Implement the industry’s lowest power capacitive touch buttons using MSP430™ MCUs featuring CapTIvate™ technology

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Agenda

• Introduction to CapTIvate touch technology
• How to tune capacitive sensors in 5 minutes or less
• Capacitive sensor design guidelines
• Summary/ Q&A
Finding more capacitive touch in everyday applications

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**Texas Instruments**
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 CapTlvate™ Technology

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

16 IOs = 64 buttons
Versatility

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

**Self capacitance:**
- Electrode = single plate, 16 CapTlvate 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 CapTlvate 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
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
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
**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 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-BSWP
- CAPTIVATE-PHONE
- CAPTIVATE-PROXIMITY

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

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

**Target Applications**
- Thermostats
- Electronic access control
- Lighting control

**In Production**

**Texas Instruments**
MSP CapTlivate 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.

CapTlivate™ touch MCU+ haptic evaluation
- Part of CapTlivate 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.
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Common Considerations

• DVCC Decoupling Capacitors
  – 0.1uF bypass
  – 4.7uF to 10uF tank recommended

• VREG Decoupling Capacitor
  – External 1uF, low ESR ≤ 200mΩ
  – As close to VREG pin as possible

• ESD Series Resistors
  – Not needed on all designs
  – Helps as line of defense for ESD strikes

• EMI Noise Filter Capacitors (optional)
  – Mutual Capacitive mode RX pins only
  – Helps minimize EMI effects
Materials and Dielectric Constants

- Dielectric constant determines how efficiently E-Field passes through material
- Typical dielectric values ($\varepsilon_r$): (Higher value means greater field propagation)
  - Air is 1
  - Glass is 7.6 to 8
  - Plastics is ~3
  - FR4 is 3.4
  - Water is ~ 80

- Typical overlay material is some type of plastic
  - Polycarbonate
  - Acrylic

- Other possible types of material include glass
LED Backlighting

- LED lighting is easy
  - Use reverse mount LEDs on backside of PCB
    - Hole should be non-plated
    - Keep size as small as possible to minimize dead spots in the sensor
    - May need a bypass capacitor to minimize effects of LED capacitance change when switching on/off.
Self-Capacitive Routing Best Practices

• Traces
  – Touch sensitive, so keep them thin and place on backside of PCB (if possible)
  – Reduce parasitic capacitance by spacing nearby grounds ≥ ½ overlay thickness away
  – Parallel scanned electrodes can run very close together, otherwise follow rules for ground spacing
  – Keep digital signals away from electrode traces
    • If need to cross paths, do so at 90 degrees

• Electrodes
  – For EMI suppression, use 25% ground hatch:
    • On bottom of PCB and/or
    • On top side, keeping spacing ≥ ½ overlay thickness
Mutual Capacitive Routing Best Practices

• Traces
  – Keep RX traces together and TX traces together, but away from each other
    • If RX and TX routed near each other (within finger spacing) creates an unintended button
    • If un-avoidable, put ground trace between RX and TX trace (adds some parasitic)
    • If RX and TX must cross, do so at 90 degrees
  – Avoid TX on a layer in parallel with RX on another PCB layer
  – Route digital signals away from RX and TX traces
    • If digital signals must cross RX or TX traces, do so at 90 degrees
  – To minimize parasitic capacitance, keep ground ½ overlay thickness away from RX and TX traces
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CapTIvate™ technology revolutionizes capacitive touch

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Industry’s highest resolution sliders and wheels

Set-up your design in five minutes or less with CapTIvate Design Center
Introduction 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
Fundamental PCB Layout and Design Guidelines
Introduction to EMC Challenges and Design with CapTIvate™ MCUs
Questions ??