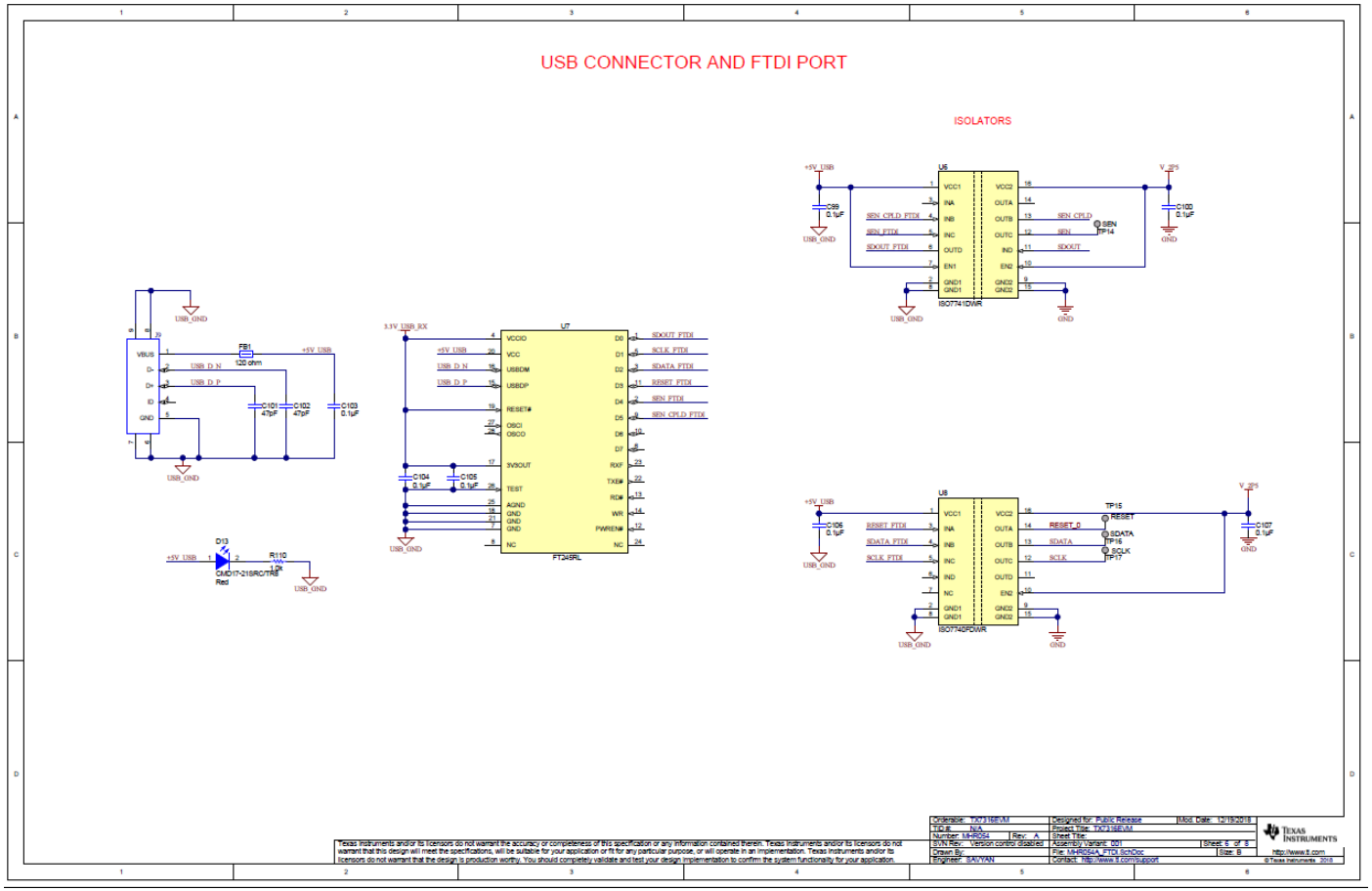


Figure 57. TX7316EVM Schematic 6 of 8

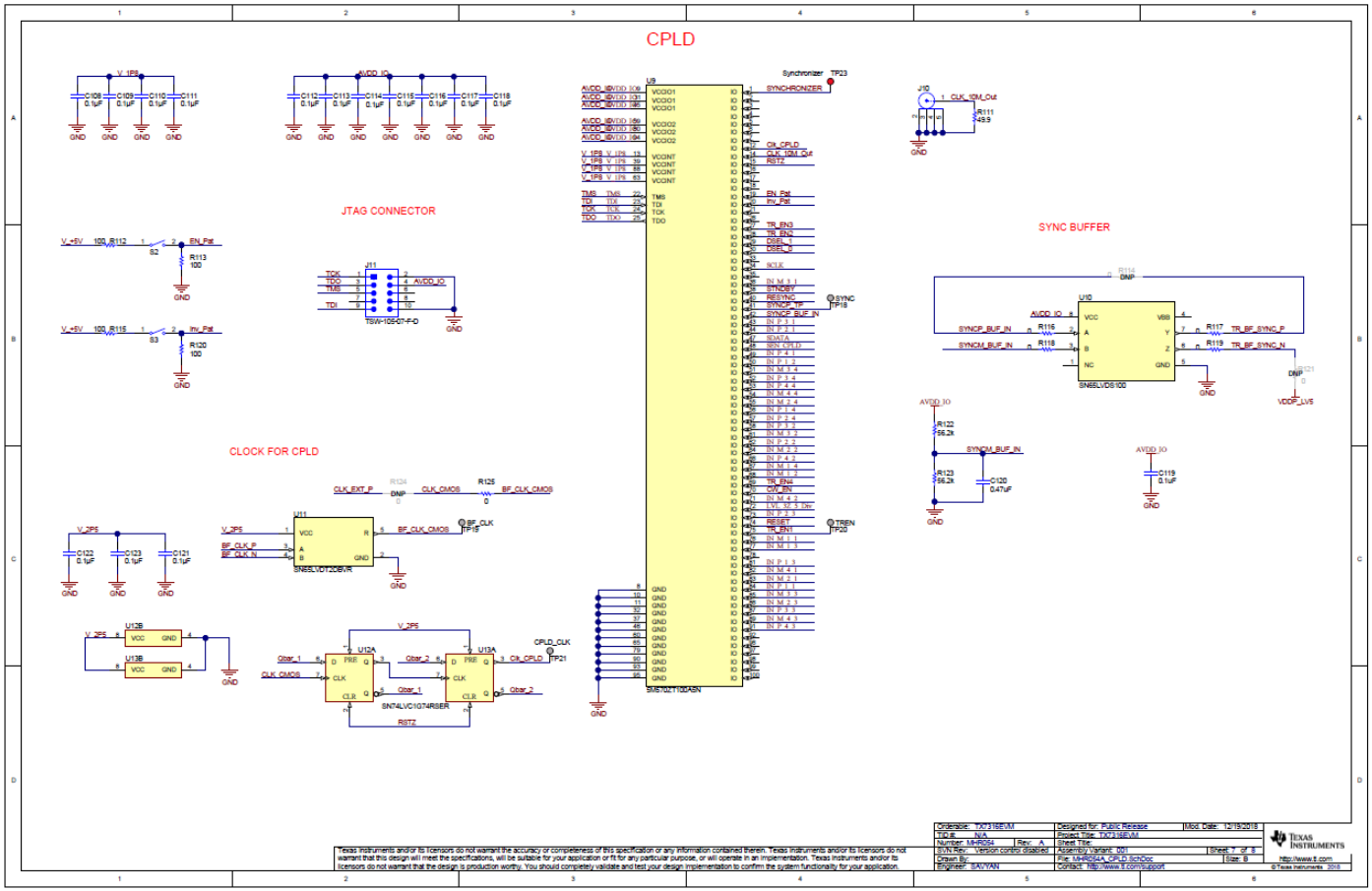


Figure 58. TX7316EVM Schematic 7 of 8

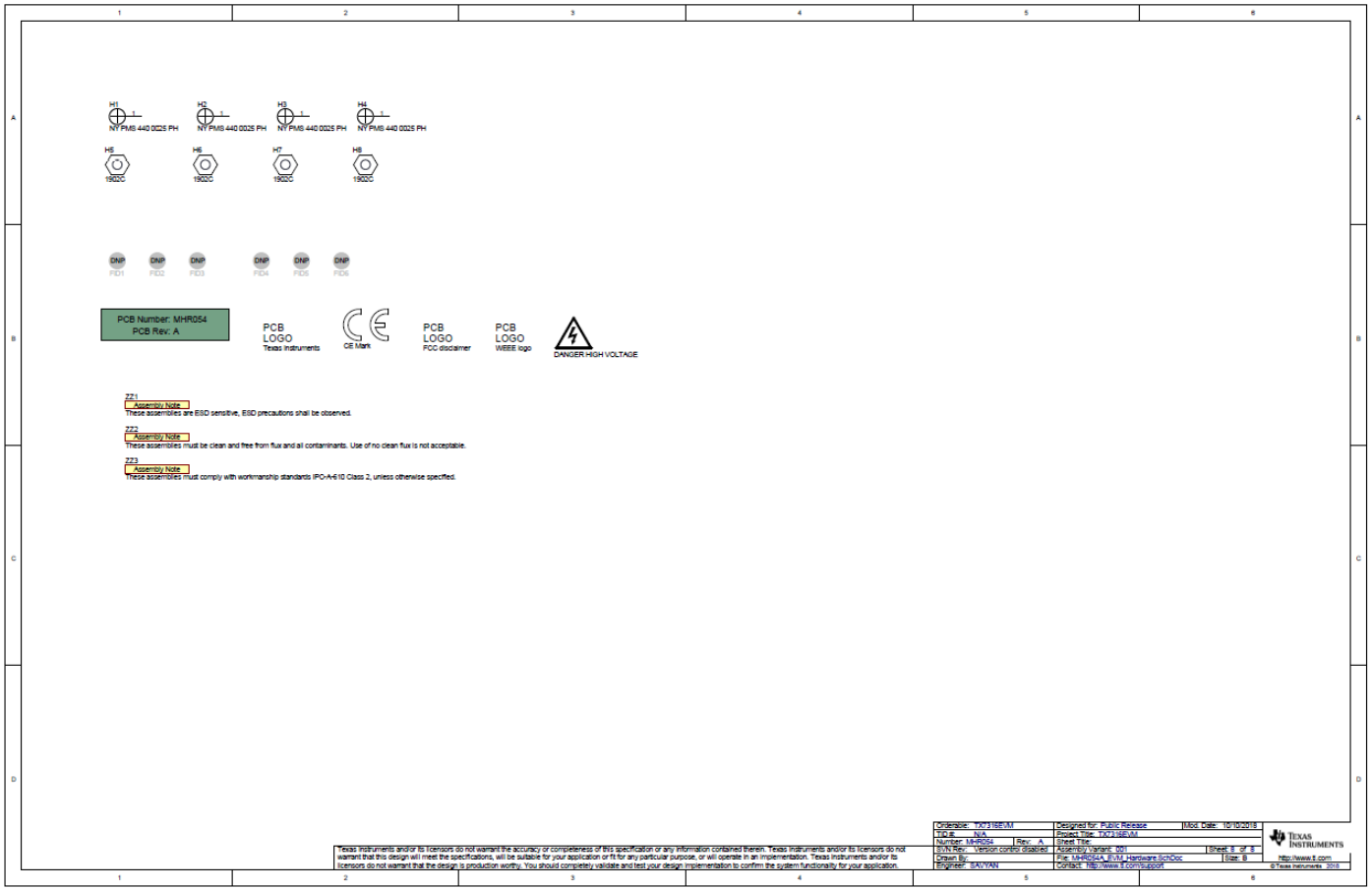


Figure 59. TX7316EVM Schematic 8 of 8

D.4 TX7316EVM Bill of Materials

Table 3. Bill of Materials[1]

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
!PCB1	1		Printed Circuit Board		MHR054	Any
C1, C3, C5, C7	4	10uF	CAP, AL, 10 uF, 200 V, ±20%, TH	RCAP_8x11.5mm	200LLE10MEFC8X11.5	Rubycon
C2, C4, C6, C8	4	0.1uF	CAP, CERM, 0.1 uF, 200 V, ±10%, X7R, 1206	1206	C1206C104K2RACTU	Kemet
C9, C20	2	10uF	CAP, AL, 10 uF, 35 V, ± 20%, 0.7 Ω, AEC-Q200 Grade 2, SMD	SMT Radial C	EEE-FK1V100R	Panasonic
C10, C14, C16, C18, C21, C119	6	0.1uF	CAP, CERM, 0.1 uF, 16 V, ± 10%, X7R, 0402	0402	0402YC104KAT2A	AVX
C11, C12, C13	3	4.7pF	CAP, CERM, 4.7 pF, 50 V, ± 2%, C0G/NP0, 0402	0402	GJM1555C1H4R7BB01D	MuRata
C15, C17, C19	3	4.7uF	CAP, CERM, 4.7 uF, 25 V, ± 10%, X5R, 0805	0805	C0805C475K3PACTU	Kemet
C22, C23, C24, C25, C26, C27, C28, C29, C30, C31, C32, C33, C34, C35, C36, C37	16	0.22uF	CAP, CERM, 0.22 µF, 10 V,± 10%, X7R, AEC-Q200 Grade 1, 0402	0402	LMK105B7224KVHF	Taiyo Yuden
C38, C39, C40, C41, C42, C43, C44, C45, C54, C55, C56, C57, C58, C59, C60, C61	16	0.1uF	CAP, CERM, 0.1 uF, 250 V,± 20%, X7T, 0805	0805	C2012X7T2E104M125AE	TDK
C46, C47, C48, C49, C50, C51, C52, C53, C62, C63, C64, C65, C99, C100, C103, C104, C105, C106, C107, C108, C109, C110, C111, C112, C113, C114, C115, C116, C117, C118, C121, C122, C123, C127, C128	35	0.1uF	CAP, CERM, 0.1 µF, 10 V,± 10%, X7R, 0402	0402	C0402C104K8RACTU	Kemet
C66, C68, C70, C72, C74, C76, C78, C80	8	20pF	CAP, CERM, 20 pF, 50 V, ± 5%, C0G/NP0, 0402	0402	C0402C200J5GACTU	Kemet
C82, C83, C84, C85, C86, C87, C88, C89, C91, C92, C93, C94, C95, C96, C97, C98	16	220pF	CAP, CERM, 220 pF, 250 V, ± 5%, C0G/NP0, 0603	0603	C1608C0G2E221J080AA	TDK
C101, C102	2	47pF	CAP, CERM, 47 pF, 50 V, ± 5%, C0G/NP0, 0402	0402	885012005044	Wurth Elektronik
C120	1	0.47uF	CAP, CERM, 0.47 uF, 6.3 V, ± 10%, X5R, 0402	0402	04026D474KAT2A	AVX
C124, C125	2	0.01uF	CAP, CERM, 0.01 µF, 16 V,± 10%, X7R, 0402	0402	C0402C103K4RACTU	Kemet

(1) Unless otherwise noted in the Alternate Part Number or Alternate Manufacturer columns, all parts may be substituted with equivalents.

Table 3. Bill of Materials[(1)] (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C126	1	10uF	CAP, CERM, 10 µF, 6.3 V,± 20%, X5R, 0402	0402	GRM155R60J106ME47D	MuRata
D1, D2, D3, D4, D5, D6	6	110V	Diode, Zener, 110 V, 200 mW, SOD-323F	SOD-323F	UDZLVTE-17110	Rohm
D7, D8	2	6V	Diode, Zener, 6 V, 500 mW, SOD-123	SOD-123	MMSZ5233B-7-F	Diodes Inc.
D9, D10, D11, D12, D13	5	Red	LED, Red, SMD	2x1.25mm	CMD17-21SRC/TR8	Visual Communications Company, LLC
FB1	1	120 Ω	Ferrite Bead, 120 Ω @ 100 MHz, 3 A, 0603	0603	BLM18SG121TN1D	MuRata
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone
J1, J2, J3	3		Terminal Block, 3x1, 2.54 mm, TH	Terminal Block, 3x1, 2.54 mm, TH	1725669	Phoenix Contact
J4, J6, J8, J10	4		SMA Straight Jack, Gold, 50 Ω, TH	SMA Straight Jack, TH	901-144-8RFX	Amphenol RF
J5, J7	2		Receptacle, 100mil, 10x2, Gold, TH	10x2 Receptacle	PPPC102LFBN-RC	Sullins Connector Solutions
J9	1		Connector, Receptacle, USB - mini AB, R/A, SMD	Receptacle, 5-Leads, Body 9.9x9mm, R/A	67803-8020	Molex
J11	1		Header, 2.54mm, 5x2, Gold, Black, TH	Header, 2.54mm, 5x2, TH	TSW-105-07-F-D	Samtec
R2, R3, R5, R6	4	100k	RES, 100 k, 0.1%, 0.25 W, AEC-Q200 Grade 1, 1206	1206	TNPW1206100KBEEA	Vishay-Dale
R7	1	5.1k	RES, 5.1 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04025K10JNED	Vishay-Dale
R8	1	18k	RES, 18 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040218K0JNED	Vishay-Dale
R9	1	11k	RES, 11 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040211K0JNED	Vishay-Dale
R10, R11, R12, R126, R127	5	10.0k	RES, 10.0 k, 1%, 0.2 W, AEC-Q200 Grade 0, 0402	0402	ERJPA2F1002X	Panasonic
R13, R110	2	1.0k	RES, 1.0 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R14, R15, R21	3	499	RES, 499, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402499RFKED	Vishay-Dale
R16, R17, R22, R25, R26, R67	6		RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
R18, R19, R112, R113, R115, R120	6	100	RES, 100, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100RJNED	Vishay-Dale
R24, R28, R43, R45, R47, R49, R51, R53, R56, R58	10	49.9	RES, 49.9, 1%, 0.063 W, 0402	0402	RC0402FR-0749R9L	Yageo America
R27	1	100	RES, 100, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW0402100RFKED	Vishay-Dale
R30	1	22k	RES, 22 k, 5%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040222K0JNED	Vishay-Dale

Table 3. Bill of Materials[(1)] (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
R31, R32, R33, R34, R35, R37, R60, R62, R63, R65, R66, R72, R74, R75, R77, R78, R79, R84, R86, R87, R89, R91, R92, R98, R100, R101, R103, R104, R105, R116, R117, R118, R119, R125, R128, R129, R130	37	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
R36, R97, R111	3	49.9	RES, 49.9, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW060349R9BEEA	Vishay-Dale
R68, R69, R70, R71, R80, R81, R82, R83, R93, R94, R95, R96, R106, R107, R108, R109	16	1.02k	RES, 1.02 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12061K02FKEA	Vishay-Dale
R122, R123	2	56.2k	RES, 56.2 k, 1%, 0.063 W, AEC-Q200 Grade 0, 0402	0402	CRCW040256K2FKED	Vishay-Dale
S1, S2, S3	3		Switch, SPST-NO, Off-Mom, 0.05 A, 12 VDC, SMD	6x3.5mm	EVQ-5PN04K	Panasonic
TP1, TP2, TP3, TP4, TP5, TP22, TP23	7		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP6, TP7	2		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
U1, U2, U3	3		Single Output High PSRR LDO, 200 mA, Adjustable 1.2 to 6.5 V Output, 2.7 to 6.5 V Input, with Low IQ, 5-pin SOT (DDC), -40 to 85 degC, Green (RoHS & no Sb/Br)	DDC0005A	TPS79901DDCR	Texas Instruments
U4	1		3-Level, 16-Channel or 5-Level, 8-Channel Transmitter with 2A Pulser, T/R Switch and Integrated Transmit Beam-Former, ZCX0216A (BGA-216)	ZCX0216A	TX7316ZCX	Texas Instruments
U5, U10	2		2 Gbps LVDS/LVPECL/CML to LVDS Buffer/Repeater/Translator, DGK0008A (VSSOP-8)	DGK0008A	SN65LVDS100DGKR or SN65LVDS100DGK	Texas Instruments
U6	1		High-Speed, Low-Power, Robust EMC Quad-Channel Digital Isolator, DW0016B (SOIC-16)	DW0016B	ISO7741DWR or ISO7741DW	Texas Instruments
U7	1		USB FIFO IC, 28SSOP	SSOP28	FT245RL	FTDI
U8	1		High-Speed, Low-Power, Robust EMC Quad-Channel Digital Isolator, DW0016B (SOIC-16)	DW0016B	ISO7740FDWR or ISO7740FDW	Texas Instruments
U9	1		IC CPLD 440MC, TQFP-100	14x14mm	5M570ZT100A5N	Altera
U11	1		Single LVDS Receiver, DBV0005A (SOT-23-5)	DBV0005A	SN65LVDT2DBVR or SN65LVDT2DBVT	Texas Instruments

Table 3. Bill of Materials[(1)] (continued)

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
U12, U13	2		Single Positive-Edge-Triggered D-Type Flip-Flop With Clear and Preset, RSE0008A (UQFN-8)	RSE0008A	SN74LVC1G74RSER	Texas Instruments
Y1	1		Crystal Oscillator, 200 MHz, LVDS, 2.5 to 3.3 V, SMD	3.2x2.5mm	SG3225VAN 200.000000M-KEGA3	Epson
C67, C69, C71, C73, C75, C77, C79, C81	0	20pF	CAP, CERM, 20 pF, 50 V, ± 5%, C0G/NP0, 0402	0402	C0402C200J5GACTU	Kemet
C90	0	5pF	CAP, CERM, 5 pF, 100 V, ± 5%, C0G/NP0, 0603	0603	GRM1885C2A5R0CA01D	MuRata
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R1, R4, R20, R23, R29, R38, R41	0		RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
R40, R61, R64, R73, R76, R85, R88, R99, R102, R114, R121, R124	0	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0402	0402	ERJ-2GE0R00X	Panasonic
R44, R46, R48, R50, R52, R54, R57, R59	0	49.9	RES, 49.9, 1%, 0.063 W, 0402	0402	RC0402FR-0749R9L	Yageo America
R55	0	49.9	RES, 49.9, 0.1%, 0.1 W, AEC-Q200 Grade 1, 0603	0603	TNPW060349R9BEEA	Vishay-Dale
R90	0	1.02k	RES, 1.02 k, 1%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12061K02FKEA	Vishay-Dale
TP8, TP9	0		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone

Measurement Techniques and Troubleshooting

E.1 Measurement Techniques

The following sub-sections describe the measurement techniques to be used while testing the device.

E.1.1 Rise and Fall Times

Rise and fall times of the device must be measured from 10% to 90% of the peak to peak output voltage. For example, for a ±100-V output swing, the thresholds used for the measurement must be ±80 V.

E.1.2 Linearity

Linearity is a very important parameter of the device; it can be measured by following these steps:

1. Configure the device in the required output pattern.
2. Capture the device output on the oscilloscope by triggering TR_BF_SYNC signal (pin 2 of J6 connector).
3. Invert the output pattern.
4. Again capture the device output on the oscilloscope by triggering TR_BF_SYNC signal.
5. Post process the data for pulse cancellation and take the FFT to check the linearity.

E.2 Troubleshooting

The following steps describe the ways to debug, if the EVM does not perform as expected.

1. **Power supplies**: Check all the power supplies and LDO voltages at their test point (See Table 2) and ensure they are as expected.
2. **Clock**: Check the BF_CLK_CMOS test point and ensure that 200-MHz clock is present.
3. **CPLD**: Check the SYNC_TP test point and ensure that 1-kHz signal is present.
4. **Thermal shutdown**: If the temperature of the device exceeds 110°C, device enters thermal shutdown, and the device functionality is disabled. TSHUT pin of the device is pulled low when this happens. This pin is connected to LED D12, and this LED glows if the device enters thermal shutdown. Reset the device to bring it out of thermal shutdown.

Revision History

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

Changes from Original (March 2019) to A Revision **Page**

- Deleted Warning. 5
- Changed the position of list of Items. 6
- Changed *GUI Software Installation* section. 6
- Changed *USB Interface to PC* section. 8
- Changed *Testing the EVM* section. 8
- Deleted *IN and TR_EN control signals* from *Off-chip beamforming*. 9
- Changed *Select a Device Pop-up Window* figure. 11
- Changed from *Pulsar* to *Pulser* across the document. 11
- Changed *Pop-up Warning Given by the GUI When the CW Mode is Selected* figure 13
- Added *Appendix C* section 36

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