I²C Load Switch GUI and EVM Board

User's Guide

Literature Number: SLVU999C
October 2013–Revised October 2014

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I²C Load GUI and EVM Board

The I²C Load Switch EVM Board contains two quad channel load switch devices that are ultra-low resistance (R_{ON}) with I²C programmable slew rate, delay time, and QOD channel. The I²C Load switch EVM is available for both the TPS22993 and the TPS22994. Multiple I²C load switch EVM boards may be connected together and controlled via a single I²C master.

1 Description

The I²C Load Switch is a multi-channel low R_{ON} load switch with user selectable controlled turn on. The device contains four N-channel MOSFET devices that can operate over an input voltage range of 1.0 V to 3.6 V. The switch is controlled by I²C making it ideal for usage with processors that have limited GPIO available. The rise time of the I²C Load Switch device is internally controlled in order to avoid inrush current. The I²C Load Switch has five programmable slew rate options. The device also has adjustable ON-delay as well as selectable quick output discharge (QOD) resistance.

The device can operate in either GPIO or I²C mode. The default mode of operation is GPIO control through the ONx pins. The address pins can be tied high or low to assign seven unique addresses.

The I²C Load Switch is available in a space-saving WQFN package (0.4-mm pitch) and is characterized for operation over the free-air temperature range of –40°C to 85°C.

1.1 Typical Applications

- Ultrabooks™
- Notebooks and Netbooks
- Tablet PC
- Consumer Electronics
- Smartphones
- Servers

1.2 Features

- EVM contains two I²C Load Switch devices, for a total of 8 independently controlled channels
  - Additional I²C Load Switch EVMs can be daisy chained (up to 4 EVMs) to give a total of 28 channels that can be controlled independently via I²C
- I²C control interface allows user to use any I²C capable microcontroller for evaluation of the EVM
  - TI I²C capable microcontroller module (USB2ANY) included in EVM kit
  - Daisy chained EVMs can only be controlled through I²C mode. USB2ANY can control only 2 devices through GPIO on the board it is directly connected to. The GPIO control for these 2 devices is accessed through the U1 and U2 tabs regardless of I²C address.
- Status LEDs for each channel output allows for quick debug of setup
- VIN input voltage range: 1V to 3.6V
- VBIAS voltage range: 4.5V to 17.2V
  - Suitable for 2S/3S/4S Li-ion battery topologies
- TPS22993 is capable of up to 1.2 A continuous current per channel
- TPS22994 is capable of up to 1.0 A continuous current per channel

2 Electrical Performance Specifications

For TPS22993 specifications refer to datasheet (SLVSCA3)

For TPS22994 specifications refer to datasheet (SLVSCL4)

3 Setup – System Requirements - Windows 7 or XP

(A) To install the software run the setup.application from the link below (http://www.ti.com/tool/tps22993evm-033) by right clicking and saying “Run as Administrator, see Figure 1.

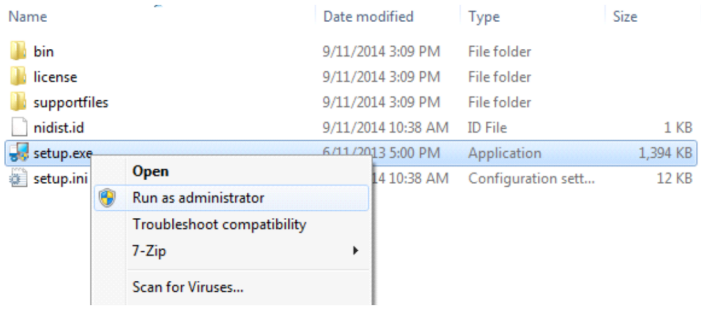

Figure 1. Select Run Administrator When Executing the Installer

(B) You should see a pop up window asking you to install the software click “Yes” and then you should see the window in Figure 2 pop up and click “Next” and agree to the terms and conditions in the installer.

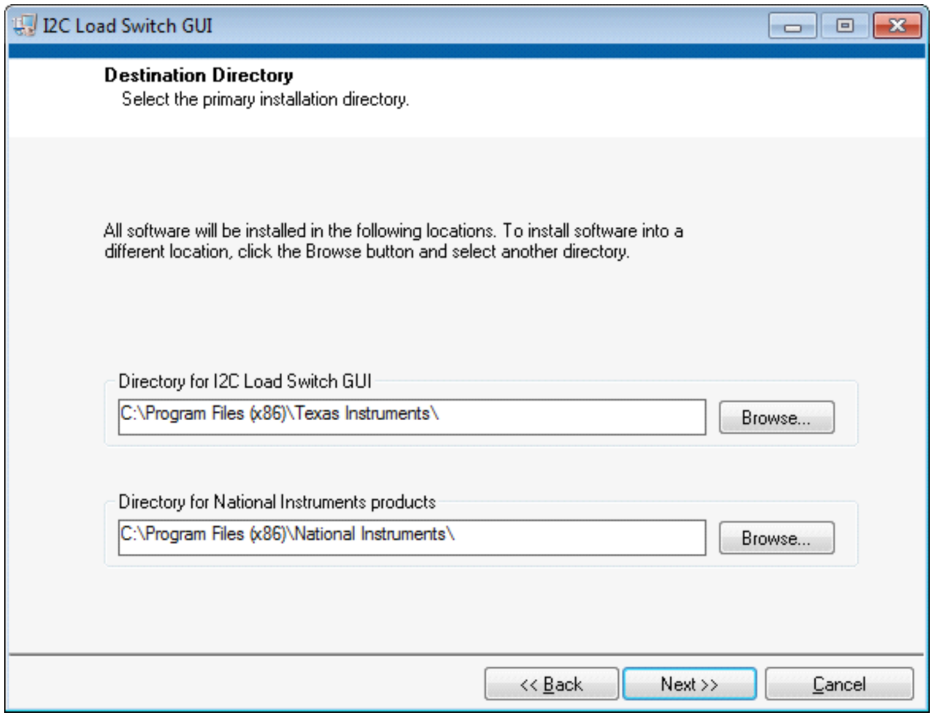

Figure 2. I²C Load Switch Application Installer

(C) You will see a Python installer begin, see Figure 3, let the installer complete and then click OK.

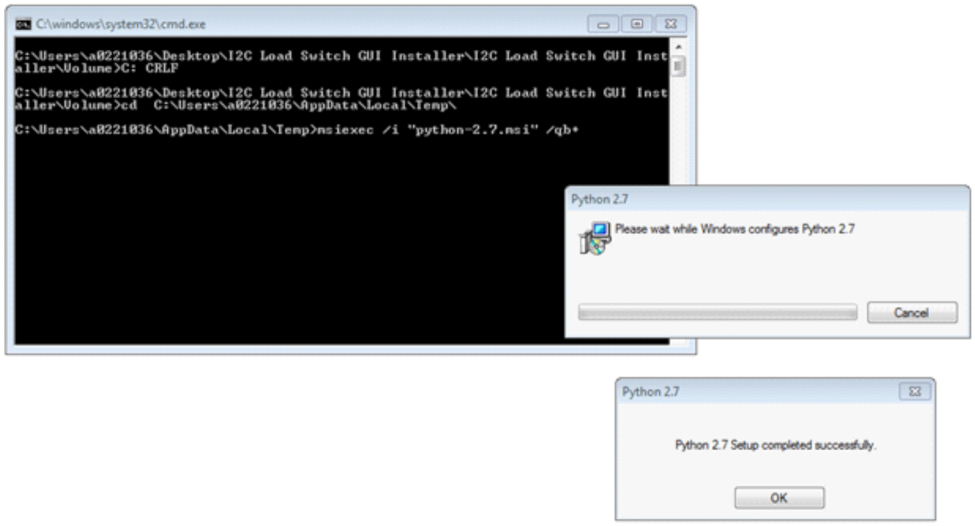

Figure 3. Python Installer

(D) Connect the USB cable to the USB2ANY and then to the computer and connect the ribbon cable to the EVM board. The setup should look like Figure 4 when you are done.

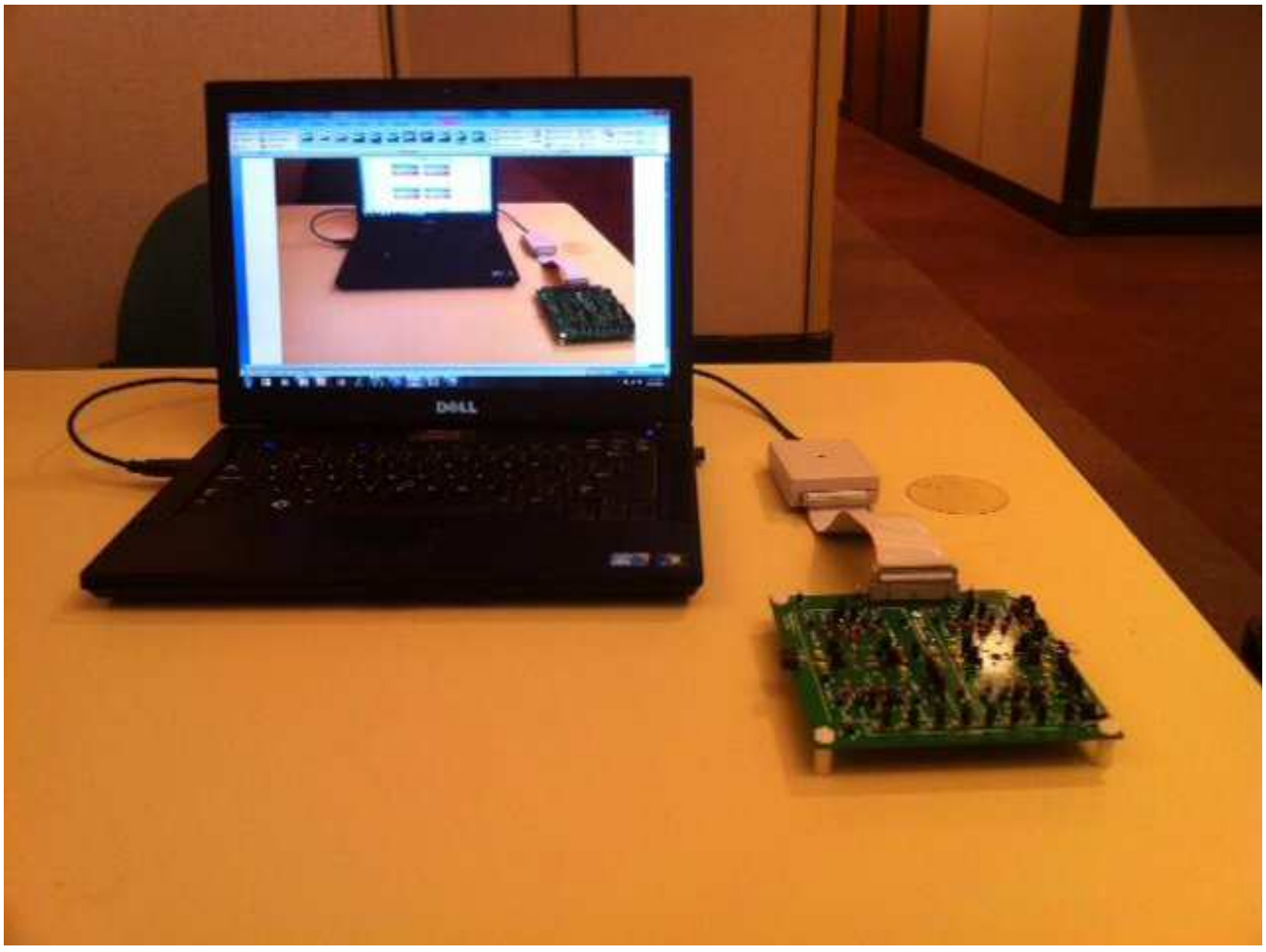

Figure 4. I²C Load Switch Board and USB2ANY Setup

4 Device GUI SW

CAUTION

Do not launch the I²C Load Switch GUI Application without having the USBB2ANY plugged into the computer first.

(A) Go to All Programs >>> Texas Instrument >> I²C Load Switch GUI to launch the application.
(B) The I²C Load Switch GUI application window should pop on your screen, see Figure 5.
(C) You are ready to begin using the software and the demo board.

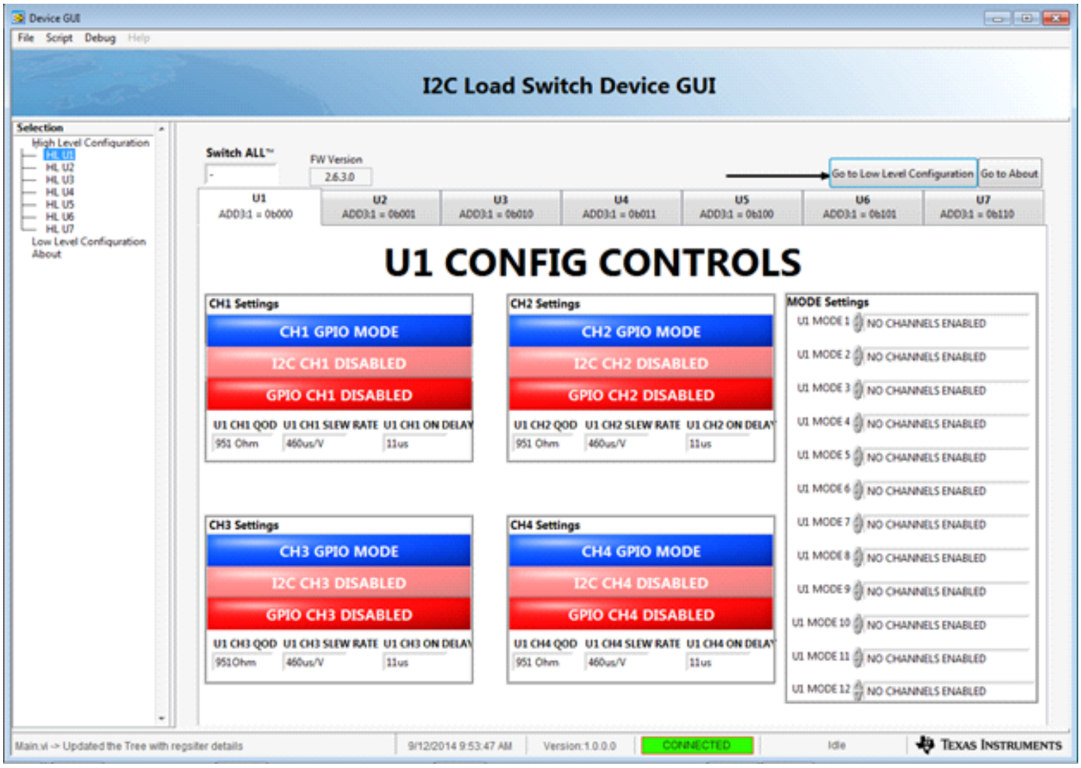

Figure 5. I²C Load Switch GUI Application Window

4.1 High Level Functionality

(A) The HL U1 – U7 Tabs contain high level controls that set the device to specific register settings. Each change in the control value results in a register write to the device.

(B) There are 6 different controls for each channel on the device

- CHx GPIO/I2C Mode
- CHx I2C Disable/Enable
- CHx GPIO Disable/Enable
- CHx QOD resistance
- CHx Turn On Slew Rate
- CHx Turn On Delay Time

(C) The GUI also provides Mode Register Controls for each device

(D) The SwitchALL™ control communicates with all devices simultaneously.

(E) See Figure 6 showing the different controls (SwitchALL™, Channel Controls, MODE Registers)

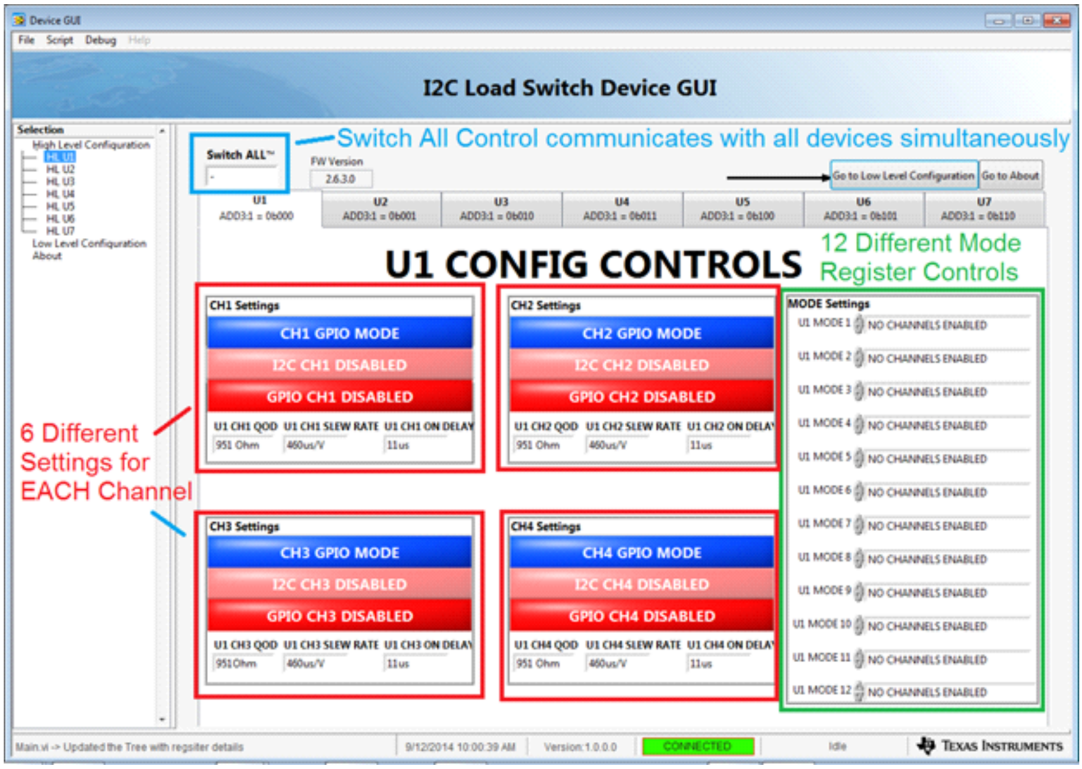

Figure 6. Description of the Different Control in the GUI

4.2 Select U1 – U7

(A) You can navigate to the controls for U1 – U7 in two different ways.

(B) The first way is by clicking the device tab (U1, U2, U3, etc.).

(C) The second way is by clicking the high level functions on the left side of the screen, see Figure 7.

(D) Be sure that the I^2C address is properly configured using jumper points JP7, JP9, JP11, JP20, JP22, and JP23. The configured address should correspond to the address appearing on the specific device tab.

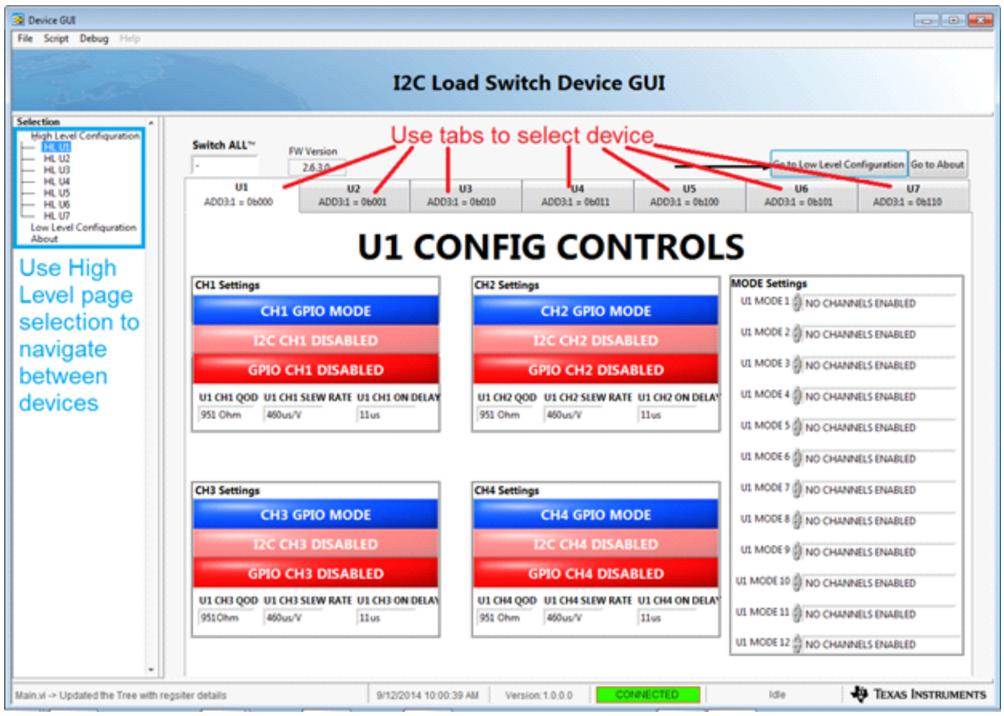

Figure 7. Ways to Select Device Control

4.3 GPIO Mode or I²C Mode for Each Channel

(A) The CHx GPIO Mode/I²C Mode Control will set the channel on that specific device to respond to either the GPIO Enable Pin or the I²C EN register bit. See Figure 8 showing CH1 and CH2 of U1 are set to the 2 different modes.

(B) Also the disable/enable control for the alternate mode will become inactive to the user. In Figure 8, I²C CH1 Disable is pink which indicates this does not have an effect on the output of CH1 and this is the same for GPIO CH2 Disabled; the user will not be able to change the value on the high level page until the channel mode selection has been changed. Figure 8 shows the controls that are active and de-activated for CH1 and CH2.

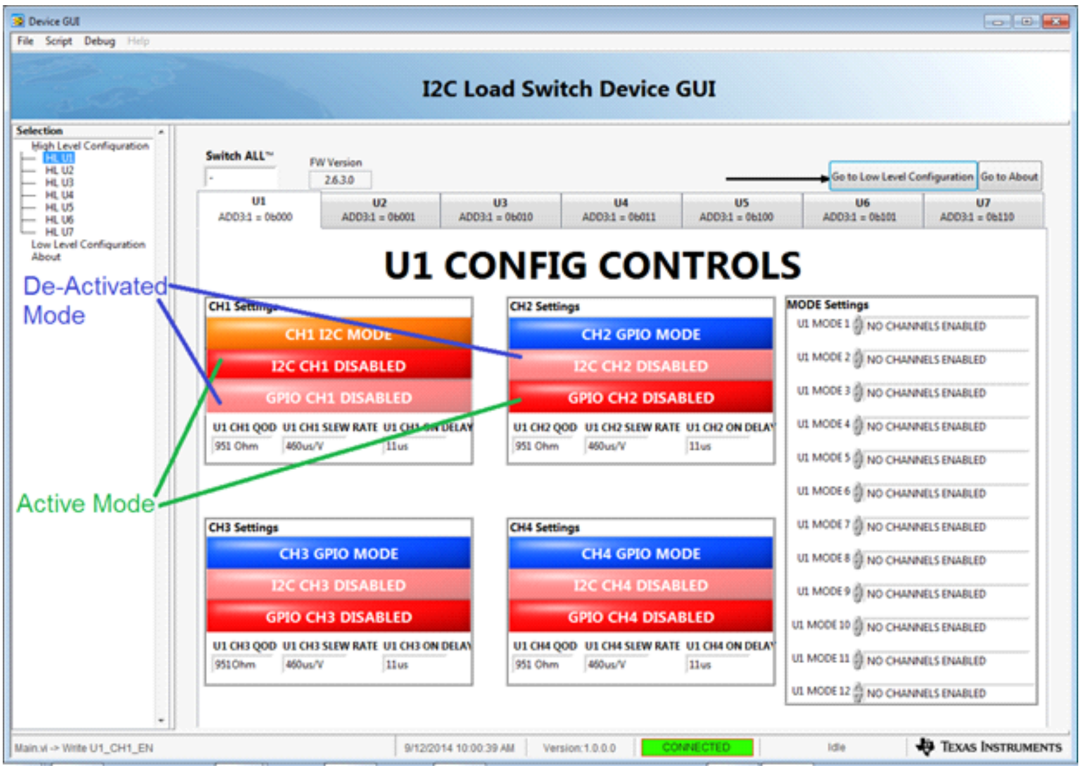

Figure 8. Set GPIO Mode or I²C Mode on Different Channels

4.4 SwitchALL™ Functionality and Mode Registers

(A) To use the SwitchAll™ function, the GUI CONFIG controls for all channels must be set to the I^2C Mode, and the I^2C communication must be enabled.

(B) You can use the SwitchALL™ functionality by configuring the Mode Register controls for each specific mode register on the two devices.

(C) For example U1 MODE1 is configured to enable CH1 only and U2 MODE1 is configured to enable CH2 only, you must set these first before sending the SwitchALL™ command, see Figure 9 and Figure 10.

(D) Once you set the SwitchALL™ control to MODE1 then SwitchALL™ command will be sent to both devices and each device will respond according to how you have configured the MODE1 register for that device, see Figure 11.

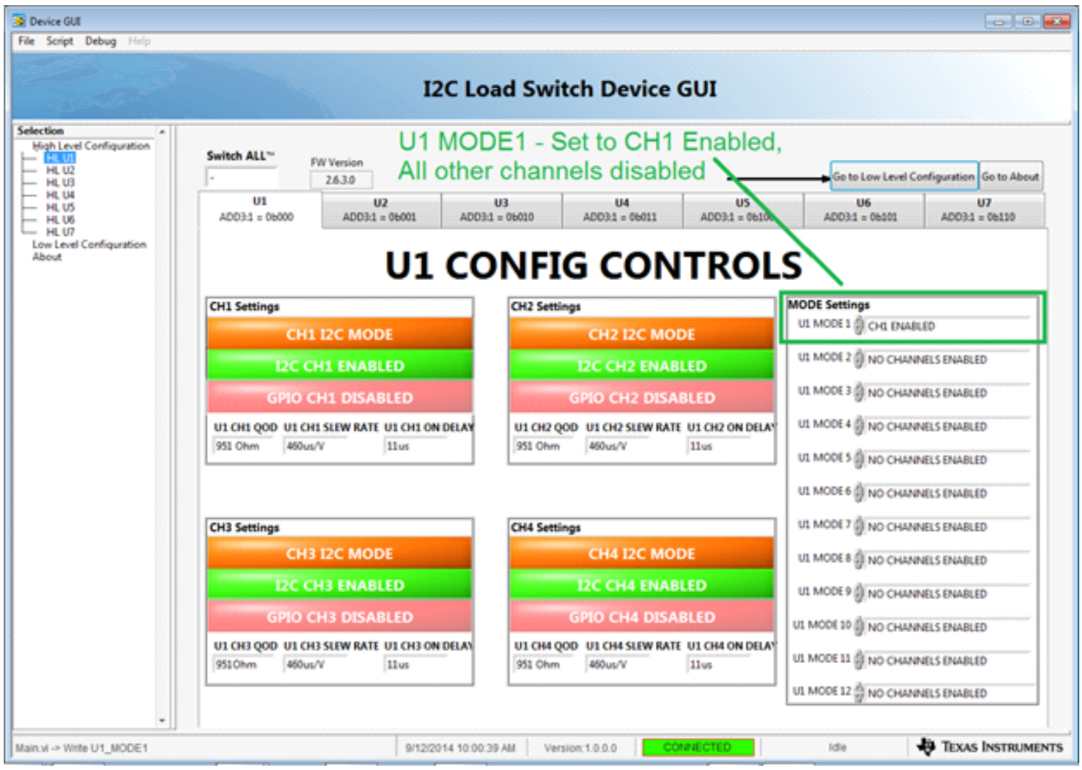

Figure 9. Set U1 Mode1 Register to CH1 Enabled

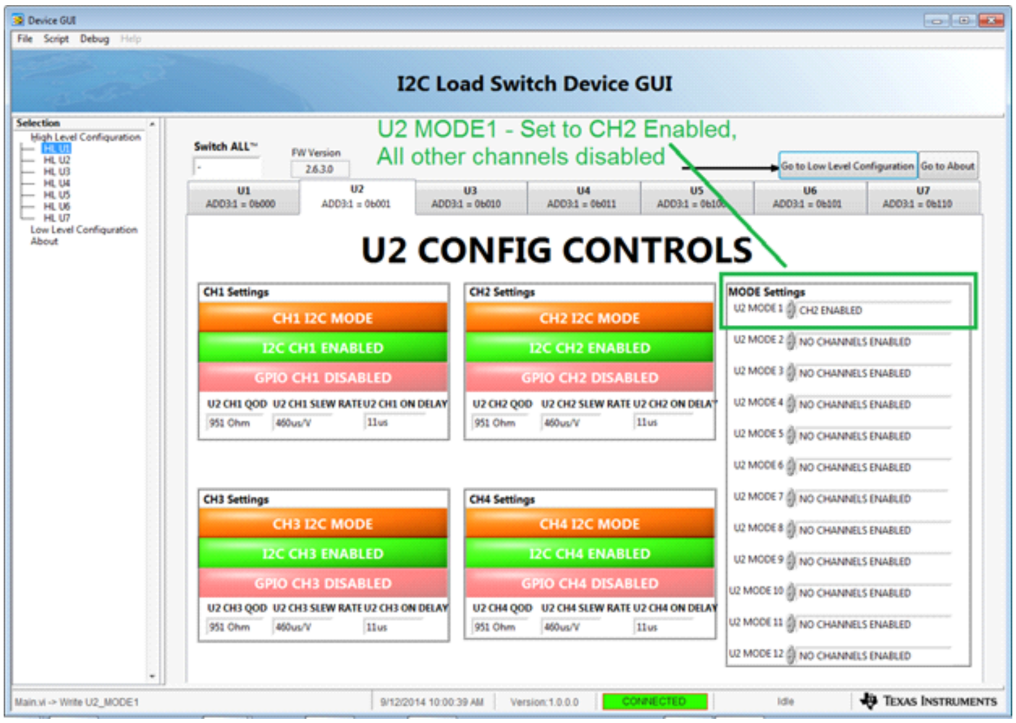

Figure 10. Set U2 Mode1 Register to CH2 Enabled

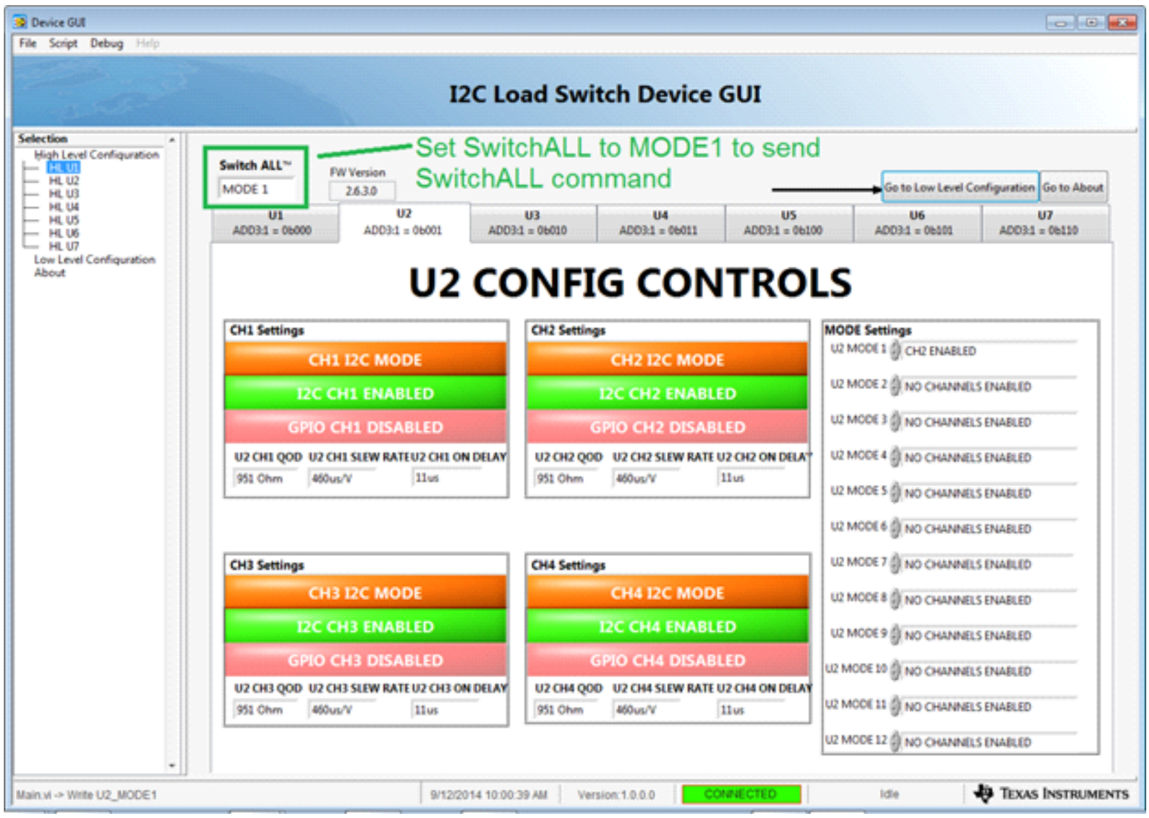

Figure 11. Set SwitchALL™ Control to MODE1 to Send SwitchALL™ Command

4.5 Scripting Functionality

(A) Restart the Device GUI to insure the GUI starts with the known default values.

(B) Go to the drop down menu Script >> Launch window as shown in Figure 12.

(C) A Python scripting window should be launched named Untitled as shown in Figure 13.

(D) Go to the drop down menu Script >> Start Recording, see Figure 14

(E) The Python script should begin flashing green and additional text should show up in the window, see Figure 15.

(F) You are now ready to record the actions in the I^2C Load Switch GUI. Click on the U2 tab to select device U2. Click on CH1 GPIO Mode it should transition to CH1 I2C MODE, Click on I2C CH1 Disable and it should transition to I2C CH1 Enabled and turn Green, Click on U2 CH1 QOD and select 110 Ω, Click on U2 CH1 Slew Rate and select 250 µs/V, and Click on U2 CH1 ON Delay and select 105 µs.

(G) Your GUI screen should look like Figure 16 after you have finished clicking the controls.

(H) These steps should have been recorded in the Python script GUI, see Figure 17.

(I) Go to the script drop down menu and select Stop Recording, see Figure 18. The Python window should now have the GUI.__del__() command added to the last of the script and the Python window should have stopped flashing green.

(J) Open the Python window and go to File >> Save As, see Figure 19

(K) Browse to the Desktop and put the file name as test_gui_script.py (to save the file, you must enter the .py file extension at the end of the file name, for example, test.py) and save it to the desktop, see Figure 20.

(L) Go to the I^2C Load Switch GUI and Select File>> Exit, see Figure 21 to exit the application.

(M) Restart the application and go to Script >>> Launch Window.

(N) In the Python window go to File >> Open>> and Browse to the test_gui_script.py file on the desktop, see Figure 22.

(O) In the Python window go to Run >> Run Module, see Figure 23. The Python script should run and another python window should pop us saying Script Completed Successfully.

(P) The I^2C Load Switch GUI setting for U2 CH2 should now be updated to the setting from the recording after restarting the application and running the script, see Figure 24.

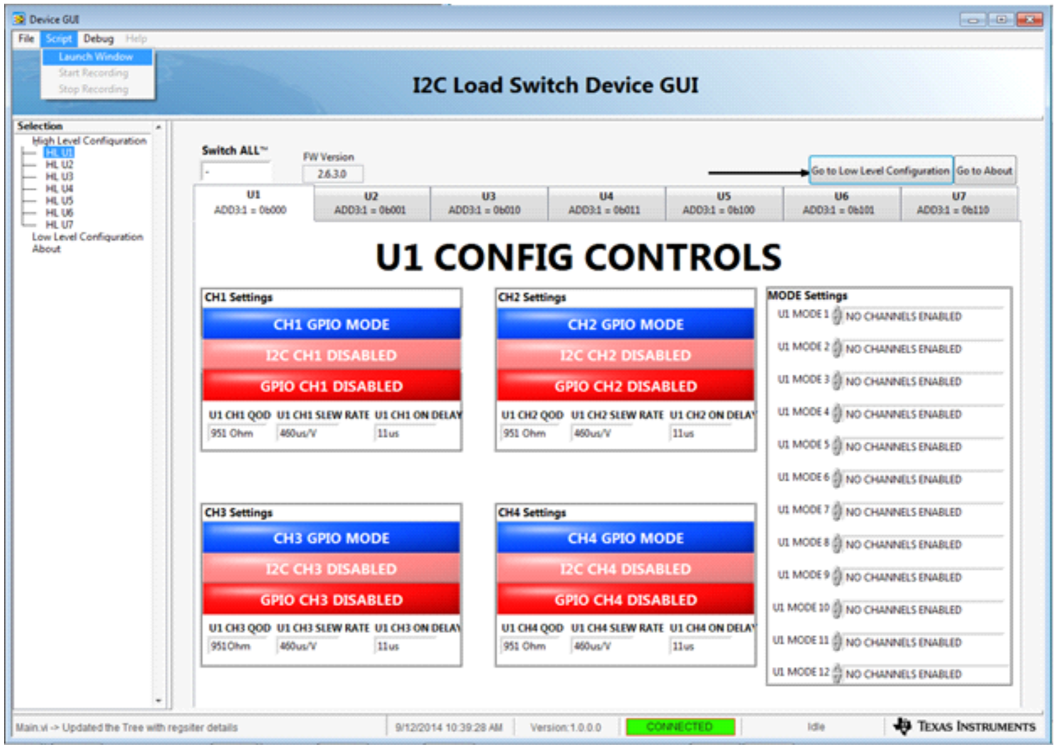

Figure 12. Launch Script Window

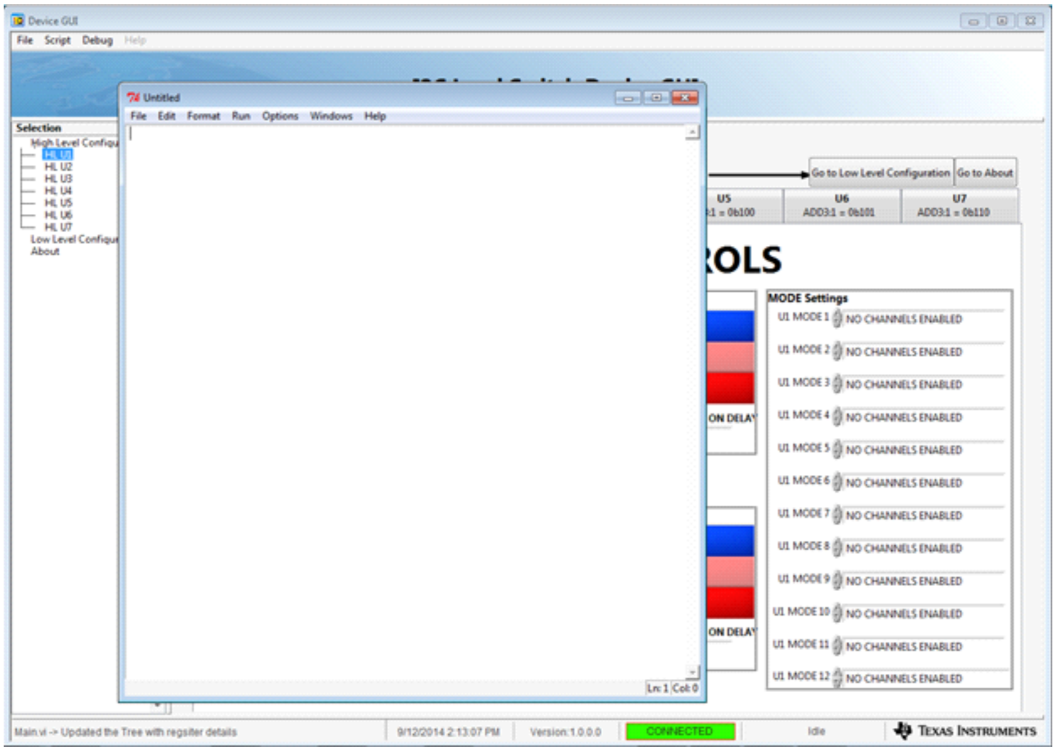

Figure 13. Python Script Window Pops Up

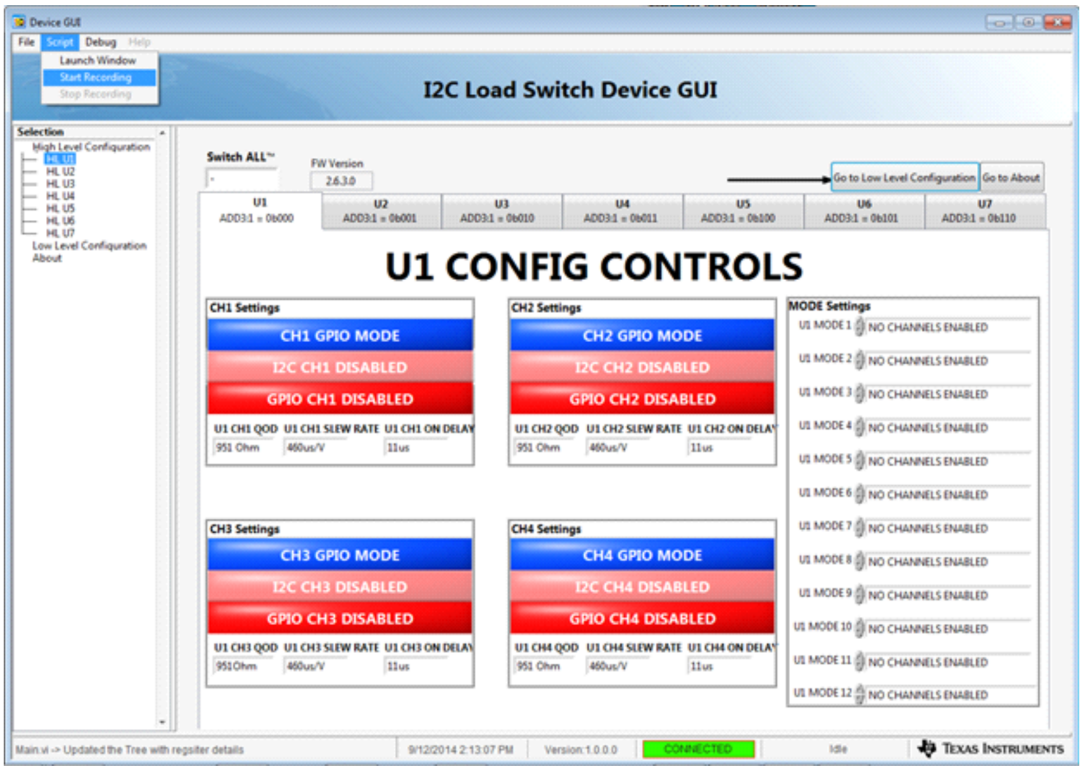

Figure 14. Select Start Recording

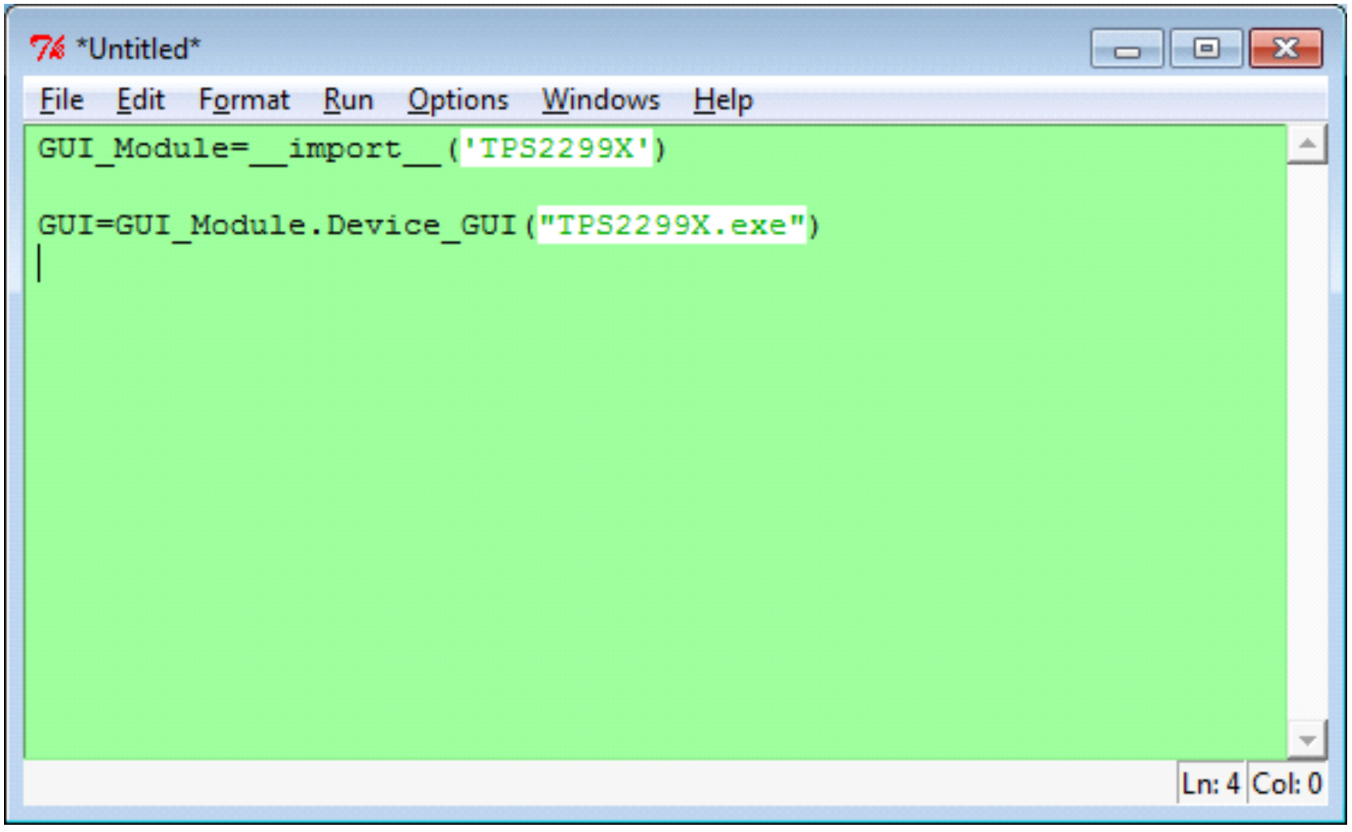

Figure 15. Python Script Window Begins Flashing Green

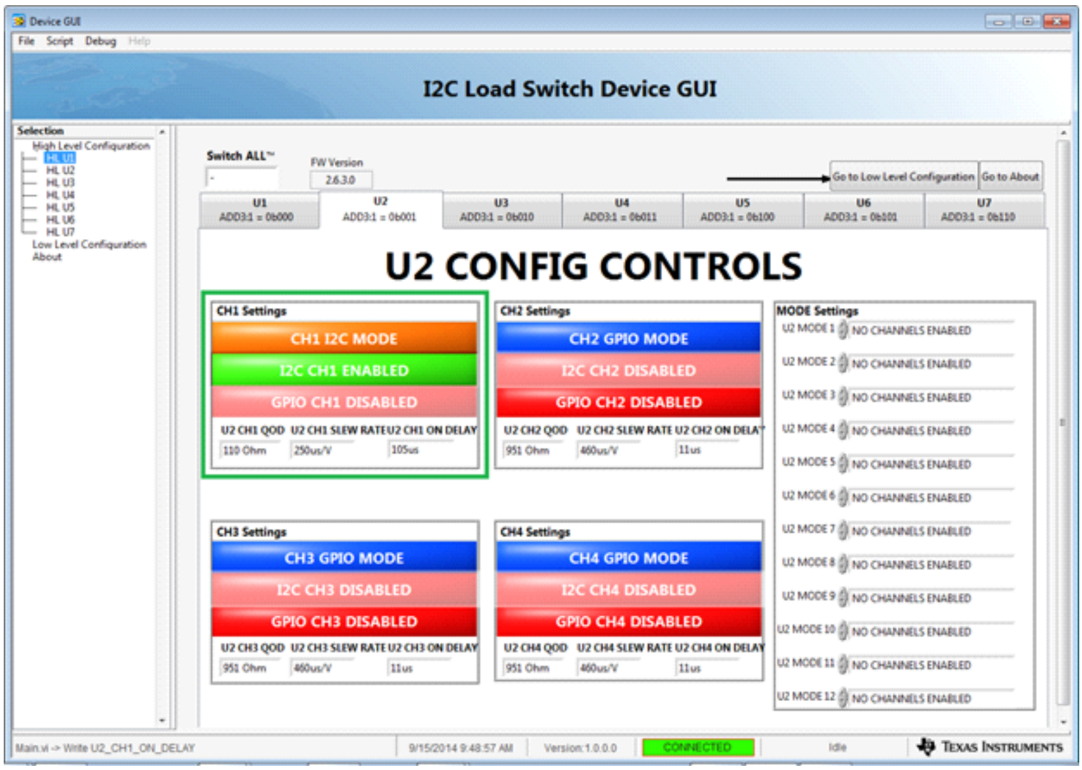

Figure 16. GUI Screen after Clicking U2 CH1 Controls

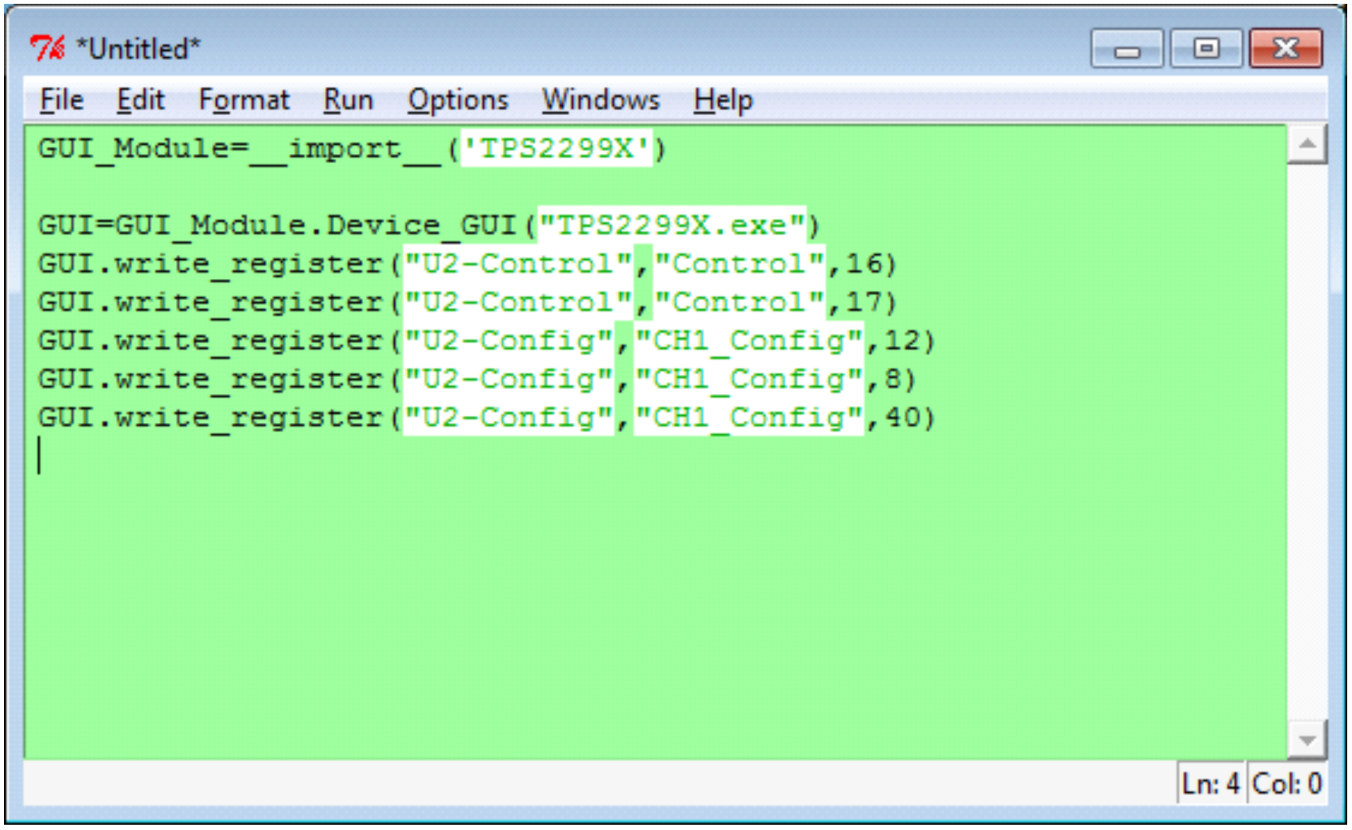

Figure 17. Python Script Window after Recording after Clicking U2 CH1 Controls

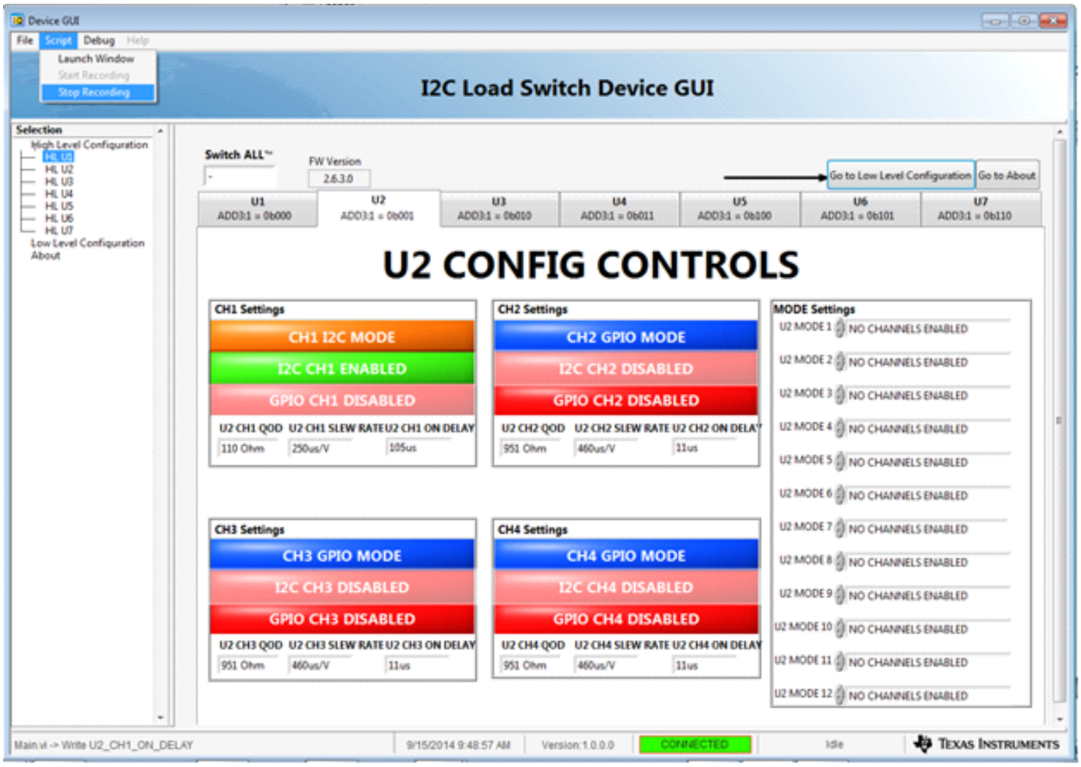

Figure 18. Python Script Window Stop Recording

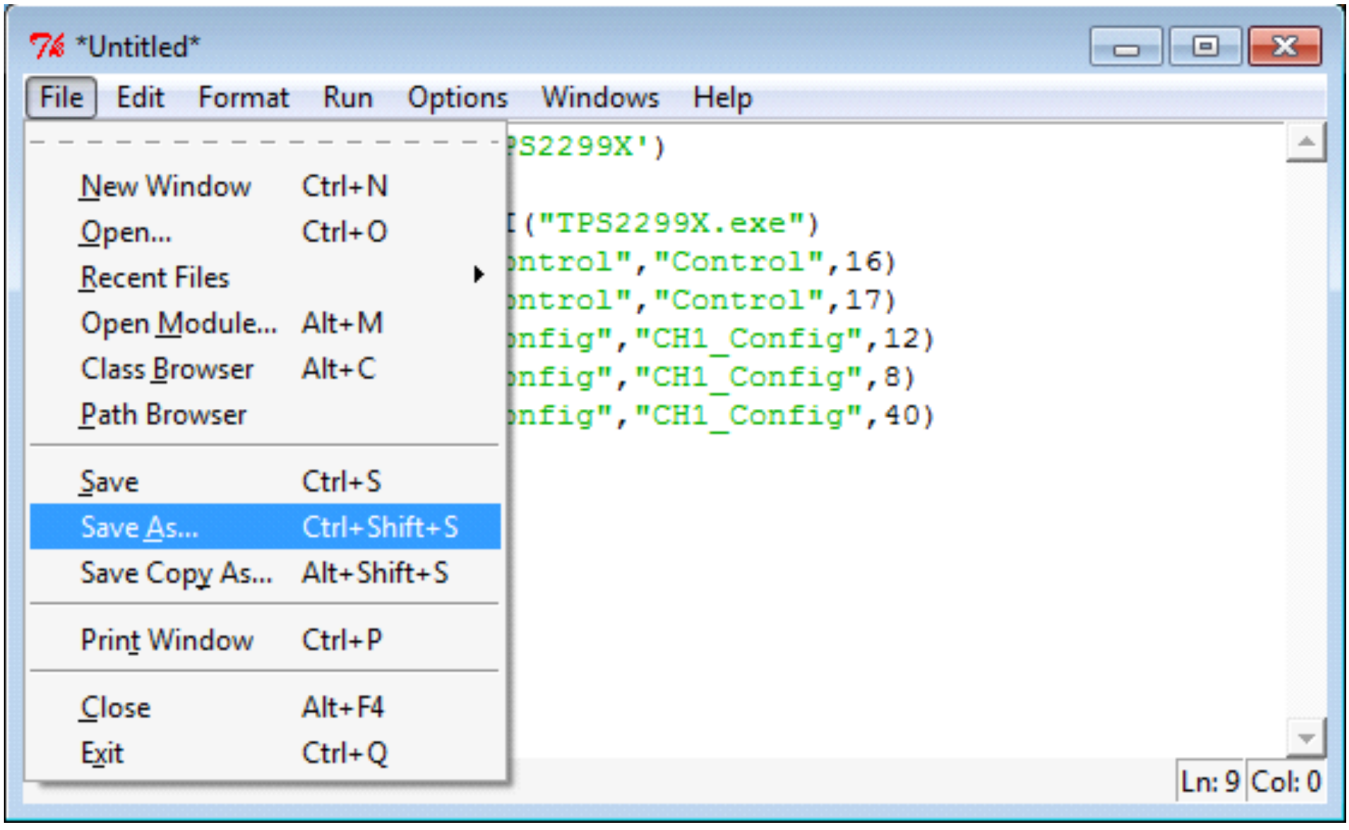

Figure 19. Save Python Script Window

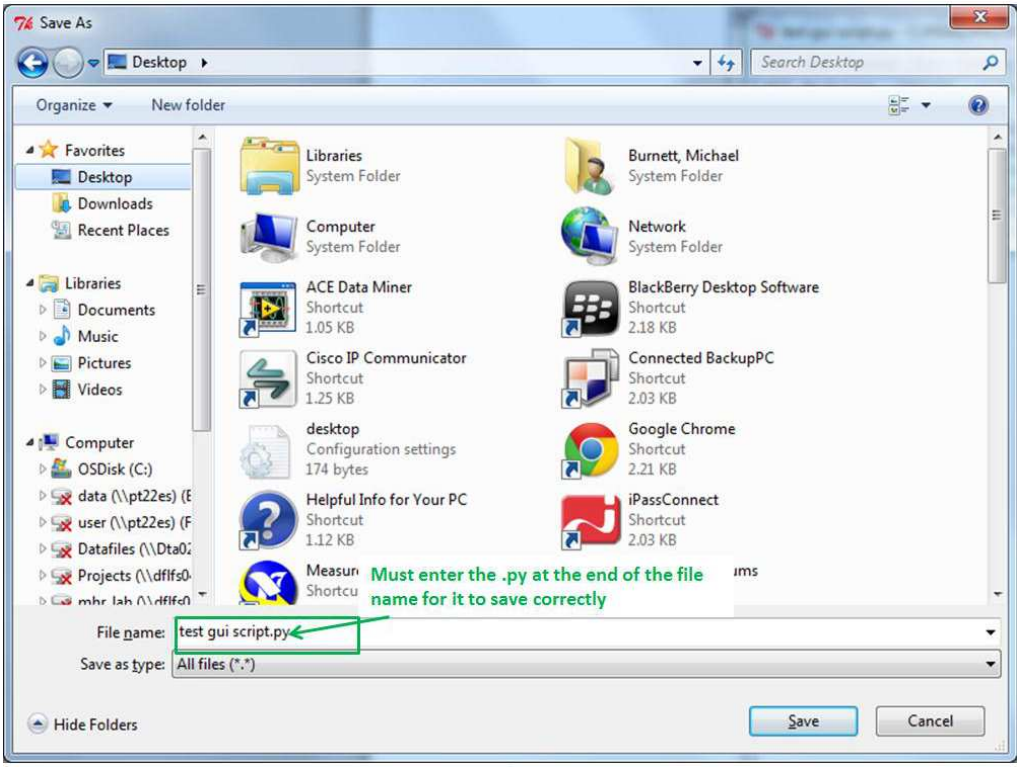

Figure 20. Must Enter the .py at the End of the File Name to Save the Python File Correctly

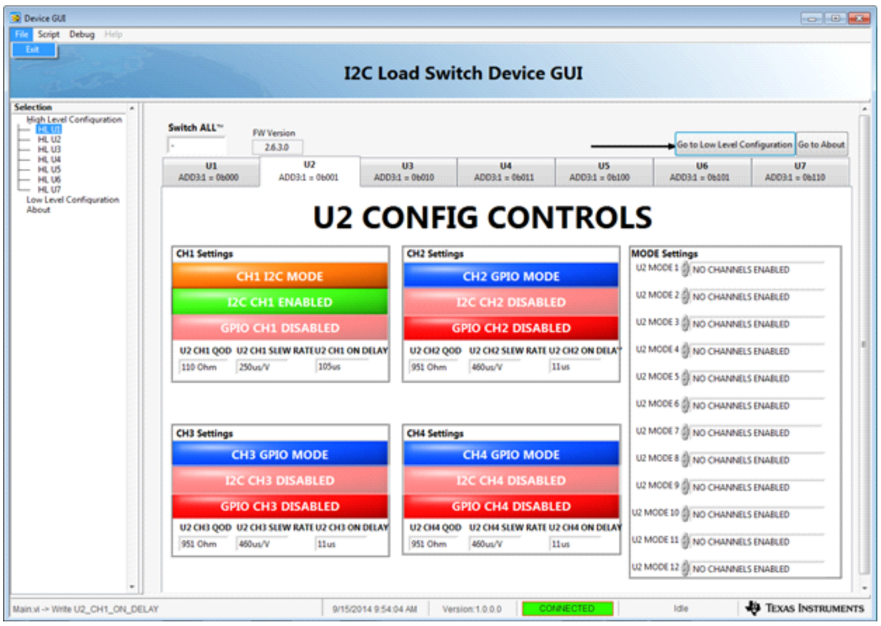

Figure 21. Select Exit on the Device GUI

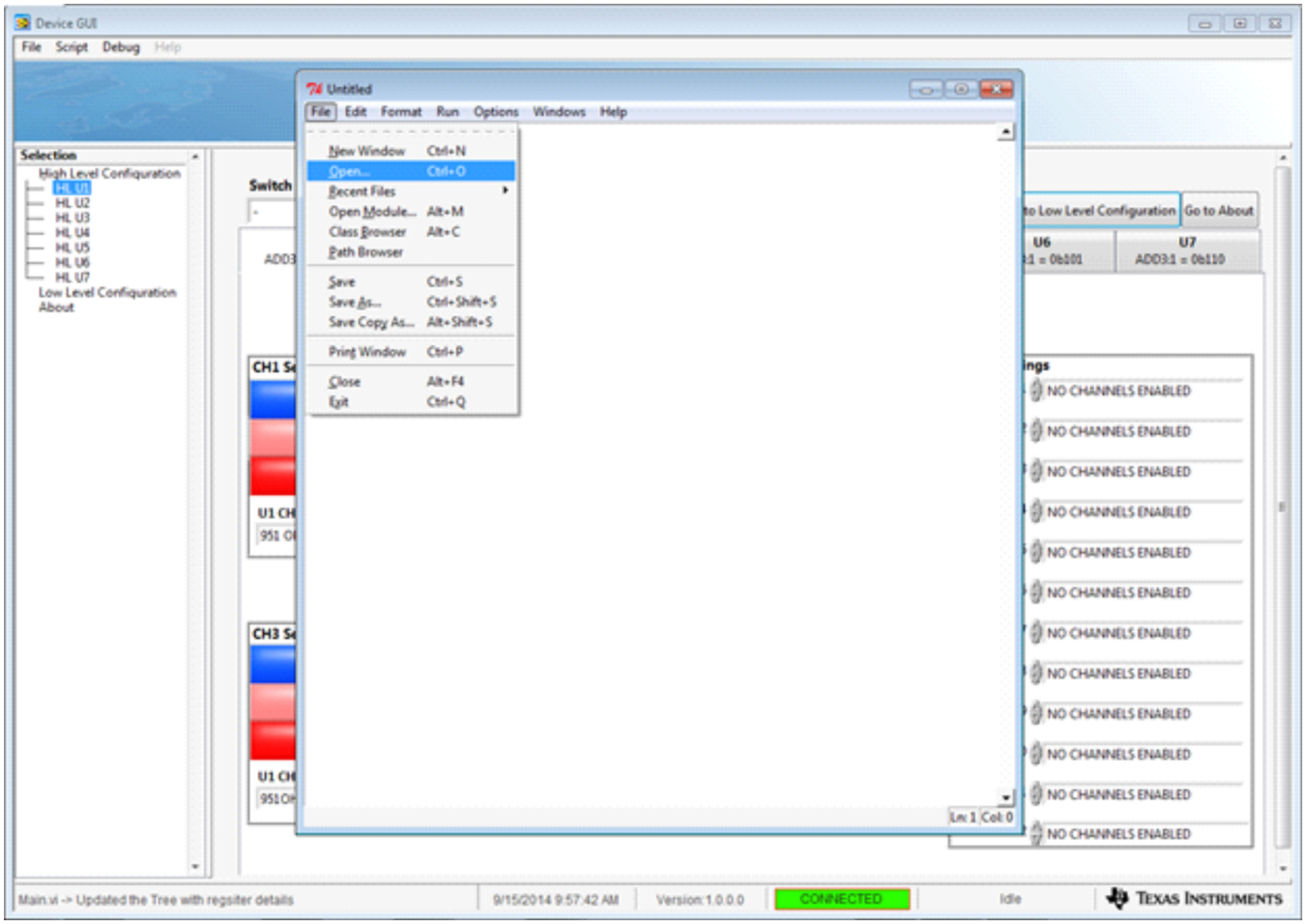

Figure 22. Open Test_gui_script.py File

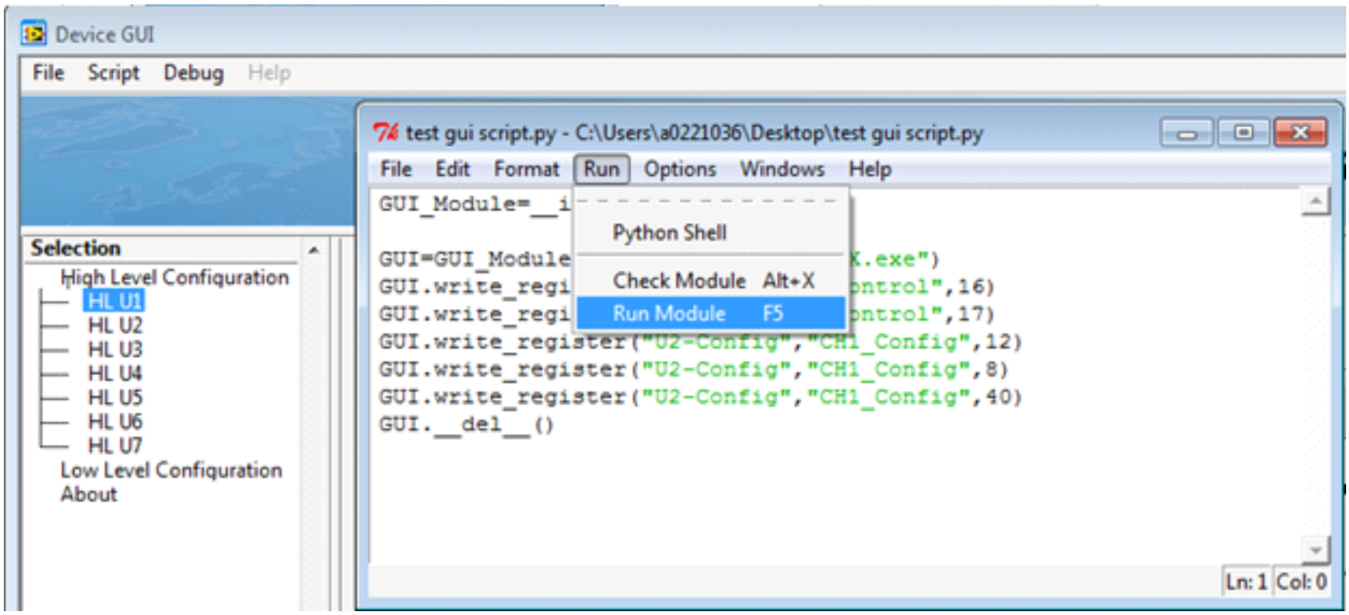

Figure 23. Run the Recorded Script

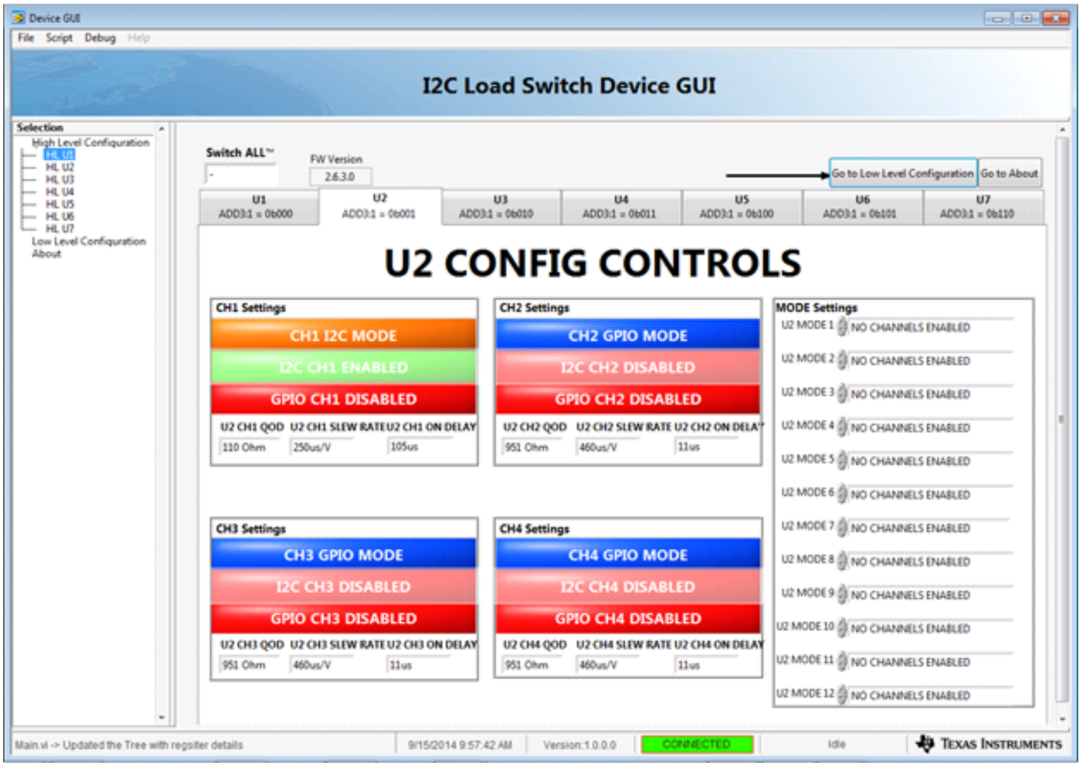

Figure 24. U2 Settings after Executing the Module and Running the Script

5 Schematics and Layouts

5.1 Schematics

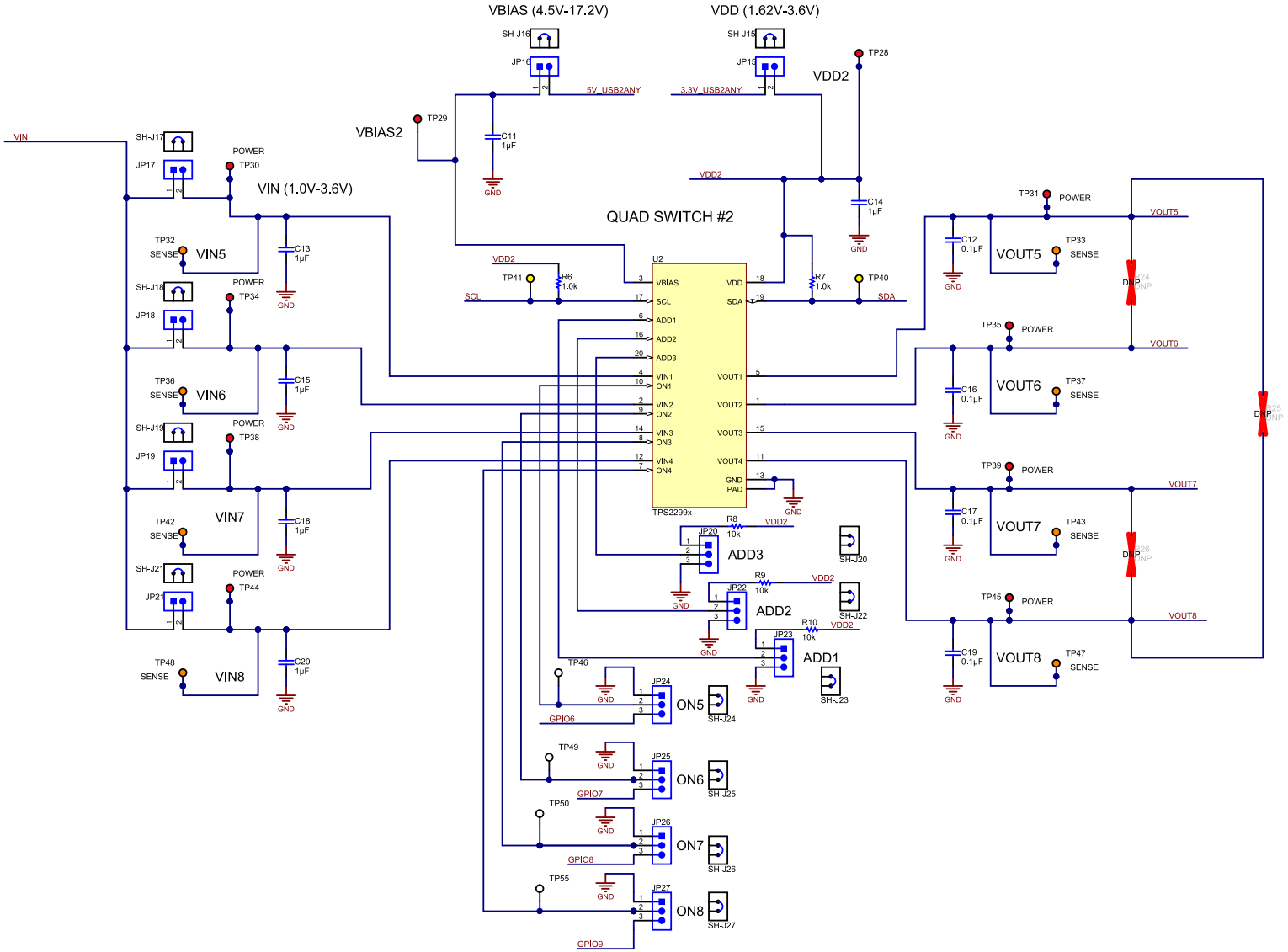

Figure 25. I²C Load Switch EVM Board Schematic (1 of 3)

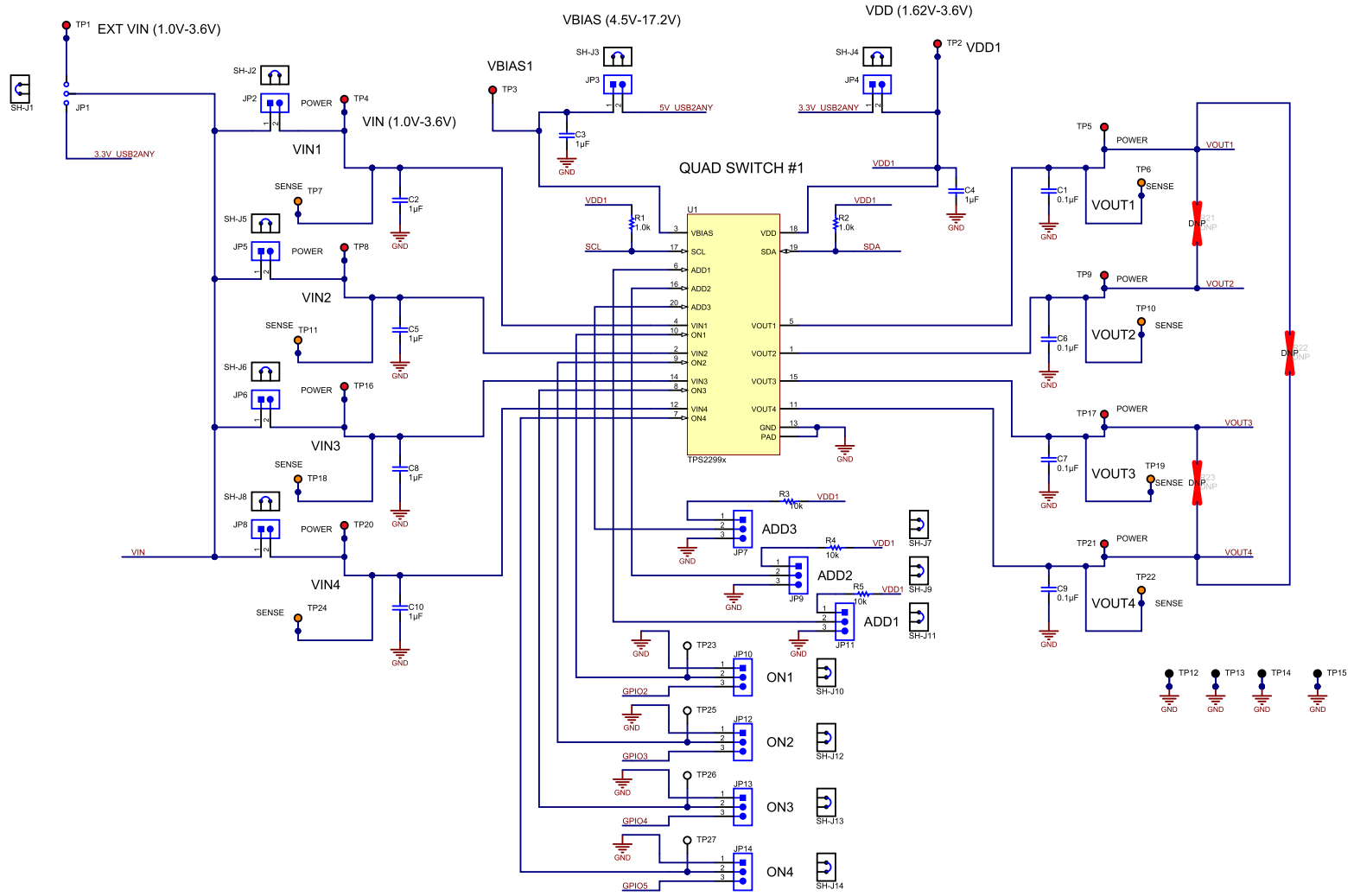

Figure 26. I²C Load Switch EVM Board Schematic (2 of 3)

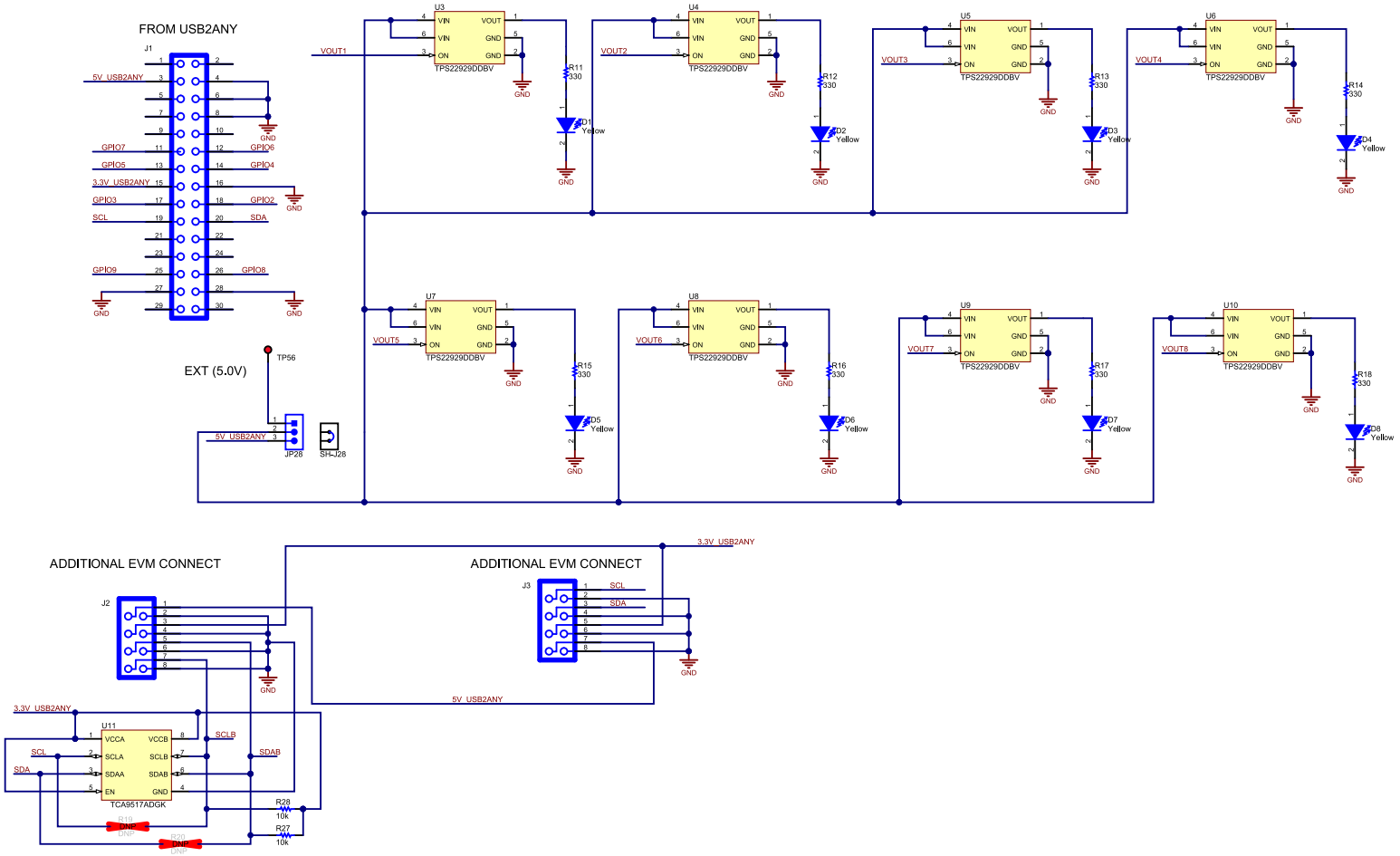

Figure 27. I²C Load Switch EVM Board Schematic (3 of 3)

5.2 Layouts

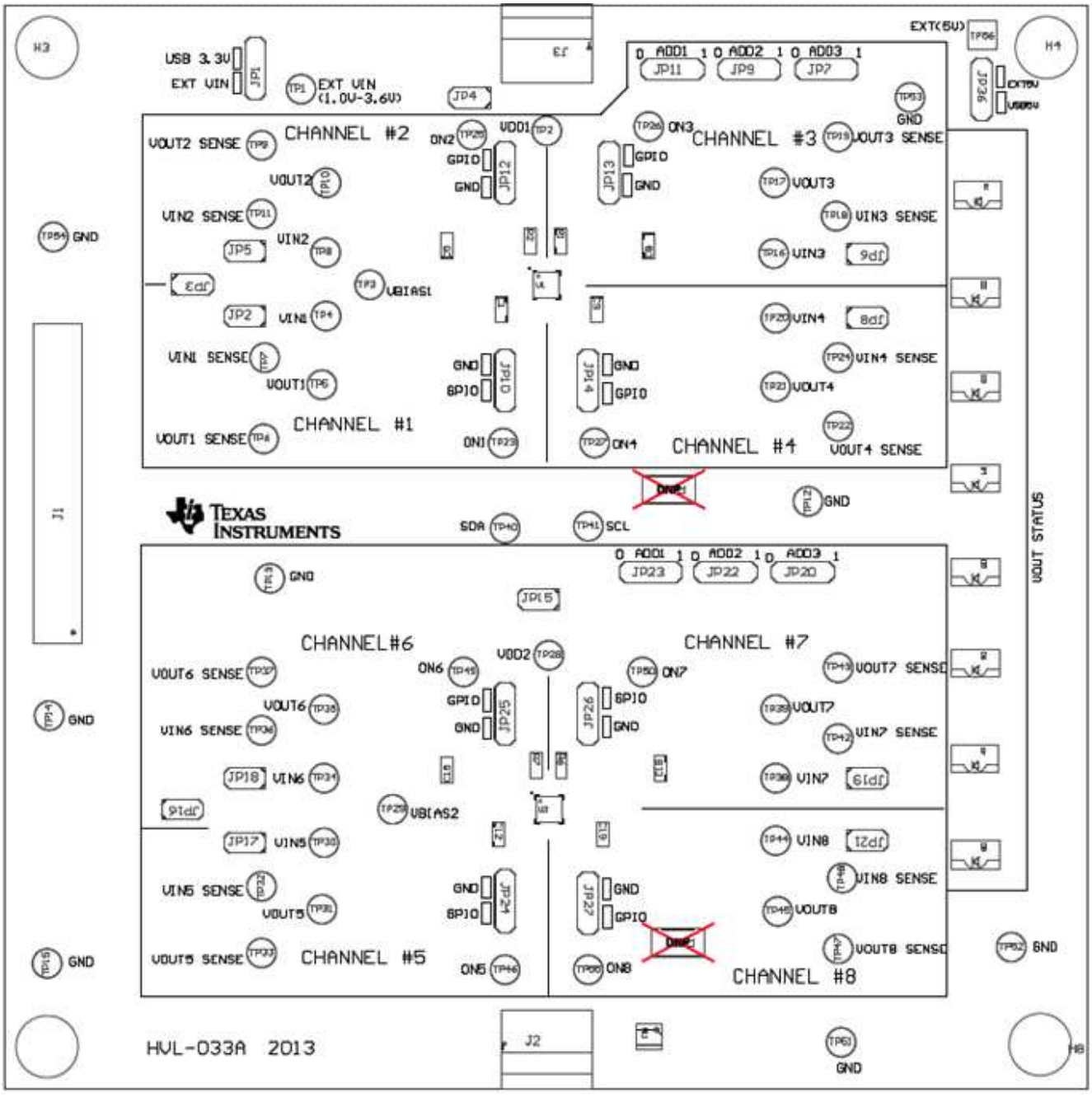

Figure 28. I²C Load Switch EVM Board Top Assembly

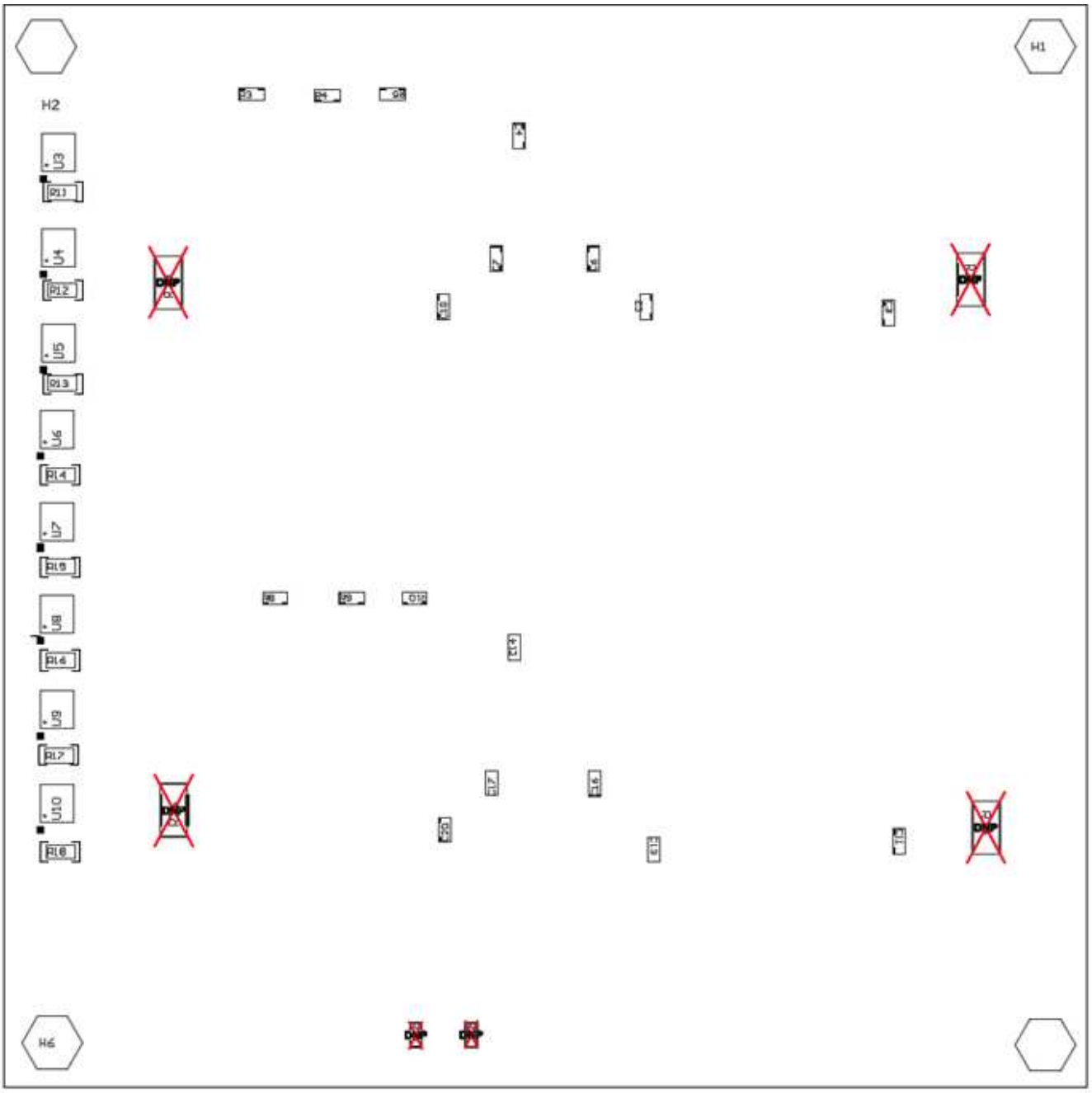

Figure 29. I²C Load Switch EVM Board Bottom Assembly

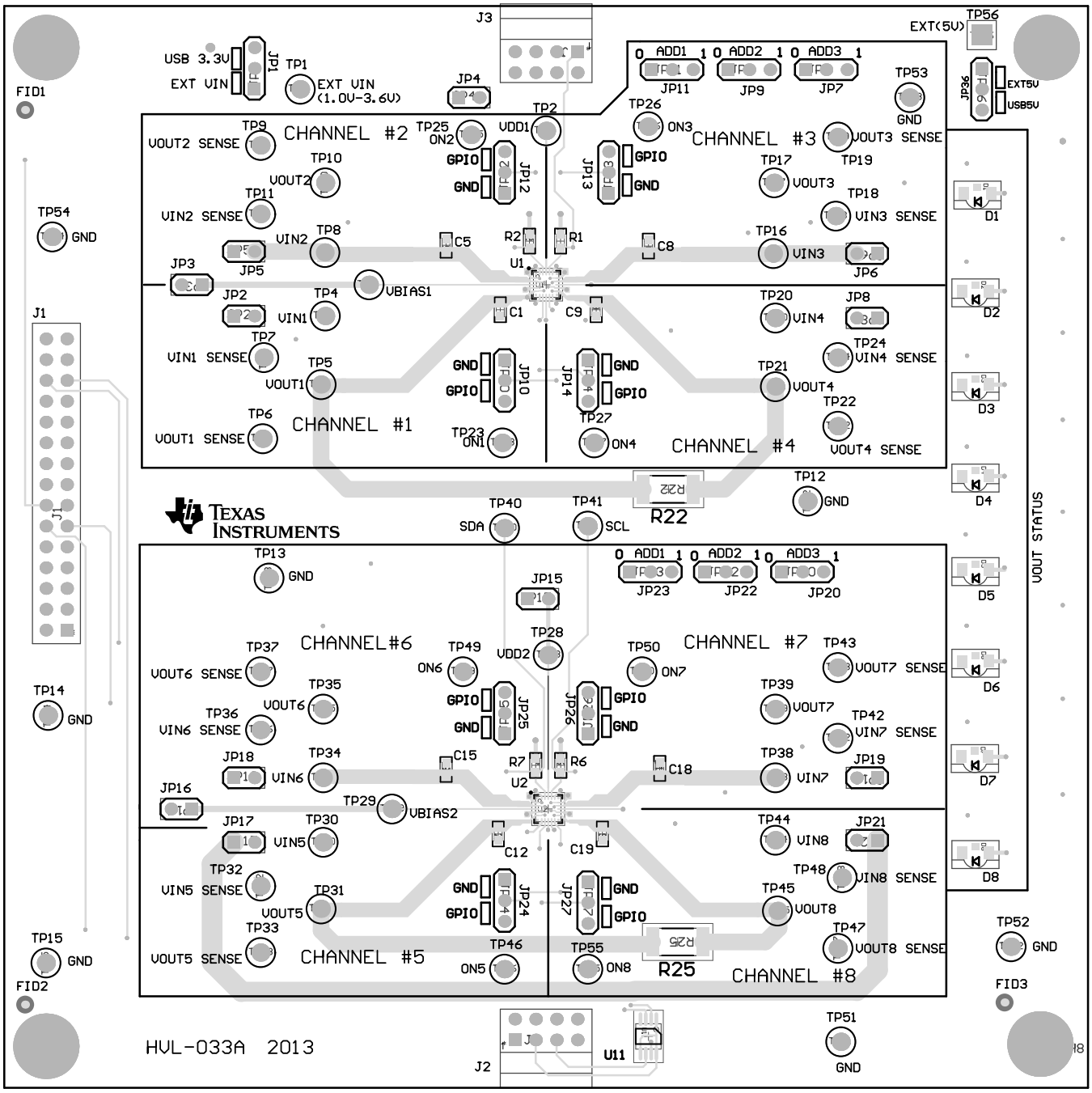

Figure 30. I²C Load Switch EVM Board Top Side (Minus GND Pour)

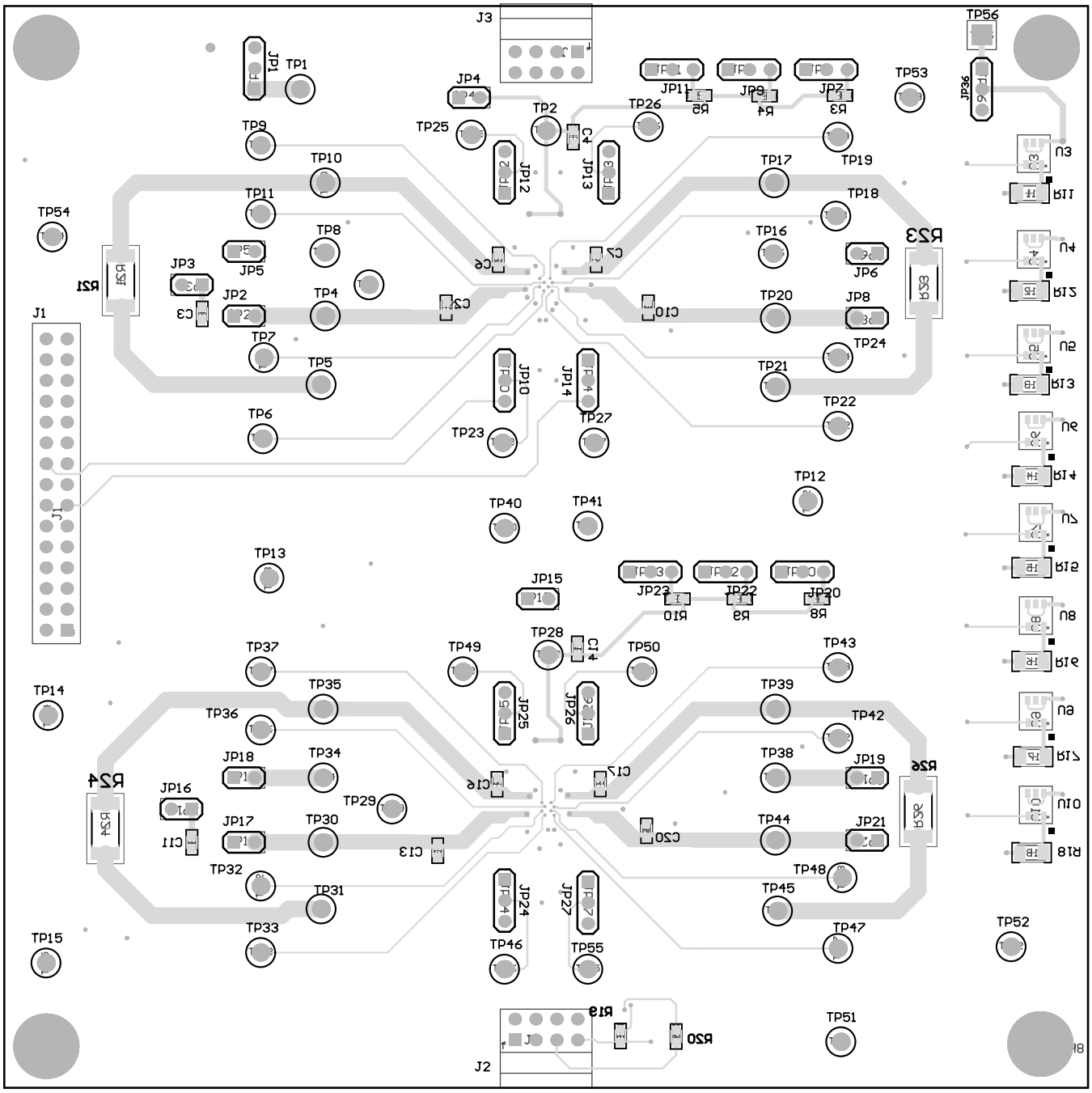

Figure 31. I²C Load Switch EVM Board Bottom Side (Minus GND Pour)

6 EVM Setup

Use Table 1 to connect to the EVM. Two operating modes will be explained further in Section 6.2 and Section 6.3. A valid voltage level for VIN, VDD, and VBIAS must be present for proper switch operation.

6.1 List of Test Points and Jumpers

Table 1. Functions of Test Points and Jumpers

Test Points	Name	Description	Default Setting
J1	USB2ANY Cable	Connects the USB2ANY to the EVM	Connected
J2	AUX EVM Bottom	Allows for an additional EVM connected to the EVM in use	Not Connected
J3	AUX EVM Top	Allows for an additional EVM connected to the EVM in use	Not Connected
JP1	EXT VIN /USB	Connects 3p3V USB2ANY or EXTPOWER VIN to VIN1-8 Jumpers	Short to USB 3.3 V
JP2	VIN1	Connects voltage to VIN1	Short
JP3	VBIAS1 /USB	Connects 5V USB2ANY voltage to VBIAS1	Short
JP4	VDD1	Connects 3.3V USB2ANY voltage to VDD1	Short
JP5	VIN2	Connects voltage to VIN2	Short
JP6	VIN3	Connects voltage to VIN3	Short
JP7	ADD3	Connects SWITCH1 ADD3 to GND or VDD1 (thru 10K ohms)	Short JP7 to 0
JP8	VIN4	Connects voltage to VIN4	Short
JP9	ADD2	Connects SWITCH1 ADD2 to GND or VDD1 (thru 10K ohms)	Short JP9 to 0
JP10	ON1	Connects SWITCH1 ON1 to GND or GPIO2	Short JP10 pin2 to 3
JP11	ADD1	Connects SWITCH1 ADD1 to GND or VDD1 (thru 10K ohms)	Short JP11 to 0
JP12	ON2	Connects SWITCH1 ON2 to GND or GPIO3	Short JP12 pin2 to 3
JP13	ON3	Connects SWITCH1 ON3 to GND or GPIO4	Short JP13 pin2 to 3
JP14	ON4	Connects SWITCH1 ON4 to GND or GPIO5	Short JP14 pin2 to 3
JP15	VDD2	Connects 3.3V USB2ANY voltage to VDD2	Short
JP16	VBIAS2 /USB	Connects 5V USB2ANY voltage to VBIAS2	Short
JP17	VIN5	Connects voltage to VIN5	Short
JP18	VIN6	Connects voltage to VIN6	Short
JP19	VIN7	Connects voltage to VIN7	Short
JP20	ADD3	Connects SWITCH2 ADD3 to GND or VDD1 (thru 10K ohms)	Short JP20 to 0
JP21	VIN8	Connects voltage to VIN8	Short
JP22	ADD2	Connects SWITCH2 ADD2 to GND or VDD1 (thru 10K ohms)	Short JP22 to 0
JP23	ADD1	Connects SWITCH2 ADD1 to GND or VDD1 (thru 10K ohms)	Short JP23 to 1
JP24	ON5	Connects SWITCH2 ON1 to GND or GPIO6	Short JP24 pin2 to 3
JP25	ON6	Connects SWITCH2 ON2 to GND or GPIO7	Short JP25 pin2 to 3
JP26	ON7	Connects SWITCH2 ON3 to GND or GPIO8	Short JP26 pin2 to 3
JP36	EXT 5.0V	Connects voltage for LED from switch	Short to USB5V
TP1	EXT VIN	Connection point foe EXT VIN input	
TP2	VDD1	Connection point to VDD1	
TP3	VBIAS1	Connection point to VBIAS1	
TP4	VIN1	Connection point to VIN1	
TP5	VOUT1	Connection point to VOUT1	
TP6	VOUT1 SENSE	Connection point to VOUT1 SENSE	
TP7	VIN2 SENSE	Connection point to VIN2 SENSE	
TP8	VIN2	Connection point to VIN2	
TP9	VOUT2	Connection point to VOUT2	
TP10	VOUT2 SENSE	Connection point to VOUT2 SENSE	
TP11	VIN2 SENSE	Connection point to VIN2 SENSE	
TP16	VIN3	Connection point to VIN3	
TP12-15	GND	Connection point to AGND	
TP17	VOUT3	Connection point to VOUT3	

Table 1. Functions of Test Points and Jumpers (continued)

Test Points	Name	Description	Default Setting
TP18	VIN3 SENSE	Connection point to VIN3 SENSE	
TP19	VOUT3 SENSE	Connection point to VOUT3 SENSE	
TP20	VIN4	Connection point to VIN4	
TP21	VOUT4	Connection point to VOUT4	
TP22	VOUT4 SENSE	Connection point to VOUT4 SENSE	
TP23	ON1	Connection point to ON1	
TP24	VIN4	Connection point to VIN4	
TP25	ON2	Connection point to ON2	
TP26	ON3	Connection point to ON3	
TP27	ON4	Connection point to ON4	
TP28	VDD2	Connection point to VDD2	
TP29	VBIAS2	Connection point to VBIAS2	
TP30	VIN5	Connection point to VIN5	
TP31	VOUT5	Connection point to VOUT5	
TP32	VIN2 SENSE	Connection point to VIN2 SENSE	
TP33	VOUT5 SENSE	Connection point to VOUT5 SENSE	
TP34	VIN6	Connection point to VIN6	
TP35	VOUT6	Connection point to VOUT6	
TP36	VIN6 SENSE	Connection point to VIN6 SENSE	
TP37	VOUT6 SENSE	Connection point to VOUT5 SENSE	
TP38	VIN7	Connection point to VIN7	
TP39	VOUT7	Connection point to VOUT7	
TP40	SDA	Connection point to SDA	
TP41	SCL	Connection point to SCL	
TP42	VIN7 SENSE	Connection point to VIN7 SENSE	
TP43	VOUT7 SENSE	Connection point to VOUT7 SENSE	
TP44	VIN8	Connection point to VIN8	
TP45	VOUT8	Connection point to VOUT8	
TP46	ON5	Connection point to ON5	
TP47	VOUT8 SENSE	Connection point to VOUT8 SENSE	
TP48	VIN8 SENSE	Connection point to VIN8 SENSE	
TP49	ON6	Connection point to ON6	
TP50	ON7	Connection point to ON7	
TP55	ON8	Connection point to ON8	
TP51-54	GND	Connection point to AGND	

6.2 EVM USB Powered Mode

When the jumpers are placed in the default setting described in Table 1. The USB2ANY module will supply all necessary power (VIN, VDD, VBIAS, and VLED) for both U1 and U2 load switches. The functionality of the load switches Trise, Tfall, Ton, and QOD can be programmed using the GUI commands and viewed by connecting a scope to the desired switch output. When powering the I^2C Load Switch in the USB powered mode the user may **NOT** place excessive loads on the switch outputs. The USB2ANY power sources are limited to 500 mA.

6.3 EVM External Powered Mode

External Power Sources can be connected directly to VIN, VDD, VBIAS, and VLED. To connect externally to VIN move JP1 shunt to pin1 to pin2 position, and connect power source to TP1. (VIN operating voltage levels are from 1.0V to 3.6V). When connecting VDD1 externally, remove JP4 shunt and connect power source to TP2, for VDD2 remove shunt from JP15 and connect voltage to TP28. (VDD operating range is 1.62 to 3.6 V). To connect directly to VBIAS1 remove JP3 shunt and connect power source to TP3. For VBIAS2 remove shunt from JP16 and connect power source to TP29. (VBIAS operating voltage levels are from 4.5 to 17.2 V). External voltage can be applied for the LED's place JP36 shunt on pin1 to 2 and connect voltage source to TP56. (VLED = 4 V – 5 V). By connecting an external power source to the VIN inputs the 1.2 A VOUT max continuous current limit may be exercised.

7 Load Switch Performance

The I^2C Load Switch enables the user to set different slew rate, delay the turn on time, and control the output discharge (or) turn off rate as desired using simple I^2C commands. Examples of this flexibility are shown in the sections below. Each switch channel is configurable independent of the other switch channels.

Each switch channel is configurable independent of the other switch channels. Examples of this flexibility are shown in the following plots using these test conditions:

- VIN = 2.6 V
- VBIAS = 7.2 V
- CIN = 1 µF
- COUT = 0.1 µF
- Rload = 10 Ω
- Temp = Room (~25°C)

Figure 32. Programmable Slew Rate Control

Figure 33. Programmable Turn on Delay Time

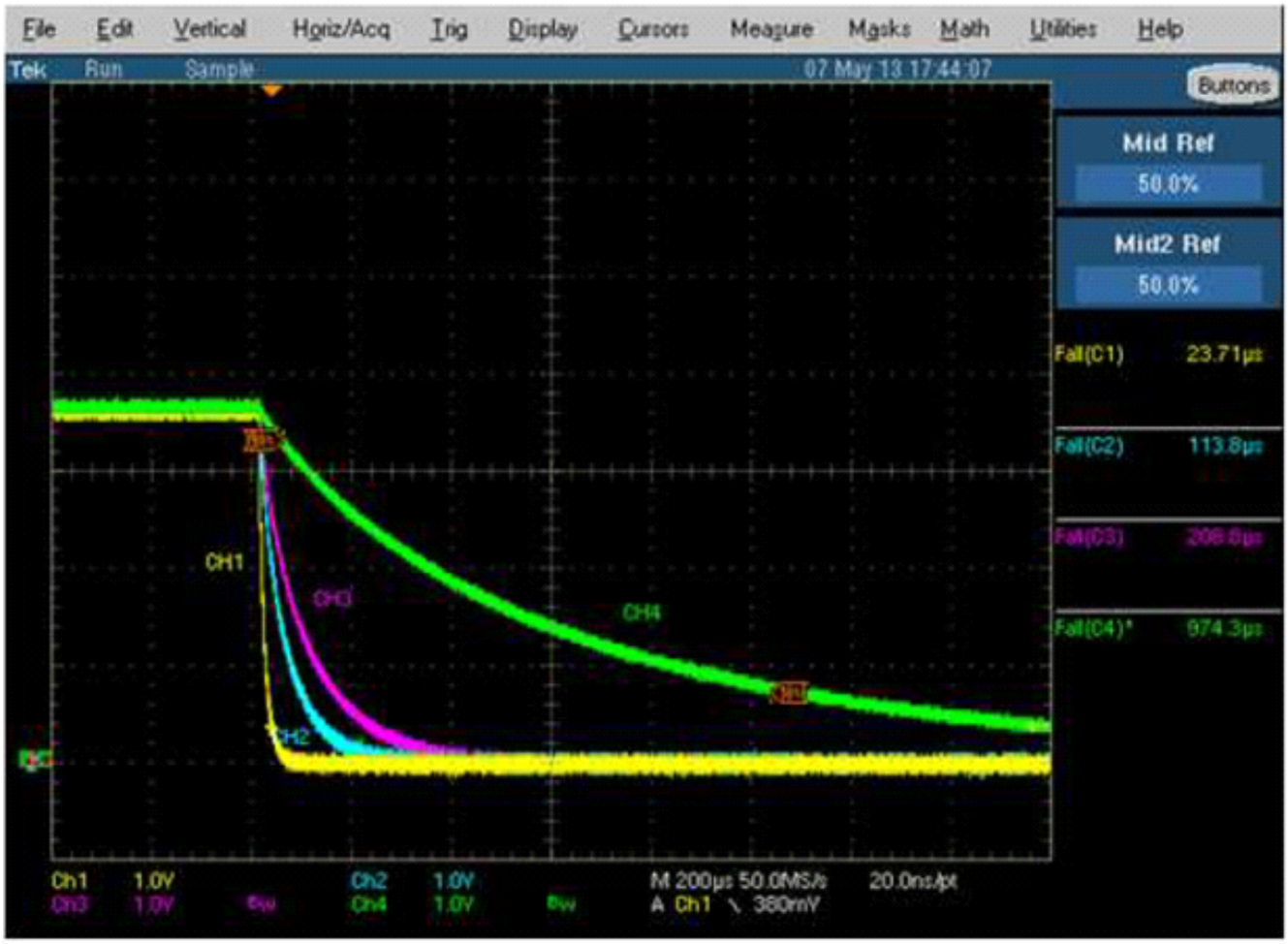

Figure 34. Programmable Output Discharge (Fall Time Control)

7.1 Switch Parallel Configuration Mode

Shorting resistors may be placed on the switch outputs to connect them in a parallel configuration; these resistors are not populated when shipped. Placing a 0 Ω 2512 1W size resistor across R21 pads connects switch1 VOUT1 and VOUT2 in parallel, R22 connects VOUT1 and VOUT4 and R23 connects VOUT3 and VOUT4. Switch2 connects in the same manner using R24, R25, and R26. When connecting switches in parallel the continuous current drawn through the device may be increased, and the On resistance (Ron) across the parallel switch configuration is decreased. Figure 30 shows switch performance examples of the TPS22993 in parallel configuration.

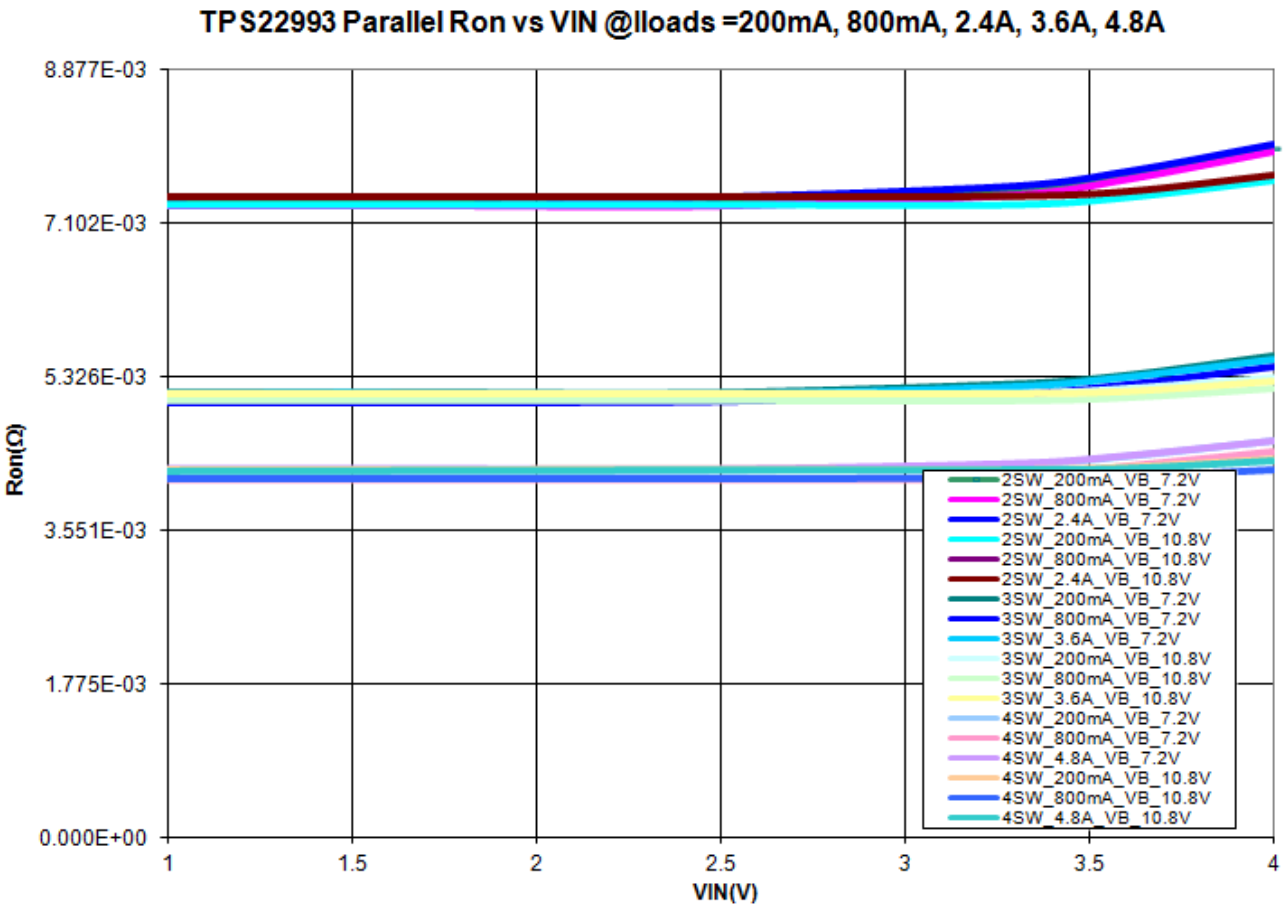

Figure 35. TPS22993 All Four Switches Connected in Parallel Configuration

Revision History

Changes from B Revision (September 2014) to C Revision	Page
• Updated Functions of Test Points and Jumpers table.	28
• Updated Functions of Test Points and Jumpers table.	29

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

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