TSC2020EVM and TSC2020EVM-PDK

This user's guide describes the characteristics, operation, and use of the TSC2020EVM, both by itself and as part of the TSC2020EVM-PDK. The TSC2020EVM and TSC2020EVM-PDK are two evaluation fixtures for the TSC2020, a resistive touch screen controller with auxiliary input and temperature measurement capabilities. This evaluation module (EVM) is a 3x5 (or 5x3) resistive multiple touch screen controller evaluation module that allows evaluation of all aspects of the TSC2020. A complete circuit description, schematic diagram, and bill of materials are included in this document.

The following related documents are available through the Texas Instruments web site at www.ti.com.

Related Documentation

Device	Literature Number
TSC2020	SBAS494
TAS1020B	SLES025
REG1117-5	SBVS001
TPS767D318	SLVS209
SN74LVC125A	SCAS290
SN74LVC1G125	SCES223
SN74LVC1G07	SCES296
5-6k Interface Board	SLAU104

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1 EVM Overview

1.1 Features

TSC2020EVM:

- Full-featured evaluation board for the TSC2020 resistive multiple touch screen controller (TSC)
- Modular design for use with a variety of DSP and microcontroller interface boards

TSC2020EVM-PDK:

- Easy-to-use evaluation software for Microsoft® Windows® XP
- Complete control of board settings

For use with a computer, the TSC2020EVM-PDK is a complete evaluation kit. This kit combines the TSC2020EVM with the USB-based USB-MODEVM motherboard and evaluation software for use with a personal computer.

The USB-MODEVM motherboard allows the TSC2020EVM to be connected to the computer via an available USB port. This manual shows how to use the USB-MODEVM as part of the TSC2020EVM-PDK, but does not provide technical details about the USB-MODEVM itself.

This manual covers the operation of both the TSC2020EVM and the TSC2020EVM-PDK. Throughout this document, the abbreviation *EVM* and the term *evaluation module* are synonymous with the TSC2020EVM.

1.2 Introduction

The TSC2020EVM is manufactured in Texas Instruments' modular EVM System specification. It can be connected to any modular EVM system interface card. The TSC2020EVM allows direct evaluation of the TSC2020 performance and operating characteristics, in addition to rapid software development and system prototyping. This EVM is compatible with the 5-6k Interface Board (SLAU104) from Texas Instruments and additional third-party boards such as the NI Speedy-33™ from National Instruments Corporation.

The TSC2020EVM-PDK is a complete evaluation and demonstration kit that includes a USB-based motherboard, the USB-MODEVM interface board. This kit also contains evaluation software for use with a personal computer equipped with Microsoft WindowsNT and XP operating systems. The TSC2020EVM-PDK is a complete package that includes the following items:

1. TSC2020EVM board
2. USB-MODEVM board
3. Evaluation software installer and related documentation (downloaded from ftp://ftp.ti.com/pub/evm-pdk/TSC2020/)

The TSC2020EVM is available as a stand-alone printed circuit board (PCB) or as part of the TSC2020EVM-PDK, which includes a USB-MODEVM motherboard and software. As a stand-alone PCB, the TSC2020EVM is useful for prototyping designs and firmware.

2 Analog Interface

For maximum flexibility, the TSC2020EVM is designed for easy interfacing to multiple analog sources by means of different connection options.

The TSC2020 supports a 3x5 analog matrix resistive multiple touch screen. A 50-pin multiple touch screen connector J4 (part number FH12A-50S-0.5SH) is installed on the TSC2020EVM PCB, and provides a direct connection to a corresponding 50-pin flat cable found on resistive multiple touch screens. Figure 1 details the pinout of the 50-pin connector on the TSC2020EVM board, and also shows the suggested connections to a 3x5 resistive multiple touch screen.

J4	TSC2020	3x5 Sensor
50		
49		
48		
47		
46		
45		
44		
43	30	X-5
42	29	X-4
41	28	X-3
40	27	X-2
39	26	X-1
38		
37		
36		
35		
34		
33	25	Y+1
32	24	Y-1
31	23	Y-2
30	22	Y-3
29		
28		
27		
26		
25		
24		
23		
22		
21		
20		
19		
18		
17		
16		
15		
14		
13	17	Y+3
12	16	Y+2
11	15	X+1
10	14	X+2
9	13	X+3
8	12	X+4
7	11	X+5
6		
5		
4		
3		
2		
1		

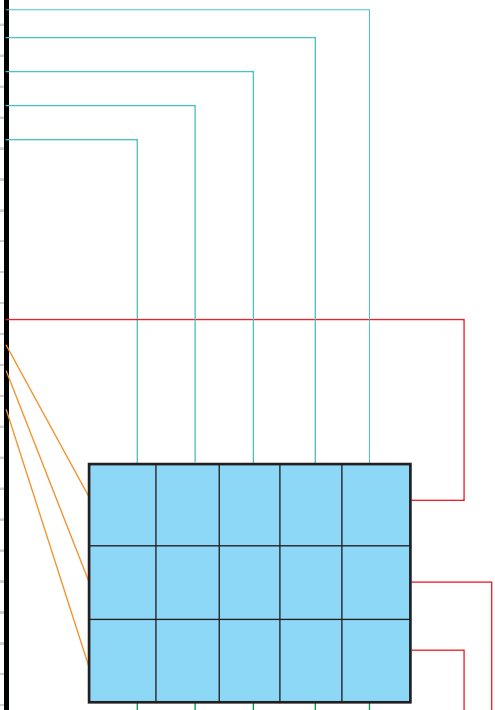


Figure 1. Analog Connection Through the 50-Pin Connector J4

Additionally, Samtec part numbers SSW-110-22-F-D-VS-K and TSM-110-01-T-DV-P provide a convenient 10-pin, dual-row, header/socket combination at J1, described in Table 1. This header/socket provides access to the analog input pins of the TSC. Consult Samtec at www.samtec.com or call 1-800-SAMTEC-9 for a variety of mating connector options.

Table 1. J1: Analog Interface Connector Pinout

Pin Number	Signal	Description
J1.1	AUX IN	Auxiliary input, ranging from 0V to VDD
J1.3	Y-3 or YD3	Negative electrode of the third column from touch screen
J1.5	Y+3 or YU3	Positive electrode of the third column from touch screen
J1.7	Y+2 or YU2	Positive electrode of the second column from touch screen
J1.9	X+1 or XR1	Positive electrode of the first row from touch screen
J1.11	X+2 or XR2	Positive electrode of the second row from touch screen
J1.13	X+3 or XR3	Positive electrode of the third row from touch screen
J1.15	X+4 or XR4	Positive electrode of the 4th row from touch screen
J1.17	X+5 or XR5	Positive electrode of the 5th row from touch screen
J1.19	AGND	Analog ground
J1.2	Unused	—
J1.4	Y-2 or YD2	Negative electrode of the second column from touch screen
J1.6	Y-1 or YD1	Negative electrode of the first column from touch screen
J1.8	Y+1 or YU1	Positive electrode of the first column from touch screen
J1.10	X-1 or XL1	Negative electrode of the first row from touch screen
J1.12	X-2 or XL2	Negative electrode of the second row from touch screen
J1.14	X-3 or XL3	Negative electrode of the third row from touch screen
J1.16	X-4 or XL4	Negative electrode of the fourth row from touch screen
J1.18	X-5 or XL5	Negative electrode of the fifth row from touch screen
J1.20	AGND	Analog ground

3 Digital Interface

The TSC2020EVM is designed to easily interface with multiple control platforms. Samtec part numbers SSW-110-22-F-D-VS-K and TSM-110-01-T-DV-P provide a convenient 10-pin, dual-row, header/socket combination at J2, described in Table 2. This header/socket provides access to the digital control and serial data pins of the TSC. Consult Samtec at www.samtec.com or call 1-800-SAMTEC-9 for a variety of mating connector options.

Table 2. J2: Digital Interface Pinout

Pin Number	Signal	Description
J2.14	$\overline{\text{RESET}}$	Hardware reset, input to TSC, active low
J2.15	$\overline{\text{PINTDAV}}$	Pen status and/or data available interrupt, output from TSC, active low
J2.16	SCL	I^2C™ bus serial clock
J2.20	SDA	I^2C bus serial data line
J2.4, J2.10, J2-18	DGND	Digital ground
J2.1 to J2.13 (odd), J2.17, J2.19	Unused	—
J2.2, J2.6, J2.8, J2.12	Unused	—

4 Power Supplies

J3 provides connection to the common power bus for the TSC2020EVM. Power is supplied on the pins listed in Table 3.

Table 3. J3: Power-Supply Pinout

Signal	Pin Number		Signal
Unused	1	2	Unused
Unused	3	4	Unused
DGND	5	6	AGND
+1.8VD	7	8	Unused
+3.3VD	9	10	Unused

When power is supplied to J3, JP1 allows for one of two different dc voltages to be selected as power for the TSC. Refer to the schematic (appended to this document) and PCB silkscreen (Figure 20) for details.

The TSC2020EVM-PDK motherboard (that is, the USB-MODEVM interface board) supplies power to J3 of the TSC2020EVM. Power for the motherboard is supplied either through its USB connection or via terminal blocks on the board.

4.1 TSC Power

Power for the TSC2020 VDD can be supplied either from the +1.8-VD terminal or from the +3.3-VD terminal.

JP1 selects the voltage that is routed to the TSC2020. When JP1 is in its default factory configuration (with a shunt placed on pins 1-2), power to the TSC comes from J3.9 (+3.3 VD). When the shunt is installed on JP1, pins 2-3, power comes from J3.7 (+1.8 VD). The user can connect to any dc power supply between 1.6 VD and 3.6 VD to VDD by removing the shunt on JP1 and connecting the power to JP1, pin 2.

The power-supply configurations for JP1 are listed in Table 4.

Table 4. JP1: Power Selection Options

Shunt on Pins	VDD	Voltage from J3 Pin
1-2	+3.3 VD	9
2-3	+1.8 VD	7
Removed	+1.6 VD to +3.6 VD	External

4.2 Stand-Alone Operation

When the TSC2020EVM PCB is used as a stand-alone EVM, power can be applied to TP10 (VDD), referenced to TP20 (GND).

CAUTION

Verify that all power supplies are within the safe operating limits shown on the TSC2020 data sheet (SBAS494) before applying power to the EVM.

4.3 USB-MODEVM Interface Power

The USB-MODEVM interface board can be powered from several different sources:

- Through a USB connection
- 6-VDC to 10-VDC ac/dc external wall supply *(not included)*
- Laboratory power supply

Each power-supply voltage has an LED (D1 to D7) that lights when the respective power supply is active.

When powered from the USB connection, JMP6 should have a shunt from pins 1-2 (the factory default configuration). When powered from 6 VDC to 10 VDC, either through the J8 terminal block or J9 barrel jack, JMP6 should have a shunt installed on pins 2-3. If power is applied in any of these ways, onboard regulators generate the required supply voltages, and no further power supplies are necessary.

If laboratory supplies are used to provide the individual voltages required by the USBMODEVM interface board, JMP6 should have no shunt installed. Voltages are then applied to J2 (+5 VA), J3 (+5 VD), J4 (+1.8 VD), and J5 (+3.3 VD). The +1.8 VD and +3.3 VD also can be generated on the board, from the +5-VD supply, by the onboard regulators; to enable this supply, the switches on SW1 must be set to enable the regulators. Move the switches to the ON position (lower position, looking at the board with text reading right-side up) to enable the regulators. If +1.8 VD and +3.3 VD are supplied externally, disable the onboard regulators by placing SW1 switches in the OFF position.

5 EVM-PDK Operation

The following sections of this user guide provide information about operating the TSC2020EVM-PDK, including setup, program installation, and using the software as well as its operational description.

5.1 EVM-PDK Setup

5.1.1 Hardware Setup

The TSC2020EVM-PDK includes three components, as noted earlier:

1. TSC2020EVM PCB
2. USB-MODEVM PCB
3. TSC2020EVM-PDK evaluation software installer and related documentation (downloaded from ftp://ftp.ti.com/pub/evm-pdk/TSC2020/)

Figure 2 shows the hardware block diagram of the TSC2020EVM-PDK. The two PCBs are connected together, and the TSC2020EVM board is seated on top of the USB-MODEVM board.

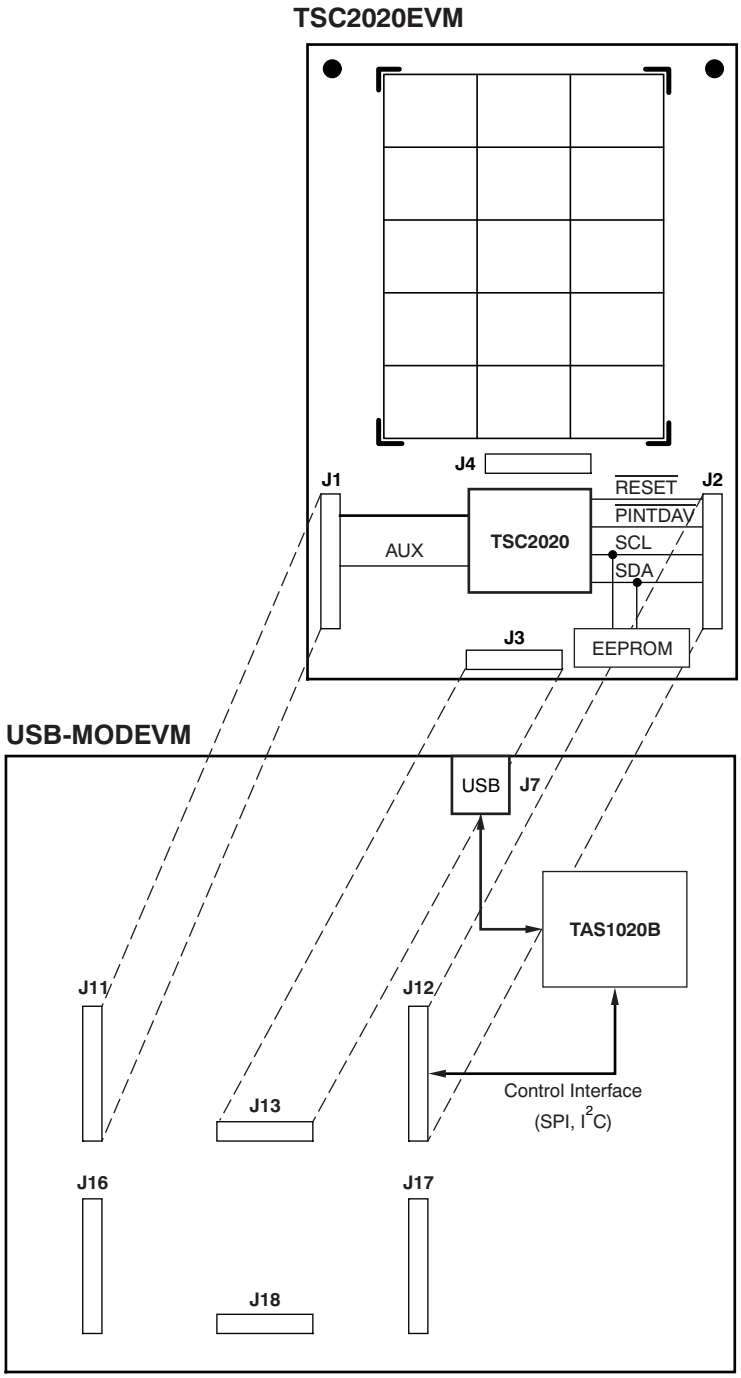


Figure 2. TSC2020EVM-PDK Hardware Block Diagram and Connection

All switches and jumpers on both mother- and daughterboards should remain in the respective default positions as shipped from the manufacturer. Double-check SW2-1 to make sure it is set to *OFF*. These positions are summarized in Table 5 and Table 6.

Table 5. USB-MODEVM Switch and Jumper Default Positions

Switch or Jumper	Setting
SW1	SW1-1 ON
	SW1-2 ON
SW2	SW2-1 OFF
	SW2-2 ON
	SW2-3 ON
	SW2-4 ON
	SW2-5 ON
	SW2-6 ON
	SW2-7 ON
	SW2-8 OFF
SW3	SW3-1 ON
	SW3-2 OFF
	SW3-3 OFF
	SW3-4 OFF
	SW3-5 OFF
	SW3-6 OFF
	SW3-7 OFF
	SW3-8 OFF
JMP1	Installed
JMP2	Installed
JMP3	Removed
JMP4	Removed
JMP5	Connect 2 to 3
JMP6	Connect 1 to 2 (USB)
JMP7	Connect 2 to 3
JMP8	Removed

Table 6. TSC2020EVM Jumper Default Positions

Jumper	Setting
JMP1	Connect 1 to 2 (+3.3V)
JMP2	Installed
JMP3	Installed

5.1.2 Software Installation

To install and set up the TSC2020EVM-PDK, follow these steps.

Step 1. Download the latest TSC2020EVM-PDK software installer from ftp://ftp.ti.com/pub/evm-pdk/TSC2020/, and unzip it using WinZIP® or similar file compression program.

Step 2. Do not connect the kit to your computer. Locate and run **setup.exe**.

Step 3. Accept the license agreement, and continue the installation.

Step 4. Follow the instructions and prompts as they appear on-screen.

Step 5. When the installation completes, click **Finish** on the TSC2020EVM installer window.

Step 6. Restart your computer. (This step may not be necessary, but it is suggested as a precaution.)

Step 7. When your computer has restarted, connect the TSC2020EVM kit to the computer via a USB cable. Microsoft Windows should recognize the new device, and start the *Found New Hardware* wizard sequence.

Step 8. Select *Install from a list or specific location (Advanced)*, and click on **Next>**.

Step 9. Select *Don't Search. I will choose the driver to install*, and click on **Next>**.

If the TSC2020EVM appears in the *Model* list, click on the name of the device to select it. You are done.

Otherwise, continue with these steps.

Step 10. If the TSC2020EVM is not in this list, the Windows *Add Hardware* wizard provides a list of *Common hardware types*; scroll through the list to find *NI-VISA USB Devices*. Select this option and then click on it.

Step 11. Click on *Have Disk...*. Select *Browse...*, and find the file TSC2020EVM.inf. This file is included with the installer and should be in this directory:

C:\Program Files\Texas Instruments\TSC2020EVM \data

Step 12. Select the **TSC2020EVM.inf** and click on it. The PC should install it automatically.

Step 13. Click on **Finish** to complete the installation.

Once the installer has completed its processes, you are done and ready to operate the TSC2020EVM software.

5.2 Quick Start

When both the hardware and software installation and setup processes have been successfully completed, attach a USB cable from the PC to the USB-MODEVM Interface board (J7 on the motherboard).

As configured at the factory, the USB-MODEVM board is powered from the USB interface. Therefore, no external power supply is needed, and the power indicator LEDs on the USB-MODEVM should light up. The yellow LED (D2, which is located next to the J7 USB plug) should light up as well.

In order to use the touch screen features, a resistive multiple touch screen must be connected to J1 or J4 of the TSC2020EVM.

NOTE: It is very important to firmly and correctly connect the touch screen to the EVM. Note the pinout of the connector J1 or J4 that is wired or connected to the screen; avoid misconnections or loose connections.

Once the USB-MODEVM is powered on, launch the TSC2020 evaluation software that is installed on your PC. The software should automatically find the TSC2020EVM, and a dialog box similar to that shown in Figure 3 should appear.

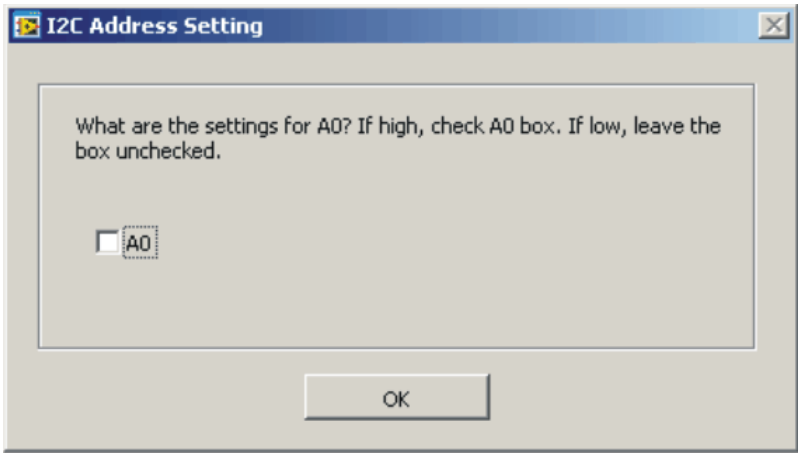


Figure 3. Prompt to Setup TSC2020 I²C Slave Address

Check the **A0** box if TSC2020EVM JMP3 is removed (that is, set to the high position). By default, A0 should be installed (refer to Table 6); thus, the A0 box should not be checked. Click on the *OK* button to continue, and the software graphical user interface (GUI) appears; see Figure 4.

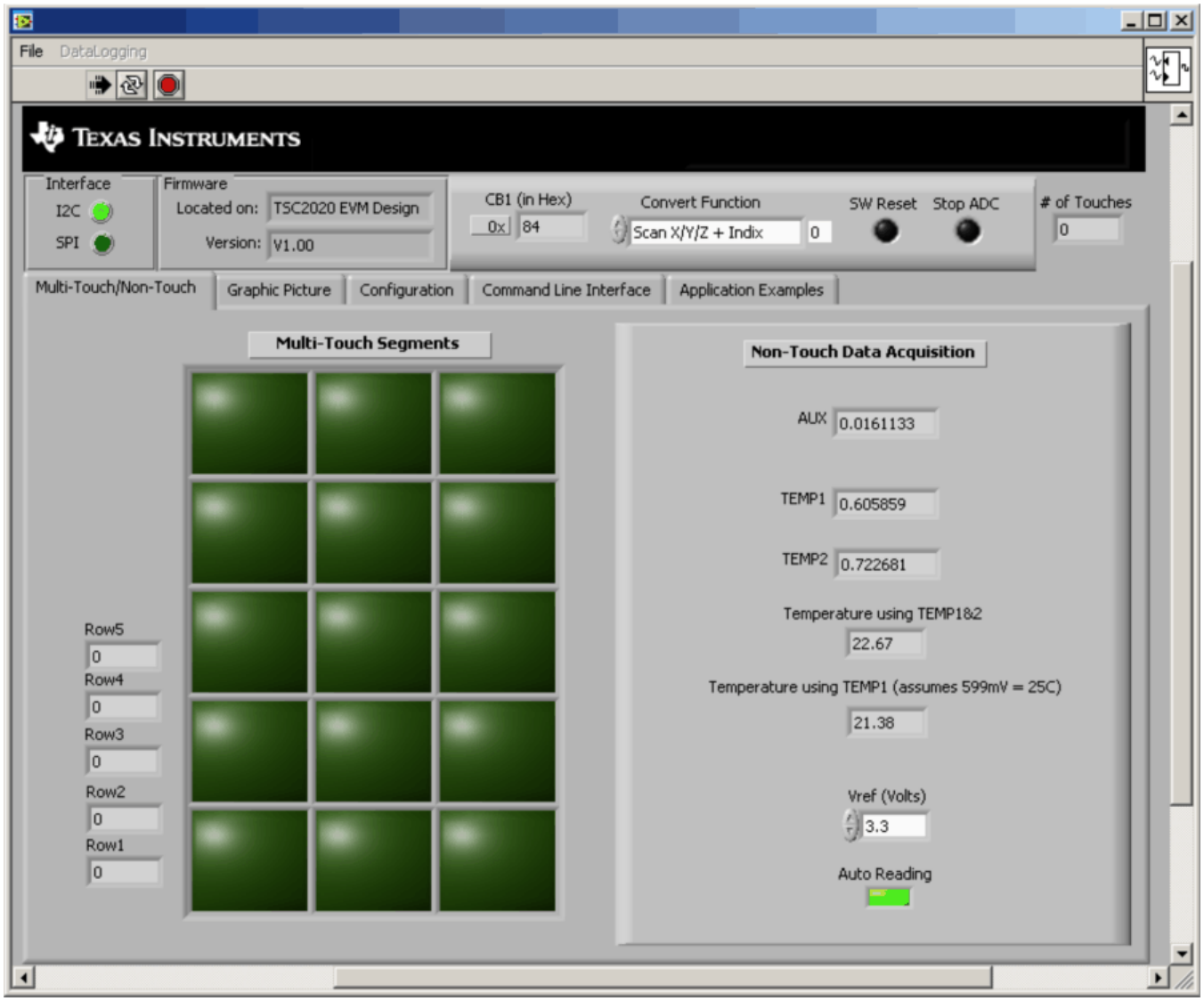


Figure 4. TSC2020EVM-PDK Software GUI: Startup Screen with Multi-Touch/Non-Touch Tab

The *Non-Touch Data Acquisition* section (located at the right hand side of the GUI tab) should be functioning properly, and correct temperature data should be displayed.

The *Multi-Touch Segments* section (located at the left hand side of the GUI tab) shows the multi-touch screen segments whenever one or more touches are pressed on the touch screen.

6 GUI Software and Operating Descriptions

Once you have connected the TSC202EVM to the USB-MODEVM motherboard and provided power to the motherboard from a USB port on your PC, start the TSC2020EVM-PDK software, and the GUI should display correctly (refer to Figure 4).

On the top-left side of the GUI, a green LED indicates the digital serial interface type. This type should be *I²C* for the TSC2020EVM-PDK. The next box to the right shows the location and version of the firmware.

At the upper center of the GUI, the box labeled *CB1* displays the current/default settings (in hex) of the TSC2020 control byte mode 1 (CB1). Data in CB1 are written to the TSC2020 when one of the following actions occurs:

- Bit 0 (STS or Stop ADC) is set by clicking on the Stop ADC LED.
- Bit 1 (SWREST or SW Reset) is set by clicking on the SW Reset LED.
- Bit 2 (RM or Resolution) is set at the Resolution selection box.
- Bits 3 through 6 (Converter Function Select) can be set at the next *Convert Function* drop-down slider.

See the TSC2020 data sheet (SBAS494) for more information about the control byte and the CB1 definition.

The two LEDs at the upper right-hand side of the GUI can be used to perform a software reset of TSC2020 and stop the TSC2020 analog-to-digital converter (ADC) operation. Note that the two LEDs reflect the corresponding bits inside the CB1 (see the TSC2020 data sheet).

When the SW Reset LED is lit (blue), bit 1 of CB1 is set to logic '1' and the TSC2020 is in software reset mode. When the LED is off (black), bit 1 is set to logic '0'; the TSC2020 is not reset and is in operating normal mode.

When the Stop ADC LED is lit (red), bit 0 of the CB1 is set to logic '1' and the TSC2020 ADC stops. When this LED is off (black), bit 0 goes to logic '0' and the TSC2020 operates normally.

At the far right side of the GUI, near the upper right hand corner, there is a box that indicates the number of touches simultaneously on the screen. A number should appear when you touch on the touch screen.

Most product and design evaluations can be implemented using the five primary tabs on the TSC2020EVM GUI: *Multi-Touch/Non-Touch*, *Graphic Picture*, *Configuration*, *Command Line Interface*, and *Application Examples*. Clicking on a tab accesses the functions that correspond to the specific tab. This section provides a detailed discussion of the functions of these five tabs.

6.1 Multi-Touch/Non-Touch Tab

Figure 4 shows the Multi-Touch/Non-Touch Tab; this screen is the default (startup) tab of the GUI, and shows both the multi-touch segments and the non-touch data (for example, AUX and temperature).

The TSC2020 provides for measuring an auxiliary input voltage (AUX) and the temperature. The Non-Touch Data Acquisition functions at the right-hand side of this tab show the measured values for these parameters. As noted previously, these measurements are updated only when the touch screen is not being pressed, and the Auto Reading LED is on.

Temperature is displayed using both measurement modes described in the TSC2020 data sheet. Using the TEMP1 and TEMP2 measurements, a temperature reading with 2°C resolution and accuracy is achieved. Using only the TEMP1 measurement, a reading with 0.3°C resolution is possible, but requires that the user know the TEMP1 value at +25°C. This setting normally requests a calibration performed by the user. The evaluation software program presumes that TEMP1 = 580 mV at +25°C.

By default, the software continuously reads non-touch data, AUX, TEMP1, and TEMP2, and automatically updates these values in the *Non-Touch Data Acquisition* section of the GUI display. To stop data acquisition, click on the green LED *Auto Reading*.

Both AUX and temperature measurements require a reference voltage, which is provided to the TSC2020 V_{REF} pin. The V_{REF} value (in volts) controller box can be written with the corresponding V_{REF} voltage. The factory default V_{REF} setting is 3.3 VDC.

The Multi-Touch Segments display box in this tab updates when one or more touches are detected on the touch screen, and indicates the touched segment(s), as shown in Figure 5.

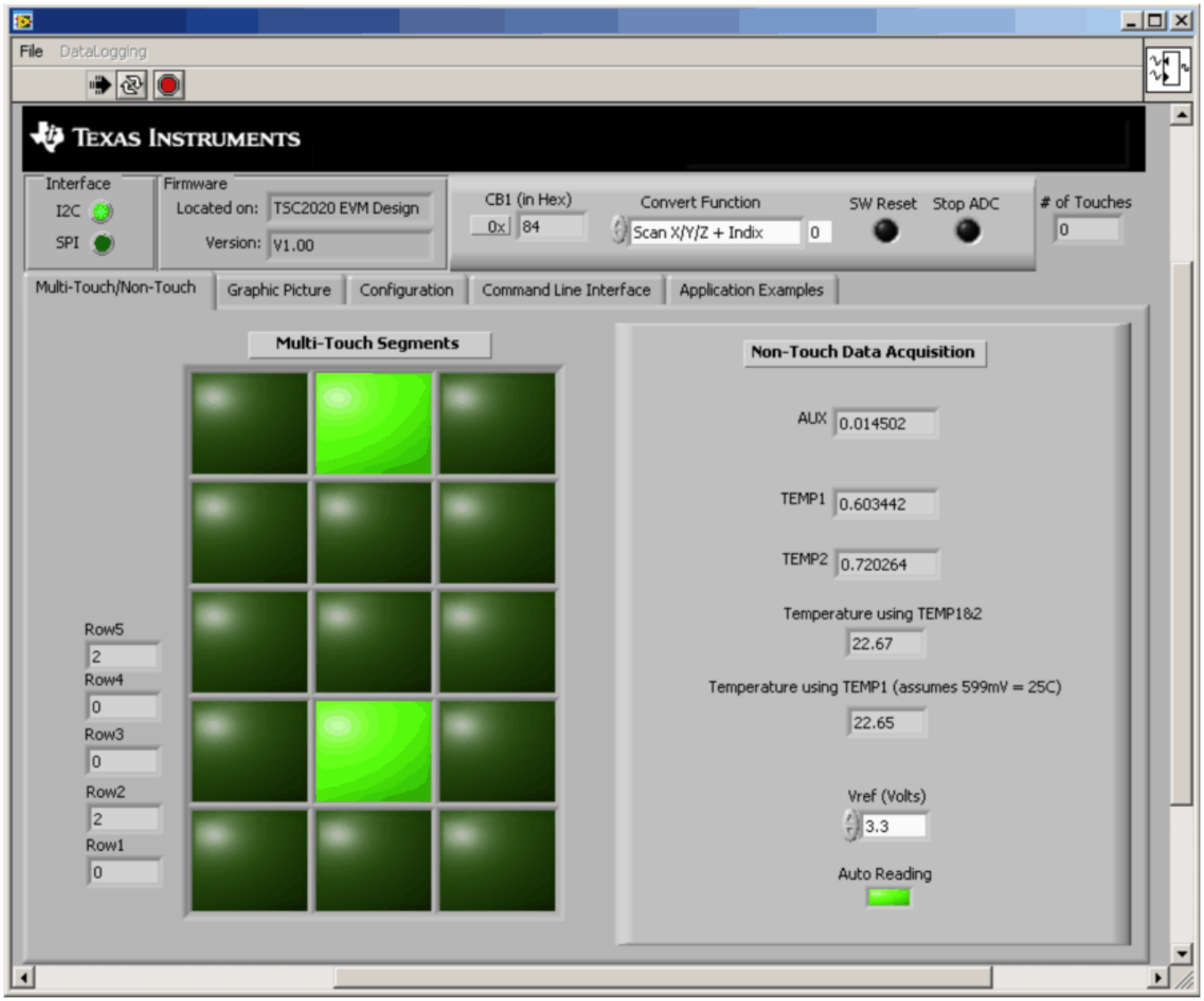


Figure 5. TSC2020EVM-PDK Software GUI: Multi-Touch/Non-Touch Tab

6.2 Graphic Picture Tab

Figure 6 shows the Graphic Picture tab, where the touch screen data (such as X, Y, and Z coordinates of each touch on the screen) are drawn on the Touchscreen Functions picture box whenever one or more touches are pressed on the touch screen.

As a touch screen senses a touch (or a drawing is made) on the screen, the motion on the touch screen is translated into pixels in the *Touchscreen Functions* box. The software takes X, Y, Z_1, and Z_2 readings, and translates the data to a pixel display. The raw data are shown at the right of the *Touchscreen Functions* box.

As the pressure of a touch increases, the pixel size increases correspondingly. In other words, a lighter touch results in thinner pixel sizes and a stronger touch produces thicker pixel sizes on the *Touchscreen Functions* display.

(Note that the Z-value displayed is not exactly what is described in the TSC2020 data sheet because the data sheet equations are calculated as if there is a known resistance of the touch screen being used.) The value used in the evaluation software is calculated by Equation 1 of the TSC2020 data sheet, but without multiplying the value by the Rx-plate resistance. This raw value is shown as *Z* beneath the measured touch data, X, Y, Z_1, and Z_2; it normally ranges from 0 to 4, with larger numbers representing a more forceful press on the screen.

The *Maximum Z Value to Display* knob on this tab is used to set a minimum threshold so that the program does not display lightly pressed points. This threshold setting helps to eliminate the display of spurious points that may result from touch screen mechanical bouncing or physical jitter.

The *Touchscreen Functions* box display can be cleared by pressing the **Clear Graph** button at the bottom of the display.

Figure 6 through Figure 11 show several display examples.

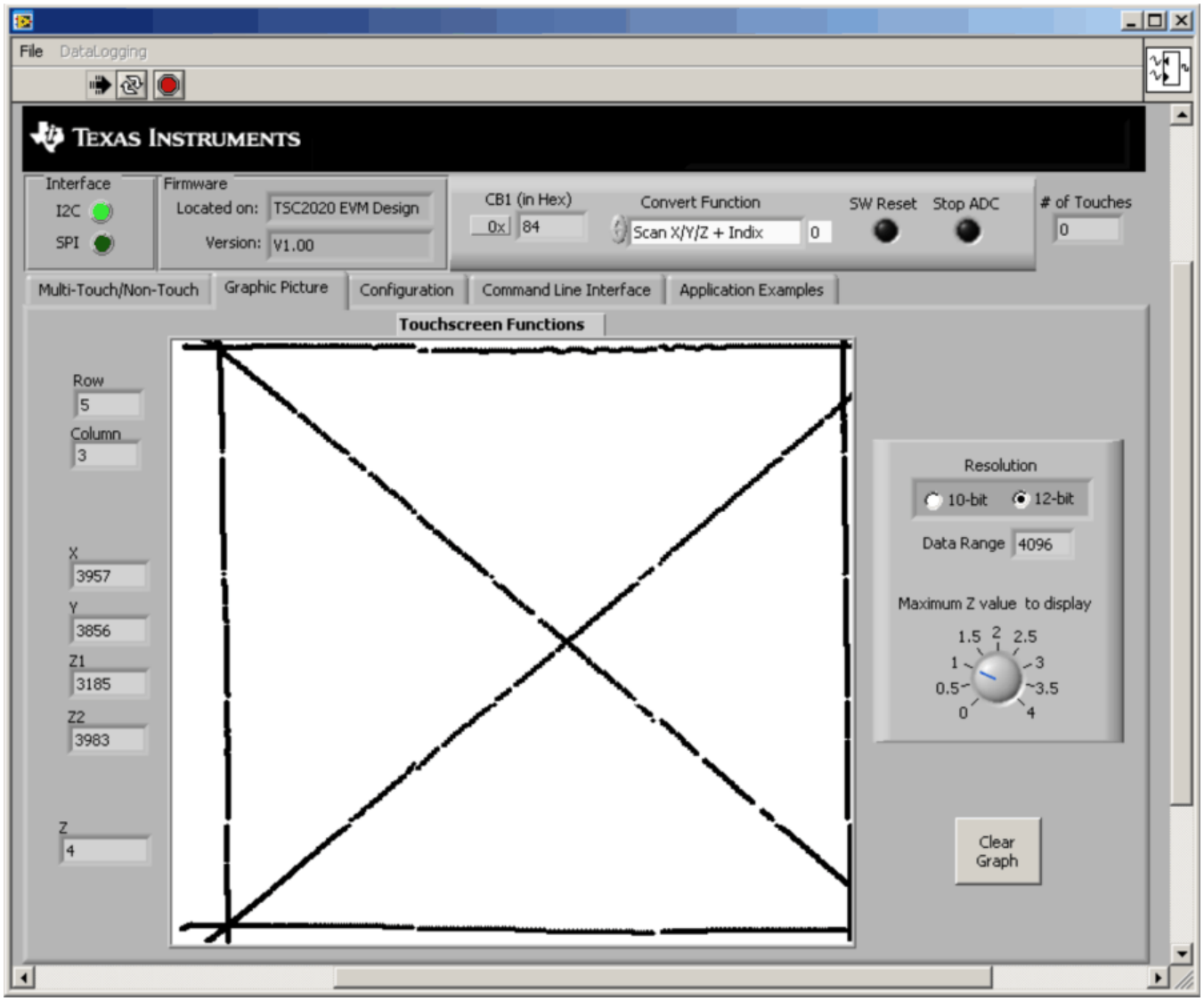


Figure 6. Single Touch and Traces

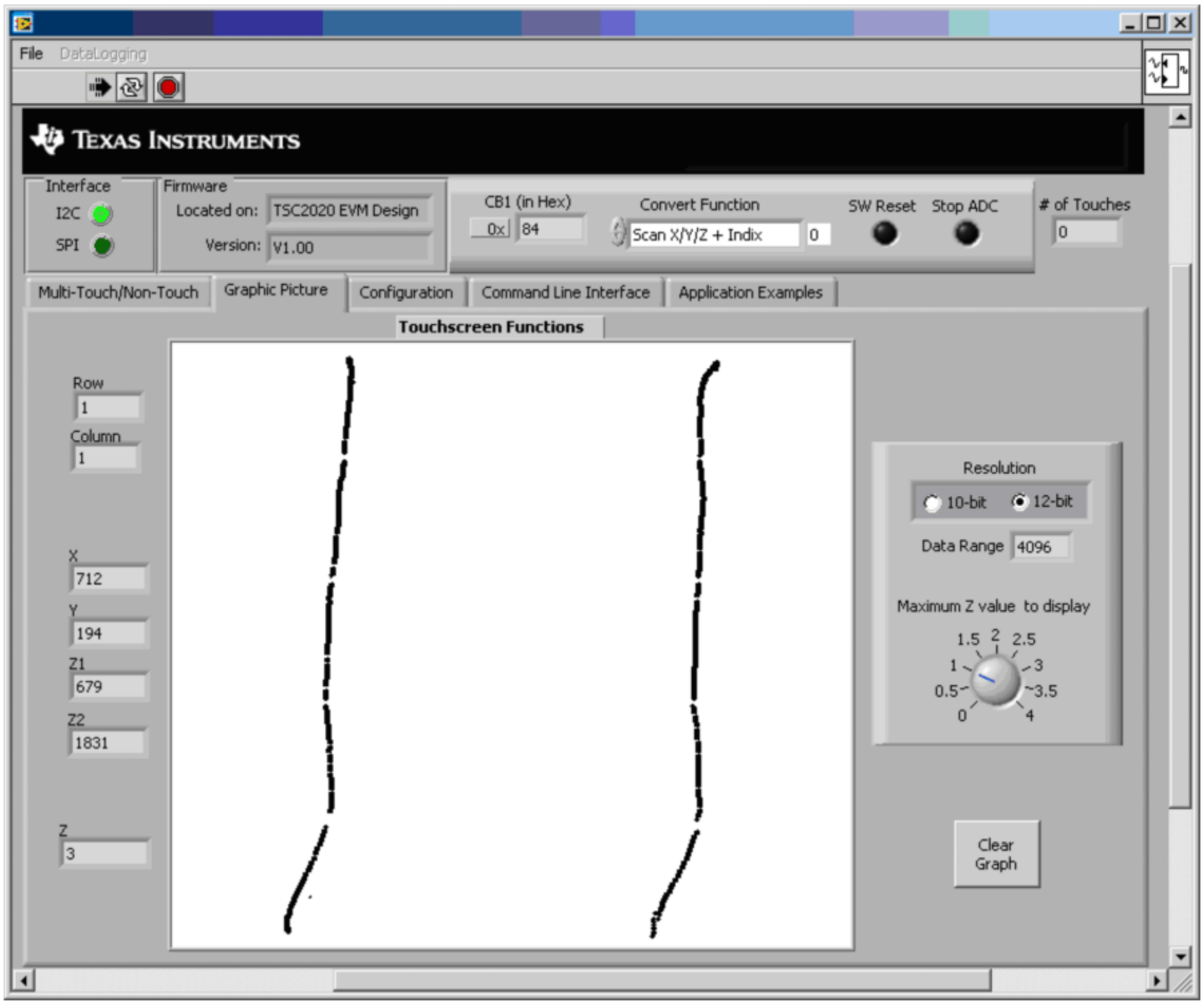


Figure 7. Two Simultaneous Parallel Touches Moving Up and Down

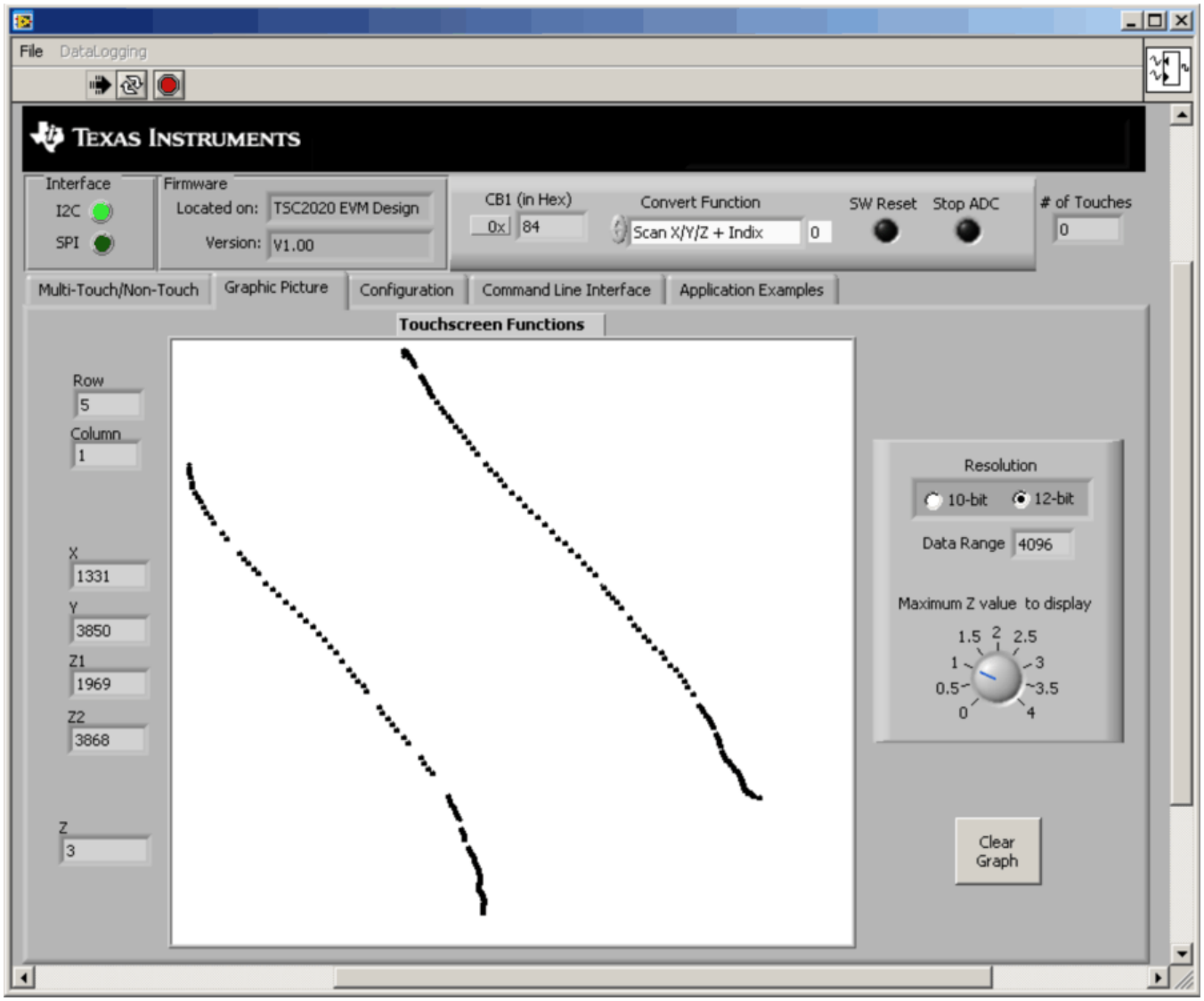


Figure 8. Two Simultaneous Parallel Touches Moving Across the Screen

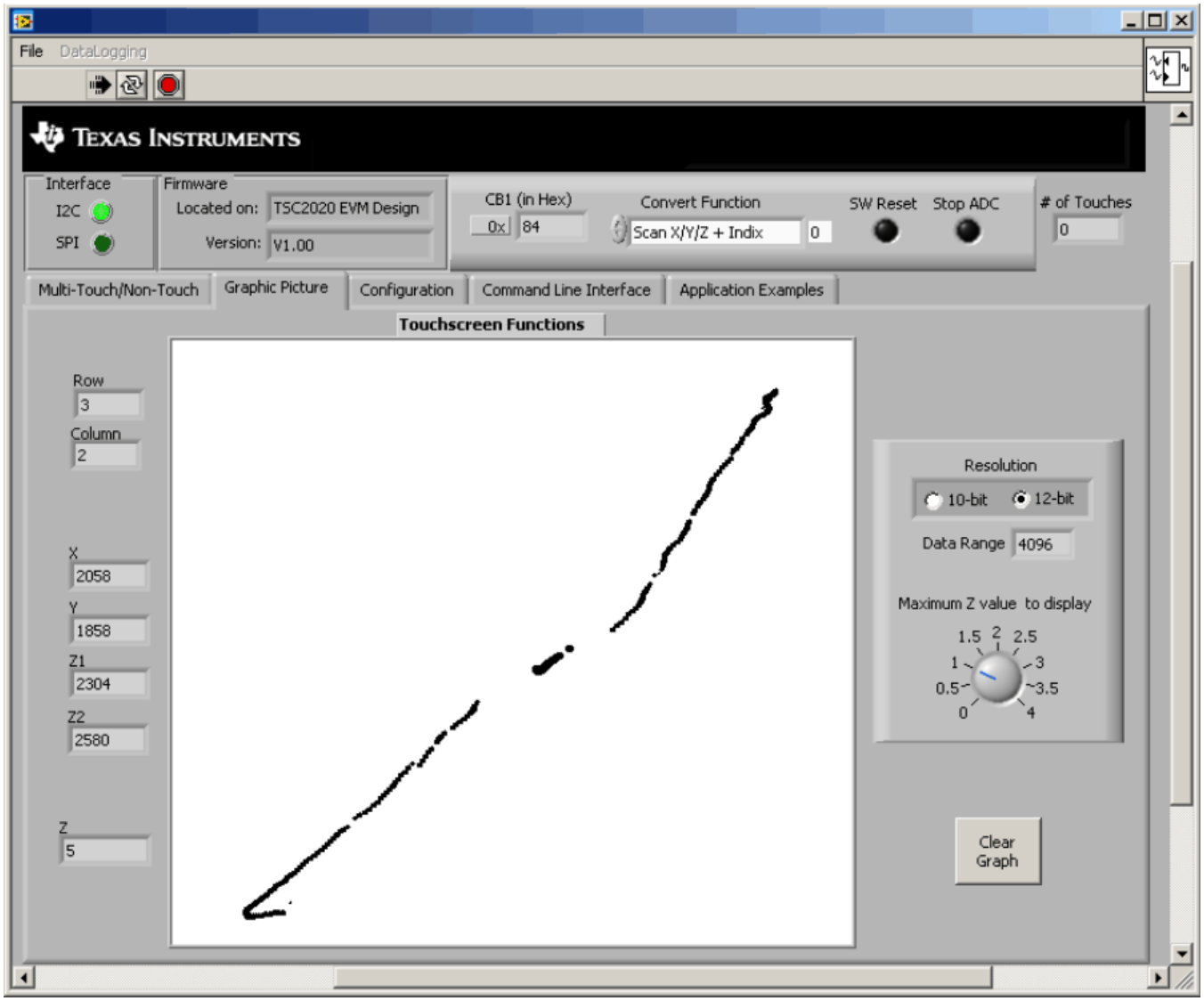


Figure 9. Two Simultaneous Touches Moving Toward One Another

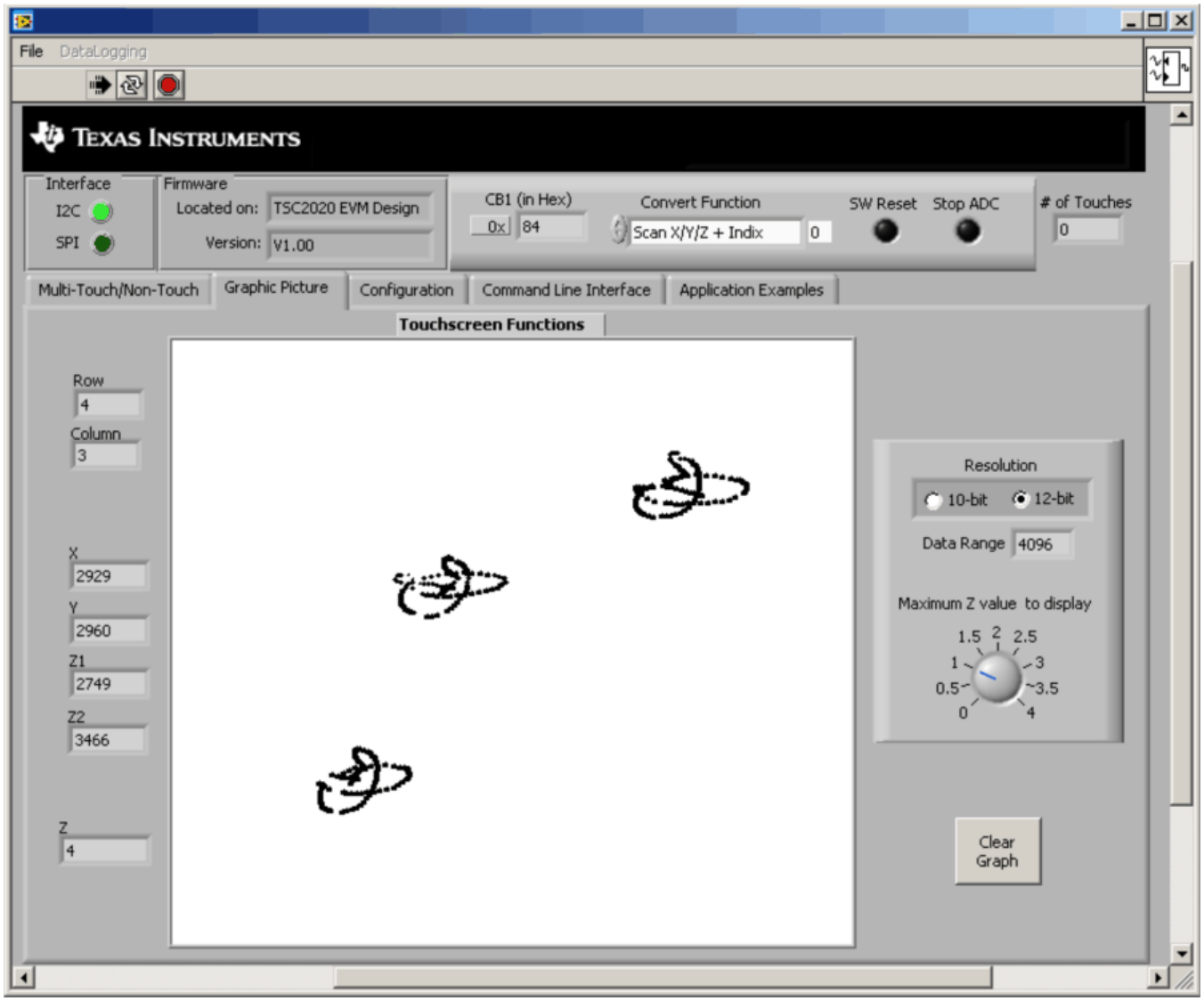


Figure 10. Three Simultaneous Touches

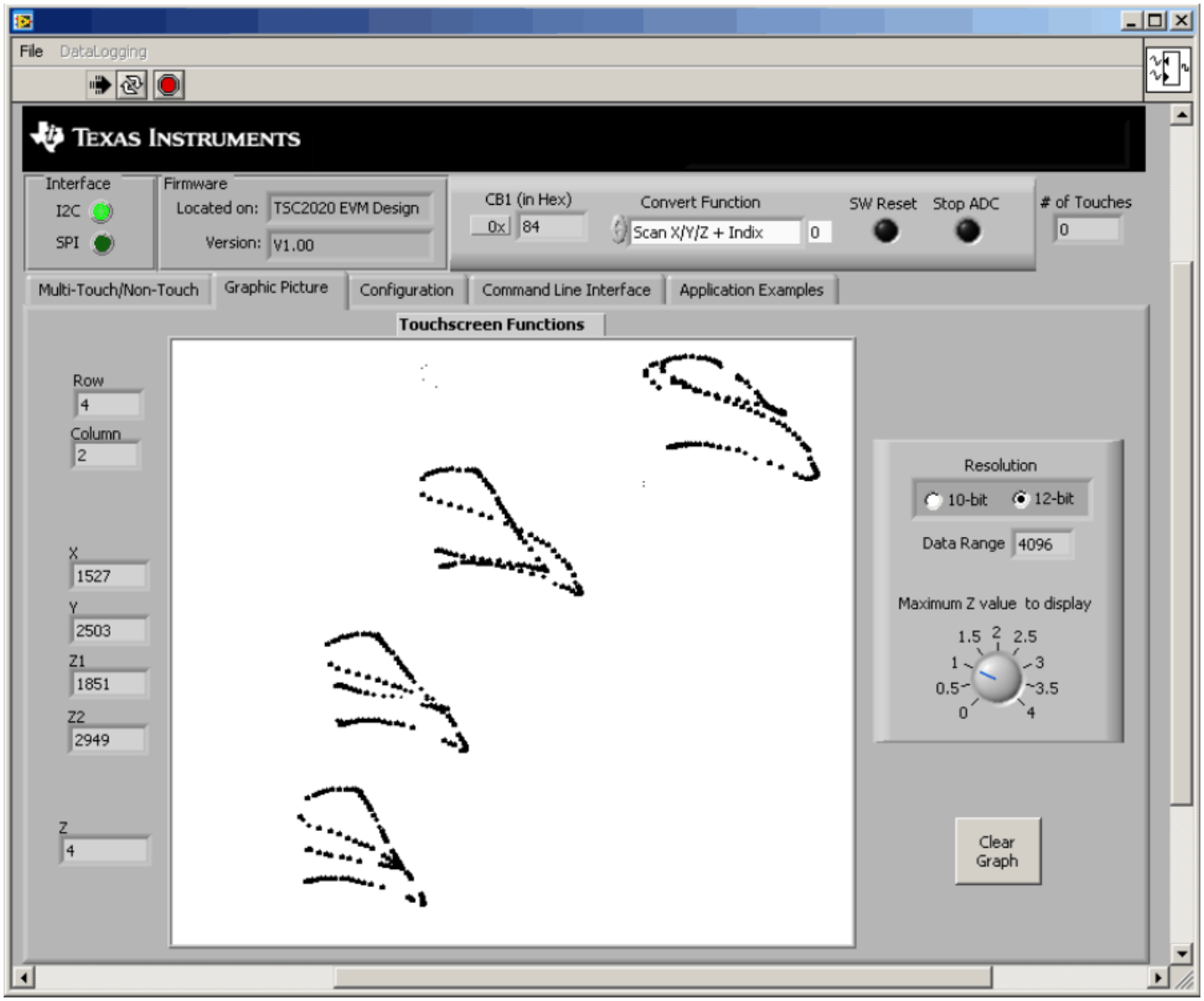


Figure 11. Four Simultaneous Touches

The TSC2020 parameters (or modes) can be set up or configured in two ways. One approach is to set up the control registers (this procedure is described in the Configuration Tab section). The second method is to write directly to TSC2020 through control bytes. Most of the device configuration information and status of the TSC2020 can be accessed through writing to or reading from the TSC2020 control registers. Additionally, several parameters or modes can be accessed through the direct configuration, including Resolution, ADC Stop, and SW Reset. See the TSC2020 data sheet for more details.

The TSC2020 ADC can be configured to operate in either 10-bit or 12-bit resolution mode. This option can be directly configured using Control Byte Mode #1 or pressing the **CB1** button in the GUI. Clicking on the resolution option here changes the resolution setting in CB1.

6.3 Configuration Tab

This tab is used to set up the TSC2020 control or configuration registers. There are four configuration sections and two status boxes on this tab, as Figure 12 shows.

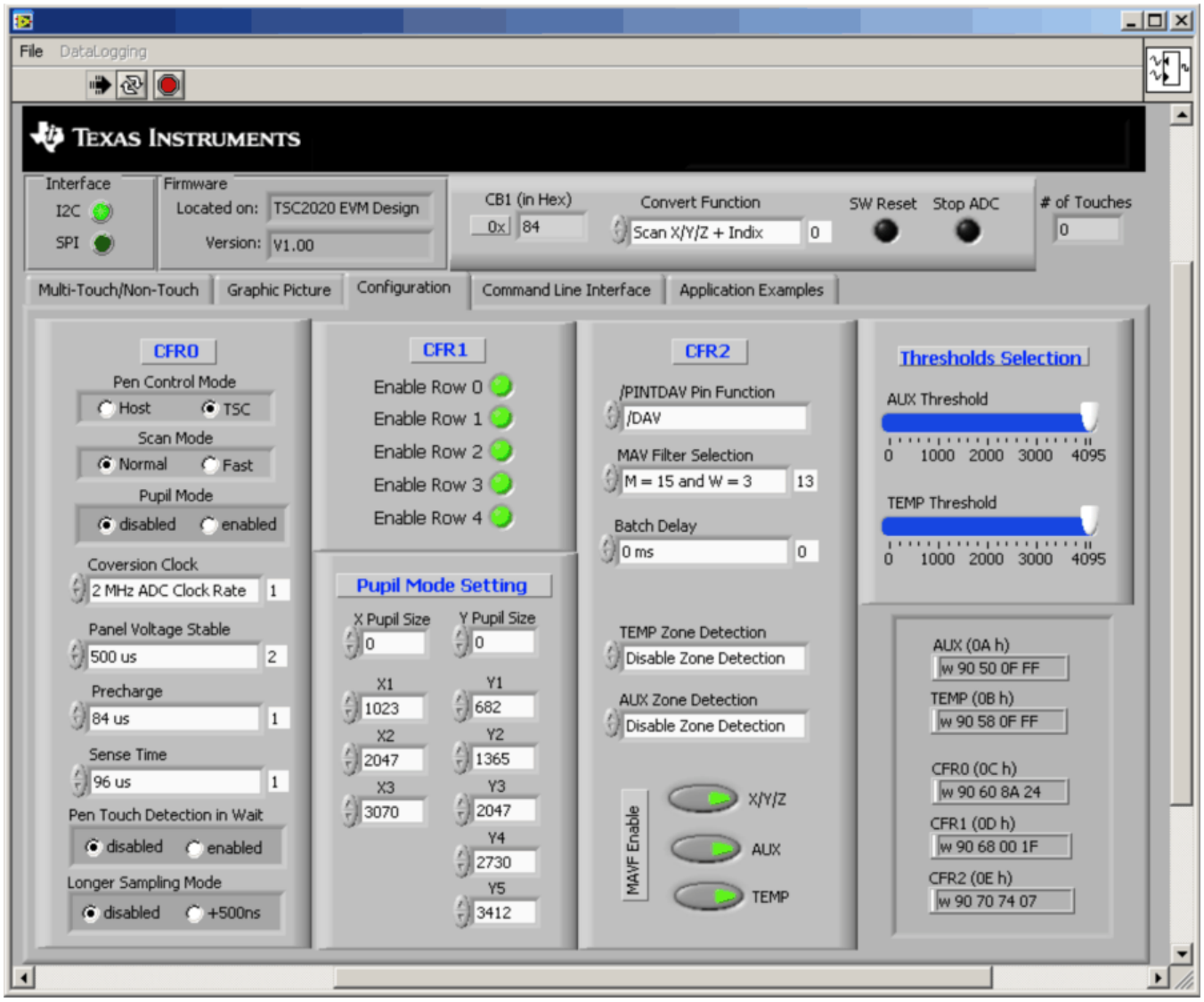


Figure 12. TSC2020EVM-PDK Software GUI: Configuration Tab

The four configuration sections correspond to the configuration registers CRF0, CFR1, CFR2, and the AUX and TEMP thresholds registers, respectively. The status box under the *Threshold Selection* section displays the current values written to these TSC2020 control and configuration registers. Thus, the corresponding value in a status box should be updated whenever a parameter or parameters in a configuration section changes.

Note that a digital box is next to each of these multiple selectors, such as *Conversion Clock* in CFR0 or *Batch Delay* in CFR2; clicking on the digital box sends the data to the corresponding control registers.

6.3.1 ADC Configuration (CFR0)

This section controls the parameters in TSC2020 configuration register CFR0. Each button or selection controls a single parameter.

- Pen Mode:

  This button controls whether the touch data acquisition is started or initialized by a host processor command (Host) or by the TSC2020 automatically (TSC). The default option is to start acquisition by the TSC2020.
- Scan Mode

  In this box, you can set the TSC for normal scan mode or fast scan mode, a very low-power operating mode when only the index (not the coronate) register updates. Refer to the TSC2020 data sheet for the details on TSC scan modes.
- Pupil Mode

  This option allows you to disable or enable the TSC2020 pupil mode. You must first set up the center value and pupil size in the *Pupil Mode Setting* section under the CFR1 before you enable the pupil mode. Refer to the product data sheet for complete details on the TSC2020 pupil mode.
- Conversion Clock

  The internal clock that runs the ADC can run at 4, 2, or 1 MHz. Note that when operating at 4 MHz, only 10-bit resolution is possible. Thus, you may need to check the resolution setting after selecting the 4-MHz conversion clock. By default, the clock runs at 2 MHz.
- Panel Voltage Stabilization Time

  This time is the period that the TSC2020 allows for the touch screen to settle after turning on the drivers.
- Precharge Time
- Sense Time

  These two parameters show the time allowed to precharge the touch panel capacitance and then sense to see if the screen has been touched. Both times are timing parameters for TSC2020 touch screen detection circuitry. For more details about these parameters, see the TSC2020 data sheet.
- Detection of Pen Touch in Wait

  This option is valid when the ADC is put into the host-controlled mode. Enabling this option puts the touch detection in the background and allows the TSC2020 to pull its $\overline{\text{PINTDAV}}$ pin high if no touch is detected while waiting for the host to issue a command, so that the host can decide whether or not a reading touch data command should be issued.
- Longer Sample Mode

  Enabling this option adds an extra 500 ns of sampling time to the normal sampling cycle. It is disabled by default.

6.3.2 Multiple Touch Screen Configuration (CFR1)

The lower five bits in CFR1 are used to enable or disable the five available rows for touch detection in the TSC2020. These bits could be used for enabling or disabling regions of the touch screen.

There are five green LEDs in this section, each corresponding to a CFR1 bit and therefore to one row on the screen. Click on an LED to enable or disable a corresponding row on the screen.

6.3.3 TSC Feature Configuration (CFR2)

TSC2020 pre-processing features, such as the $\overline{\text{PINTDAV}}$ interrupt, MAV filter, batch delay, and zone detection, can be programmed to be set up for optimal performance according to the user's specific application or system. These TSC2020 features can be controlled or configured in CFR2:

- $\overline{\text{PINTDAV}}$ Pin Function

  The TSC2020 interrupt pin $\overline{\text{PINTDAV}}$ can be programmed as a pen touch interrupt ($\overline{\text{PENIRQ}}$), data available ($\overline{\text{DAV}}$) function, or both $\overline{\text{PENIRQ}}$ + DAV. This option can be set up through the $\overline{\text{PINTDAV}}$ Pin Function in the CFR2 configuration section. Clicking on the digital box writes the selected value to the CFR2 Register.
- MAV Filter Selection

  The preprocessing MAV filter (MAVF) within the TSC2020 reduces sampling noise. (See the TSC2020 data sheet for details about the MAVF.) Clicking on the *MAV Filter Selection* option box brings up a list of settings for M and W values. Select an eligible option from the list (do not select the *Reserved* option) and the corresponding digital value appears in the next box. Click on the digital box to write the selected value to the CFR2 Register.

  The CFR2 section has three selectable switches (MAVF Enable) on the bottom that can be used to individually enable/disable the MAVF on touch data (X/Y/Z), or non-touch data, AUX and Temperature.
- Batch Delay

  Another TSC2020 feature is the Batch Delay Mode. Under the TSC-controlled ADC mode, this feature adds a delay between ADC samples and thus controls the time interval between samples. The batch delay ranges from 0 ms to 100 ms, as provided in the Batch Delay option box. Click on the digital box to write the selected value to the CFR2 Register.
- TEMP and AUX Zone Detection

  Zone detection is another feature of the TSC2020. The zone detection function was designed to monitor the zone or range of the non-touch inputs, including AUX and TEMP1/TEMP2. The zone detection modes can be controlled or selected through the two option boxes, *TEMP Zone Detection* and *AUX Zone Detection*, in the CFR2 section. Click on the digital box to write the selected value to the CFR2 Register.

6.3.4 Zone Detection Threshold Selection (Threshold Section)

Threshold Section selection is associated with TEMP or AUX zone detection. There are two control registers onboard the TSC2020 that are used to configure the upper threshold limits of AUX and TEMP1/TEMP2. These two registers can be accessed by the two moving slides in the *Threshold Selection* section of the *Configuration* tab.

6.3.5 TSC2020 Control Register Writing Status

These two status boxes show what exactly is written to the TSC2020 Control Registers. The data in a status box change when either CFR0, CFR1, CFR2 or Threshold Selection is set. The last four digital values in a status box indicator reflect the value to the corresponding TSC2020 register.

6.4 Command Line Interface Tab

Clicking on the *Command Line Interface* tab brings up a screen similar to that shown in Figure 13, which provides a flexible way to read from and write to the TSC2020EVM by the use of scripts.

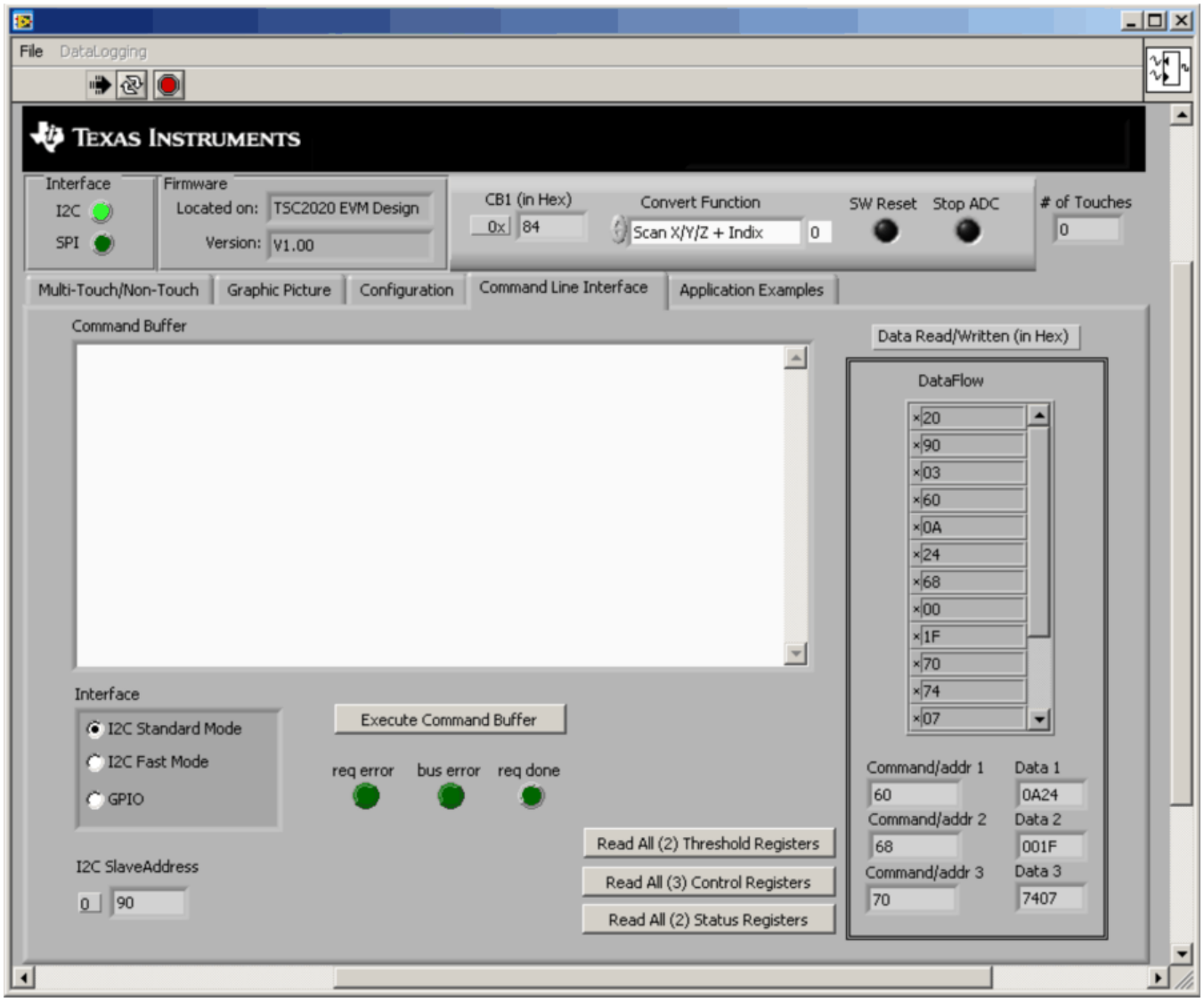


Figure 13. TSC2020EVM-PDK Software GUI: Command Line Interface Tab

The line or lines of the script are typed or loaded into the Command Buffer. Clicking on the **Execute Command Buffer** button runs the script.

If a line of the script is a reading command, the data that are read appear in the *Data Read/Written* section. If the line of the script is a writing command, the written data bytes also are returned to the *Data Read/Written* section.

There are three LEDs on this tab. The **req done** LED lights up (that is, it turns green) after the script finishes execution. A corresponding error LED lights up if a communication error occurs.

Three read buttons reveal the contents of the Threshold, Control, and Status Registers of the TSC2020; these contents are also displayed in the *Data Read/Written* section of the screen. The data flow shows at the top of the screen, and is interpreted and listed correspondingly on the button. For example, Figure 13 shows a read result of the three TSC2020 configuration registers CFR0, CFR1, and CFR2 after clicking on the **Read All (3) Control Registers** button.

6.4.1 Software Script

The TSC2020EVM-PDK software was designed to identify and decipher several scripting commands, as described in Table 7.

Table 7. Script Command Types

Command Type	Description
w	Write to TSC through the I^2C serial control bus
r	Read from TSC through the I^2C serial control bus
#	Comment line
b	Break
d	Delay

Each line in a script file is a command, and a line is terminated by a carriage return.

- The first character of a command line indicates the command type. Table 7 lists all the command types that can be recognized and implemented by the TSC2020EVM-PDK software.
- Following the command type *w* or *r*, the byte is the I^2C device address. For the TSC2020, this address is either **0x90** (if A0 = 0) or **0x92** (if A0 = 1). No byte follows a # (comment) or a *b* (break) command. The byte or bytes that follow a command type *d* are the delay time in milliseconds (ms).
- The second byte in a *w* or *r* command line is the address of the configuration register. Refer to the TSC2020 data sheet for its register address.

In an *r* command, the byte after the TSC2020 register address indicates the number of registers to be read from. The next byte is ignored. If more than one register must be read, the next byte is the next register address and is followed by two dummy bytes that are ignored.

In a *w* command, the two bytes after the register address are the data written to the 16-bit TSC2020 registers. If more than one registers must be written, the next byte is the next register address, followed by two data bytes.

For writing to CB1 of the TSC2020, this byte includes both address and content; thus, there are no further bytes after this address byte.

6.4.2 Software Script Command Line Examples

This section provides several command line script examples for use with the TSC2020EVM evaluation software.

Example 1. Writing to CB1 and Changing to 10-bit Resolution Mode

```
w 90 80
```

Example 2. Writing 0x8A00 to Register CFR0

```
w 90 60 8A 00
```

Example 3. Writing the Two Threshold Registers to Set Up the Max Threshold (0xFF0)

```
w 90 50 0F F0 58 0F F0
```

Example 4. Reading the STATUS Register Contents

```
r 91 38 01 00
```

Example 5. Reading Back the Index, X, Y, Z_1, and Z_2 Data Registers

```
r 91 00 04 00 08 00 00 10 00 00 18 00 00 20 00 00
```

6.4.3 Uploading Software Scripts

To upload an existing script into the Control Buffer within this tab, first go to the *File* menu, then select *Open Command File...* This menu option opens a file-select window and allows you to browse and find an existing script file. Select the file, click on *Open*, and the script is loaded into the command buffer.

6.5 Application Examples Tab

There are many applications and featured functions that can be obtained by using TSC2020 multiple touch data. This tab displays several examples of such applications.

There are four sub-tabs within the *Application Examples* tab, showing the Scroll/Slide Bars function, and other true multi-touch related functions.

Example for Scroll or Slide Bars

The Scroll/Slide Bars tab has eight vertical scrolls or sliders, as Figure 14 shows.

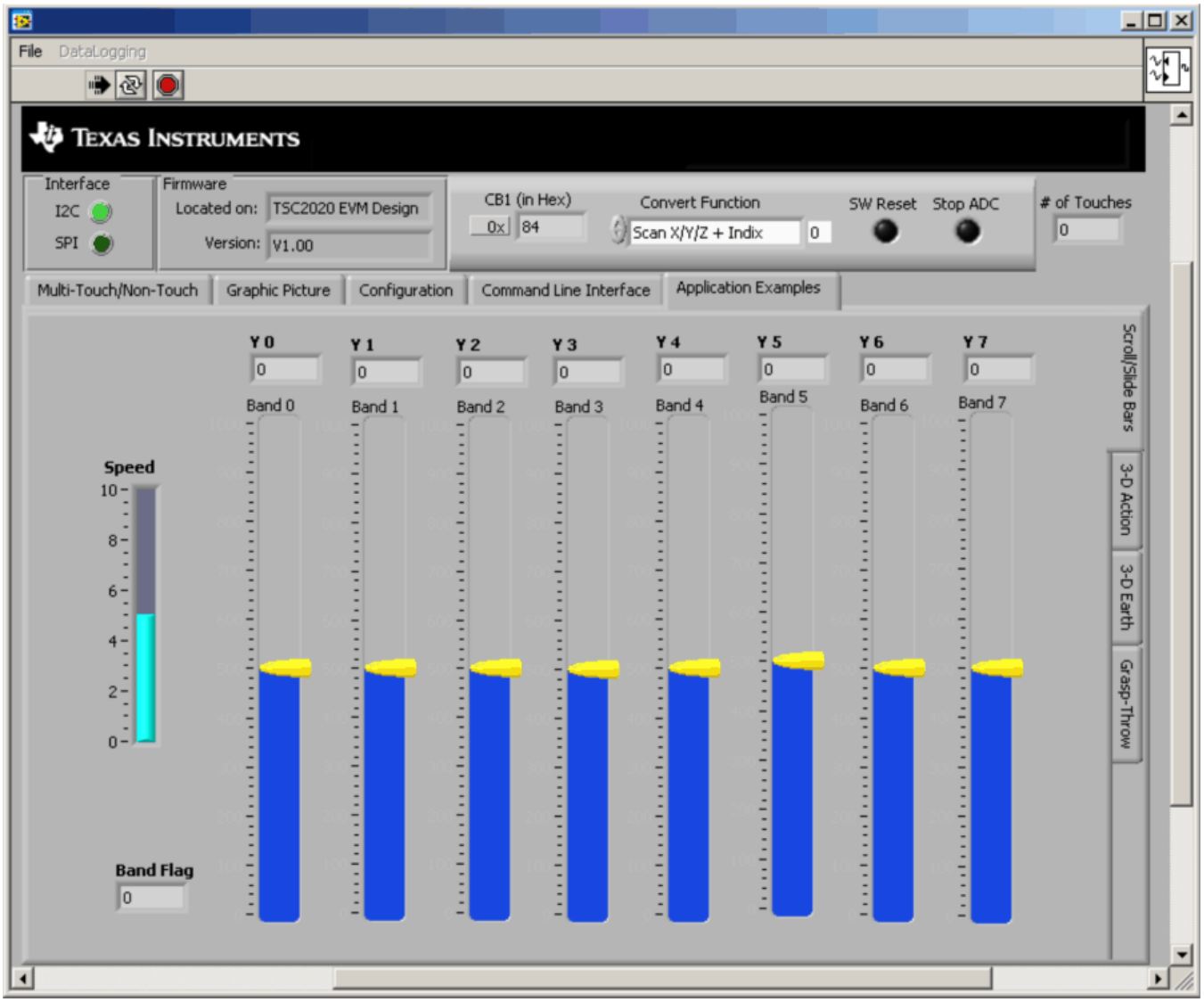


Figure 14. TSC2020EVM-PDK Software GUI: Scroll/Slide Bars (in Application Examples Tab)

These scrolls or sliders can be moved or rolled up and down by touch. One or multiple touches can be placed on a touch screen to move one slider or multiple sliders simultaneously. You may hold or drag the yellow handle and move up/down along the touch screen Y-axis or roll your fingers up/down in a small area upon the touch screen.

The *Band Flag* indicator shows the band or bands the user is touching in. The *Speed* slider can be used to select the moving rate of the bars.

Example for Rotation

The 3-D Action tab, shown in Figure 15, shows the solar system with the sun in the center of the image; the Earth that rotates around the sun as well as rotates independently; and the moon that rotates around the Earth.

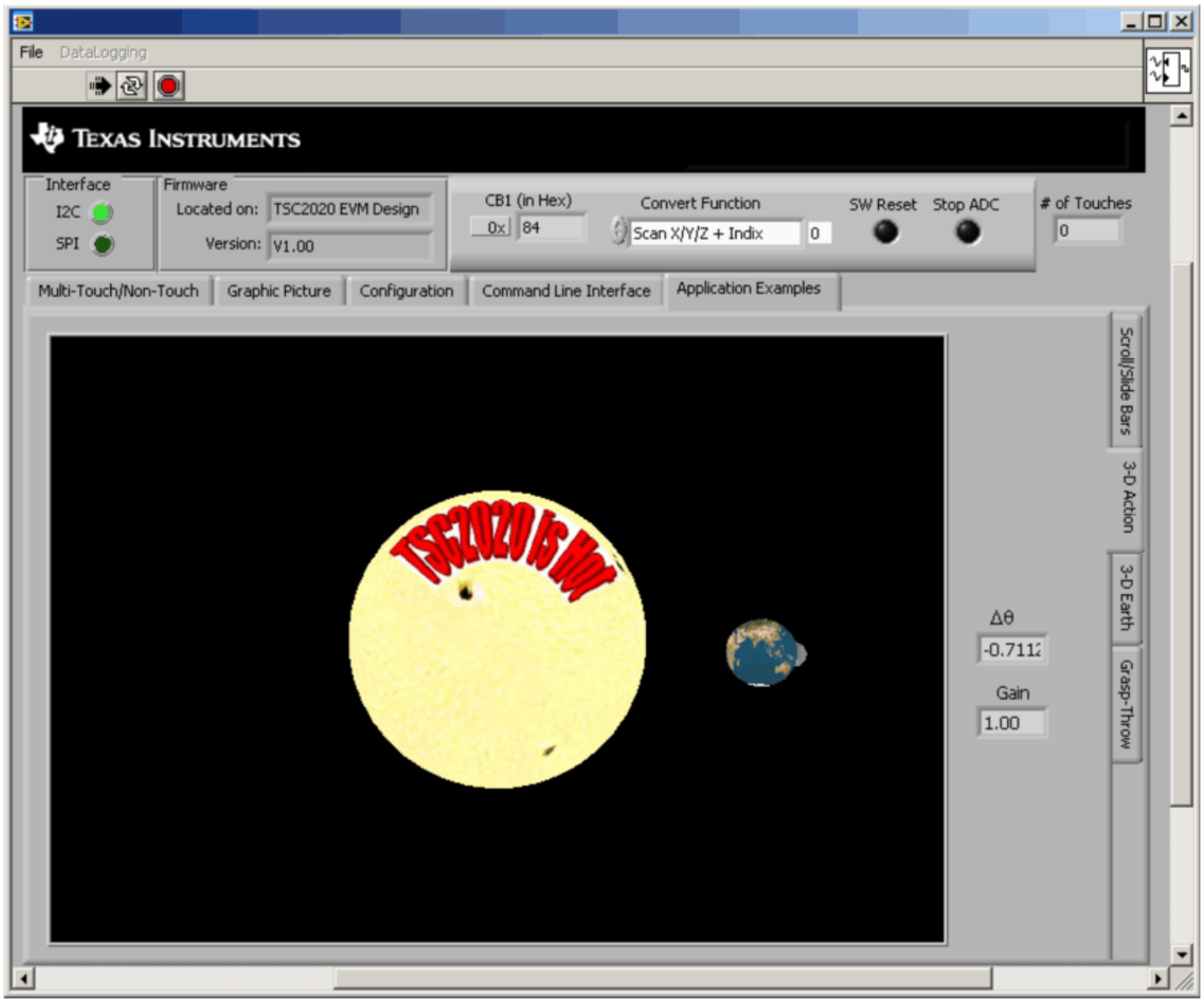


Figure 15. TSC2020EVM-PDK Software GUI: 3-D Action (in Application Examples Tab)

- Rotation by One or Multiple Touches

  The solar system can be rotated by one or multiple touches moving around the center of the touch screen, clockwise or counter-clockwise.
- Zoom In/Out with One Touch at Bottom

  Touching with a finger at the bottom of the screen and moving from left-to-right, the solar system image is enlarged (that is, zooms in). Alternatively, touching with a finger at the bottom of the screen and moving from right-to-left decreases the image size (zooms out).
- Rotation and Zoom

  You can use one hand to apply the rotation function and one finger of another hand to execute the zoom in/out function, or to perform truly multi-touch actions of rotation and zoom in/out simultaneously.

Example for 2-D Rotation, 3-D Rotation, and Zoom-In/Out

The 3-D Earth tab, shown in Figure 16, can be used to perform 2-D rotation, zoom-in/-out, and 3-D rotation.

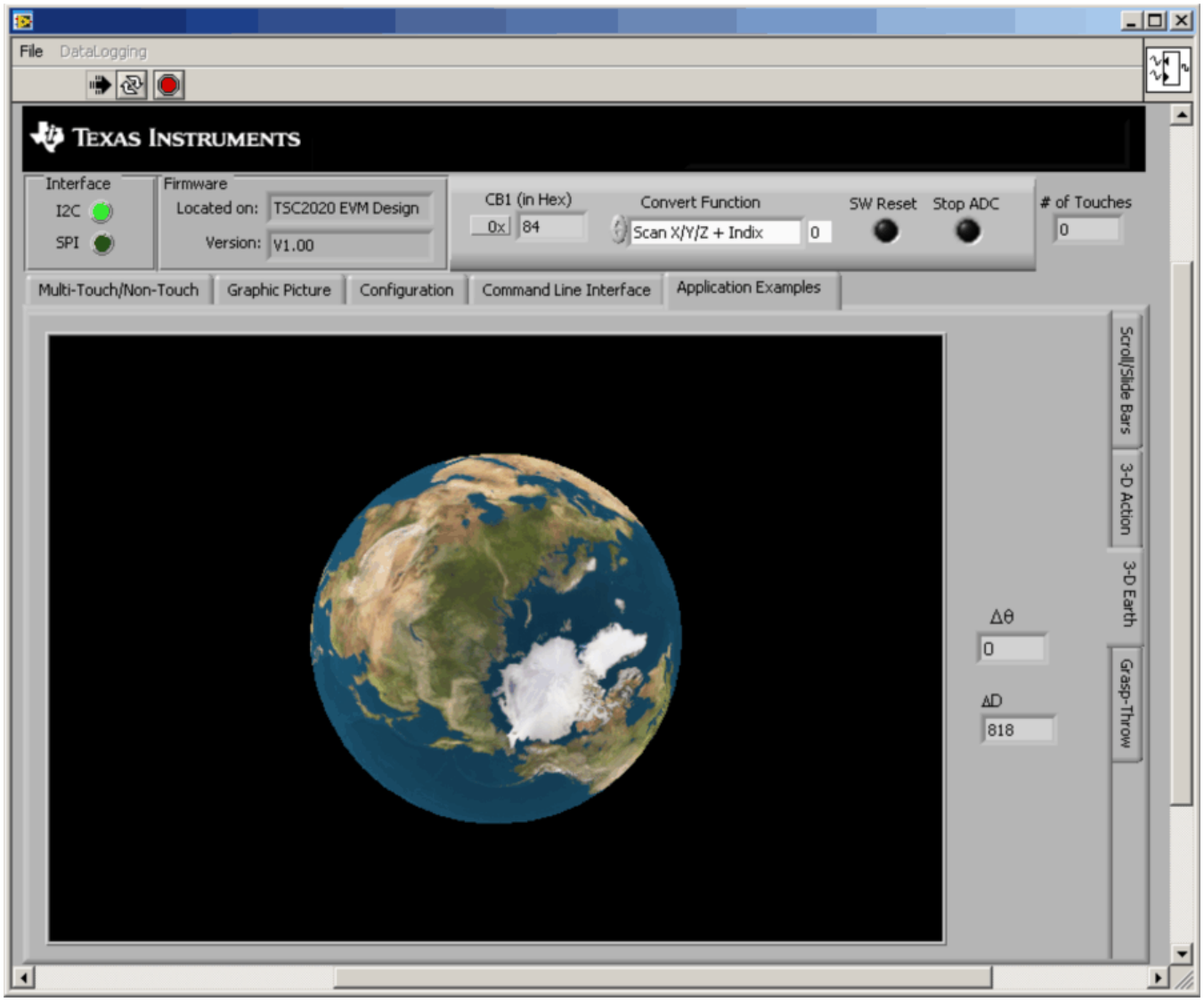


Figure 16. TSC2020EVM-PDK Software GUI: 3-D Earth (in Application Examples Tab)

- One Finger (Single Touch) for 2-D Rotation
  One finger moves around the center of the touch screen and makes the image (the earth) rotate clockwise or counterclockwise, correspondingly.
- Two Fingers (Two Simultaneous Touches) for Zoom In/Out
  Two fingers moving toward each other make the image zoom out (become smaller); two fingers that move apart from each other zoom in on the image (that is, enlarge it).
- Three Fingers (Three Simultaneous Touches) for 3-D Rotation
  Three fingers touching and moving simultaneously on the touch screen rotates the image in 3-D space.

Examples for More Fun with 3-D Rotation and Zoom

The Grasp-Throw tab simulates the following sequence of functions:

- Initial Button (Image Reset)
  A touch at the left-bottom corner of the screen brings the image of Earth back to center, as shown in Figure 17.

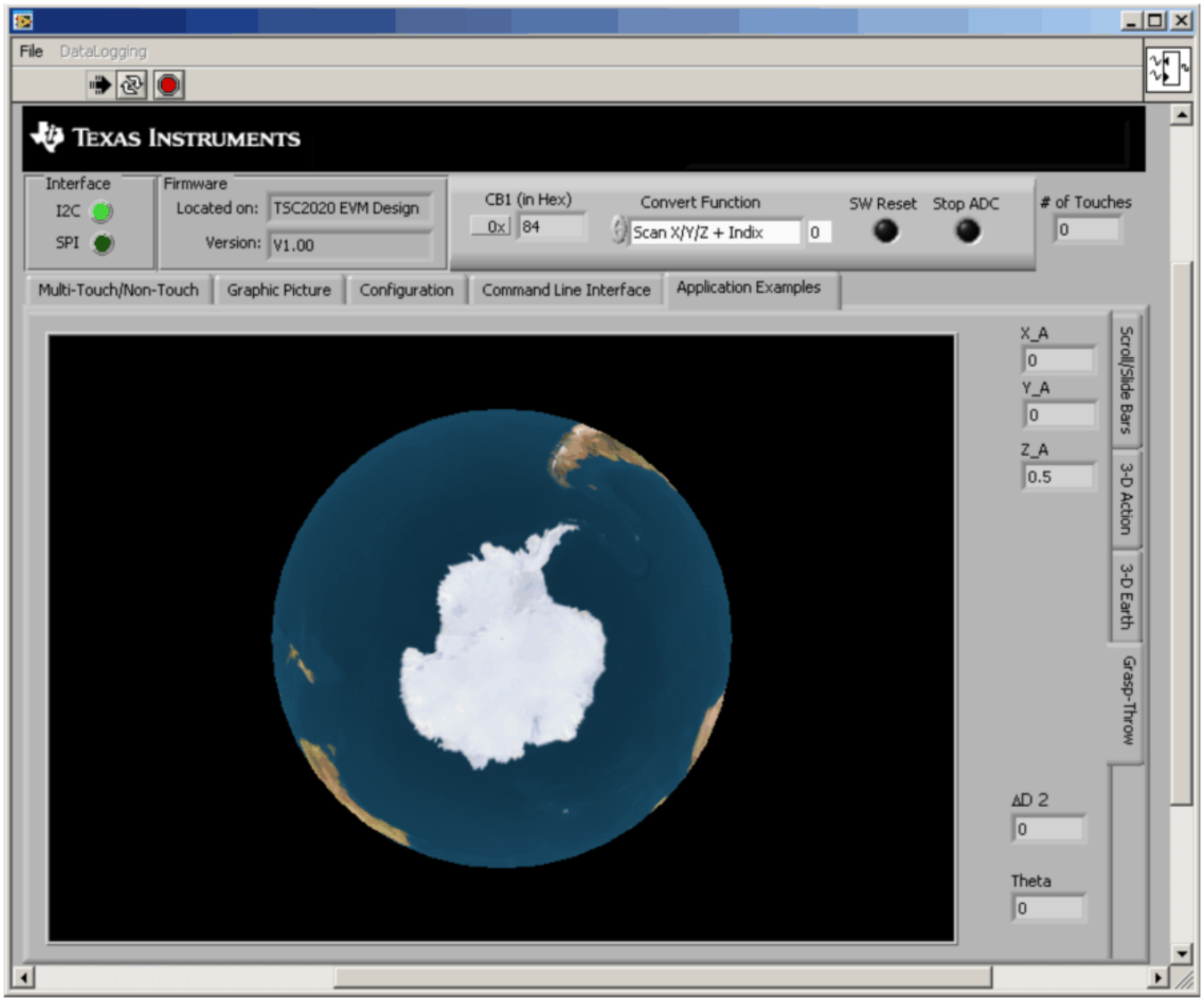


Figure 17. TSC2020EVM-PDK Software GUI: Grasp-Throw (in Application Examples Tab)

- Grasp and Squeeze (Image Zoom Out)
  Grasp the image of the Earth by using three or more touches simultaneously on the touch screen; hold these multiple touches on the screen and move your fingers together (just as if you are grasping a ball, but grasp it tighter and tighter; this is squeezing the image). The earth image becomes smaller as you squeeze it, as shown in Figure 18.

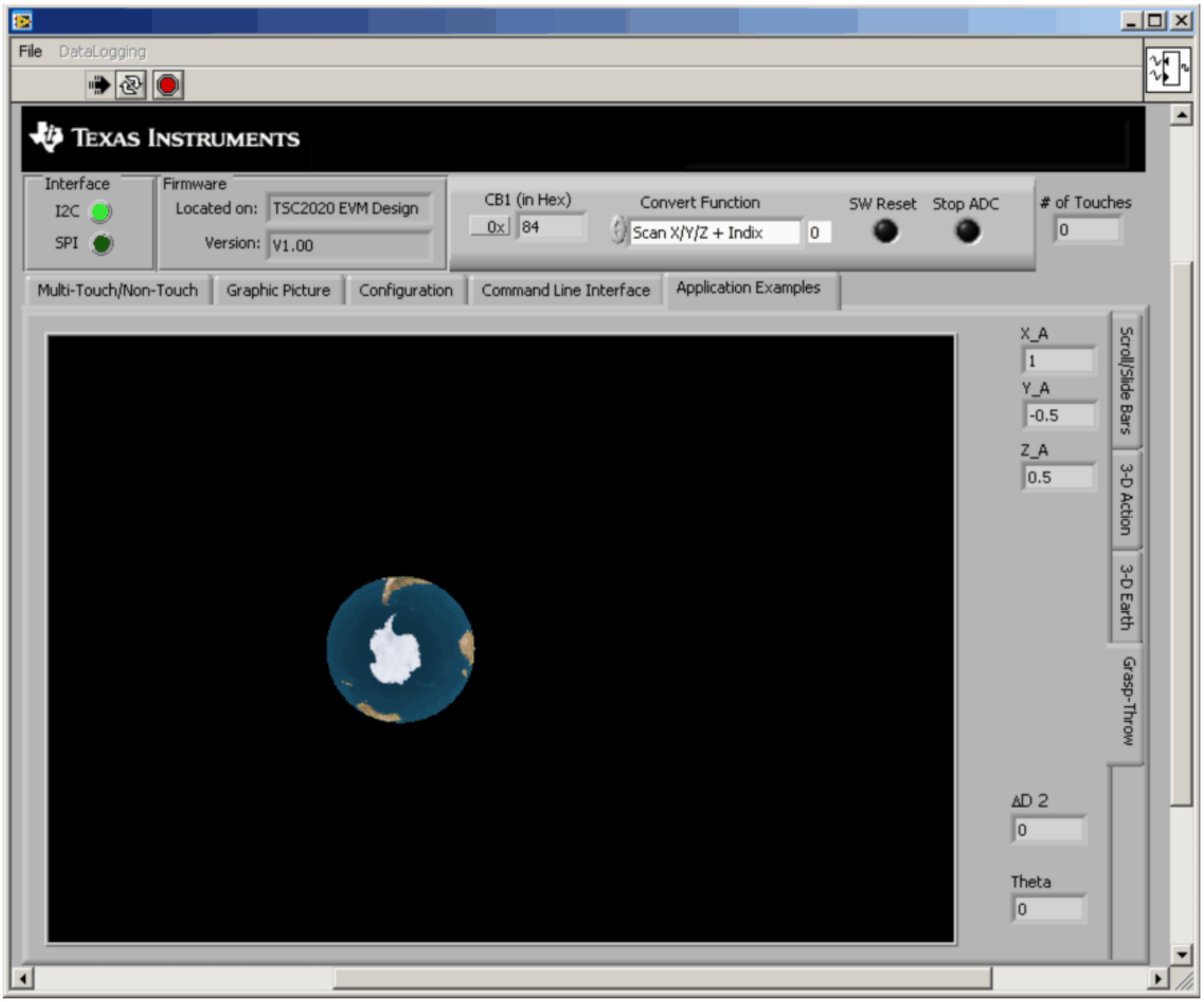


Figure 18. Grasp and Squeeze the Ball with a Hand (Multi-Touch)

- Rotation

  Rotating the touch on the touch screen (as if you are rolling your arm around in the air and getting ready to throw a ball) causes the ball to rotate in space.

- Throw Out

  Figure 19 shows the effect of moving the touch on the screen in a straight line in a given direction on the screen (as if you are finding a direction before you throw a ball). Before you remove your hand from the touch screen, move your touch or touches in a straight line on the screen to point out a direction where you would like the Earth image to go after your touch is moved out or left away (as if you would point in a direction before you throw a ball). Removing all touches from the screen, the ball is *thrown* and flies in the direction of your last touch. Figure 19 is the image after all touches are removed, and when the earth is freely flying into the space, following the direction of your last movement on the screen.

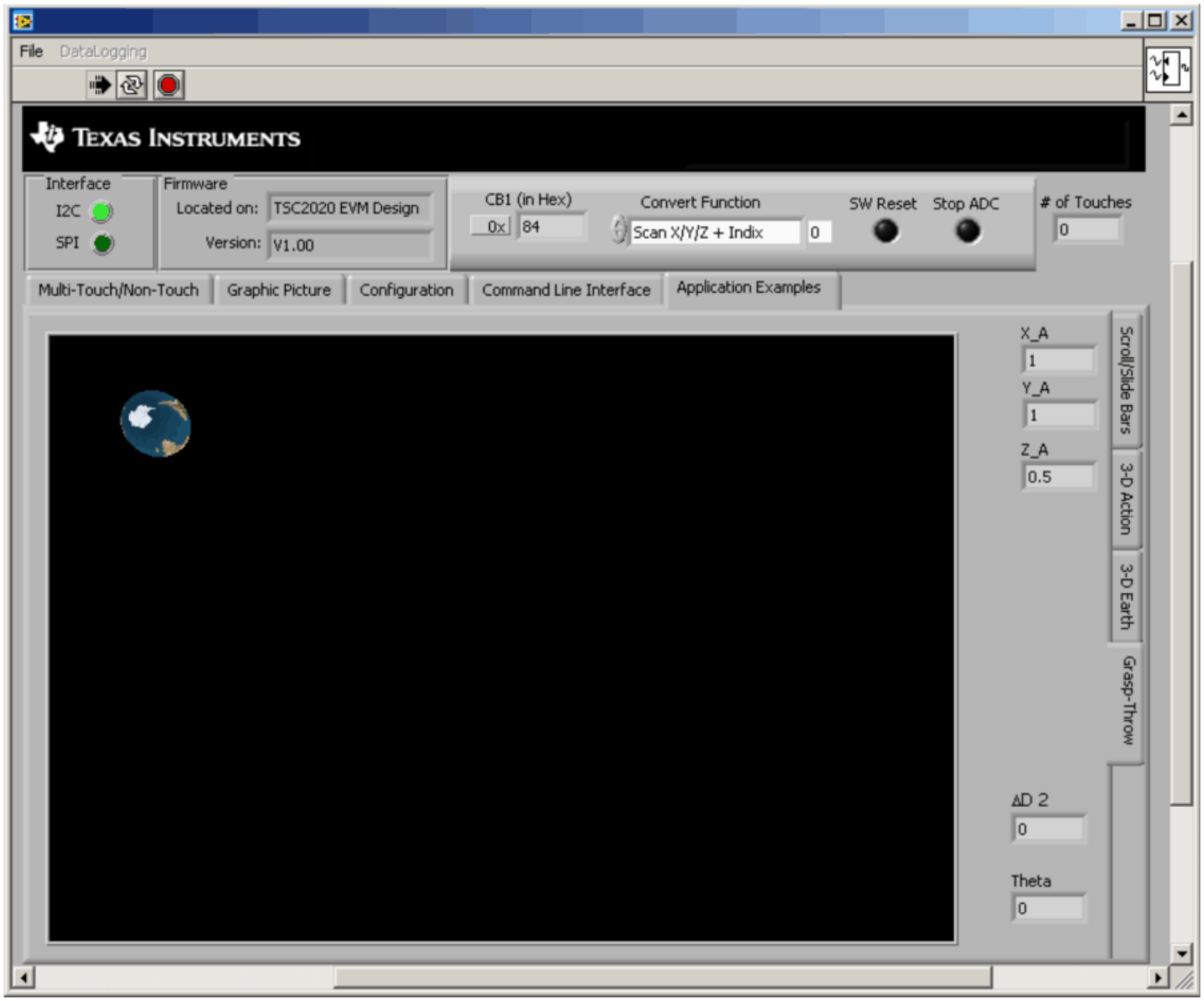


Figure 19. Ball is Thrown and Flies Freely into Space

7 Log Script and Data

The TSC2020EVM software can track and record the script or data used while using the TSC2020 EVM GUI. From the *File* menu, select the option *Log Script and Results...* or *Log Data to File...* to generate the script or data log file.

7.1 Log Script and Results

Go to the *File* dropdown menu and select *Log Script and Results...* This option opens a file-select window and allows you to specify a log file to write the script and results to. At this point, the script to read/write and the subsequent results begins to be logged into the file. For example, a data write is logged into the file for any action performed at the Configuration Tab; and a data read and the subsequent read results are logged into the file if one of the read buttons on the Command Line Interface tab is clicked.

7.2 Log Data to File

Go to the *File* dropdown menu and select *Log Data to File...* This selection opens a file-select window and allows you to specify a log file to write the data to (the default log data file name is *TSC2020evm_Data.txt*). The data logging menu is enabled during subsequent software operations. When you are ready to begin recording data to a file, select *Datalogging → Start Logging*. Data are written to the file until *Datalogging → Stop Logging* is selected.

When the screen is not touched, the AUX, TEMP1, and TEMP2 values are written to the file; at the same time, the Index, X, Y, Z_1, and Z_2 parameters are written to the file with values of *9999* to indicate that they are not updated. When the screen is touched, the X, Y, Z_1, and Z_2 parameters are written while the AUX, TEMP1, and TEMP2 values are written to the file as *9999*.

The data file follows this format: Column 1 is the time in milliseconds (note that this field is simply a timer in the program that arbitrarily starts at any number). Columns 2 through 9 are Index, X, Y, Z_1, Z_2, AUX, TEMP1, and TEMP2, respectively. Every new reading is a new row in the file.

After the *Start Logging* command has been received, data are constantly updated and the logged data file can quickly become quite large. Therefore, log only those data which are necessary.

8 EVM Bill of Materials

Table 8 provides a complete bill of materials for the modular TSC2020EVM evaluation board.

Table 8. TSC2020EVM Bill of Materials

Item	Count	RefDes	Description	MFR (1)	Part Number (1)
1	1	NA	Printed wiring board	TI	6510630
1	3	C1, C2, C3	Capacitor, ceramic 0.1µF 50V 10% X7R 0603	Murata	GRM188R71H104 KA93D
2	1	C4	Capacitor, ceramic 10µF 10V 10% X5R 0805	Murata	GRM219R61A106 KE44D
3	2	J1, J2	10-pin, dual row, SM header (20-pos.)	Samtec	TSM-110-01-T-DV-P
4	2	J1B, J2B(2)	10-pin, dual row, SM header (20-pos.)	Samtec	SSW-110-22-F-D-VS-K
5	1	J3	5-pin, dual row, SM header (10-pos.)	Samtec	TSM-105-01-T-DV-P
6		J3B(2)	5-pin, dual row, SM header (10-pos.)	Samtec	SSW-105-22-F-D-VS-K
7	1	J4	Connector, FPC/FFC 50-Pos .5MM Horz SMD	Hirose	FH12A-50S-0.5SH(55)
8	1	JP1	3-position header	Samtec	TSW-103-22-T-S
9	1	JP2, JP3	2-position header	Samtec	TSW-102-22-T-S
10	1	R1	Resistor, 100Ω 1/10W 1% 0603 SMD	Yageo	RC0603FR-07100RL
11	3	R2, R5, R6	Resistor, 20.0kΩ 1/10W 1% 0603 SMD	Yageo	RC0603FR-0720KL
12	2	R3, R4	Resistor, 2.74kΩ 1/10W 1% 0603 SMD	Yageo	RC0603FR-072K74L
13	22	TP1 to TP19, TP21, TP22, TP23	Test point PC Mini .040"D Red	Keystone	5000
14	1	TP20, TP24	Test point PC Mini .040"D Black	Keystone	5001
15	1	U1	TSC2020IRTV, 5x5 QFN-32 Multiple Location Touch Screen Controller with I^2C Interface	TI	TSC2020IRTV
16	1	U2(3)	IC EEPROM 256kBit 400kHz 8TSSOP	Microchip	24AA256-I/ST
Additional Components					
17	3	N/A	0.100 Shunt - Black Shunts	Samtec	SNT-100-BK-T

(1) Manufacturer and part numbers for items may be substituted with electrically equivalent items.

(2) J1B, J2B, J3B bottom side parts are not shown in the schematic diagram.
- J1B is installed on the bottom side of the PWB opposite J1.
- J2B is installed on the bottom side of the PWB opposite J2.
- J3B is installed on the bottom side of the PWB opposite J3.

(3) Refer to the PCA assembly instruction (6510630 ASSY_A.PDF, Assembly Drawing).

9 PCB Layout

Figure 20 illustrates the silkscreen image for the TSC2020EVM.

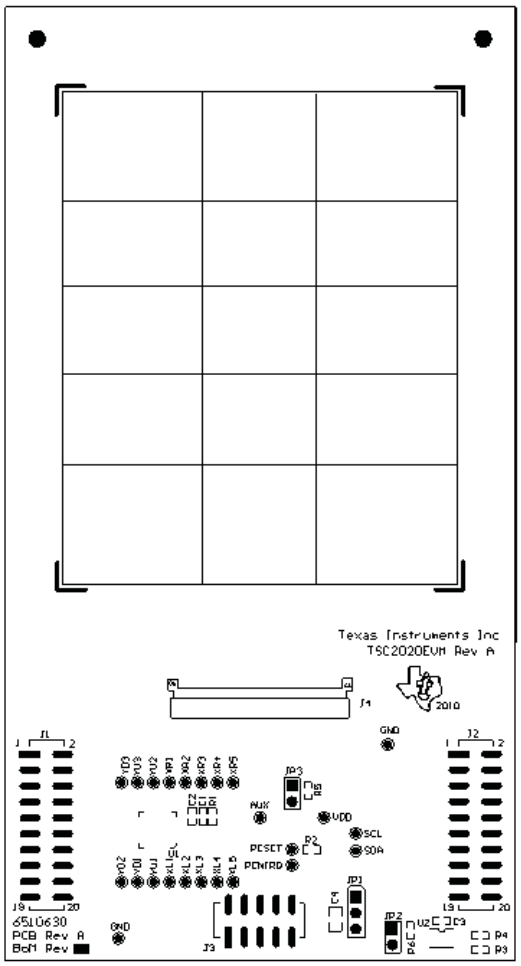


Figure 20. PCB Silkscreen

10 TSC2020EVM Schematic

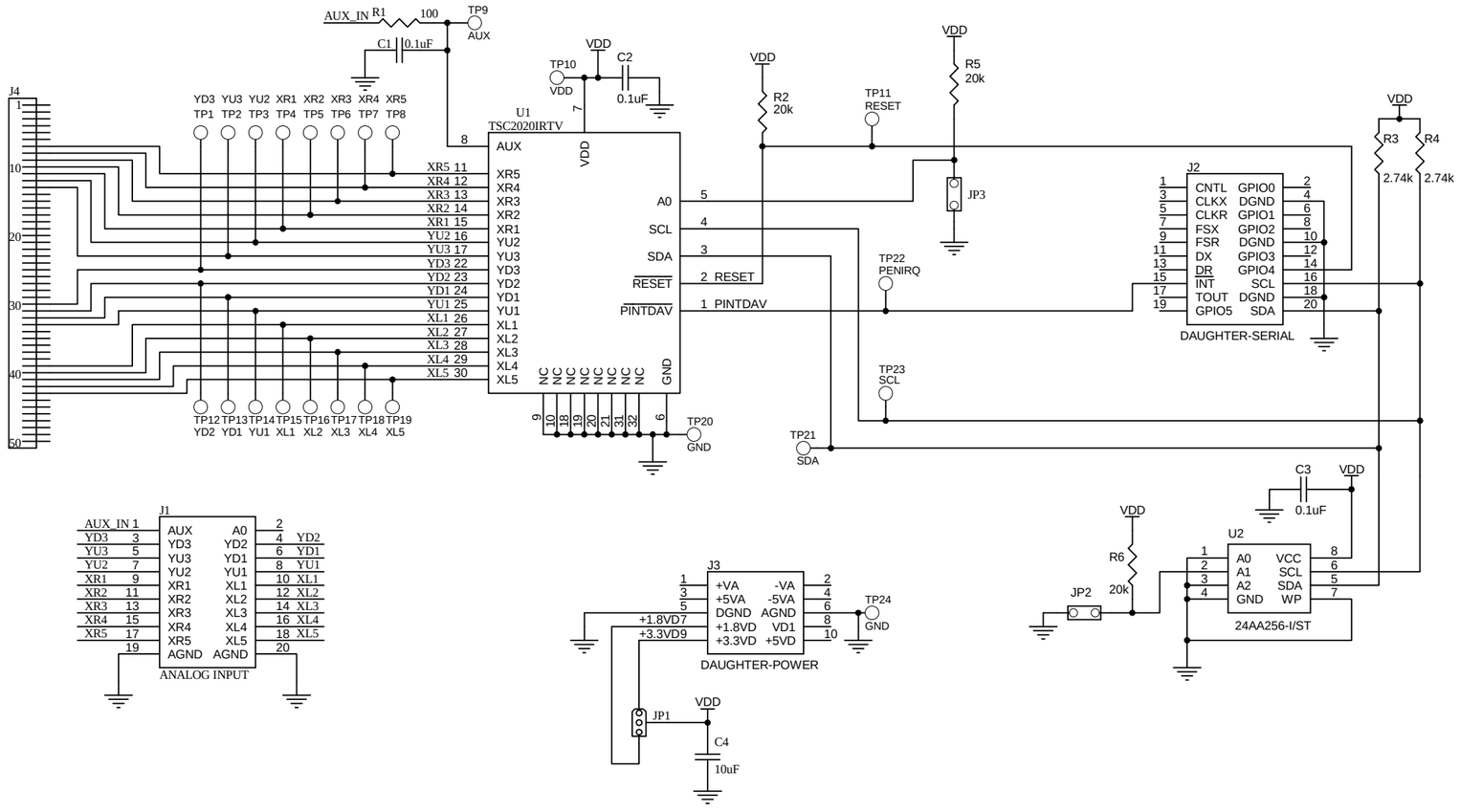
The schematic for the TSC2020EVM is appended to this user's guide.

Revision History

Changes from Original (February, 2010) to A Revision	Page
• Updated Section 6	13
• Revised Section 6.5, *Application Examples Tab*; changed figure titles and replaced Figure 14 through Figure 18	29

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

Revision History		
REV	ECN Number	Approved



TEXAS INSTRUMENTS
12500 TI Blvd. Dallas, Texas 75243

Title: **TSC2020EVM**

Engineer: **Wendy Fang**			
Drawn By: **Lisa Parker**	SIZE: **B**	DATE: 1-Feb-2010	REV: **A**
FILE: **TSC2020EVM_A.SCH**			SHEET: **1** OF: **1**

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EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 0V to +3.6V and the output voltage range of 0V to +3.6V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than +30° C. The EVM is designed to operate properly with certain components above +85° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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