HV2903 Analog Switch Evaluation Board User's Guide

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Preface

NOTICE TO CUSTOMERS

All documentation becomes dated, and this manual is no exception. Microchip tools and documentation are constantly evolving to meet customer needs, so some actual dialogs and/or tool descriptions may differ from those in this document. Please refer to our website (www.microchip.com) to obtain the latest documentation available.

Documents are identified with a "DS" number. This number is located on the bottom of each page, in front of the page number. The numbering convention for the DS number is "DSXXXXXXXXA", where "XXXXXXXX" is the document number and "A" is the revision level of the document.

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INTRODUCTION

This chapter contains general information that will be useful to know before using the HV2903 Analog Switch Evaluation Board. Items discussed in this chapter include:

- Document Layout
- Conventions Used in this Guide
- Recommended Reading
- The Microchip Website
- Customer Support
- Document Revision History

DOCUMENT LAYOUT

This document describes how to use the HV2903 Analog Switch Evaluation Board as a development tool to evaluate the HV2903 No High-Voltage Bias, Low Harmonic Distortion, 32-Channel, High-Voltage Analog Switch IC. The user's guide layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the HV2903 Analog Switch Evaluation Board.
- **Chapter 2. "Installation and Operation"** – This chapter includes a detailed description of each function of the demonstration board and instructions for how to begin using the HV2903 Analog Switch Evaluation Board.
- **Chapter 3. "PCB Design and Layout Notes"** – This chapter explains important points of the PCB design and layout of HV2903 Analog Switch Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and PCB layout diagrams for the HV2903 Analog Switch Evaluation Board and the HV MUX Controller Board.
- **Appendix B. "Bill of Materials"** – Lists the parts used to build the HV2903 Analog Switch Evaluation Board and the HV MUX Controller Board.
- **Appendix C. "Demo Board Waveforms"** – Describes the various demo waveforms for the HV2903 Analog Switch Evaluation Board.

CONVENTIONS USED IN THIS GUIDE

This manual uses the following documentation conventions:

DOCUMENTATION CONVENTIONS

Description	Represents	Examples
Arial font:		
Italic characters	Referenced books	*MPLAB® IDE User's Guide*
	Emphasized text	...is the *only* compiler...
Initial caps	A window	the Output window
	A dialog	the Settings dialog
	A menu selection	select Enable Programmer
Quotes	A field name in a window or dialog	"Save project before build"
Underlined, italic text with right angle bracket	A menu path	*File>Save*
Bold characters	A dialog button	Click **OK**
	A tab	Click the **Power** tab
N'Rnnnn	A number in verilog format, where N is the total number of digits, R is the radix and n is a digit.	4'b0010, 2'hF1
Text in angle brackets < >	A key on the keyboard	Press <Enter>, <F1>
Courier New font:		
Plain Courier New	Sample source code	`#define START`
	Filenames	`autoexec.bat`
	File paths	`c:\mcc18\h`
	Keywords	`_asm, _endasm, static`
	Command-line options	`-Opa+, -Opa-`
	Bit values	`0, 1`
	Constants	`0xFF, 'A'`
Italic Courier New	A variable argument	*file*.o, where *file* can be any valid filename
Square brackets [ ]	Optional arguments	`mcc18 [options]` *file* `[options]`
Curly brackets and pipe character: { | }	Choice of mutually exclusive arguments; an OR selection	`errorlevel {0|1}`
Ellipses...	Replaces repeated text	`var_name [, var_name...]`

	Represents code supplied by user	`void main (void)`
		`{ ...`
		`}`

RECOMMENDED READING

This user's guide describes how to use the HV2903 Analog Switch Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource.

- **HV2903 Data Sheet – *"HV2803/HV2903/HV2904 – No High-Voltage Bias, Low Harmonic Distortion, 32-Channel, High-Voltage Analog Switch"* (DS20005721)**

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

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Technical support is available through the website at: http://support.microchip.com.

DOCUMENT REVISION HISTORY

Revision B (September 2018)

- Grammar corrections
- Improved page numbering

Revision A (December 2017)

- Initial Release of this Document

NOTES:

Chapter 1. Product Overview

1.1 INTRODUCTION

HV2903 Analog Switch Evaluation Board (ADM00795) works with HV MUX Controller Board (ADM00825) to provide 32-channel, high-voltage (HV) analog switches, without HV supplies demonstration, including basic switch ON/OFF operation and 2:1 MUX operation, with two built-in MD1822 and TC6320 pulser circuits.

1.2 HV2903 INTEGRATED CIRCUIT – DESCRIPTION

The HV2903 device is a no HV bias, low-harmonic distortion, low-charge injection, consisting of 32-channel, HV analog switches. It is designed for use in applications requiring high-voltage switching controlled by low-voltage control signals, such as medical ultrasound imaging, driving piezoelectric transducers and printers. The typical 10Ω on resistance analog switch can pass the analog pulse signal up to ±3A of current at ±100V, without high-voltage supplies such as ±100V. It requires only ±6V or ±5V for the ON/OFF switch operation and 3.3V for logic operation.

The HV2903 device has two modes of operation: Individual Switching mode and Bank Switching mode. The user can select the mode with the MODE pin logic input. The 32 analog switches can be controlled individually through a digital interface when the MODE input is high (Individual Switching mode). The digital interface clock operates up to 66 MHz. All 16 even switches and all 16 odd switches can be controlled together through simple 2-input logic when the MODE input is low (Bank Switching mode).

The Standby mode is used to decrease power consumption during idle state. When $\overline{\text{STBY}}$ logic input is low, the HV2903 device operates in Standby mode and consumes very low current. When $\overline{\text{STBY}}$ logic input is high, the device operates normally.

1.3 HV2903 ANALOG SWITCH EVALUATION BOARD – FEATURES

- One HV2903 No High-voltage Bias, Low Harmonic Distortion, 32-Channel, High-Voltage Analog Switch
- Designed to work with Microchip HV MUX Controller Board (ADM00825)
- Two 2:1 MUX with built-in MD1822 and TC6320 pulsers
- 5 MHz 3-level voltage pulse waveform outputs
- On-board 330 pF//2.5 kΩ dummy load per SW8A, SW9A, SW24A, SW25A
- Mode selection and Switch ON/OFF control through PC GUI and controller board
- Pulser ON/OFF and time domain control through PC GUI and controller board

1.4 HV2903 ANALOG SWITCH EVALUATION BOARD – FUNCTIONAL DESCRIPTION

The HV2903 Analog Switch Evaluation Board can control the HV2903 operation and built-in pulsers that are connected to two 2:1 MUX switches for demonstration. Four switch outputs of two 2:1 MUX have SMA connectors and the user can connect four transducer elements. The other side of the 2:1 MUX is connected to two built-in MD1822 and TC6320 pulsers. The HV2903 Analog Switch Evaluation Board can drive four transducer elements with 5 MHz, ±100V pulse signals.

The evaluation board features one HV2903/AHA 12x12x1.2 mm 132-Lead TFBGA packaged integrated circuit, two MD1822K6-G 3x3x1 mm 16-Lead QFN packaged integrated circuits, and four TC6320K6-G 4x4x1 mm 8-Lead DFN packaged NMOS and PMOS pair integrated circuits.

The HV2903 Analog Switch Evaluation Board uses two high-speed 20-signal pair carrying-capable, right-angle backplane connectors, which are designed to work with the Microchip HV MUX Controller Board (ADM00825) as a control signal source.

The HV MUX Controller Board has an FPGA that generates pulser waveform and logic control signals, and a USB bridge IC that connects the control board to a PC. By means of a Microsoft® Windows® driver and GUI, the user can control the HV2903 device and two built-in pulsers.

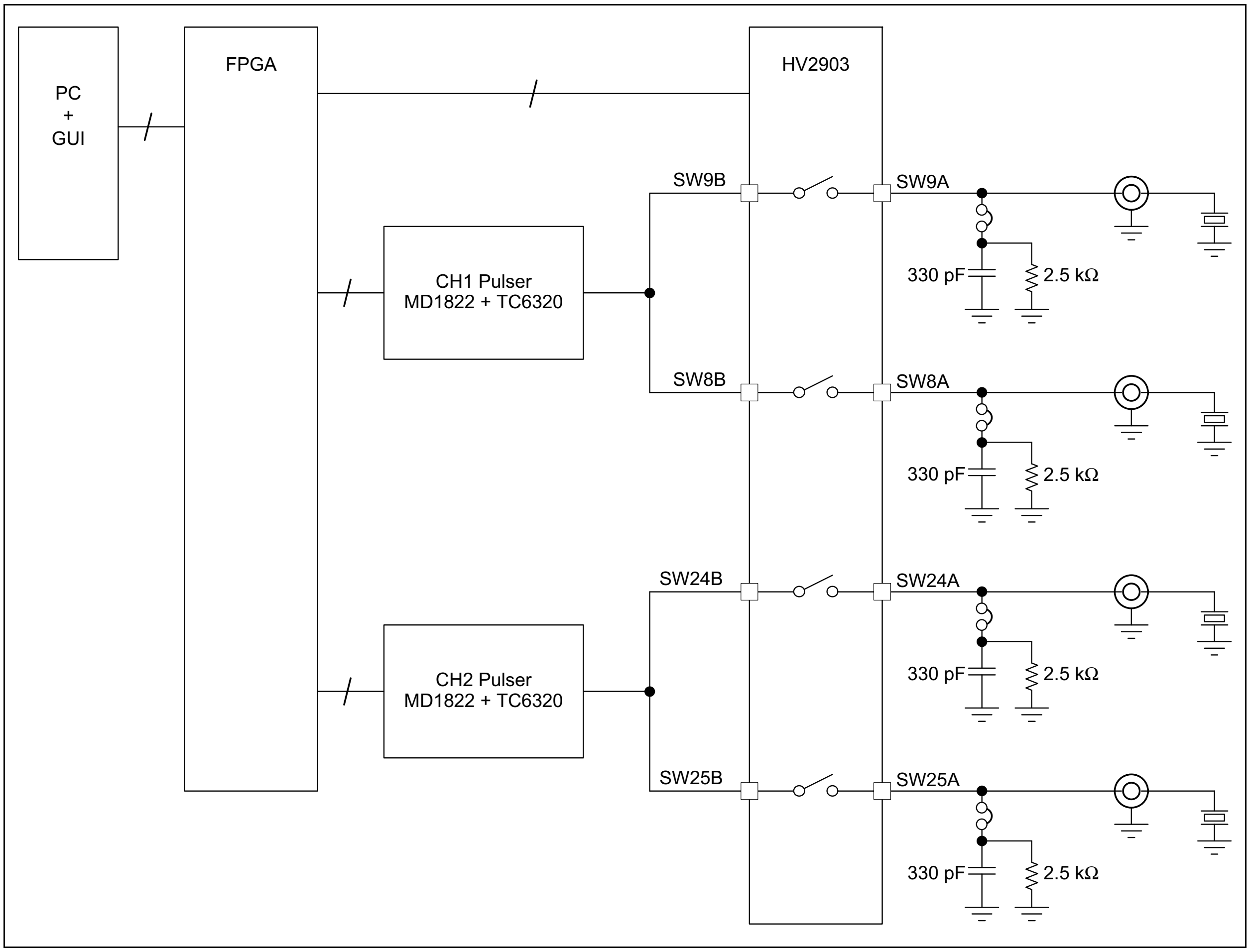
Four switch terminals, consisting of two MUX configurations on the PCB, have SMA connectors to which the user can connect loads. Jumpers close to SMA connectors are for connecting the on-board dummy R-C load (330 pF//2.5 kΩ) optionally to the pulser output.

WARNING
Risk warning of electrical shock. This board uses **multiple hazardous high voltages**. Disconnect all high-voltage supplies before working on it. **Electrical safety precautions** must be taken when working on or using this board.

TABLE 1-1: HV2903 ANALOG SWITCH EVALUATION BOARD TECHNICAL KIT

Parameter	Value
HV2903 Modes of Operation	Individual Switching, Bank Switching and Standby modes
Pulser Frequency	5 MHz
Number of Pulses in the Train	1 to 90
T_{OFF} Time Between Pulse Trains	5 to 30 ms
Pulse Peak Voltage and Current	0 to ±100V and ±3A typical
Interface of FPGA Control Signals and USB PC-GUI Software	J1 and J2 Connect to ADM00825 Controller Interface Board
Pulser R-C Test Load and User's Transducer Interface	Built-in, 330 pF//2.5 kΩ per Channel with Jumper and 50Ω SMA
PCB Board Dimension	115x110 mm (4.5x4.3 in.)

FIGURE 1-1: HV2903 ANALOG SWITCH EVALUATION BOARD SIMPLIFIED BLOCK DIAGRAM



1.5 WHAT DOES THE HV2903 ANALOG SWITCH EVALUATION BOARD KIT INCLUDE?

The HV2903 Analog Switch Evaluation Board includes:

- HV2903 Analog Switch Evaluation Board (ADM00795)
- Important Information Sheet

NOTES:

Chapter 2. Installation and Operation

2.1 GETTING STARTED

The HV2903 Analog Switch Evaluation Board is fully assembled and tested. The board requires six power supply voltage rails of +3.3V, +10V, ±6.0V and ±100V.

2.1.1 Additional Tools Required for Operation

1. An oscilloscope with minimum 500 MHz bandwidth and two high-impedance probes.

WARNING
Make sure that the grounds of the power supply sources are correctly connected to the same ground as the testing oscilloscope ground.

2. A Microchip HV MUX Controller (ADM00825).
3. A Microsoft® Windows® 7 PC that has the HV MUX Controller GUI software installed and running:
   - Connect J1 and J2 to the HV MUX Controller
   - Connect the HV MUX Controller via USB to the Windows 7 PC

2.2 HV MUX GUI INSTALLATION

The HV MUX GUI software installer can be downloaded from the Microchip website at www.mircochip.com. Search for the evaluation board on the website by part number: ADM000795.

1. Open the `HVMUXGUI-v1.0.0-windows-installer.exe`.
2. Initiate the HV MUX GUI software installer by launching the Application Install dialog box.
3. Click **Next** to start the installation.

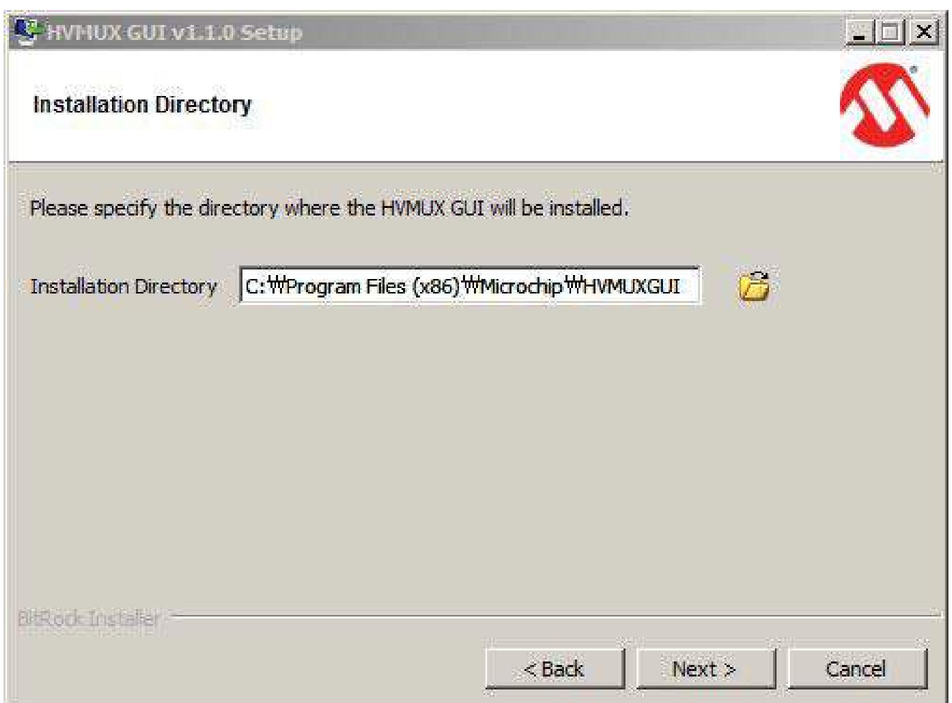
FIGURE 2-1: HV MUX GUI – APPLICATION INSTALL DIALOG BOX

4. Read the License Agreement and accept by checking the box corresponding to “I accept the agreement”, then click **Next** to proceed with the installation.

FIGURE 2-2: HV MUX GUI – LICENSE AGREEMENT DIALOG BOX

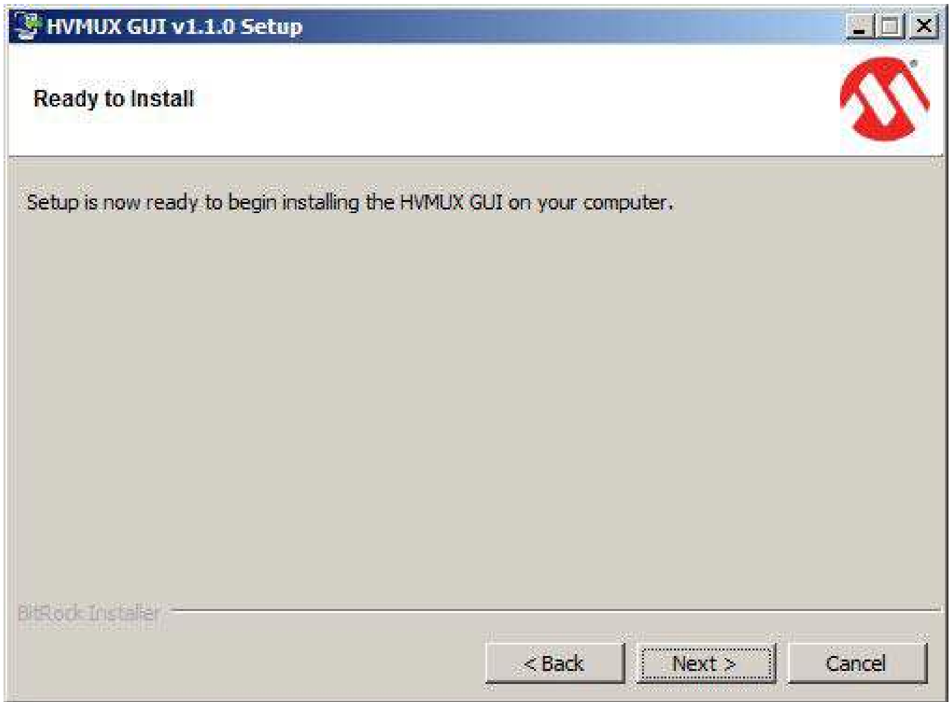
5. On the Installation Directory dialog box, browse for the desired location or click **Next** to install in the default location.

FIGURE 2-3: HV MUX GUI – INSTALLATION DIRECTORY DIALOG BOX



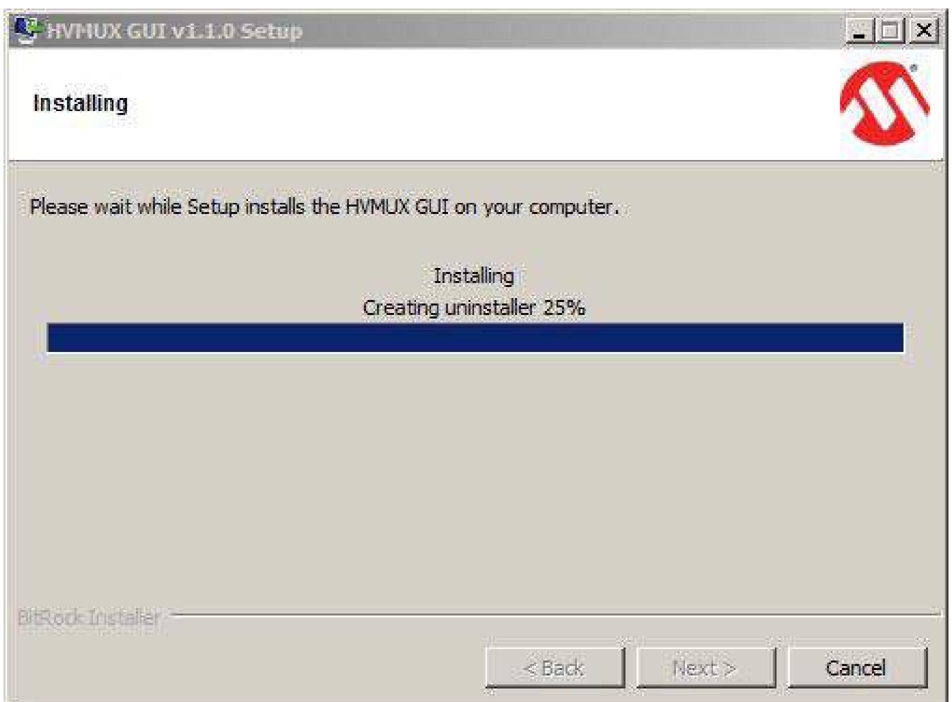
6. Once the installation path is chosen, the software is ready to install. Click **Next.**

FIGURE 2-4: HV MUX GUI – READY TO INSTALL DIALOG BOX



7. The Installation Status window appears, showing the installation progress.
8. After the installation has completed, click **Next** to continue.

FIGURE 2-5: HV MUX GUI – INSTALLATION STATUS DIALOG BOX



9. Once the Installation Complete dialog box appears, click the **Finish** button to exit the installer.

FIGURE 2-6: HV MUX GUI – INSTALLATION COMPLETE DIALOG BOX

2.3 SETUP PROCEDURE

To operate the HV2903 Analog Switch Evaluation Board, the following steps must be completed:

1. Attach to the HV MUX Controller (ADM00825) with connectors J1 and J2.
2. Connect all jumpers on J5, J6, J7 and J11 for the on-board R-C load.
3. Connect all power supplies to the voltage supply input connectors J3 and J4, as indicated in Table 2-1 by observing the polarity.

WARNING
Observe the polarity of each power supply rail and set the voltage and current limit carefully.

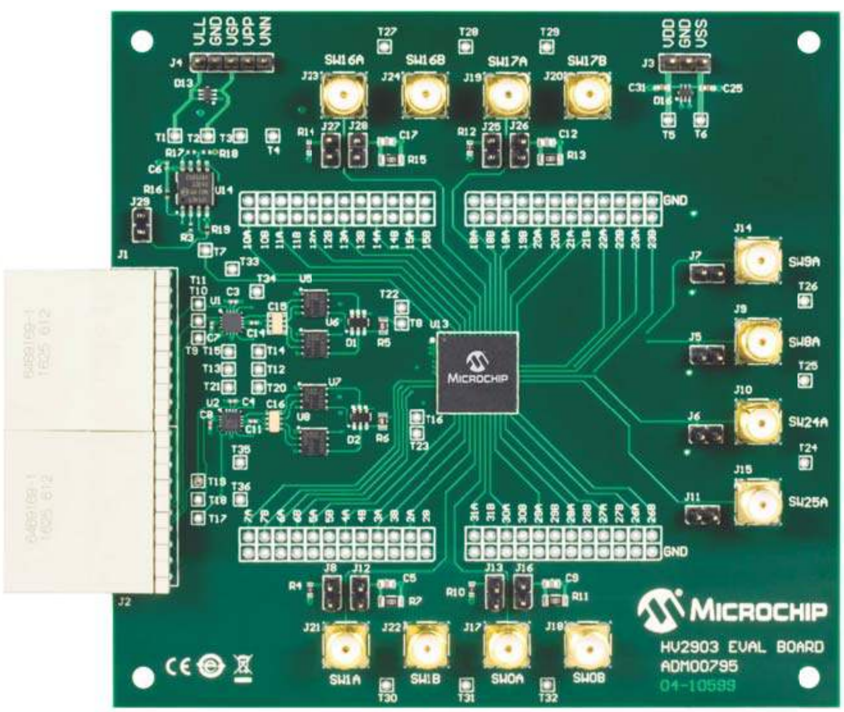
4. Connect a USB cable from the Controller Board to the PC.
5. Connect +12V/1A power to the Controller Board and turn on the board.
6. Turn on the V_{SS} first and then turn on the V_{DD}.
7. Turn on the V_{LL}.
8. Turn on the V_{GP} and V_{PP}/V_{NN}.
9. Run the HV MUX GUI software in the PC.
10. Click the **Initialize HV MUX Controller** button in the GUI; the Status window in the bottom displays an “initialization complete” message.
11. Unselect the $\overline{STBY}$ check box to set HV2903 in normal operation and choose the Switching mode by selecting/unselecting the MODE check box.

12. Click the **Set HV MUX** button. All digital control signals are applied to HV MUX.
13. Set the number of pulses and T_{OFF} time of the pulser.
14. Select CH1 or CH2 to set pulser ch1 or pulser ch2.
15. Click the **Start** button for the selected pulser to start generating pulse trains.
16. Click the **Stop** button for the selected pulser to stop generating pulse trains.

TABLE 2-1: POWER SUPPLY VOLTAGES AND CURRENT-LIMIT SETTINGS

Terminal	Rail Name	Voltage	Average Current Limit
J3-1	V_{DD}	+6V	+20 mA
J3-2	GND	0V	—
J3-3	V_{SS}	-6V	-20 mA
J4-1	V_{LL}	+3.3V	+150 mA
J4-2	GND	0V	—
J4-3	V_{GP}	+5 to +11.5V	+10 mA
J4-4	V_{PP}	+100V	+5 mA
J4-5	V_{NN}	-100V	-5 mA

FIGURE 2-7: HV2903 ANALOG SWITCH EVALUATION BOARD – FRONT VIEW



2.3.1 Recommended Power-up and Power-Down Sequences

Table 2-2 shows the recommended power-up and power-down sequences of the HV2903 Analog Switch Evaluation Board.

TABLE 2-2: HV2903 ANALOG SWITCH EVALUATION BOARD POWER-UP AND POWER-DOWN SEQUENCES

Step	Power-up Description	Step	Power-Down Description
1	V_{SS} on	1	V_{PP} and V_{NN} off
2	V_{DD} on	2	V_{GP} off
3	V_{LL} on with logic signal low	3	V_{LL} off with logic signal low
4	V_{GP} on	4	V_{DD} off
5	V_{PP} and V_{NN} on	5	V_{SS} off

WARNING

Powering the HV2903 Evaluation Board up/down in an arbitrary sequence may cause damage to the device.

2.4 INTERFACE CONNECTIONS

TABLE 2-3: J2 CONTROL INTERFACE SIGNALS[1]

Pin #	Name	Test Point	I/O Type	Signal Discretion
J2-A2	SCK	—	LVCMOS-2.5V Input	EEPROM Serial Clock Input
J2-B2	CSB	—	LVCMOS-2.5V Input	EEPROM Chip Select Input
J2-A3	MISO	—	LVCMOS-2.5V Output	EEPROM Serial Data Output
J2-B3	MOSI	—	LVCMOS-2.5V Input	EEPROM Serial Data Input
J2-A5	CLR	TP15	LVCMOS-3.3V Input	HV2903 Latch Clear Logic Input
J2-B5	CLK	TP14	LVCMOS-3.3V Input	HV2903 Clock Logic Input
J2-C5	$\overline{\text{LE}}$/EN	TP12	LVCMOS-3.3V Input	HV2903 Latch Enable Logic Input
J2-D5	MODE	TP13	LVCMOS-3.3V Input	HV2903 Mode Logic Input
J2-A6	DIN/A$\overline{\text{B}}$	TP20	LVCMOS-3.3V Input	HV2903 Data In Logic Input
J2-B6	$\overline{\text{STBY}}$	TP21	LVCMOS-3.3V Input	HV2903 Standby Logic Input, Low Active
J2-C6	1_A	TP11	LVCMOS-3.3V Input	Ch1 Pulser Input for NMOS to V_{NN}
J2-D6	1_B	TP10	LVCMOS-3.3V Input	Ch1 Pulser Input for PMOS to V_{PP}
J2-A7	1_DMP	TP9	LVCMOS-3.3V Input	Ch1 Pulser Damp Input for PMOS/NMOS to GND
J2-B7	2_A	TP19	LVCMOS-3.3V Input	Ch2 Pulser Input for NMOS to V_{NN}
J2-C7	2_B	TP18	LVCMOS-3.3V Input	Ch2 Pulser Input for PMOS to V_{PP}
J2-D7	2_DMP	TP17	LVCMOS-3.3V Input	Ch2 Pulser Damp Input for PMOS/NMOS to GND

Note 1: All pins that are not included in this table are “no connect”.

2.5 TESTING THE HV2903 ANALOG SWITCH EVALUATION BOARD

2.5.1 HV2903 Individual Switching Mode Operation ($\overline{\text{STBY}}$ = 1, MODE = 1)

In the Individual Switching mode, the user can turn on/off 32 switches individually through the USB connected PC GUI software program:

1. Click the **Initialize HV MUX Controller** button at the top left corner.
2. Unselect $\overline{\text{STBY}}$ to set HV2903 in normal operation.
3. Select MODE to set HV2903 in Individual Switching mode.
4. Put 32-bit data in DIN to set switches on and off. Data '1' means the switch is on and data '0' means the switch is off.
5. Click the **Set HV MUX** button.
6. Then, the GUI and controller board generate 32-bit data and 32 clocks, followed by one $\overline{\text{LE}}$ negative pulse, and switches are on and off according to DIN in the GUI.
7. If the user selects CLR and then clicks the **Set HV MUX** button, all the switches are off.

2.5.2 HV2903 Bank Switching Mode Operation ($\overline{\text{STBY}}$ = 1, MODE = 0)

In the Bank Switching mode, the user can turn on/off all the even switches (SW0, SW2,..., SW30) together and all the odd switches (SW1, SW3,..., SW31) through the USB connected PC GUI software program:

1. Click the **Initialize HV MUX Controller** button at the top left corner.
2. Unselect $\overline{\text{STBY}}$ to set HV MUX in normal operation.
3. Unselect MODE to set HV2903 in Bank Switching mode.
4. Select EN to set HV2903 Bank Switching to active. If EN is not selected, all the switches are set to off.
5. Select A/$\overline{\text{B}}$ to set all the even switches on and all the odd switches off.
6. Or, unselect A/$\overline{\text{B}}$ to set all the even switches off and all the odd switches on.
7. Click the **Set HV MUX** button.
8. The GUI and the HV MUX Controller generate digital control signals according to the control data of the GUI that the user sets.

Note:	The typical voltage and waveforms are provided in **Appendix C. "Demo Board Waveforms"**.

2.6 HV MUX CONTROLLER AND GUI MANUAL

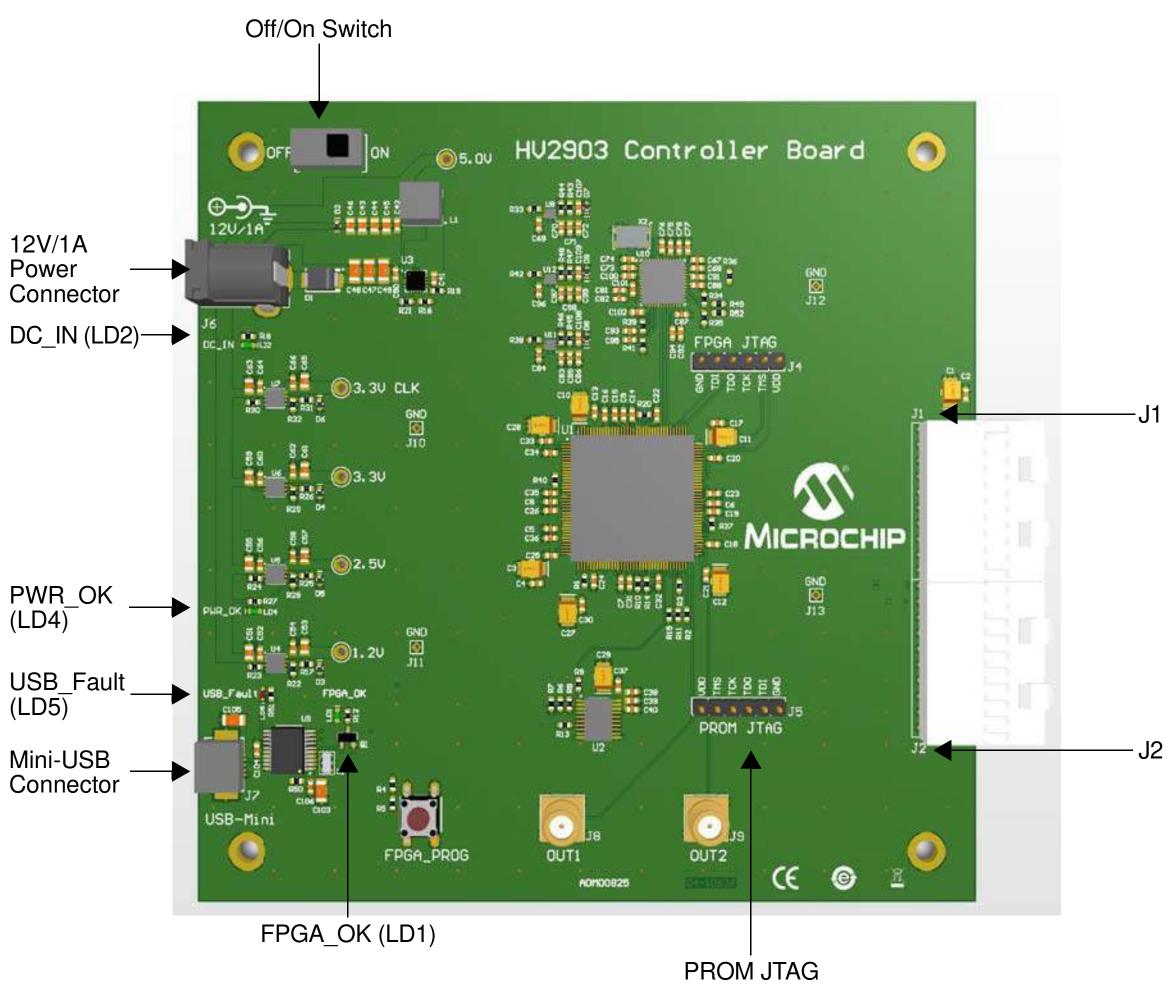
The HV MUX Controller generates control signals for the HV2903 Analog Switch Evaluation Board; it features a Spartan-6 XC6SLX9 FPGA.

2.6.1 Setup Procedure

1. Before powering up the HV2903 Analog Switch Evaluation Board and the HV MUX Controller, make sure that the latest GUI software is installed on the PC.
2. Start the GUI program; the “Not Connected” message is displayed on the bottom left of the status bar.
3. Connect the appropriate power supply and turn on the power switch to power up the HV MUX Controller. The FPGA_OK (LD1) and DC_IN (LD2) on the HV MUX Controller light up green. A “Connected” message is displayed on the bottom left of the status bar of the GUI.

The HV MUX Controller is now ready to control the HV2903 Evaluation Board.

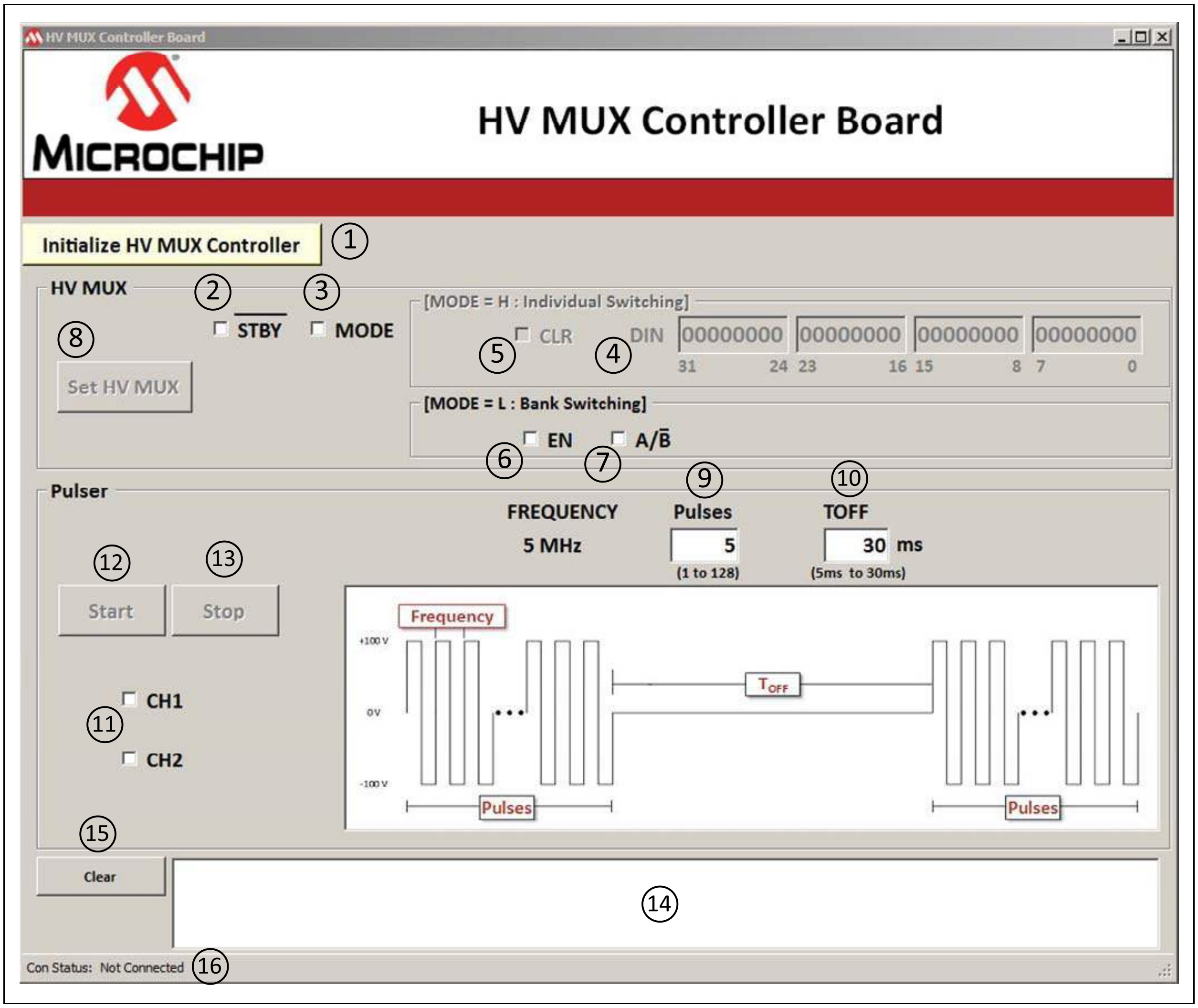
FIGURE 2-8: HV MUX CONTROLLER (ADM00825) – FRONT VIEW



2.6.2 HV2903 Analog Switch Evaluation Board GUI Description

Figure 2-9 displays a screen capture of the GUI. Every item indicated by circled numbers is explained below the figure. The selection of the check box, binary data in the DIN entry box, and number in Pulses and T_{OFF} entry box are just settings. They do not change the operation of the HV2903 device and built-in pulsers immediately. By clicking **Set HV MUX**, **Start** and **Stop** buttons, the control data set by the user in the GUI changes operation of HV2903 and turns on/off the built-in pulsers in the HV2903 Analog Switch Evaluation Board. See the explanation for each corresponding item.

FIGURE 2-9: HV MUX CONTROLLER BOARD GUI SCREEN CAPTURE



1. **Initialize HV MUX Controller:** When clicked, the GUI starts the initialization of FPGA on the HV MUX Controller, and the communication between the GUI and the HV MUX Controller. If there is no error, the "Initialization Complete" text is displayed in the Message window.
2. **$\overline{STBY}$:** When checked, the $\overline{STBY}$ logic input is set to low and HV2903 is set to operate in Standby mode to decrease power consumption. When unchecked, the $\overline{STBY}$ logic input is set to high and HV2903 is set to operate in Normal mode.
3. **MODE:** When checked, the MODE logic input is set to high and HV2903 is set to operate in Individual Switching mode. When unchecked, the MODE logic input is set to low and HV2903 is set to operate in Bank Switching mode.

4. **DIN:** 32-bit data entry boxes. Each bit in the boxes is related to each analog switch. If data entry is '1', the associated switch is set to on. If data entry is '0', the associated switch is set to off.
5. **CLR:** When checked, the CLR logic input is set to high and all the switches of HV2903 are set to off. When unchecked, the CLR logic input is set to low and the 32 switches of HV2903 are set to ON/OFF states, according to the DIN data entry.
6. **EN:** When checked, the EN logic input is set to high and HV2903 is set to active for Bank Switching mode. When unchecked, the EN logic input is set to low and all the switches are set to off.
7. **A/$\overline{\text{B}}$:** When checked, the A/$\overline{\text{B}}$ logic input is set to high, all the even switches are set to on and all the odd switches are set to off. When unchecked, the A/$\overline{\text{B}}$ logic input is set to low, all the even switches are set to off and all the odd switches are set to on.
8. **Set HV MUX:** When clicked, the data that the user sets at Steps 2 through 7 is applied to HV2903. Note that the 32-bit DIN data, 32 clocks and one negative $\overline{\text{LE}}$ pulse are applied one time only at the Individual Switching mode.
9. **Pulses:** Entry box to define the number of pulses in the pulse train generated by the selected pulser. A pulse is a half of the cycle and the pulse train always starts on the positive pulse first.
10. **TOFF:** Entry box to define the off time between pulse trains generated by the selected pulser.
11. **CH1/CH2:** When checked, the selected pulser is set to generate 5 MHz pulse trains defined at Steps 9 and 10 by the user.
12. **Start:** When clicked, the selected pulser starts generating the pulse train.
13. **Stop:** When clicked, the selected pulser stops generating the pulse train.
14. **Message window:** Shows information from the GUI program.
15. **Clear:** When clicked, the messages in the Message window are cleared.
16. **Connection Status window:** Displays the status of the connection between the GUI and the HV MUX Controller.

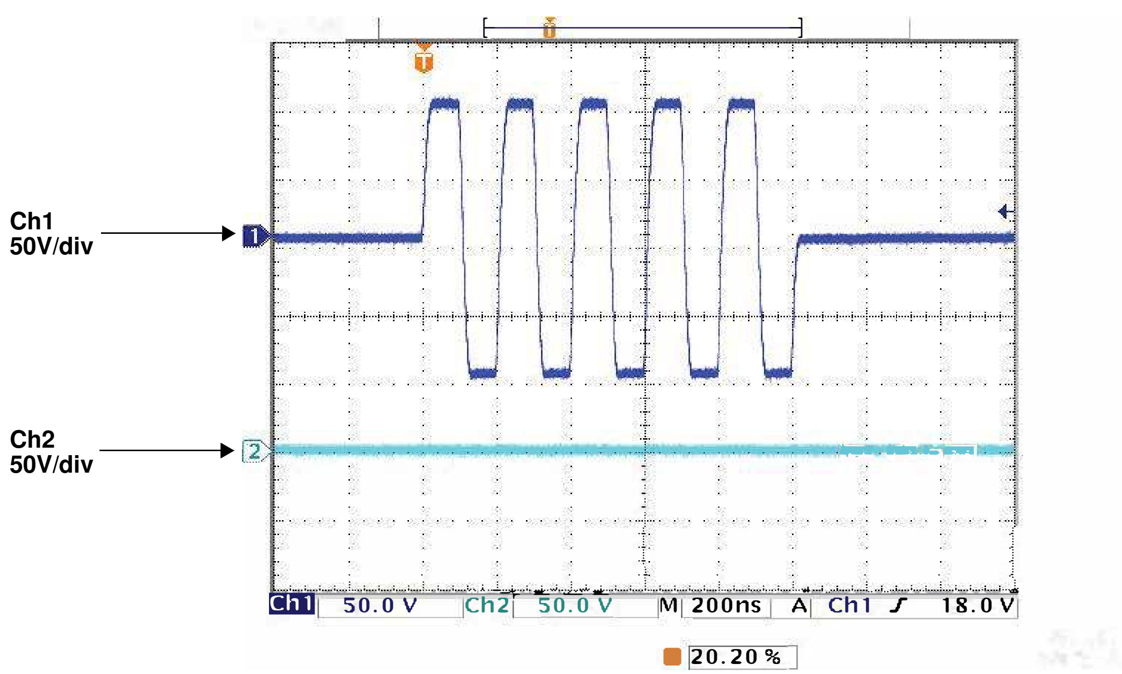
2.7 GENERATION OF PULSER OUTPUT AT SW8A OF HV MUX

This section provides the step-by-step procedure to make the Ch1 pulser output at the SW8A SMA connector by configuring the GUI.

1. Before powering up the HV2903 Analog Switch Evaluation Board, make sure that the latest GUI software is installed on the PC.
2. Start the GUI program. On the bottom left of the status bar, the "Not Connected" message is displayed.
3. Power up the HV MUX Controller and the HV2903 Analog Switch Evaluation Board as described in **Section 2.6.1 "Setup Procedure"**. The prompt, "Connected", is now displayed in the status bar.
4. Click the **Initialize HV MUX Controller** button and check the Message window to see "Initialization Complete".
5. Uncheck $\overline{\text{STBY}}$ to set the HV2903 to operate normally.
6. Check MODE to set the HV2903 to Individual Switching mode.
7. Change the DIN to Bit 8 from '`0`' to '`1`' to set SW8 ON (DIN = `00000000 00000000 00000001 00000000`).
8. Click the **Set HV MUX** button to turn on the HV2903 SW8.
9. Change Pulses to 10.
10. Check CH1.
11. Click the **Start** button. The CH1 pulser starts to generate pulse trains with 10 pulses and a 30 ms T_{OFF} time.

The Ch1 and Ch2 of the oscilloscope in Figure 2-10 display the SW8A and the SW9A waveforms.

FIGURE 2-10: TYPICAL WAVEFORM OF 2:1 MUX CONNECTED TO PULSER



Chapter 3. PCB Design and Layout Notes

3.1 PCB LAYOUT TECHNIQUES FOR HV2903

The HV2903 Evaluation Board is equipped with a HV2903 device, which has 32 analog switches and is able to pass high-voltage, high-current and high-frequency pulses. The PCB design and layout of the board are important to ensure the success of the implementation.

3.1.1 High-Voltage and High-Speed Grounding, and Layout Techniques

The center balls at the bottom of the HV2903 TFBGA package are internally connected to the IC's substrate (V_{SUB}). These balls should be connected to GND, externally on the PCB.

The designer must pay attention to the connecting traces, since the analog switches pass the high-voltage and high-speed signals. In particular, controlled impedance of 50Ω to the ground plane and more trace spacing needs to be applied in this situation.

High-speed PCB trace design practices are used for the HV2903 Analog Switch Evaluation Board PCB layout. The internal circuitry of the HV2903 can operate at a high frequency, with the primary speed limitation being the load capacitance. Because of this high speed and the high transient currents that result from driving capacitive loads, the supply voltage bypass capacitors should be as close to the pins as possible.

All the GND pins should have low-inductance feedthrough via connections that are connected directly to a solid ground plane at the second layer of the PCB.

It is advisable to minimize the trace length to the ground plane, and to insert a ferrite bead in the power supply lead to the capacitor, in order to prevent resonance in the power supply lines.

Pay particular attention to minimizing trace lengths and using sufficient trace width to reduce inductance. Surface mount components are highly recommended.

The use of a solid ground plane, and good power and signal layout practices will prevent any possible parasitic capacitance coupling. The user should also ensure that the circulating ground return current from a capacitive load cannot react with common inductance to create noise voltages in the input logic circuitry.

3.1.2 Decoupling Capacitors Selection

The V_{LL}, V_{DD} and V_{SS} supply voltage rails can provide fast transient current. Therefore, they should have a low-impedance bypass capacitor at each of the chip's pins. Use a surface mount ceramic capacitor of 1.0 to 2.2 µF capacitance with an appropriate voltage rating.

The user needs to pay additional attention to what type of ceramic capacitor is selected for these bypass capacitors. The low impedance means low-ESR/ESL impedance within the frequency bandwidth range of ultrasound pulses transmitted, including the very fast dV/dt of the pulse's rising and falling edges. A capacitor with low-temperature coefficient and low-voltage coefficient is also recommended. The type of X7R and X5R, or other more advanced multilayer ceramic types, should be selected for these purposes.

NOTES:

Appendix A. Schematic and Layouts

A.1 INTRODUCTION

This appendix contains the following schematics and layouts for the HV2903 Analog Switch Evaluation Board (ADM00795) and the HV MUX Controller Board (ADM00825).

- HV2903 Analog Switch Evaluation Board (ADM00795):
  - ADM00795 – Schematic
  - ADM00795 – Top Silk
  - ADM00795 – Top Copper and Silk
  - ADM00795 – Top Copper
  - ADM00795 – Inner 1
  - ADM00795 – Inner 2
  - ADM00795 – Inner 3
  - ADM00795 – Bottom Copper
  - ADM00795 – Bottom Copper and Silk
  - ADM00795 – Bottom Silk
- HV MUX Controller Board (ADM00825):
  - ADM00825 – Schematic (Connection)
  - ADM00825 – Schematic (Power Supply)
  - ADM00825 – Schematic (USB to SPI)
  - ADM00825 – Schematic (Programmable Clock)
  - ADM00825 – Schematic (FPGA)
  - ADM00825 – Schematic (FPGA Decoupling Capacitors)
  - ADM00825 – Schematic (Connectors)
  - ADM00825 – Top Silk
  - ADM00825 – Top Copper and Silk
  - ADM00825 – Top Copper
  - ADM00825 – Inner 1
  - ADM00825 – Inner 2
  - ADM00825 – Inner 3
  - ADM00825 – Inner 4
  - ADM00825 – Bottom Copper
  - ADM00825 – Bottom Copper and Silk
  - ADM00825 – Bottom Silk

FIGURE A-1: ADM00795 – SCHEMATIC

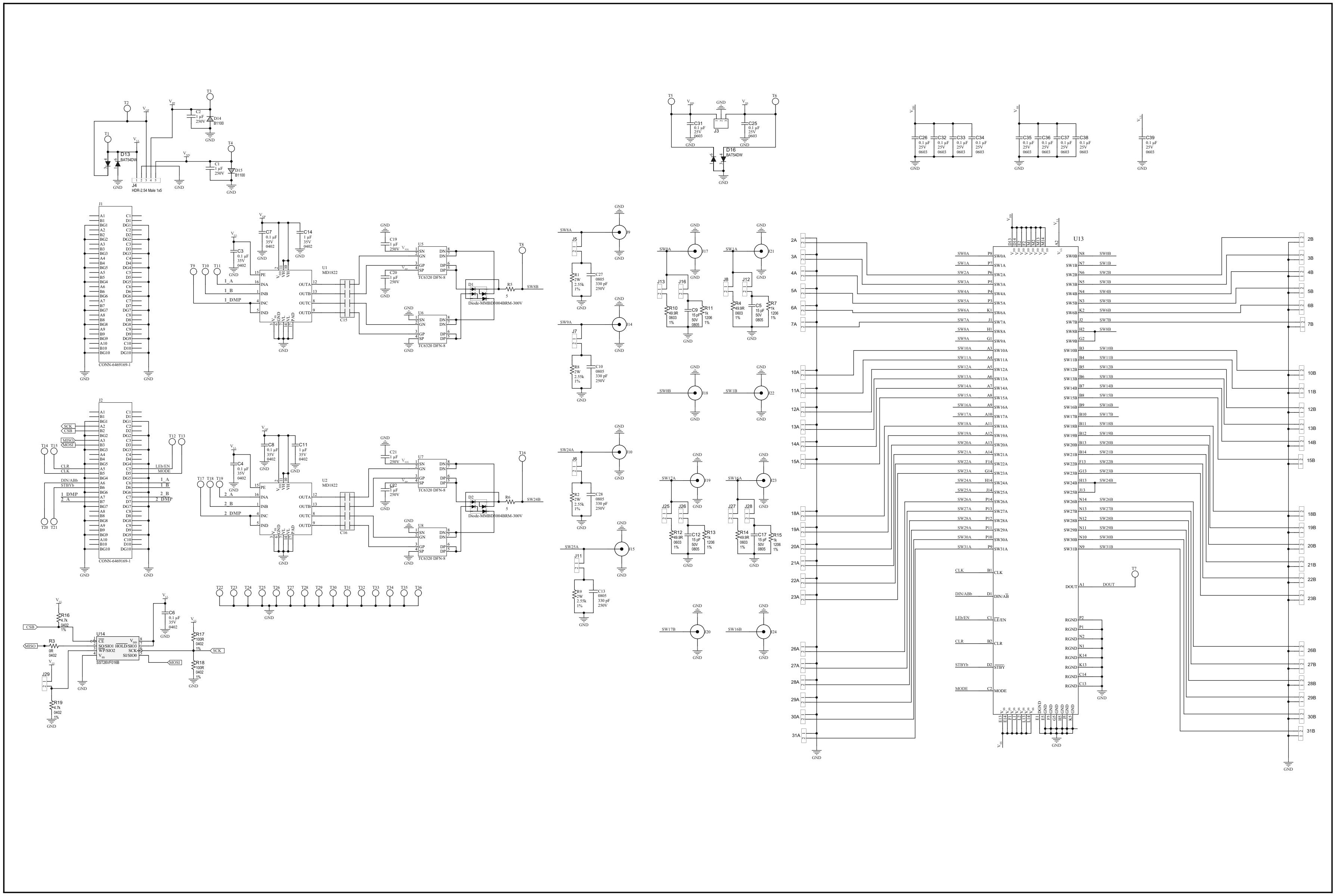


FIGURE A-2: ADM00795 – TOP SILK

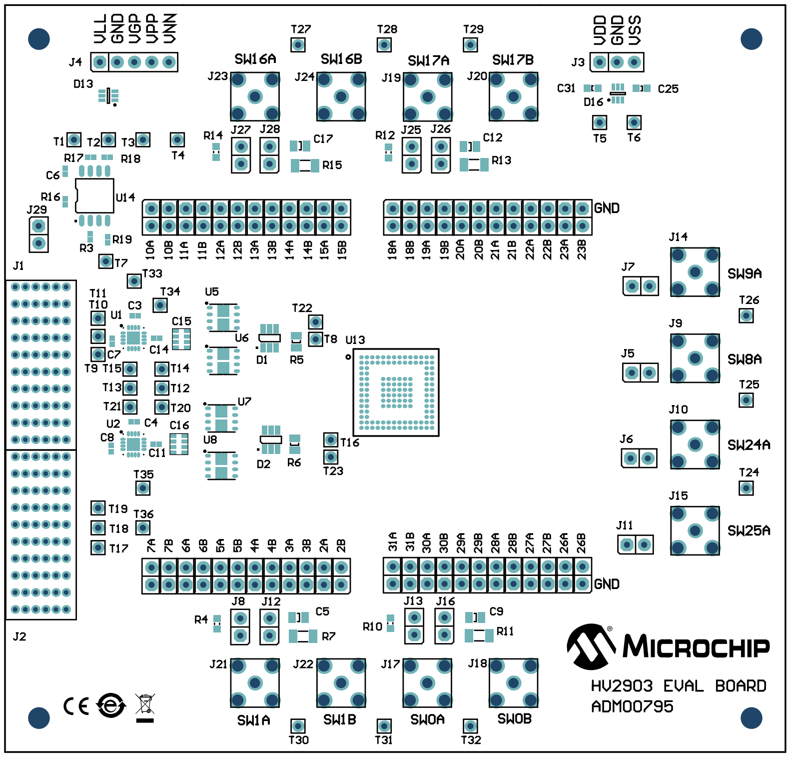


FIGURE A-3: ADM00795 – TOP COPPER AND SILK

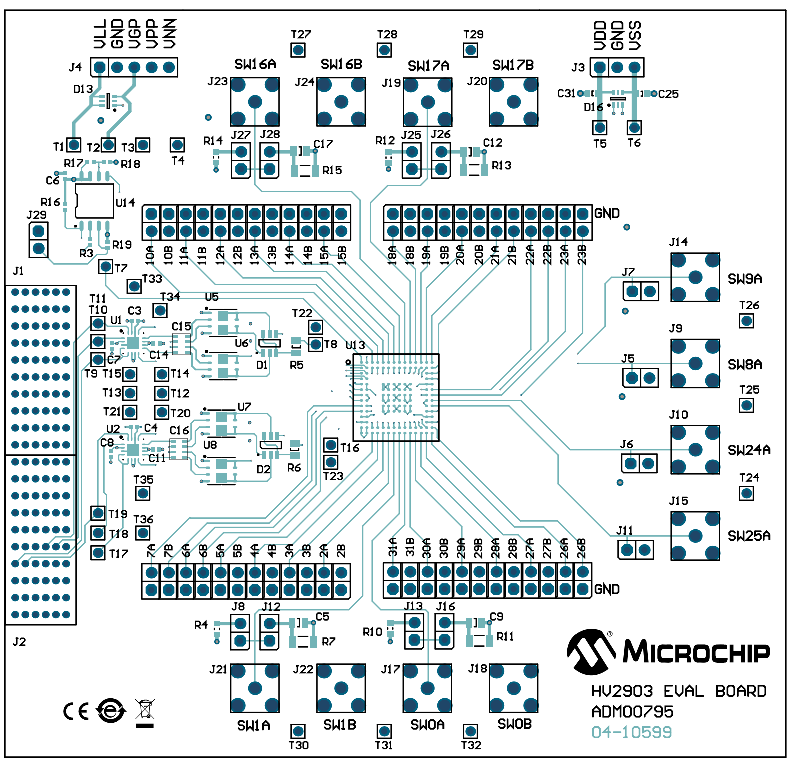


FIGURE A-4: ADM00795 – TOP COPPER

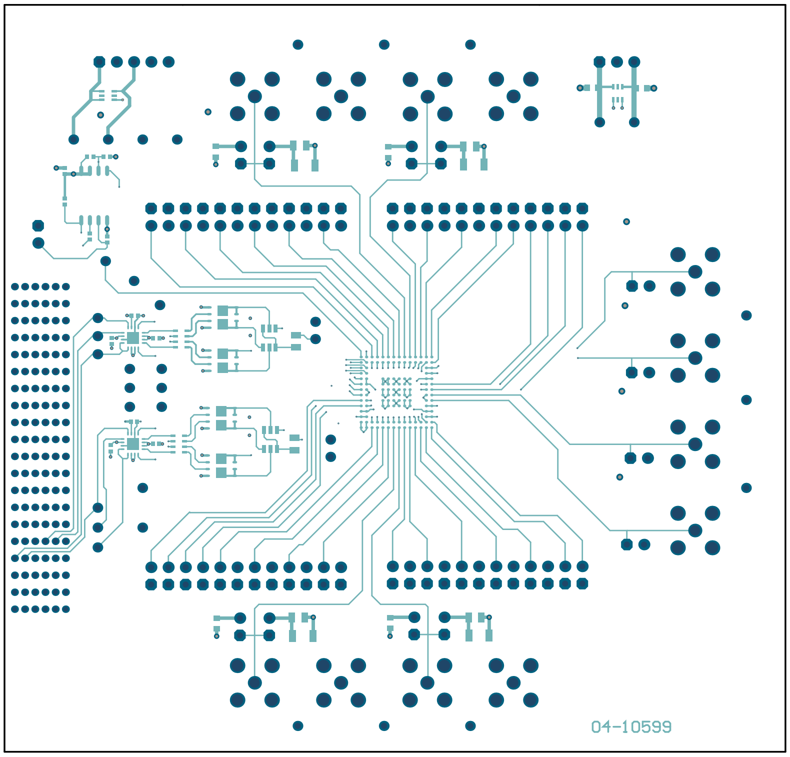


FIGURE A-5: ADM00795 – INNER 1

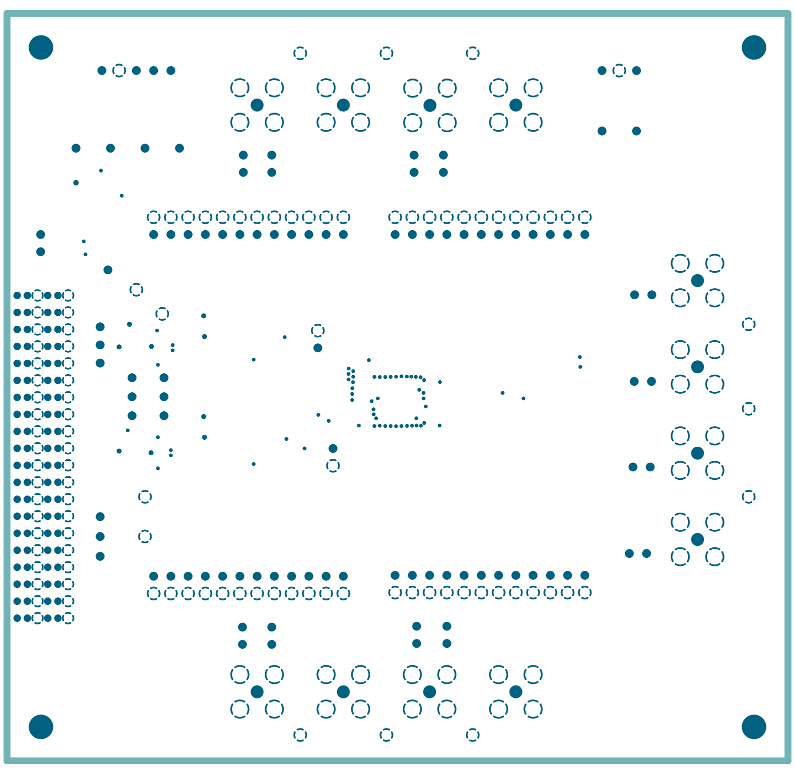


FIGURE A-6: ADM00795 – INNER 2

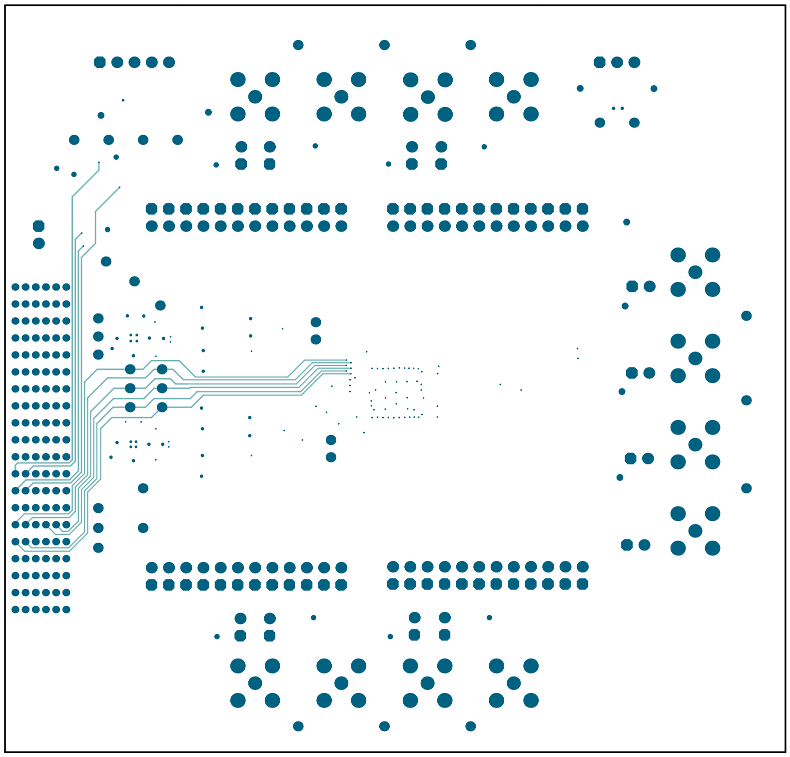


FIGURE A-7: ADM00795 – INNER 3

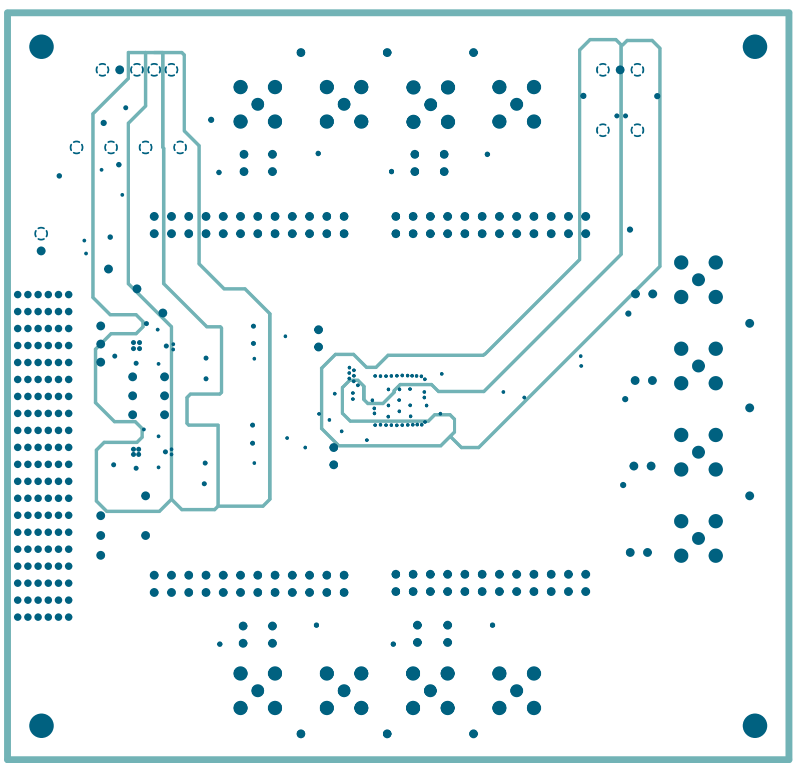


FIGURE A-8: ADM00795 – BOTTOM COPPER

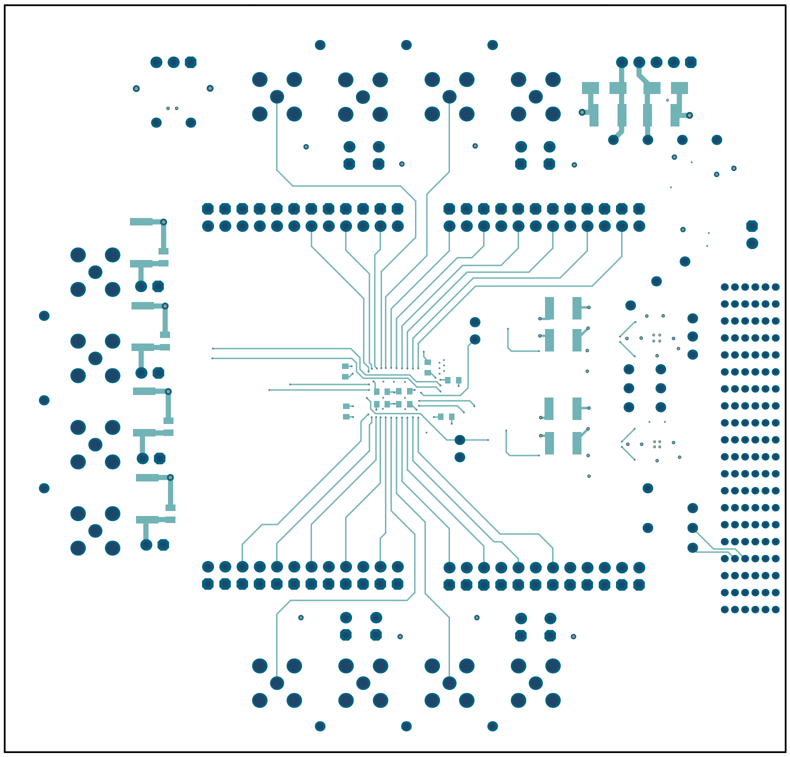


FIGURE A-9: ADM00795 – BOTTOM COPPER AND SILK

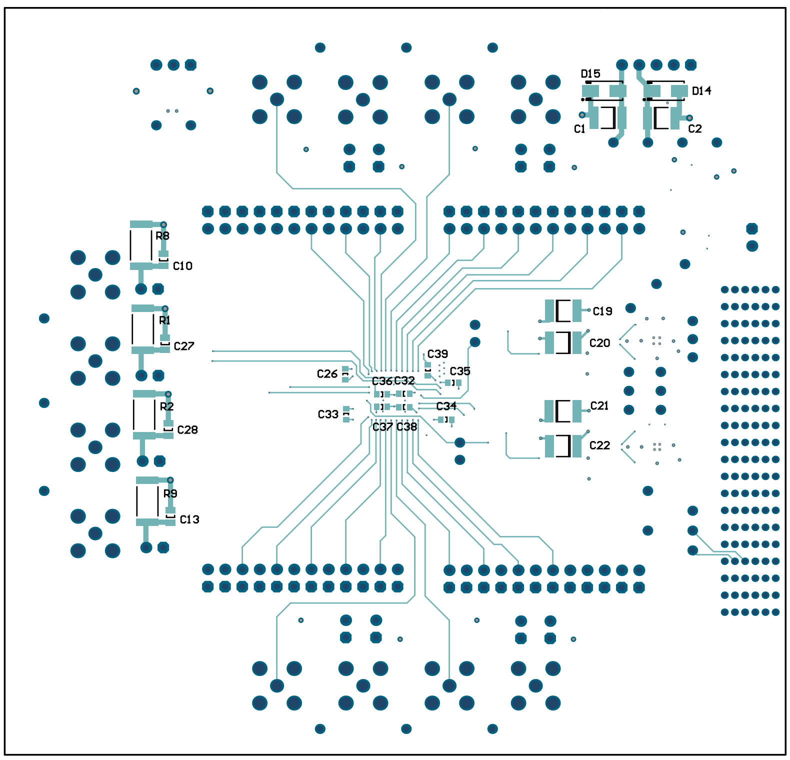


FIGURE A-10: ADM00795 – BOTTOM SILK

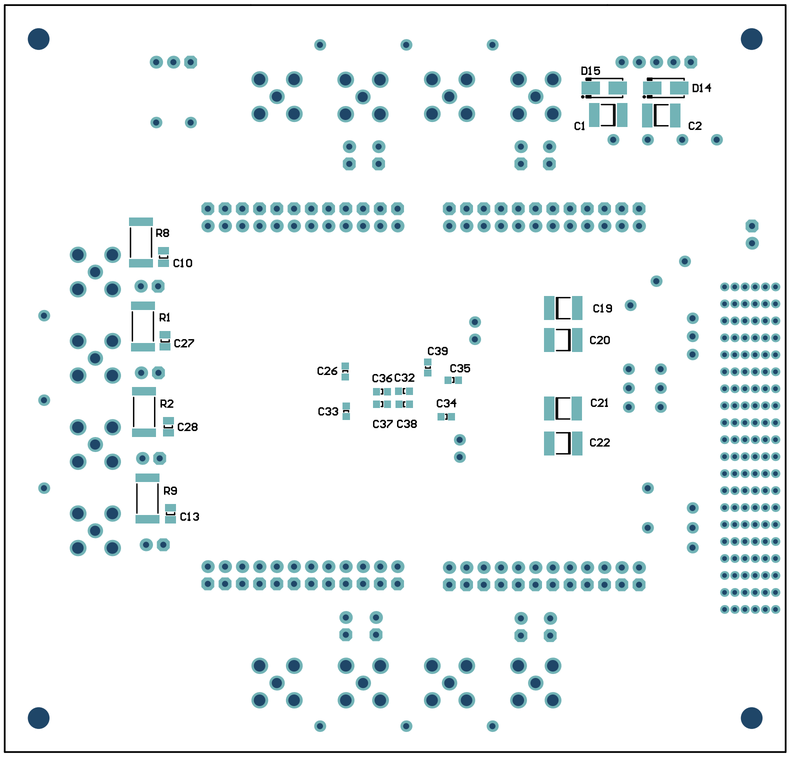


FIGURE A-11: ADM00825 – SCHEMATIC (CONNECTION)

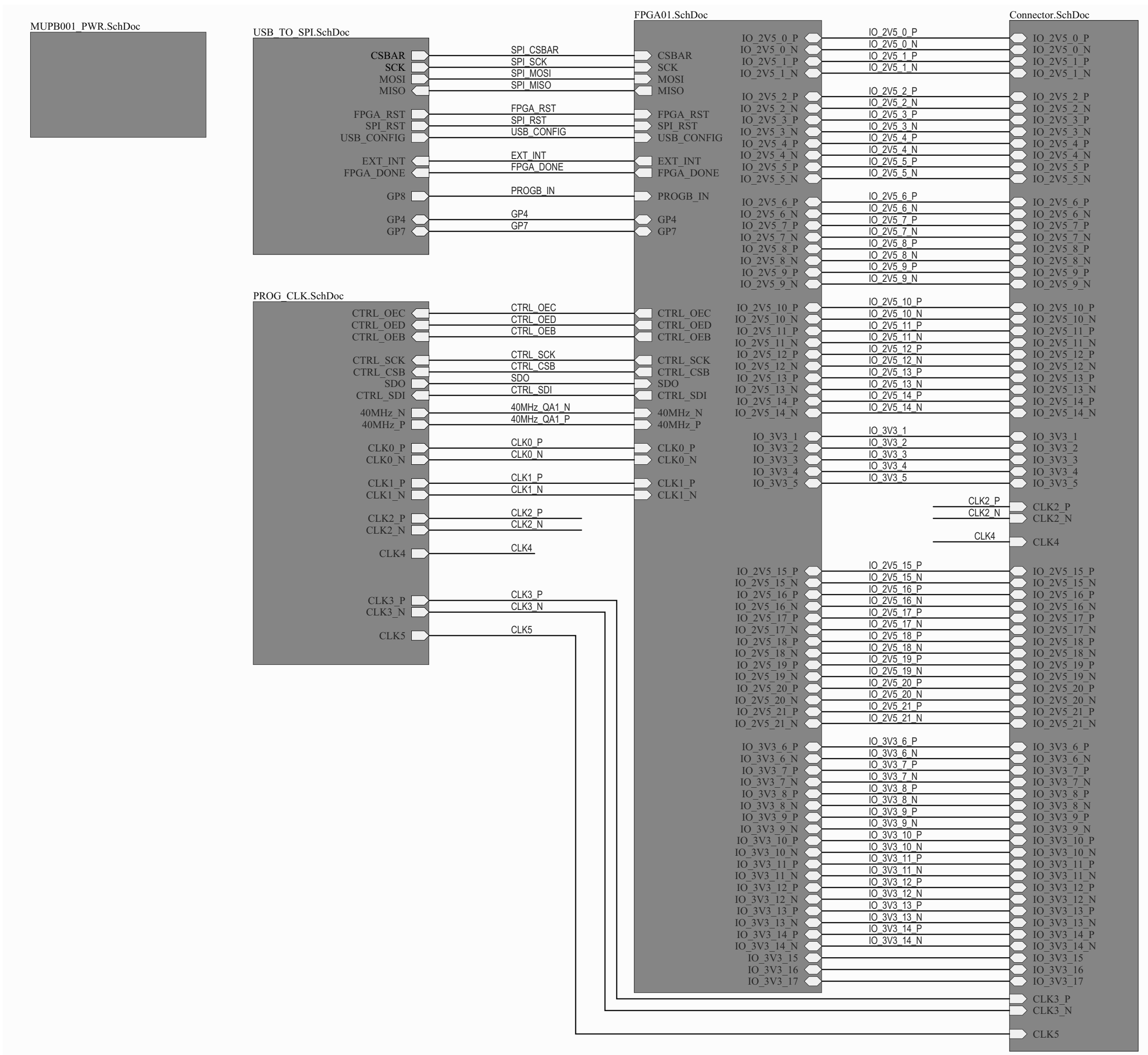


FIGURE A-12: ADM00825 – SCHEMATIC (POWER SUPPLY)

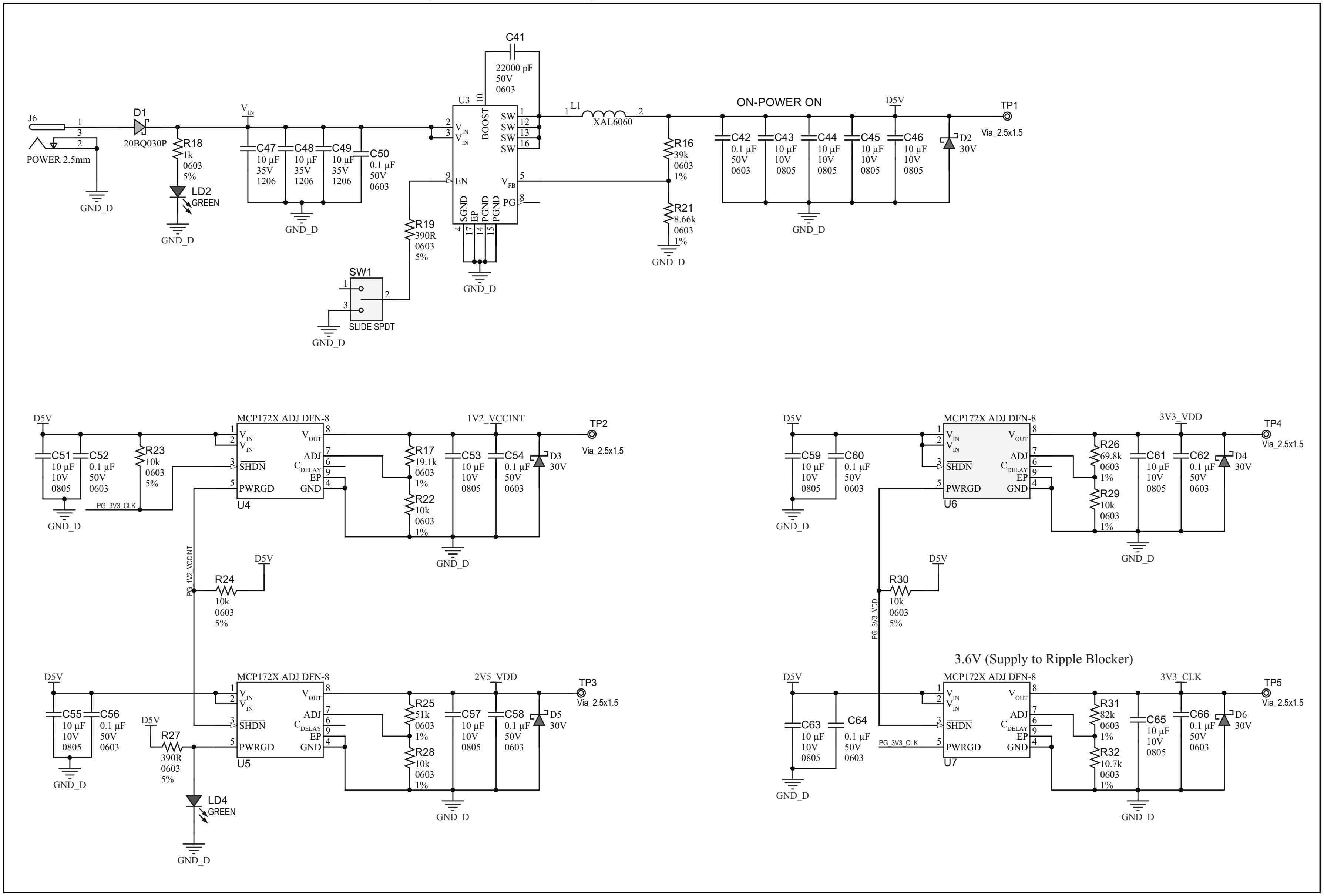


FIGURE A-13: ADM00825 – SCHEMATIC (USB TO SPI)

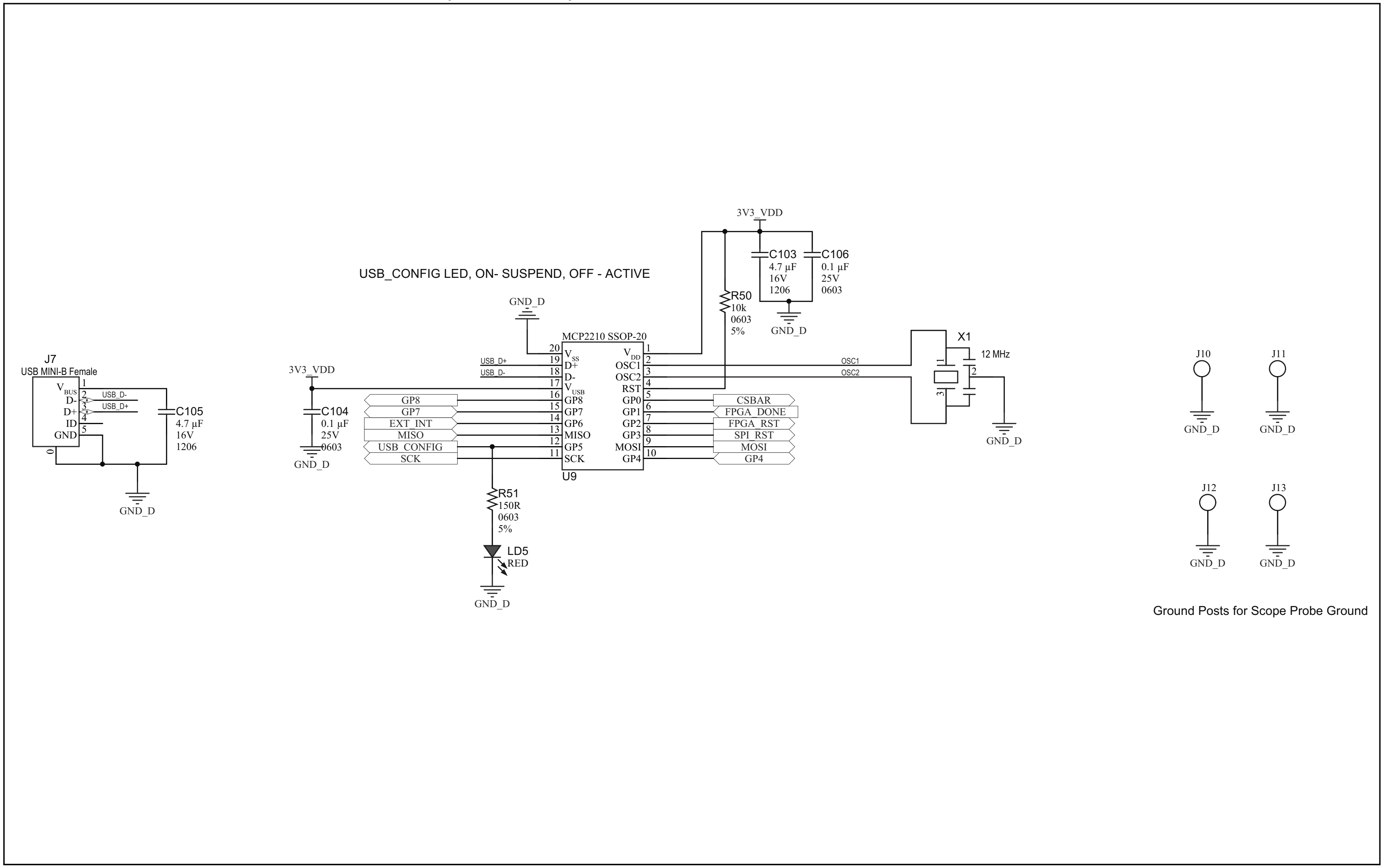


FIGURE A-14: ADM00825 – SCHEMATIC (PROGRAMMABLE CLOCK)

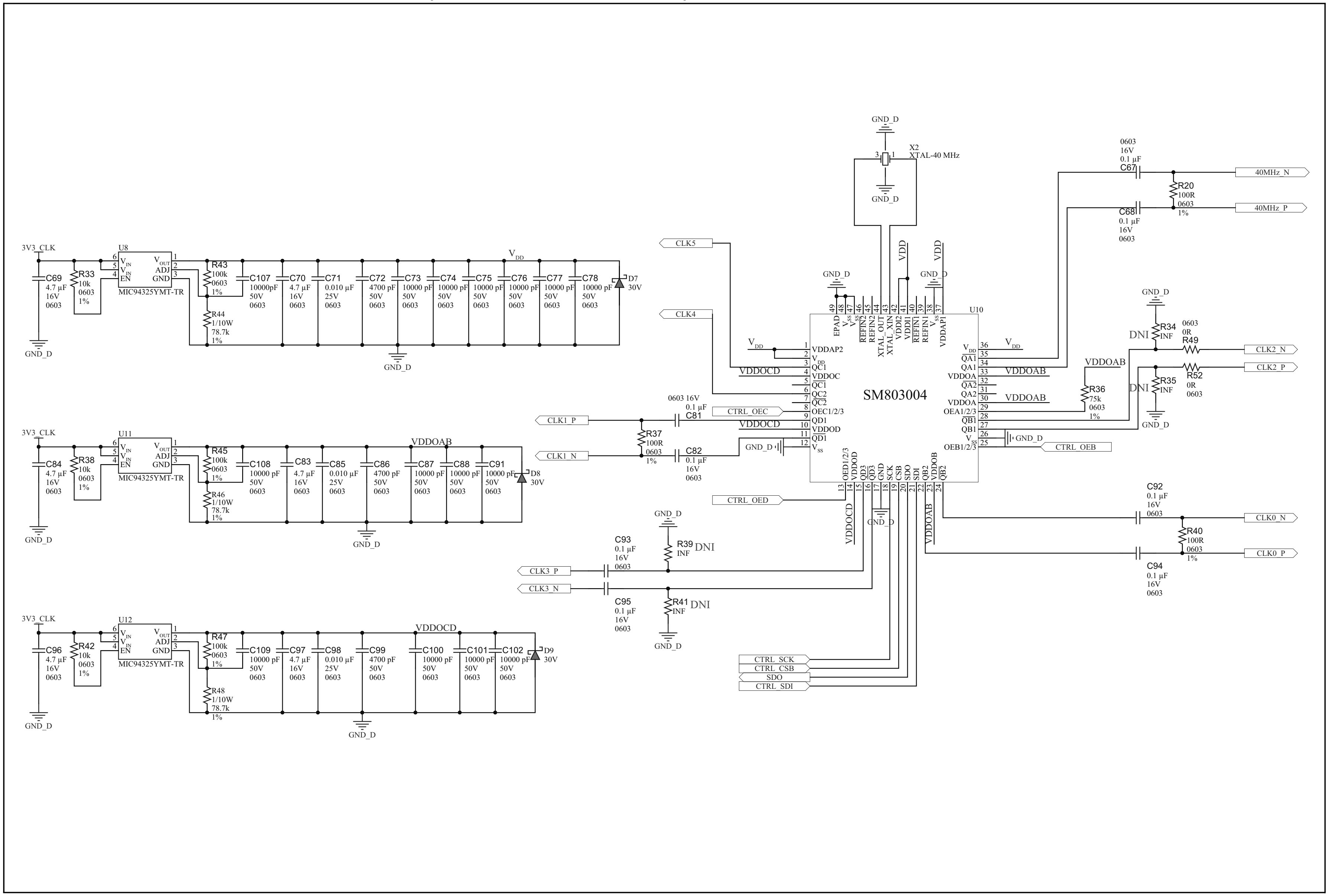


FIGURE A-15: ADM00825 – SCHEMATIC (FPGA)

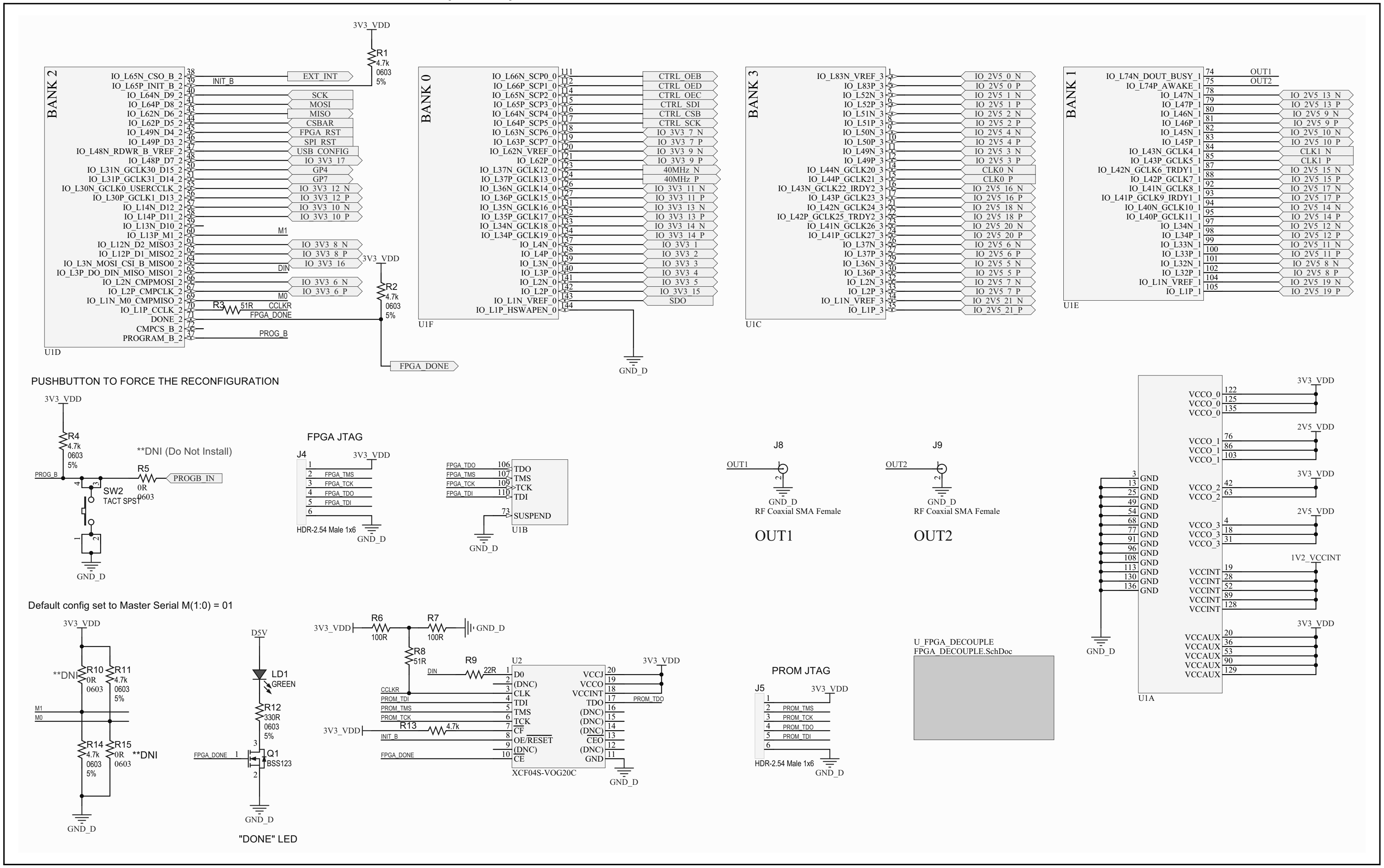


FIGURE A-16: ADM00825 – SCHEMATIC (FPGA DECOUPLING CAPACITORS)

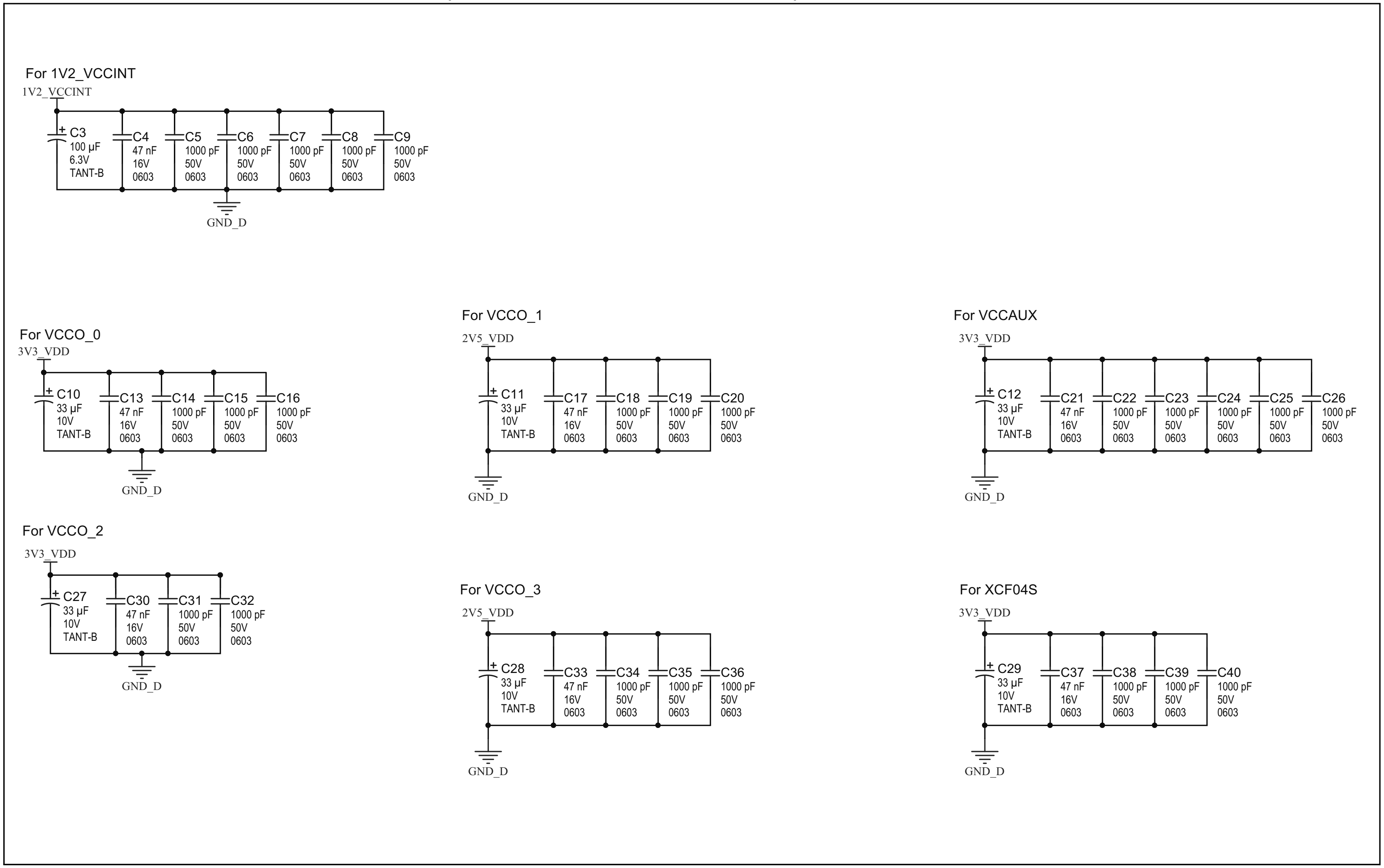


FIGURE A-17: ADM00825 – SCHEMATIC (CONNECTORS)

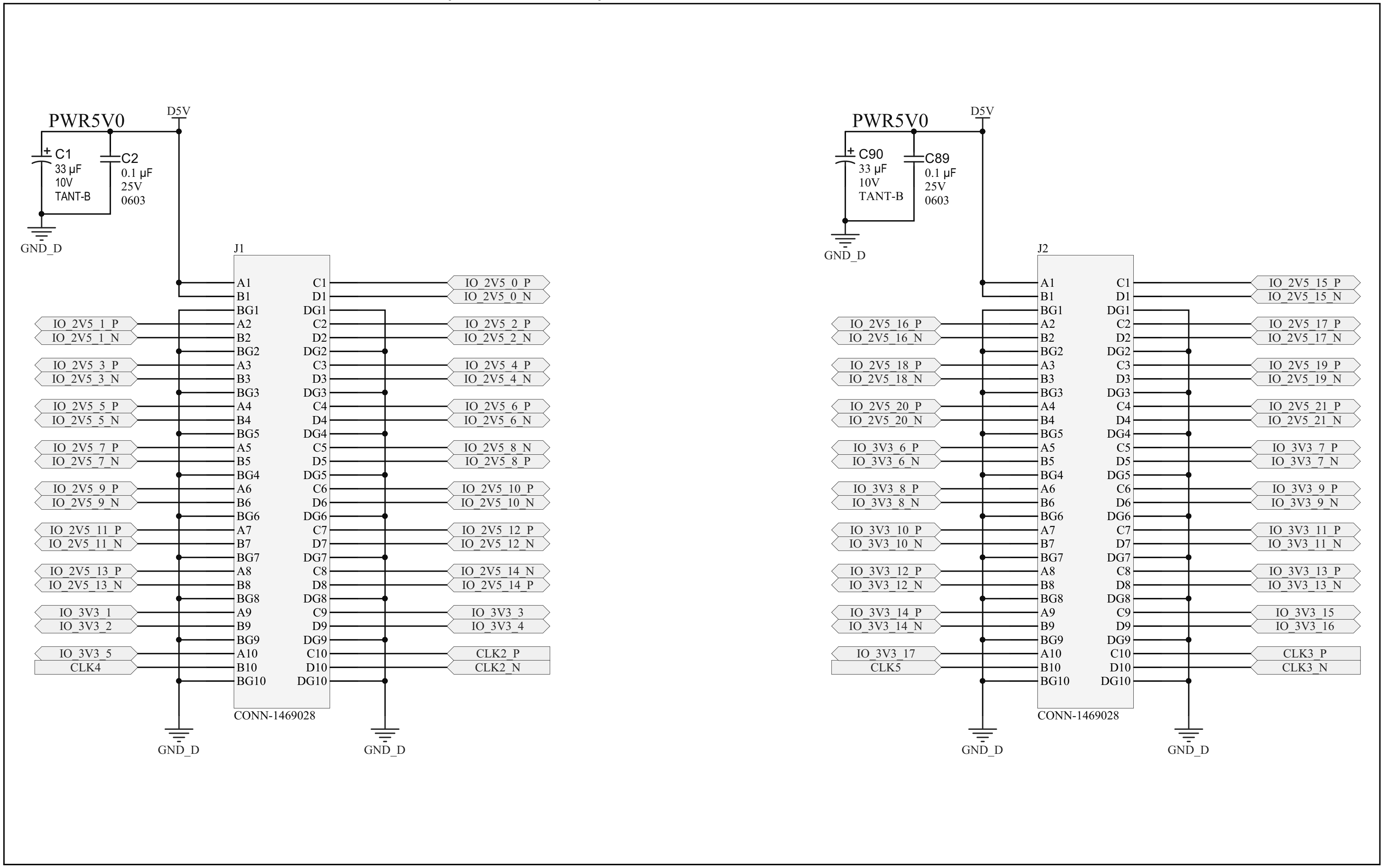


FIGURE A-18: ADM00825 – TOP SILK

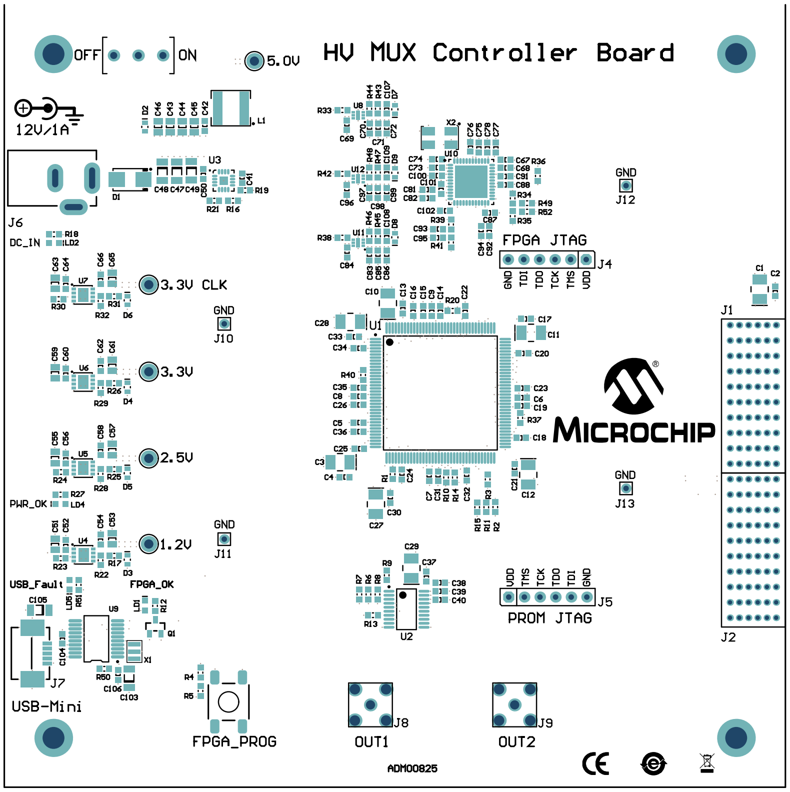


FIGURE A-19: ADM00825 – TOP COPPER AND SILK

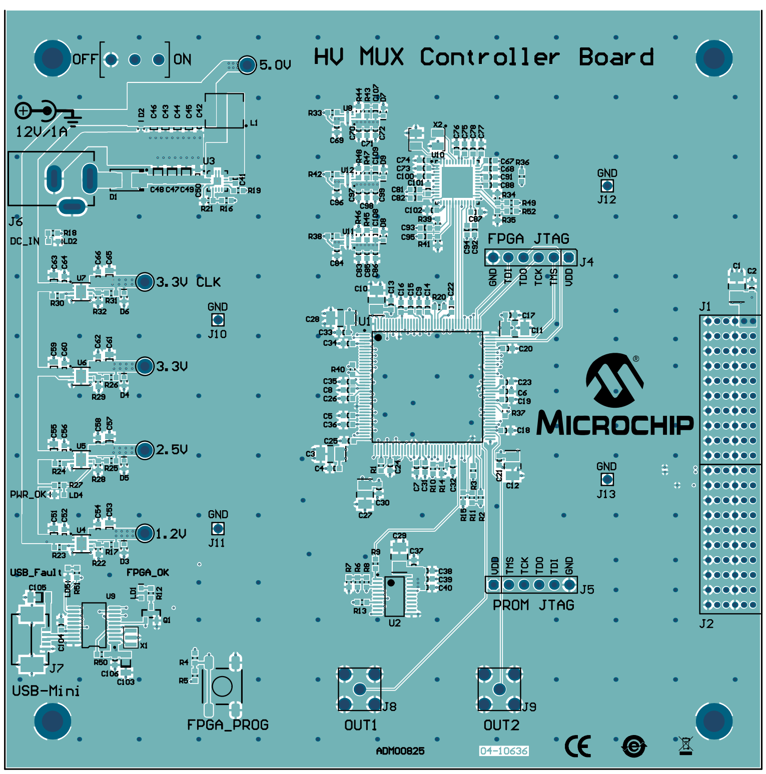


FIGURE A-20: ADM00825 – TOP COPPER

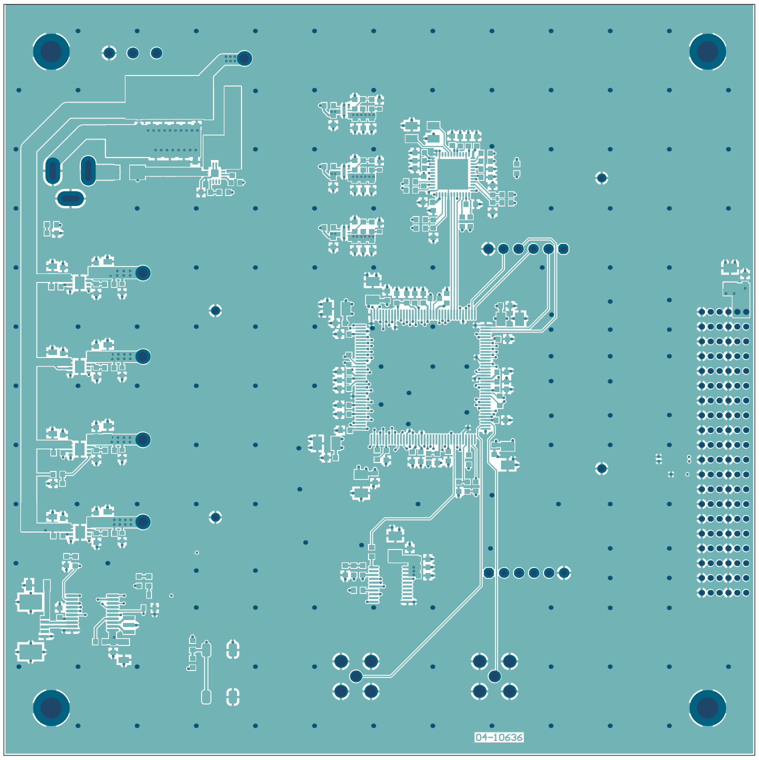


FIGURE A-21: ADM00825 – INNER 1

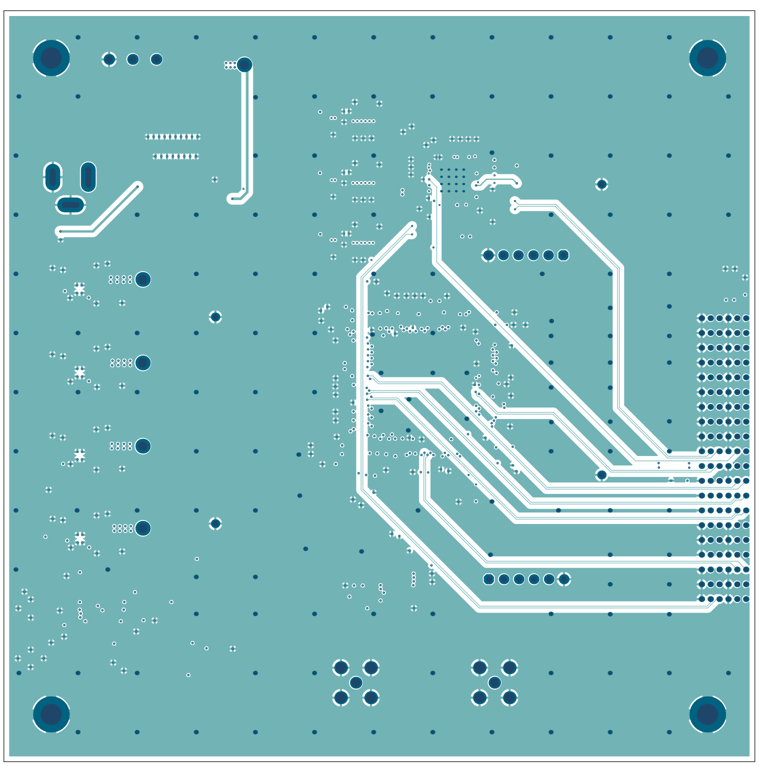


FIGURE A-22: ADM00825 – INNER 2

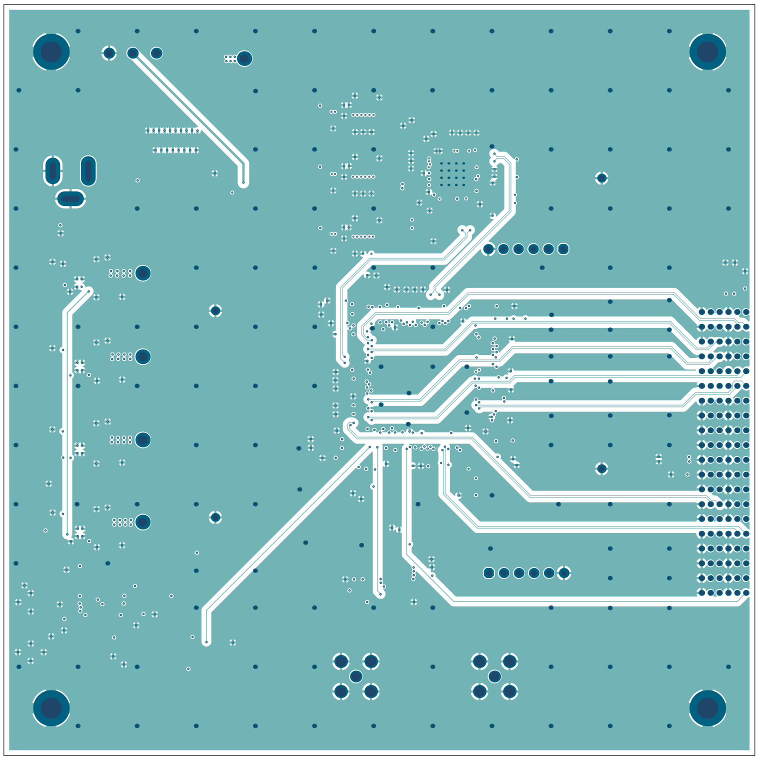


FIGURE A-23: ADM00825 – INNER 3

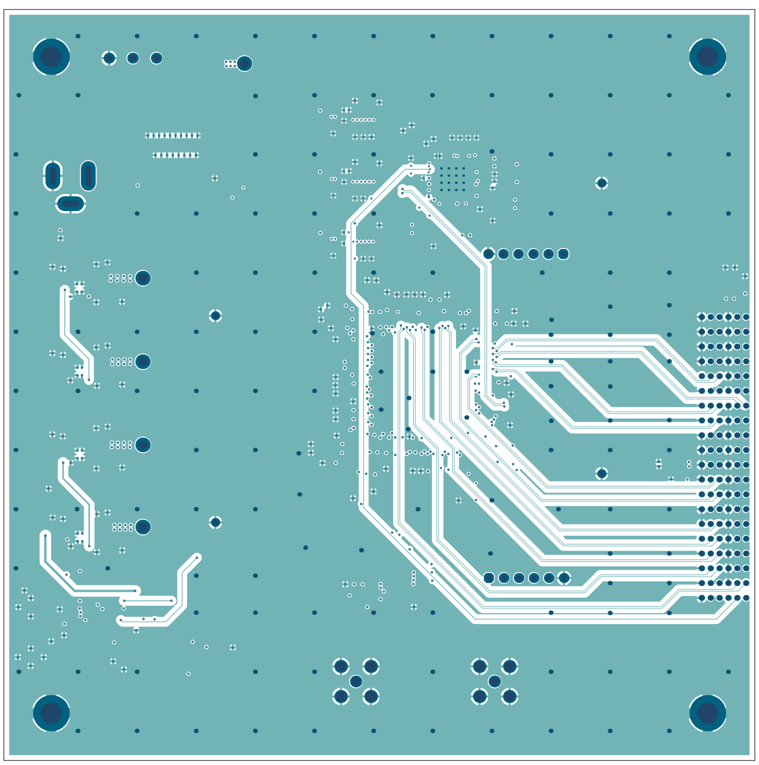


FIGURE A-24: ADM00825 – INNER 4

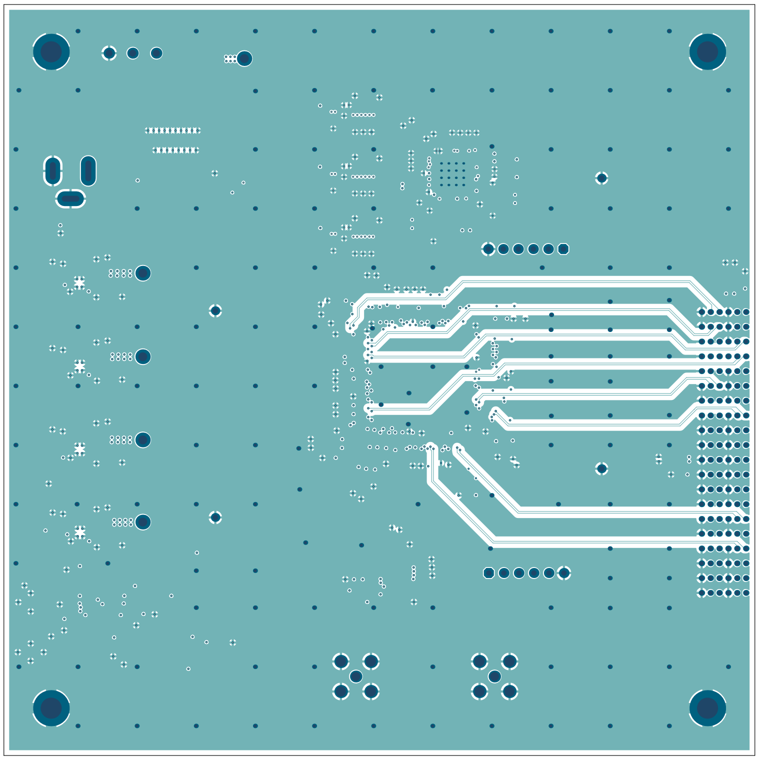


FIGURE A-25: ADM00825 – BOTTOM COPPER

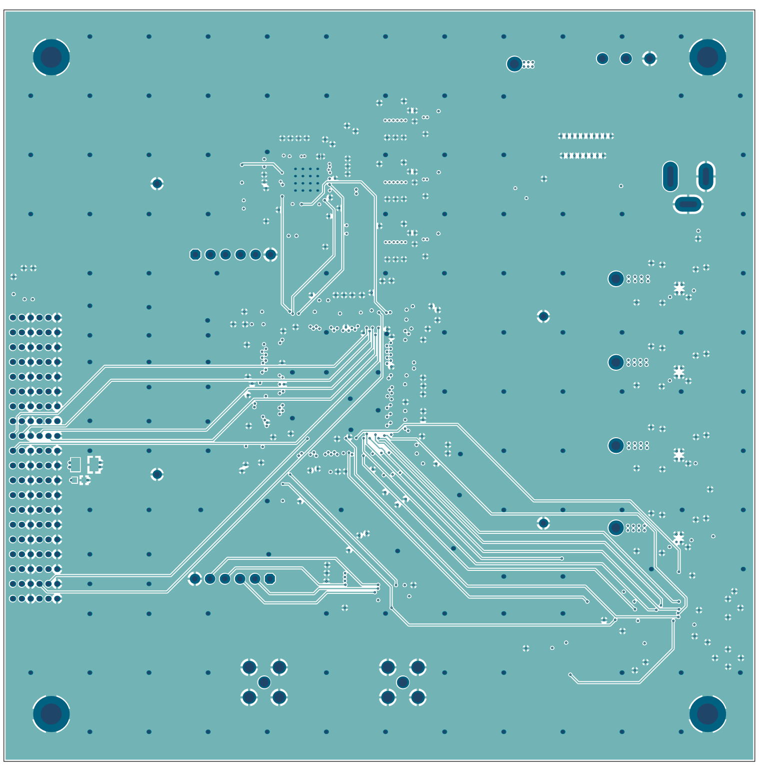


FIGURE A-26: ADM00825 – BOTTOM COPPER AND SILK

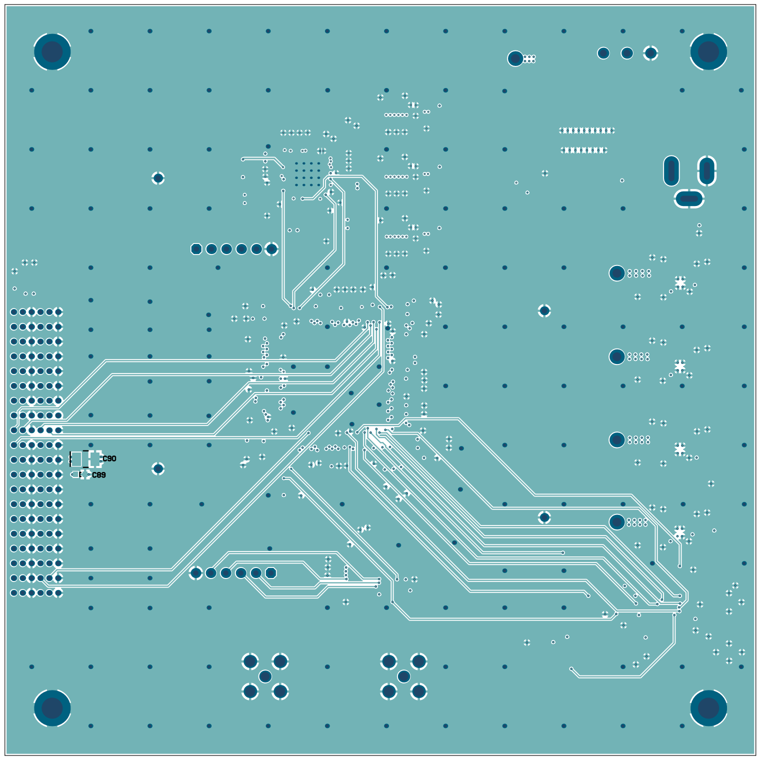
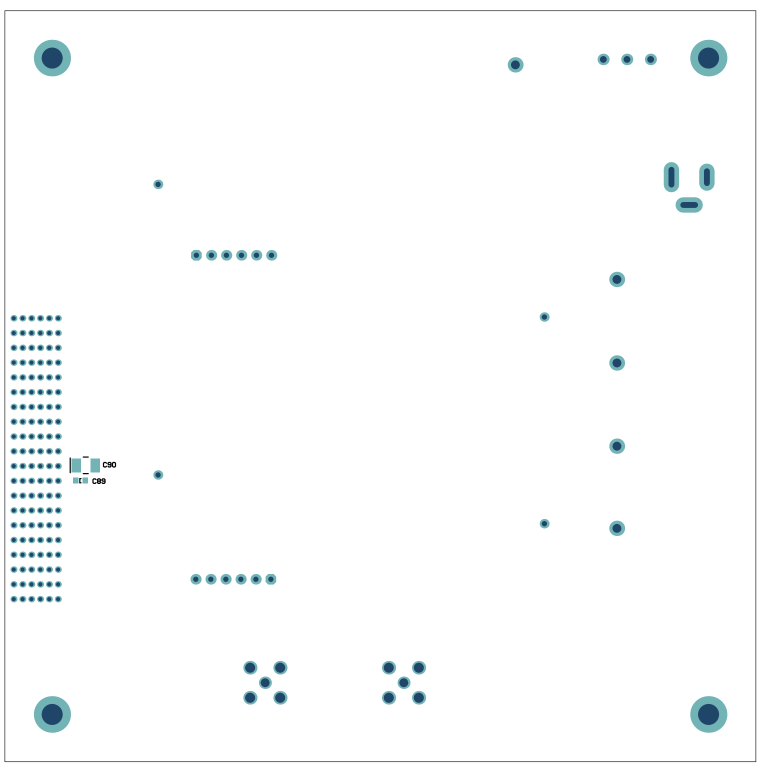


FIGURE A-27: ADM00825 – BOTTOM SILK



NOTES:

Appendix B. Bill of Materials

B.1 HV2903 ANALOG SWITCH EVALUATION BOARD

TABLE B-1: BILL OF MATERIALS (BOM)(1)

Qty.	Reference	Description	Manufacturer	Part Number
6	C1, C2, C19, C20, C21, C22	Capacitor	TDK Corporation	C4532X7T2E105M250KA
4	C10, C13, C27, C28	Capacitor	Murata Manufacturing Co., Ltd.	GCM21A7U2E331JX01D
2	C15, C16	Capacitor, Array, 10 nF	AVX Corporation	W3A41C103MAT2A
11	C25, C26, C31, C32, C33, C34, C35, C36, C37, C38, C39	Capacitor	Cal-Chip Electronics Inc.	GMC10Y5V104Z25NTLF
7	C3, C4, C6, C7, C8, C11, C14	Capacitor	TDK Corporation	CGA2B3X7R1V104K050BB
4	C5, C9, C12, C17	Capacitor	Panasonic® - ECG	ECU-V1H150JCN
2	D1, D2	MMBD3004BRM-300V	Diodes Incorporated®	MMBD3004BRM-7-F
2	D13, D16	—	Diodes Incorporated	BAT54DW-7FDICT-ND
2	D14, D15	Diode Schottky, B1100, 790 mV, 1A, 70V, DO-214AC_SMA	Diodes Incorporated	B1100-13-F
2	J1, J2	Connector Header, 40-Position, 2-Row, R/A, HM-ZD, Tin	TE Connectivity, Ltd.	6469169-1
1	J3	—	Samtec, Inc.	TSW-103-07-T-S
1	J4	—	Samtec, Inc.	TSW-105-07-S-S
13	J5, J6, J7, J11, J8, J12, J13, J16, J25, J26, J27, J28, J29	—	FCI	77311-118-02LF
12	J9, J10, J14, J15, J17, J18, J19, J20, J21, J22, J23, J24	Connector SMA	TE Connectivity, Ltd.	5-1814832-1
1	PCB	HV2903 Analog Switch Evaluation Board – Printed Circuit Board	Microchip Technology Inc.	**04-10599**
4	R1, R2, R8, R9	Resistor, 2.55K, 2W	Panasonic - ECG	ERJ-1TNF2551U
1	R16, R19	Resistor	Yageo Corporation	RC0402JR-074K7L
5	R17, R18	Resistor	Panasonic - ECG	—
1	R3	Resistor	Yageo Corporation	RC0402JR-070RL
4	R4, R10, R12, R14	Resistor	Vishay Intertechnology, Inc.	CRCW060349R9FKEAHP
2	R5, R6	Resistor, 4.99Ω, 1/16W, SMD0805	Stackpole Electronics, Inc.	RMCF0805FT4R99

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-1: BILL OF MATERIALS (BOM)[1] (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
4	R7, R11, R13, R15	Resistor	Yageo Corporation	RC1206FR-071KL
12	T24, T25, T26, T27, T28, T29, T30, T31, T32, T33, T34, T35, T36	Test Point	—	—
2	U1, U2	MD1822	Microchip Technology Inc.	**MD1822K6-G**
1	U13	HV2903	Microchip Technology Inc.	**HV2903/AHA**
1	U14	SQI Serial Flash	Micron Technology Inc.	N25Q128A13ESE40E
4	U5, U6, U7, U8	TC6320 DFN-8	Microchip Technology Inc.	**TC6320K6-G**

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

B.2 HV MUX CONTROLLER BOARD

TABLE B-2: BILL OF MATERIALS (BOM)(1)

Qty.	Reference	Description	Manufacturer	Part Number
8	C1, C10, C11, C12, C27, C28, C29, C90	Capacitor Tantalum, 33 µF, 10V, 10%, 1.4Ω, SMD, B	KEMET	T494B336K010AT
2	C103, C105	Capacitor Ceramic, 4.7 µF, 16V, 10%, X7R, SMD, 1206	KEMET	C1206C475K4RACTU
4	C2, C89, C104, C106	Capacitor Ceramic, 0.1 µF, 25V, 10%, X7R, SMD, 0603	Murata Manufacturing Co., Ltd.	GRM188R71E104KA01D
1	C3	Capacitor Tantalum, 100 µF, 6.3V, 10%, 400 mΩ, SMD, B	AVX Corporation	TPSB107K006R0400
7	C4, C13, C17, C21, C30, C33, C37	Capacitor Ceramic, 47 nF, 16V, 10%, X7R, SMD, 0603	Murata Manufacturing Co., Ltd.	GRM188R71C473KA01D
1	C41	Capacitor Ceramic, 22000 pF, 50V, 5%, X7R, SMD, 0603	AVX Corporation	06035C223JAT2A
10	C42, C50, C52, C54, C56, C58, C60, C62, C64, C66	Capacitor Ceramic, 0.1 µF, 50V, 20%, X7R, SMD, 0603	TDK Corporation	C1608X7R1H104M
12	C43, C44, C45, C46, C51, C53, C55, C57, C59, C61, C63, C65	Capacitor Ceramic, 10 µF, 10V, 10%, X7R, SMD, 0805	Murata Manufacturing Co., Ltd.	GRM21BR71A106KE51L
3	C47, C48, C49	Capacitor Ceramic, 10 µF, 35V, 10%, X5R, SMD, 1206	Taiyo Yuden Co., Ltd.	GMK316BJ106KL-T
24	C5, C6, C7, C8, C9, C14, C15, C16, C18, C19, C20, C22, C23, C24, C25, C26, C31, C32, C34, C35, C36, C38, C39, C40	Capacitor Ceramic, 1000 pF, 50V, 10%, X7R, SMD, 0603	NIC Components Corp.	NMC0603X7R102K50TRPF
8	C67, C68, C81, C82, C92, C93, C94, C95	Capacitor Ceramic, 0.1 µF, 16V, 10%, X7R, SMD, 0603	Samsung Electro-Mechanics America, Inc.	CL10B104KO8NNNC
9	C69, C70, C83, C84, C96, C97,107,108,109	Capacitor Ceramic, 4.7 µF, 16V, 10%, X5R, SMD, 0603	TDK Corporation	C1608X5R1C475K080AC
3	C71, C85, C98	Capacitor Ceramic, 0.010 µF, 25V, 10%, X7R, SMD, 0603	Yageo Corporation	CC0603KRX7R8BB103
3	C72, C86, C99	Capacitor Ceramic, 4700 pF, 50V, 10%, X7R, SMD, 0603	KEMET	C0603C472K5RACTU
12	C73, C74, C75, C76, C77, C78, C87, C88, C91, C100, C101, C102	Capacitor Ceramic, 10000 pF, 50V, 10%, X7R, 0603	AVX Corporation	06035C103KAT2A
1	D1	Diode Schottky, 20BQ030P, 470 mV, 2A, 30V, DO-214AA_SMB	ON Semiconductor®	MBRS130LT3G

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-2: BILL OF MATERIALS (BOM)[1] (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
8	D2, D3, D4, D5, D6, D7, D8, D9	Diode Schottky, 30V, 200 mA, SOD523	Micro Commercial Components	BAT54WX-TP
2	J1, J2	Connector Receptor, 40-Position, 2-Row, Right Angle, T/H	TE Connectivity, Ltd.	1469028-1
4	J10, J11, J12, J13	Connector PC, Pin, Circle, 0.030 Diameter, Gold	Mill-Max Mfg. Corporation	3132-0-00-15-00-00-08-0
2	J4, J5	Connector Header-2.54 Male, 1x6, Tin, 5.84 MH, TH, Vertical	Sullins Connector Solutions	PEC06SAAN
1	J6	Connector Power, 2.5 mm, 5.5 mm Switch, TH, R/A	CUI Inc.	PJ-002B
1	J7	Connector USB Mini-B, Female, SMD, R/A	Hirose Electric Co., Ltd.	UX60SC-MB-5ST(80)
2	J8, J9	Connector RF, Coaxial, SMA, Female, 2P, TH, Vertical	TE Connectivity, Ltd.	5-1814832-1
1	L1	4.7 µH, 11A, Inductor	Coilcraft	XAL6060-472MEB
3	LD1, LD2, LD4	Diode LED Green, 2.2V, 25 mA, 15 mcd, Clear, SMD, 0603	Kingbright Electronic Co., Ltd.	APT1608SGC
1	LD5	Diode LED Red, 2V, 25 mA, 104 mcd, Diffuse, SMD, 0603	OSRAM Opto Semiconductors GmbH.	LS Q976-NR-1-0-20-R18
1	PCB	HV MUX Controller Board – Printed Circuit Board	Microchip Technology Inc.	**04-10636**
1	Q1	Transistor FET, N-CH, BSS123, 100V, 170 mA, 300 mW, SOT-23-3	Diodes Incorporated®	BSS123-7-F
6	R1, R2, R4, R11, R13, R14	Resistor TKF, 4.7 kΩ, 5%, 1/10W, SMD, 0603	Panasonic® - ECG	ERJ-3GEYJ472V
1	R12	Resistor MF, 330R, 5%, 1/16W, SMD, 0603	Panasonic - ECG	ERA-V33J331V
1	R16	Resistor TKF, 39 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF3902V
1	R17	Resistor TKF, 19.1 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1912V
1	R18	Resistor TKF, 1 kΩ, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ102V
2	R19, R27	Resistor TKF, 390R, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ391V
3	R20, R37, R40	Resistor TKF, 100R, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1000V
1	R21	Resistor TKF, 8.66 kΩ, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-078K66L
6	R22, R28, R29, R33, R38, R42	Resistor TKF, 10 kΩ, 1%, 1/8W, SMD, 0603	Vishay Beyschlag	MCT06030C1002FP500
4	R23, R24, R30, R50	Resistor TKF, 10 kΩ, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ103V
1	R25	Resistor TKF, 51 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF5102V

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

TABLE B-2: BILL OF MATERIALS (BOM)[1] (CONTINUED)

Qty.	Reference	Description	Manufacturer	Part Number
1	R26	Resistor TKF, 69.8 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF6982V
2	R3, R8	Resistor TKF, 51R, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ510V
1	R31	Resistor TKF, 82 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF8202V
1	R32	Resistor TKF, 10.7 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF1072V
4	R34, R35, R39, R41	Resistor TKF, 150R, 1%, 1/10W, SMD, 0603	Stackpole Electronics, Inc.	RMCF0603FT150R
1	R36	Resistor TKF, 75 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3EKF7502V
3	R43,R45,R47	Resistor TKF, 100 kΩ, 1%, 1/10W, SMD, 0603	Panasonic - ECG	—
3	R44, R46, R48	Resistor, 78.7 kΩ, 1%, 1/10W, SMD, 0603	Yageo Corporation	RC0603FR-0778K7L
2	R49,R52	Resistor SMD, 0.0Ω, Jumper, 1/10W, 0603	Panasonic - ECG	ERJ-3GEY0R00V
3	R5, R10, R15	Resistor TKF, 0R, 1/10W, SMD, 0603	NIC Components Corp.	NRC06Z0TRF
1	R51	Resistor TKF, 150R, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GEYJ151V
2	R6, R7	Resistor TKF, 100R, 5%, 1/10W, SMD, 0603	Vishay Intertechnology, Inc.	CRCW0603100RJNEA
1	R9	Resistor TKF, 22R, 5%, 1/10W, SMD, 0603	Panasonic - ECG	ERJ-3GSYJ220V
1	SW1	Switch Slide, SPDT, Mini, 50V, 0.5A, G4050X-R, TH	Jameco® Electronics	G4050X-R
1	SW2	Switch Tactical, SPST, 12V, 50 mA, TL3301NF160QG/TR, SMD	E-Switch®, Inc.	TL3301NF260QG/TR
1	U1	IC FPGA, 102 I/O, 144 TQFP	Xilinx Inc.	XC6SLX9-2TQG144C
1	U10	Flexible Ultra-Low Jitter Clock Generator	Microchip Technology Inc.	**SM803234**
1	U2	IC PROM SRL for 4M Gate	Xilinx Inc.	XCF04SVOG20C
1	U3	3A Buck, 5V, QFN-16	Semtech Corporation	TS30013-M000QFNR
4	U4, U5, U6, U7	Microchip Analog LDO, 0.8V-5V, MCP1727T-ADJE/MF, DFN-8	Microchip Technology Inc.	**MCP1727-ADJE/MF**
3	U8, U11, U12	Adjustable LDO Ripple Blocker	Microchip Technology Inc.	**MIC94325YMT-TR**
1	U9	Microchip Interface USB SPI, MCP2210-I/SS, SSOP-20	Microchip Technology Inc.	**MCP2210T-I/SS**
1	X1	Resonator 12 MHz, 0.1%, SMD, CSTCE-G	Murata Manufacturing Co., Ltd.	CSTCE12M0G15L99-R0
1	X2	40 MHz ±30 ppm Crystal, 12 pF, 40Ω, -20°C ~ 70°C, Surface Mount, 4-SMD	TXC Corporation	7B-40.000MAAE-T

Note 1: The components listed in this Bill of Materials are representative of the PCB assembly. The released BOM used in manufacturing uses all RoHS-compliant components.

NOTES:

Appendix C. Demo Board Waveforms

C.1 BOARD TYPICAL WAVEFORMS

FIGURE C-1: 5 MHz, FOUR PULSES, Ch1 PULSER INPUT WHEN ALL SW OFF

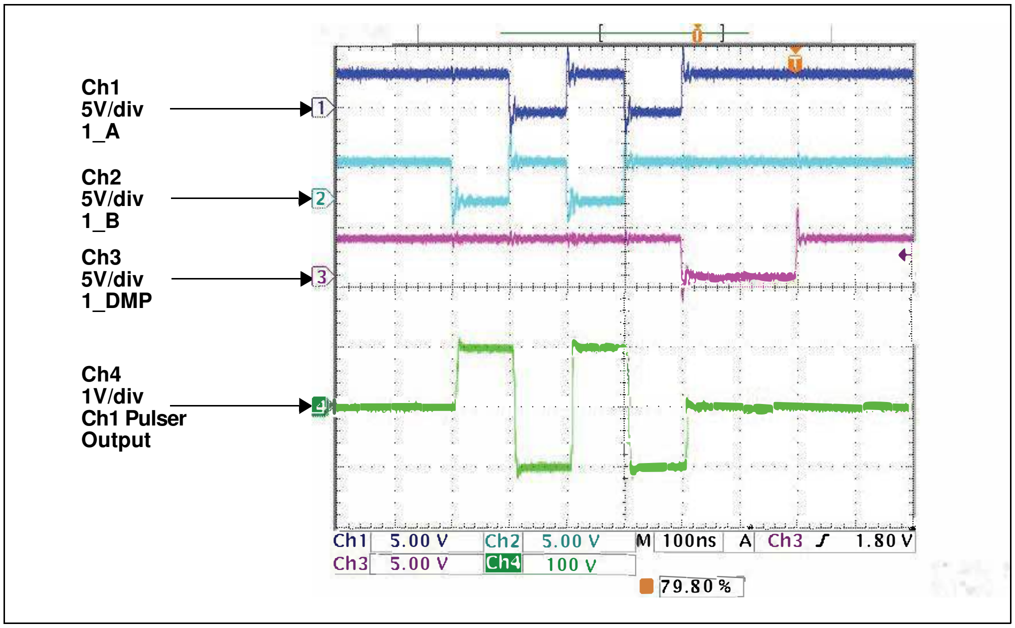
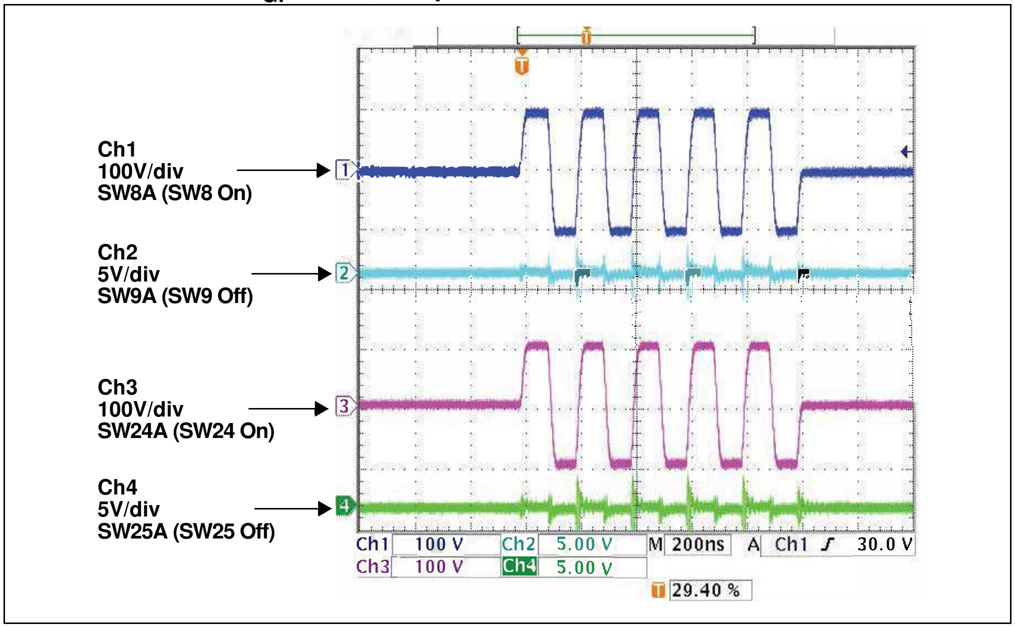


FIGURE C-2: 5 MHz, 10 PULSES, V_{PP}/V_{NN} = ±100V, V_{DD}/V_{SS} = ±6V, V_{GP} = 10V, 330 pF//2.5 kΩ LOAD



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