Fitting High-Tech, Capacitive Human Machine Interfaces into Space Constrained Form Factors

Brian McCarthy – MSP430 Marketing Director
Sunil Oak – MSP430 Systems Engineer
Agenda

I. HMI is changing
II. Driving innovation in 2017
   • Introducing our small form factor capacitive touch solution in a die-size BGA
III. The development experience
IV. Get started today!
HMI is changing
Change enabler: 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**

**Sleek industrial designs:** Seamless glass, plastic or metal surfaces. Supports HMI in different shapes and sizes

**Reliability:** No moving parts make the design less prone to failure

**Harsh environment operation:** Operates in moisture sensitive or other dirty and environmental conditions
Challenges: 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
Solutions: Designing with capacitive touch

- "Always-on" capacitive touch technology drains power
- The world's lowest-power FRAM capacitive touch microcontroller
- IEC61000-4-6 certified touch solutions for noise immunity
- 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

Industrial designs are driving the need for more advanced interfaces

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

Noise triggers false touch detections

Texas Instruments
Agenda

I. HMI is changing
II. Driving innovation in 2017
   • Introducing our small form factor capacitive touch solution in a die-size BGA
III. The development experience
IV. Get started today!
Driving capacitive touch innovation: MSP430 MCUs with CapTIvate Technology

Capacitive Touch + Moisture Rejection with SimpleLink™ wireless connectivity

Capacitive Touch ITO (Up to 64 buttons on LCD with ITO layer)

Capacitive Touch Through Metal evaluation module releasing this quarter

Introducing CapTIvate DSBGA!
Fitting High-Tech, Capacitive Human Machine Interfaces into Space Constrained Form Factors
New small form factor CapTIvate DSBGA package

MSP430FR2633IYQWR
Die-size ball grid array (DSBGA)
• CapTIvate Technology with support for up to 16 buttons
• 24 balls with 0.4mm ball pitch
• Package size equal to die size
• Smallest footprint per I/O count
• No interposer between the silicon IC and the PCB (reduces overall height)
Applications benefiting from **small capacitive touch MCUs**

- Space-constrained systems requiring small capacitive sensors
- Systems with very small sensors with wired interface to main PCB
- Systems with space constraints and noise immunity concerns

---

**Pneumatic sensor**

**Small Tools and Appliances**

**Personal electronics**

**Nano Drones**

**Mechanical Button Replacement**

- 2.3 mm
- 18 mm

24-ball DSBGA

- 68% smaller area than 4x4
Agenda

I. HMI is changing

II. Driving innovation in 2017
   • Introducing our small form factor capacitive touch solution in a die-size BGA

III. The development experience

IV. Get started today!
Addressing small form factor design challenges

• Reliability
  – Sensitivity: Small sensor area could reduce the sensitivity to accurately detect touches
  – Crosstalk: A touch on any button could impact other button’s detection
  – Noise susceptibility: Due to the space constraint, the lack of shielding around the sensor could increase the susceptibility to noise

• Versatility
  – Self vs mutual capacitance: Space-constrained applications require more flexibility on the sensor configuration

• Low power
  – Low-power consumption system is a key requirement for battery-powered applications

• Complexity
  – Space-constrained form factor makes ideal sensor tuning and routing difficult
Design considerations: Reliability

- **Sensitivity**: Small sensor area could reduce the sensitivity to accurately detect touches
  - **Mechanical**
    - Reduce the thickness of the top overlay and minimize airgap
    - Separate electrically grounded enclosure from the sensor
  - **Sensor Design**
    - Self capacitance normally provides better sensitivity than mutual
    - Increase the separation to ground pour
    - Increase the sensor size to cover the required touch area
    - Keep TX and RX trace on separate layers for mutual capacitance
  - **Firmware Tuning**
    - Supported via CapTIvate Design Center GUI
      - Increase the conversion count and decrease the conversion gain
      - Adjust the touch and proximity threshold
      - Dynamic threshold adjustment (DTA), long-term-average (LTA) tracking and runtime recalibration algorithms ensure a consistent sensitivity
**Design considerations: Reliability**

- **Crosstalk:** A touch on any button could impact other button’s detection.
  - Keep a safe distance between sensor trace lines.
  - Keep the digital signals at least 4mm away from the sensor trace.
  - Use CapTIvate dominate element detection feature to prevent sensor crosstalk.

- **Noise Susceptibility:** Due to the space constraint, the lack of enough shielding around the sensor could increase the susceptibility to noise.
  - Main CapTIvate technology features to improve noise immunity
    - Integrator-based charge transfer engine
    - Frequency-modulated oscillator
  - Hardware design techniques
    - Ground shielding of electrodes in layout
    - 68pF noise filter-capacitors on receive sensing lines (mutual)
  - Signal-processing algorithms in CapTIvate Software Library
    - 4-conversion-frequency processing (MFP) algorithm
    - Dynamic threshold adjustment (DTA) algorithm in self mode
Design considerations: Versatility & low power

- **Versatility**: Space constrained applications require more flexibility on the sensor configuration
  - CapTIvate technology supports both self capacitance and mutual capacitance
  - With DSBGA package and blind vias, the single button solution size is only 7mm x 3.5mm

- **Low Power**: Low power consumption system is a key requirement for battery-powered applications
  - DSBGA package with < 4 uA power consumption using wake-on-touch with 2 sensors
  - Use appropriate crystal frequency to achieve lowest base LPM3 current
  - Use CapTIvate Design Center GUI to tune performance / power
  - Use wake-on-proximity feature to effectively minimize the CPU awake time

Mutual Capacitance
Self Capacitance
Design considerations: **Complexity**

- **Complexity**: Space constrained form factor makes ideal sensor tuning and routing difficult
  - Use CapTiVate Design Center GUI to configure and optimize the sensor connections to MSP430
  - Use CapTiVate Design Center GUI to view detailed sensor data, to configure and tune sensor performance and to perform SNR measurements in real-time
Design Considerations: **Complexity**

- **Complexity**: Space constrained form factor makes ideal sensor tuning and routing difficult
  - MSP430FR2633 DSBGA package provides a small footprint and is designed to help make the routing easier on space constrained form factor applications

- All the CapTIvate IOs on the perimeter of the IC makes it easy to route the sensor single.
MSP430FR2633 DSBGA design examples

7mm x 3.5mm Single Button

- 4 copper layers, FR4 dielectric, 0.5mm overall PCB thickness
- One mutual capacitance button
- Plugged and plated via-in-pad used for chip scale package
- All components on the bottom layer

- Overall PCB dimensions (w x h): 7mm x 3.5mm
- Mutual button dimensions (w x h): 6mm x 3mm
MSP430FR2633 DSBGA design examples

- 4 copper layers, FR4 dielectric, 0.5mm overall PCB thickness
- Self and mutual capacitance buttons with varying geometries
- Plugged and plated via-in-pad used for chip scale package
- Enabled by industries highest resolution Capacitive touch: <10fF and up to 300pF range
- Optimized pin placement to ease mechanical design
CapTIvate FR2633-DSBGA demo video
Agenda

I.  HMI is changing

II. Driving innovation in 2017
   •  Introducing our small form factor capacitive touch solution in a die-size BGA

III. The development experience

IV. Get started today!
CapTIvate DSBGA: MSP430FR2633IYQWR

**Features & Benefits**
- Fully programmable with ULP MSP430 core
- IEC61000-4-x certified touch solutions for noise immunity
- Supports metal touch and glove friendly designs
- < 4 uA Wake on touch with 2 sensors
- Easily configure capacitive sensors with CapTIvate Design Center
- Touch library in ROM allows more application space in FRAM
- *Self and mutual capacitance in the same design – Up to 16 buttons*

**Target Applications**
- **Small appliance & power tools**
- **Factory automation:** Sensor designs
- **Personal electronics:** Virtual assistants, BT speakers, headsets, earbuds, shavers, toothbrushes, stylus

**Schedule**
Volume Production NOW!

**Tools & Collateral**
- CapTIvate Development Kit
- Touch Software Lib (ROM)
- CapTIvate Technology Guide
- *DSBGA Use Cases White Paper*
- *DSBGA in Smart Wearables*
- Code Composer Studio & IAR

**CapTIvate Design Center**

**Size**
2.3mm x 2.3mm

**Example Videos Coming Soon!**
CapTivate™ Touch MCUs

Learn about MSP430™ MCUs with CapTivate touch technology

MSP430™ MCUs with CapTivate touch technology make it easier to add capacitive touch capabilities to building, industrial and personal applications all at the world’s lowest power. CapTivate technology delivers the industry’s most noise-immune, IEC61000-4-6 certified capacitive sensing MCU-based solutions. With flexibility to support capacitive buttons, sliders, wheels, and proximity sensors as well as operation through thick glass, plastic and metal overlays, and in moist, dirty or greasy conditions, MCUs with CapTivate touch technology deliver sleek HMI options for any application.

Touch the Revolution with MSP MCUs featuring CapTivate™ technology

MSP MCUs with CapTivate technology are the most noise-immune capacitive touch microcontrollers, and the first to offer IEC61000-4-6 certified solutions. These FRAM-based MCUs offer support for metal touch, the industry’s highest resolution slide. Get started with the MSP CapTivate MCU Development Kit →
CapTIvate technology resources

Website: 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

Reference 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
Remote control

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
All the tools and support to get started today

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 development kit limited time promotion

Start your evaluation & design now!

50% off MSP-CAPT-FR2633 (CapTIvate Development Kit)

Only 50 kits will be offered at this discounted price for webinar attendees only so order now!

www.digikey.com/MSP430
Thank You!