

Texas Instruments

CapTivate™ Track/Gesture Pad

Quick Start Guide

MSP Applications Team

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Version 0.4

Document Revision History.....	3
Preface	4
Overview	4
MSP430 FR26xx_25xx CapTivate™ Technology Features.....	4
Track/Gesture Pad Features	4
Demonstration PCB Description	5
Performance Specifications	5
Performance	6
Track / Gesture Pad Demonstrations.....	7
Hardware Setup	8
Trackpad Demo Description – Active Mode	9
Trackpad Demo Description – Low Power Mode	9
Running the Demos.....	10
Operating Parameters.....	13
Enabling CapTivate Features – Compile Time Options (not real time).....	14
Creating a New CapTivate™ Design Center Trackpad Project	15
Schematic.....	21
Hardware Setup	22
Technical Reference.....	23
Communication Timing Waveforms	23

Document Revision History

Version 0.1 - Aug 22, 2016

- Initial release

Version 0.2 – Sept 27, 2016

- Added performance tables for power, sensor processing and communications

Version 0.3 – Dec 14, 2016

- Added section describing how to create customer trackpad sensor configurations for the CapTivate design center

Version 0.4 – April 3, 2018

- Adding “how to create trackpad” with full support in the design center

Preface

The new MSP430FR2633 is an ultra-low power family of FRAM 16-bit MCUs featuring CapTivate™ Capacitive Touch Technology. The flexibility of this technology enables buttons, sliders, wheels and track/gesture pad HMI applications in any combination within the same design.

For detailed information about CapTivate™ Technology, CapTivate™ Design Center and capacitive sensor design guidelines, refer to CapTivate™ documentation located in:

- CapTivate™ Design Center GUI – select help > topics
- On-line @ www.ti.com/CapTivateTechGuide

Overview

The MSP430FR2633 MCU with CapTivate™ Technology can support basic Trackpad sensor functionality with as few as 8 CapTivate™ I/O pins. Depending on the family variant, up to 8 additional CapTivate™ I/O pins can be assigned as buttons, proximity, slider and wheel sensors.

The purpose of this guide is to aid the user in becoming familiar with and using CapTivate Technology for Trackpad and gesturing applications. This document focuses on:

- Trackpad Performance Specifications
- Technology Demonstration

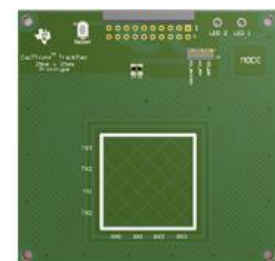
MSP430 FR26xx_25xx CapTivate™ Technology Features

- Integrated CapTivate IP
- 5uA typical with **wake on proximity** (great for battery powered applications)
- Supports multiple combinations of sensors in the same design
- CapTivate Library in ROM allows more user code in FRAM



Track/Gesture Pad Features

- User programmable resolution (1000 pts default)
- Reports X,Y position
- Gestures (Swipe up, down, left, right, Tap, double-tap, tap and hold)
- Programmable Sensor Scan Rate (10ms default)
- Up to 3mm plastic or glass overlay
- Demo PCBs sizes supported 25x25 mm and 50x50 mm
- More details in performance section

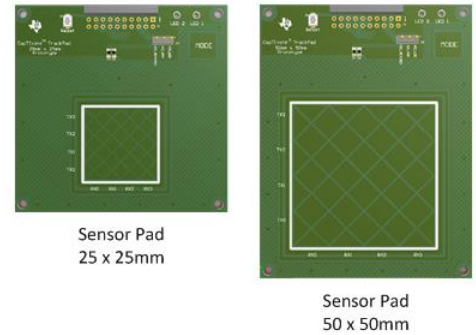


Sensor Pad
25 x 25mm

Demonstration PCB Description

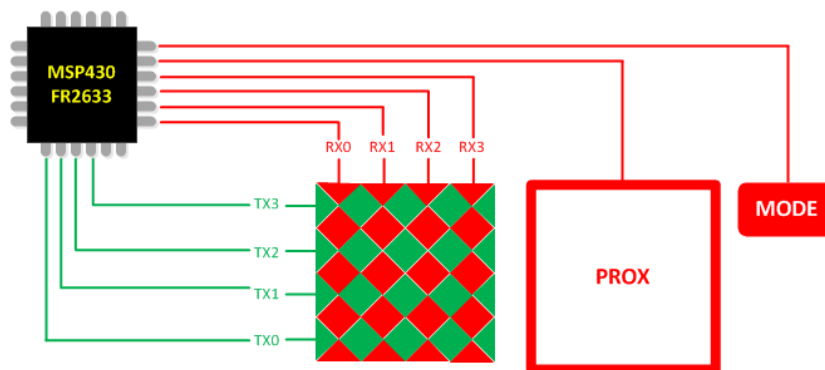
The track / gesture pad demonstration PCB support Trackpad and gesturing applications using CapTivate™ Technology. The PCBs feature a 25 x 25 mm and 50 x 50 mm mutual capacitive Trackpad sensor, a self-capacitive mode button and proximity sensor.

In order to power the demo PCBs and provide communications to the CapTivate Design Center, connect a CAPTIVATE-PGMR PCB (from CapTivate EVM kit), then connect a USB cable to a PC.



The architecture or design of this system is simple. A track/gesture pad can be created by a matrix of 4 column receiver signals and 4 row transmitter signals. The MSP430FR2633 is configured for “Mutual Capacitance” measurement mode. For more information about Mutual and Self capacitance modes, refer to the CapTivate Design Center document:

<http://www.ti.com/captivatetechguide>



Performance Specifications

Performance characterization of the CapTivate™ capacitive touch technology and software libraries supporting Trackpad and gesturing capabilities are summarized in the table below.

Performance

Refer to Technical Reference Section at the end of this document for details (work in progress)

Power and Timing

Mode	Scan Rate	No Touch	Touch	Comments
Active ⁽¹⁾	10	560	640	uA
	20	280	330	uA
WakeOnProximity ⁽²⁾	100	5	NA	uA
Processing Time		No Touch	Touch	
Trackpad		15	372	uSec
Button		2	2	uSec
Proximity		2	2	uSec
Measurement Time ⁽³⁾⁽⁴⁾				
Trackpad		1595	1596	uSec
Button		584	548	uSec
Proximity(4)		713	683	uSec
Total Time		1610	1968	uSec
		586	550	uSec
		715	685	uSec

(1) Active mode, MCU @ 8MHz, communications disabled, no LEDs, scanning Trackpad + button + proximity

(2) CPU in LPM3, FSM scanning proximity sensor

(3) Individual sensor measurement time calculated from: (Total – processing)

(4) Self cap sensor Touch value will be < No Touch, Mutual cap sensor Touch value will be > No Touch

Full Trackpad /gesture memory usage

Application Code and Data Memory size

Trackpad + Button + Prox Sensor	FRAM	RAM	Comments
With CDC communications (default)	11586	1835	
With USER communications (use with host MCU)	11102	1835	
No communications	9108	1411	
No communications, No WakeOnProximity	8662	1407	

Memory usage can be displayed in Code Composer Studio using the menu options:

View > Memory Allocation.

Required Software Tools and Installation instructions

- Java run-time engine (JRE) version 1.7 or later is required
 - To verify which version you are using, from a command line prompt, type *java -version*
 - If update is needed, download and install the latest version from www.java.com
- CapTivate™ Design Center PC GUI Tool
 - The CapTivate™ Design Center is a PC GUI tool for configuring and tuning CapTivate™ touch panels
 - Current version supporting trackpad is 1.60.00.00 and later
 - www.ti.com/captivatedesigncenter
 - Default installation directory is `c:\ti\msp`

If performing any modifications to code or creating your own design, please download TI Code Composer Studio











- TI Code Composer Studio v6.13 or greater (current version is 9.00)
 - Code Composer Studio can be downloaded from the following Wiki page:
http://processors.wiki.ti.com/index.php/Download_CCS.

IMPORTANT – Enabling Trackpad in CapTivate Design Center

Trackpad or gesture pads are advanced HMI capacitive touch sensors compared to simple buttons, sliders and wheels. The software library only supports single finger position and gesture reporting at this time.

Since trackpad sensors are not publicly promoted at this time, support for this sensor is available, but hidden in the CapTivate Design Center. To enable support, make sure to close the CapTivate Design Center then add an empty text file named “trackpad.txt” to the default installation directory in the sub-directory shown here. Re-launch the CapTivate Design Center. This enables the trackpad icon to appear on the canvas menu.

`C:\ti\msp\CapTivateDesignCenter_1.60.00.00\CapTivateDesignCenter\DeviceConfig`

Name	Date modified	Type
 MSP430FR2532IRGE	8/14/2017 5:14 PM	File folder
 MSP430FR2533IDA	8/14/2017 5:14 PM	File folder
 MSP430FR2533IRHB	8/14/2017 5:14 PM	File folder
 MSP430FR2632IRGE	8/14/2017 5:14 PM	File folder
 MSP430FR2632YQW	8/14/2017 5:14 PM	File folder
 MSP430FR2633IDA	8/14/2017 5:14 PM	File folder
 MSP430FR2633IRHB	8/14/2017 5:14 PM	File folder
 MSP430FR2633YQW	8/14/2017 5:13 PM	File folder
 SourceTemplates	8/14/2017 5:13 PM	File folder
 trackpad.txt	9/13/2017 8:49 PM	Text Document

Track / Gesture Pad Demonstrations

The goal is to demonstrate the ability to support Trackpad and gesturing applications using CapTIvate™ Technology.

Two PCB demo sizes are currently available:

- Both are identical except for the sizes of the sensor pads
- Both PCBs can be programmed with the same demo firmware

There are two versions of firmware:

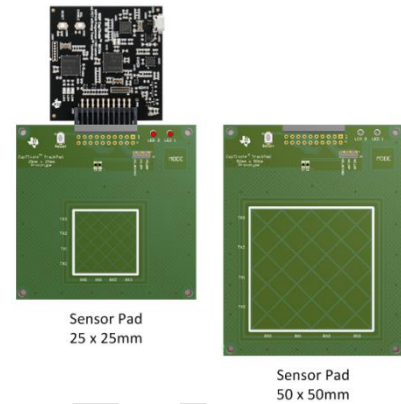
- Trackpad Active (MCU always active)
- Trackpad Low-Power (Demonstrates wake on proximity feature)

Note: The Trackpad demo PCBs are provided by TI pre-programmed with the Trackpad /Gesture Low-power firmware. To re-program the MCU with either demo firmware, refer to the section “Programming the MCU” the end of this document.

Both demonstrations are programmed to send real-time sensor data to the CapTIvate Design Center in order to view the Trackpad outputs.

Hardware Setup

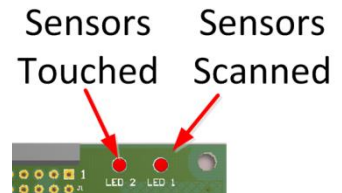
Refer to the hardware setup section at the end of this document.



Trackpad Demo Description – Active Mode

When the Trackpad is operating in Active mode, the MCU is running continuously, scanning the Trackpad, button and proximity sensors plus sending sensor status and data to the design center GUI every 10ms.

- LED1 turns on when sensors are scanned by the MCU
- LED2 turns when any sensor is touched

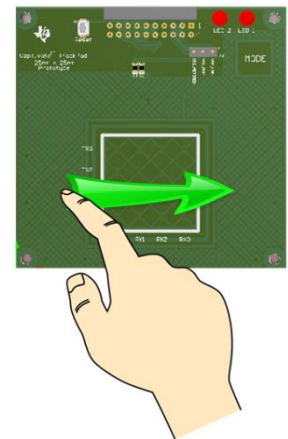


Trackpad Demo Description – Low Power Mode

When the Trackpad is operating in the low-power “wake on proximity” mode, both LEDs are off and the MCU initially enters a low-power wake on proximity mode, leaving the CapTivate™ hardware to autonomously scan a user designated “wake on proximity” sensor every 100ms (default). For this demo, the wake on proximity sensor is the proximity sensor that surrounds the Trackpad sensor. Swiping a finger across the Trackpad will cause a wake on proximity event.

Wake on Proximity Feature Behavior

- MCU enters low-power, enabling the wake on proximity feature
- In this state, the MCU is consuming only a few micro-amps of current.
- Swiping a finger across the Trackpad sensor in any direction will wake up the MCU from sleep mode.
- LED1 and LED2 will turn on
 - LED1 indicates the MCU is actively scanning the sensor.
 - LED2 indicates there is a valid touch condition.
- Both LEDs will remain on while there is an interaction with the sensor.
- When the finger is removed from the sensor, LED2 will turn off, indicating no touch is detected.
- LED1 will remain on for a few seconds while the MCU continues to look for a new touch condition.
- If no touch after a user programmable period, the MCU enters sleep mode and the wake on proximity feature is re-enabled.



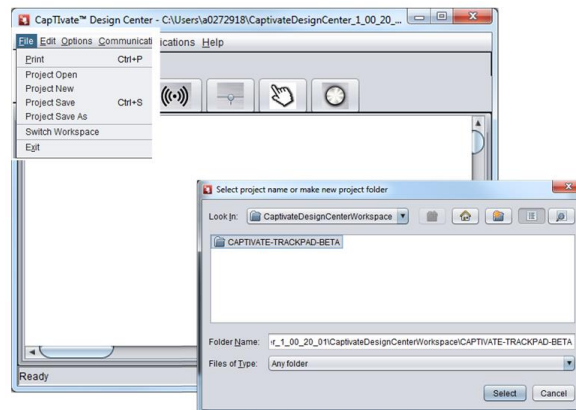
Running the Demos

Launch CapTivate Design Center GUI

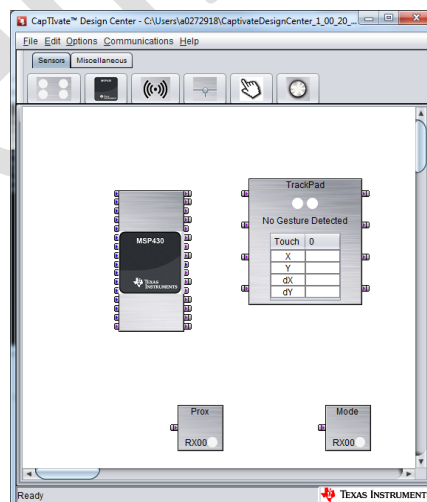
Need help with CapTivate Design Center? www.ti.com/CapTivateTechGuide

Open CapTivate Design Center Trackpad demo project

- Select from the GUI menu, File > ProjectOpen and click on CAPTIVATE-TRACKPAD -BETA.
Note: You will be prompted to save changes – select DISCARD this very first time.



- The CapTivate Design Center Trackpad design project is shown here. Each sensor and MCU icon on the canvas represents the sensors and MSP430FR2633 device on the demo PCB.

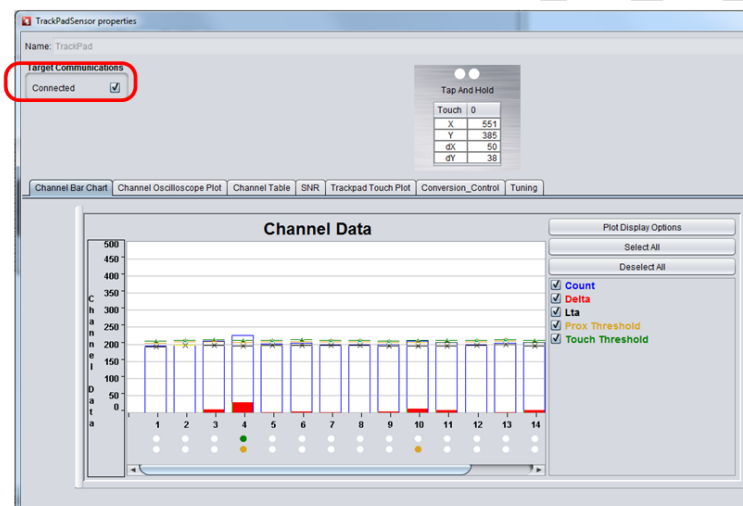


Trackpad Property View Descriptions

The Trackpad Sensor properties window offers several different views to monitor real time sensor data streaming from the target MCU as well as to modify run-time parameters that control sensor sensitivity, scan rates and other design parameters.

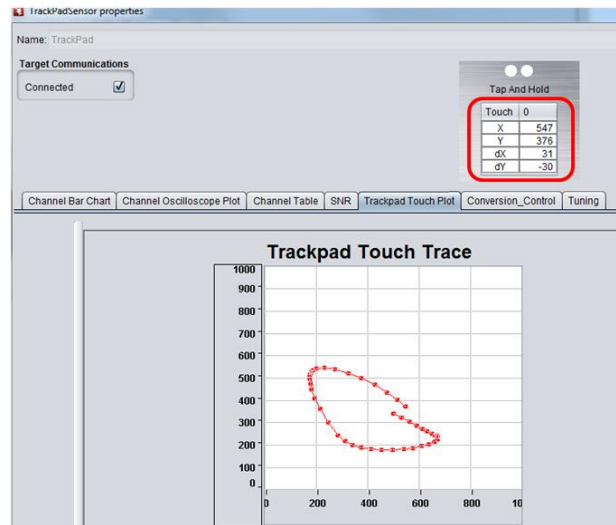
Channel Bar View

- Double click on the Trackpad icon to open the Trackpad Sensor Properties view
- To enable communications, check the Target Communications Connected box as shown below
- Select the Channel Bar Chart View
- Move a finger around on the Trackpad sensor and the sensor data will appear
- Experiment with the Channel Oscilloscope and Channel Table views



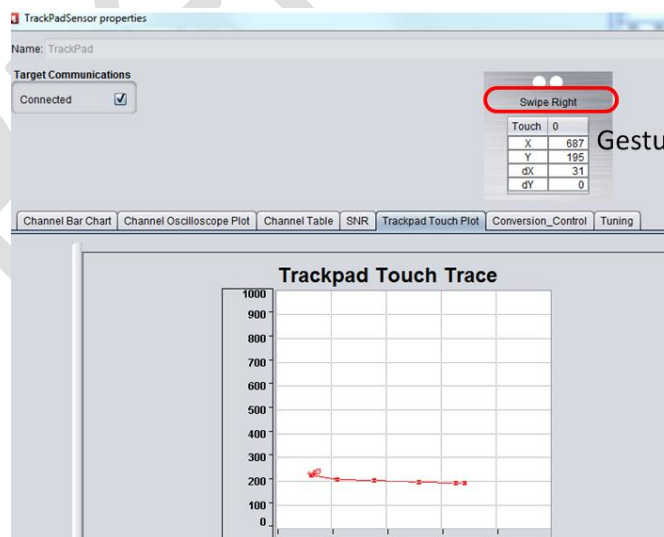
Trackpad Touch Plot View

- Select the Trackpad Touch Plot tab
- Move a finger around the Trackpad sensor and the position is displayed on the graph
- The absolute and delta positions are displayed in the highlighted box



Trackpad Gestures

- Swipe a finger left, right, up or down across the Trackpad sensor
- The gesture will appear as shown



Gestures Displayed

Operating Parameters

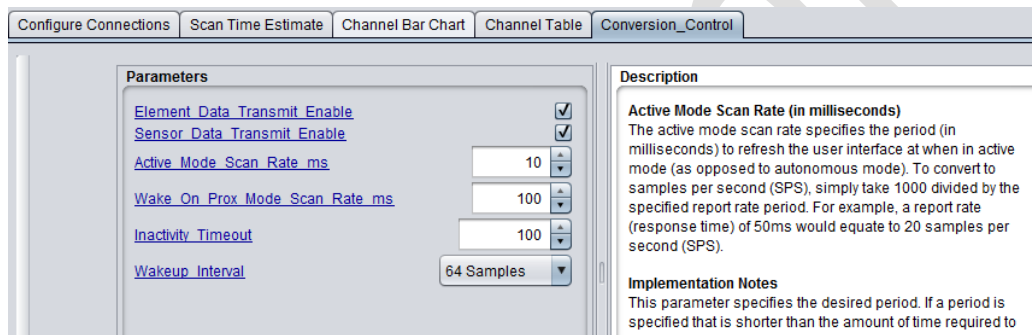
Many of the CapTlvate peripheral operating parameters can be changed in real time using the CapTlvate Design Center or can be changed by user code during run time. Most are sensor parameters, but a few are related to the controller.

In each sensor view, all parameters have a hyper-link that provides a description of the parameter when selected.

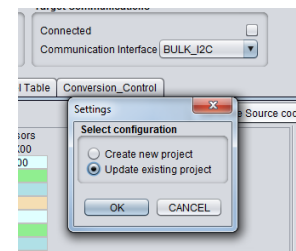
For more information about the operating parameters visit: www.ti.com/CapTlvateTechGuide

Controller Parameters Relevant for Demo PCBs

- Active mode scan rate
- WakeOnProximity scan rate



When changing these parameters while connected to the CapTlvate Design Center, you will see the effects immediately. If the device loses power, these updated values will be lost. So it is important to update the existing project, rebuild and re-program the MCU.

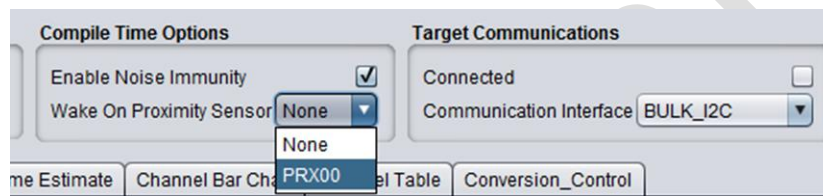


Enabling CapTivate Features – Compile Time Options (not real time)

CapTivate features such as low power and conducted noise immunity are features that are selected as a compile time option. These features require the MCU to be re-programmed with the new selected features. For this reason, these features cannot be configured while the MCU is operating.

- Enabling wake on proximity and selecting the wake up sensor
- Enabling noise immunity
- Selecting BULK_I2C or UART for communications with CapTivate Design Center

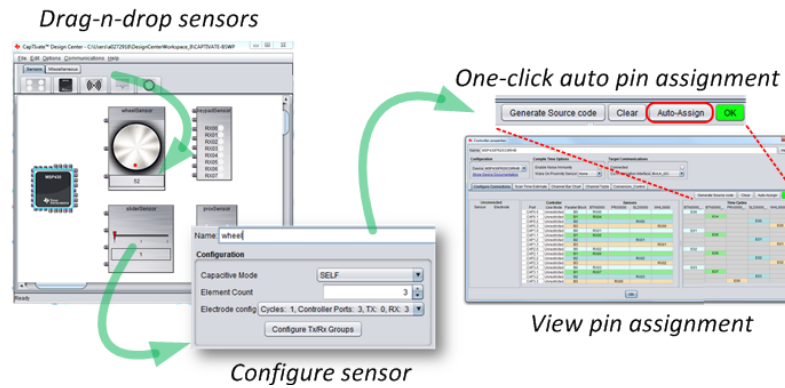
Note: Communication Interface REGISTER_I2C is reserved for user application when communicating with a Host MCU.



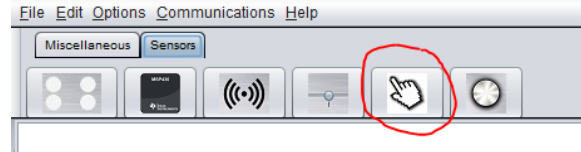
Creating a New CapTivate™ Design Center Trackpad Project

We begin the process by creating a new project using the CapTivate™ Design Center.

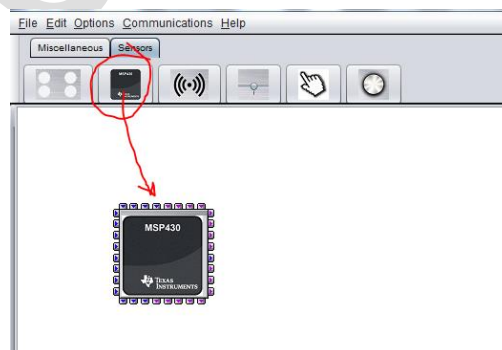
Note: the normal workflow for creating and configuring sensors such as buttons, sliders, wheels and proximity, are illustrated by the actions shown below.



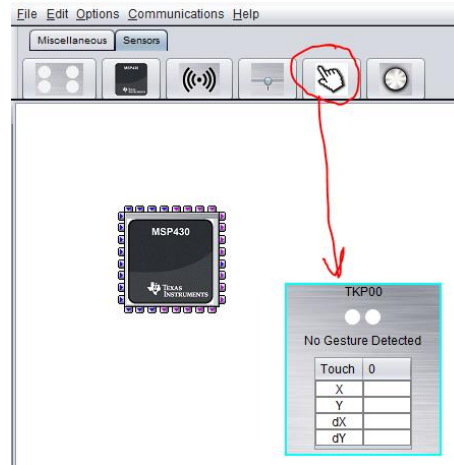
Next, launch the design center and a new trackpad icon should appear below the menu with all the other sensor icons.



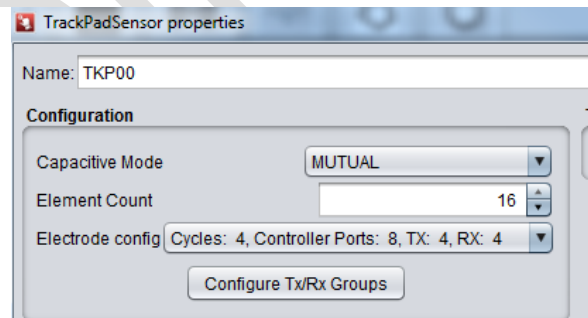
- Right-click once on the MCU icon, then click on the canvas to drop it in place.



- Right-click once on the Trackpad icon, then click on the canvas to drop it in place. Your canvas should look like the following

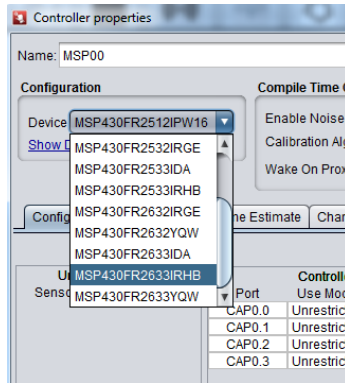


- Double click on the Trackpad to view the trackpad properties
- Select mutual (projected) capacitive mode.
- Select the element count. The element count represents the number of RX channels times the number of TX channels. For example, a 4x4 configuration (4RX and 4TX) creates a 16 element sensor. It is possible to create many different combinations up to an 8x8 or 64 element sensor.

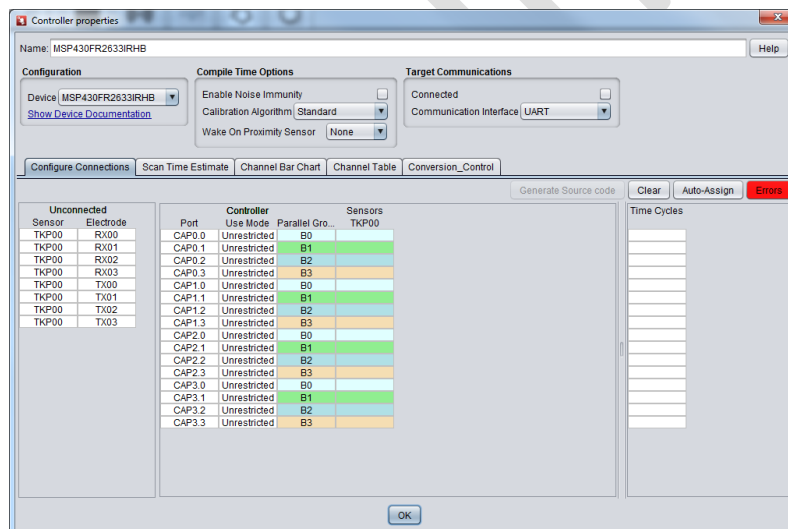


- Close the sensor view.

- Double click on MUC to view controller properties
- Select the MCU variant for your application by clicking in the device drop-down box. Typically this will be the MSP430FR2633IRHB. Note, devices with fewer CapTivate IO pins will not support the larger configurations. For example, the MSP430FR2522 can only support up to 16 elements (4x4)



- At this point the controller properties shows no connections between the sensor and the MCU.



- Allow the design center to choose the connections by clicking on the “Auto-Assign” button
 - If routing manually, please refer to the “captivate_trackpad_hardware_design_guide.pdf” for guidance on how to choose the MCU to sensor connections

Controller properties

Name: MSP430FR2633IRHB

Help

Configuration

Device: MSP430FR2633IRHB

Show Device Documentation

Compile Time Options

Enable Noise Immunity

Calibration Algorithm: Standard

Wake On Proximity Sensor: None

Target Communications

Connected

Communication Interface: UART

Configure Connections

Scan Time Estimate

Channel Bar Chart

Channel Table

Conversion_Control

Generate Source code

Clear

Auto-Assign

OK

Unconnected

Sensor

Electrode

Controller

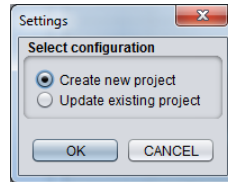
Port	Use Mode	Parallel Gro...	Sensors
CAP0.0	Unrestricted	B0	RX00
CAP0.1	Unrestricted	B1	
CAP0.2	Unrestricted	B2	
CAP0.3	Unrestricted	B3	TX03
CAP1.0	Unrestricted	B0	RX01
CAP1.1	Unrestricted	B1	
CAP1.2	Unrestricted	B2	
CAP1.3	Unrestricted	B3	TX02
CAP2.0	Unrestricted	B0	RX02
CAP2.1	Unrestricted	B1	
CAP2.2	Unrestricted	B2	
CAP2.3	Unrestricted	B3	TX01
CAP3.0	Unrestricted	B0	RX03
CAP3.1	Unrestricted	B1	
CAP3.2	Unrestricted	B2	
CAP3.3	Unrestricted	B3	TX00

Time Cycles

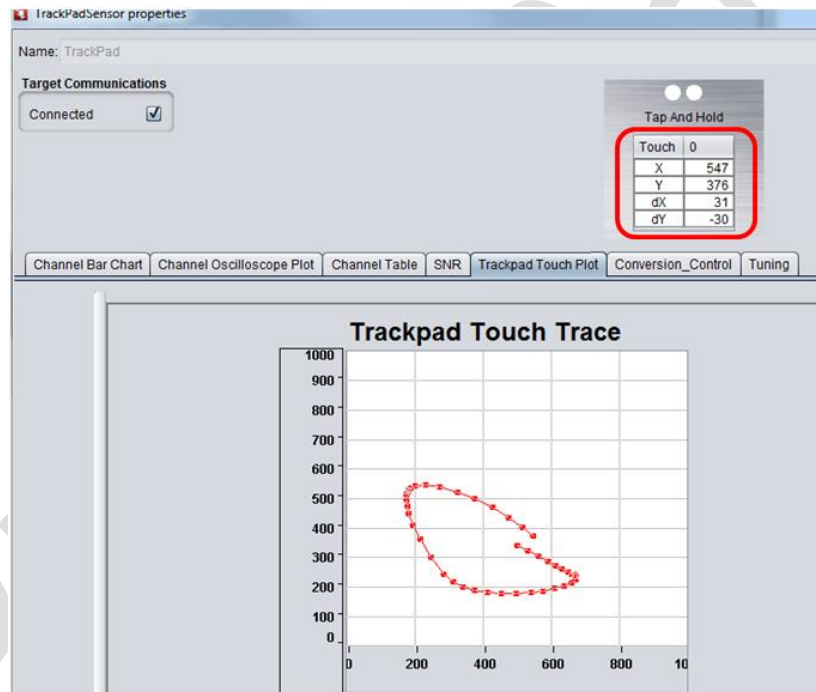
TKP00_C00	TKP00_C01	TKP00_C02	TKP00_C03
E00	E04	E08	E12
			TX
E01	E05	E09	E13
		TX	
E02	E06	E10	E14
	TX		
E03	E07	E11	E15
TX			

OK

- Generate new source code by clicking on the “Generate Source Code” button, then select “Create New project”. Note the location! You will need to remember the directory name when importing the project into CCS.



- CCS – import code – navigate to the directory from above - click on the project name only
- Build and program MCU
- Enable communication in the CapTivate Design Center and view the data
- Double click on the trackpad sensor, the select the Trackpad Touch Plot view.



Update existing trackpad demo source code project with new sensor

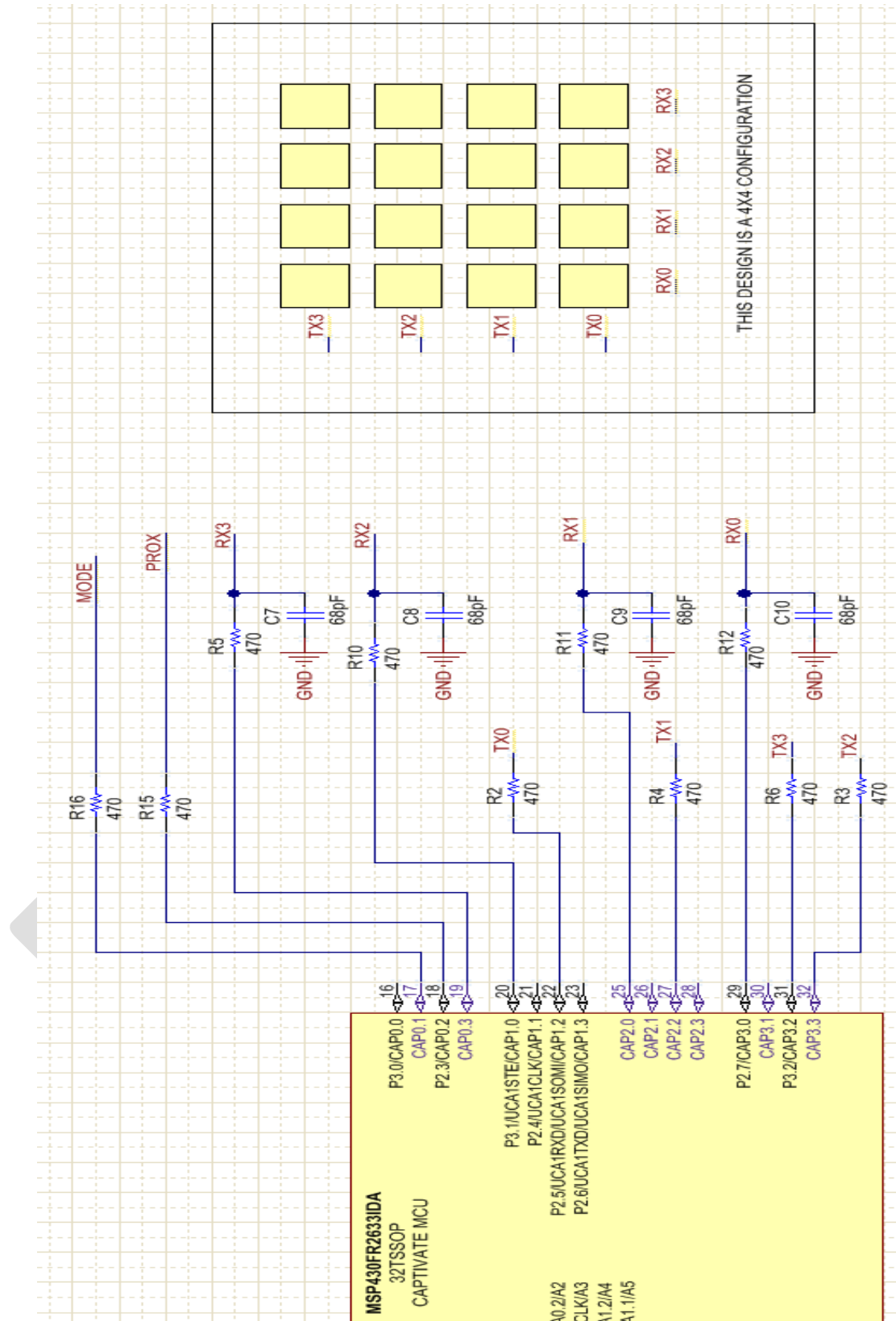
Once the new custom device has been created, you can easily update the original trackpad demo source code in code composer studio from within the CapTivate design center.

In the CapTivate design center, open the MCU controller view and click the Generate Source Code button. Select Update existing Project and point to your code composer studio workspace where the existing trackpad project is located.

Rebuild the project and program the target MCU

Preliminary

Schematic



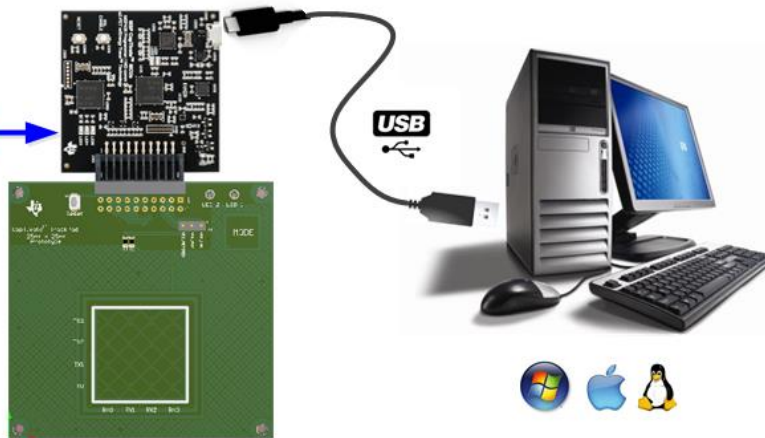
Hardware Setup

Please perform the following:

- Connect the Trackpad to the CAPT-PGMR PCB
- Connect the micro-USB cable to the PC
- Verify the Power Good LED is on solid and the USB Enumeration LED blinks on/off every second

HID Bridge Status LEDs

Power Good
USB Enumeration
Communications



Technical Reference

Information supporting the data collected for power and execution timing will be provided in this section.

Communication Timing Waveforms

These are the I2C waveform captures showing a typical transmission between the target MCU and the CapTivate Design Center. The data for each sensor is transmitted after the corresponding sensor has been measured and processed.

- Scan rate = 10ms
- Total processing and communication time for 2 buttons and track/gesture pad = 8ms.

