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Touch Through Metal

mTouch™ Metal Over Capacitive Technology Part 1

Hello and welcome to Microchip's Touch Through Metal presentation, part 1.

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Introduction & Agenda

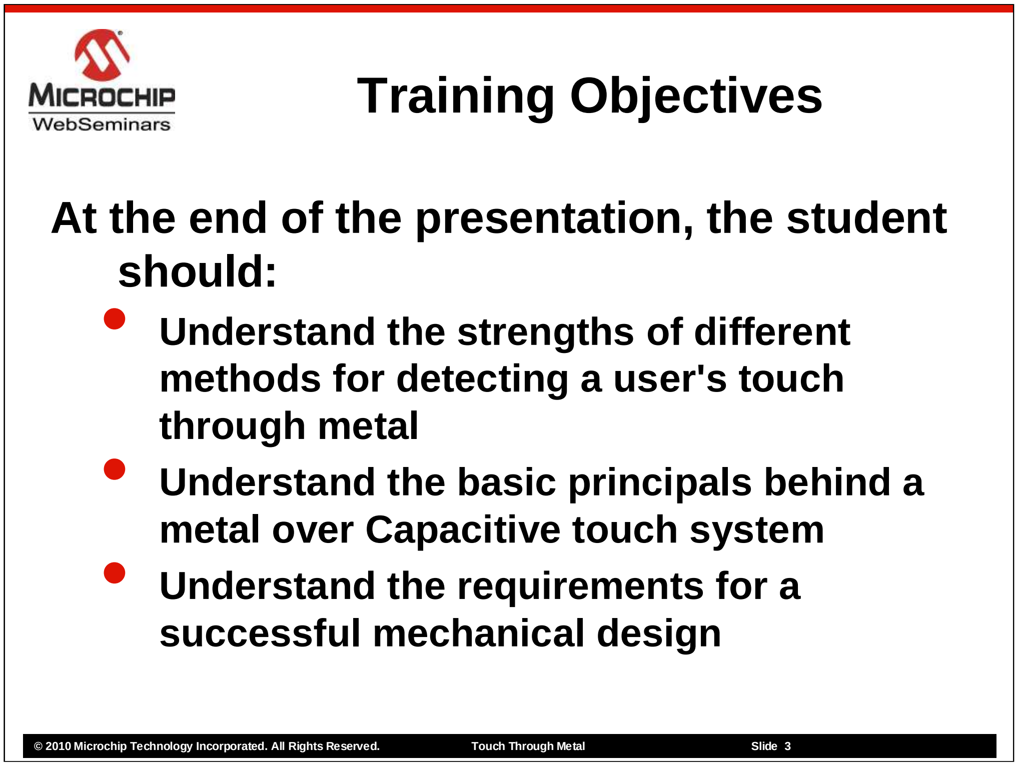
- Presenter
  - Keith Curtis Technical Staff Engineer
- Subject
  - Implementing capacitive touch through a metal cover
- Approximately 25 minutes
- This presentation is an introduction to metal over capacitive
- This presentation includes the mechanical design section

My name is Keith Curtis and I am a Technical Staff Engineer for Microchip.

Today we will be talking about implementing a capacitive touch system that operates through a metal cover.

We will be talking approximately 25 minutes about both the basic system overview and the requirements for a successful mechanical design.

Part 2 of the presentation will cover the electrical and firmware portion of the design.



Our first objective today will be explaining the various touch through metal technologies available today, and their strengths and their limitations.

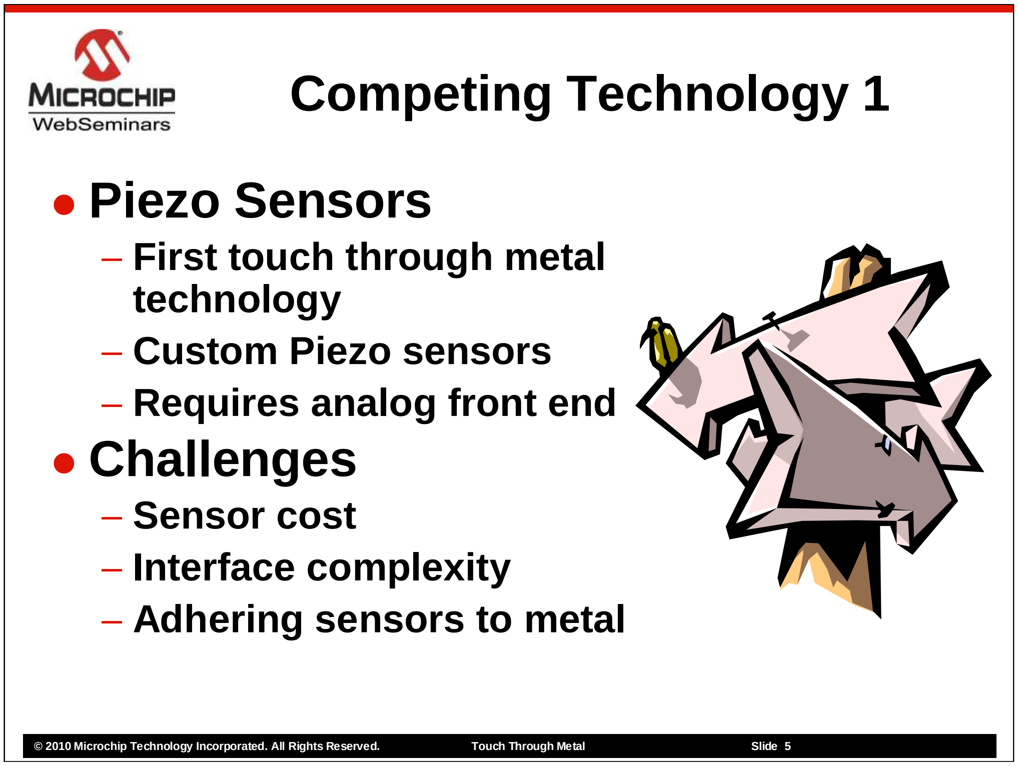
Next we will discuss the basic principals behind Microchip’s Metal over Capacitive touch system.

And, finally, we will discuss the requirements for a successful mechanical design.

The first question that is typically asked, is “why touch through metal?”

Well, there are several good reasons:

1. It is very easy to clean, making it a preferred interface option for both medical and food preparation.
2. It is sealed so dust, moisture, and chemicals are locked out of sensitive internal electronics.
3. The interface is very robust with both exceptional reliability and wear resistance.
4. The requirement for an actual actuation force, rather than just the presence of the user’s finger, opens up the interface for gloves, fingernails, and a stylus for actuation the button.
   This also allows the system to be used in Braille applications for visually impaired users.
5. Finally, the stylish look and feel of a metal finish for the user interface is visually appealing to customers.



OK, so touch through metal has several advantages, but aren't there other technologies that accomplish the same thing?

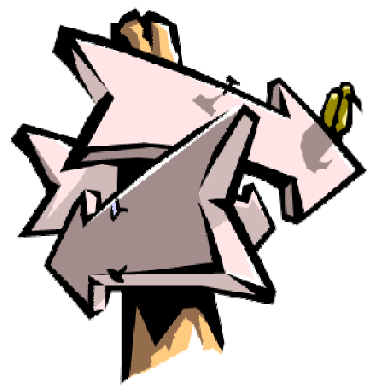
Yes, there are couple of alternatives. One is Piezo sensors which mount behind the front panel. These sensors generate a positive pulse when the sensor is flexed by the user's press, and a negative pulse when released.

While these were the first sensors designed to work through metal, they do have some limitations and challenges in their implementation:

1. The sensor cost is significant.
2. The analog circuitry to monitor the sensors is complex.
3. Adhesion of the sensors to the metal cover requires a special adhesive.
4. The sensors do not provide steady state information on the press of the sensor.

Competing Technology 2

- **Inductive Touch**
  - Second touch through metal technology
  - Simple spiral inductor sensors
  - Requires analog front end
- **Challenges**
  - Current consumption
  - Interface complexity
  - Mechanical design



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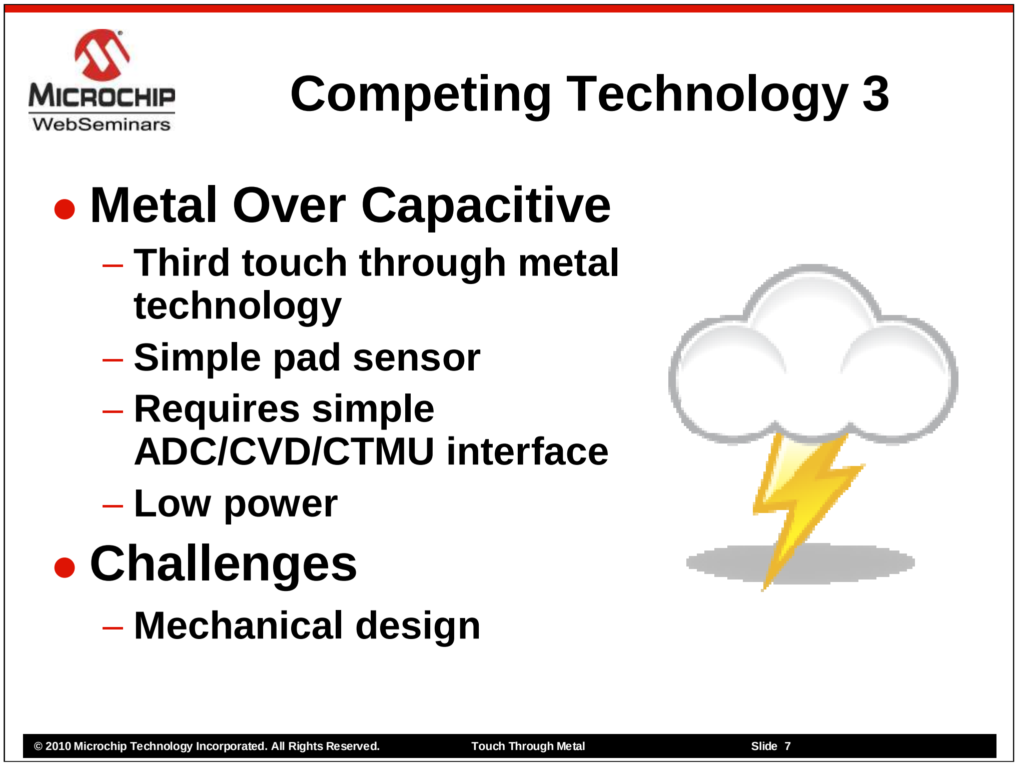
The next alternative is Microchip's inductive touch technology. This technology uses an inductive coil sensor behind the metal cover, sensing then the spacing between the cover and the coil changes due to deflection from a user's press.

It does have an advantage over the Piezo system in that the sensors are significantly less expensive than the Piezo system. It also provides a steady state indication of the deflection in the metal cover.

However, the system still requires a fairly complex analog front end and special adhesives to bond the sensor PCB to the metal cover.

In addition, the sensing circuitry does draw 10s of milli amps to sense the movement of the metal cover.



Microchip's Metal over Capacitive actually requires very little in the way of interface electronics, requiring only an ADC or CTMU to perform the actual conversion on the sensor.

The sensor design is just a button shaped pad suspended below the metal cover, and the power requirements are only minimally higher than a traditional capacitive touch system.

The system does require careful mechanical design to achieve low button press pressures; however, the design is not any more complex than the Piezo or Inductive touch system.

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Theory of Operation

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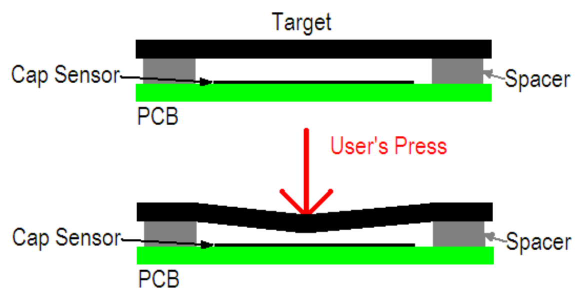
Let’s talk now about the actual operation of the metal over capacitive touch system.

Theory of Operation

- **User presses on fascia causing deformation**
- **Target moves toward sensor**
- **Closer target increases capacitance**



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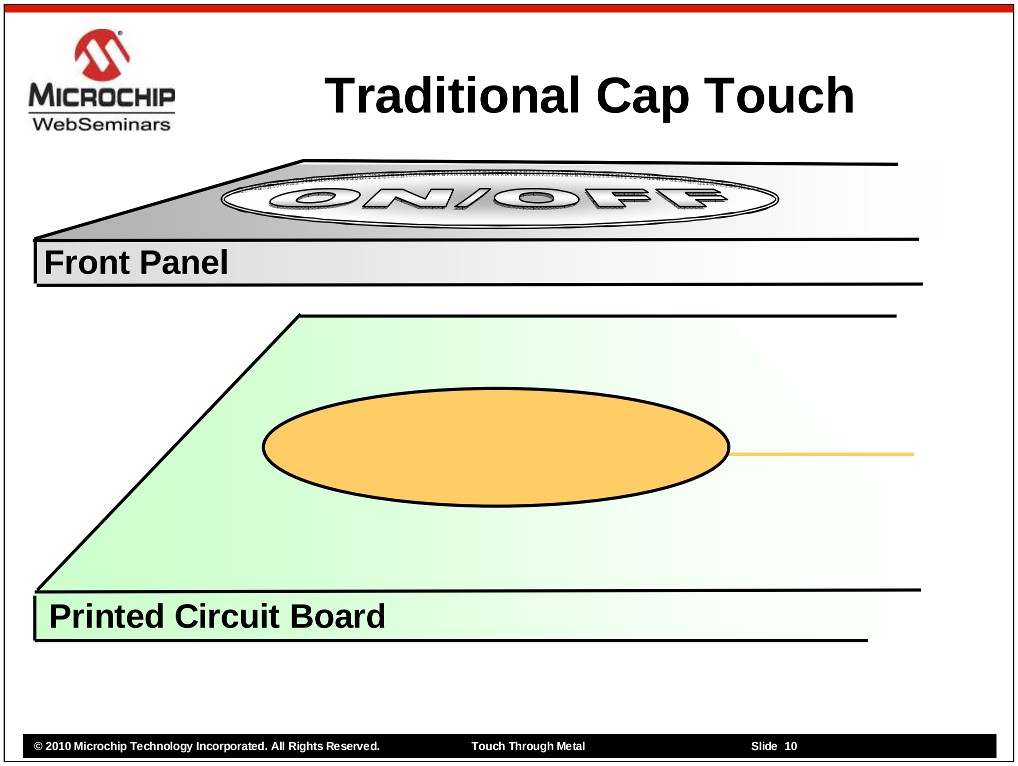
A metal over capacitive system uses the basic equation for capacitance, C = e0 er Area / distance.

When the user presses on the target or cover, distance between the two plates of the capacitor is decreased, resulting in a net increase in capacitance.

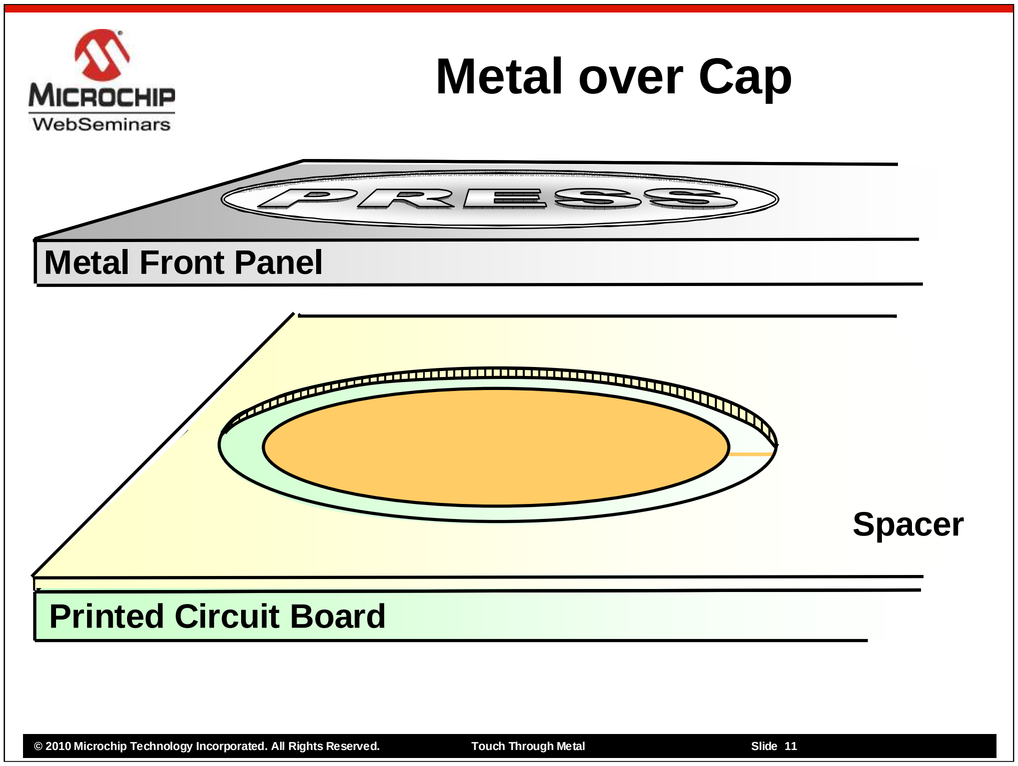
By careful mechanical design, we can set the actuation force by specifying the thickness and elasticity of the cover material.

This combined with the spacing between the PCB and the target will determine the unpressed and pressed capacitance of the system.



In a traditional touch system, the sensor is a simple pad on the top surface of the PCB.

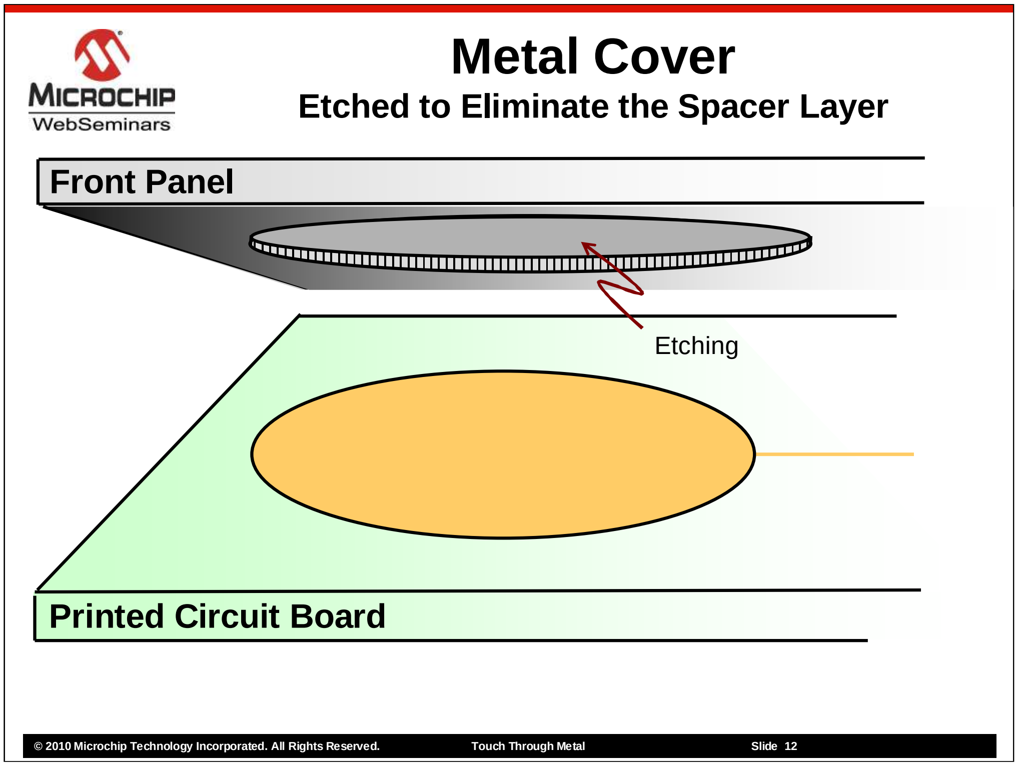
An insulating cover is then place over the pad to provide protection and a mounting surface for the interface markings.



In a Metal over Capacitive system, the front cover is metal instead of glass or plastic, and a spacer layer is introduced to suspend the sensor below the front panel.

This spacer is on the order of 3-5 mils thick and is typically built from an insulating material.

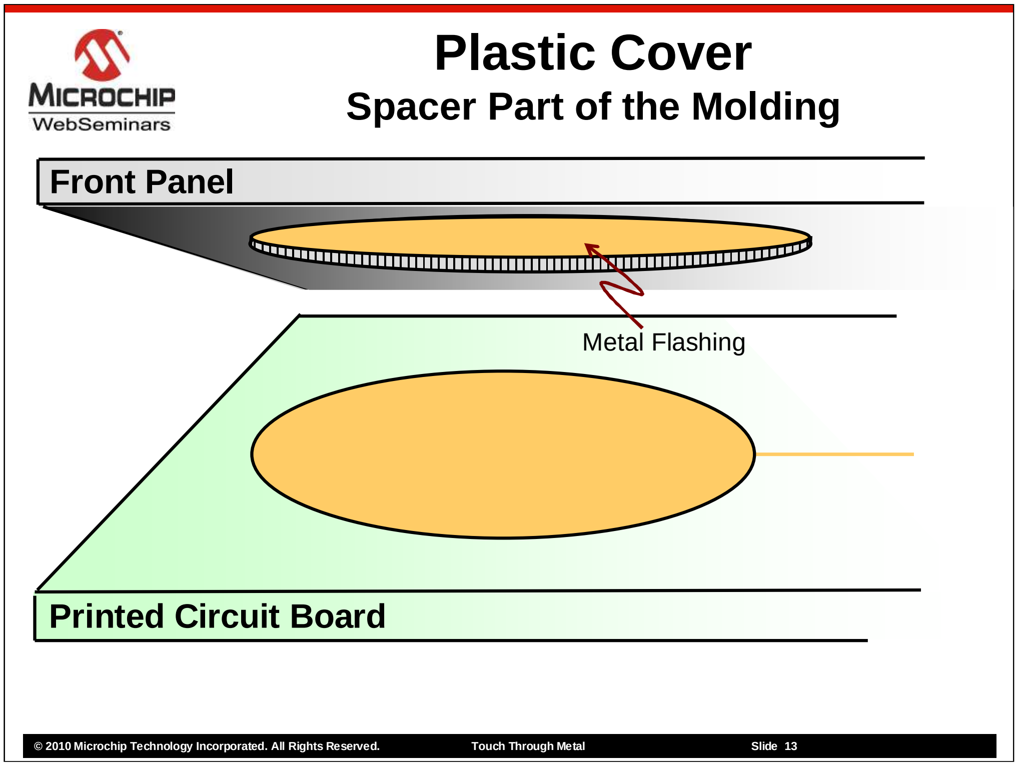
All three layers are bonded together using an adhesive.



An alternative design is to back etch the metal cover, creating a hollow of sufficient depth to provide the spacing between the sensor and the metal cover.

This is particularly useful in designs that have overly thick metal covers with insufficient elasticity to allow sufficient deflection in response to the customer's press.

This also simplifies the assembly of the system by eliminating the spacer layer and one glue joint.



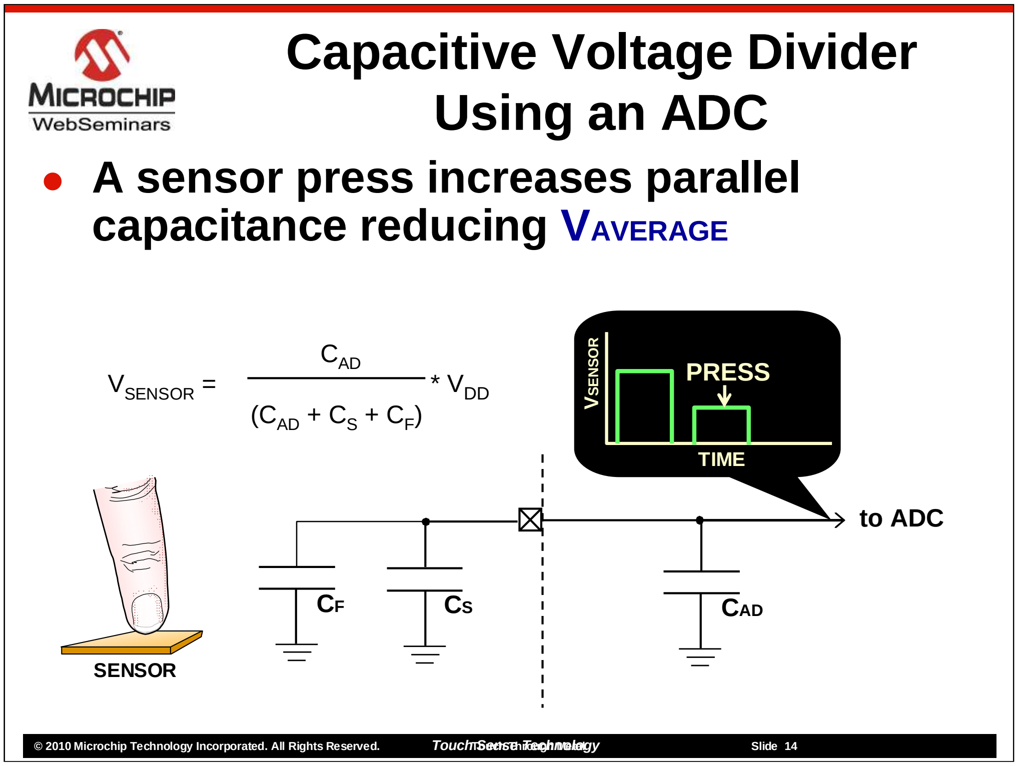
A third option is to use a plastic cover, with an etched back hollow or spacer layer, and a metal flashing on the underside of the plastic cover.

This does present a challenge in that the metal flashing must be grounded for the system to operate.

If the flashing is not grounded, then the system is just a simple capacitive touch system.

While the flashing on the plastic cover can be extended to make contact with the system ground, there is an alternative construction that gets around the problem.

Simply divide the sensor pad on the PCB in half and ground one side. Now the flashing on the plastic cover provides a capacitive connection between the sensor and the sensor ground.



To measure the capacitance of the sensor, we use the capacitive voltage divider or CVD system.

This involves charging the sample/hold capacitance of the ADC input to a known voltage, discharging the unknown capacitance of the sensor to zero volts, and then connecting the sample/hold capacitance and the sensor. The resulting voltage across the total capacitance (both sensor and Sample/hold) is then converted into a digital value by the ADC.

Any shifts in the capacitance of the sensor will result in a shift in the resulting ADC conversion value that the software can evaluate to determine a user's touch.

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The Mechanical Design

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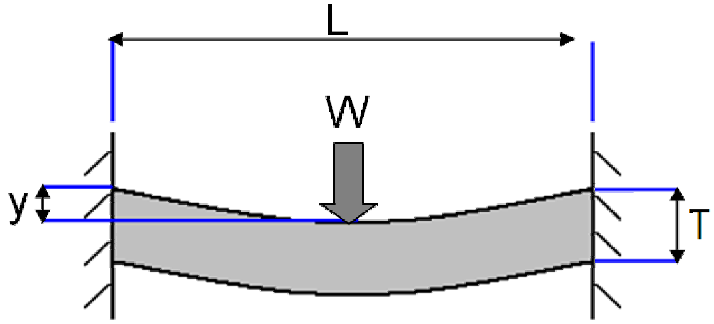
As we mentioned earlier, this first presentation will also include the requirements for a successful mechanical design for a metal over capacitice touch system.

Mechanical Deflection



Second Moment of Area (I) = (L x T³)/12

Deflection (D) = (W x L³ x K1)/(192 x E x I)

Young's Modulus (E)		Etching Factor K1	
Stainless	2.0×10^{11}	No Etch	1.225
Aluminum	7.0×10^{10}	Spiral	3.370
Mild Steel	2.1×10^{11}	Showerhead	22.000
Polycarbonate	2.8×10^{9}	Pattern (33% skin thickness)	3.550
ABS plastic	2.4×10^{9}		

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A metal over capacitive touch system relies on the sufficient deflection of the cover material to cause a measurable shift in capacitance.

Typically the deviation must be a minimum of 5 microns for accurate touch detection.

To create a button with the right actuation force, it is necessary to understand the physics behind the deflection of the cover.

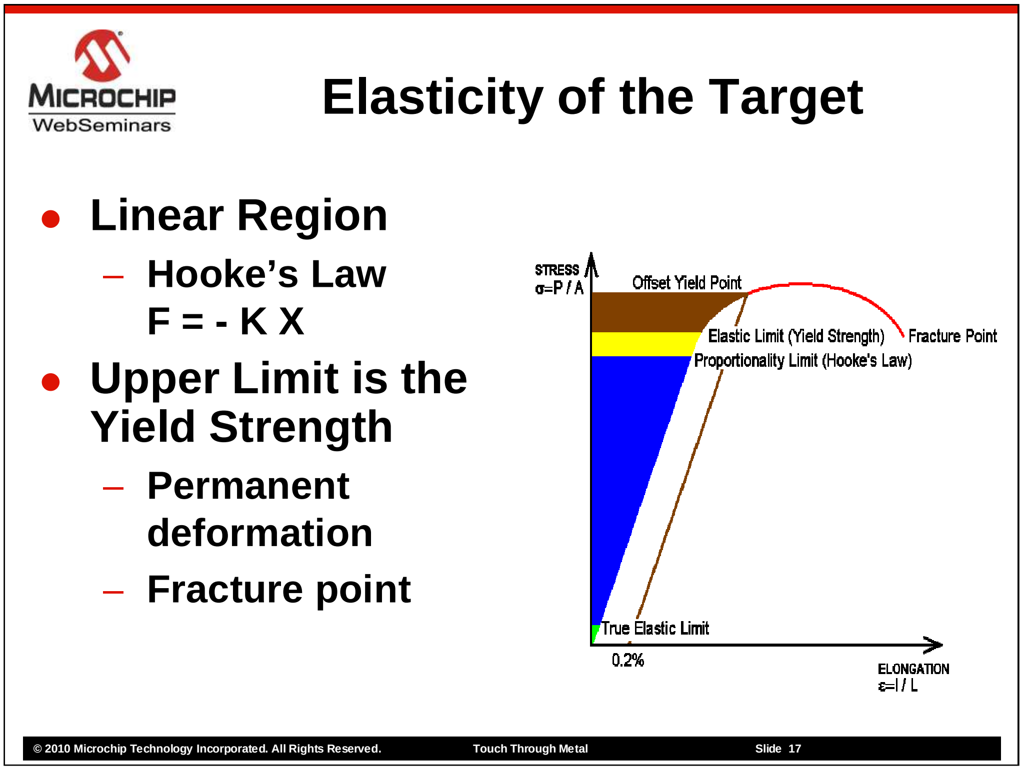
If we consider a circular section of the metal cover, which is the diameter of the opening spacer layer, we can model the deflection using the equations shown here.

The amount of force required to create a deflection of 5 microns is determined by:

1. The dimensions of the plate, both the diameter L and the thickness T
2. The Young's modulus of the material
3. And, any etching on the backside of the plate.

The first value is the second moment of area, which is determined by the physical size and shape of the cover.

The second value is the actual deflection in response to touch pressure by the user. This is determined by the Second Moment of are, the Young's modulus of the material, back etching and a proportionality constant of 192, which is determined by the shape of the section. 192 is the constant for a circular section and is the only practical shape for a simple analysis.

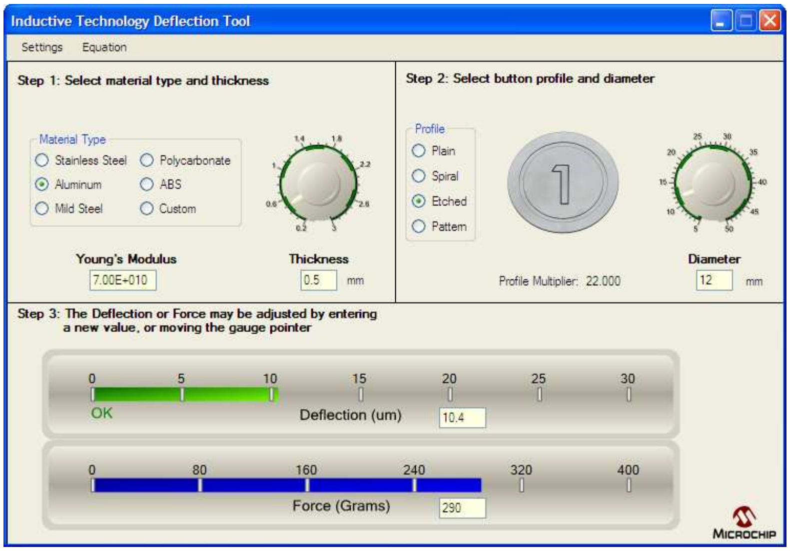


This graph shows the different regions of force versus displacement for the target/fascia of an inductive touch interface. Note that the blue region is elastic, i.e. a displacement will spring back to its original state, but if you exceed the yield strength the material will be permanently deformed.

What this means for a design is that both the yield strength and Young's modulus should be considered in a design. The elasticity of the material is important to determine the sensitivity of the design, but the yield strength will determine the maximum force that can be exerted on the sensor.

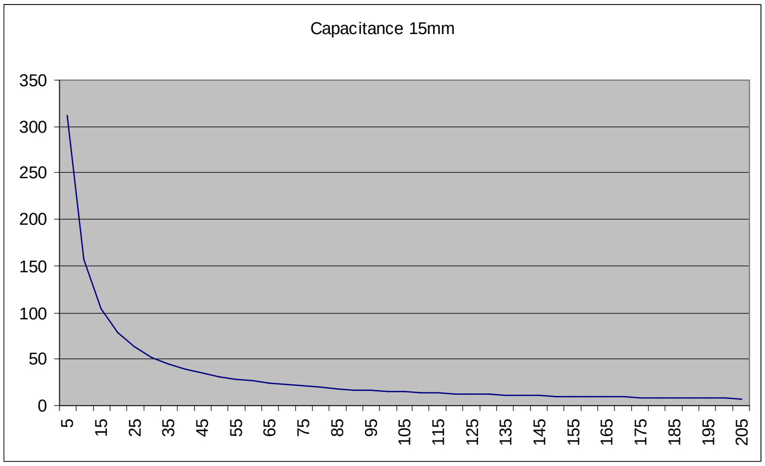
So it is important that mechanical design is involved early in the design so the appropriate metal can be chosen for the design.

Deflection Design Tool



15mm Sensor Versus Spacer Thickness

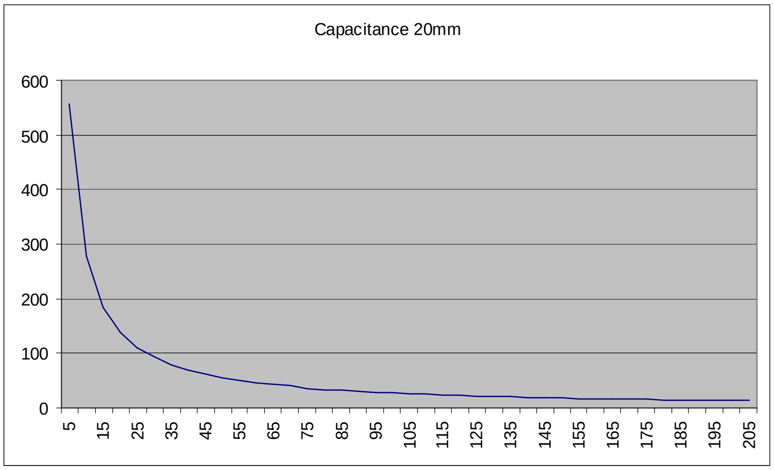
Capacitance in pF



Spacer Thickness in um

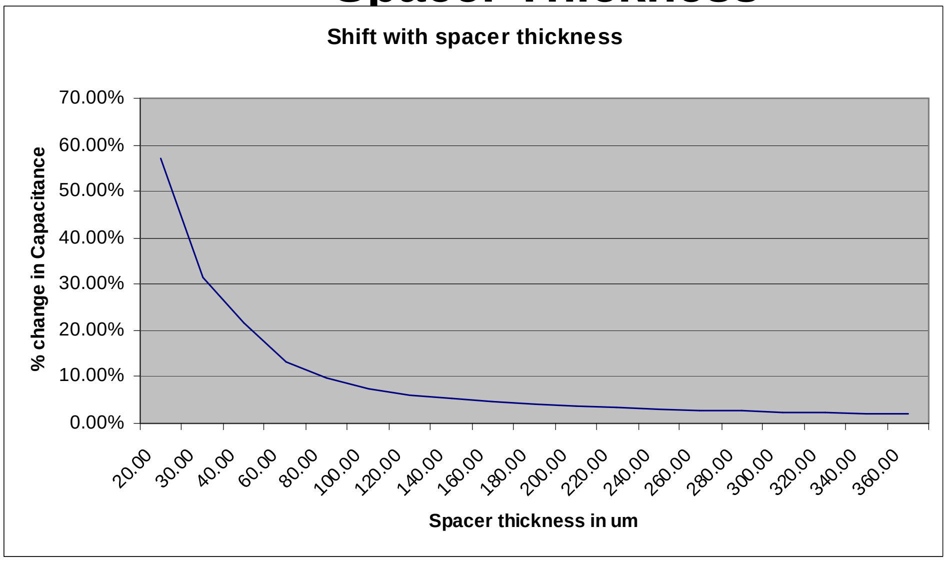
20mm Sensor Versus Spacer Thickness

Capacitance in pF



Spacer Thickness in um

15mm Sensor Shift Versus Spacer Thickness



What if not possible???

Continued in Part 2

- Implementing a capacitive touch through a metal cover hardware solution
- Implementing a capacitive touch through a metal cover software solution
- Handling noise considerations in the electrical and software design

Summary

- This presentation provided a general overview of metal over capacitive
- This presentation also covered the mechanical design of a metal over capacitive system
- This presentation is continued in the next metal over capacitive webinar
- Please provide feedback on this training session through Microchip's website

Where to Get More Information

- **Weblinks**
  - **mTouch™ Design Center www.microchip.com/mTouch**
- **Application Notes**
  - **AN1325 - mTouch Metal Over Cap Technology**
  - **AN1298 - Capacitive Touch Using Only an ADC (CVD)**

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