MSP with CapTIvate™ Technology

A New Capacitive Touch Technology from TI

Industry-leading MCU Portfolio

Low-Power MCUs

- More than 500 low-power MCUs
- Industry's lowest power MCU
- The world's only embedded FRAM MCU family
- Combines smart analog with low system power to fit any power budget
- Broad range of applications include smart grid, wearables, sensors and energy harvesting

Performance MCUs

- More than 275 high-performance MCUs
- Specialize in control loop and functional safety applications
- Includes support for functional safety standards like IEC61508 and ISO 26262
- Broad range of applications include motor control, industrial drives, digital power, functional safety and transportation

Wireless MCUs

- Support for more than 14 wireless connectivity technologies – focus on ease of use and low power
- Enable faster IoT designs to connect everything
- Broad range of applications include building automation, wearables, sensors and smart grid

Ultra-low-power MSP FRAM Microcontrollers

Memory

Broad portfolio

- Over 100 devices
- 16-24 MHz max frequency
- 4 – 128 KB FRAM
- 21 – 83 I/O pins
- 11 packages
- Software compatible

MSP430FR5x

- Up to 128 KB FRAM
- ADC12 – Differential
- Comparator
- 5 Timers
- 256-bit AES accelerator
- Direct Memory Access

MSP430FR6x

- Up to 128 KB FRAM
- Integrated LCD Controller
- ADC12 – Differential
- Comparator
- 5 Timers
- 256-bit AES accelerator
- Direct Memory Access
- Scan interface
- Up to 83 I/O

MSP430FR2x

- Up to 16 KB FRAM
- CapTIvate™ Touch Technology
- ADC10
- IR Modulation Logic
- Up to 60 I/O
- Small Package (4x4)

MSP430FR4x

- Up to 16 KB FRAM
- Integrated LCD Controller
- ADC10
- IR Modulation Logic
- Up to 60 I/O

MSP430FR57x

- Up to 16 KB FRAM
- ADC10
- Comparator
- 5 Timers
- DSBGA Package (2x2)

Integration

Introducing the FRAM Advantage

The lowest power

- Because you spend so much time in standby, current consumption as low as 350 nA
- When your application wakes up, 100µA/MHz active mode current for efficient operation
- Write quicker to save power; 13 KB in milliseconds, not seconds

The smartest designs

- Adjust to changing memory requirements with flexible non-volatile FRAM; store your application, data or both
- Restore your system state after power failure with two lines of code and no backup power source
- Update your system over the air with on-the-fly, bit level data writes and no buffering or pre-erase required

The highest reliability

- Log data continuously with 10^{15} write endurance and proven 10 year data retention at 85° C
- Prevent unauthorized memory and data communication access with IP encapsulation and hardware AES
- Diminish data loss with undetectable soft error rates and other inherent security advantages of FRAM

All-in-one: FRAM Delivers Max Benefits

All-in-one: FRAM MCU delievers max benefits				
Specifications	**FRAM**	**SRAM**	**EEPROM**	**Flash**
Non-volatile *Retains data w/o power*	Yes	No	Yes	Yes
Write speed *(13 KB)*	10ms	<10ms	2 secs	1 sec
Average active Power [µA/MHz] *16 bit word access by the CPU*	100	<60	50,000+	230
Write endurance	10^{15}	Unlimited	100,000	10,000
Soft Errors	Below Measurable Limits	Yes	Yes	Yes
Bit-wise programmable	Yes	Yes	No	No
Unified Memory *Flexible code and data partitioning*	Yes	No	No	No

Customers can learn more at: www.ti.com/fram

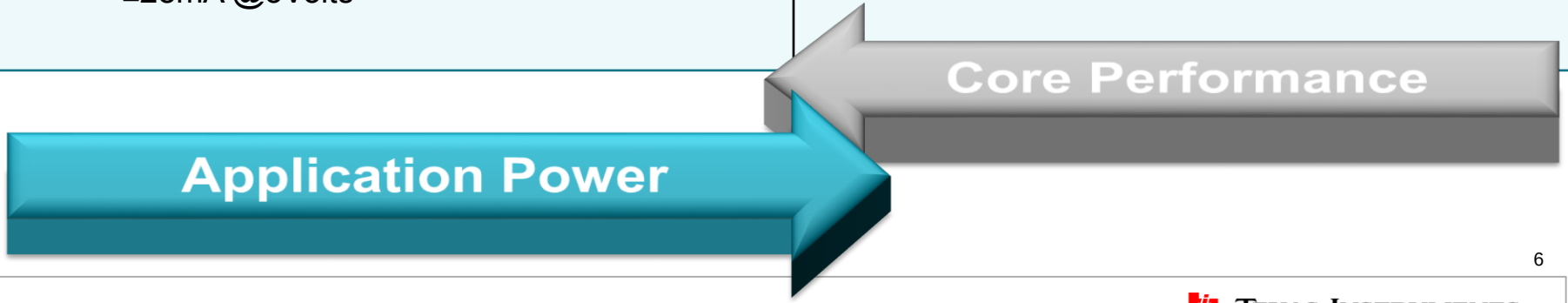
Choosing the right Benchmark

ULPBENCH™	COREMARK®

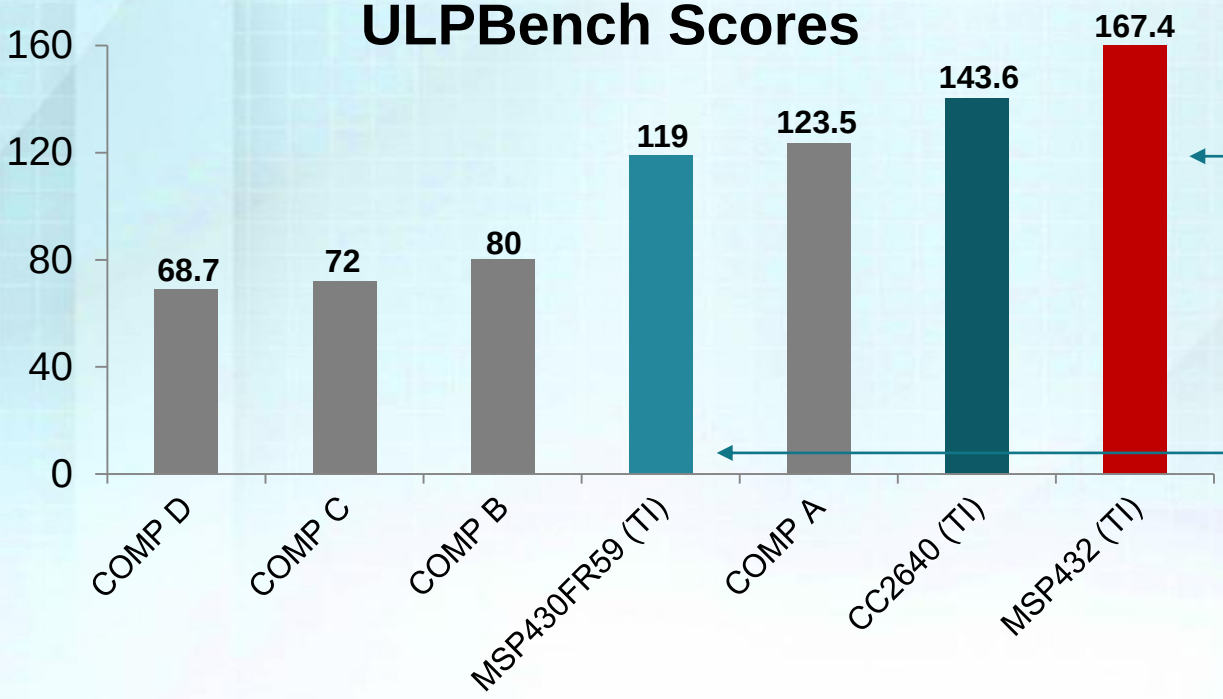
The Embedded Microprocessor Benchmark Consortium (EEMBC) develops benchmark software to help system designers select the optimal processors, and benchmark tools to help consumers and IT professionals select the appropriate smart phones/tablets and networking firewall appliances. EEMBC organizes its benchmark suites targeting Automotive, Digital Media, Java, Multicore Processors, Networking, Office Automation, Signal Processing, Smartphones/Tablets and Browsers.

- Focus on application-level power
  - Accounts for system functions: real-time clock, power modes, and integrated hardware
  - Provides a true comparison of microcontrollers when current consumption ≤28mA @3Volts

- Isolate the CPU's core performance
  - Primary focus on CPU pipeline - read/write, integer and control operations
  - Provides a simple starting point for comprehension of MCU performance in an application



Industry Leading Power Consumption



MSP MCUs:

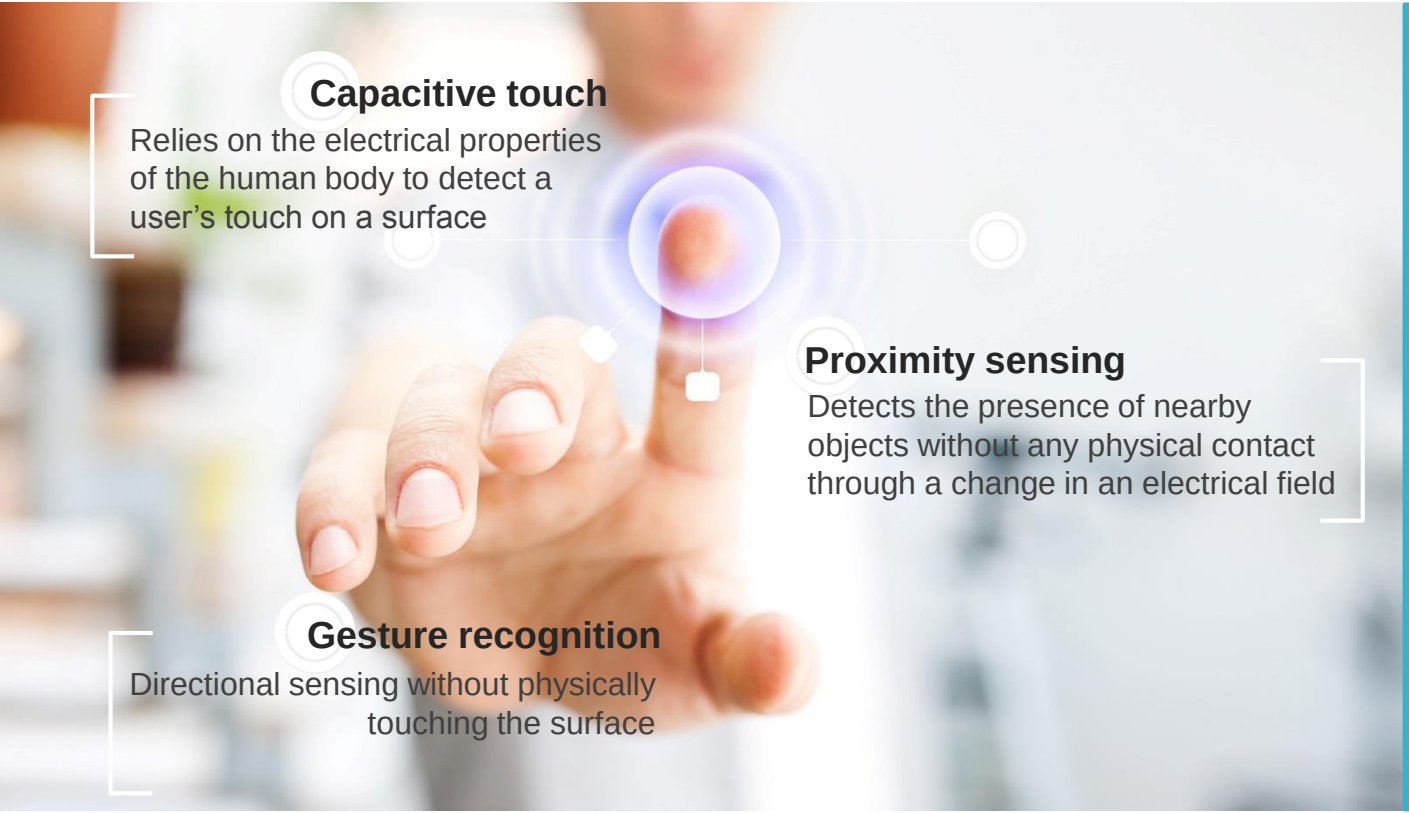
Industry's lowest power

16-bit MCUs and 32-bit Cortex-M4F MCUs.

Leverage the EnergyMonitor tool to evaluate MCU power using your application code.

See for yourself: www.eembc.org/ulpbench

What is capacitive and proximity sensing?



Capacitive touch

Relies on the electrical properties of the human body to detect a user's touch on a surface

Proximity sensing

Detects the presence of nearby objects without any physical contact through a change in an electrical field

Gesture recognition

Directional sensing without physically touching the surface

BENEFITS

Flexibility sleek industrial designs with seamless blending with glass, plastic or metal surfaces and support for HMI of different shapes and sizes

Reliability no moving parts make the design less prone to failure

Easy to clean and maintain surfaces

Finding more capacitive touch in everyday applications

Appliances

Access control

Industrial gauges

Consumer applications

Thermostats

POS terminals

Security systems

Sanitary applications

Challenges of designing with capacitive touch

Noise triggers false touch detections

Industrial designs are driving the need for more advanced interfaces

“Always-on” capacitive touch technology drains power

Limited application designs due to sensitivity and resolution

Spend months designing and optimizing capacitive touch solutions

Revolutionize your design with CapTIvate™ technology

Noise triggers false touch detections

IEC61000-4-6 certified touch solutions for noise immunity

Industrial designs are driving the need for more advanced interfaces

Metal touch, 3D gesture, glove friendly and the most configurable solutions

"Always-on" capacitive touch technology drains power

The world's lowest-power FRAM capacitive touch microcontroller

Limited application designs due to sensitivity and resolution

Industry's highest resolution sliders and wheels

Spend months designing and optimizing capacitive touch solutions

Set-up your design in five minutes or less with CapTIvate Design Center

Reliability

IEC61000-4-x certified touch solutions for noise immunity

Sixty to 70 percent of capacitive touch solutions will require IEC61000-4-x certification

- Hardware: Frequency hopping and zero crossing sync techniques in-silicon provide robust detection
- Software: Oversampling, de-bounce, AC noise filtering minimize false detects
- System: Comprehensive reference designs to meet EMC compliance

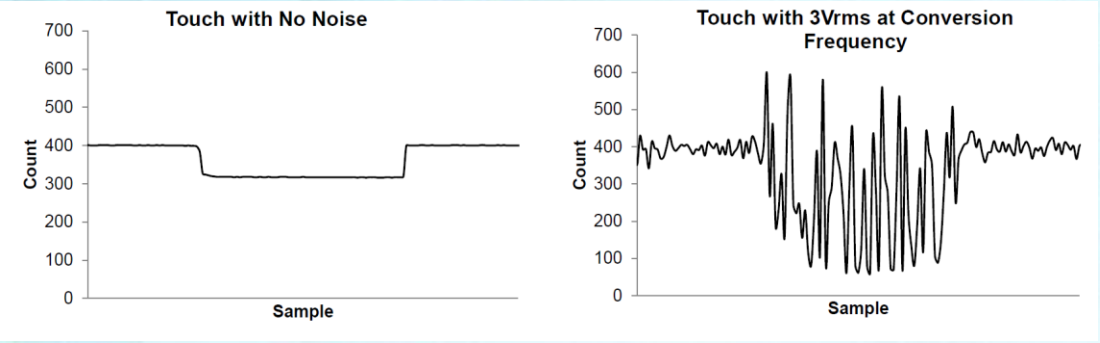
Avoid false detects in presence of moisture

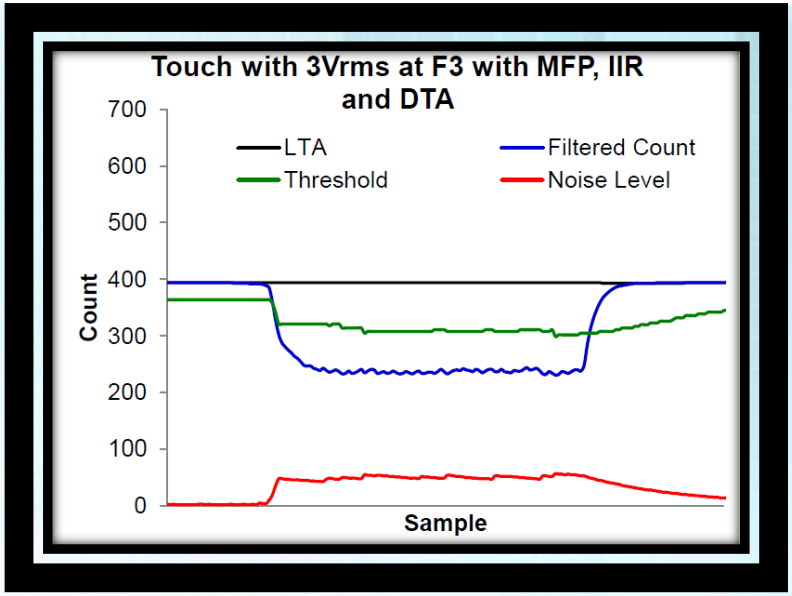
- Moisture rejection using guard channel techniques helps system differentiate between a touch and moisture
- Make designs waterproof using metal overlays for outdoor or wet environments

CapTIvate™ technology can also reduce emissions

Reliability

Improving Noise Immunity

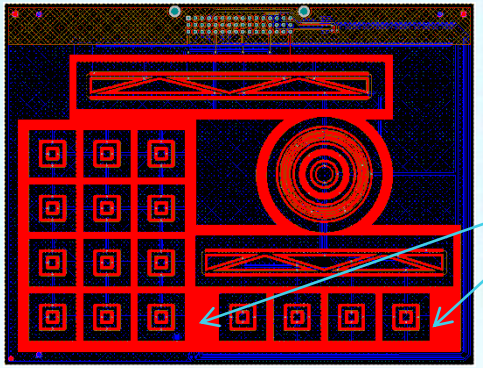




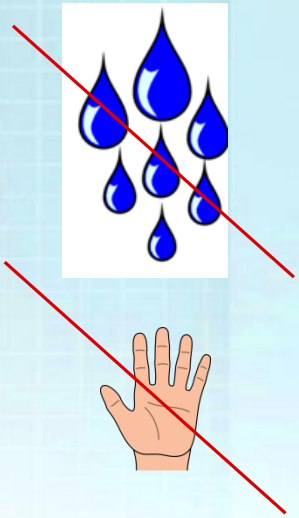
1) Multi-frequency scan from 4 frequencies
2) Spread spectrum modulation to reduce amplitude
3) Multi-frequency processing: 4 inputs, single result
4) IIR Filtering
5) Dynamic thresh-hold adjustment

Reliability

Moisture and palm rejection



Guard Channel Connected to CapTIvate IO



- Guard channel serves allows for palm rejection and moisture rejection
- Guard channel reaching a certain threshold masks all other channels

Versatility

Metal touch, 3D gesture, glove friendly and the most configurable solutions

Differentiate your solution with metal touch

- Seamlessly integrate your sensors with stainless steel or metal panels
- Increase functionality with multi-touch and force-touch
- Also supports glass and plastic overlays

Most configurable button, slider and wheel combinations

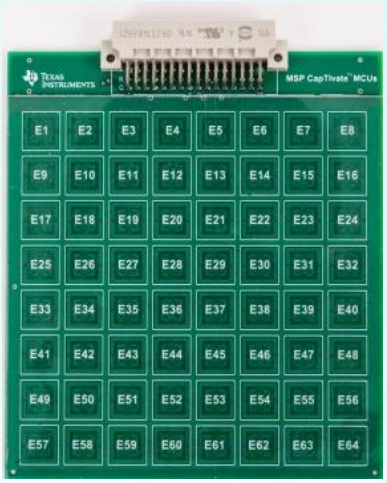
- Design up to 64 buttons with just 16 IOs to simplify designs and reduce cost
- Concurrently measure mutual and self-capacitance

Proximity and 3D gesture sensing is also possible with CapTIvate™ Technology

Versatility

Metal touch, 3D gesture, glove friendly and the most configurable solutions

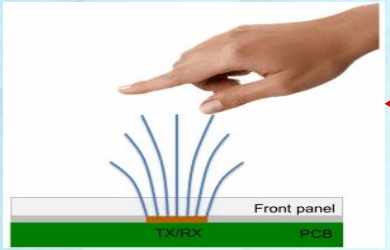
16 IOs = 32 buttons + 4 sliders + 4 wheels
Self & Mutual Cap on the same design



16 IOs = 64 buttons

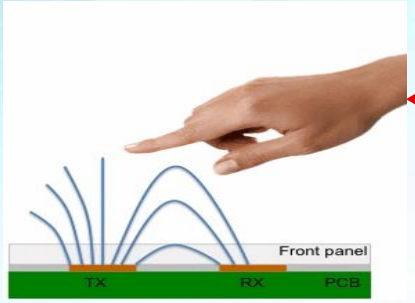
Metal Overlay
- Works with gloves
- Works with gunk
- Force touch capable

Versatility
Self or Mutual or Hybrid



Self capacitance:

- Electrode = single plate, 16 CapTIvate Touch IOs = 16 Electrodes
- Ultra **high resolution sliders** & wheels (> 10-bit) . Eg. 12" slider = 4 electrodes
- proximity sensors resulting in **higher distances**



Mutual capacitance:

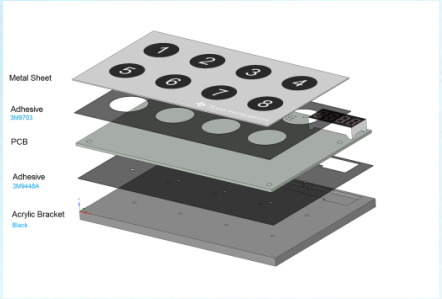
- Electrode is made up of two plates (one Tx, one Rx)
- Allows for up to **64 buttons** with 16 CapTIvate Touch IOs (8Tx, 8Rx)
- Allows for tightly packed buttons with low cross talk
- Allows **Multi-touch** matrix implementations.

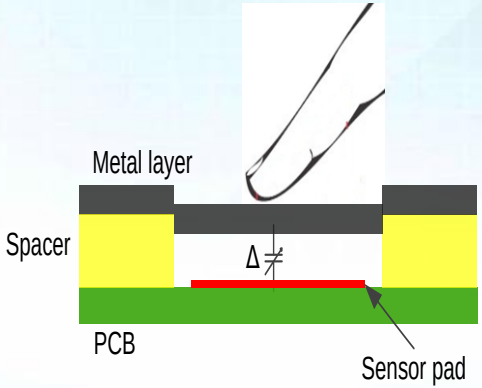
Hybrid solutions = Concurrent self+mutual

- Self cap for proximity/Guard Channel detection Eg. keypad illumination
- Use Mutual capacitance for multiple buttons Eg. Keypad

CapTIvate Technology supports self & mutual capacitance in the same design

Versatility
Metal Touch





- Advantages
  - Waterproof
  - Dust-proof
  - Wear resistance
- Requires an actuation force
  - Touch with gloves
  - Soft touch and hard touch (force touch)
- High noise immunity
  - RF noise immunity
- Elegant designs

Low-power

The world's lowest-power FRAM capacitive touch microcontroller

Up to 90 percent lower power than other solutions

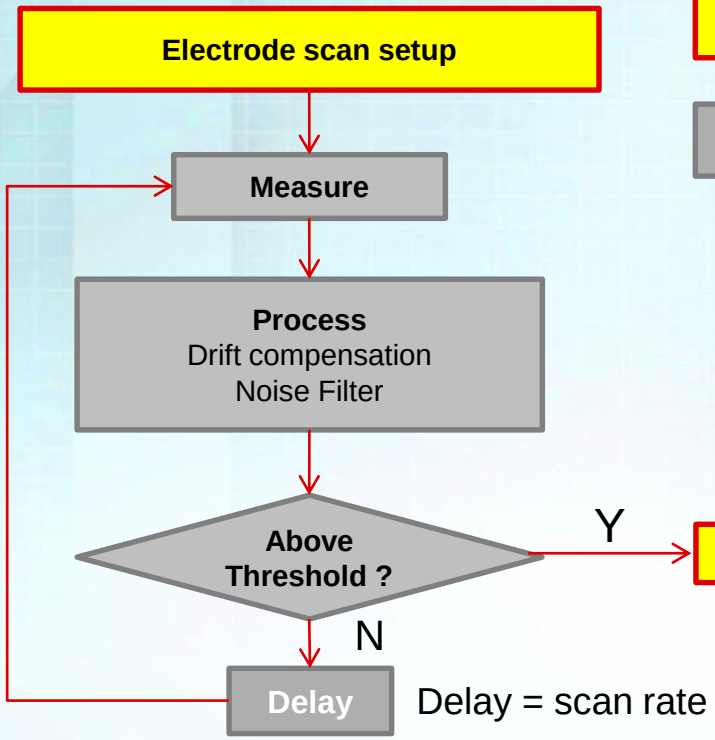
- Scan up to four buttons at 0.9 µA per button with the CPU completely turned off
- Autonomous peripherals enable you to do more with less power
- Experience up to 15 years of battery life on a single coin cell battery

World's only FRAM MCU with CapTIvate™ technology

- FRAM and CapTIvate technology on the same device allows for HMI applications with ultra-low-power datalogging and state retention capabilities
- 10^{15} write endurance
- 100x faster and 250x lower energy writes than other non-volatile technology

Low-power

Wake on touch– 4 buttons



MCU Active

SM Active (MCU sleeping or other activities)

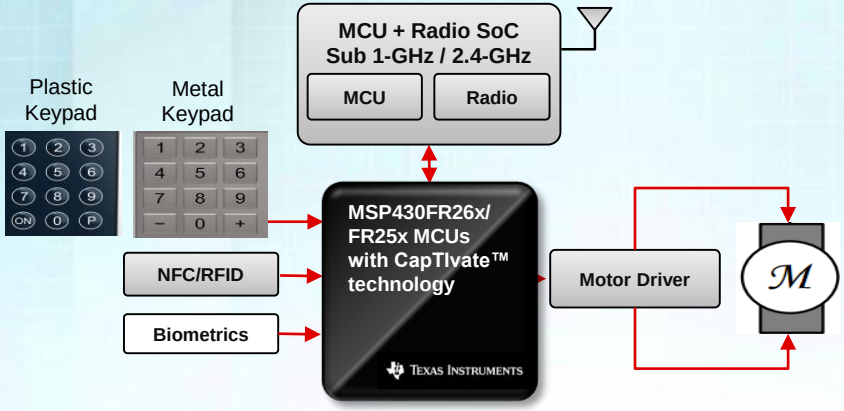
Scan Period	Avg. Current consumption
30 Hz	10uA*
10 Hz	4uA

*per Electrode (button) current ~ 3uA (avg)

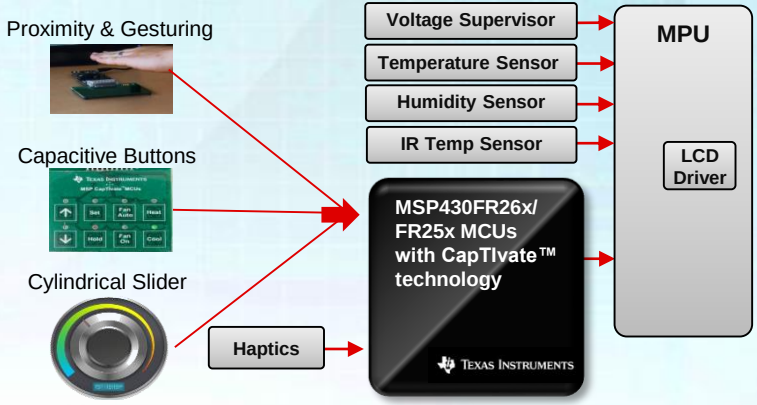
CapTIvate™ technology + FRAM MCUs: A perfect pair

Write endurance, speed and power of FRAM allow you to:

Add data logging to electronic locks



Add intelligence to your Thermostat



High Resolution

Industry's highest resolution sliders and wheels

Support low-power 3D gesture recognition

- Scans four sensors simultaneously within 500 µsec to enable advanced gesture features
- Higher proximity distances (up to 30cm)

Industry's highest resolution slider and wheels

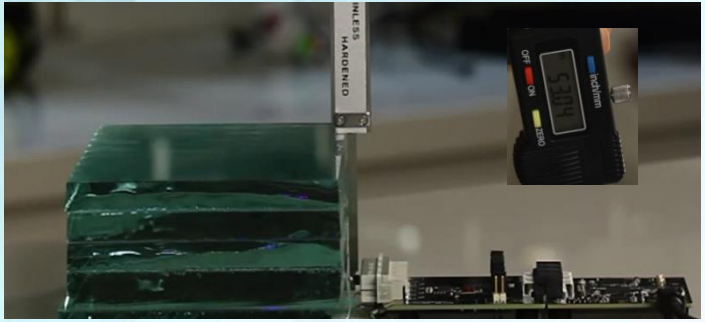
- Thirty centimeter slider with 1/250 cm resolution and only four sensors
- High resolution allows for high degree of linearity in sliders

Create designs with thicker glass and plastic overlays

- Detect change as low as 10 Femtofarads
- Minimize effect of parasitic capacitance for more robust designs and flexibility

High Resolution

Industry's highest resolution sliders and wheels



Sense through 60mm thick glass

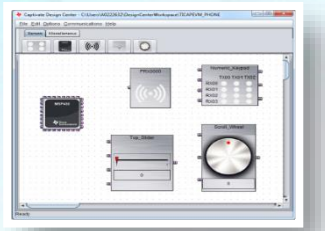
4 IOs = 12 inch slider,
1/100th inch accuracy

30-cm Proximity
3D gestures

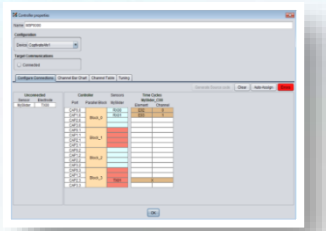
Ease-of-use

Set-up your design in five minutes or less with CapTIvate Design Center

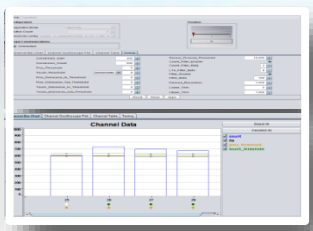
- Simplify and accelerate touch design with CapTIvate Design Center - one stop shop for tools, software and documentation
- Intuitive GUI tools for creating, configuring touch sensors and tuning them in real time
- Tune buttons, sliders, wheels and proximity sensors for sensitivity, noise performance and power consumption
- Automated generation of complete source code projects for Code Composer Studio™ IDE and IAR® IDEs



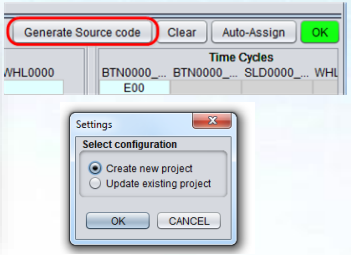
Drag & Drop



Configure



Real-time tuning

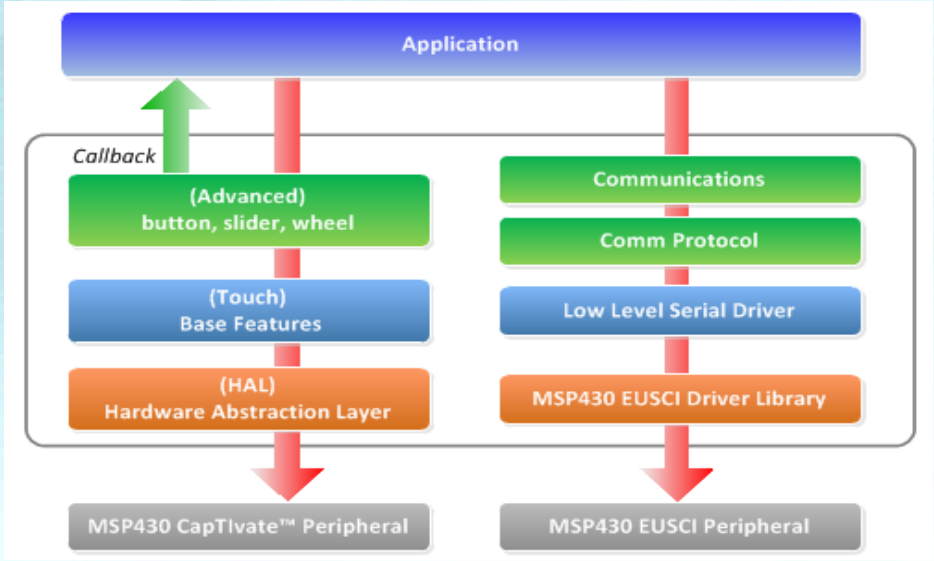


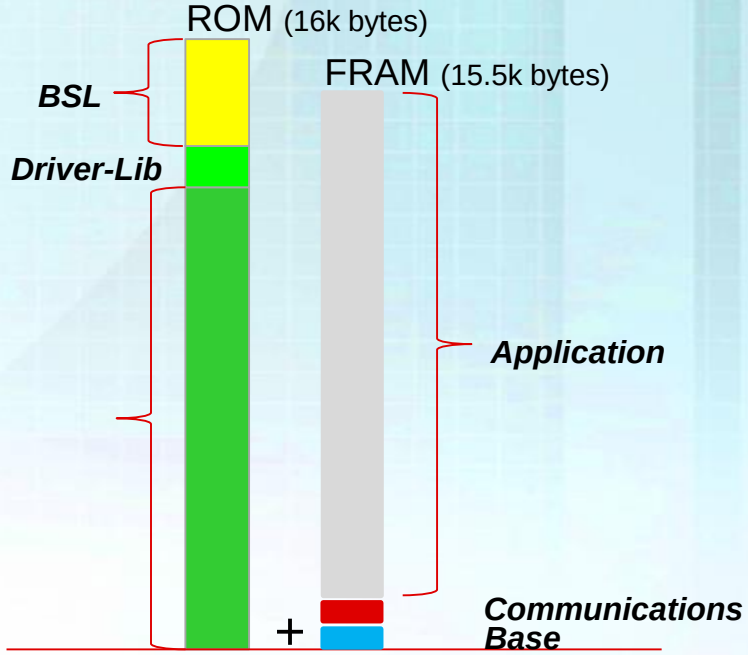
Generate

Build

Ease-of-use

Do more with Software Library in ROM





CapTIvate™ Library Code Footprint

All the tools and support to get developers started today

CAPTIVATE-BSWP
Self Capacitance

MSP CapTIvate Development Kit (MSP-CAPT-FR2633)

- Based on MSP430FR2633 MCU includes Sensor PCBs demonstrating mutual, self and proximity sensing. Available on TI Store for USD $99.

CapTIvate™ touch MCU+ haptic evaluation

- Part of CapTIvate MCU development Kit with haptic feedback provided by TI's DRV2605L haptic driver + Linear Resonant Actuator (LRA).
- Haptics technology enhances capacitive button, slider and wheel solution by providing mechanical (tactile) feedback to reduce user error, improve user experience and create differentiated products.

CAPTIVATE-PHONE
Mutual Capacitance

CAPTIVATE-proximity
Proximity & Gestures

MSP430™ FR253x/263x

Features/Benefits

IEC61000-4-x certified touch solutions for noise immunity

Metal touch, 3D gesture, glove friendly and the most configurable solutions

< 4 uA Wake on touch with 4 sensors.

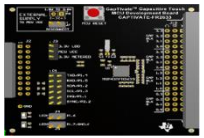
30 cm slider, 1/250th cm resolution, Just 4 IOs

Set-up your design in five minutes or less with CapTIvate Design Center

Touch library in ROM

Self and mutual capacitance in the same design - Upto 64 buttons

Tools



CAPTIVATE-FR2633

CAPTIVATE-BSWP

CAPTIVATE-PHONE

CAPTIVATE-PROXIMITY

Software

- CapTIvate Touch Software Library (in ROM)
- CapTIvate Design Center – Configure, Tune sensors in real time, auto generate code

Samples:Nov'15, Production: Dec'15

MSP430FR253x/263x

Temperatures	-40°C to 85°C

MSP430F2(5/6)3x
16-bit
Up to 16 MHz

System Module
- MPY32

Data Protection
- CRC16

Serial Interface
- 2 × UART + IrDA or SPI
- 1× I²C or SPI

Analog
- 1 × 10 bit SAR ADC on-chip bandgap for battery voltage monitor. On-chip temperature sensor (up to 8 ch)

Packages
- 32-pin QFN/TSSOP
- 24-pin QFN
- 24-pin DSBGA (TBD)

Memory
- Up to 16KB FRAM (with segment protections for code/data)
- Up to 4KB SRAM
- 16KB ROM

Debug
- Embedded Emulation
- Real-time JTAG/SBW
- Bootstrap Loader

Timers
- Watchdog Timer
- 2× 16 bit TA w/ 3CC regs
- 2 × 16 bit pure TA
- Real-Time Clock (Counter only)

Power & Clocking
- PMM with BOR, POR,PUC &SVS
- LFXT
- DCO
- FLL
- REFO
- VLO

GPIO
- Up to 17 GPIOs with 8 CapTIvate IOs

CapTIvate Touch
- Up to16 CapTIvate IOs, 64 buttons
- Wake-on-Prox , zero CPU State Machine
- Dedicated 16MHz Oscillator
- Dedicated 16-bit Timer

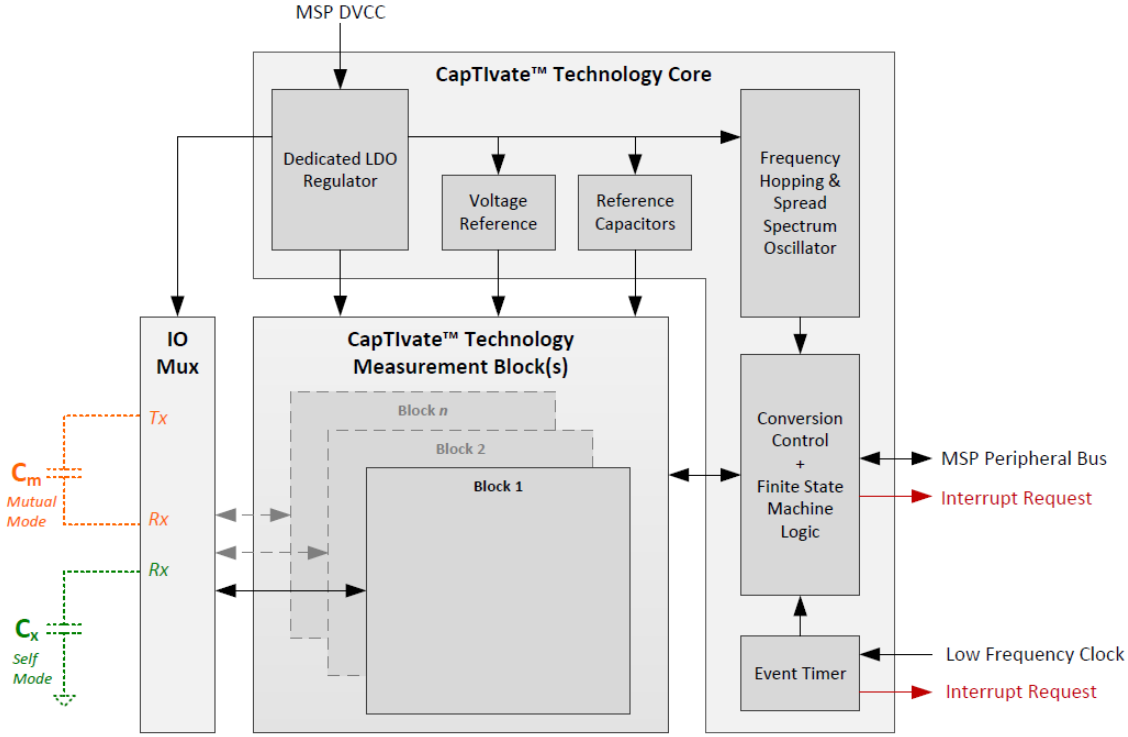
	FR2532	FR2632	FR2533	FR2633
FRAM/RAM	8K/1K	8K/2K	16K/2K	16K/4K

Target Applications

- Thermostats
- Electronic access control
- Lighting control
- Electronic Locks
- White goods
- Small appliances
- Personal electronics

Texas Instruments

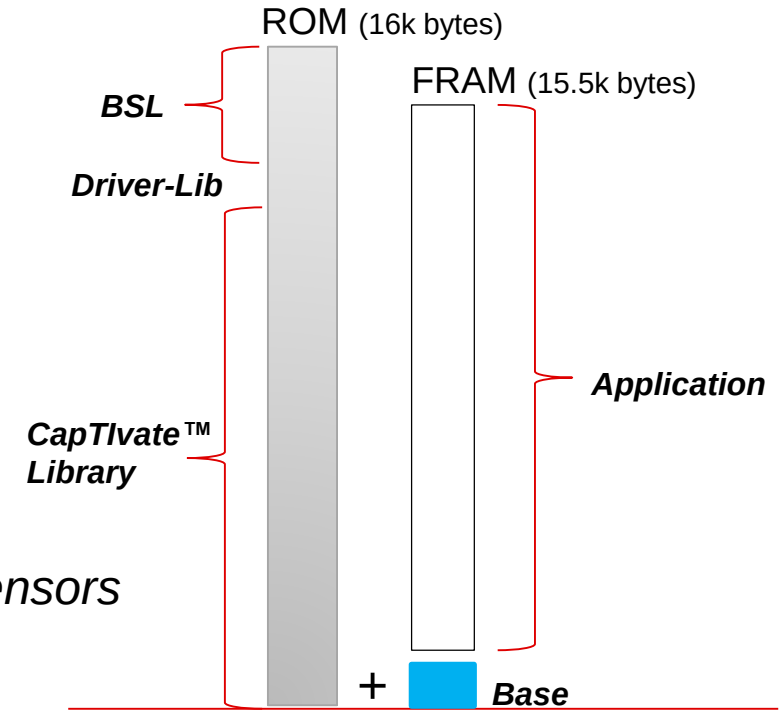
CapTIvate™ Technology IP



Conceptual diagram

CapTIvate™ Technology Touch Library

- ROM
  - BSL (4k bytes)
  - CapTIvate™ Technology Touch Library (10.2k bytes)
  - Driver-lib EUSCI I2C, UART drivers (1.8k bytes)
- Code size
  - FRAM base code
    - 2.1K bytes (3.5K bytes w/communications)
    - *Size <u>does not</u> vary with type or number of sensors*
- Data Size
  - *Size <u>does</u> vary with number and type of sensors*
  - *Ex. ~650 bytes for BSWP out of box demo*
  - *Stack usage: 106 bytes*

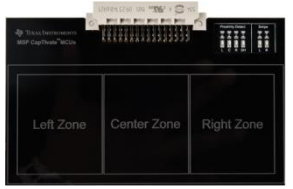


CapTIvate Firmware Footprint

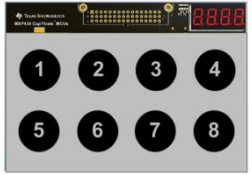
CapTIvate™ Technology MCU Development Kit

- MSP-CAPT-FR2633
  - Bundled Kit contains
    - eZFET™ programmer/debugger with EnergyTrace™
    - MSP430FR2633 MCU Processor PCB
    - Isolation PCB for battery operation and EMI testing
    - Sensor PCBs demonstrating mutual, self, metal and proximity
    - Exception – Metal touch will be available separately
  - Available on e-store by CS – target price $99

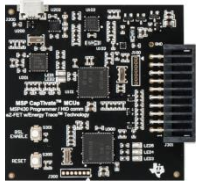
CAPTIVATE-proximity



CAPTIVATE-METAL
(Sold separately/Available 1Q16)

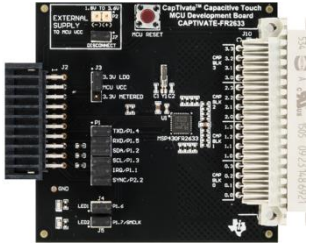


CAPTIVATE-PGMR



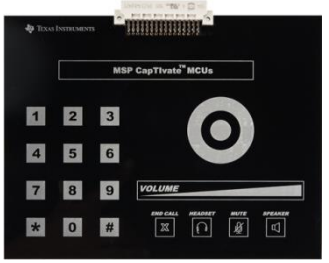
CAPTIVATE-ISO

CAPTIVATE-FR2633



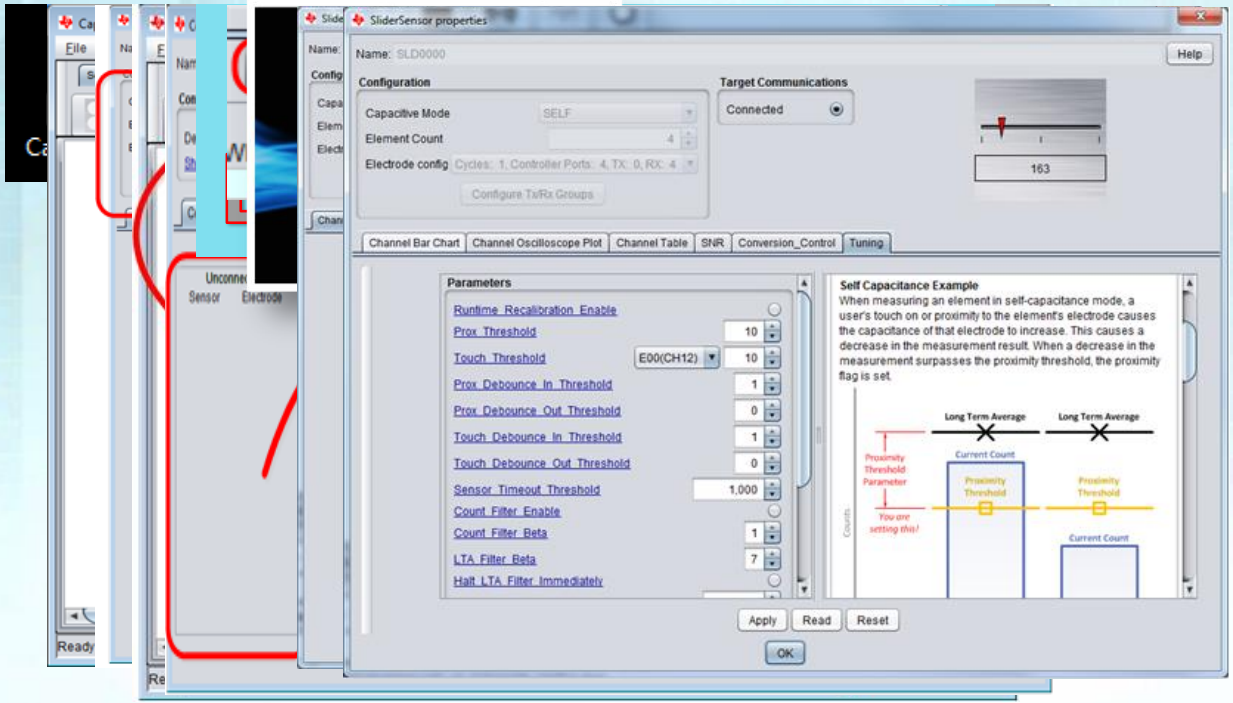
CAPTIVATE-BSWP

CAPTIVATE-PHONE



Ease-of-use

Set-up your design in five minutes or less with CapTIvate Design Center



Resources

Website: www.ti.com/CapTIvate

Downloads:
CCS : http://processors.wiki.ti.com/index.php/Category:Code_Composer_Studio_v6
Captivate Design Center : http://www.ti.com/tool/mspcaptdsnctr
Videos:
Part 1: Introducing MSP MCUs featuring CapTIvate Technology
Part 2: The MSP CapTIvate MCU Development Kit
Part 3: Tune Capacitive Sensors in 5 Minutes or Less with the CapTIvate Design Center
Part 4: Low-power Features of MSP MCUs featuring CapTIvate Technology
Part 5: Capacitive Button, Slider and Wheel Interfaces
Part 6: Proximity Sensing and 3D Gestures
Part 7: Moisture Rejection in Capacitive Touch Designs
Part 8: Noise Immunity in Capacitive Touch Designs
TI Designs:
Capacitive Touch Thermostat User Interface Reference Design
64-Button Capacitive Touch Panel With TI Microcontroller With CapTIvate Technology Reference Design
Low-Power Touch Through Glass Reference Design

Thank You