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Reducing Time to Market: How to Design Your Capacitive Touch User Interface Right the First Time with CapTIvate™ Technology

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Today's Discussion Topics

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• Beginner's Overview of Capacitive Touch	5 minutes
• Examples of Common Design Challenges	10 minutes
• Capacitive Touch Development Process	10 minutes
• CapTIvate Ecosystem Overview	5 minutes
• Quick Start Demo with CapTIvate Design Center	15 minutes
• Reference Designs	5 minutes
• Time for Questions & Answers	10 minutes

What is capacitive touch?

- Let’s speak the same language!
- Capacitive touch sensing is the process of performing a measurement to detect a relative change in capacitance to a sensing element due to human interaction. A sensing element can be any sufficiently conductive material. Common examples include a copper PCB plane, a wire, silver, or indium-tin-oxide (ITO) in transparent applications.

- Common Applications
  – Buttons & Keypads
  – Sliders
  – Scroll Wheels
  – Gesture Recognition
  – Proximity Detection
  – Grip Detection

Measurement Topologies

- There are two sensing topologies in the industry: *self capacitance* and *mutual capacitance*. CapTIvate technology supports both methods, and there are reasons why one may be preferable to the other depending on the requirements of the application being designed.

Self Capacitance	Mutual Capacitance
- Measures relative changes in the 'self' capacitance of a single sensing electrode. This includes the IO capacitance, layout capacitance, free-space capacitance, and touch capacitance - One MCU IO pin is used per sensor (called an 'RX') - A touch adds additional parallel (shunt) capacitance - Capacitances measured are usually larger than mutual capacitances (on the order of 10pF to 100pF typically)	- Measures relative changes in the 'mutual' capacitance between two sensing electrodes. This mutual capacitance is defined by the PCB layout and mechanical overlay - Two MCU IO pins are used per sensor (called an 'RX' and a 'TX') - A touch reduces the established mutual capacitance between the RX and TX - Matrices of RX's and TX's is allowed, as each RX/TX intersection is a unique mutual capacitance - Capacitances measured are small (on the order of 0.1pF to 10pF typically)

Measurement Topologies

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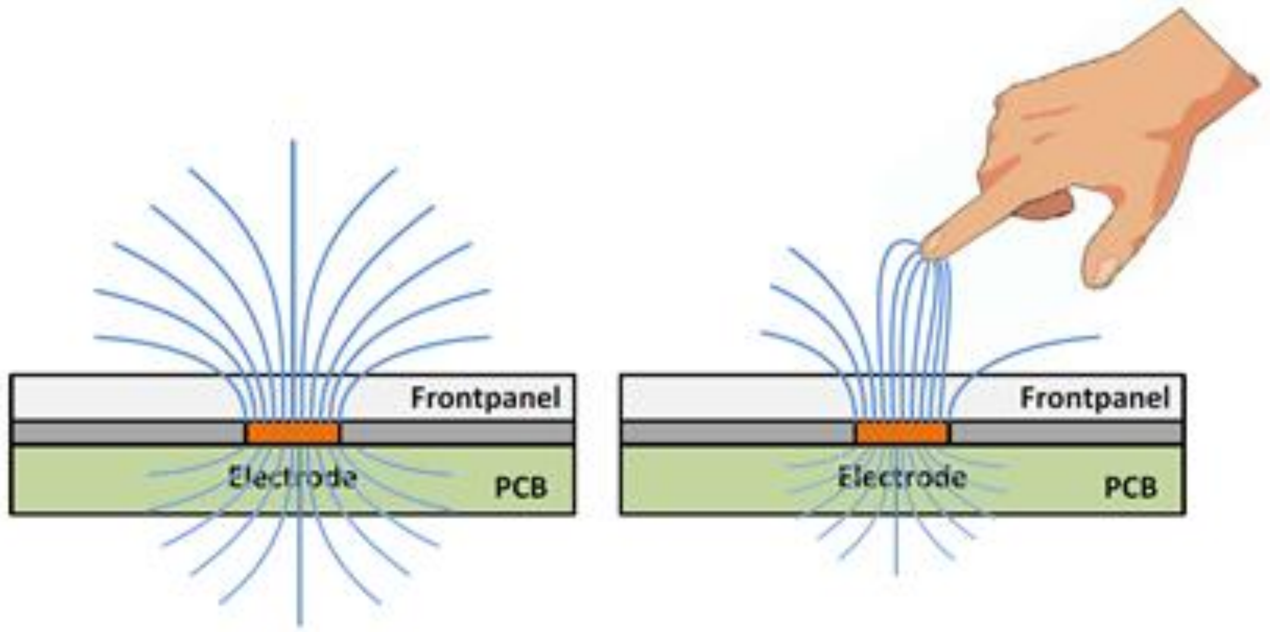
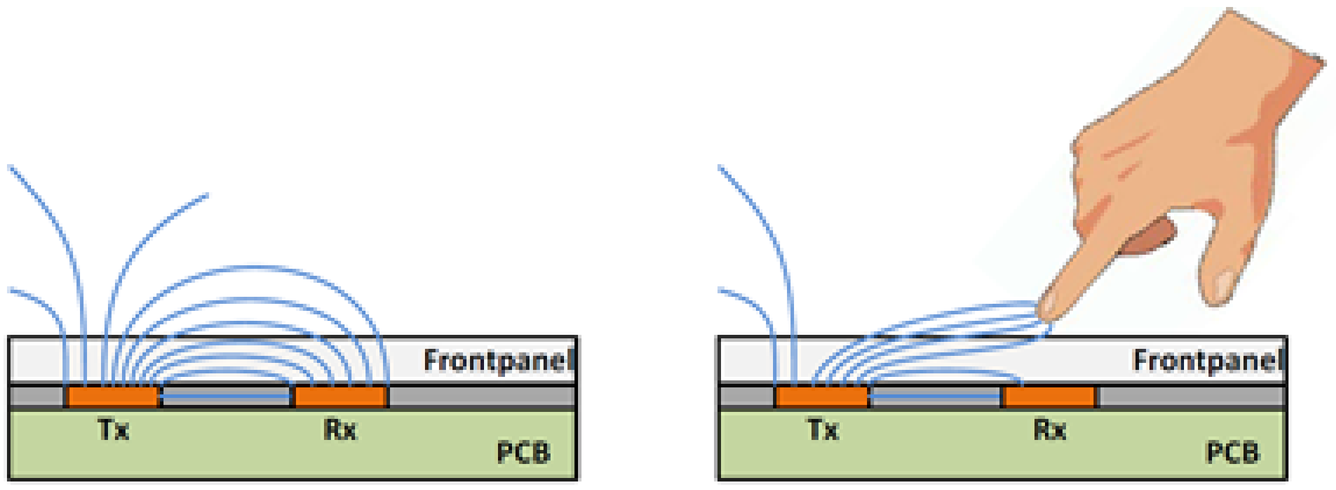
Self Capacitance

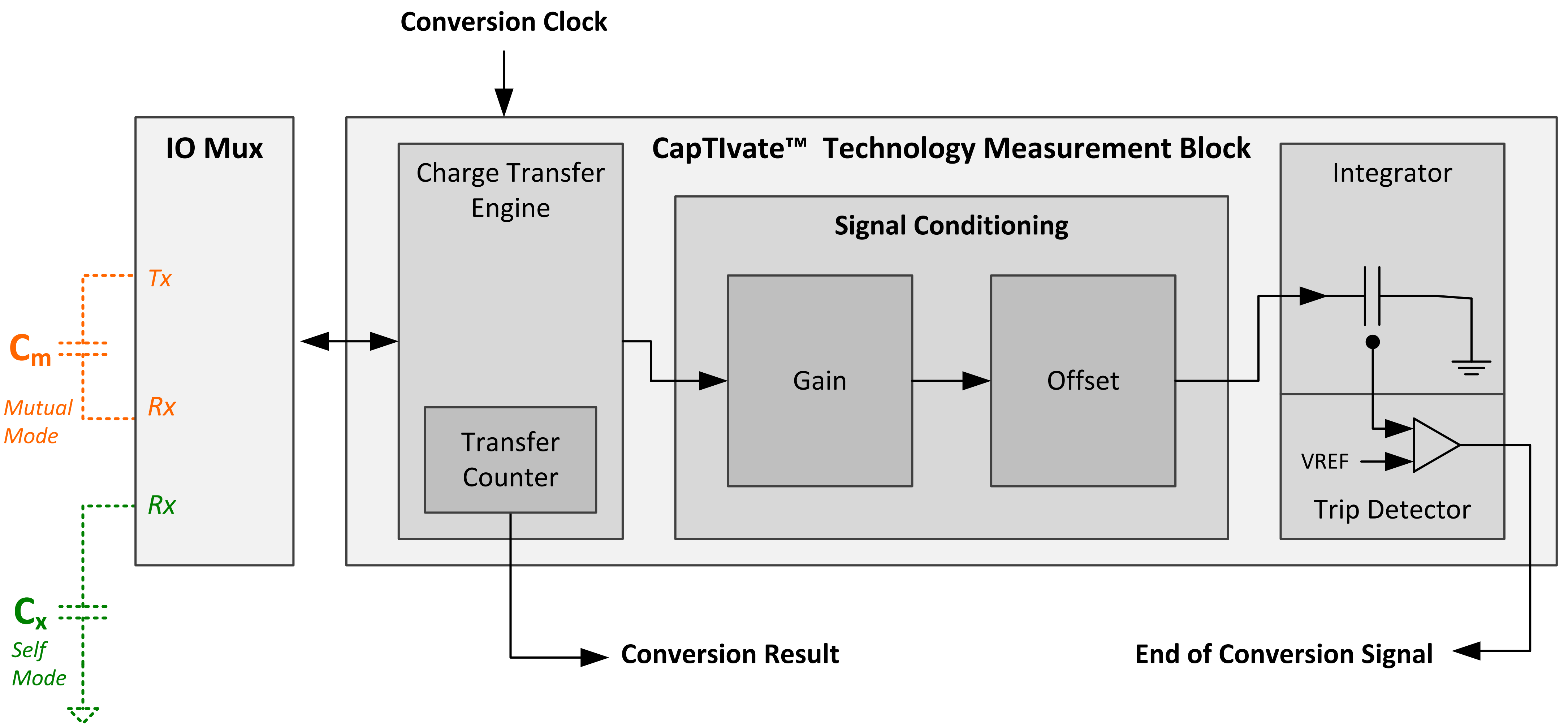


Mutual Capacitance



Measuring Changes in Capacitance with CapTIvate

- The CapTIvate measurement block detects changes in capacitance by comparing the size of the unknown sensing electrode capacitance to a fixed capacitance internal to the device.



Examples of Design Challenges

- Like any other product development flow, late changes to a capacitive touch design due to an issue are the changes that significantly impact release schedules and require the most re-work.
- The goal of this training is to walk through common pitfalls, so that when you begin a design you know what to look out for up front to prevent issues that require significant re-work.
- Let’s look at a few examples of designs that had issues come up late in the development process

Examples of Design Challenges

Example 1

- Proper ground shielding techniques were not used during PCB layout, leading to poor noise immunity performance

Example 2

- The bonding of the overlay dielectric material to the sensor PCB was inconsistent, leading to errors in measurement when pressure is applied to the overlay

Example 3

- CapTIvate sensor-to-pin mapping was done before software was considered, leading to a pin assignment that prohibited the use of parallel scanning, leading to longer scan times and higher power consumption than expected

Example 4

- RX pins were routed near TX pins, leading to ghost-touch areas on the PCB (areas were touch sensitive that were not intended to be touch sensitive)

Development Flow

Understand the sensors needed and the system level requirements

Battery vs. line powered	Installed environment	Moisture tolerance	Temperature variation	Noise immunity	Mechanical stackup	Product lifetime

Start with CapTIvate Design Center

Create sensors	Select a CapTIvate MCU	Assign pins optimally	Generate starter firmware

Develop first PCB

Use pin assignment from Design Center	Incorporate system requirements into schematic and layout	Review schematic and PCB design guidelines	For a complex design, plan for at least 1 PCB revision

Characterize performance

Tune sensors with CapTIvate Design Center	Test for system requirements (mechanical, noise immunity, temperature variation, moisture tolerance)

CapTIvate Ecosystem www.ti.com/captivate

- **SILICON The CapTIvate Touch Sensing Peripheral**
  - Available on select MSP430 MCUs

- **TOOLS The CapTIvate Design Center**
  - One stop shop development GUI
  - Real-time tuning
  - Data viewing and capture
  - Source code generation
  - Integrated documentation

- **SOFTWARE The CapTIvate Software Library**
  - Components in ROM
  - Highly abstracted
  - Event based
  - Configured with the CapTIvate Design Center

- **HARDWARE The CapTIvate Dev Kit**
  - Programmer/debug module
  - MSP430FR2633 MCU module
  - 3 sensor boards
  - Isolation board

- **REFERENCE DESIGNS CapTIvate TI Designs**
  - E-lock
  - Thermostat
  - EMC Reference Design
  - Industrial Meter Touch Through Glass
  - Digital Multimeter
  - 64-button

CapTIvate Ecosystem www.ti.com/captivate

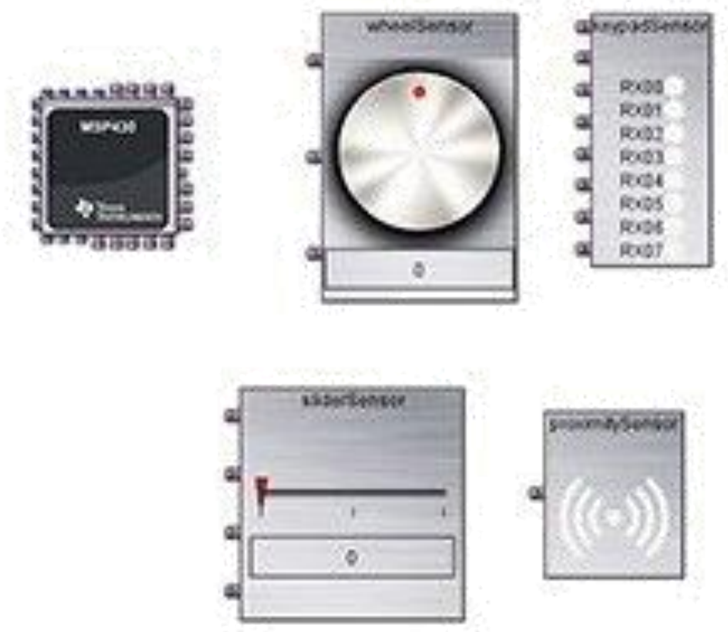
- **TRAINING MATERIAL Video Series**
  - Introduction to CapTIvate Technology Training Series
    https://training.ti.com/captivate-training-series#section-1
  - Fundamental PCB Layout and Design Guidelines
    https://training.ti.com/captivate-training-series#section-2
  - Introduction to EMC Challenges and Design with CapTIvate MCUs
    https://training.ti.com/captivate-training-series#section-3

- **TRAINING MATERIAL Documentation**
  - CapTIvate Technology Guide
    http://www.ti.com/captivatetechguide

Quick Start Demo with CapTIvate Design Center

Start new designs with the CapTIvate Design Center

Tool Folder: http://www.ti.com/tool/MSPCAPTDSNCTR



TI Design – Electronic Lock (E-Lock)
Capacitive Touch Keypad for Access Control

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Description

This reference design demonstrates an ultra-low-power capacitive touch panel solution based on a single MSP430™ microcontroller (MCU) with CapTIvate™ technology. The use of self and mutual capacitance technology enables multifunctional capacitive touch panels (buttons, and proximity sensor) for eLocks and other applications with various human interfaces available. This TI Design also demonstrates how to extend battery life by duty-cycling the MSP430 CPU and switch between low-power mode and active mode.

Features

- 12 touch buttons with one proximity sensor for system wake up and guard key
- 12 LEDs to indicate touch operation
- Haptics and beep available for touch feedback and lock status
- Ultra-low standby power consumption
- Anti-moisture performance

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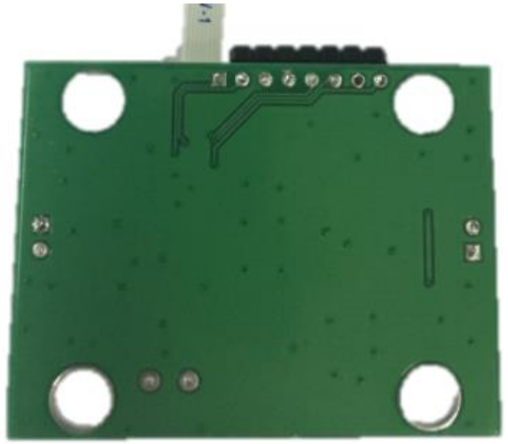
Part number:
TIDM-CAPTIVATE-E-LOCK



TI Design – Basic Thermostat Touch Panel
Eight Button Thermostat User Interface

Description

This TI Design implements a basic 8-button capacitive touch interface for thermostats. It demonstrates momentary buttons and toggle buttons, and utilizes the embedded FRAM to retain states through a power loss. It can be configured for a battery powered application with I-avg, or for a line-powered application with conducted noise immunity.

Features

- IEC 61000-4-6 3Vrms conducted noise immunity with direct DC power (3.3V)
- Mutual capacitance enables 8 buttons with just 6 MCU pins with full multi-touch capability
- FRAM provides button state retention through power loss

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Part number:
TIDM-CAPTIVATE-THERMOSTAT-UI

TI Design – Designing for EMC
Touch Sensing EMC Reference Design

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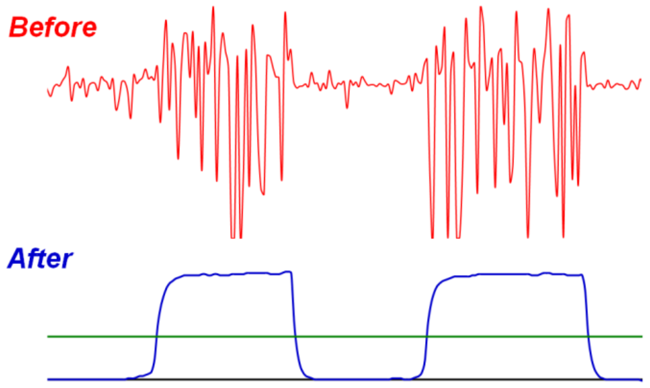
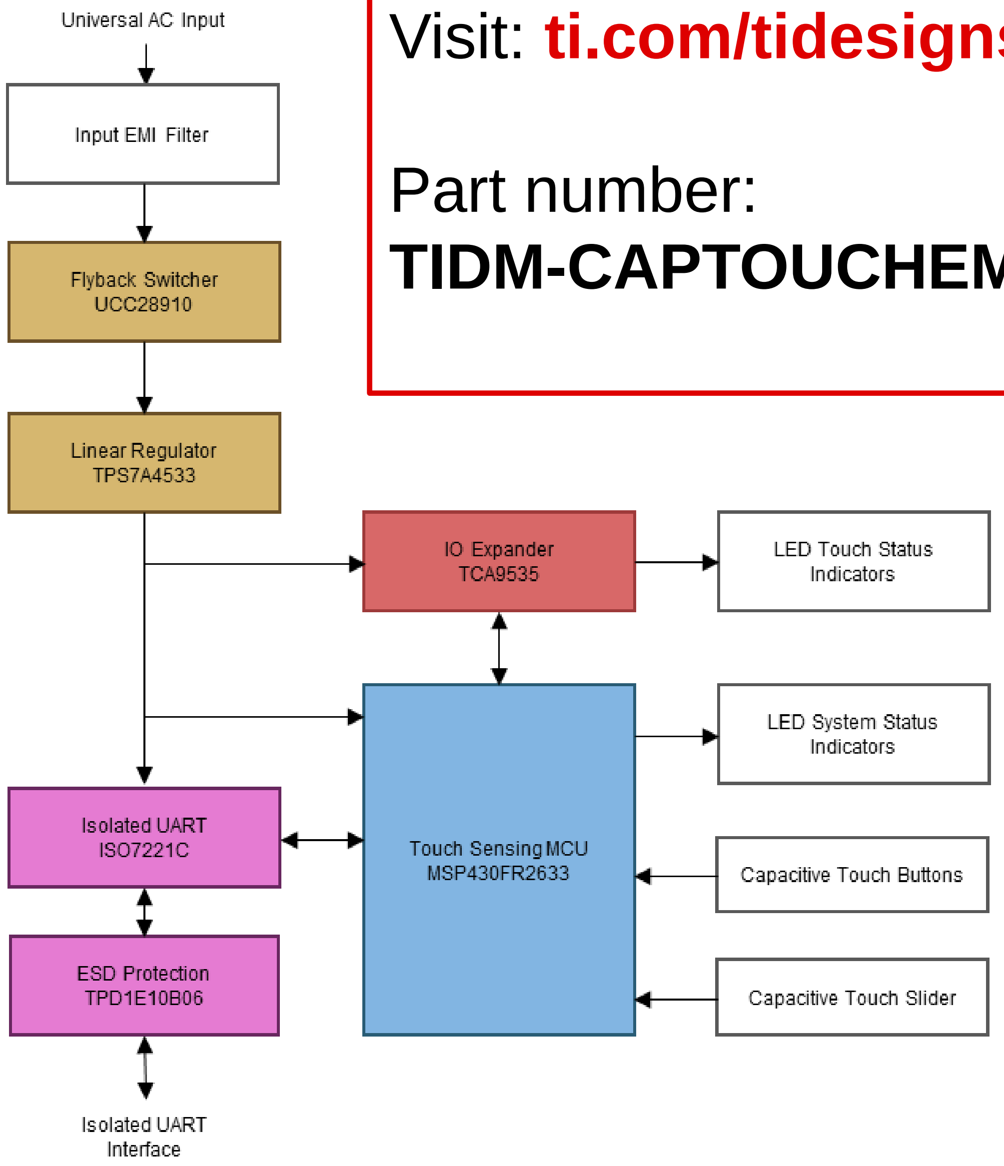
Description

This TI Design demonstrates how to meet product EMC requirements with a robust, flexible, high-performance capacitive touch interface.

Features

- MSP430FR2633 MCU for noise-tolerant capacitive touch sensing with CapTIvate™ technology
- System level ESD, EFT/B, and conducted noise tolerance
- Mutual and self capacitive sensing modules
- Universal AC and 12V DC power supply modules
- Isolated communications port for debug and test





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Part number:
TIDM-CAPTOUCHEMCREF

TI Design – Touch Through Thick Glass
Capacitive Touch Keypad for Access Control

Description

The TIDA-00494 reference design offers an HMI solution for harsh and hazardous area applications. In process plants, operators are required to interact with keypads for programming functions, encapsulated in explosive proof screw-on metallic enclosures with thick glass windows for local readouts through a liquid-crystal display (LCD).

This TI Design uses MSP430™ microcontrollers (MCUs) with TI CapTIvate™ technology which allows the operator to interact with the keypad without needing to open the enclosure, saving time by avoiding work permit or plant shutdown. The operator can read results from a LCD and get notified with a light-emitting diode (LED) with only one integrated circuit (IC).

Features

- Single and multistep button touch
- Four robust buttons option implemented
- Finger detection through 10mm thick glass
- Four LEDs and ultra-low power LCD as feedback
- Work with gloves and in harsh environment(water, oil, dust, etc)
- Temperature Range: -40°C to 85°C

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Part number:
TIDA-00494

TI Design – DMM with Capacitive Wake-Up

Bluetooth® Low Energy, 4½ Digit, 100kHz True RMS DMM

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Description

Many products are now becoming connected through the Internet of Things (IoT), including test equipment such as digital multimeters (DMM). Enabled by Texas Instruments' SimpleLink™ ultra-low power wireless microcontroller (MCU) platform, the TIDA-01012 reference design demonstrates a connected, 4½ Digit, 100kHz true RMS, DMM with *Bluetooth*® low energy connectivity, NFC Bluetooth pairing, and an Automatic Wake-Up feature enabled by TI's CapTIvate™ technology.

Features

- Automatic wake-up enabled by CapTIvate capacitive touch technology
- 4 1/2 digit, 50K count resolution
- Wireless MCU enabling bluetooth low energy (BLE) for IoT wireless
- Low power design and power management systems
- BLE mobile app pairing enabled by NFC dynamic interface
- Firmware-based true RMS measurements

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Part number:
TIDA-01012