# HV2070 Analog Switch Evaluation Board User's Guide

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# HV2070 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.**

**For the most up-to-date information on development tools, see the MPLAB® IDE online help. Select the Help menu, and then Topics, to open a list of available online help files.**

## INTRODUCTION

This chapter contains general information that will be useful to know before using the HV2070 Analog Switch Evaluation Board. Items discussed in this chapter include:

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

## DOCUMENT LAYOUT

This document describes how to use the HV2070 Analog Switch Evaluation Board as a development tool to emulate and debug firmware on a target board. The manual layout is as follows:

- **Chapter 1. "Product Overview"** – Important information about the HV2070 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 HV2070 Analog Switch Evaluation Board.
- **Chapter 3. "GUI Description"** – This chapter describes the features of the GUI PC software.
- **Chapter 4. "PCB Design and Layout Notes"** – This chapter explains important points of the PCB design and layout of HV2070 Analog Switch Evaluation Board.
- **Appendix A. "Schematic and Layouts"** – Shows the schematic and PCB layout diagrams for the HV2070 Analog Switch Evaluation Board.
- **Appendix B. "Bill of Materials (BOM)"** – Lists the parts used to build the HV2070 Analog Switch Evaluation Board.
- **Appendix C. "Demo Board Waveforms"** – Describes the various demo waveforms for the HV2070 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 HV2070 Analog Switch Evaluation Board. Another useful document is listed below. The following Microchip document is available and recommended as a supplemental reference resource:

**HV2070 Data Sheet – *"No High-Voltage Bias, 32-Channel, High-Voltage Analog Switch with L-Switch Architecture"* (DS20005923A)**

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- **General Technical Support** – Frequently Asked Questions (FAQs), technical support requests, online discussion groups, Microchip consultant program member listing
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- Field Application Engineer (FAE)
- Technical Support

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Technical support is available through the web site at:
http://www.microchip.com/support.

## DOCUMENT REVISION HISTORY

### Revision A (December 2017)

- Initial Release of this Document.

**NOTES:**

# Chapter 1. Product Overview

## 1.1 INTRODUCTION

The HV2070 Analog Switch Evaluation Board (ADM00853) works with the HV MUX Controller Board (ADM00825) to provide No High-Voltage Bias, 32-Channel, High-Voltage Analog Switches, with L-Switch Architecture, demonstration including basic switch ON/OFF operation, and 2:1 MUX operation with two built-in MD1822 and TC6320 pulser circuits.

## 1.2 HV2070 DEVICE SHORT OVERVIEW

The HV2070 device is a No High-Voltage Bias, 32-Channel, High-Voltage Analog Switches, with L-Switch Architecture. It is designed to be used in applications requiring high-voltage switching, controlled by low-voltage command signals, such as medical ultrasound imaging, driving piezoelectric transducers and in printers. Using the patented L-Switch architecture, the typical 4.5Ω on-resistance analog switch can pass the analog pulse signal up to ±3.7A 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 the logic operation.

The HV2070 device has two modes of operation: individual switching mode and bank switching mode. The user can select the mode through the MODE pin logic input. The 32 analog switches can be controlled individually through 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 logic inputs, when the MODE input is low (bank switching mode).

HV2070 has a standby mode, in order to decrease power consumption at idle state. When $\overline{\text{STBY}}$ logic input is low, the device operates in standby mode and consumes very low current. When $\overline{\text{STBY}}$ logic input is high, the device operates normally.

## 1.3 HV2070 ANALOG SWITCH EVALUATION BOARD FEATURES

- HV2070 No High-Voltage Bias, 32-Channel, High-Voltage Analog Switches, with L-Switch Architecture
- Designed to work with Microchip HV MUX Controller Board
- 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 SW8T, SW9T, SW24T, SW25T
- Mode selection and ON/OFF switch, controlled through the PC GUI and the HV MUX Controller Board
- Pulser ON/OFF and time domain, controlled through the PC GUI and the HV MUX Controller Board

## 1.4 WHAT IS THE HV2070 ANALOG SWITCH EVALUATION BOARD?

The HV2070 Analog Switch Evaluation Board can control the HV2070 device's operation and built-in pulsers that are connected to the two 2:1 MUX switches for demonstration. Four switch outputs, two of which are 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 HV2070 Analog Switch Evaluation Board can drive four transducer elements with 5 MHz ±100V pulse signals.

The HV2070 Analog Switch Evaluation Board features one HV2070/AJA 10x10x1.1 mm 121-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 HV2070 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 using a Microsoft® Windows® operated PC and the GUI software, the user can control the HV2070 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. The jumpers close to the 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.

## 1.5 HV2070 ANALOG SWITCH EVALUATION BOARD TECHNICAL PARAMETERS

**TABLE 1-1: HV2070 ANALOG SWITCH EVALUATION BOARD TECHNICAL PARAMETERS**

| Parameter | Value |
|---|---|
| HV2070 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 msec |
| Pulse Peak Voltage & Current | 0 to ±100V and ±3.7A (typical) |
| Interface of FPGA Control Signals & USB PC-GUI Software | J1 and J2 Connects to ADM00825 Controller Interface Board |
| Pulser R-C Test-Load & User's Transducer Interface | Built-in, 330 pF//2.5 KΩ per Channel with jumper and 50Ω SMA |
| PCB Board Dimension | 115 mm x 110 mm |

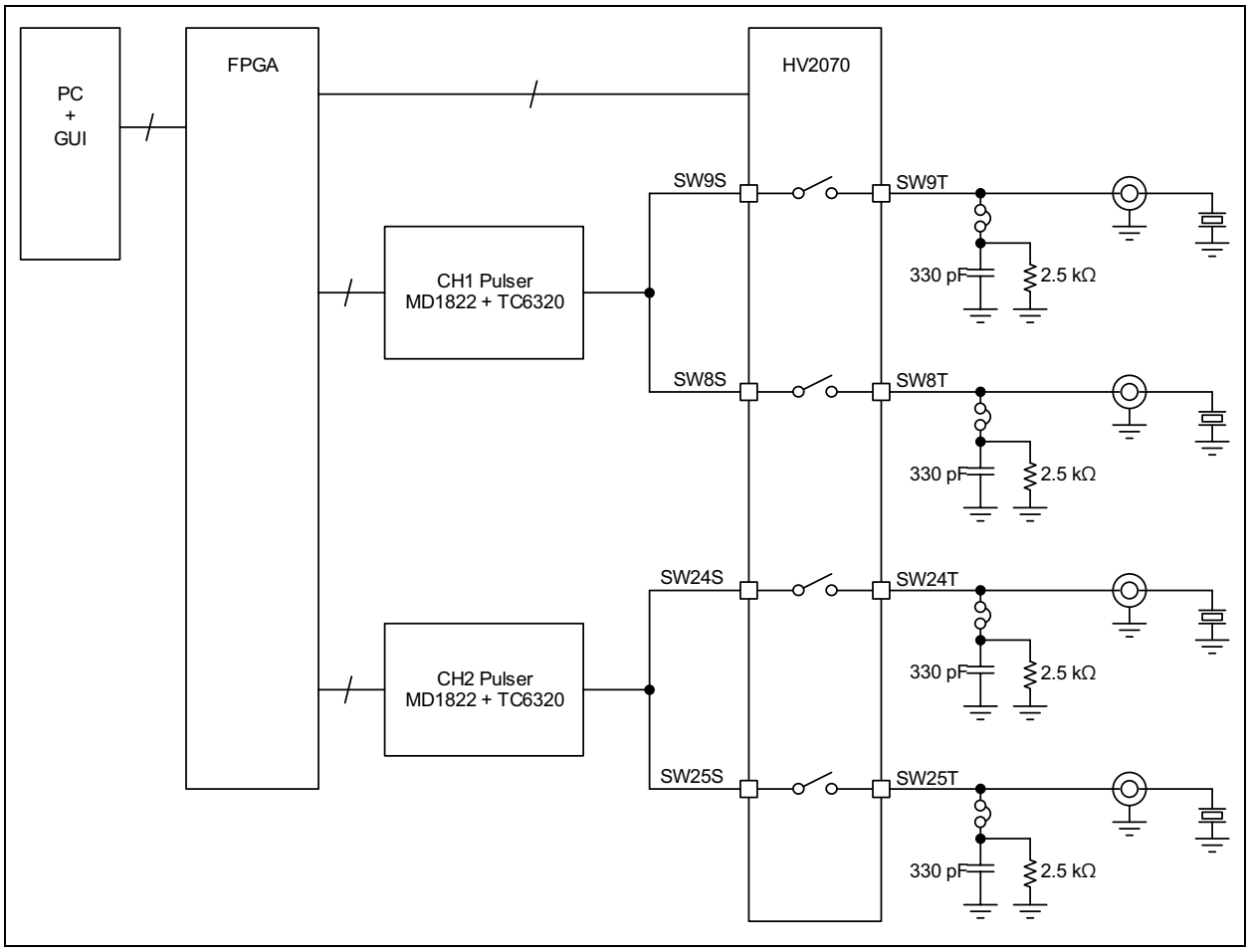



***FIGURE 1-1:*** *HV2070 Analog Switch Evaluation Board Simplified Block Diagram.*

## 1.6 HV2070 ANALOG SWITCH EVALUATION BOARD KIT CONTENTS

The HV2070 Analog Switch Evaluation Board includes:

- HV2070 Analog Switch Evaluation Board (ADM00853)
- Important Information Sheet

**NOTES:**

# Chapter 2. Installation and Operation

## 2.1 GETTING STARTED

The HV2070 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. Make sure 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 Board (ADM00825);
3. A Microsoft® Windows® 7 PC, with the HV MUX Controller Board GUI software installed and running;
   - connect J1 and J2 to the HV MUX Controller Board
   - connect the HV MUX Controller Board through the USB port to the Windows 7 PC

## 2.2 HV MUX GUI INSTALLATION

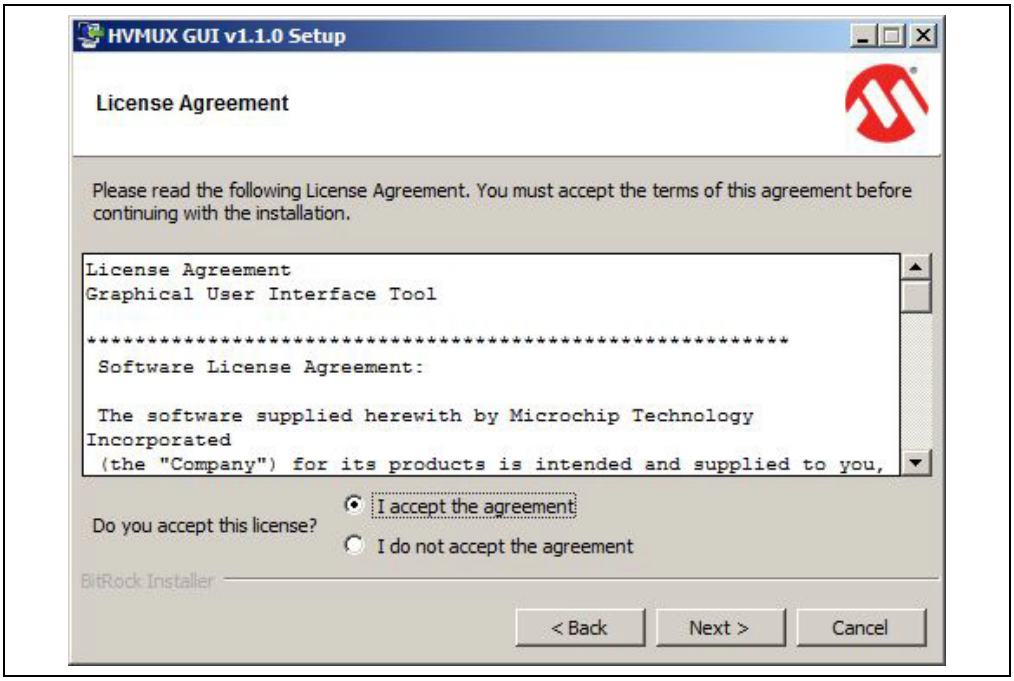
The HV MUX GUI software installer can be downloaded from the Microchip web site at www.mircochip.com. Search for the evaluation board on the web site by the part number ADM00853.

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**

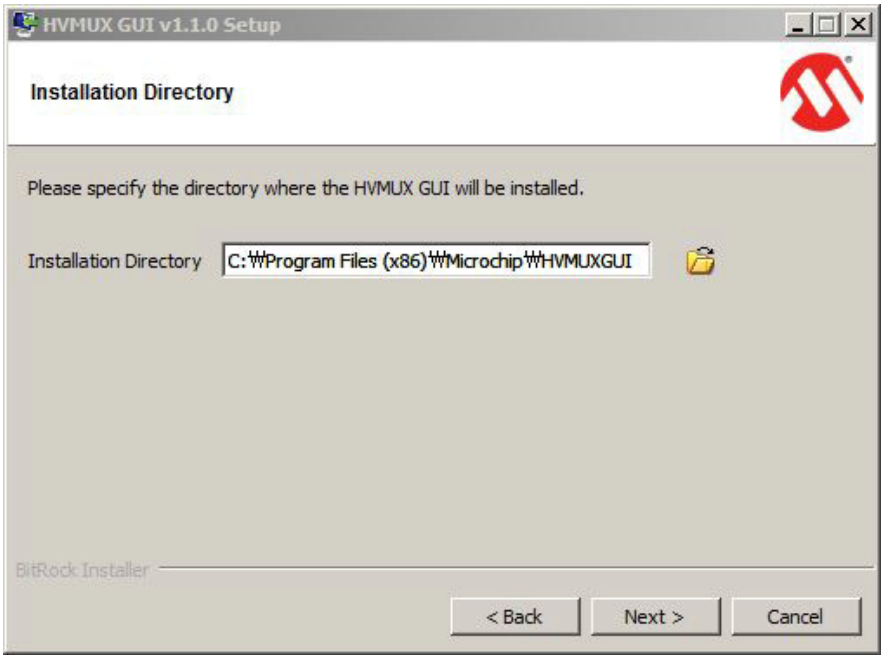

4. Read the License Agreement and accept it by checking the box corresponding to "I accept the agreement". Click **Next** to proceed with the installation.

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



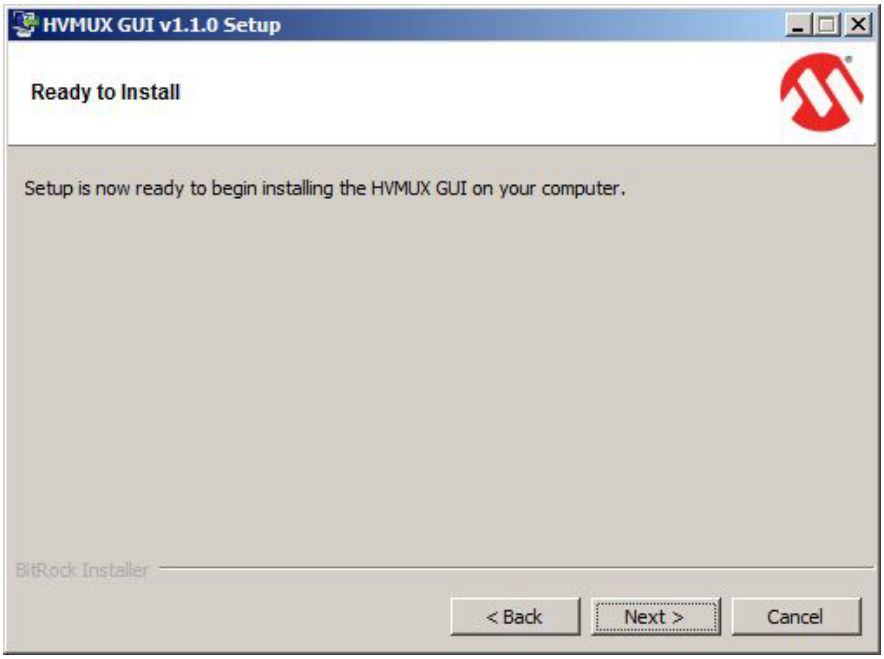

5. On the Installation Directory dialog box, browse for the desired location or click **Next** to install in the default location.

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



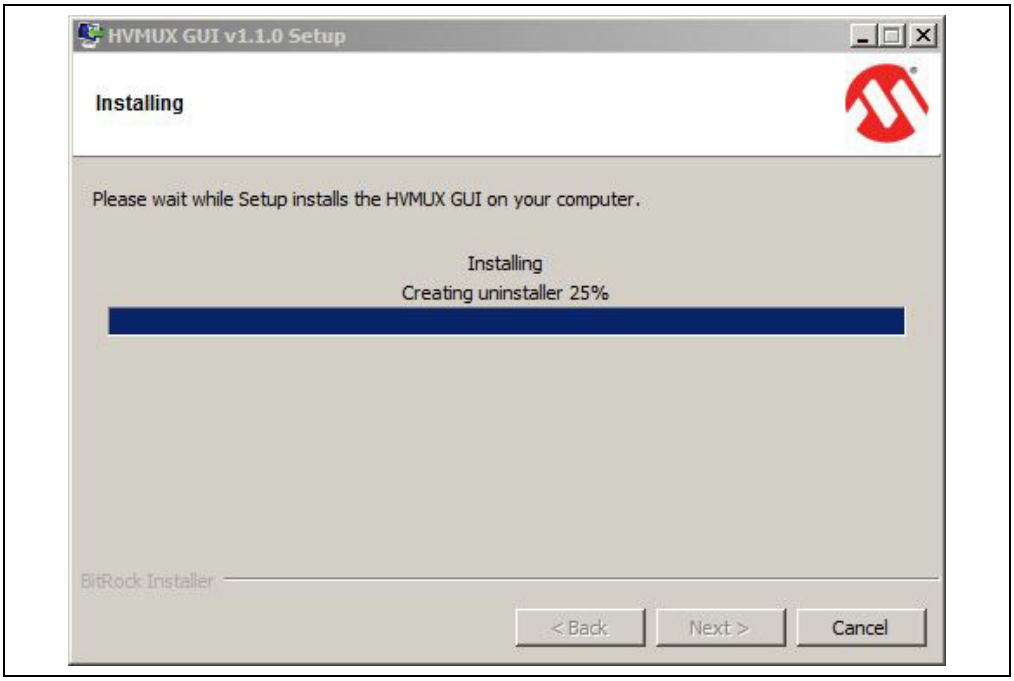

6. Once the installation path is chosen, the software is ready to install. Click **Next.**

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



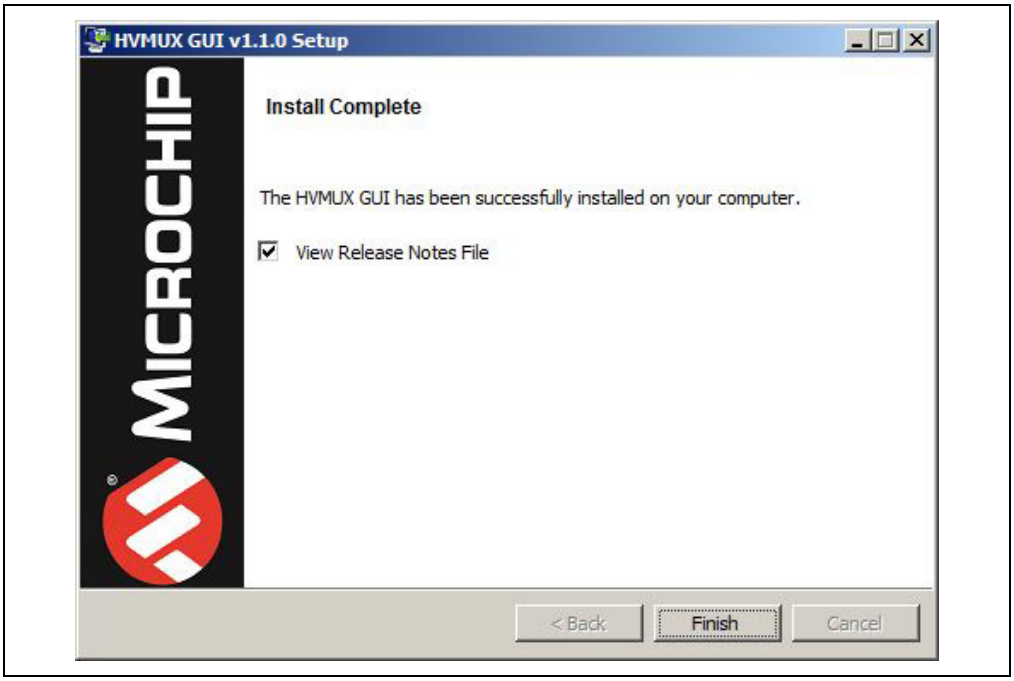

7. The installation status window appears, showing the installation progress.
8. After the installation has completed, click **Next**.

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




9. Once 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 HV2070 ANALOG SWITCH EVALUATION BOARD SETUP PROCEDURE

To operate the HV2070 Analog Switch Evaluation Board, the following steps must be completed:

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

**WARNING**

**Please observe the polarity of each power supply rail and set the voltage and current limit carefully.**

4. Turn on the $V_{SS}$ first and then turn on the $V_{DD}$.
5. Turn on the $V_{LL}$.
6. Turn on the $V_{GP}$ and $V_{PP}/V_{NN}$.
7. Connect a USB cable from the HV MUX Controller Board to the PC.
8. Connect +12V/1A power to the HV MUX Controller Board.
9. Run the HV MUX GUI software on the PC.
10. Click the **Initialize HV MUX Controller Board** button in the GUI. This causes the status window at the bottom of the screen to display an “initialization complete” message.
11. Clear the $\overline{\text{STBY}}$ check box to set HV2070 in normal operation and choose the switching mode by selecting/clearing the MODE check box.
12. Click the **Set HV MUX** button. All digital control signals are applied to HV2070.
13. Set the number of pulses and $T_{OFF}$ time of the pulser.
14. Select CH1 or CH2 to set the channel 1 pulser or the channel 2 pulser, respectively.
15. Click the **Start** button for the selected pulser to generate 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 | $V_{DD}$ | +5V or +6V | +20 mA |
| J3-2 | GND | 0V | — |
| J3-3 | $V_{SS}$ | –5V or –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 |
| J11-2 | $V_{NN}$ | –100V | –5 mA |

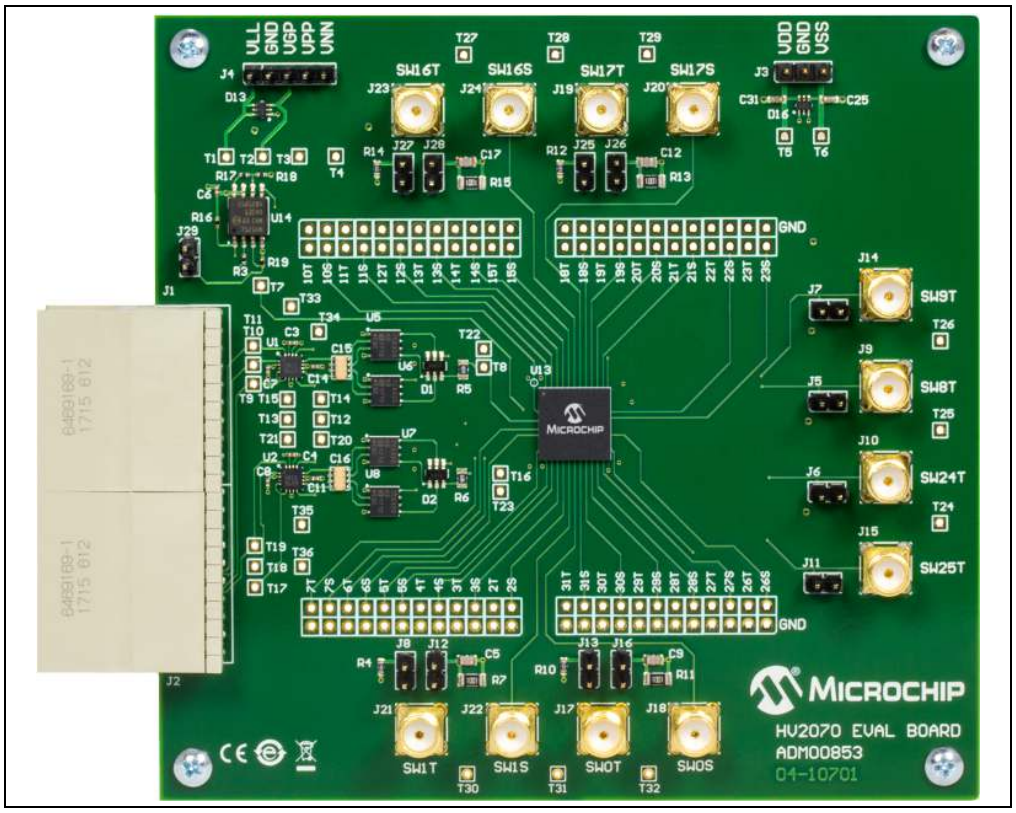



***FIGURE 2-7:*** *HV2070 Analog Switch Evaluation Board - Front View.*

### 2.3.1 Recommended Power-Up and Power-Down Sequences

Table 2-2 shows the recommended power-up and power-down sequences of the HV2070 Analog Switch Evaluation Board.

**TABLE 2-2: HV2070 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 HV2070 Analog Switch 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**

| 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 | HV2070 Latch Clear Logic Input |
| J2-B5 | CLK | TP14 | LVCMOS-3.3V Input | HV2070 Clock Logic Input |
| J2-C5 | $\overline{LE}$/EN | TP12 | LVCMOS-3.3V Input | HV2070 Latch Enable Logic Input |
| J2-D5 | MODE | TP13 | LVCMOS-3.3V Input | HV2070 Mode Logic Input |
| J2-A6 | DIN/$A\overline{B}$ | TP20 | LVCMOS-3.3V Input | HV2070 Data In Logic Input |
| J2-B6 | $\overline{STBY}$ | TP21 | LVCMOS-3.3V Input | HV2070 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 the pins that are not included in this table are no-connect.

## 2.5 HV MUX CONTROLLER BOARD SETUP PROCEDURE

The HV MUX Controller Board generates control signals for HV2070 Analog Switch Evaluation Board and features a Spartan-6 XC6SLX9 FPGA.

1. Before powering up the HV2070 Analog Switch Evaluation Board and the HV MUX Controller Board, make sure that the latest GUI software is installed on the PC.
2. Start the GUI program. If the board is not connected, a "Not Connected" message is displayed in the Status bar, located at the bottom left of the screen.
3. Connect the appropriate power supply and turn on the power switch to power-up the HV MUX Controller Board. The FPGA_OK(LD1) and DC_IN (LD2) on the HV MUX Controller Board should light up green. A "Connected" message is displayed on the bottom left of the Status bar of the GUI.

The HV MUX Controller Board is now ready to control the HV2070 Analog Switch Evaluation Board.

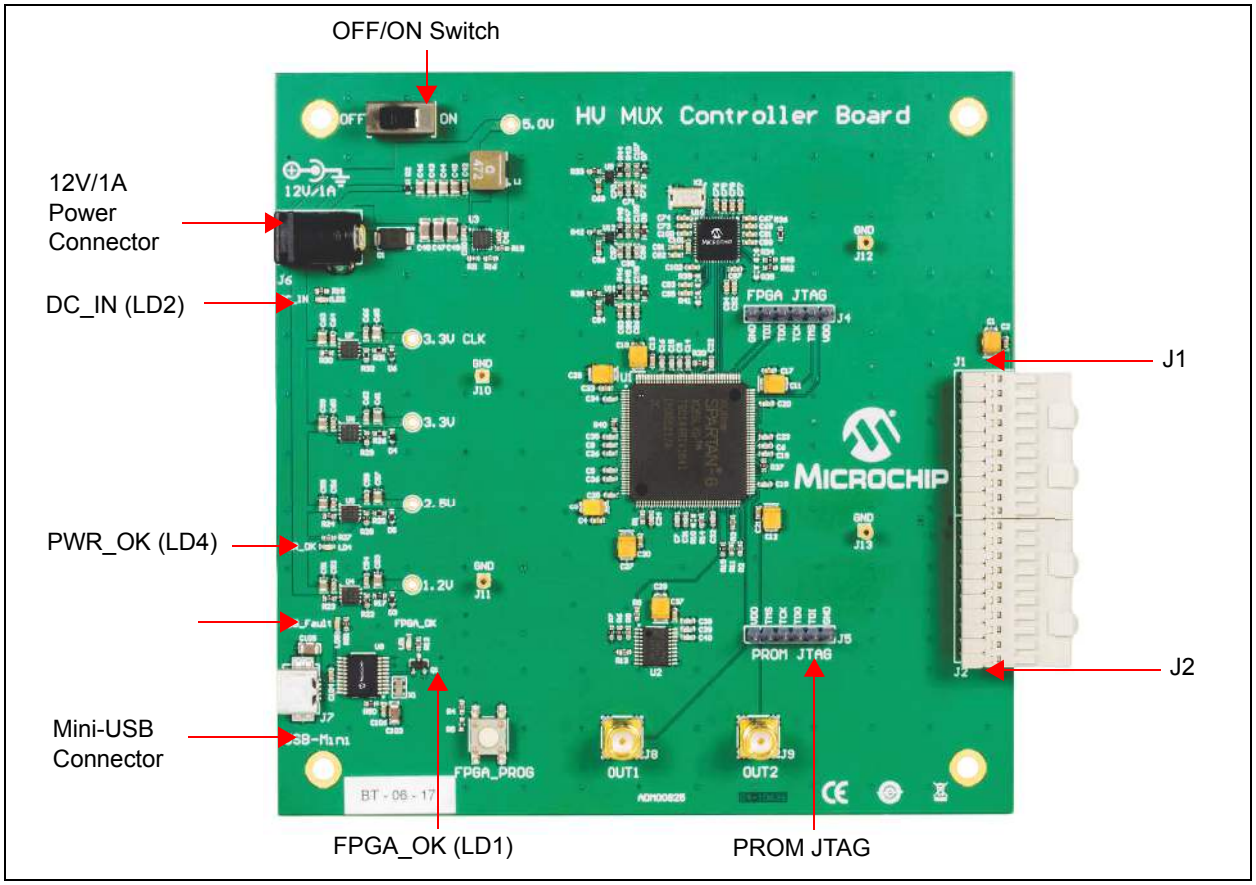



***FIGURE 2-8:*** *HV MUX Controller Board (ADM00825) - Front View.*

## 2.6 TESTING THE HV2070 ANALOG SWITCH EVALUATION BOARD

### 2.6.1 HV2070 Individual Switching Mode Operation (STBY=1, MODE=1):

In the individual switching mode, the user can turn on/off each of the 32 switches through the USB connected PC GUI software program:

1. Click the **Initialize HV MUX Controller** button located at the top left corner.
2. Clear $\overline{\text{STBY}}$ to set HV2070 in normal operation.
3. Select MODE to set HV2070 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.

### 2.6.2 HV2070 Bank Switching Mode Operation (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) together through the USB connected PC GUI software program:

1. Click the **Initialize HV MUX Controller** button at the top left corner.
2. Clear $\overline{\text{STBY}}$ to set HV2070 in normal operation.
3. Clear MODE to set HV2070 in bank switching mode.
4. Select the EN check box to set HV2070 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**, clear 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 Board 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"**.

## 2.7 GENERATION OF PULSER OUTPUT AT SW8T OF HV2070

This section provides the simple step-by-step procedure to make the Ch1 pulser output at SW8T SMA connector by configuring the GUI.

1. Before powering up the HV2070 Analog Switch Evaluation Board, make sure that the latest GUI software is installed on the PC.
2. Start the GUI program. If the board is not connected, a "Not Connected" message is displayed in the Status bar, located at the bottom left of the screen.
3. Power up the HV MUX Controller Board and HV2070 Analog Switch Evaluation Board as described in the previous section. The prompt "Connected" is displayed in the Status bar.
4. Click the **Initialize HV MUX Controller** button and check the message window

to see "Initialization Complete".

5. Clear the $\overline{\text{STBY}}$ check box to set the HV2070 device to operate normally.
6. Select MODE to set the HV2070 device 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 HV2070 SW8.
9. Change the Pluses to 10.
10. Select CH1.
11. Click the **Start** button so that the CH1 pulser starts to generate pulse trains with 10 pulses and 30 ms $T_{OFF}$ time.

The Ch1 and Ch2 of the oscilloscope in Figure 2-9 show the SW8T and the SW9T.

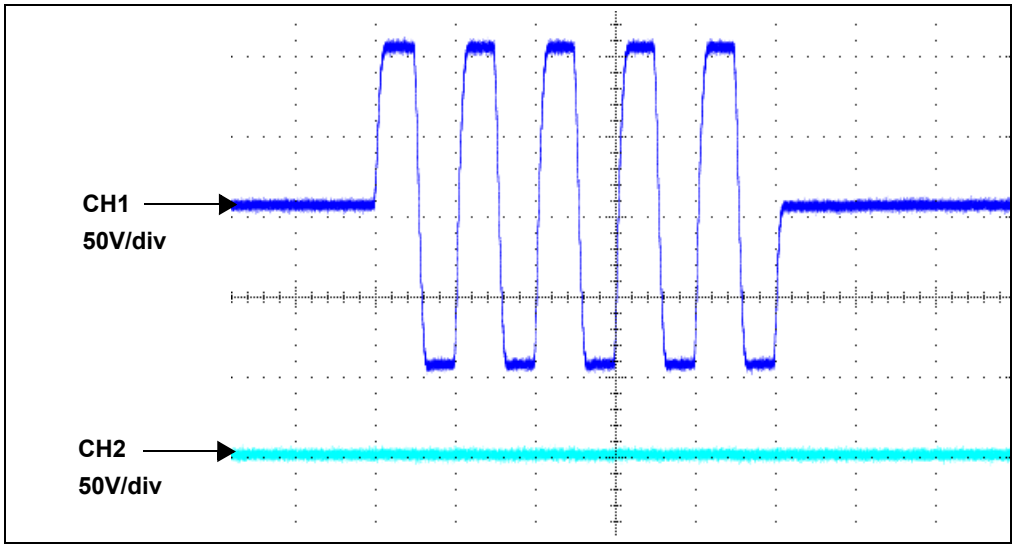



***FIGURE 2-9:*** *Typical Waveform of 2:1 MUX Connected to Pulser.*

# Chapter 3. GUI Description

## 3.1 HV2070 ANALOG SWITCH EVALUATION BOARD GUI DESCRIPTION

Figure 3-1 displays a screen capture of the HV MUX Controller Board GUI. Table 3-1provides a detailed description of every item numbered in the screen capture. The selection of the check box, binary data in the DIN entry box and number in Pulses and TOFF entry box are just settings and don't change the operation of HV2070 and built-in pulsers immediately. By clicking the **Set HV MUX**, **Start** and **Stop** buttons, the control data set by the user in the GUI changes operation of HV2070 and turn on/off the built-in pulsers in the HV2070 Analog Switch Evaluation Board. Follow the explanation for each corresponding item.

**FIGURE 3-1: HV MUX CONTROLLER BOARD GUI SCREEN CAPTURE**

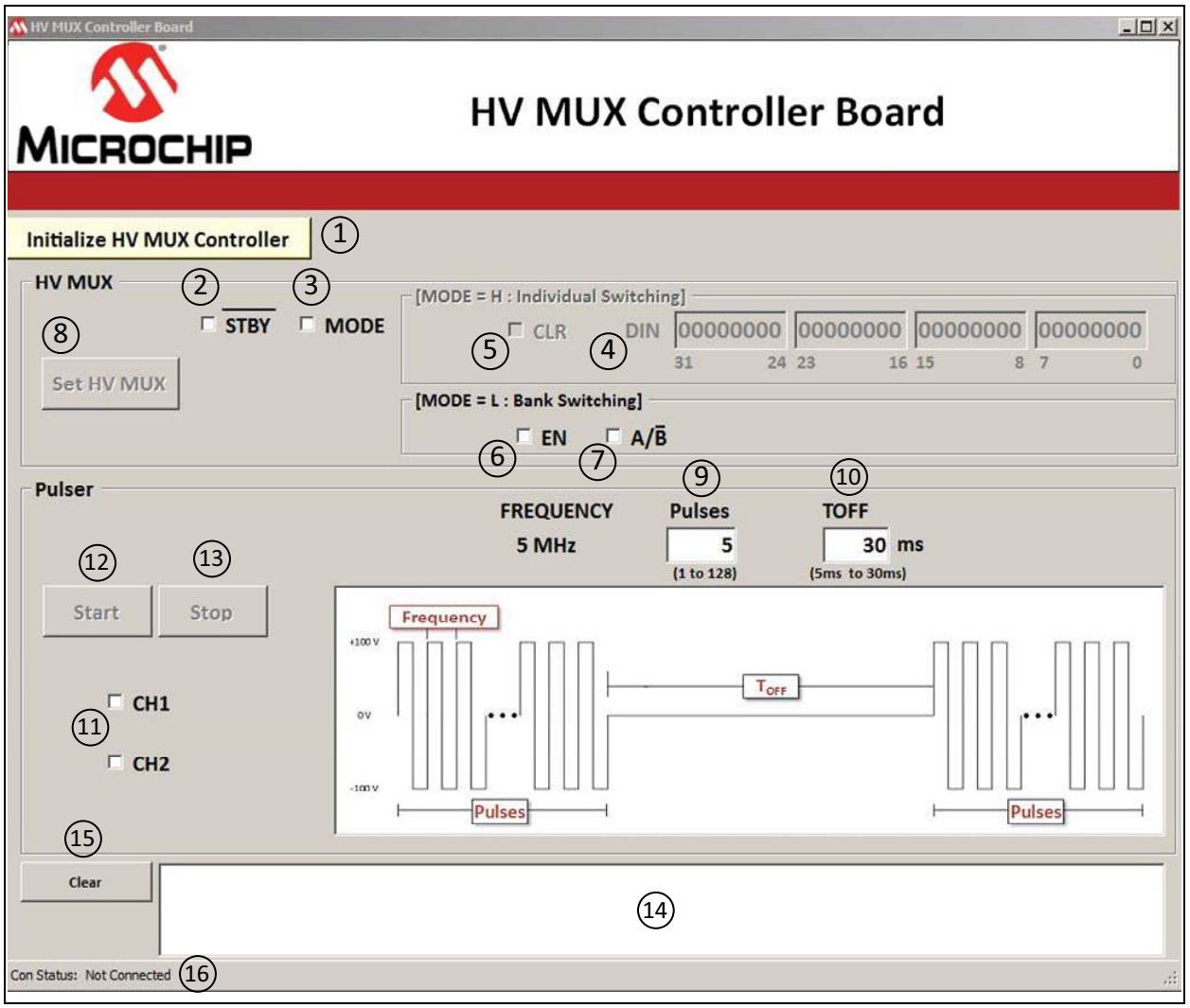


**TABLE 3-1: HV2070 ANALOG SWITCH EVALUATION BOARD GUI DESCRIPTION**

| Item Number | Item Name | Item Description |
|---|---|---|
| 1 | **Initialize HV MUX Controller** | This button controls whether the GUI starts the initialization of FPGA on the HV MUX Controller Board and the communication between the GUI and the HV MUX Controller Board. If there is no error, the "Initialization Complete" message is displayed in the Message Window. |
| 2 | $\overline{\text{STBY}}$ | When this check box is selected, the $\overline{\text{STBY}}$ logic input is set to low and HV2070 is set to operate in standby mode, in order to decrease power consumption. When cleared, the $\overline{\text{STBY}}$ logic input is set to high and HV2070 is set to operate in normal mode. |
| 3 | MODE | When this check box selected, the MODE logic input is set to high and HV2070 is set to operate in individual switching mode. When cleared, the MODE logic input is set to low and HV2070 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 this check box is selected, the CLR logic input is set to high and all the switches of HV2070 are set to OFF. When cleared, the CLR logic input is set to low and the 32 switches of HV2070 are set to ON/OFF states, according to the DIN data entry |
| 6 | EN | When this check box is selected, the EN logic input is set to high and HV2070 is activated for bank switching mode. When cleared, the EN logic input is set to low and all the switches are set to OFF. |
| 7 | A/$\overline{\text{B}}$ | When this check box is selected, 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 cleared, 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** | This button controls whether the data described in the items 2 to 7 is applied to HV2070. 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 | This text box defines 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 the positive pulse first. |
| 10 | TOFF | This text box defines the interval between pulse trains generated by the selected pulser. |
| 11 | CH1/CH2 | When one of these check boxes is selected, the respective pulser is set to generate 5 MHz pulse trains defined at steps 9 and 10 by the user. |
| 12 | **Start** | This button controls if the selected pulser starts generating the pulse train. |
| 13 | **Stop** | This button controls if the selected pulser stops generating the pulse train. |
| 14 | Message Window | This window displays information from the GUI program. |
| 15 | **Clear** | This button clears the messages in the Message window. |
| 16 | Connection Status | This window displays status of the connection between the GUI and the HV MUX Controller Board. |

# Chapter 4. PCB Design and Layout Notes

## 4.1 PCB LAYOUT TECHNIQUES FOR HV2070

The HV2070 Analog Switch Evaluation Board is an analog switch to pass high-voltage, high-current and high-frequency pulses. The PCB design and layout are important to ensure the success of the implementation.

### 4.1.1 High-Voltage & High-Speed Grounding and Layout Techniques

The center balls at the bottom of the HV2070 TFBGA package are internally connected to the IC's substrate ($V_{SUB}$). These balls should be connected to GND, externally on the PCB.

The user 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 HV2070 Analog Switch Evaluation Board PCB layout. The internal circuitry of the HV2070 can operate at quite 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 feed through connections that are connected directly to a solid ground plane at the second layer of the PCB.

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

It is important to minimize trace lengths and use 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.

### 4.1.2 Decoupling Capacitors Selection

The $V_{LL}$, $V_{DD}$ and $V_{SS}$ supply voltage rails are able to provide fast transient current. Therefore, they should have a low-impedance bypass capacitor close to each of the power supply pins. Use a surface-mounted ceramic capacitor of 1.0 to 2.2 µF capacitance with an appropriate voltage rating.

It is important to verify 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:**

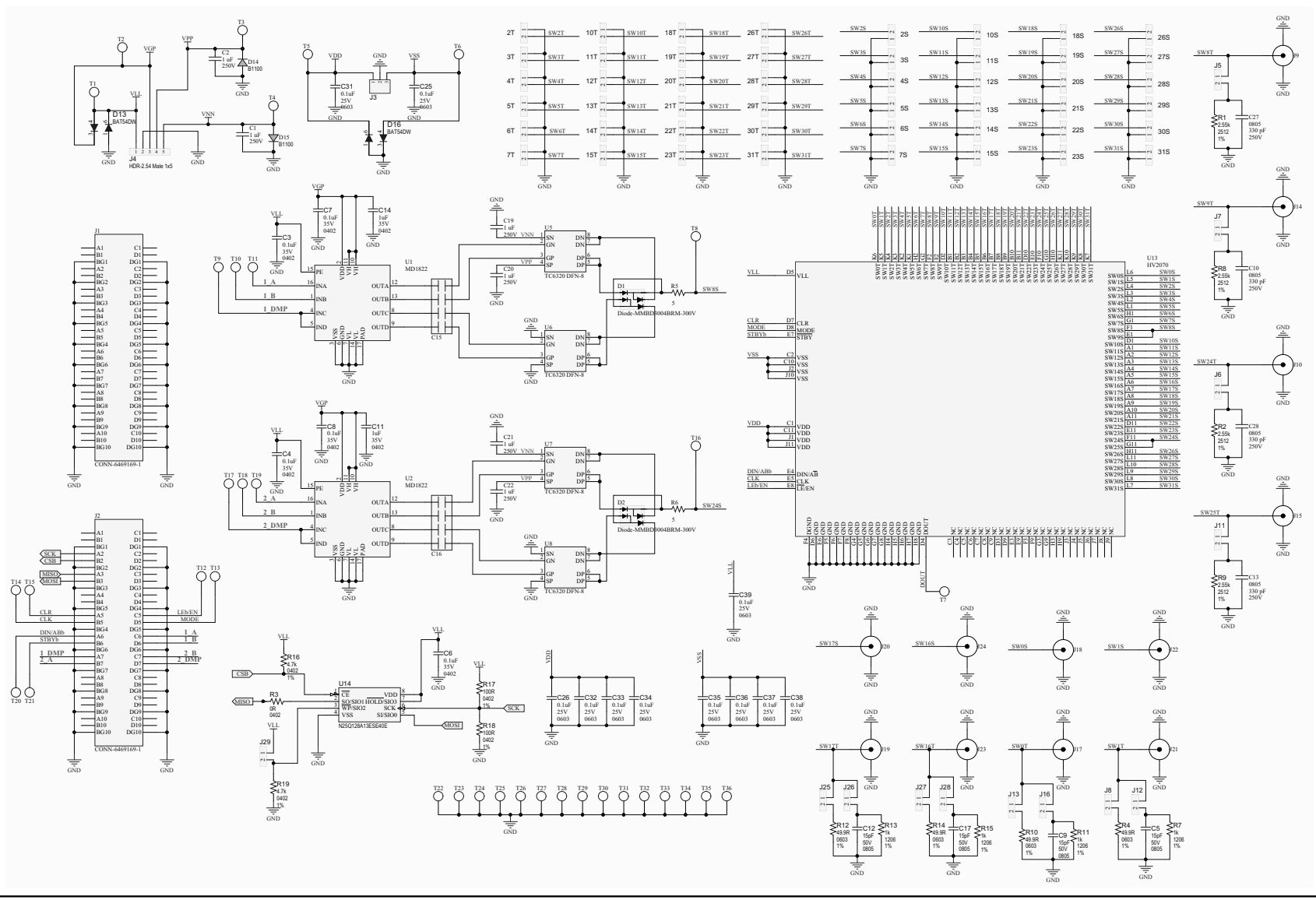
# Appendix A. Schematic and Layouts

## A.1 INTRODUCTION

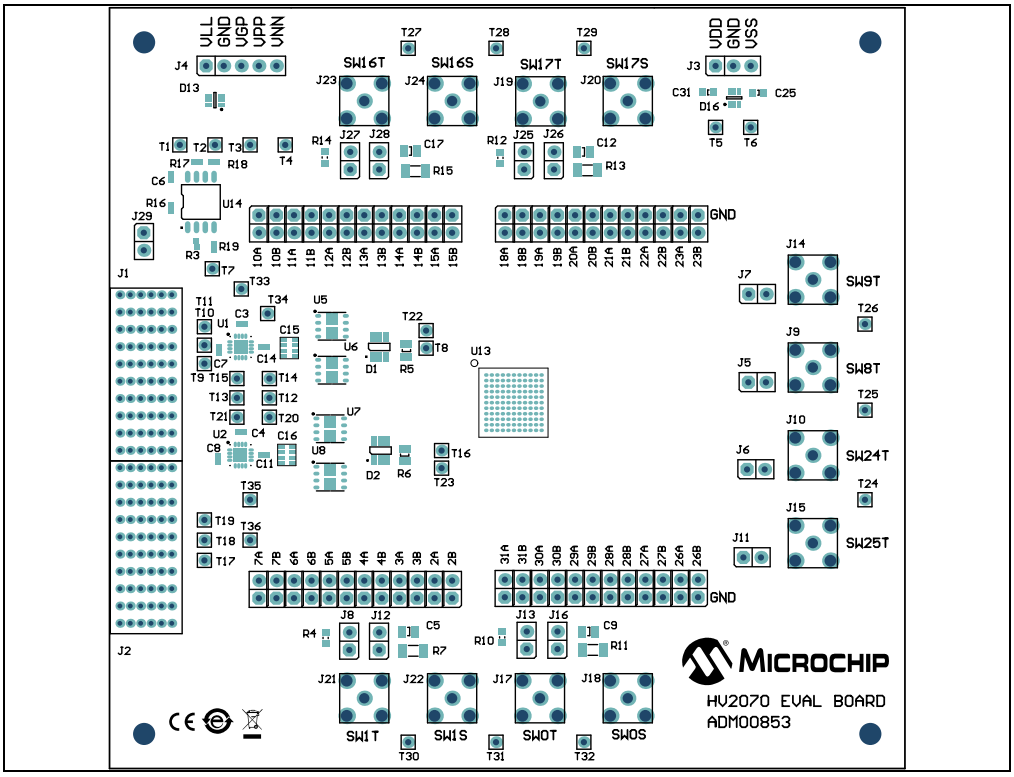
This appendix contains the following schematics and layouts for the HV2070 Analog Switch Evaluation Board (ADM00853) and the HV MUX Controller Board (ADM00825)

- HV2070 Analog Switch Evaluation Board (ADM00853):
  - ADM00853 - Schematic
  - ADM00853 - Top Silk
  - ADM00853 - Top Copper and Silk
  - ADM00853 - Top Copper
  - ADM00853 - Inner 1
  - ADM00853 - Inner 2
  - ADM00853 - Inner 3
  - ADM00853 - Bottom Copper
  - ADM00853 - Bottom Copper and Silk
  - ADM00853 - 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

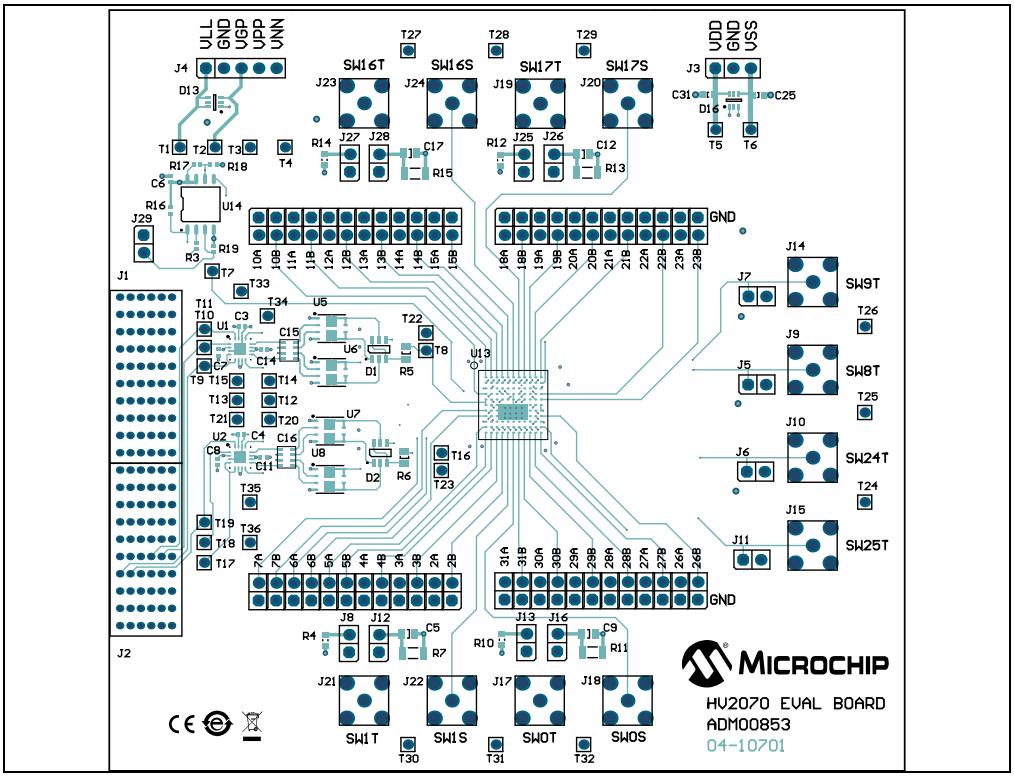
## A.2 ADM00853 - SCHEMATIC



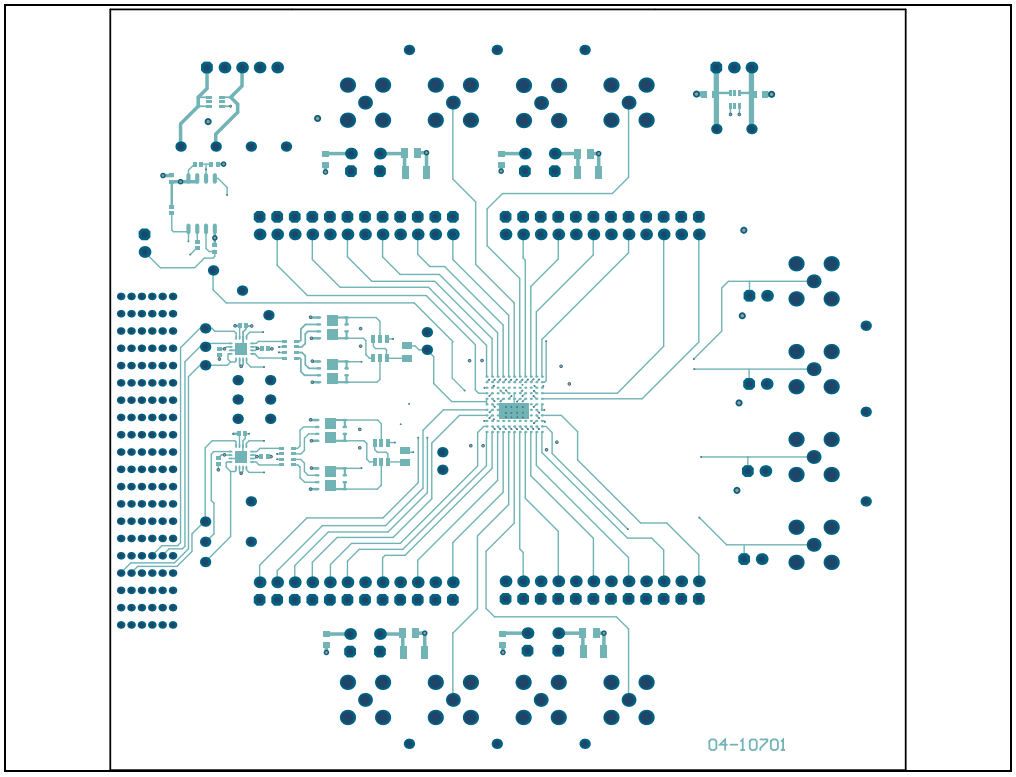
## A.3 ADM00853 - TOP SILK



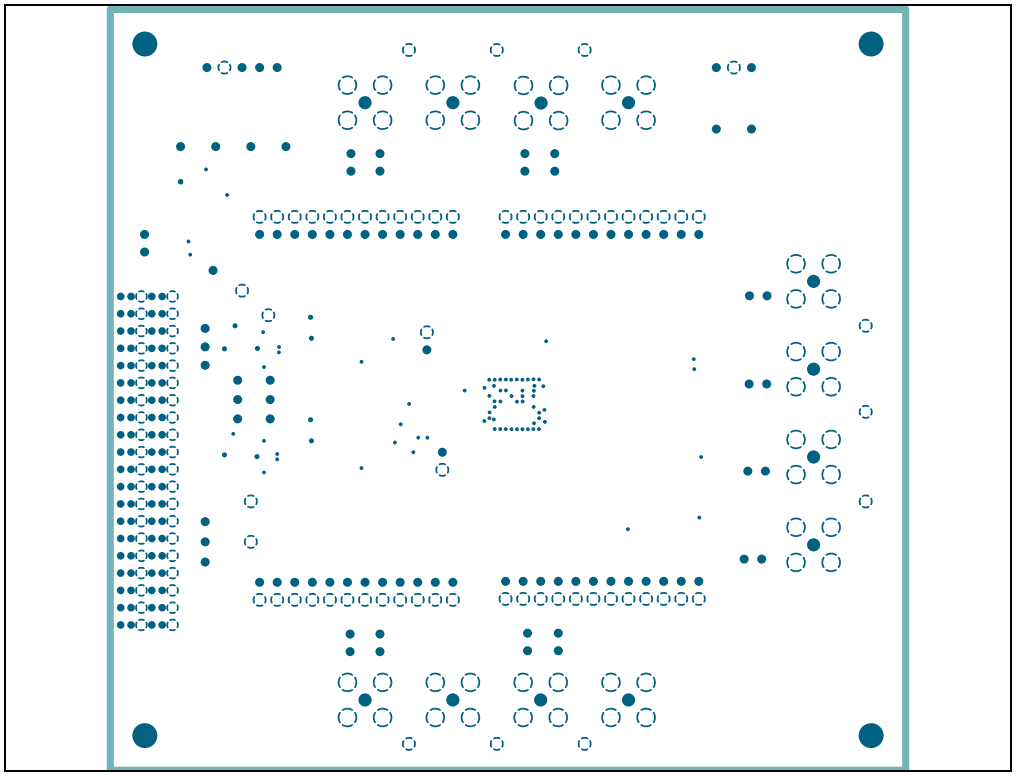

## A.4 ADM00853 - TOP COPPER AND SILK



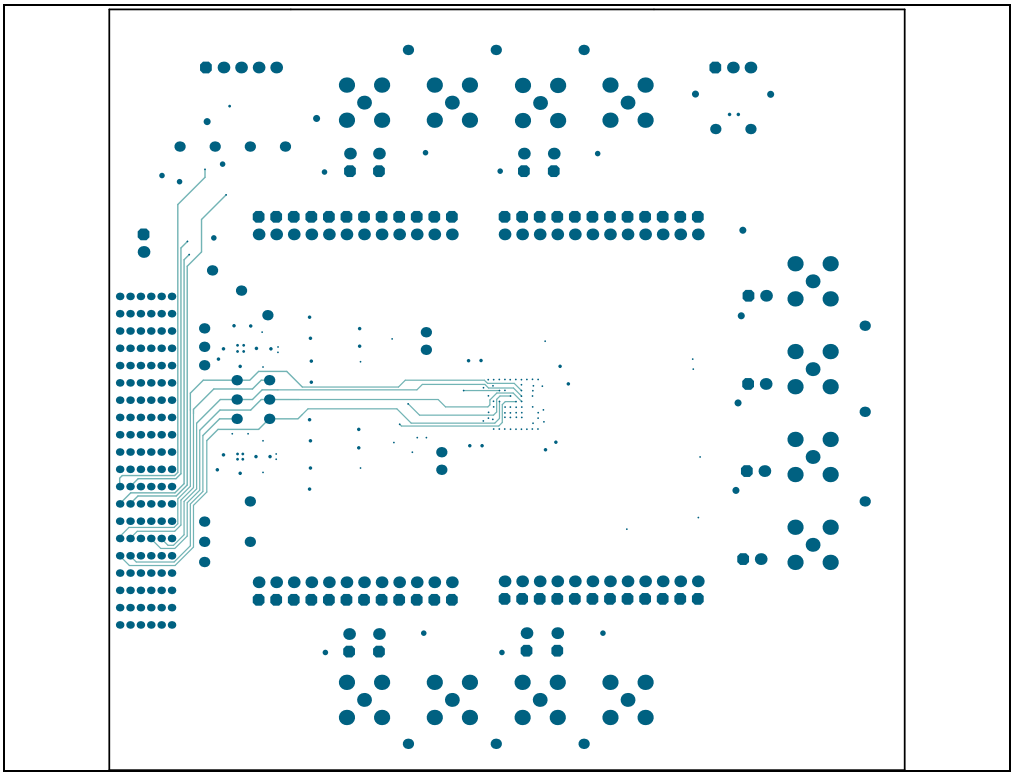
## A.5 ADM00853 - TOP COPPER



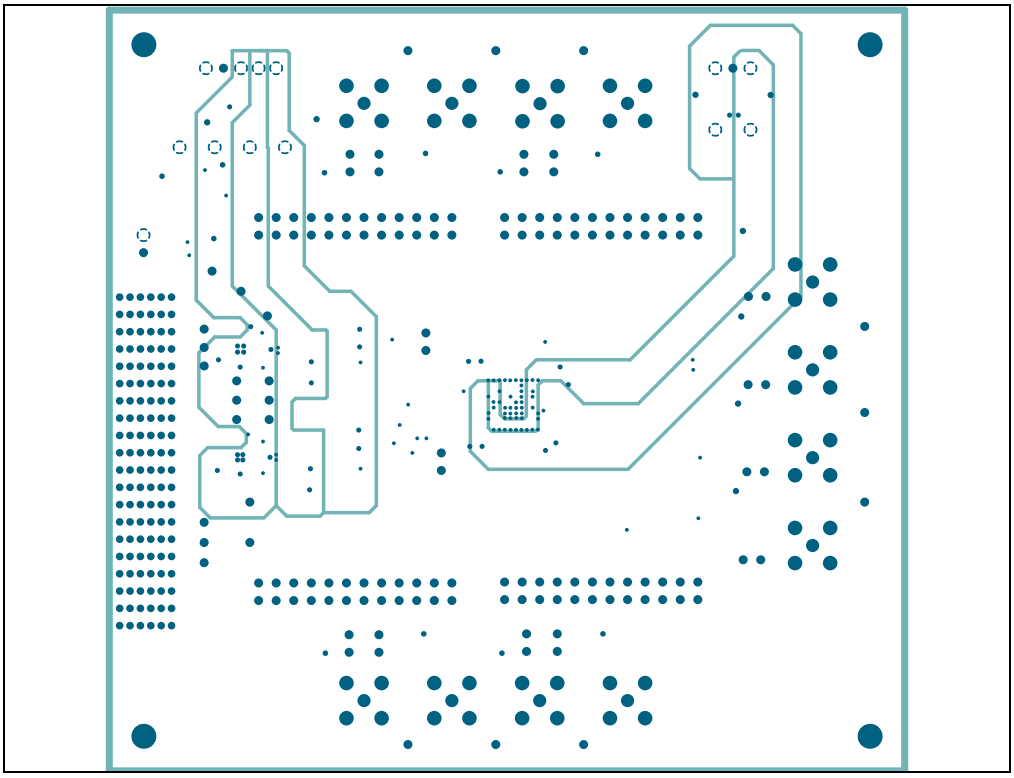

## A.6 ADM00853 - INNER 1



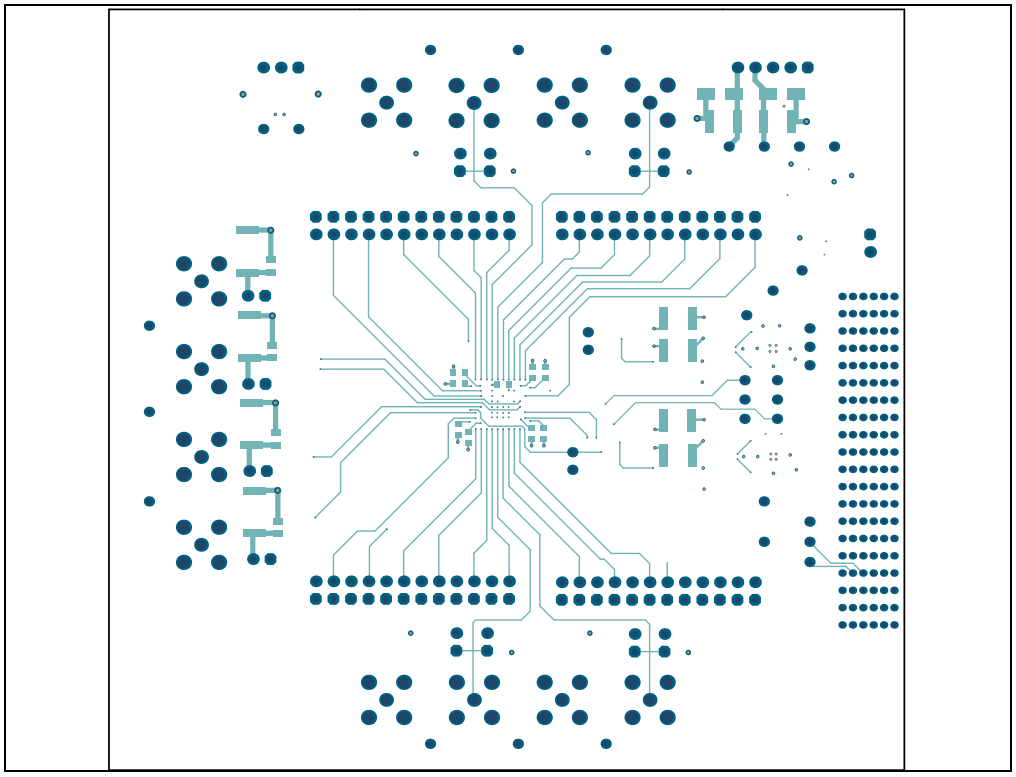
## A.7 ADM00853 - INNER 2



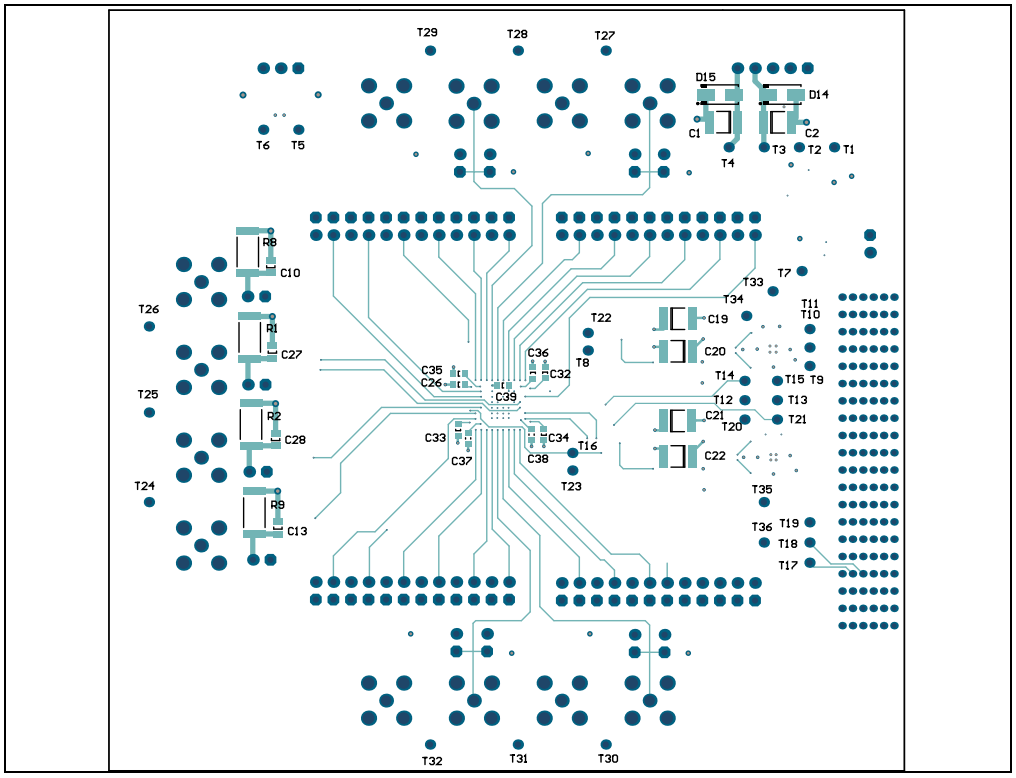
## A.8 ADM00853 - INNER 3



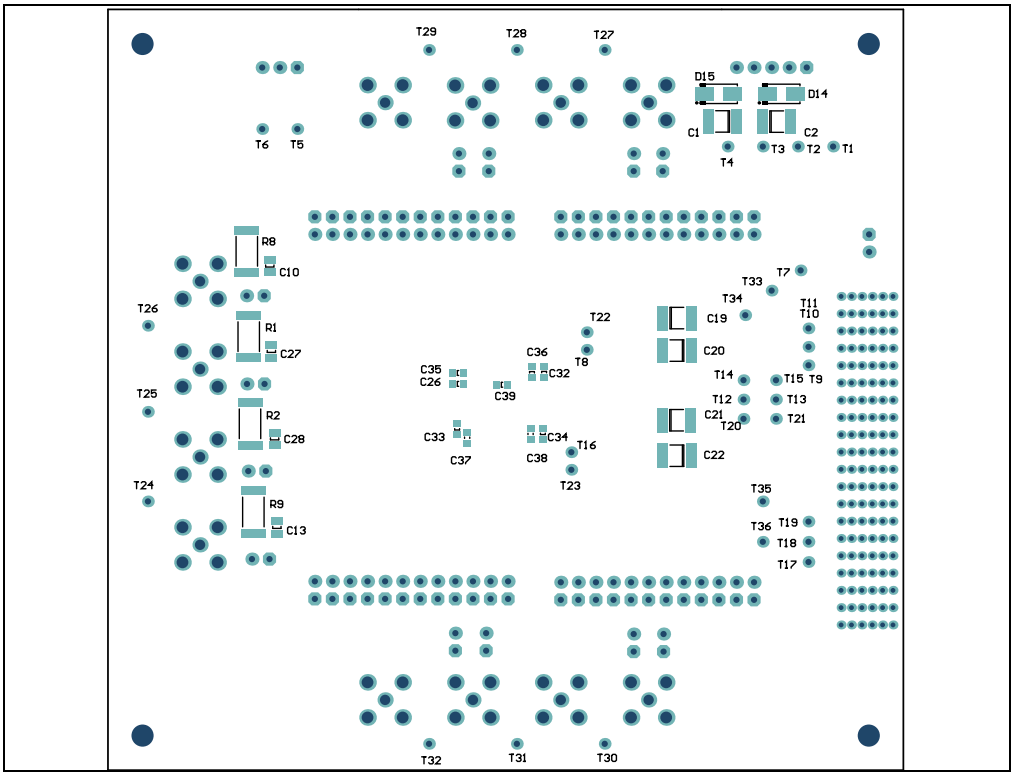
## A.9 ADM00853 - BOTTOM COPPER



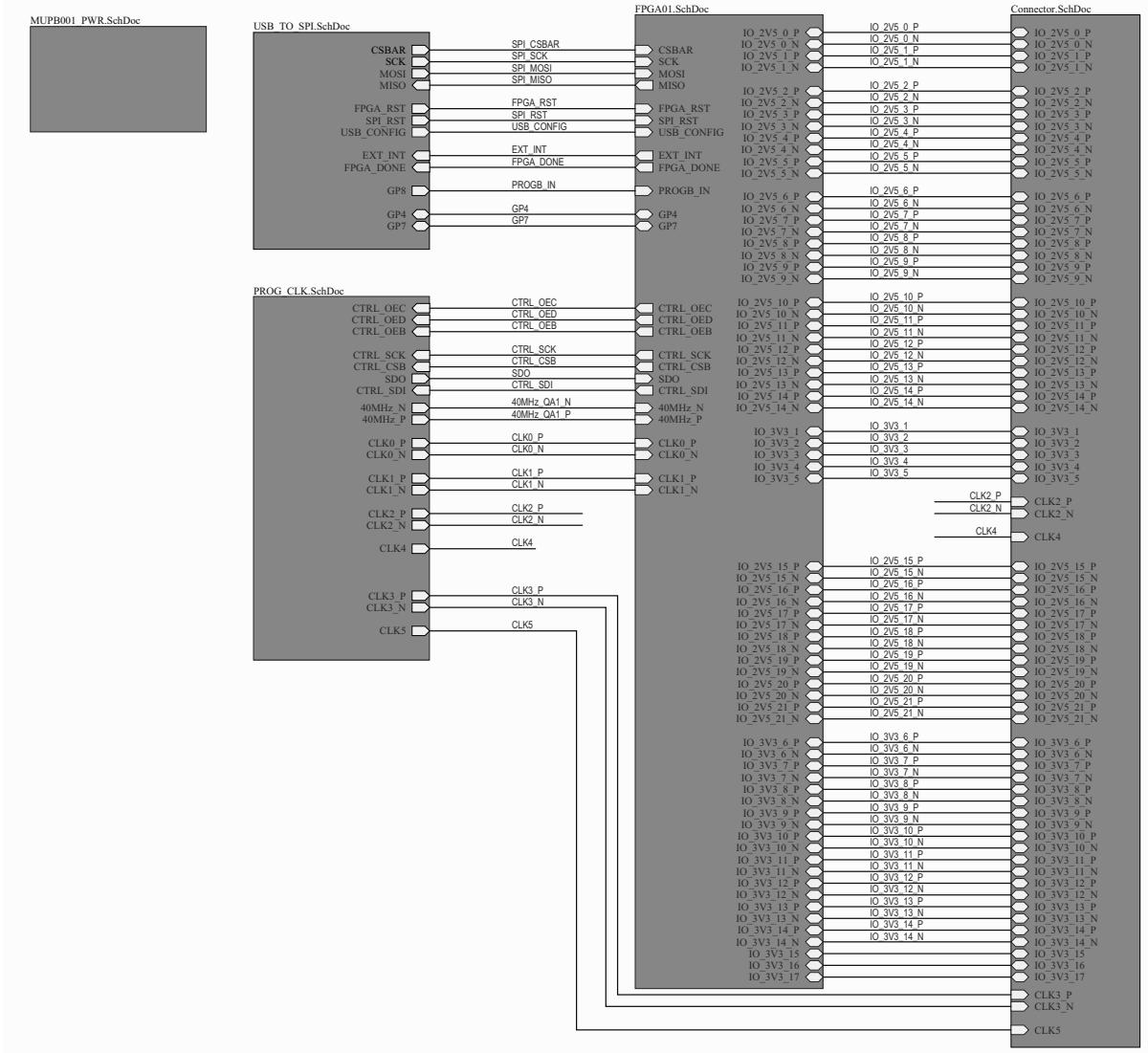
## A.10 ADM00853 - BOTTOM COPPER AND SILK



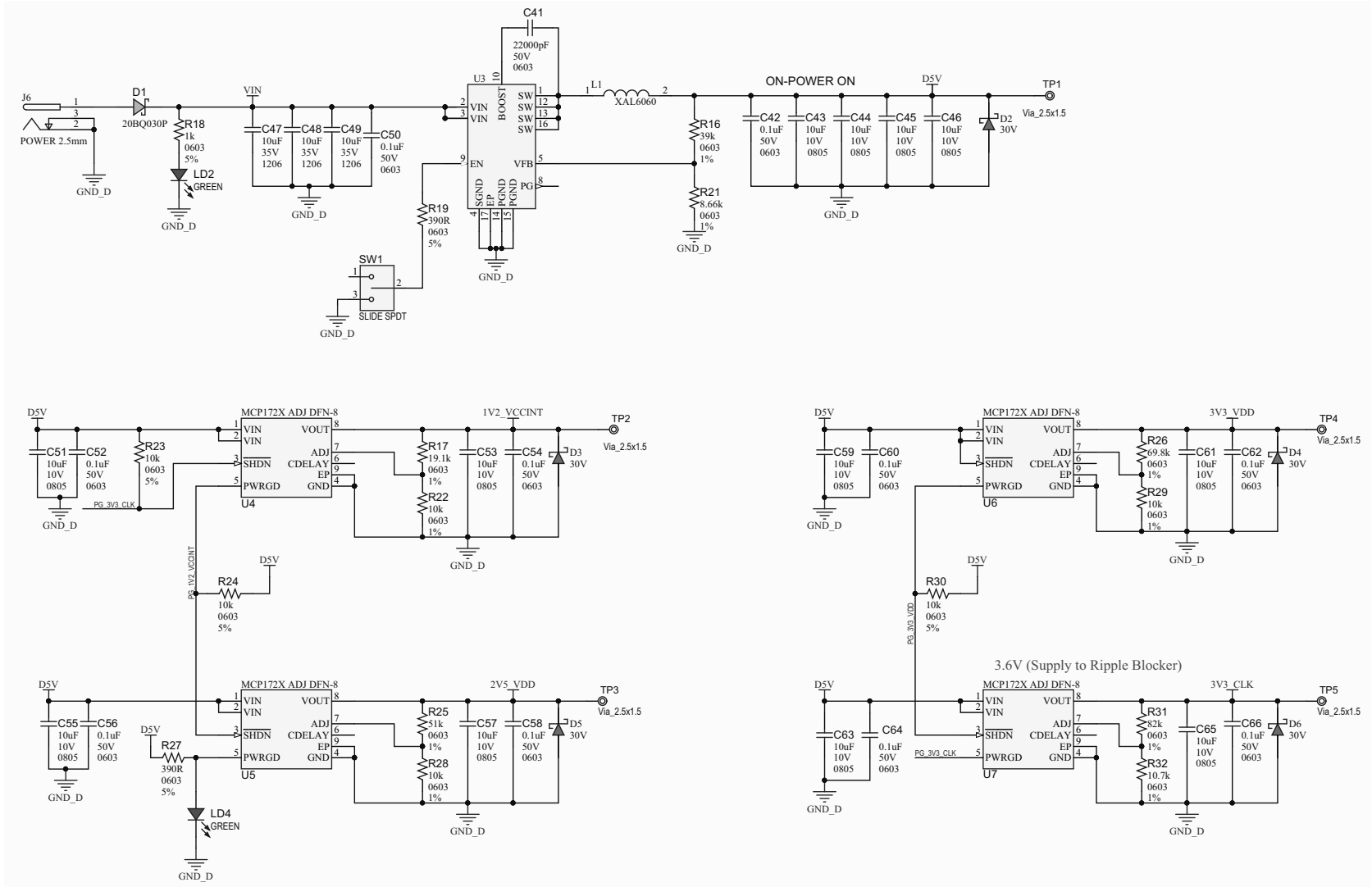
## A.11 ADM00853 - BOTTOM SILK



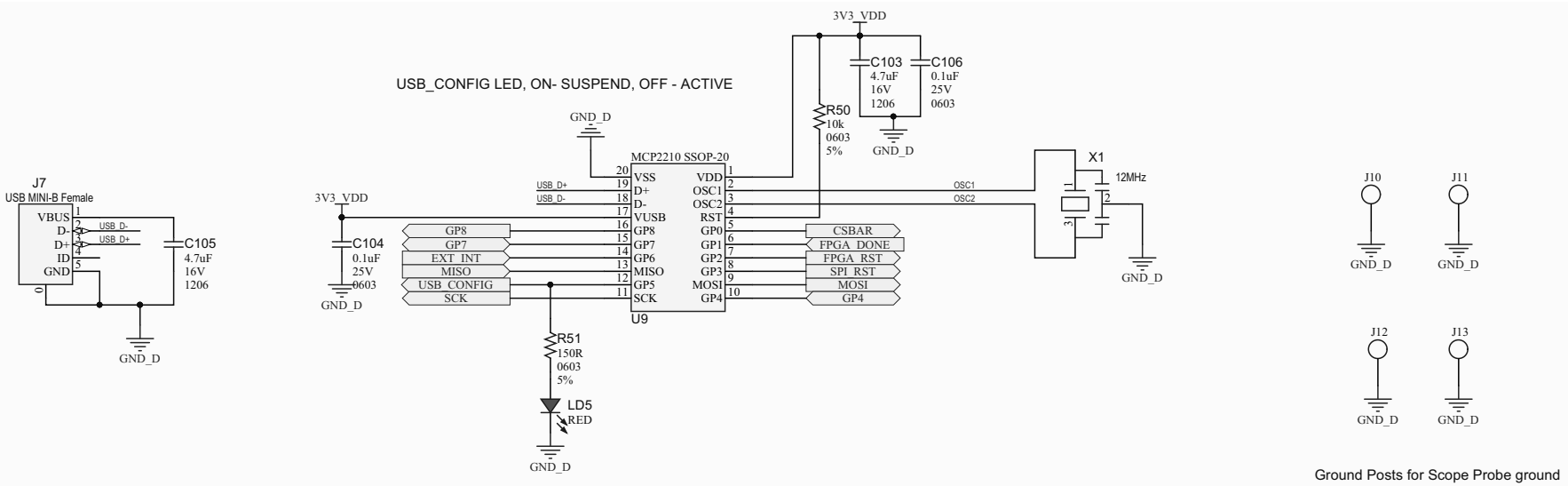
## A.12 ADM00825 - SCHEMATIC (CONNECTION)



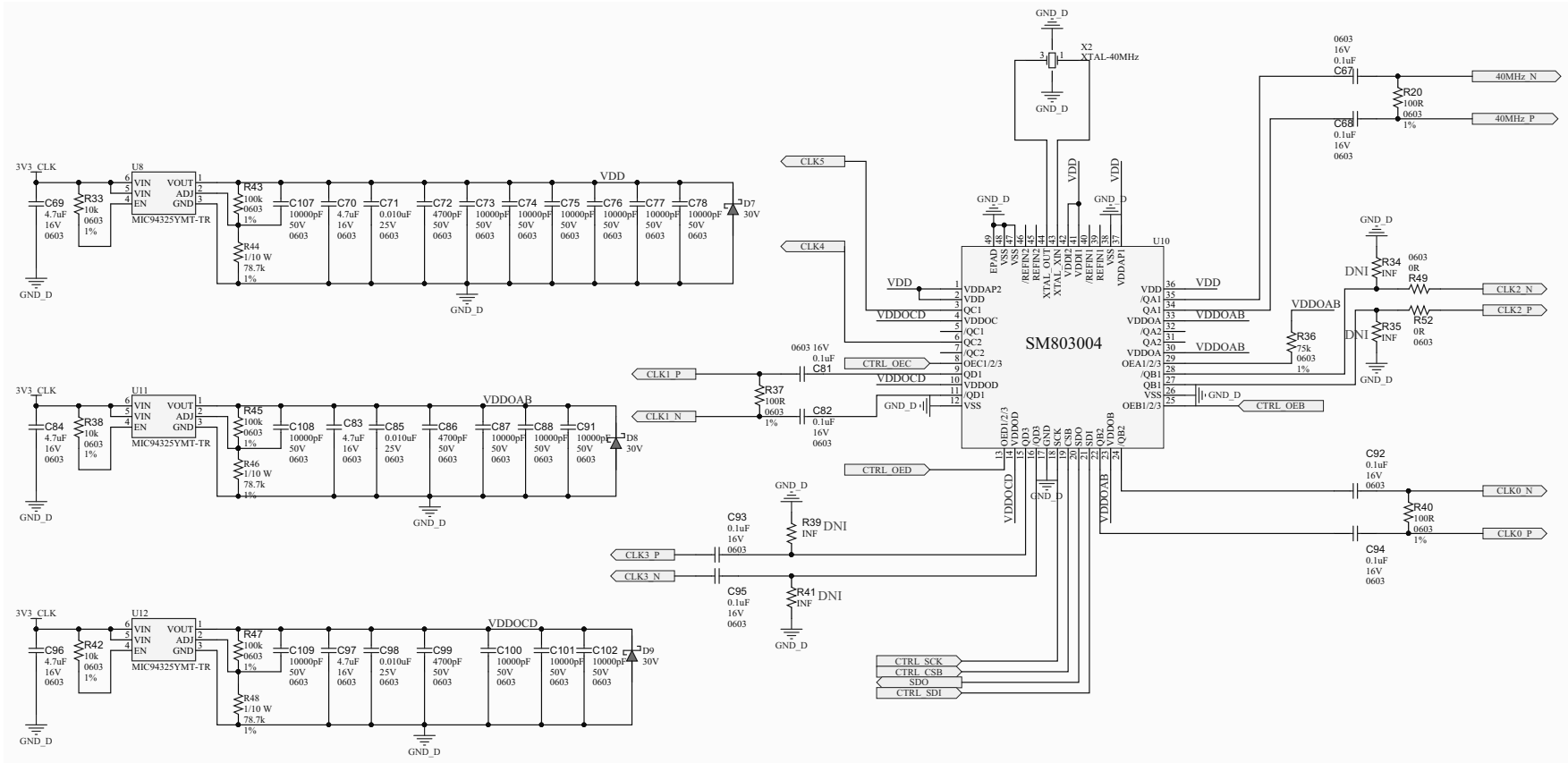
# A.13 ADM00825 - SCHEMATIC (POWER SUPPLY)



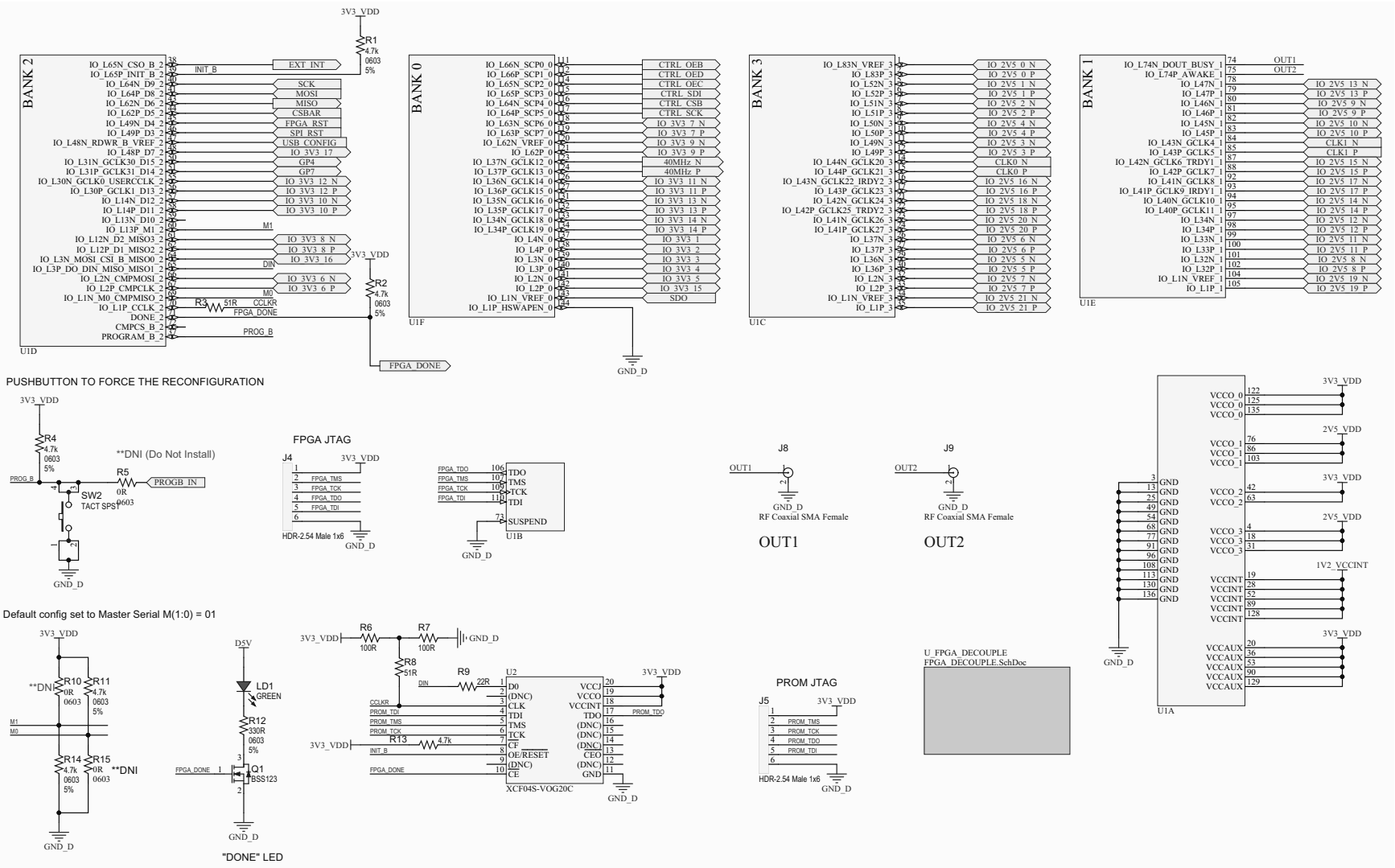
## A.14 ADM00825 - SCHEMATIC (USB TO SPI)



# A.15 ADM00825 - SCHEMATIC (PROGRAMMABLE CLOCK)

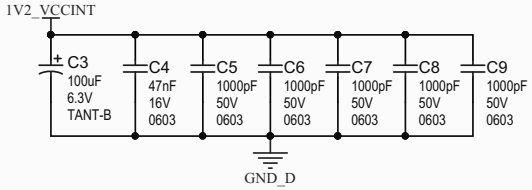


# A.16 ADM00825 - SCHEMATIC (FPGA)

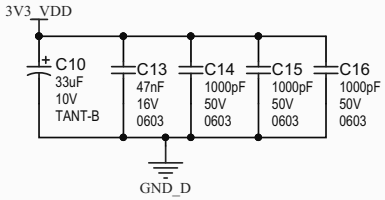


## A.17 ADM00825 - SCHEMATIC (FPGA DECOUPLING CAPACITORS)

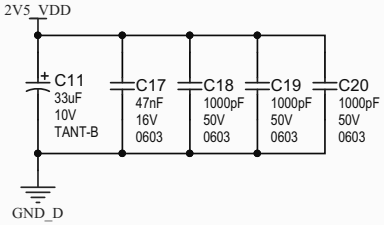
For 1V2_VCCINT



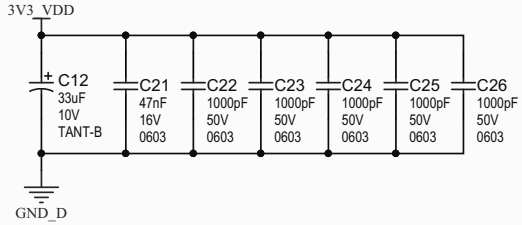

For VCCO_0



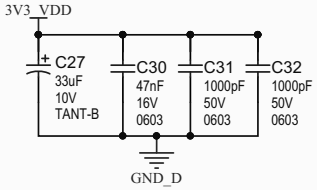

For VCCO_1



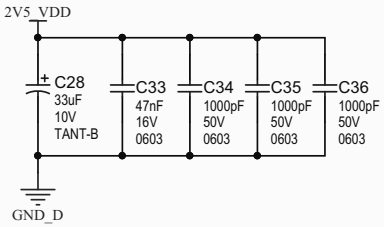

For VCCAUX



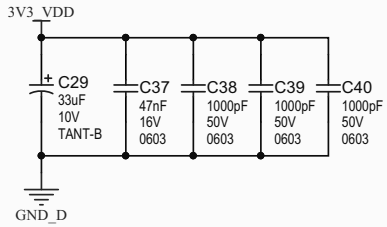

For VCCO_2



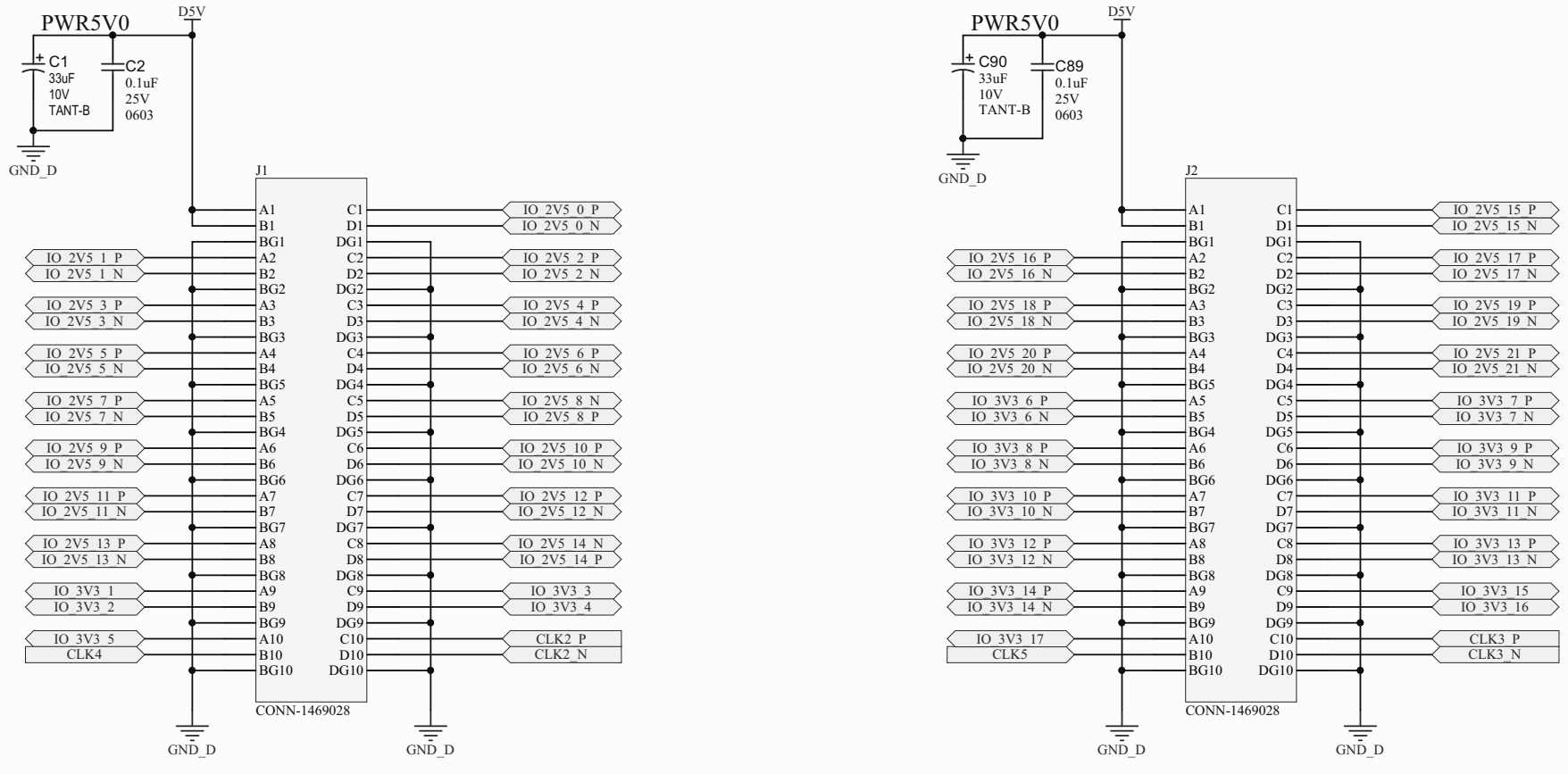

For VCCO_3



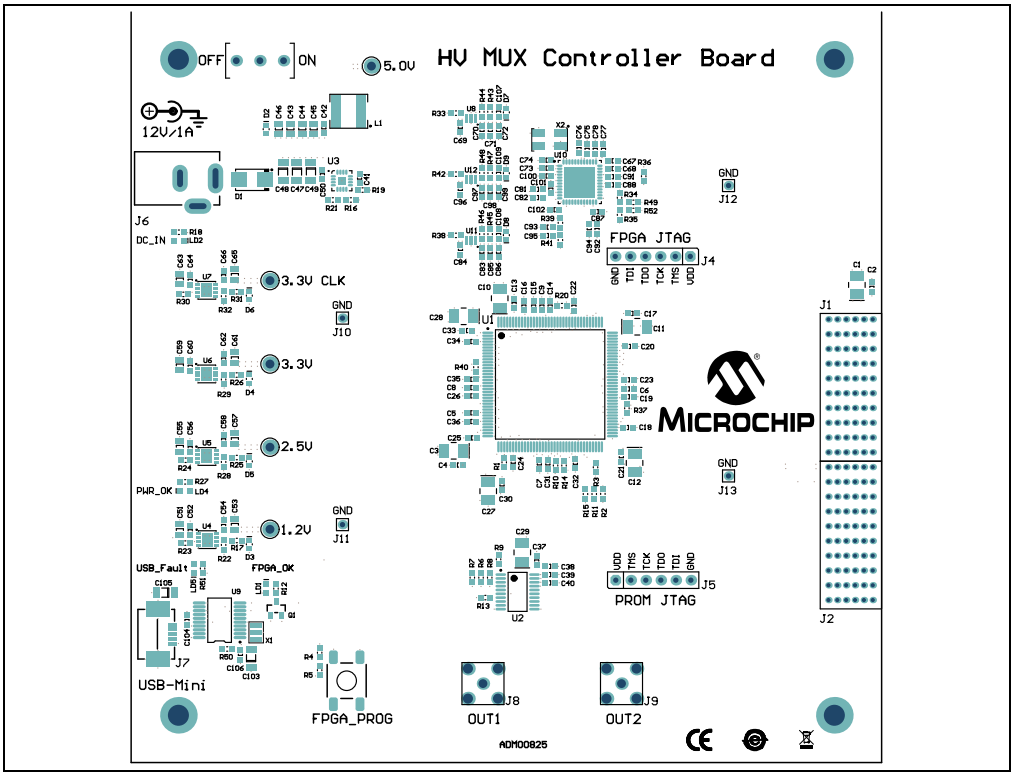

For XCF04S



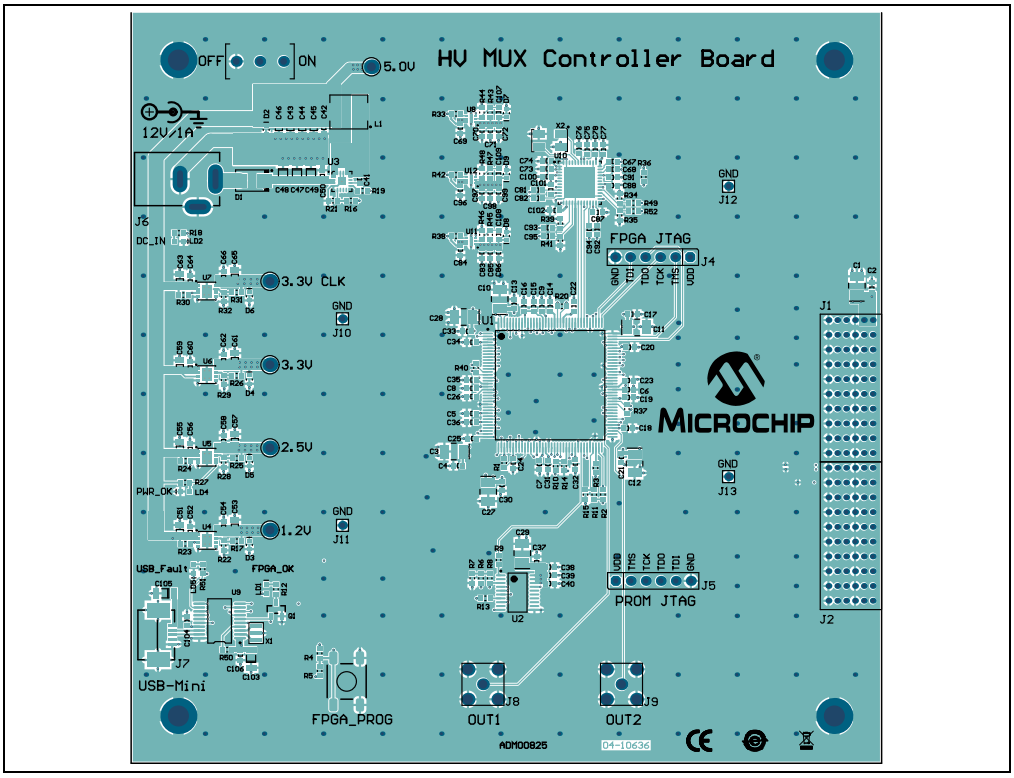
## A.18 ADM00825 - SCHEMATIC (CONNECTORS)



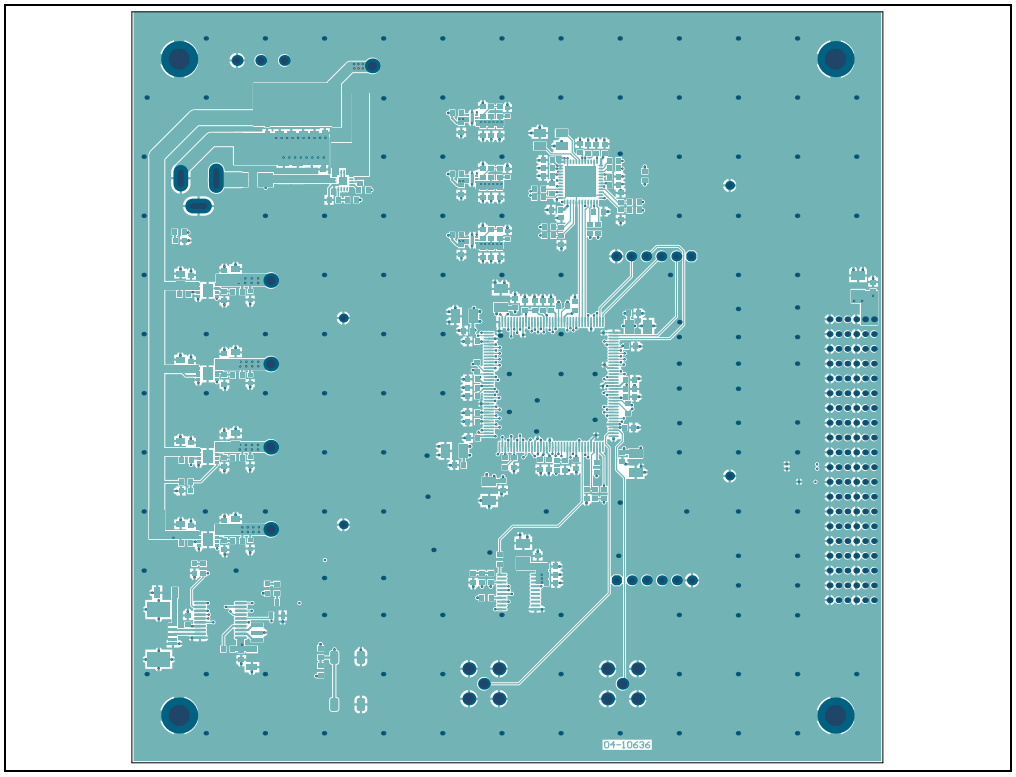
## A.19 ADM00825 - TOP SILK



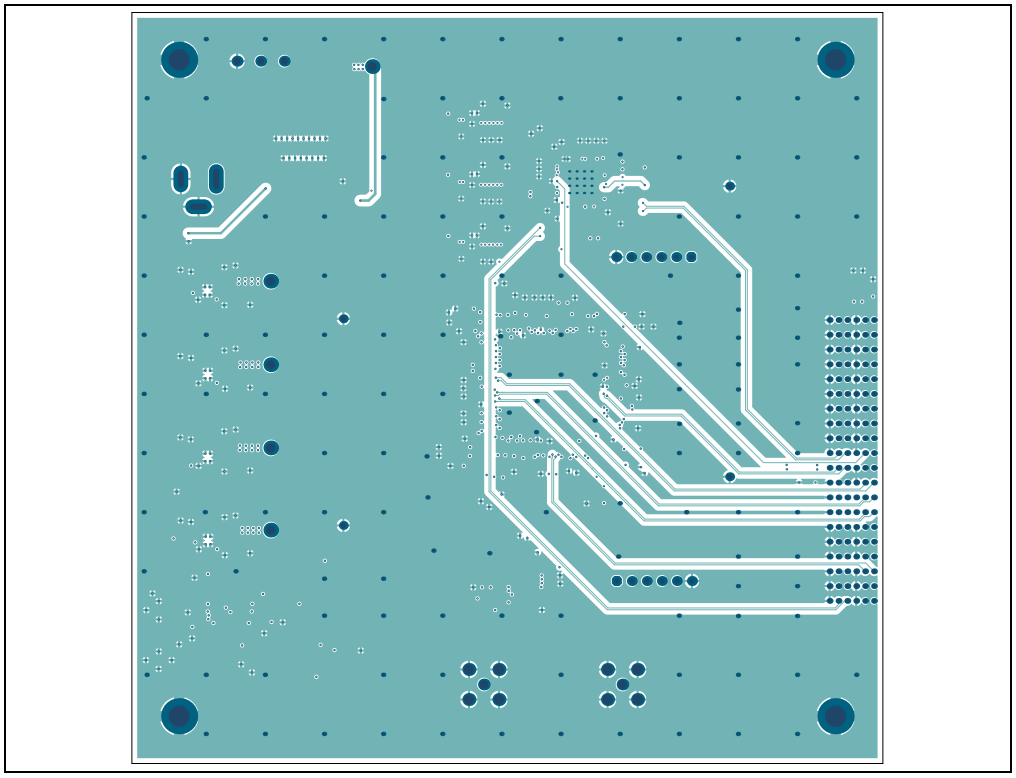

## A.20 ADM00825 - TOP COPPER AND SILK



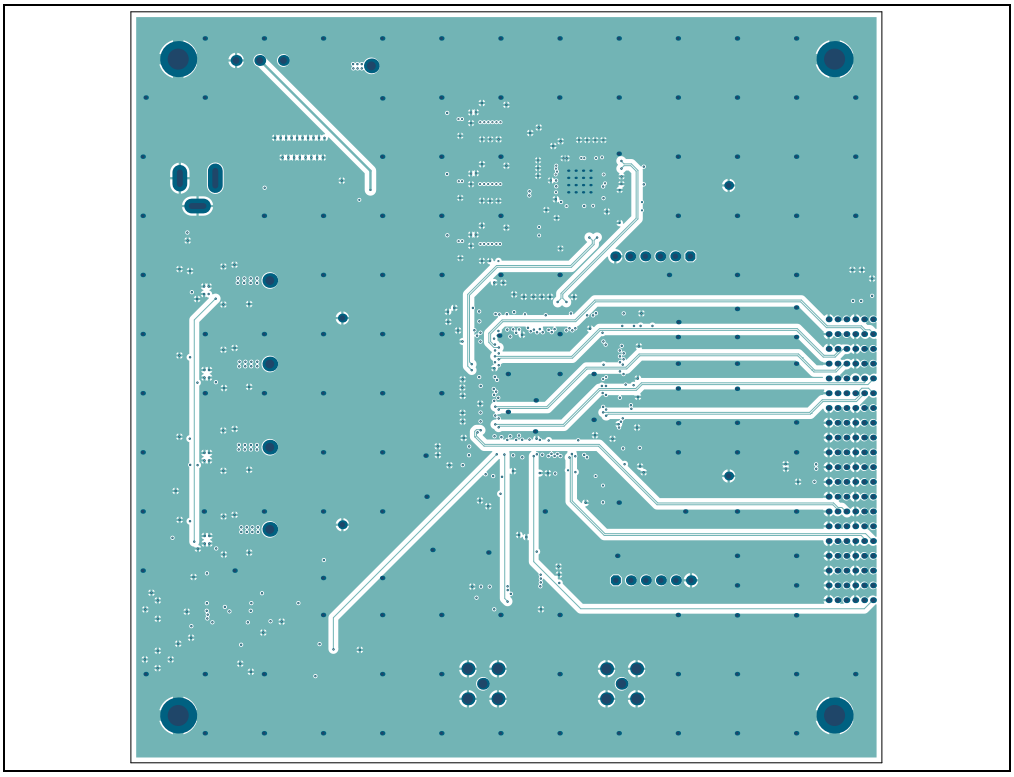
## A.21 ADM00825 - TOP COPPER



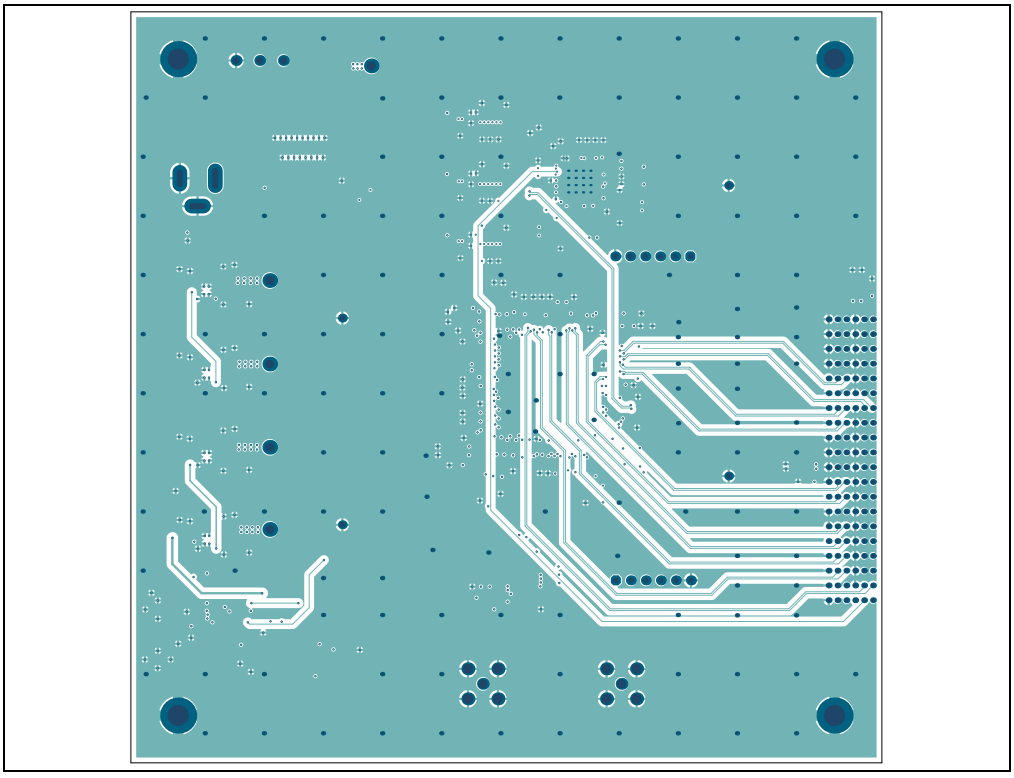

## A.22 ADM00825 - INNER 1



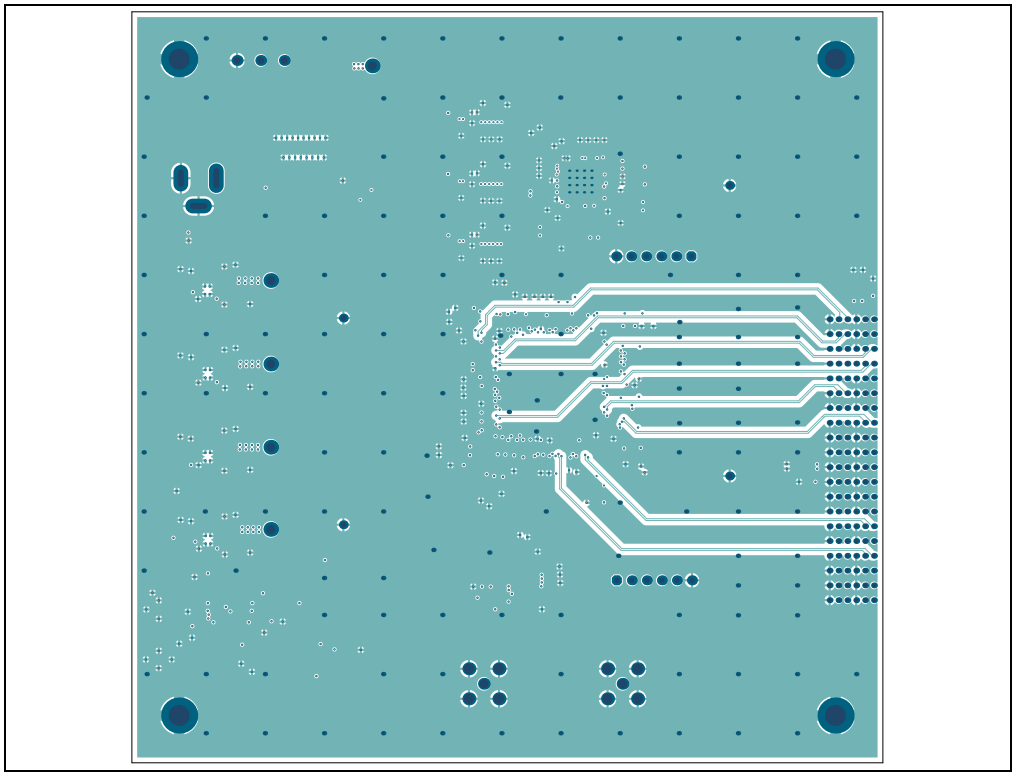
## A.23 ADM00825 - INNER 2



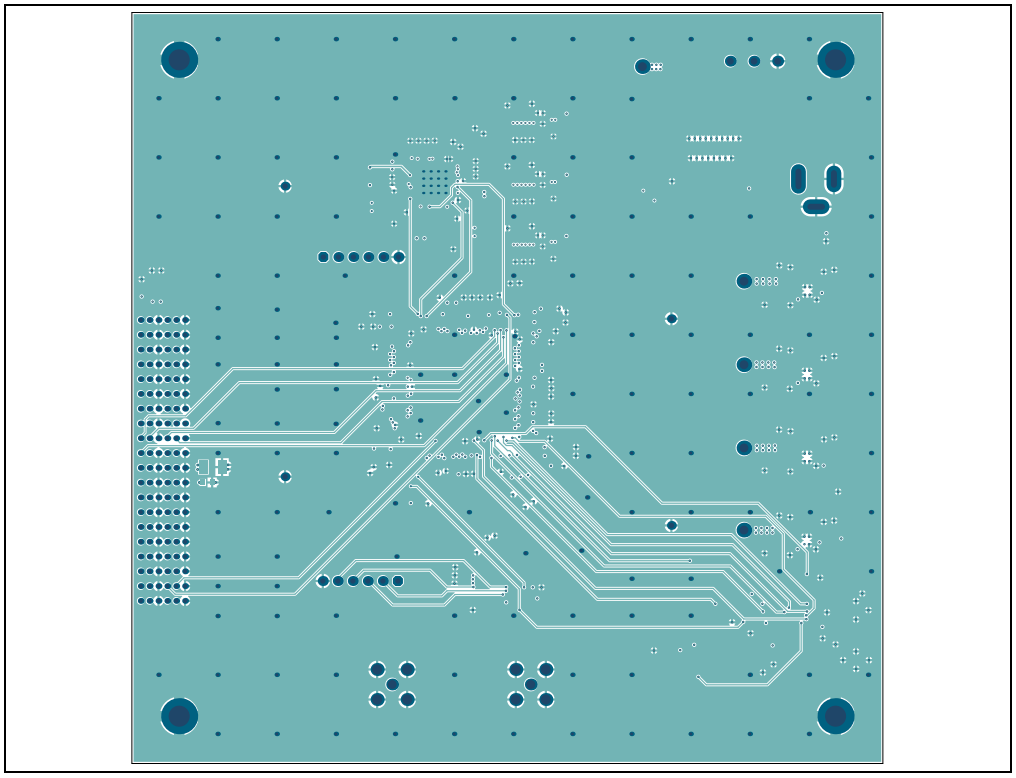
## A.24 ADM00825 - INNER 3



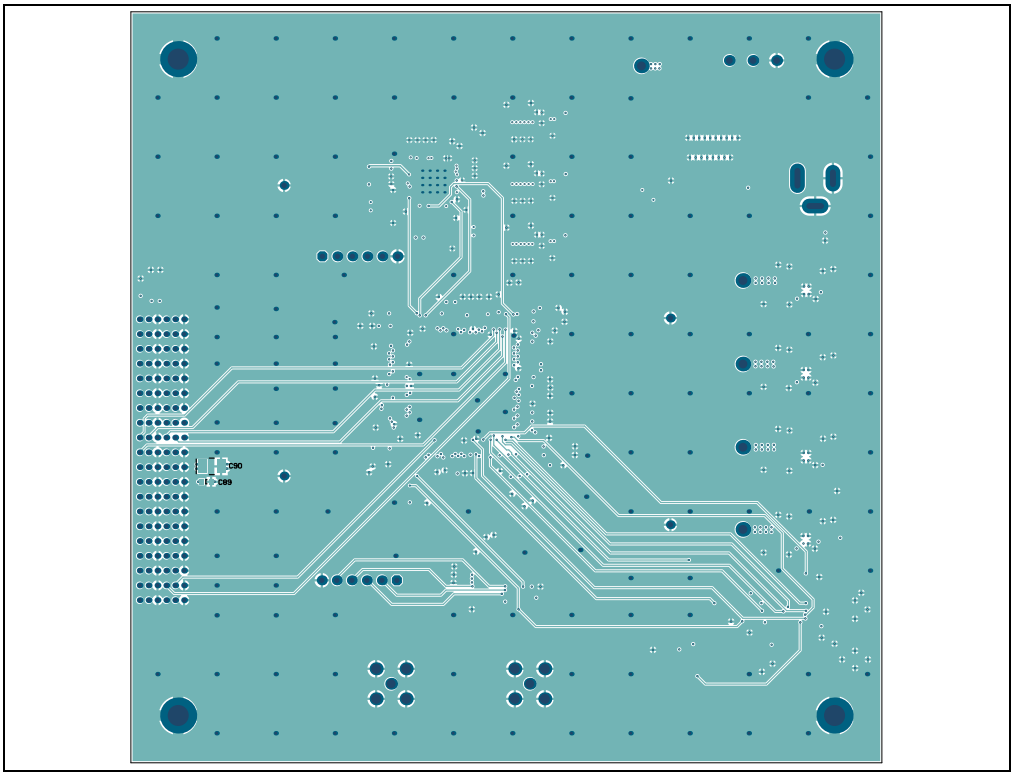
## A.25 ADM00825 - INNER 4



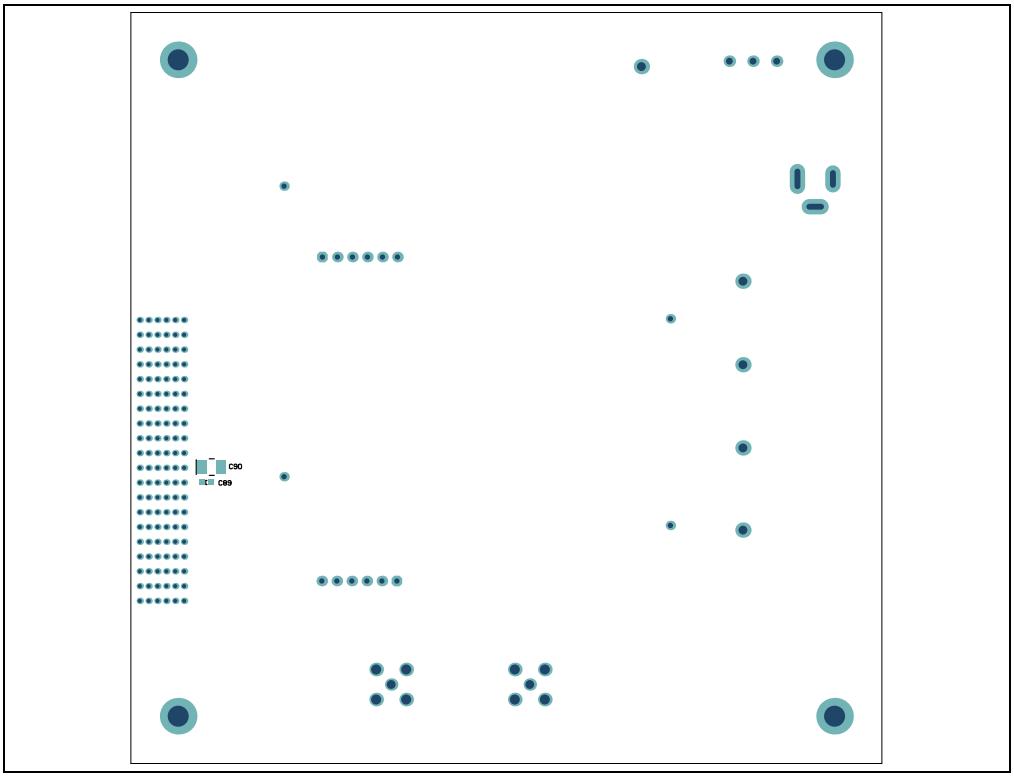
## A.26 ADM00825 - BOTTOM COPPER



## A.27 ADM00825 - BOTTOM COPPER AND SILK



## A.28 ADM00825 - BOTTOM SILK



**NOTES:**

# Appendix B. Bill of Materials (BOM)

## B.1 HV2070 ANALOG SWITCH EVALUATION BOARD (ADM00853)

**TABLE B-1: ADM00853 – BILL OF MATERIALS (BOM)**

| 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 | CONN, Header, 40 POS, 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 | CONN, SMA | TE Connectivity, Ltd. | 5-1814832-1 |
| 1 | PCB | HV2070 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 |
| 4 | R7, R11, R13, R15 | Resistor | Yageo Corporation | RC1206FR-071KL |

**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: ADM00853 – BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 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 | HV2070 | Microchip Technology Inc. | **HV2070/AJA** |
| 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 (ADM00825)

**TABLE B-2: ADM00825 – BILL OF MATERIALS (BOM)**

| 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 |

**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: ADM00825 – BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 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 |
| 8 | D2, D3, D4, D5, D6, D7, D8, D9 | Diode, Schottky, 30V, 200 mA, SOD523 | Micro Commercial Components | BAT54WX-TP |
| 2 | J1, J2 | Connector, Receptacle, 40, POS, 2 Row, RT, ANG, T/H | TE Connectivity, Ltd. | 1469028-1 |
| 4 | J10, J11, J12, J13 | Connector, PC, Pin, Circuit, 0.030, DIA, Gold | Mill-Max Mfg. Corporation | 3132-0-00-15-00-00-08-0 |
| 2 | J4, J5 | CON, HDR-2.54, Male, 1x6, Tin, 5.84, MH, TH, VERT | Sullins Connector Solutions | PEC06SAAN |
| 1 | J6 | CON, Power, 2.5 mm, 5.5 mm, Switch, TH, R/A | CUI Inc. | PJ-002B |
| 1 | J7 | CON, USB, Mini-B, Female, SMD, R/A | Hirose Electric Co., Ltd. | UX60SC-MB-5ST(80) |
| 2 | J8, J9 | CON, RF, Coaxial, SMA, Female, 2P, TH, VERT | 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 |

**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: ADM00825 – BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 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, TF, 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 |
| 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 |

**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: ADM00825 – BILL OF MATERIALS (BOM) (CONTINUED)**

| Qty. | Reference | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | SW1 | Switch, Slide, SPDT, Mini, 50V, 0.5A, G4050X-R TH | Jameco® Electronics | G4050X-R |
| 1 | SW2 | Switch, Tact, SPST, 12V, 50 mA, TL3301NF, 160QG/TR, SMD | E-Switch®, Inc. | TL3301NF260QG/TR |
| 1 | U1 | IC FPGA, 102, I/O, 144T, QFP | 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

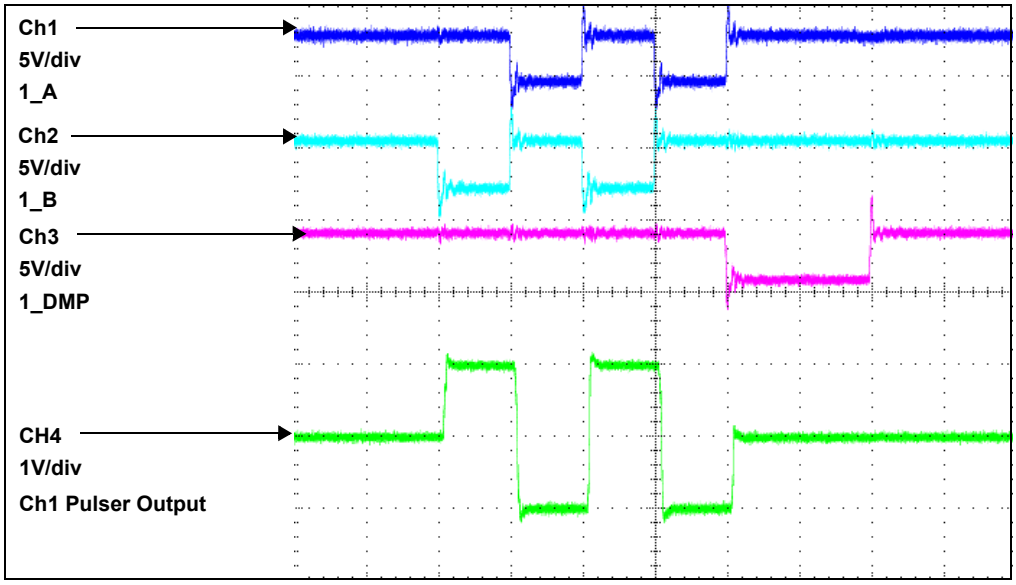



***FIGURE C-1:*** *5 MHz 4 Pulses Ch1 Pulser Input and Output When All SW OFF.*

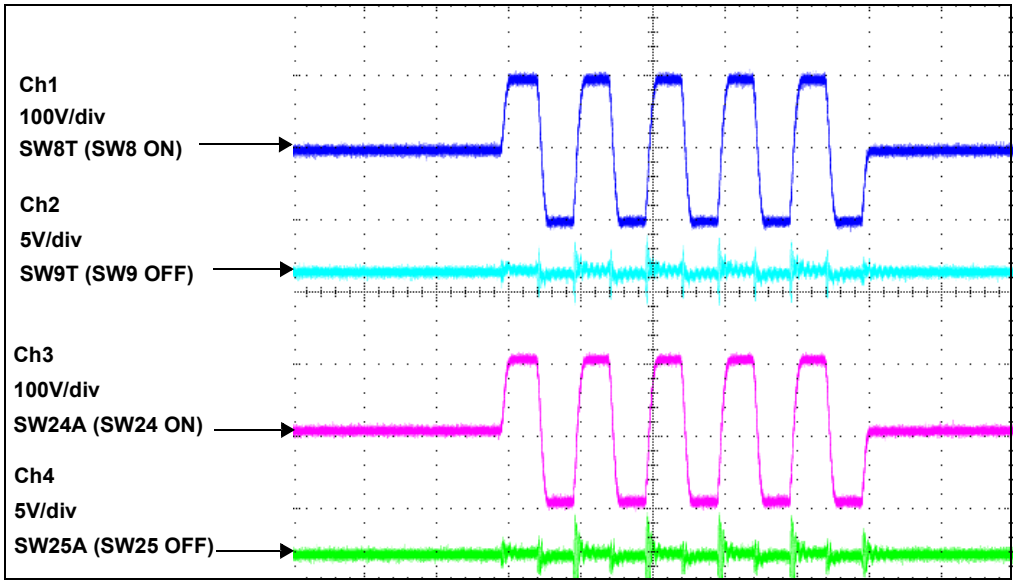



***FIGURE C-2:*** *5 MHz 10 Pulses, VPP/VNN = ±100V, VDD/VSS = ±6V, VGP = 10V, 330 pF//2.5 KΩ Load.*

**NOTES:**

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