Creating robust, innovative, low-power HMI interfaces for e-lock, security, thermostats and other building automation interfaces with CapTIvate touch technology

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Agenda

• Capacitive touch and Key benefits of CapTIvate™ technology
• CapTIvate – Silicon, Tools, Eco system
• Applications for CapTIvate in Building Automation
• Summary and collateral
TOUCH THE REVOLUTION VIDEO
1min..
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.
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
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
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

16 IOs = 32 buttons + 4 sliders + 4 wheels + 1 prox

16 IOs = 64 buttons
Versatility

CapTlstrate™ technology supports self and mutual capacitance in the same design

Self capacitance:
- Electrode = single plate, 16 CapTlstrate 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 CapTlstrate Touch IOs (8Tx, 8Rx)
- Allows for tightly packed buttons with low cross talk
- Allows multi-touch matrix implementations.

Hybrid solutions= concurrent self and mutual capacitance
- Self capacitance for proximity/guard channel detection eg. keypad illumination
- Use mutual capacitance for multiple buttons eg. keypad
Versatility
Metal Touch

Advantages:
- Waterproof
- Dustproof
- Wear resistance

Requires an actuation force:
- Touch with gloves
- Soft touch and hard touch (force touch)

High noise immunity:
- RF noise immunity
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
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 0.029 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

Sense through 60mm thick glass
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**MSP430™ FR253x/263x**

### Features/Benefits

- IEC61000-4-4 certified touch solutions for noise immunity
- Metal touch, 3D gesture, glove friendly and the most configurable solutions
- < 4 μA  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-BSWP
- CAPTIVATE-PHONE
- CAPTIVATE-PROXIMITY

### Software

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

### In Production

- CAPTIVATE-

### Target Applications

- Thermostats
- Electronic access control
- Lighting control

### In Production

- CAPTIVATE-

### Power & Clocking

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

### SPI

- Up to 16 GPIOs with 8 CapTIvate IOs

### 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

### Data Protection

- CRC16

### Serial Interface

- 2 × UART + I²C 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)

### 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)

### Packages

- FR2532
- FR2632
- FR2533
- FR2633

### 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)
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.
Ease-of-use

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

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

Board Layout Based on pinout

Build with Code Composer IAR
Ease-of-use
Set-up your design in five minutes or less with CapTIvate Design Center
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CapTIvate in Building Automation

Captivate benefits:
• <3uA Avg power => Years of battery life
• Moisture rejection capability
• Plastic/glass or metal overlay
• FRAM for state/passcode retention

Electronic Locks/Keypad

Captivate benefits:
• Low power => Use with energy stealing
• Replace resistive with captouch
• Support for ITO (transparent sensors)
• FRAM for user profile retention

Featured Collateral
TIDA-00343 (Touch through glass)
Coming soon
TIDM-CAPTIVATE-ELOCK

Thermostat

Featured Collateral
TIDM-CAPTIVATE-THERMOSTAT-UI
CapTIvate in Building Automation

Captivate benefits:
• <3uA => Years of battery life
• Use 3D gestures
• Upto 64 buttons with mutual capacitance
• Upto 10cm prox sensing for back light
• Gesture pad for more complex HMI

Featured Collateral
TIDM-CAPTIVATE-64-BUTTON
Coming soon
TIDM-CAPTIVATE-REMOTECONTROL (gesture pad)

Security Panel

Captivate benefits:
• Immune to power line noise
• Design flexibility with Plastic, glass, wood, metal overlay
• FRAM for user profile retention

Featured Collateral
TIDM-CAPTOUCHEMCREF
TIDM-CAPTIVATE-THERMOSTAT-UI

Light Switches
CapTlvable in Building Automation

Captivate benefits:
• Immune to power line noise
• Support for metal touch
• 64 buttons on a single device

Featured Collateral
TIDM-CAPTIVATE-64-BUTTON
TIDM-CAPTOUCHEMCREF

Coming soon
Touch on metal reference design
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CapTIvate™ technology revolutionizes capacitive touch

IEC61000-4-6 certified touch solutions for noise immunity

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

The world’s lowest-power FRAM capacitive touch microcontroller

Industry’s highest resolution sliders and wheels

Set-up your design in five minutes or less with CapTIvate Design Center
Resources
Website: [www.ti.com/CapTIvate](http://www.ti.com/CapTIvate)

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
- Touch Through Glass with Sharp ® LCD Reference Design
- Noise Tolerant Capacitive Touch HMI Reference Design

Deep Dive trainings:
- [https://training.ti.com/captivate-training-series](https://training.ti.com/captivate-training-series)
- Fundamental PCB Layout and Design Guidelines
- Introduction to EMC Challenges and Design with CapTIvate™ MCUs
THANK YOU
Touch Sensing EMC Ref. Design

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

Benefits

- Demonstrates how to meet product EMC requirements with a robust, flexible, high-performance capacitive touch interface

Target Applications

- Appliances and White Goods
- Industrial Control Panels
- TV, AV, and Set Top Box Interfaces
- Building Automation User Interfaces

Tools & Resources

Coming Soon – Early 2Q16

Video: Noise Immunity in Capacitive Touch Designs
64-Button Capacitive Touch Panel

**Features**
- Single touch and multi-touch detection
- Mutual capacitance technology enables 64-buttons with only 16 pins
- More than 100 samples-per-second and 15-ms typical response time
- 0.23-µA-per-button average current with wake-on-touch mode

**Benefits**
- Demonstrates use of CapTIvate to support large number of buttons in a low power system

**Target Applications**
- Appliances and White Goods
- Industrial Control Panels
- TV, AV, and Set Top Box Interfaces
- Building Automation User Interfaces

**Tools & Resources**
- Schematics, Design files
- Released at TI.com

Video: CapTIvate 64 Button Panel
HMI - Low Power Touch Through Glass Reference Design

**TI Designs Number:** TIDA-00343

<table>
<thead>
<tr>
<th>Design Features</th>
<th>Design Benefits</th>
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</thead>
<tbody>
<tr>
<td>• Single and multi-step button press</td>
<td>• Finger detection through tick glass (8 – 12 mm)</td>
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<tr>
<td>• Three or more robust buttons option implemented</td>
<td>• Work with gloves and in harsh environment (water, oil, dust)</td>
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<tr>
<td>• Three LEDs feedback</td>
<td>• No calibration</td>
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<tr>
<td>• Easy to use</td>
<td></td>
</tr>
<tr>
<td>• Variable air gap between buttons and glass</td>
<td></td>
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<tr>
<td>• Low power: 1.7uA/Button</td>
<td></td>
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<tr>
<td>• Temperature range: -40°C to 85°C</td>
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**Tools & Resources**

<table>
<thead>
<tr>
<th>Board Image</th>
<th>TIDA-00343 Tools Folder</th>
<th>Design Guide</th>
<th>Design Files: Schematics, BOM, Gerbers, Software, and more</th>
<th>Device Datasheets:</th>
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<td>MSP430 capTIvate</td>
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**Block Diagram**

*Video: Low Power Touch through Glass TI Design*
Capacitive Touch Thermostat UI

**TIDM-CAPTIVATE-THERMOSTAT-UI**

**Features**
- MSP430 CapTIvate technology based thermostat UI design
- 8 buttons with only 6 IOs and visual feedback
- < 50 μA Avg power
- FRAM NVM technology: $10^{15}$ write endurance, 100x faster and 250x lower energy writes

**Benefits**
- 2 years battery life on AAA
- Save States on FRAM memory

**Target Applications**
- Thermostat

**Tools & Resources**
- TI Design at TI.com

CapTIvate Thermostat Video
CapTIvate Elock: TIDM-CAPTIVATE-ELOCK

Features

- CapTIvate Capacitive Touch functions
  - 12x Touch Buttons
  - 1x Proximity Sensor for system wake up
- 12 LEDs to indicate touch operation
- Wake-on touch with ultra-low power standby mode
- Haptics available
- Beep indicate touch feedback and lock status
- Moto drive circuitry available
- 2 x AAA or 4 x AAA reference power circuitry

Target Applications

- Smart Entrance
- Control Panel

Tools & Resources

- TI Design User Guide
- Design Files:
  - Schematics
  - BOM
  - Gerbers
  - Software
- Device :
  - MSP430FR2633
  - TPS6275
  - TPS61020

Benefits

- Ultra Low power in active and standby modes extends battery life

Board Image

- Power Board
  - Mosfet
  - Elock Moto
  - Battery AAA x 4
  - TPS61020
  - DC Boost
  - 3V->5.5V
  - (Reserve)
  - TPS62745
  - DC-DC
  - 6V->3.3V
  - ezFET-HID-Bridge
  - CAPTIVATE-PGMR

CapTIvate ELock

- GPIO
- CapTIvate I/O
- Proximity Sensor x1
- Touch Button x12
- CapTIvate MCU
  - MSP430FR2633
- LEDs x 12
- Haptics
- Beep
- SBW
- UART0
**CapTIvate Remote Control**

**Features**
- CapTIvate Capacitive Touch functions
  - 8x Touch Buttons
  - 1x Touch Slider for volume control
  - 1x GesturePad for slide and tap gestures
  - 1x Proximity Sensor for grip detection
- 2 LEDs to indicate power status and touch operation
- Wake-on grip detection with ultra-low power standby mode
- PC GUI for demo of remote control capabilities
- I2C & UART communication interface
- Bluetooth connectivity to PC through Bluetooth EVM CC2650EM-7ID
- Haptic circuitry available

**Target Applications**
- Smart TV & SET-TOP Box remotes
- Sound system remotes

**Tools & Resources**
- **TI Design User Guide**
- **Design Files:**
  - Schematics
  - BOM
  - Gerbers
  - Software
- **Device Datasheets:**
  - MSP430FR2633
  - DRV2605L
  - CC2650EM-7ID

**Benefits**
- Multifunctional capacitive touch panel for remote control with Buttons, Slider and GesturePad functions
- Low power in active and standby modes extends battery life
- Various communication interfaces available for future application extension

**Board Image**

![Board Image](image-url)
MSP432 + CapTIvate Demo

Features
- Single touch and multi-touch detection
- Mutual capacitance technology enables 17 buttons, 2 sliders, 1 wheel, and 1 proximity/guard channel with only 16 pins
- Supports both UART and I2C interfaces
- >20 ms touch-to-display worst-case response time

Benefits
- Demonstrates use of CapTIvate MCU as a dedicated HMI controller with external host
- Haptic feedback controlled by CapTIvate MCU provides better user experience

Target Applications
- IP Phone Panels
- Industrial Control Panels
- Building Automation User Interfaces
- Appliances and White Goods
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 threshold adjustment

Reliability
Improving noise immunity
Reliability
Moisture and palm rejection

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