



HMI Sensors: The Next Frontier

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Qorvo
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qorvo[®]

all around you

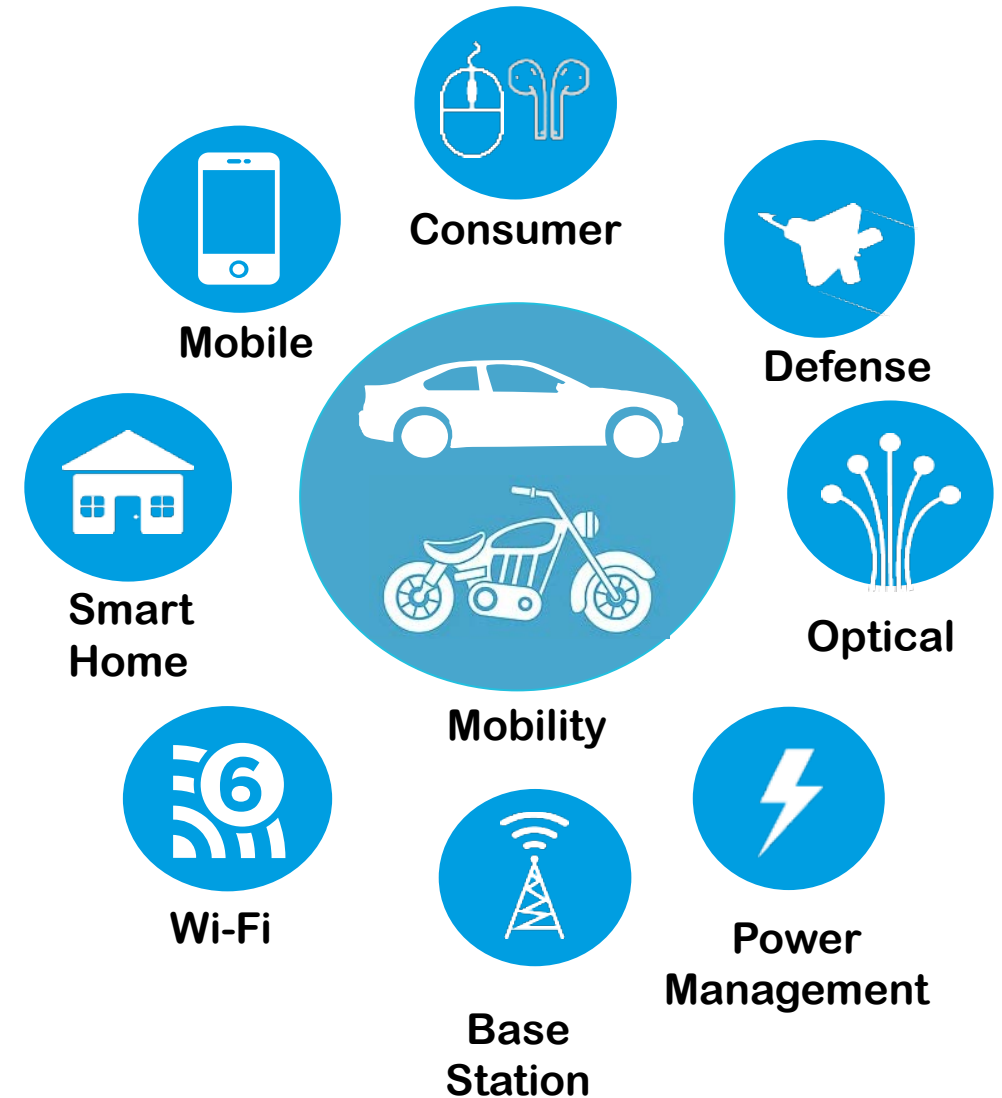


About Qorvo...

Diversified and Above-Market Growth

- Well established supplier in the wireless, wired, power and automotive market
- Strong technology leadership combined with high volume manufacturing capabilities
- 2015 merger of TriQuint & RF Micro Devices
- 2021 acquired: NextInput for HMI Sensors
- 2023 revenue: \$3.6 billion
- 8,500+ global employees
- An S&P 500 company – Nasdaq: QRVO
- Recognized by the Global Semiconductor Alliance (GSA) as the most respected public semiconductor company in 2022

Source: Industry reports and management estimates.



Our Global Footprint



**NextInput
=> SFBU**

- | | | | |
|----------------------|-----------------------------------|--------------------------|-------------------------|
| 1. Hillsboro, OR | 13. Farmers Branch, TX | 25. Zele, Belgium | 37. Taipei, Taiwan |
| 2. Bend, OR | 14. Richardson, TX | 26. Utrecht, Netherlands | 38. Zhubei City, Taiwan |
| 3. Plymouth, MN | 15. Greensboro, NC | 27. Norresundby, Denmark | 39. Zhongshan, China |
| 4. Waseca, MN | 16. Apopka, FL | 28. Nuremberg, Germany | 40. Shenzhen, China |
| 5. Hiawatha, IA | 17. Fort Lauderdale, FL | 29. Munich, Germany | 41. Hong Kong, China |
| 6. Princeton, NJ | 18. Heredia, Costa Rica | 30. Helsinki, Finland | 42. Hanoi, Vietnam |
| 7. Chelmsford, MA | 19. Dublin, Ireland | 31. Bangalore, India | 43. Ipoh, Malaysia |
| 8. Mountain View, CA | 20. Reading, United Kingdom | 32. Dezhou, China | 44. Singapore |
| 9. San Jose, CA | 21. Paris, France | 33. Beijing, China | 45. Biñan, Philippines |
| 10. Torrance, CA | 22. Colomiers, France | 34. Seoul, South Korea | |
| 11. Newbury Park, CA | 23. Toulouse, France | 35. Osaka, Japan | |
| 12. Chandler, AZ | 24. Nice/Sophia-Antipolis, France | 36. Shanghai, China | |

Agenda

Background of HMI Sensors

HMI Sensor Applications

Technical Details

Examples

Q&A





Background of HMI Sensors

Human-Machine Interface Sensors



First Market Driver – Apple’s Innovation (The Start)

Cap (Capacitive) Touch or Force Touch by Apple

iPhone 6s first featuring Force Touch Technology



- Requires a solid back plate to host the capacitive sensing array
- Sensitivity changes significantly if structure deforms
- High manufacturing cost



Capacitive sensors in iPhone 6s



Qorvo's HMI Sensor Solution (The Next)

Force Sensor by Qorvo (for Blackshark Gaming Phone)



Capacitive sensor array in iPhone 6s

- Requires a solid back plate
- Sensitivity changes after deformation
- High manufacturing cost



Improvements:

- Flexible design
- Less changes when deformed
- Less costly





HMI Sensors Applications

Smart Phone/Watch, TWS, Automotive etc.



Benefits of the Force Sensing in HMI

Comparing to Mechanical Buttons / Capacitive Sensors

Limit false touches:

- Limiting false touch with customizable multiple force levels
Example: Smart phones/watches, Smart screen on cars
- When you cannot see it, you must apply some force
Example: TWS earbuds

Allow seamless interface:

- Sense through gapless metal
Example: headphones, earbuds
- Sense glove or in any watery environments
Example: screen on motorcycles/cars

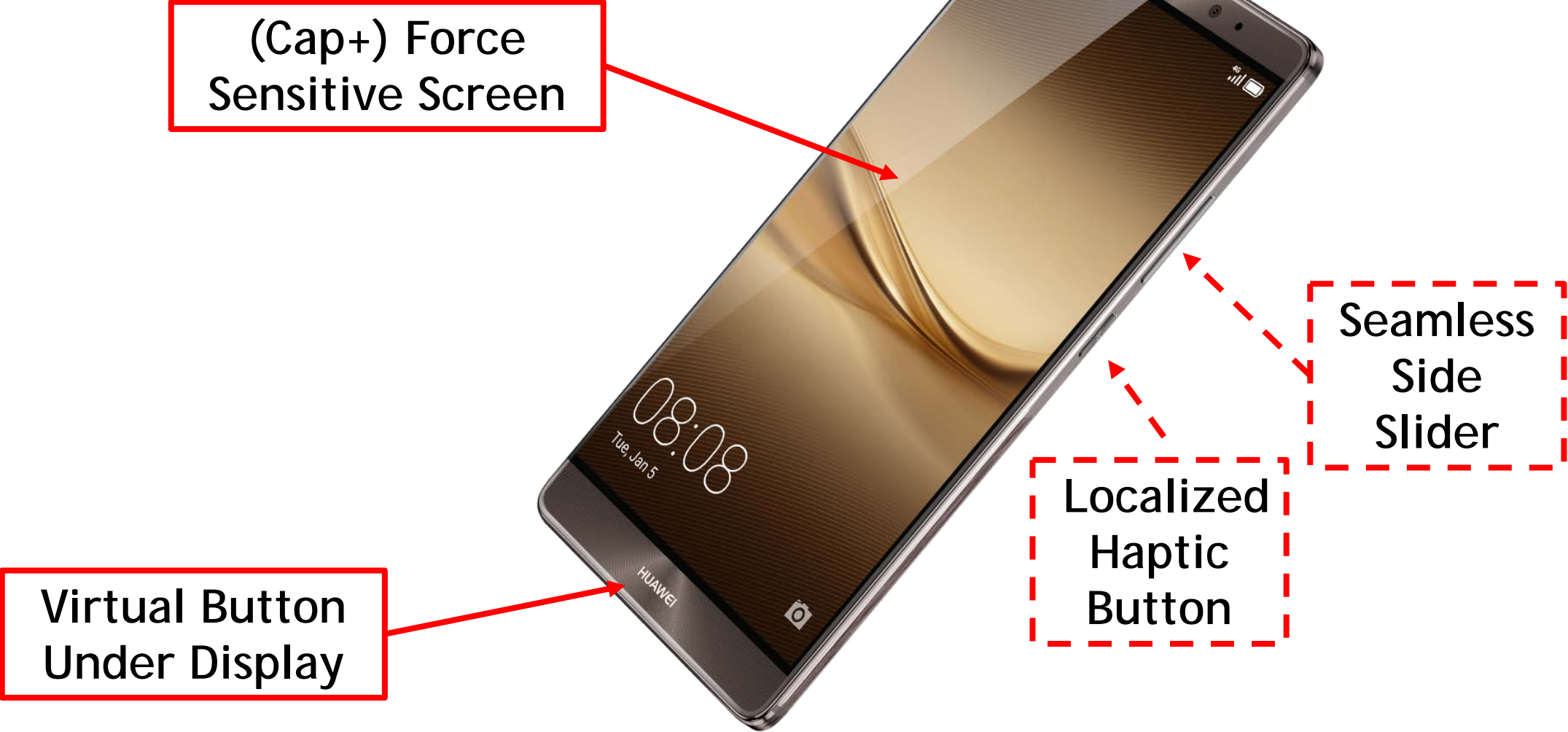
Add additional user interface:

- Adding “select” feature to a touch screen
Example: any touch screen in phones/cars
- Deep press, half press slider (PoC for now)t
Example: Smart screen on cars, headphones



Smart Phone Applications

Force Sensor by Qorvo



Consumer, TWS and Automotive Applications

Force Sensor by Qorvo (Products in Production)

Fitbit Sense/Versa 3
Charge 6



Various TWS
(True Wireless Stereo)



Latest Tesla Model S/X and Other Car Models:



Qorvo Sensor Fusion Solutions

Enabling Innovative Human Machine Interface Solutions

CMOS + PZR MEMS sensors

- Highest sensitivity (up to 200 gauge-factor)
- Smallest size (1.77mm², down to 0.9mm²)
- Lowest power (<10uA operating)
- Multi level actuations



Enabling new human machine interface capabilities

- Any material, shape, thickness (plastic, steel, wood)
- Any input method (finger, glove, stylus)
- Any environment (hot/cold, wet, dirty, grime)





Technical Details

Hardware, Software and System Integration



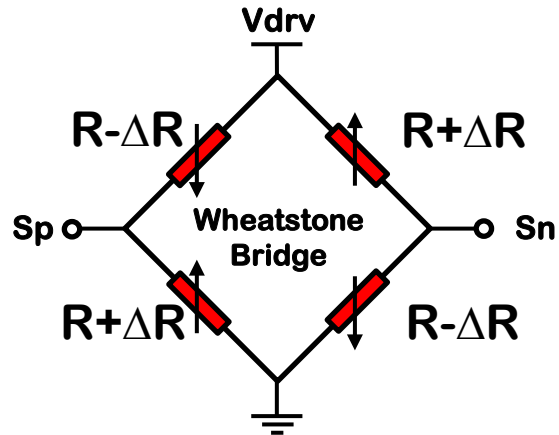
Force Sensor Mechanism – PZR Transducer

Differential Wheatstone Bridge

Keep features:

- Piezoresistive elements formed by Boron implant
- Inherent common mode rejection/temperature compensation
- Robust sensing technology

Representative Circuit:



$$S_p = \frac{R + \Delta R}{2R} V_{drv}$$

$$S_n = \frac{R - \Delta R}{2R} V_{drv}$$

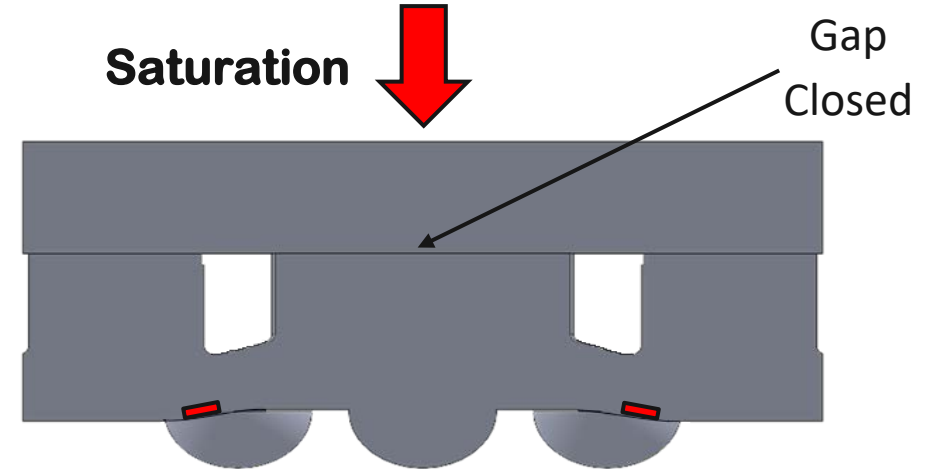
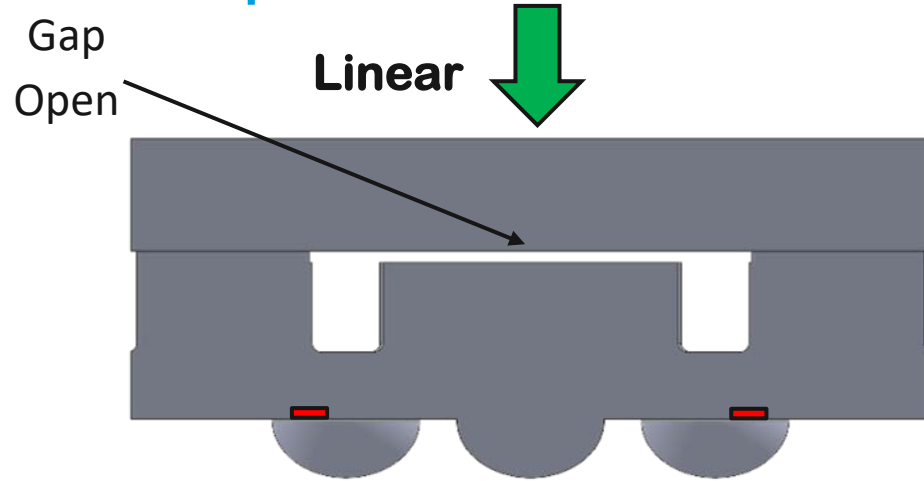


$$S_p - S_n = S_v = \frac{\Delta R}{R} V_{drv}$$

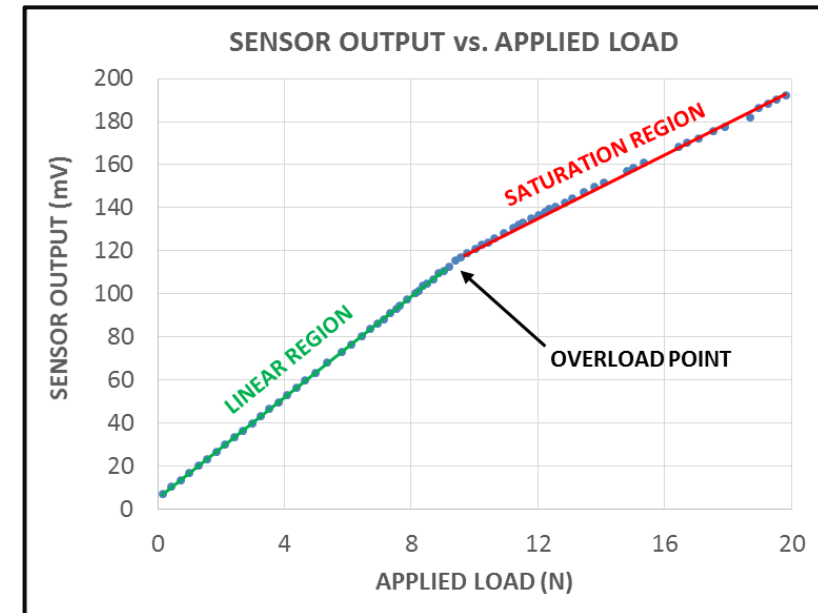


Preloaded Force Sensor (1st Category) Output

Vertical Compression



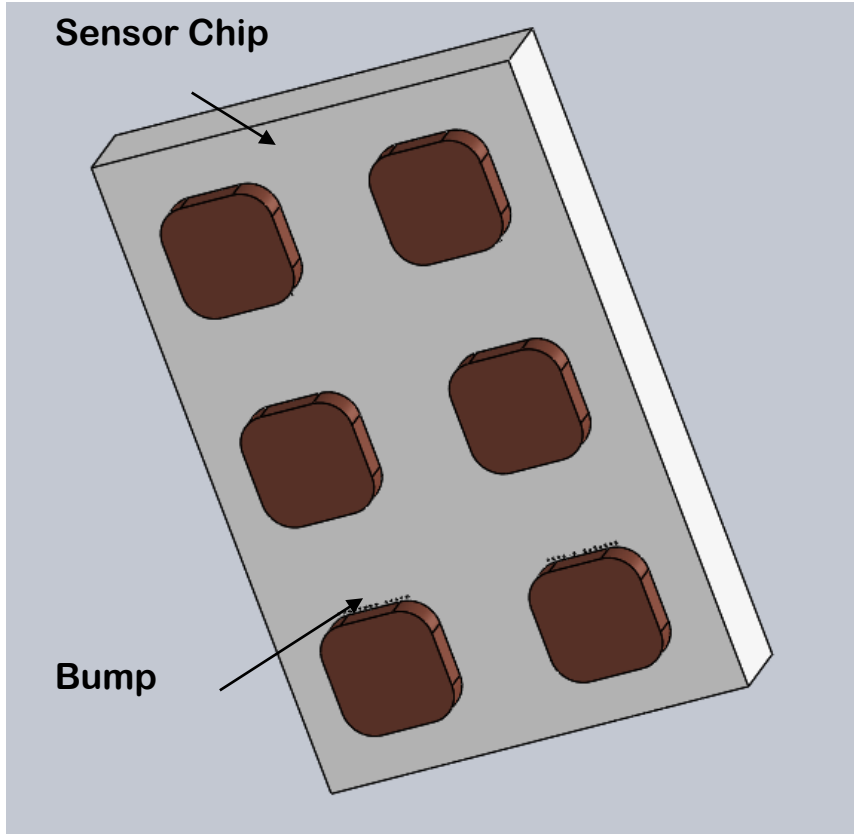
- **Linear Sensitivity:** 3.6 mV/V/N
- **Saturated Sensitivity:** 2.3 mV/V/N
- **Linearity:** 0.99+
- **Range:** 10 N
- **Bias:** 1 - 3.63 V



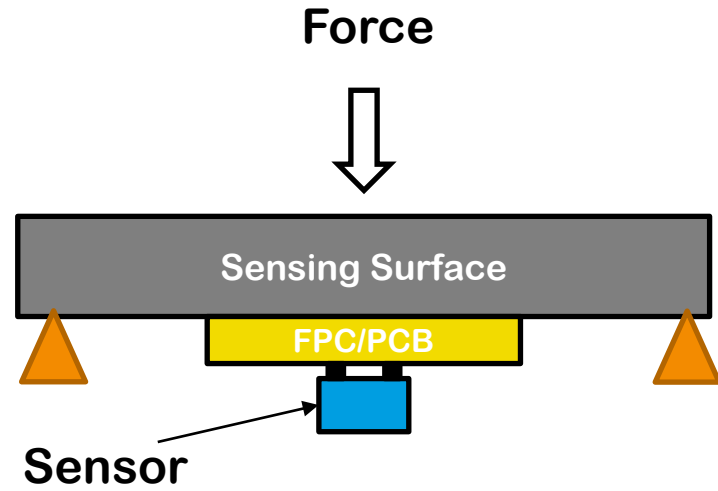
Suspended Sensor (2nd Category)

Bending

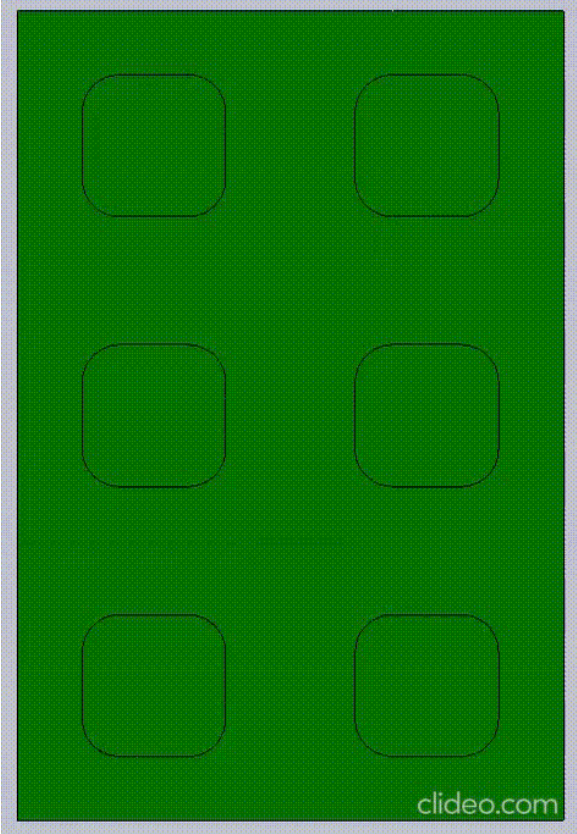
Sensor Structure



Application Example

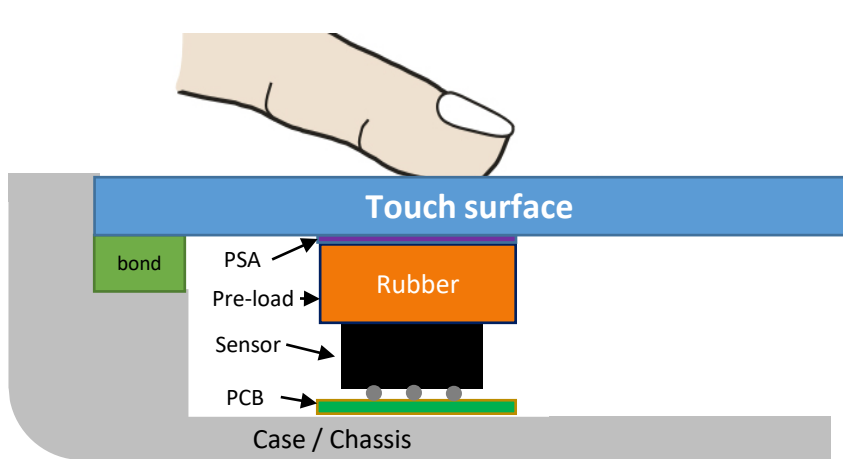


Stress Distribution

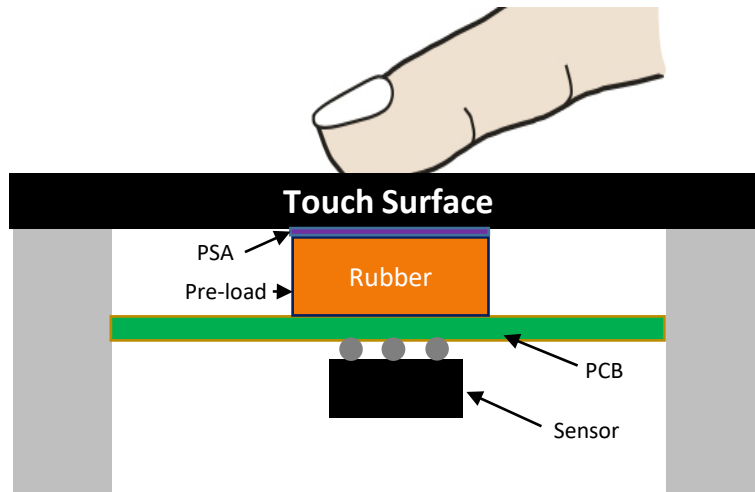


MEMS Force Sensor Families & Stack-up

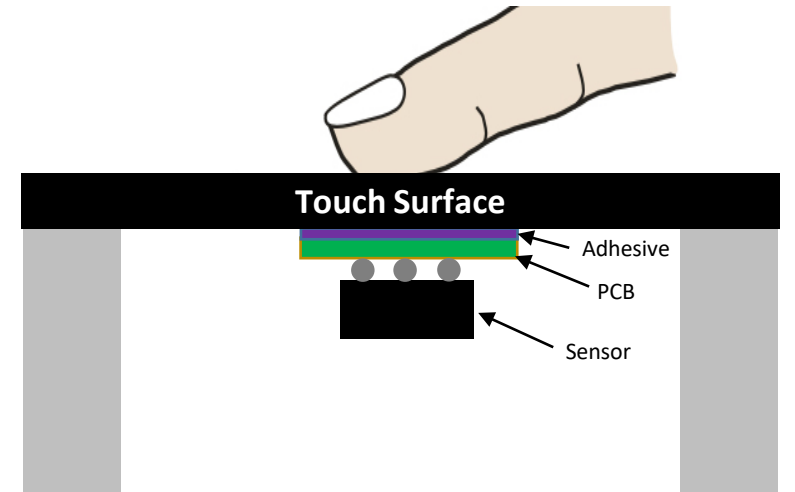
Flexibility to Meet Sensitivity & Manufacturing Needs of Any Application



Pre-Loaded
(Requires contact on both sides)



Pseudo Pre-Loaded
(Contact on one side)



Suspended
(Contact on one side)

Vertical Compression

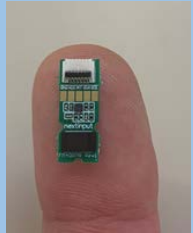
Bending



Enablement Tools

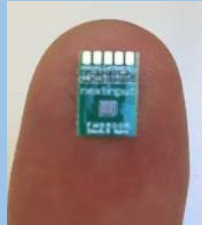
Dev-Kits, GUI, Drivers (Software)

MEMS Force

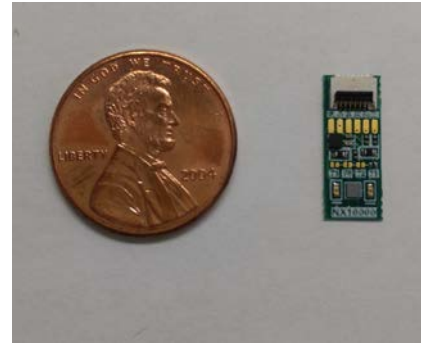


FT-4100PCK

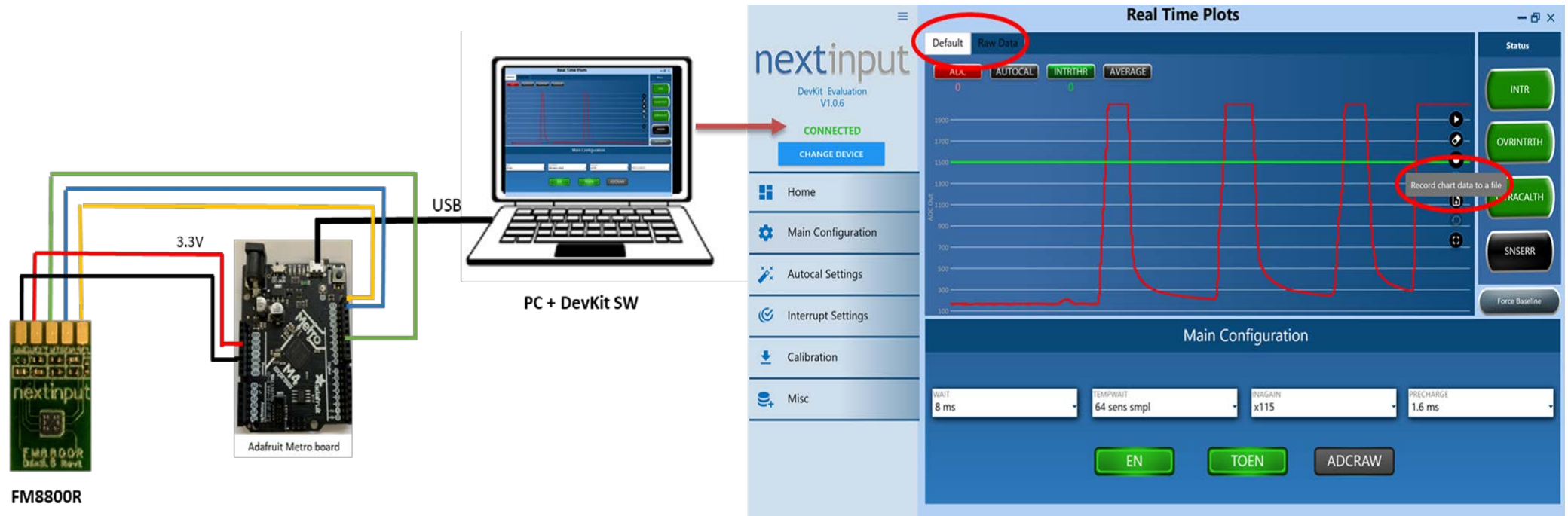
Integrated



DF-8800PCK



NX-10500PCK



Simple Demo with a Brick & the Dev Kit

https://www.youtube.com/embed/IL2_OAJXzDY?feature=oembed&skip_registered_account_check=true



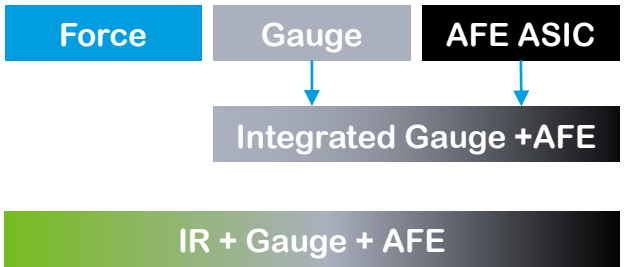
Sensing Solutions

Comprehensive Support to Enable Customer Success

Silicon Sensors



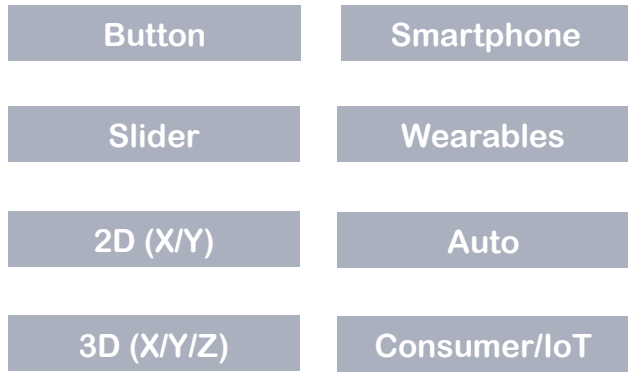
Discrete, integrated, and hybrid sensors



Software



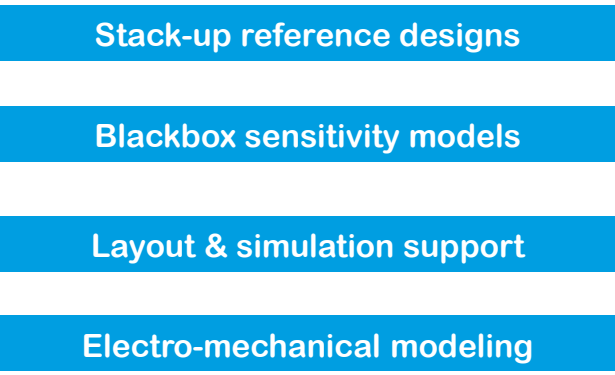
Drivers & algos that run on host MCU



System Integration



Design examples, service, & support



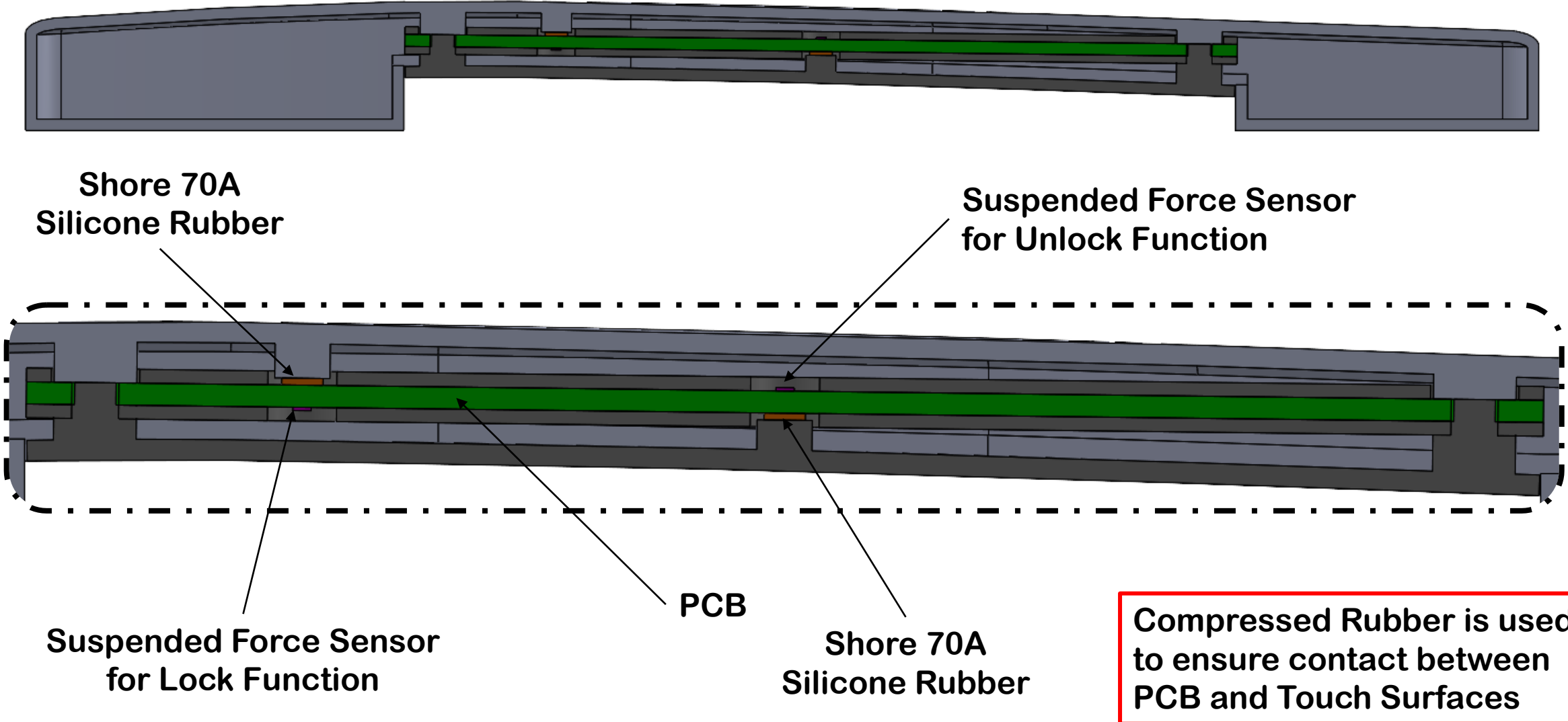
HMI Sensor Examples & Demos

With or Without Capacitive Touch Sensors



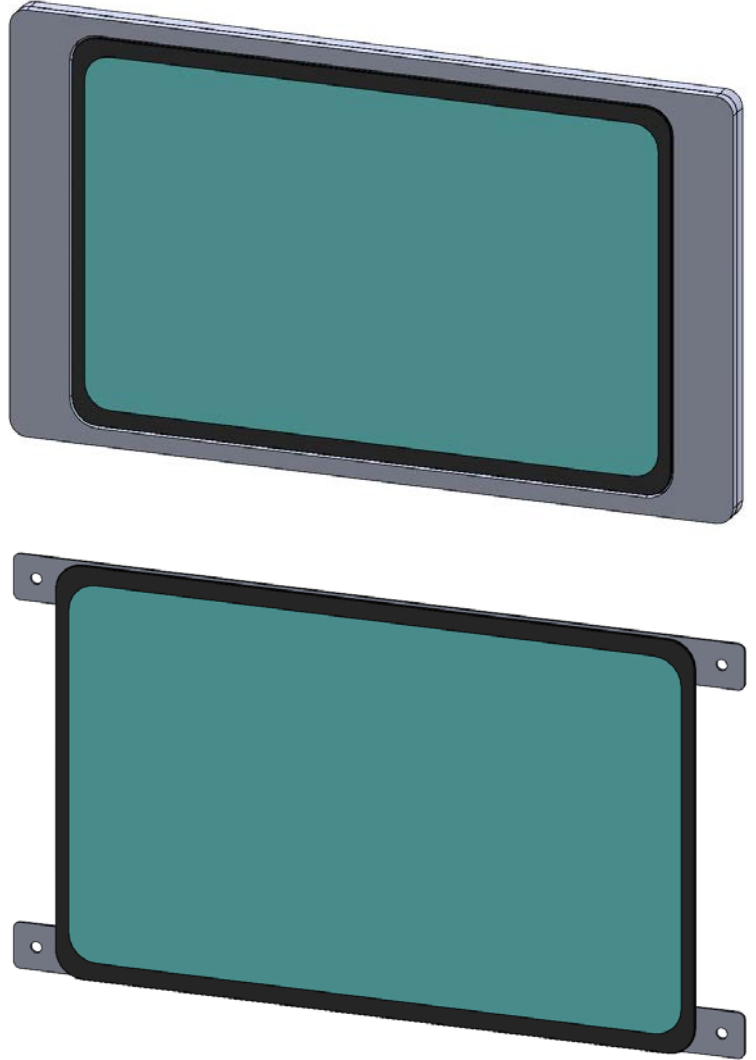
Door Handle – Force Sensor Only (Section View)

Plastic Housing



Capacitive + Force Bracket Floating Concept

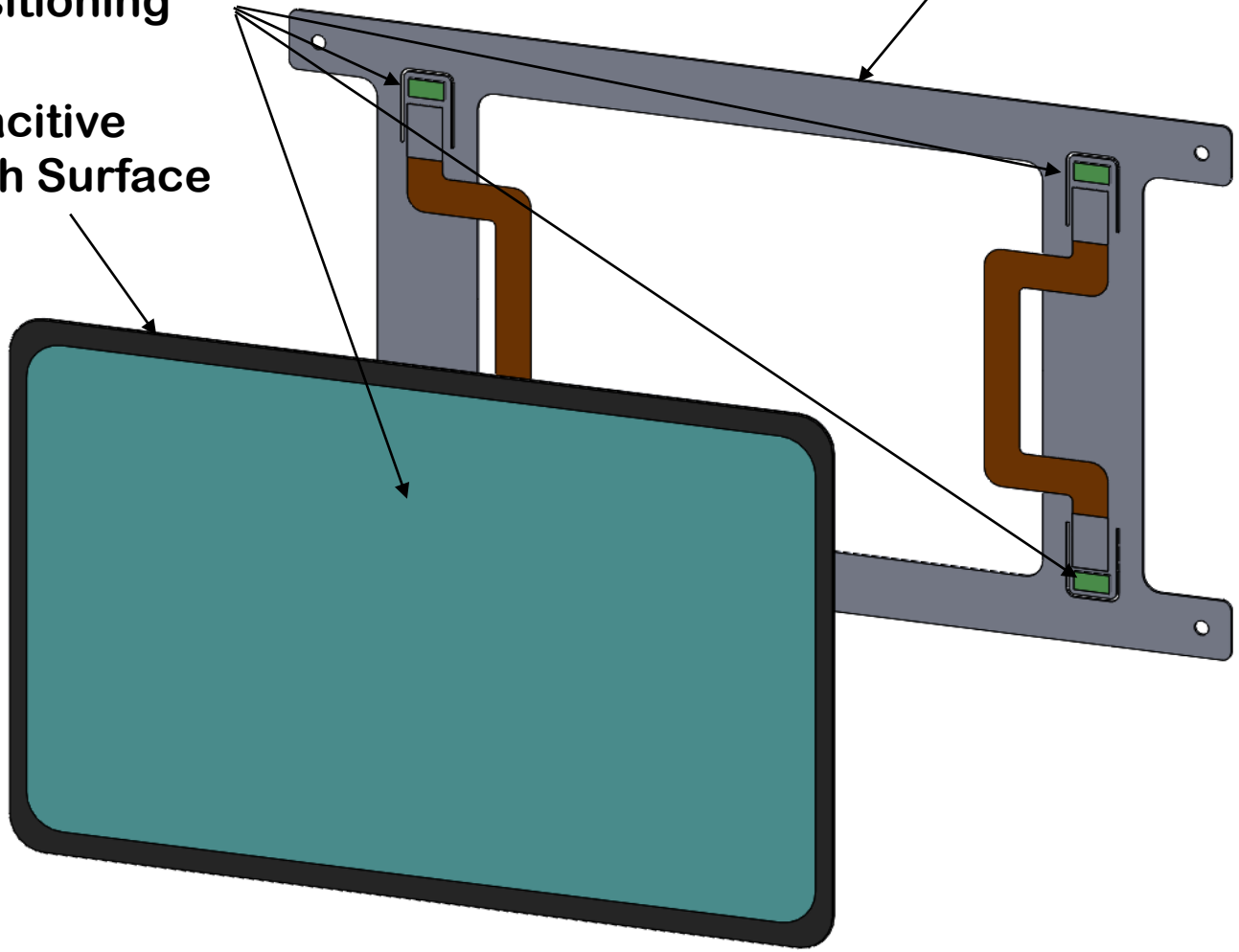
Bracket Module



Pre-loaded Force Sensor for Positioning

Sensor Bracket Module

Capacitive Touch Surface



Qorvo SFBU Experience/Demo Center

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Q&A

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Thank You



qorvo
all around you