TDC7201-ZAX-EVM

This guide details the use of the TDC7201-ZAX-EVM Evaluation Module (referred to as TDC7201EVM for the remainder of this document). The TDC7201EVM is an evaluation module that allows users to evaluate the operation and performance of the TDC7201 Time-to-Digital Converter. One example application that requires accurate time-to-digital conversion is LIDAR.

The TDC7201EVM connects to the MSP430 LaunchPad evaluation kit for capturing data, and it connects to a user-friendly Graphic User Interface (GUI) to modify the registers and display the data.

Contents

Trademarks

1 General Description

1.1 TDC7201EVM Key Features

1. Evaluate TDC7201 Time-to-Digital Converter
2. Connects with MSP430 Launch Pad (MSP-EXP430F5529LP)
3. User-friendly TDC720xEVM GUI interface
4. Connection for START1, START2, STOP1, and STOP2 inputs
5. Powered by MSP430 LaunchPad (no external power needed)

1.2 TDC7201EVM

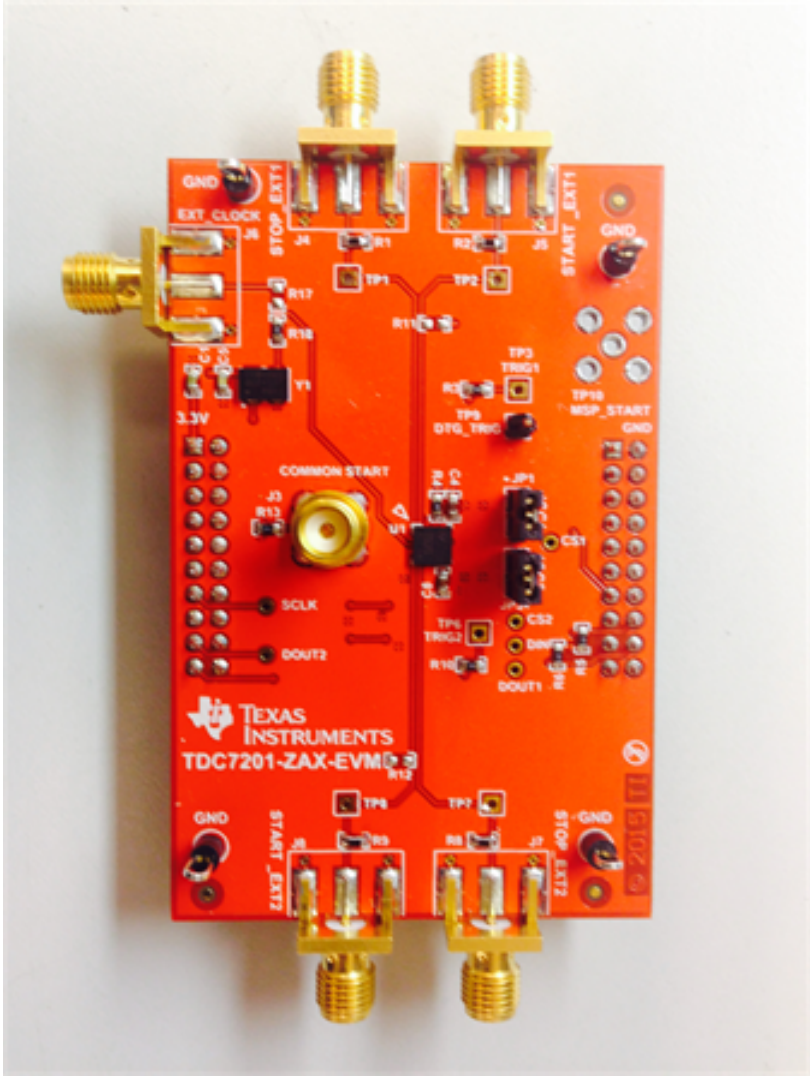

Figure 1. TDC7201EVM Evaluation Board

2 Equipment List

1. TDC7201EVM
2. TDC720xEVM GUI (http://www.ti.com/tool/tdc7201-zax-evm)
3. MSP430 launchpad (http://www.ti.com/tool/msp-exp430f5529lp)
4. Micro-USB cable
5. Dual function generator (for example: Tektronix AFG3102 1GS/s, 100MHz)
6. PC with Windows XP or Windows 7
7. 4 BNC-to-SMA cables

3 Quick Start

1. Download and Install TDC720xEVM (GUI) Software. See Section 4 for more information.
2. Connect the USB cable from the MSP430 LaunchPad to the PC.
3. Connect the TDC7201EVM to the MSP430 LaunchPad via J1 and J2.
4. Connect START1 and STOP1 pulses to the TDC7201EVM via J5 and J4. See Section 5 for more information.
5. Launch the GUI. See Section 6 for more information.
6. On the **GRAPH** tab, press the **START GRAPH** button.

4 Software Installation

This section describes software installation, firmware upgrade, and how to update USB Driver.

4.1 Installing the TDC720xEVM GUI

1. Download the TDC720xEVM Software GUI zip file to your desktop. This should be located in http://www.ti.com/tool/tdc7201-zax-evm.
2. Unzip the file.
3. Run the **setup.exe** file.
4. Follow the instructions to install the GUI.
5. Once done, you should be able to see the installation in default installation folder; for example, C:\Program Files (x86)\Texas Instruments\TDC720xEVM.

4.2 MSP430 Firmware Upgrade (This is only needed for a new Launchpad.)

1. Open the **TDC720xEVM GUI**.
2. Click on the **Debug** tab.
3. Click on **Update Firmware**.
4. Click **Next** to proceed on the first prompt; read and accept the license agreement, and click **Next** to continue.
5. Choose **Select Firmware**, and then click **Browse**.
   a. Go to the folder where you downloaded the TDC720xEVM GUI. The default install folder is C:\Program Files (x86)\Texas Instruments\TDC720xEVM
   b. Find the Firmware folder. It is located within the default installation folder, C:\Program Files (x86)\Texas Instruments\TDC720xEVM\Firmware
   c. Select the TDC720xEVM firmware text file.
6. On the MSP430 LaunchPad board, press the **BSL button** (S5) and **connect the MSP430 Launch Pad to your PC** using a **USB cable**. If detected, the text displayed on the Firmware Upgrade tool changes from **No device connected** to **Found 1 device**. See Figure 2.
7. On the MSP430 USB Firmware Upgrade GUI, click **Upgrade Firmware**.
8. Click **Close** when done.

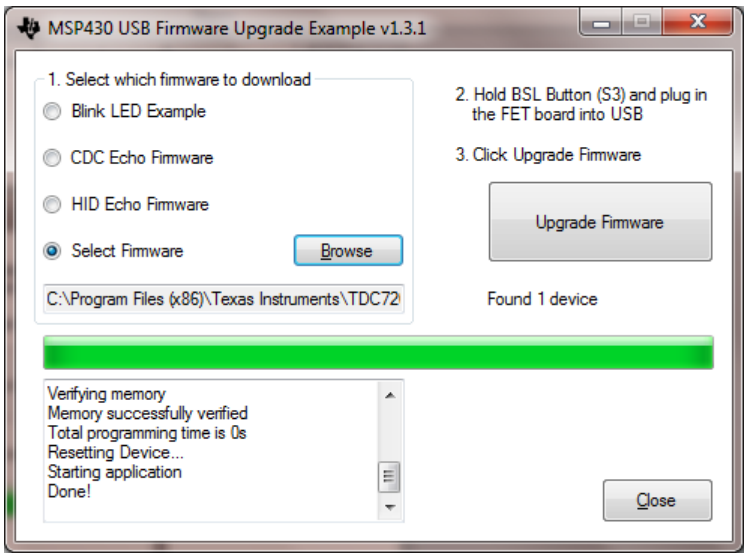

Figure 2. Upgrading MSP430 Firmware

4.3 Checking Connection

1. If you haven't done so, connect the **USB cable** from the MSP430 Launch Pad to your PC.
2. If you haven't done so, connect the **TDC7201EVM** to the MSP430 Launch Pad via J1 and J2 as shown in Figure 6.
3. Open the computer's **Device Manager** . To do this, right-click **My Computer**, click **Properties**, and select **Device Manager**.
4. Scroll down to **Ports (COM & LPT)** and check **TDC7200EVM (COMx)** connection as shown in Figure 3.

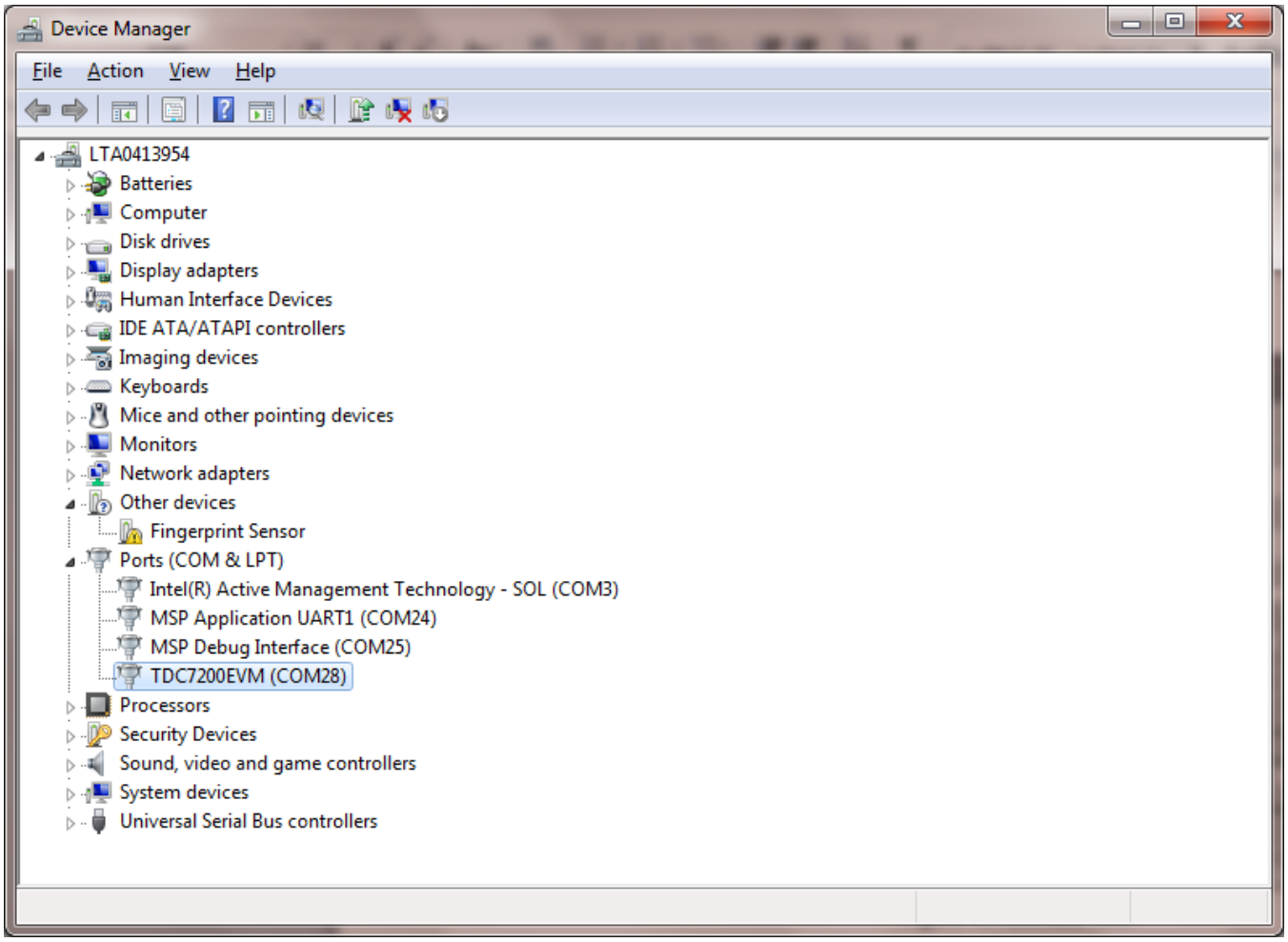

Figure 3. Device Manager

4.4 Opening the GUI

1. If you haven't done so, connect the **USB cable** from the **MSP430 Launch Pad** to your **PC.**
2. If you haven't done so, connect the **TDC7201EVM** to the MSP430 Launch Pad via J1 and J2 as shown in Figure 6.
3. Run the TDC720xEVM GUI from the Start Menu. By default, it is located in **Programs\Texas Instruments\TDC720xEVM**.
4. GUI should automatically connect and show the screen depicted in Figure 4.

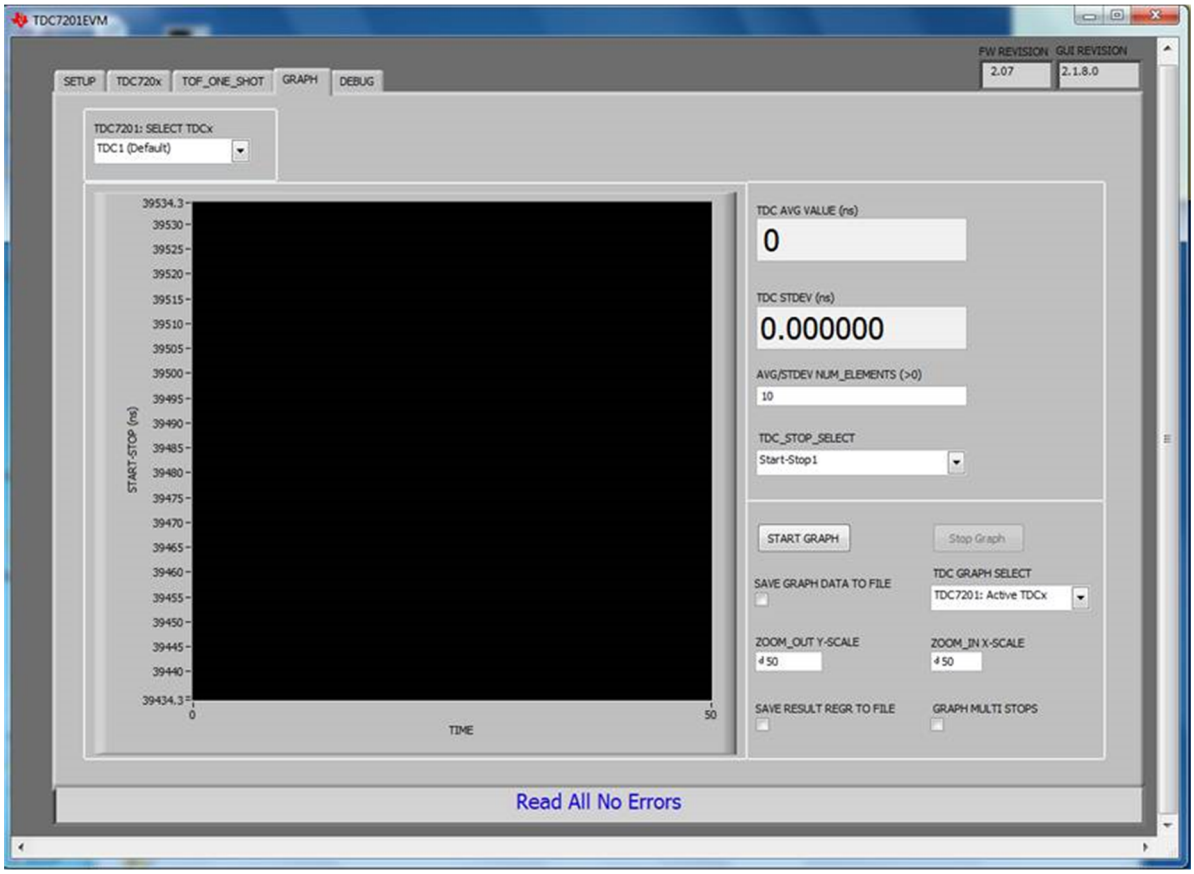

Figure 4. TDC720xEVM GUI

5 Hardware Configuration

This section describes how to properly set up the connections on the EVM

5.1 TDC7201EVM Connections

1. If you haven't done so, connect the **USB cable** from the **MSP430 Launch Pad** to your **PC**.
2. If you haven't done so, connect the TDC7201EVM to the **MSP430 Launch Pad** via **J1** and **J2** as shown in Figure 6.
3. **Setting the Dual Channel Function Generator**:
   i. Set channel 1 of the dual function generator to the following (see Figure 5):
      i. Pulse 1-Cycle
      ii. Burst mode
      iii. Freq = 40 kHz
      iv. Delay = 0 s
      v. Amplitude = 3.3 Vpp
      vi. Offset = 1.65 V
      vii. Duty = 20%
      viii. Burst Trigger Source = External
   ii. Set channel 2 of the dual function generator to the following (see Figure 5):
      i. Pulse 1-Cycle
      ii. Burst mode
      iii. Freq = 40 kHz
      iv. Delay = 19 µs --> **this is the time-of-flight (TOF)**
      v. Amplitude = 3.3 Vpp
      vi. Offset = 1.65 V
      vii. Duty = 20%
      viii. Burst Trigger Source = External

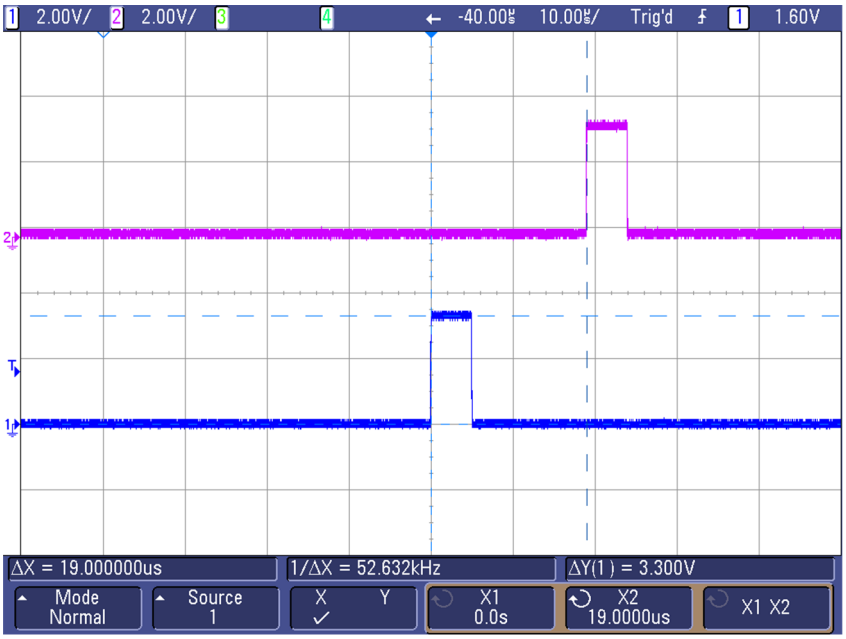

Figure 5. START and STOP Signals Scope Shot

4. **Connecting the Input Signal**:
   a. Using a USB-to-SMA cable, connect channel 1 of the dual function generator to TDC7201EVM's **START1_EXT** connector (J5).
   b. Using a USB-to-SMA cable, connect channel 2 of the dual function generator to TDC7201EVM's **STOP1_EXT** connector (J4). See Figure 6.
5. Connecting the Trigger Input:
   a. Connect DTG_TRIG (TP9) to the TRIGG input of the dual function generator. DTG_TRIG is generated by the MCU whenever a new measurement is started by the TDC7201. See Figure 6 and Figure 7.

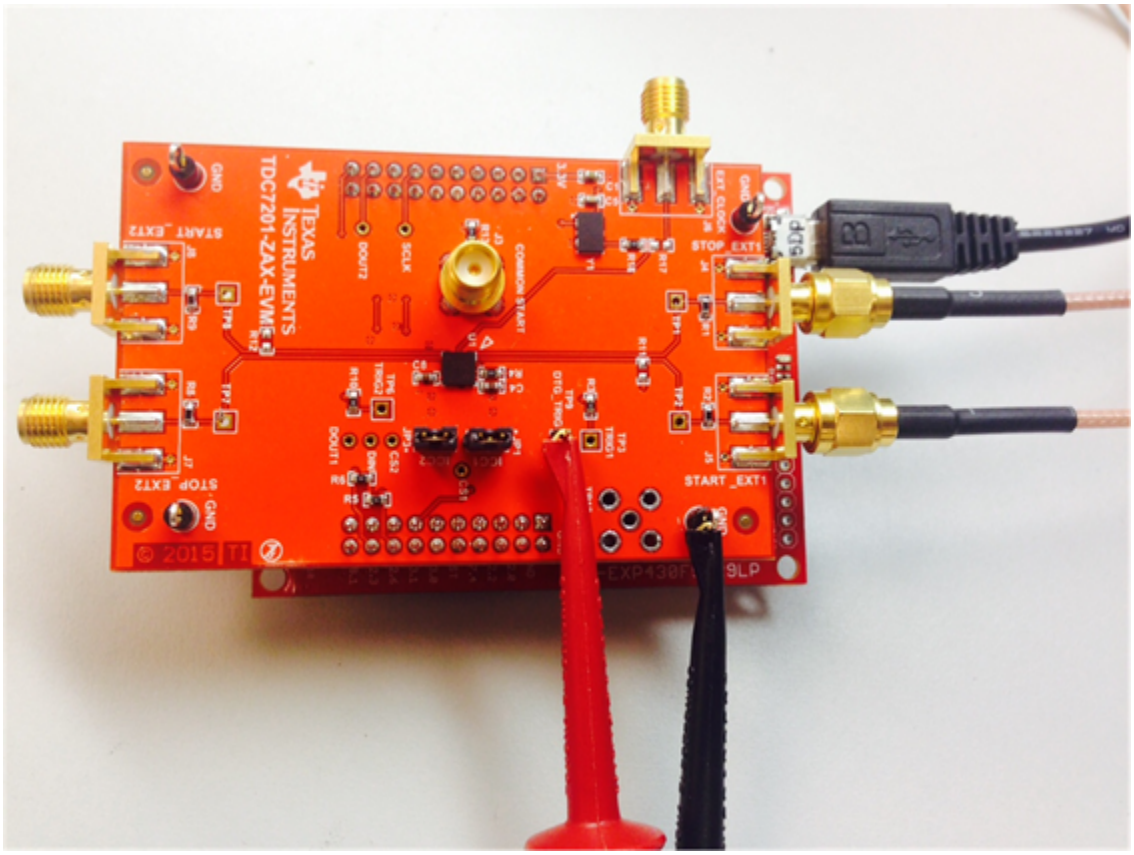

Figure 6. TDC7201EVM Connection Setup

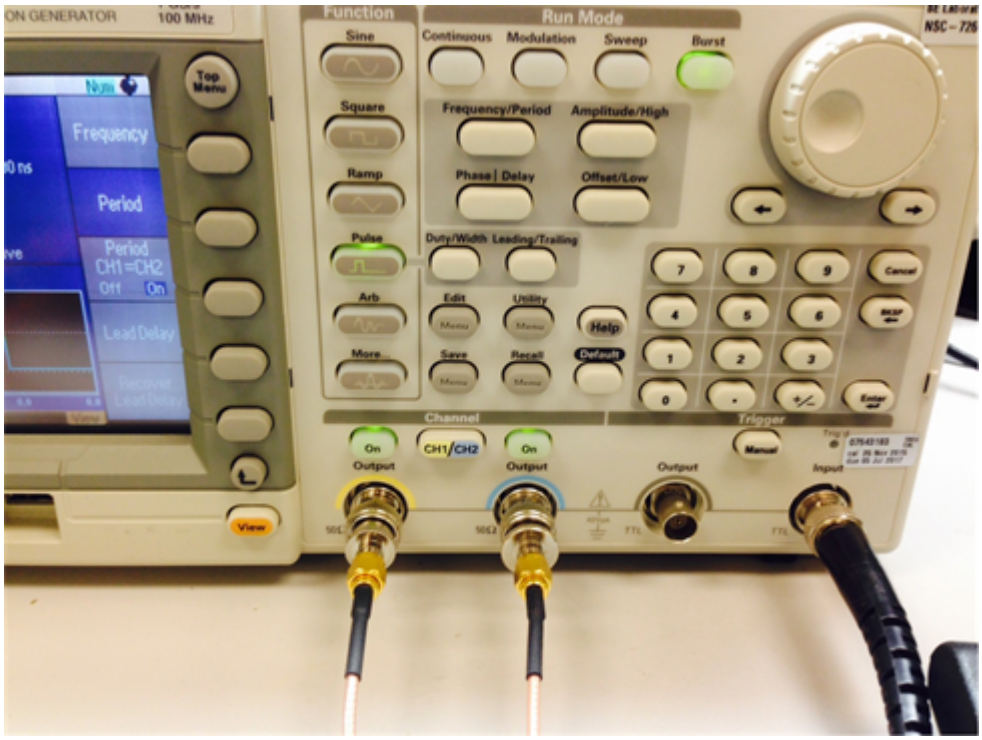

Figure 7. Tektronix AFG3102 Connections

5.2 Jumpers

The following shows the jumper connection:

1. JP1: Jumper for VCC power
   a. Connect Pin 1 to Pin 2 – power VCC via MSP430 (**recommended**)
   b. Open Pin 1 and Pin 2 – no connection to VCC via MSP430; need to apply external power
2. JP2: Jumper for CLOCK source
   a. Connect Pin 1 to Pin 2 – power VCC via MSP430 (**recommended**)
   b. Open Pin 1 and Pin 2 – no connection to VCC via MSP430; need to apply external power

6 GUI and Operation

1. If you haven't done so, open the **TDC720xEVM GUI**. The EVM GUI software can be run by clicking on **Start**, then clicking **All Program**s, **Texas Instruments**, and **TDC720xEVM** and selecting **TDC720xEVM**.
2. Click on the **TDC720x** tab and make sure TDC1 is selected with the register configuration in Figure 8:

Figure 8. Recommended TDC7201:TDC1 Register Configuration

3. Click on the **Graph** tab, then click on **START GRAPH**. You should be able to read **19 µs** (assuming you follow the instructions as specified in Section 5.1).

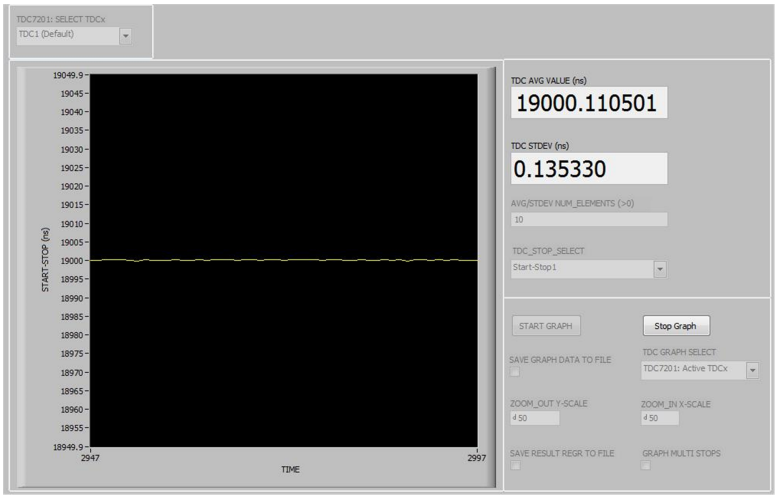

Figure 9. Graphing

4. **Calculating Time-of-Flight:**
   a. In the GUI, click on the **TOF_ONE_SHOT** tab.
   b. You should be able to see *similar* measurement results register values as shown in Figure 10 (assuming you follow the instructions as specified in Section 5.1).

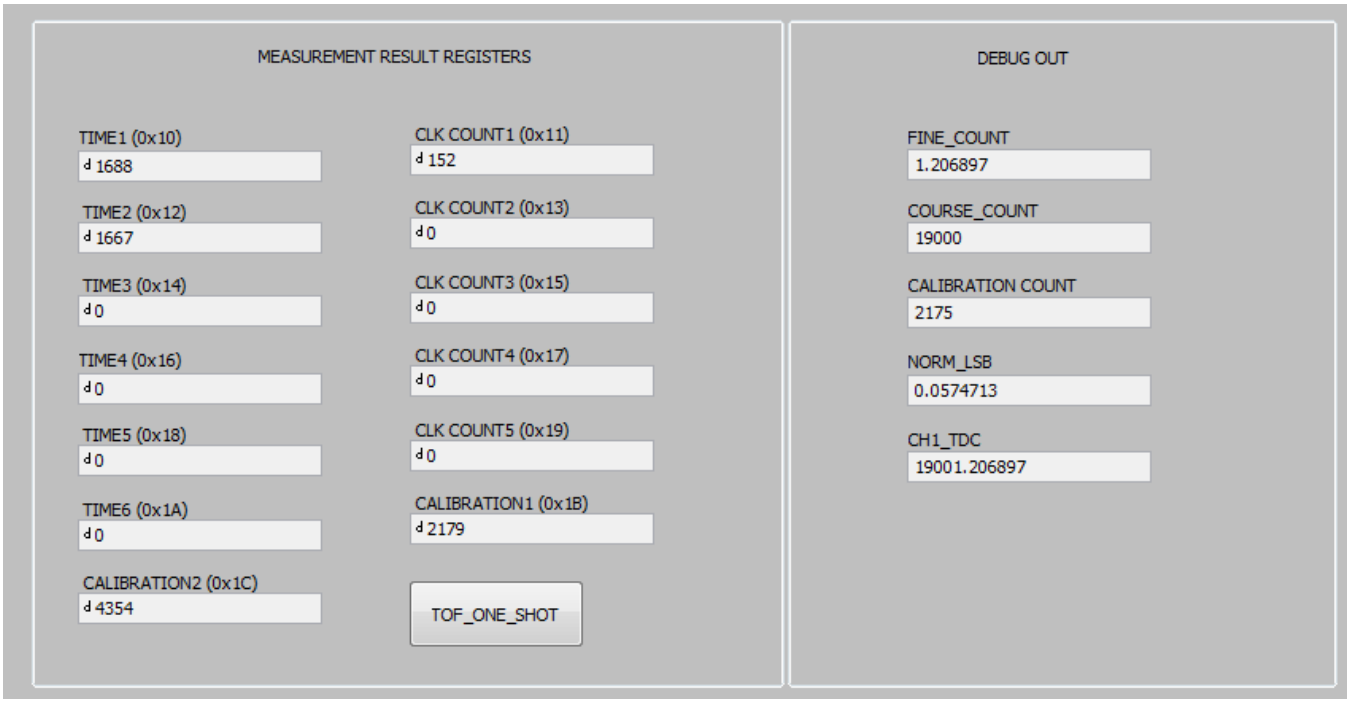

Figure 10. Measurement Results

   c. To calculate the time-of-flight, use the Measurement Mode 2 Time-of-Flight calculation as shown in Equation 1. For more information, refer to the TDC7201 data sheet (SNAS686).
   d. Use the values reported in the Measurement Result Registers (Figure 10) to validate the time-of-flight as approximately 19 µs (assuming you follow the instructions as specified in Section 5.1).

$$TOF_n = \left[(TIME1)(normLSB) + offset\right] + (CLOCK\_COUNT_n)(CLOCKperiod) - \left[(TIME_{n+1})(normLSB) + offset\right]$$

$$TOF_n = normLSB(TIME1 - TIME_{n+1}) + (CLOCK\_COUNT_n)(CLOCKperiod)$$

$$normLSB = \frac{(CLOCKperiod)}{(calCount)}$$

$$calCount = \frac{CALIBRATION2 - CALIBRATION1}{(CALIBRATION2\_PERIODS) - 1}$$

where

- TOFn [second] = time-of-flight measurement from the START to the nth STOP
- normLSB [sec] = normalized LSB value from calibration
- TIME1 = time 1 measurement given by the TDC7201 register address 0x10
- $TIME_{n+1}$ = (n+1) time measurement given by the TDC7201 register addresses 0x12, 0x14, 0x16, 0x18, and 0x1A
- CLOCK_COUNTn = nth clock count values in register addresses 0x11, 0x13, 0x15, 0x17, and 0x19
- CLOCKperiod [sec] = external CLOCK period
- offset [sec]= constant measurement offset
- CALIBRATION1 [count] = TDC count for first calibration cycle, located in register address 0x1B
- CALIBRATION2 [count] = TDC count for second calibration cycle, located in register address 0x1C
- CALIBRATION2_PERIODS = calibration count bits, located in register address 0x01 (1)

$$calCount = \frac{CALIBRATION2 - CALIBRATION1}{(CALIBRATION2\_PERIODS) - 1} = \frac{(4354 - 2179)}{(2) - 1} = 2175$$

$$normLSB = \frac{(CLOCKperiod)}{(calCount)} = \frac{(1/8MHz)}{2175} = 57.4ps$$

$$TOF1 = normLSB(TIME1 - TIME2) + (CLOCK\_COUNT1)(CLOCKperiod)$$

$$TOF1 = (5.74 * 10^{-11})(1688 - 1667) + (152)(1/8MHz)$$

$$TOF1 = 19.001us \quad (2)$$

5. START_EXT2/STOP_EXT2 Testing
   a. Modification to Input Signal Connections:
      1. Disconnect USB-to-SMA cable connection to START_EXT1 (J5). Instead, reconnect channel 1 of the dual function generator to TDC7201EVM's START_EXT2 connector (J8).
      2. Disconnect USB-to-SMA cable connection to STOP_EXT1 (J4). Instead, reconnect channel 2 of the dual function generator to TDC7201EVM's STOP_EXT2 connector (J7). See Figure 4.
   b. Now repeat steps 1 through 4 from Section 6 with the following modification to step 2: Click on the **TDC720x** tab and make sure the **TDC7201: Select TDCx** field is as shown in Figure 11.

Figure 11. Recommended TDC7201:TDC2 Register Configuration

7 Board Layout

NOTE: The board layout is not to scale. Figure 12 thru Figure 15 are intended to show how the board is laid out; it is not intended to be used for manufacturing.

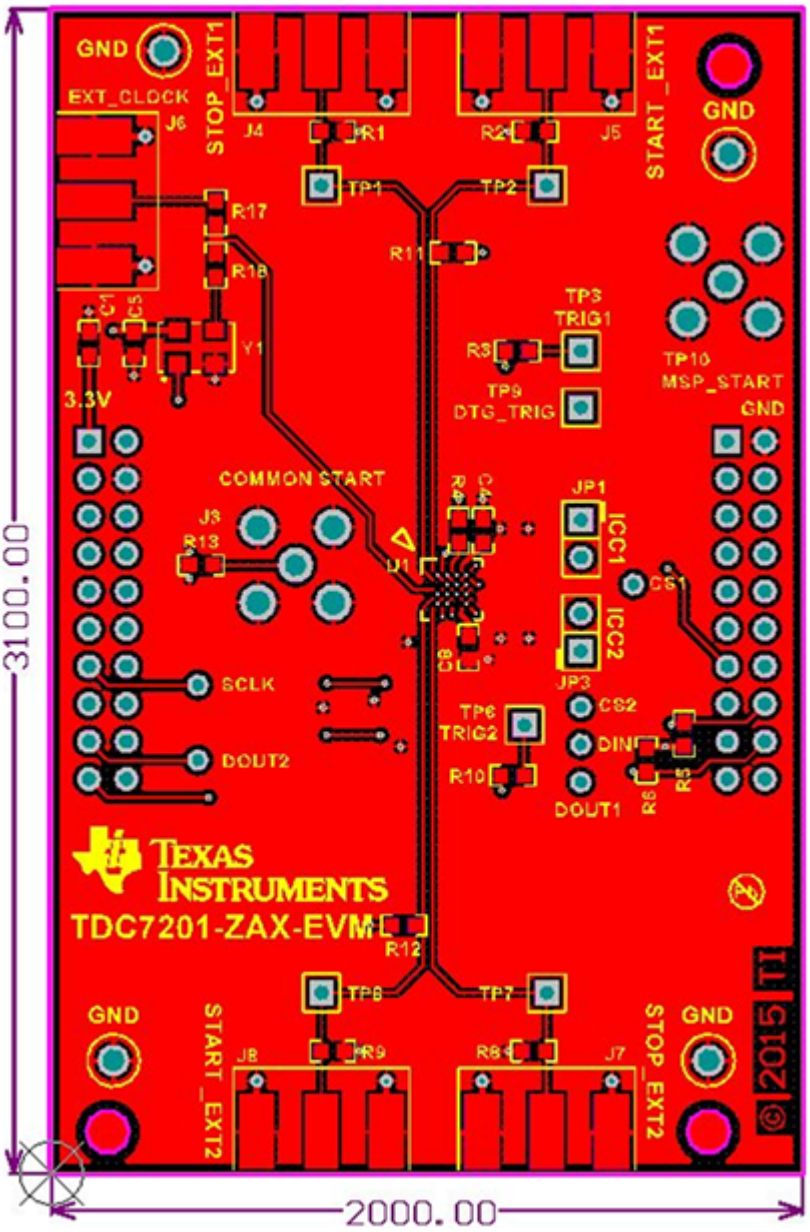

Figure 12. TDC7201EVM Top Layer

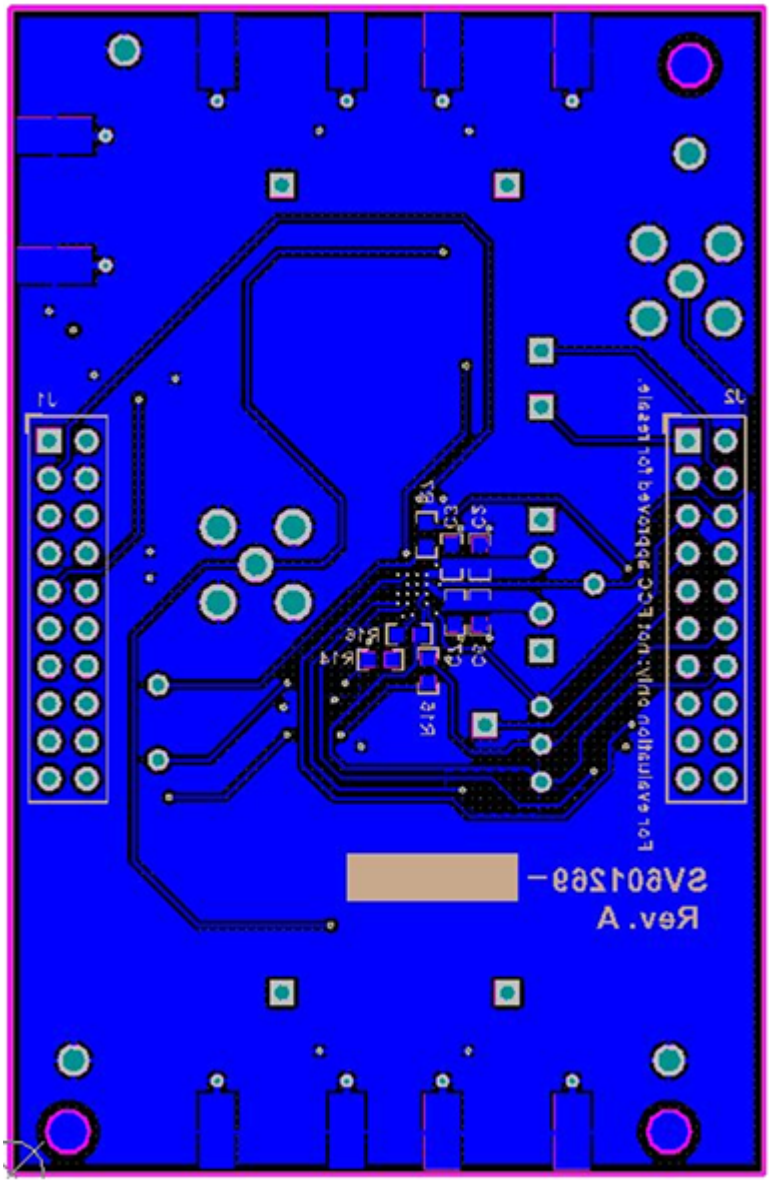

Figure 13. TDC7201EVM Bottom Layer

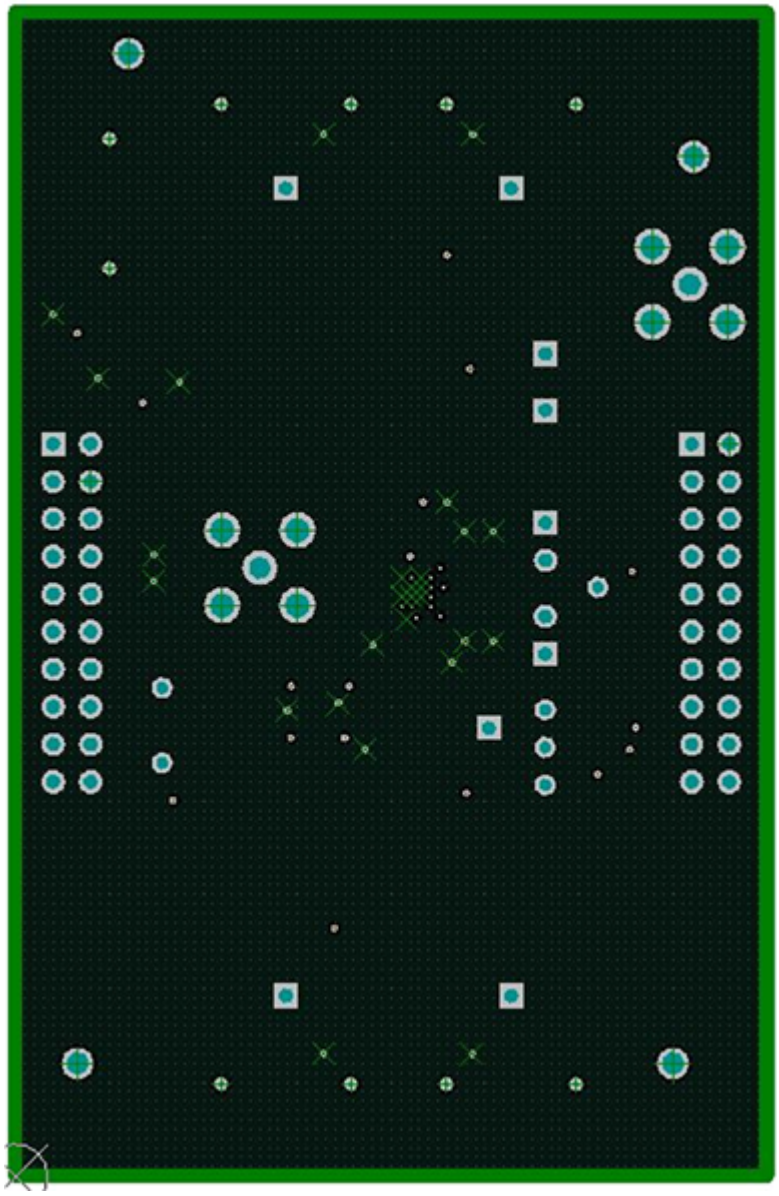

Figure 14. TDC7201EVM Ground Plane

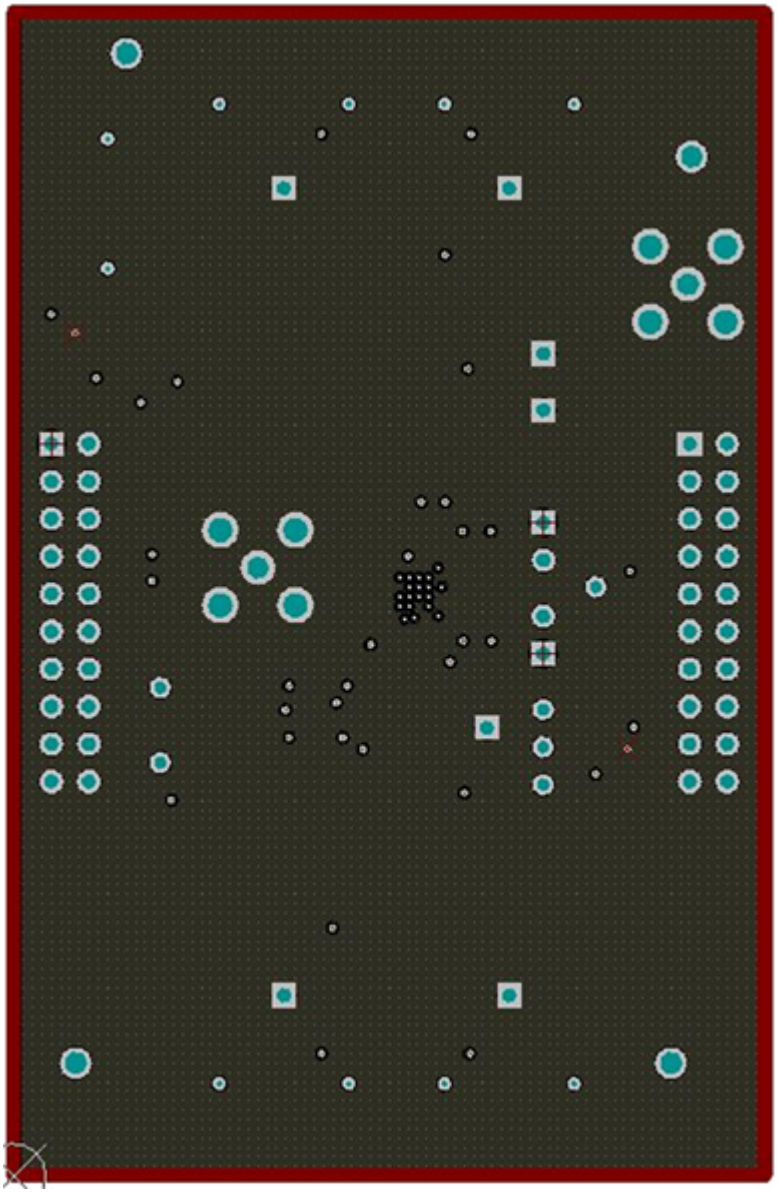

Figure 15. TDC7201EVM Power Plane

8 TDC7201EVM Schematic

The TDC7201EVM Schematic is shown in Figure 16.

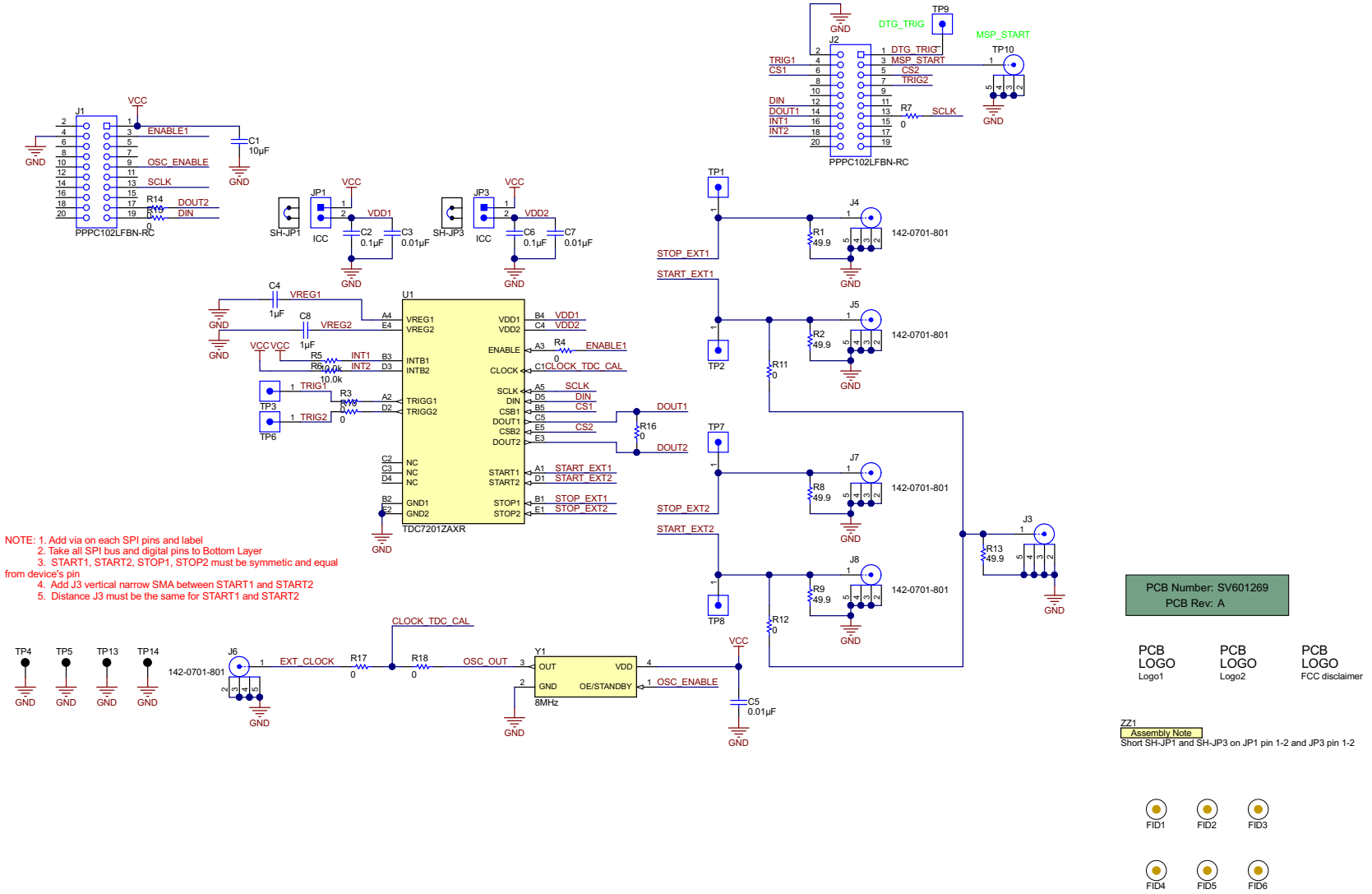

Figure 16. TDC7201EVM Schematic

9 Bill of Materials

Table 1. TDC7201EVM Bill of Materials

Designator	Qty	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	10uF	CAP, CERM, 10 µF, 6.3 V, +/- 20%, X5R, 0603	0603	C0603C106M9PACTU	Kemet
C2, C6	2	0.1uF	CAP, CERM, 0.1 µF, 16 V, +/- 5%, X7R, 0603	0603	0603YC104JAT2A	AVX
C3, C5, C7	3	0.01uF	CAP, CERM, 0.01 µF, 100 V, +/- 5%, X7R, 0603	0603	06031C103JAT2A	AVX
C4, C8	2	1uF	CAP, CERM, 1 µF, 16 V, +/- 10%, X7R, 0603	0603	EMK107B7105KA-T	Taiyo Yuden
J1, J2	2		Receptacle, 100mil, 10x2, Gold, TH	10x2 Receptacle	PPPC102LFBN-RC	Sullins Connector Solutions
J3	1		Connector, TH, SMA	SMA	142-0701-201	Emerson Network Power
J4, J5, J6, J7, J8	5		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Johnson
JP1, JP3	2		Header, 100mil, 2x1, Gold, TH	2x1 Header	TSW-102-07-G-S	Samtec
R1, R2, R8, R9, R13	5	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R3, R4, R10, R16, R18	5	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R5, R6	2	10.0k	RES, 10.0 k, 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
SH-JP1, SH-JP3	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP4, TP5, TP13, TP14	4	Black	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
TP9	1		Header, 100mil, 1pos, Gold, TH	Testpoint	TSW-101-07-G-S	Samtec
U1	1		Time-to-Digital Converter for Time-of-FlightApplications in LIDAR, Magnetostrictive andFlowMeters, ZAX0025A	ZAX0025A	TDC7201ZAXR	Texas Instruments
Y1	1		OSC, 8MHz, 15pF, SMD	OSC, 3.2x.85x5mm	ASFLMB-8.000MHZ-LY-T	Abracon Corporation
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A
R7, R11, R12, R14, R15, R17	0	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
TP1, TP2, TP3, TP6, TP7, TP8	0		Header, 100mil, 1pos, Gold, TH	Testpoint	TSW-101-07-G-S	Samtec
TP10	0		Connector, TH, SMA	SMA	142-0701-201	Emerson Network Power

Revision History

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

Changes from Original (May 2016) to A Revision	Page
• Changed link to Gui	3
• Changed link to Gui	4

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