

TDC7200EVM User's Guide

User's Guide



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General Description

This guide details the use of the TDC7200EVM evaluation module (referred to as EVM for the remainder of this document). The TDC7200EVM is an evaluation module that allows users to evaluate the operation and performance of the TDC7200 Time-to-Digital Converter. One example application that requires accurate time-to-digital conversion is flow sensing. For this, the TDC7200 can be used with the TDC1000 ultrasonic analog-front-end to capture accurate time sensing for water/gas/heat flow meters. The EVM 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.

1 EVM Key Features

1. Evaluate TDC7200 Time-to-Digital Converter
2. EVM connect with MSP430 Launch Pad (MSP-EXP430F5529LP)
3. User friendly TDC7200 GUI interface
4. Connection for START and STOP inputs
5. Powered by MSP430 LaunchPad (no external power needed)

2 EVM

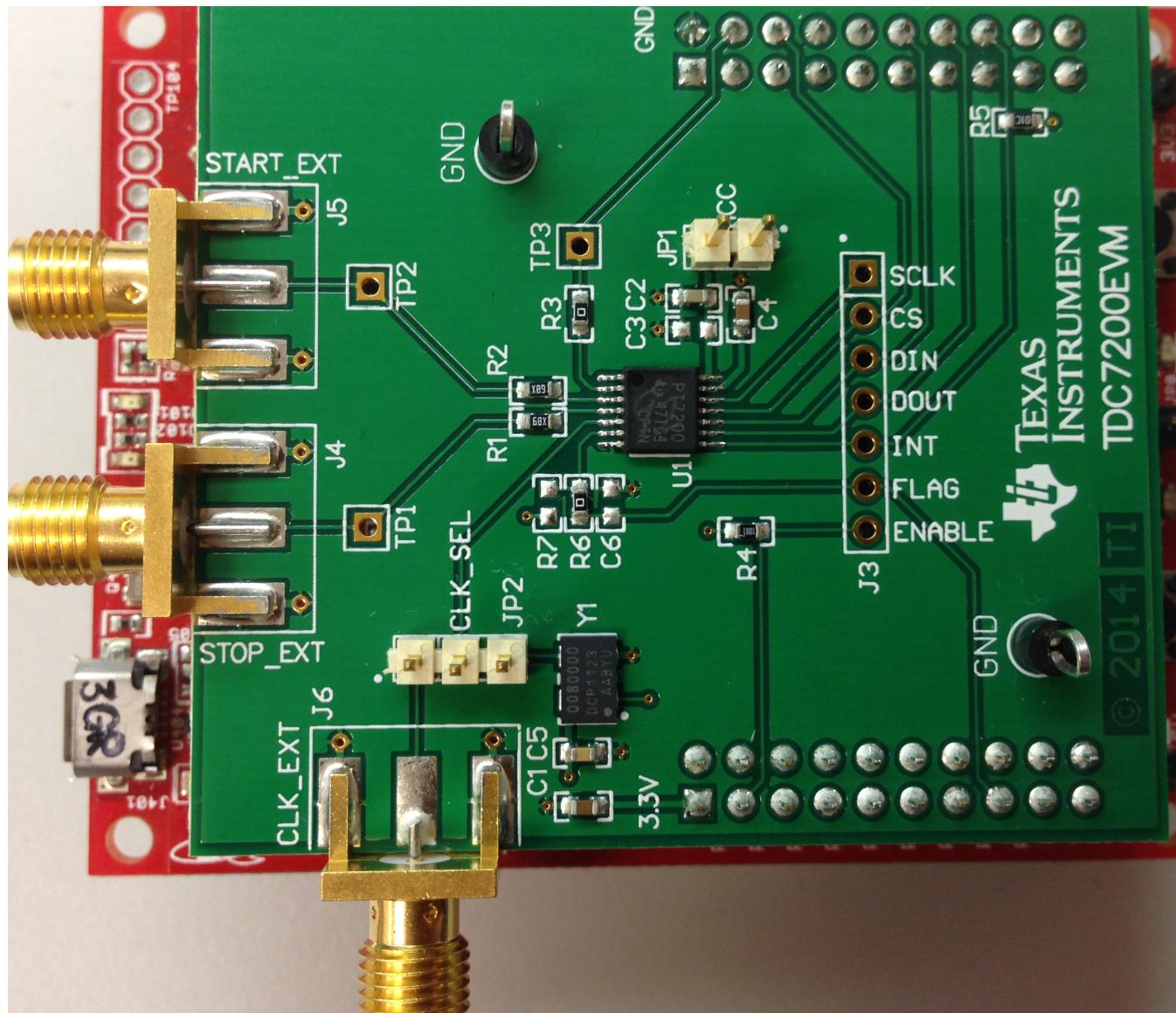


Figure 1. TDC7200EVM Evaluation Board

3 Equipment List

1. TDC7200EVM
2. TDC7200 GUI
3. MSP430 launchpad (<http://www.ti.com/tool/msp-exp430f5529lp>)
4. Micro-USB cable
5. Dual function generator (for example: Tektronix's AFG3102)
6. PC with Windows XP or Windows 7
7. 2 BNC-to-SMA cables

4 Quick Start

1. Download and Install TDC7200EVM (GUI) Software. See [Section 5](#) for more information.
2. Connect the USB cable from the MSP430 LaunchPad to the PC
3. Connect the TDC7200EVM to the MSP430 LaunchPad via J1 and J2
4. Connect START and STOP pulses to the TDC7200EVM via J5 and J4. See [Section 6](#) for more information.
5. Launch the GUI. See [Section 7](#) for more information
6. On the “GRAPH” tab, press the “START GRAPH” button.

5 Software Installation

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

5.1 Installing the TDC7200 GUI

1. Download the TDC7200 Software GUI zip file to your desktop.
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 your folder, for example, C:\ folder, such as C:\Program Files (x86)\Texas Instruments\TDC7200EVM.
6. Note: as part of this GUI installation, the GUI driver for the TDC7200EVM is also installed.

5.2 MSP430 Firmware Upgrade

1. Open the **TDC7200 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 hit “**Browse**”
 - (a) Go to the folder where you downloaded the TDC7200 GUI. For example: C:\Program Files (x86)\Texas Instruments\TDC7200EVM
 - (b) Find the **Firmware folder**. For example: C:\Program Files (x86)\Texas Instruments\TDC7200EVM\Firmware
 - (c) Select the TDC7200 firmware text file
6. On the MSP430 LaunchPad board, press the **BSL button** (S5 or S3) and **connect the MSP430 Launch Pad to your PC using a USB cable**. If detected, the text 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.

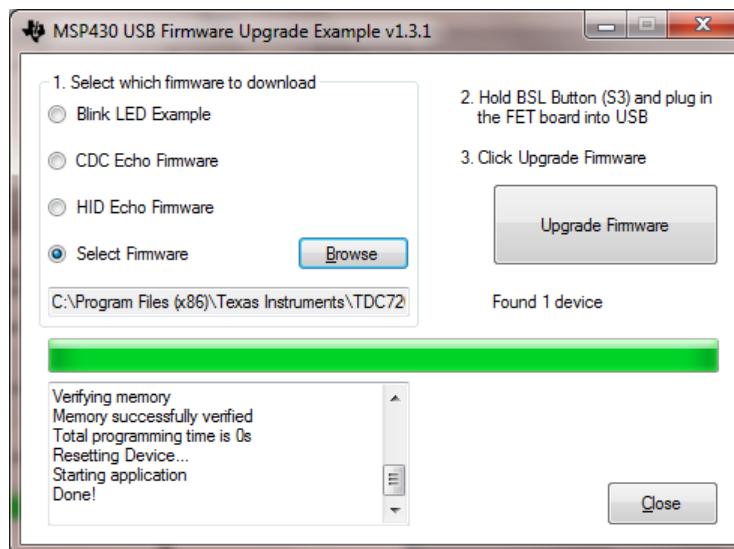


Figure 2. Upgrading MSP430 Firmware

5.3 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 **TDC7200EVM** to the MSP430 Launch Pad via J1 and J2 as shown in [Figure 6](#).
3. Open the computer's **Device Manager**. This can be done by right clicking on "My Computer", choose "Properties", then click on "Device Manager".
4. Scroll down to "**Ports (COM & LPT)**"
5. You should be able to see the "**TDC7200EVM (COMx)**" as shown in [Figure 3](#)

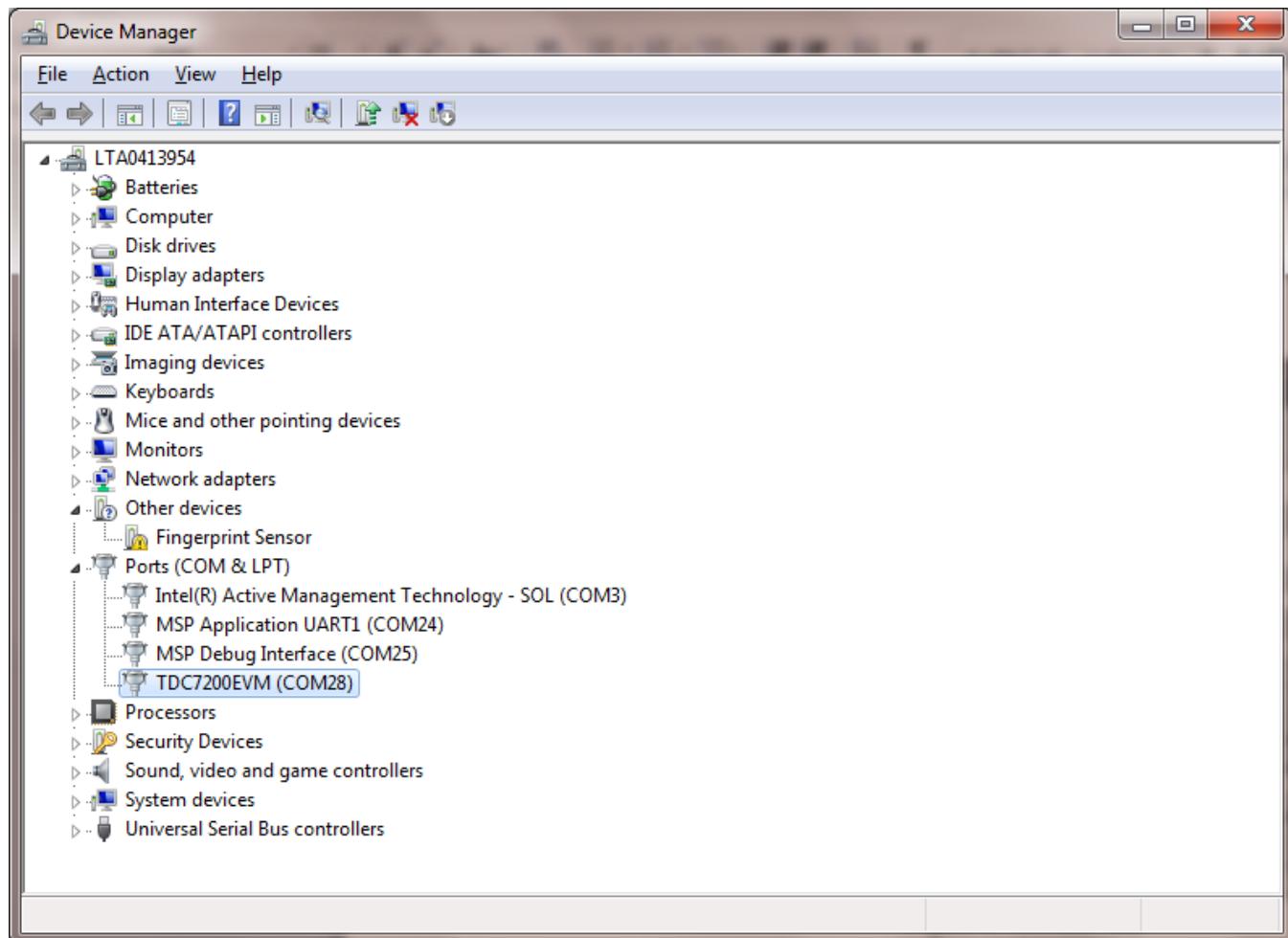


Figure 3. Device Manager

5.4 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 **TDC7200EVM** to the MSP430 Launch Pad via J1 and J2 as shown in [Figure 6](#).
3. Run the TDC7200 GUI from the "Start Menu". By default, it is located in "Programs\Texas Instruments\TDC7200EVM"
4. GUI should automatically connect and show the screen depicted in [Figure 4](#).

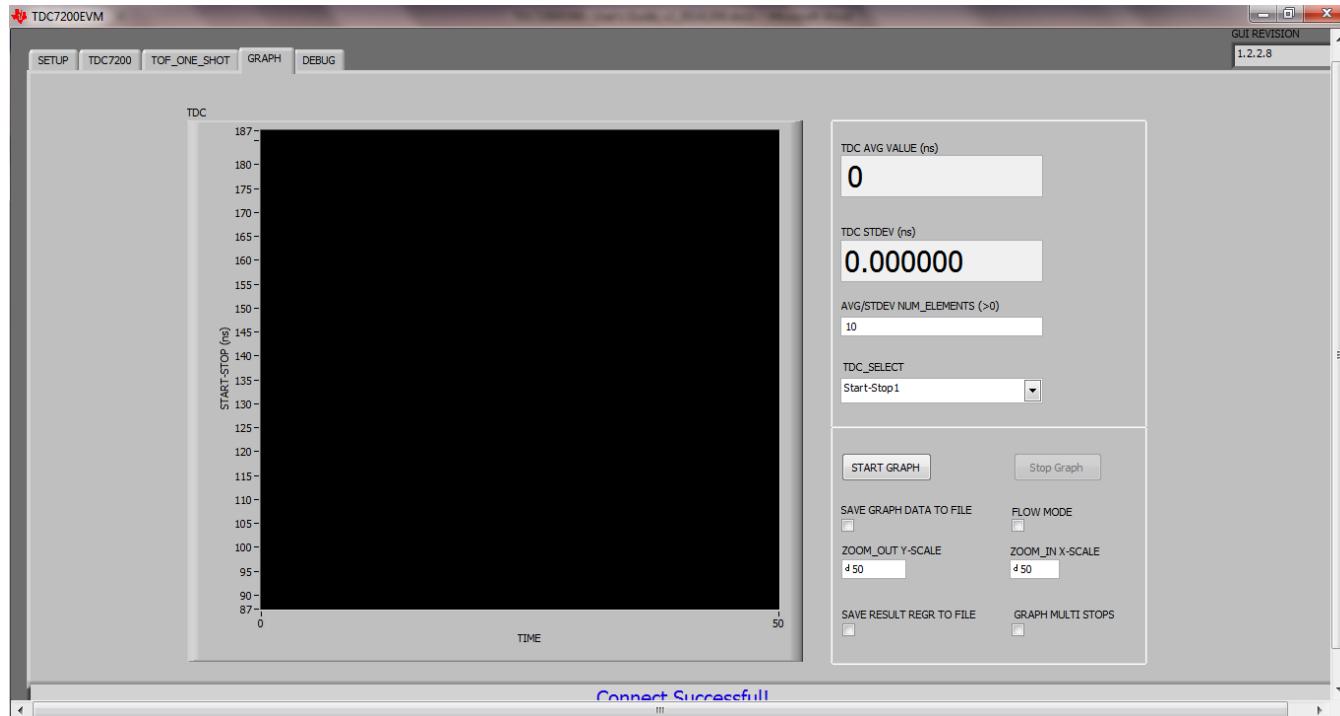


Figure 4. TDC7200 GUI

6 Hardware Configuration

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

6.1 EVM 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 TDC7200EVM to the MSP430 Launch Pad via J1 and J2 as shown in [Figure 6](#).
3. Setting the Dual Channel Function Generator (for example: Tektronix's AFG3102):
 - (a) Set channel 1 of the dual function generator to as follows (see [Figure 5](#)):
 - (i) Pulse 1-Cycle
 - (ii) Burst mode
 - (iii) Freq = 40kHz
 - (iv) Delay = 0s
 - (v) Amplitude = 3.3Vpp
 - (vi) Offset = 1.65V
 - (vii) Duty = 20%
 - (b) Set channel 2 of the dual function generator to as follows (see [Figure 5](#)):
 - (i) Pulse 1-Cycle
 - (ii) Burst mode
 - (iii) Freq = 40 kHz
 - (iv) Delay = 19us --> **this is the time-of-flight (TOF)**
 - (v) Amplitude = 3.3 Vpp
 - (vi) Offset = 1.65 V
 - (vii) Duty = 20%

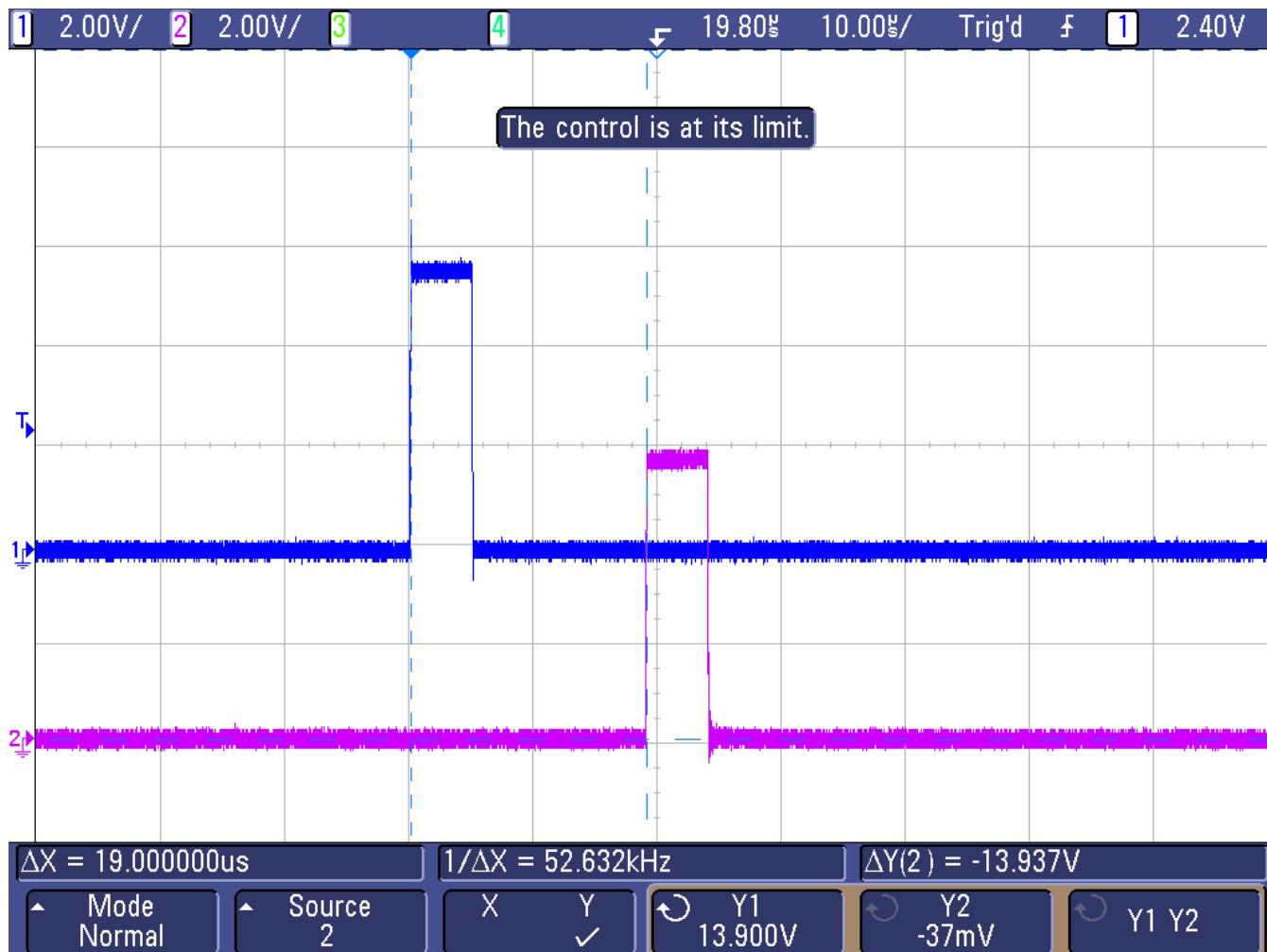


Figure 5. START and STOP Signals Scope Shot

4. Connecting the Input Signal:
 - (a) Using a USB-to-SMA cable, connect channel 1 of the dual function generator to TDC7200EVM's **START** connector (J5)
 - (b) Using a USB-to-SMA cable, connect channel 2 of the dual function generator to TDC7200EVM's **STOP** connector (J4). See [Figure 6](#).

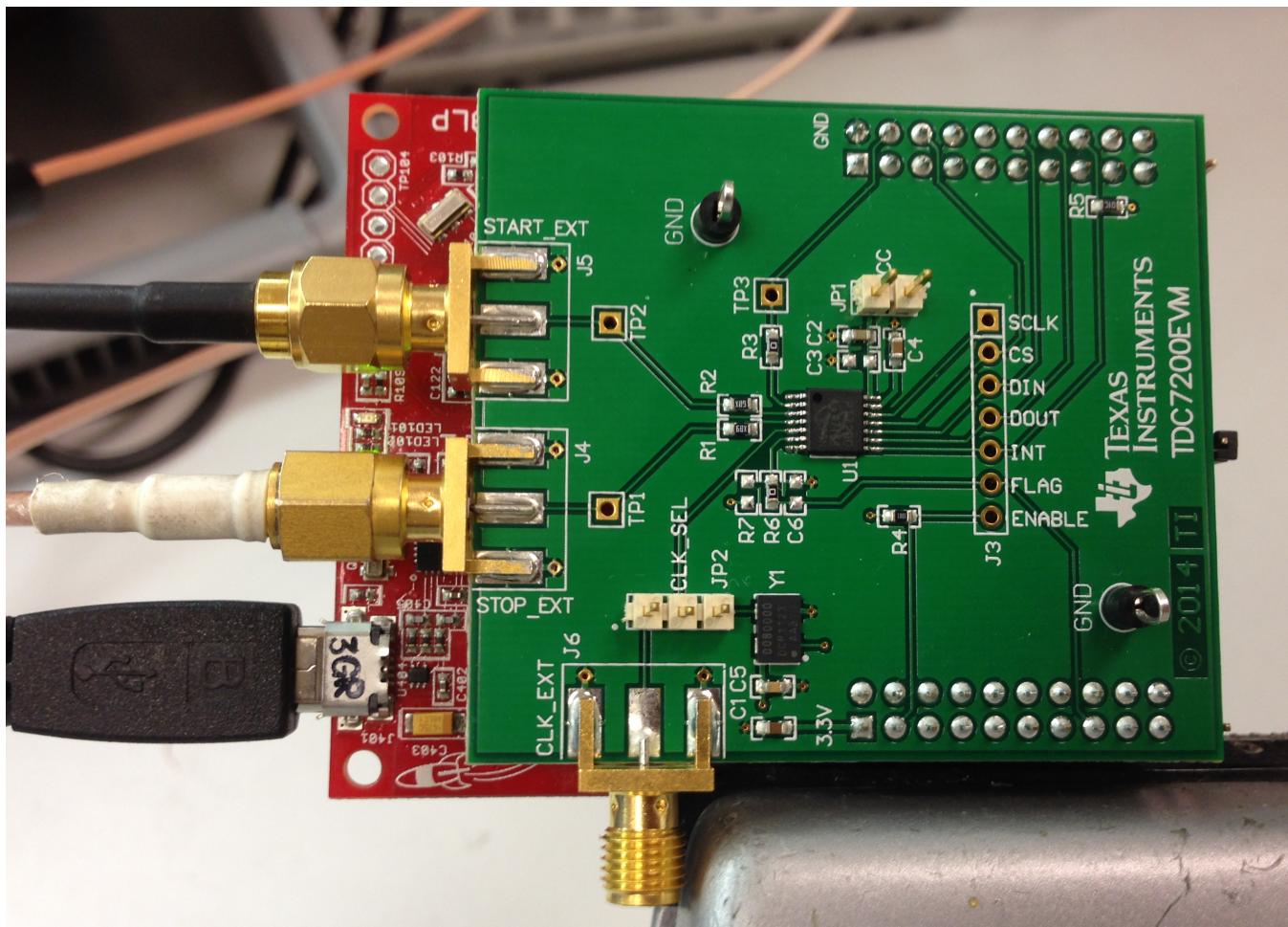


Figure 6. TDC7200EVM Connection

6.2 Jumpers

The following shows the jumper connection:

1. Jumper JP1: VCC power
 - (a) Connect Pin 1 to Pin 2 – power VCC via MSP430 (**recommend**)
 - (b) Open Pin 1 and Pin2 – no connection to VCC via MSP430; need to apply external power
2. Jumper JP2: CLOCK source
 - (a) Connect Pin 1 to Pin 2 – use external clock as the CLOCK source.
 - (b) Connect Pin 2 to Pin 3 – use Y1 as the CLOCK source (**recommend**)

7 GUI and Operation

1. If you haven't done so, open the **TDC7200EVMGUI**. The EVM GUI software can be run by clicking on Start >> All Programs >> Texas Instruments >> TDC7200.
2. Click on the “**TDC7200**” tab and make sure the TDC7200 register configuration is as follows (default settings):

CONFIG1 (0x00)	CONFIG2 (0x01)	INTERRUPT STATUS (0x02)	INTERRUPT MASK (0x03)
START No Effect	NUMBER OF STOPS Single	NEW_MEAS_INT Interrupt Detected	NEW_MEAS_MASK Interrupt Enabled
MODE Measurement Mode 2	AVERAGING CYCLES 1 Meas Cycle	COARSE CNTR OVERFLOW INT Overflow Not Detected	COARSE_CNTR_OVERFLOW_MASK Interrupt Enabled
START EDGE POLARITY Rising Edge	CALIBRATION 2 PERIODS 2 Clock Periods	CLOCK CNTR OVERFLOW INT Overflow Not Detected	CLOCK_CNTR_OVERFLOW_MASK Interrupt Enabled
STOP EDGE POLARITY Rising Edge	R		R
TRIGG EDGE POLARITY Rising Edge	COARSE CNTR OV_H (0x04) xFF	MEASUREMENT STARTED FLAG Measurement Started	CLOCK CNTR STOP MASK_H (0x08) x00
PARITY_EN Disabled	R		R
FORCE CALIBRATION No Calibration after intrpt	COARSE CNTR OV_L (0x05) xFF	MEASUREMENT COMPLTD FLAG Measurement Complete	CLOCK CNTR STOP MASK_L (0x09) x00
R	R	R	R
CLOCK CNTR OV_H (0x06) xFF	CLOCK CNTR OV_L (0x07) xFF	READ ALL	LOAD CONFIG
R	R		SAVE CONFIG

Figure 7. Recommended TDC7200 Register Configuration (Default Settings)

3. Click on the “Graph” tab, then click on “START GRAPH”. You should be able to read **19 μ s** (assuming you follow the instructions as specified in [Section 6.1](#)).

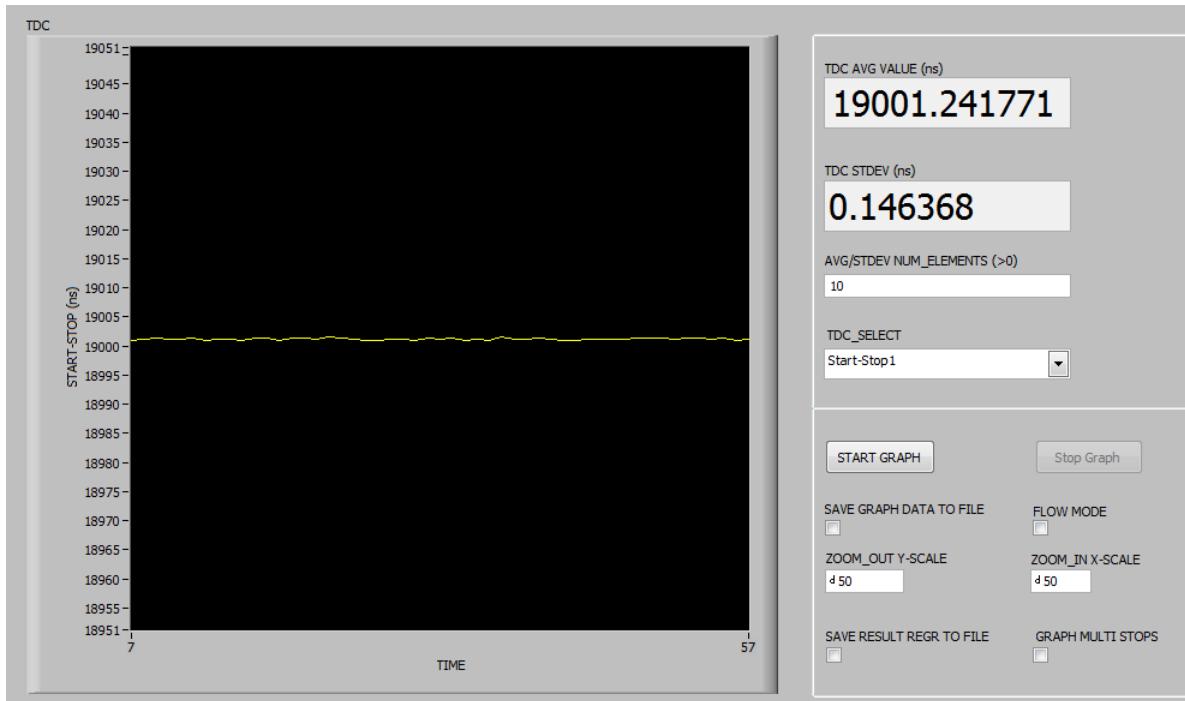


Figure 8. Graphing

4. Calculating Time-of-Flight:
- In the GUI, click on the “TOF_ONE_SHOT” tab
 - You should be able to see SIMILAR measurement results register values as shown in [Figure 9](#) (assuming you follow the instructions as specified in [Section 6.1](#)).

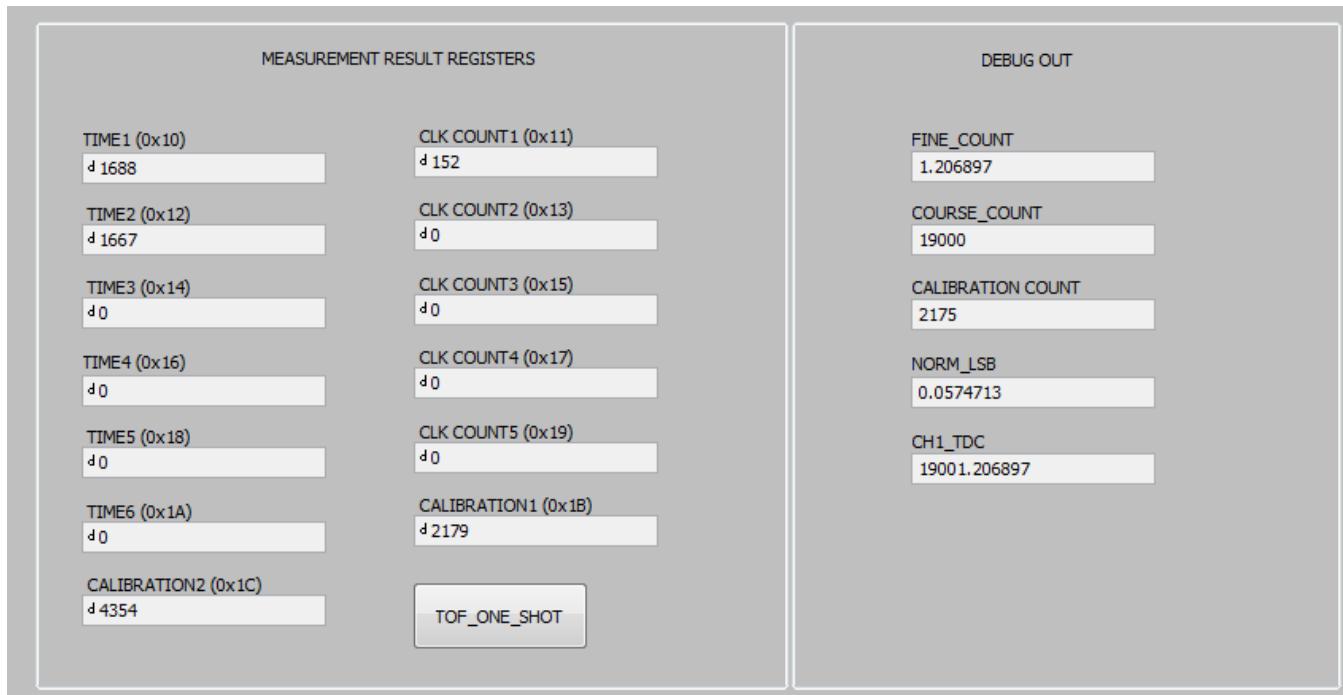


Figure 9. Measurement Results

(c) To calculate the time-of-flight, use the Measurement Mode 2 Time-of-Flight calculation as shown in [Equation 1](#) (equation shown below). For more information, refer to the TDC7200 datasheet.

(d) Use the values reported in the Measurement Result Registers ([Figure 9](#)) to validate the time-of-flight as ~19us (assuming you follow the instructions as specified in [Section 6.1](#)).

$$\text{TOF}_n = [(TIME1)(\text{normLSB}) + \text{offset}] + (\text{CLOCK_COUNT}_n)(\text{CLOCKperiod}) - [(TIME_{n+1})(\text{normLSB}) + \text{offset}]$$

$$\text{TOF}_n = \text{normLSB}(\text{TIME1} - \text{TIME}_{n+1}) + (\text{CLOCK_COUNT}_n)(\text{CLOCKperiod})$$

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

$$\text{calCount} = \frac{\text{CALIBRATION2} - \text{CALIBRATION1}}{(\text{CALIBRATION2_PERIODS}) - 1}$$

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 TDC7200 register address 0x10
 - TIME_{n+1} = (n+1) time measurement given by the TDC7200 register addresses 0x12, 0x14, 0x16, 0x18, and 0x1A
 - CLOCK_COUNT_n = 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
 - $\text{CALIBRATION2_PERIODS}$ = calibration count bits, located in register address 0x01
- (1)

$$\text{calCount} = \frac{\text{CALIBRATION2} - \text{CALIBRATION1}}{(\text{CALIBRATION2_PERIODS}) - 1} = \frac{(4354 - 2179)}{(2) - 1} = 2175$$

$$\text{normLSB} = \frac{(\text{CLOCKperiod})}{(\text{calCount})} = \frac{(1/8\text{MHz})}{2175} = 5.74 * 10^{-11}$$

$$\text{TOF1} = \text{normLSB}(\text{TIME1} - \text{TIME2}) + (\text{CLOCK_COUNT1})(\text{CLOCKperiod})$$

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

$$\text{TOF1} = 19.001\text{us} \quad (2)$$

8 Board Layout

NOTE: The board layout is not to scale. The following figures are intended to show how the board is laid out; it is not intended to be used for manufacturing.

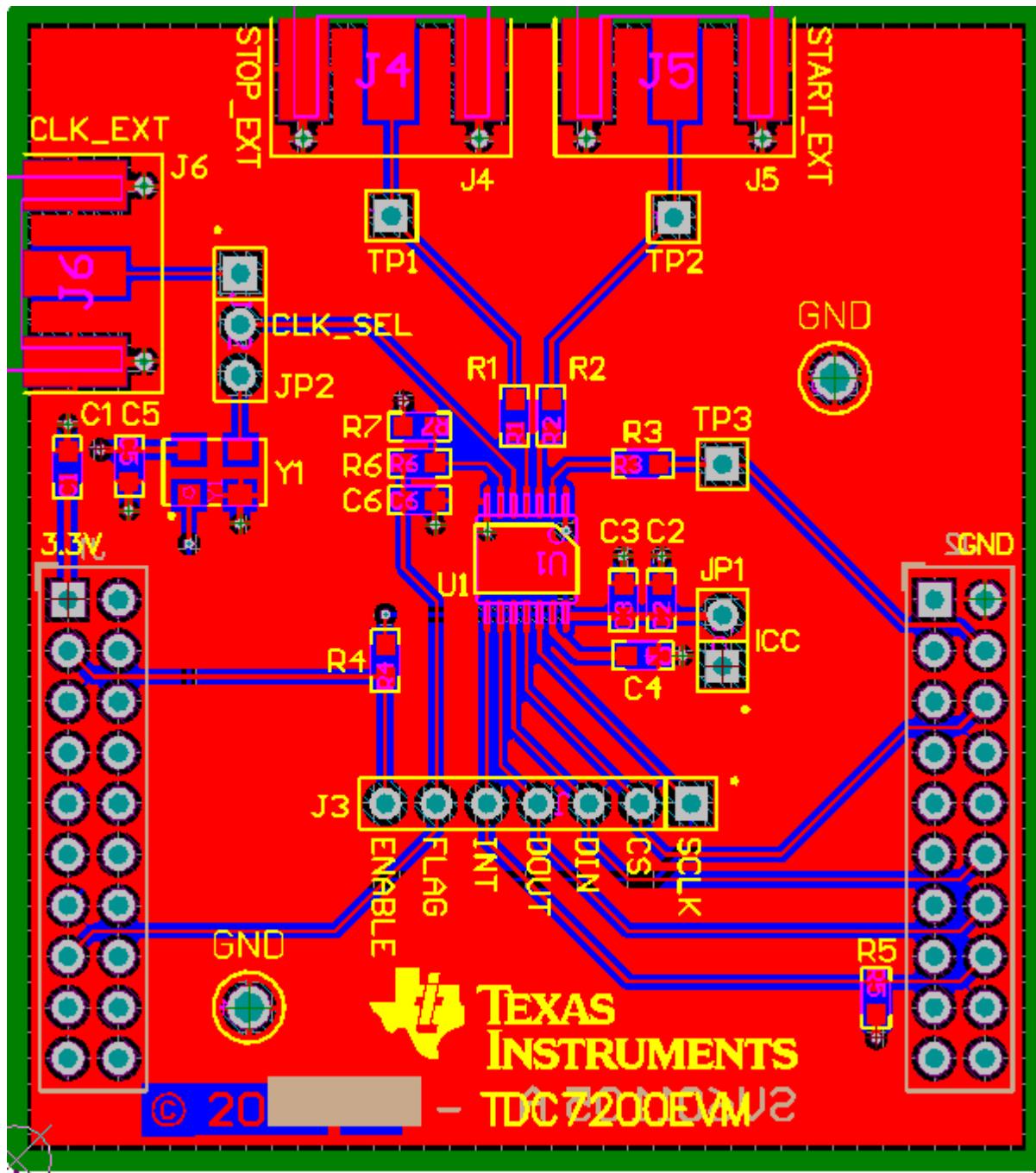


Figure 10. Top Assembly Layer

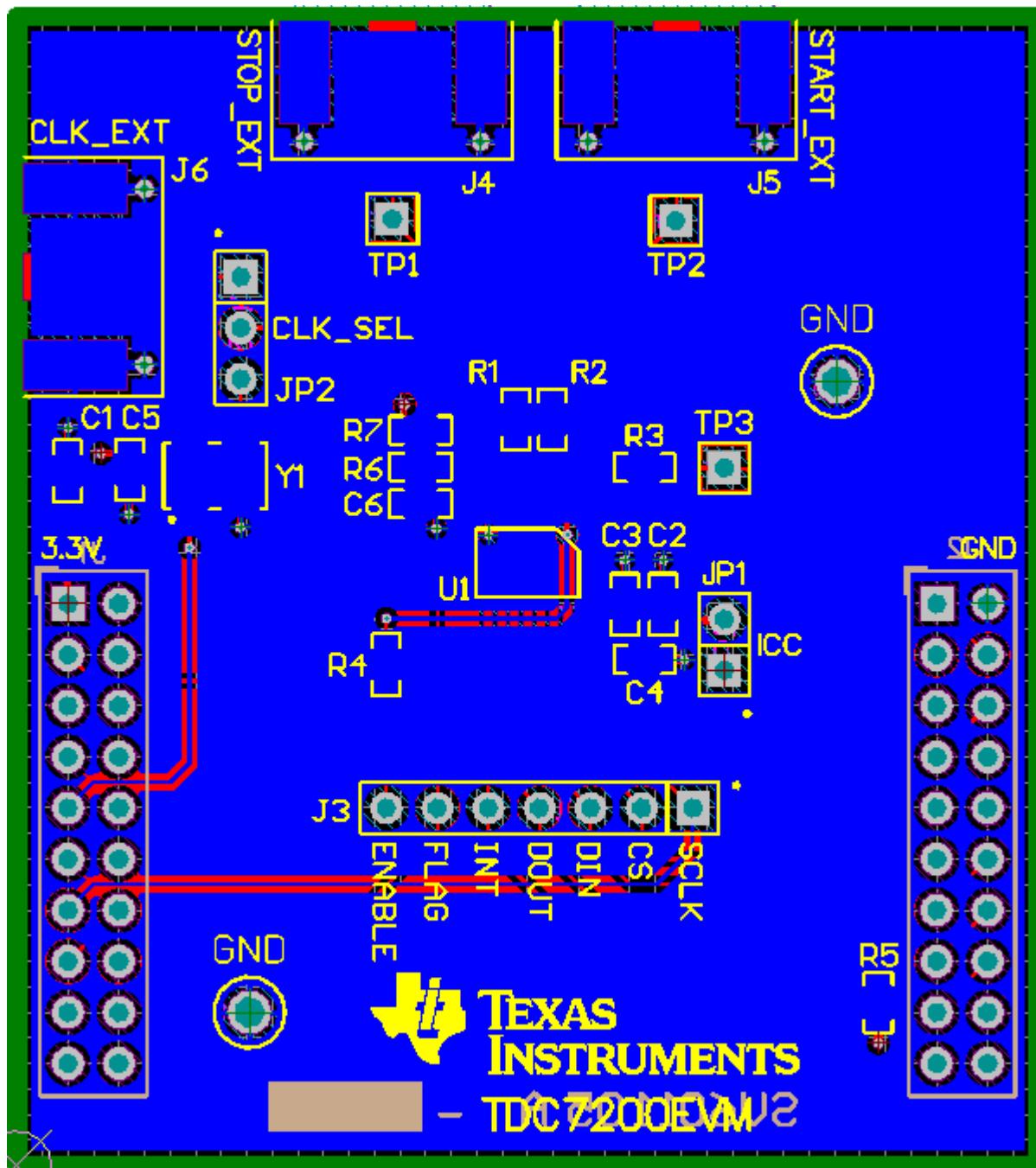
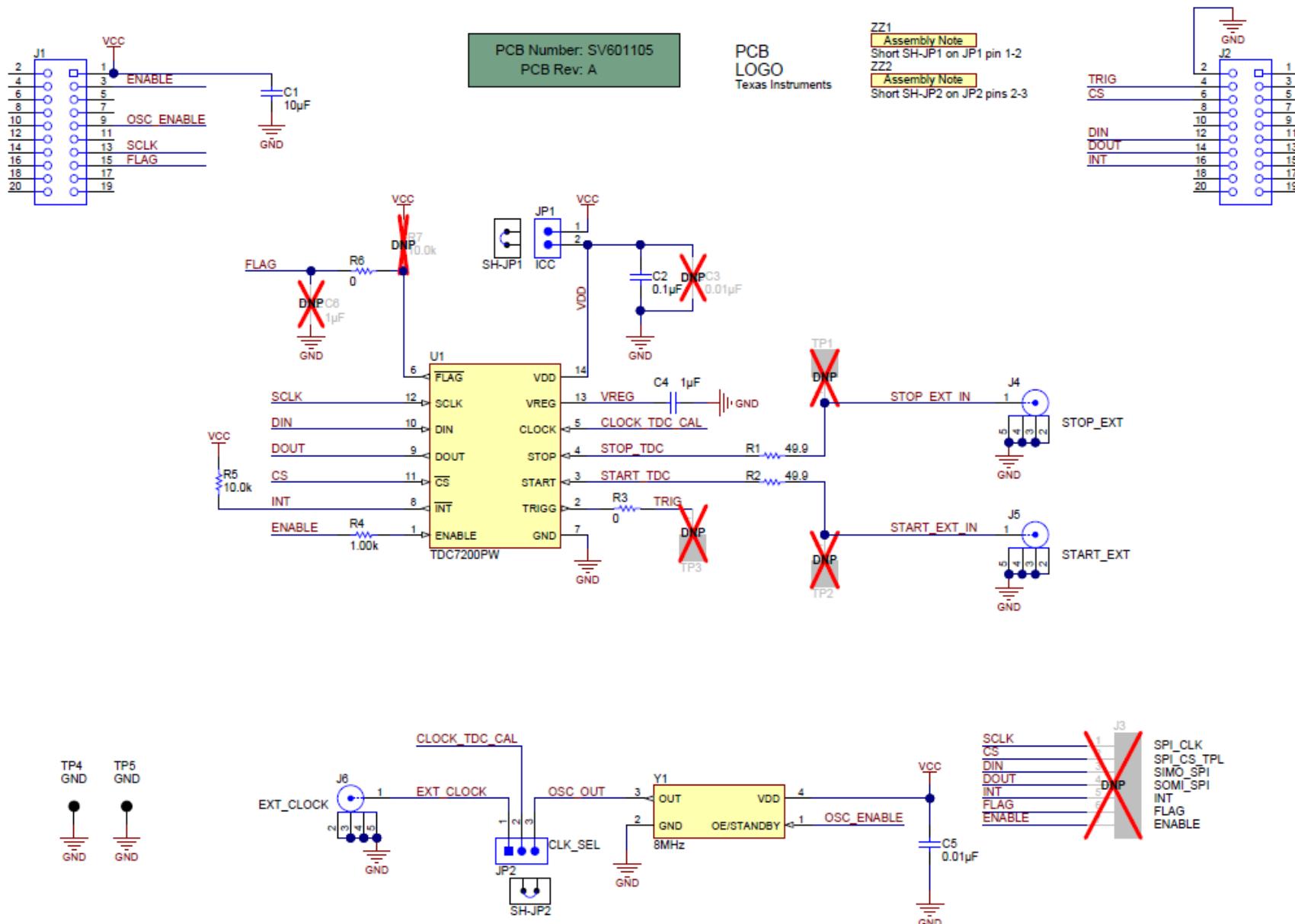


Figure 11. Bottom Layer

**Figure 12. Schematic**

9 Bill of Materials

Table 1. TDC7200 Bill of Materials

DESIGNATOR	QTY.	VALUE	DESCRIPTION	PACKAGE REFERENCE	PART NUMBER	MANUFACTURER
C1	1	10uF	CAP, CERM, 10uF, 6.3V, +/-20%, X5R, 0603	0603	C0603C106M9PACTU	Kemet
C2	1	0.1uF	CAP, CERM, 0.1uF, 16V, +/-5%, X7R, 0603	0603	0603YC104JAT2A	AVX
C4	1	1uF	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	0603	EMK107B7105KA-T	Taiyo Yuden
C5	1	0.01uF	CAP, CERM, 0.01uF, 100V, +/-5%, X7R, 0603	0603	06031C103JAT2A	AVX
J1, J2	2		Receptacle, 10x2, 100mil, TH	10x2 Receptacle	PPPC102LFBN-RC	Sullins Connector Solutions
J4, J5, J6	3		Connector, End launch SMA, 50 ohm, SMT	End Launch SMA	142-0701-801	Johnson
JP1	1		Header, TH, 100mil, 2x1, Gold plated, 230 mil above insulator	2x1 Header	TSW-102-07-G-S	Samtec
JP2	1		Header, TH, 100mil, 3x1, Gold plated, 230 mil above insulator	3x1 Header	TSW-103-07-G-S	Samtec
R1, R2	2	49.9	RES, 49.9 ohm, 1%, 0.1W, 0603	0603	CRCW060349R9FKEA	Vishay-Dale
R3, R6	2	0	RES, 0 ohm, 5%, 0.1W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R4	1	1.00k	RES, 1.00k ohm, 1%, 0.1W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R5	1	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
SH-JP1, SH-JP2	2	1x2	Shunt, 100mil, Gold plated, Black	Shunt	969102-0000-DA	3M
TP4, TP5	2	Black	Test Point, Multipurpose, Black, TH	Black Multipurpose Testpoint	5011	Keystone
U1	1		STOPWATCH IC FOR TIME MEASUREMENT BETWEEN TWO EVENTS, PW0014A	PW0014A	TDC7200PW	Texas Instruments
Y1	1		OSC, 8MHz, 15pF, SMD	OSC, 3.2x.85x5mm	ASFLMB-8.000MHZ-LY-T	Abracan Corporation
C3	0	0.01uF	CAP, CERM, 0.01uF, 100V, +/-5%, X7R, 0603	0603	06031C103JAT2A	AVX
C6	0	1uF	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	0603	EMK107B7105KA-T	Taiyo Yuden
J3	0		Header, TH, 100mil, 7x1, Gold plated, 230 mil above insulator	7x1 Header	TSW-107-07-G-S	Samtec
R7	0	10.0k	RES, 10.0k ohm, 1%, 0.1W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
TP1, TP2, TP3	0		Header, TH, 100mil, 1pos, Gold plated, 230 mil above insulator	Testpoint	TSW-101-07-G-S	Samtec

STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
 - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductors products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software.
 - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
- 2 *Limited Warranty and Related Remedies/Disclaimers:*
 - 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
 - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
 - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.

- 3 *Regulatory Notices:*

- 3.1 *United States*

- 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.

- 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

3.3 Japan

3.3.1 Notice for EVMs delivered in Japan: Please see http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_01.page 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。 http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_01.page

3.3.2 Notice for Users of EVMs Considered "Radio Frequency Products" in Japan: EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】

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3.3.3 *Notice for EVMs for Power Line Communication: Please see http://www.tij.co.jp/lsts/ti_ja/general/eStore/notice_02.page*

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