

## *TIDA-00506 TI Design Test Data*

### *Automotive Kick-To-Open Testing with FDC1004*

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#### **Abstract**

The following report details the procedures and results for testing the proximity sensitivity of the FDC1004EVM for a kick to open application within a plastic bumper. Testing also included exposure to mud and water to determine the impact of common environmental factors.

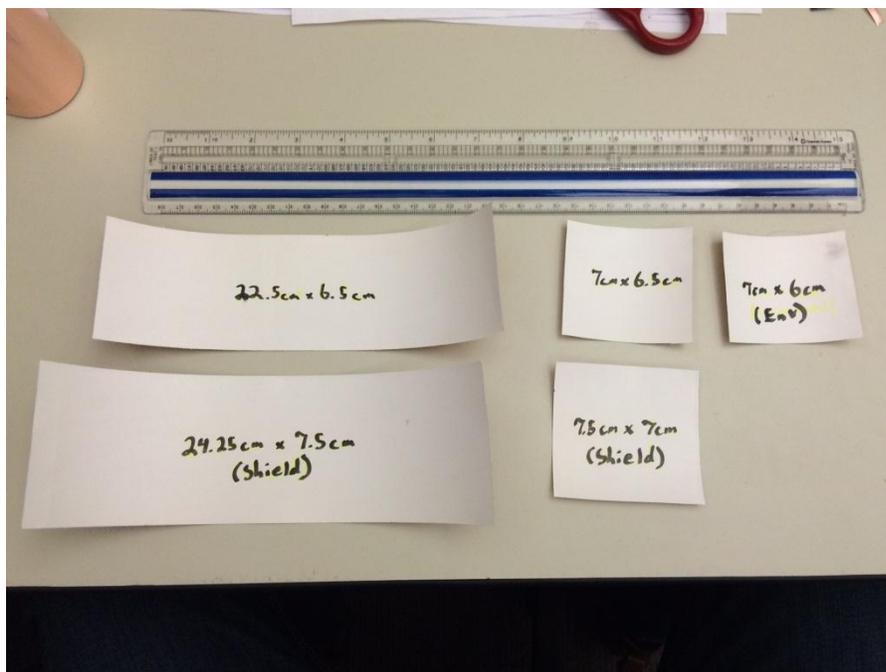
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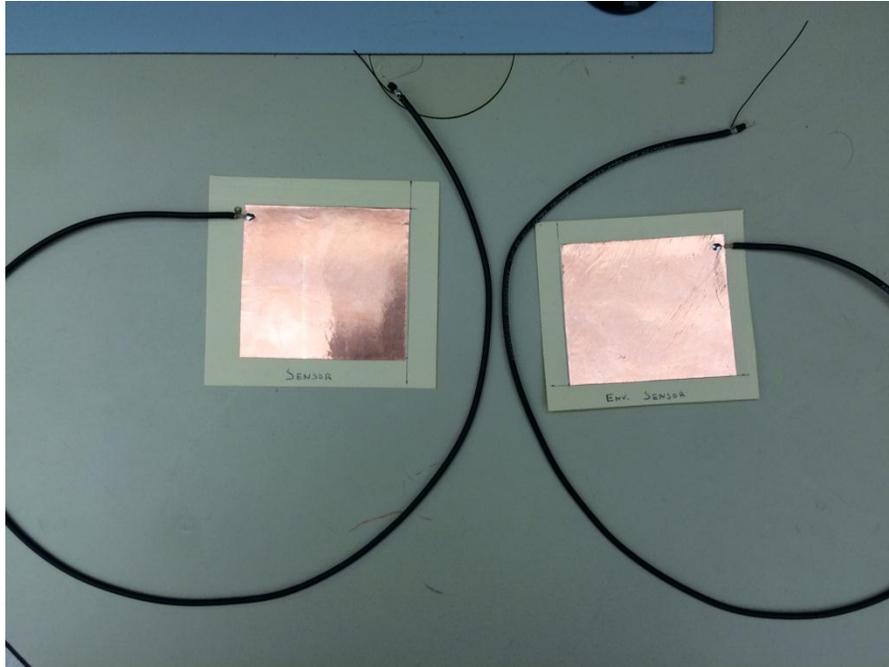
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#### **A. Sensor Dimensions**

To capture changes in capacitance only toward the rear of the vehicle, the sensors were designed to be directional with shielded backings that were slightly larger than the measured copper tape sensors. Two sensor sizes were tested – one 6.5cm x 22cm copper tape sensor, and one 6.5cm x 7cm copper tape sensor.



Each sensor is connected to the FDC1004EVM via 24 inches of RG-174 coaxial cable, with the outside conductor connected to the corresponding driven shield.

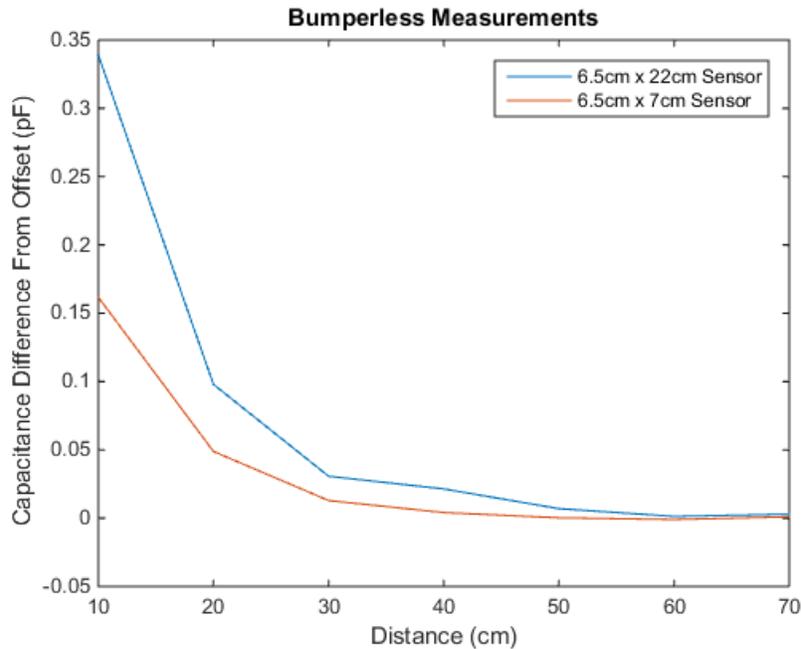


**B. Bumperless Testing**

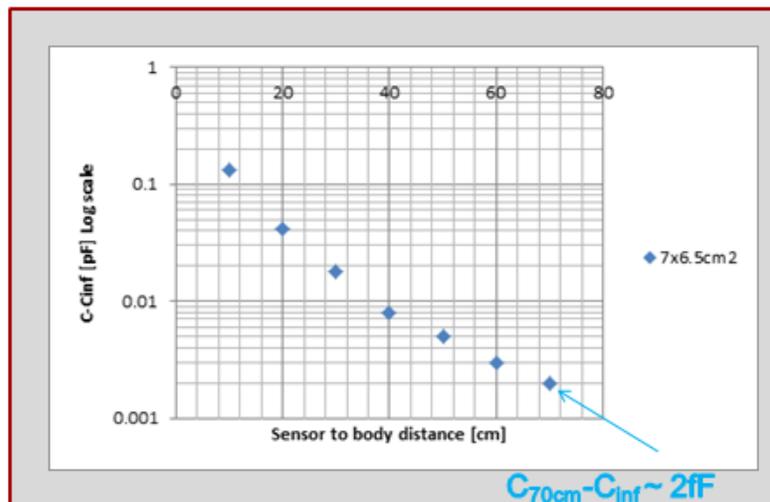
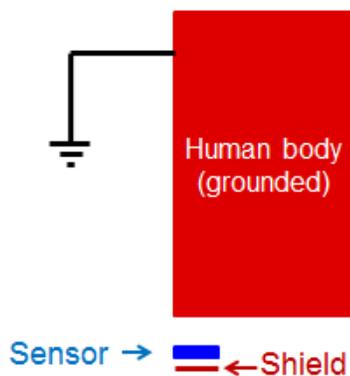
Initial measurements utilized bare directional sensors mounted perpendicular to the measured distances with no object introduced. This data was averaged to create an offset for each respective sensor in the bumperless measurements figured below.



For the following data, the arm of a non-grounded test subject laid parallel to the mounted directional sensors while multiple measurements were recorded with a 400Sps measurement rate and 100ms sampling rate in the FDC1004EVM GUI. Below demonstrates the averages of each capture with an object introduced minus the offset, starting at 10cm distance and continuing to 70cm in 10cm increments. For a simple interpretation of the following data, the slope of the line will correlate to detection sensitivity. In the following measurements without a bumper, the larger 6.5cm x 22cm sensor will more easily detect an approaching object than the smaller 6.5cm x 7cm sensor.



The small 6.5cm x 7cm sensor size was chosen to match that of a similar dataset captured with a grounded human body for comparison. Original results are pictured below.



**C. Bumper Sensor Placement**

The copper tape sensors were mounted with masking tape to the interior of an approximately 3cm thick Toyota Corolla aftermarket plastic bumper, adjacent to the license plate mount.



**D. Water Introduction**

For testing the effects of water on the exterior of the bumper, similar measurements were capture after having tap water evenly misted across the surface of the bumper using a spray bottle.



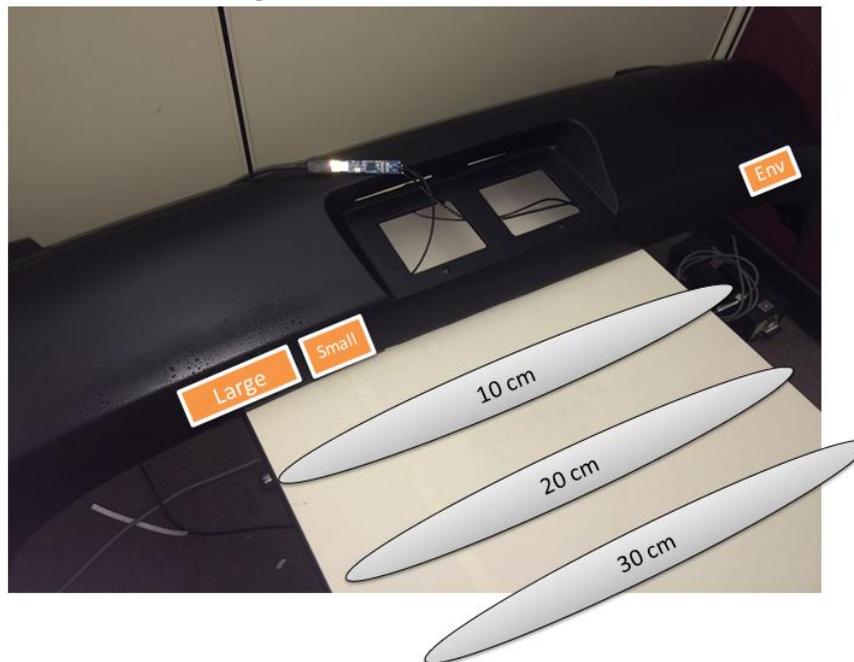
**E. Mud Introduction**

For testing the effects of mud on the exterior of the bumper, similar measurements were captured while a mixture of top soil and water spread across the surface of the bumper was still wet.



**F. Object Proximity Diagram**

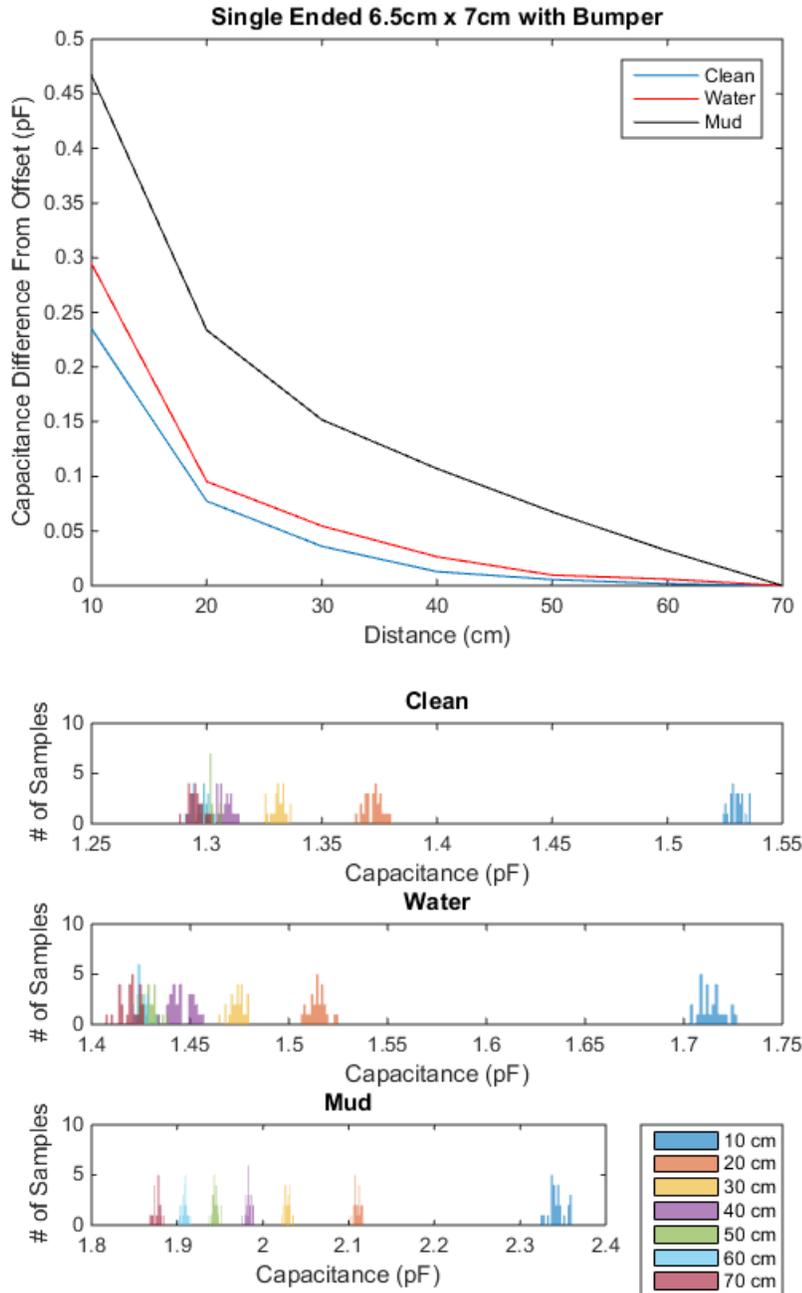
The following demonstrates the approximate test setup for the following captures, wherein the effects of a non-grounded human arm were measured at 10cm distances from the labelled copper tape sensors. White borders indicate the presence of a larger shield backing to create a directional capacitive measurement.

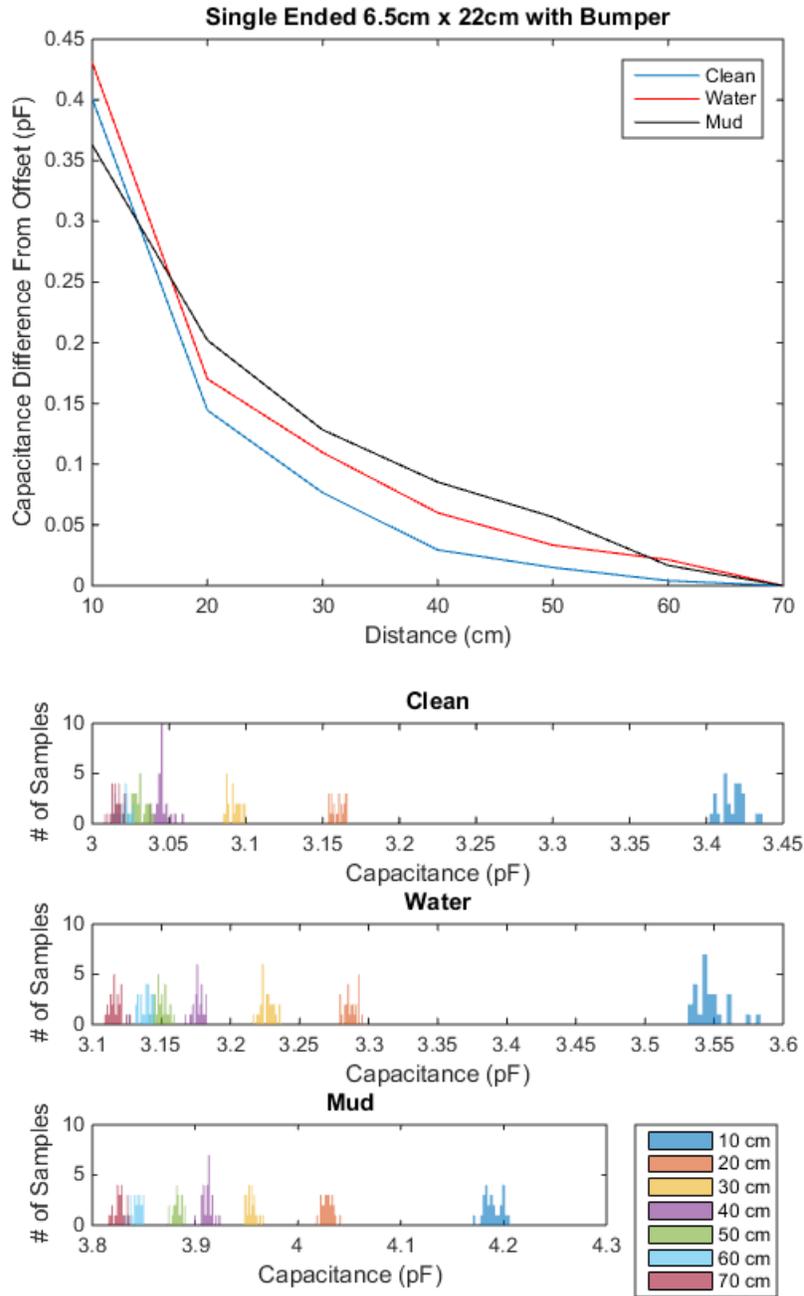


**G. Proximity Measurements – Single Ended**

A laptop operating off the battery and sitting to the back left side of the bumper was used to capture the data for the following datasets. Unique offsets for each testing condition (clean bumper, water on bumper, and mud on bumper) were

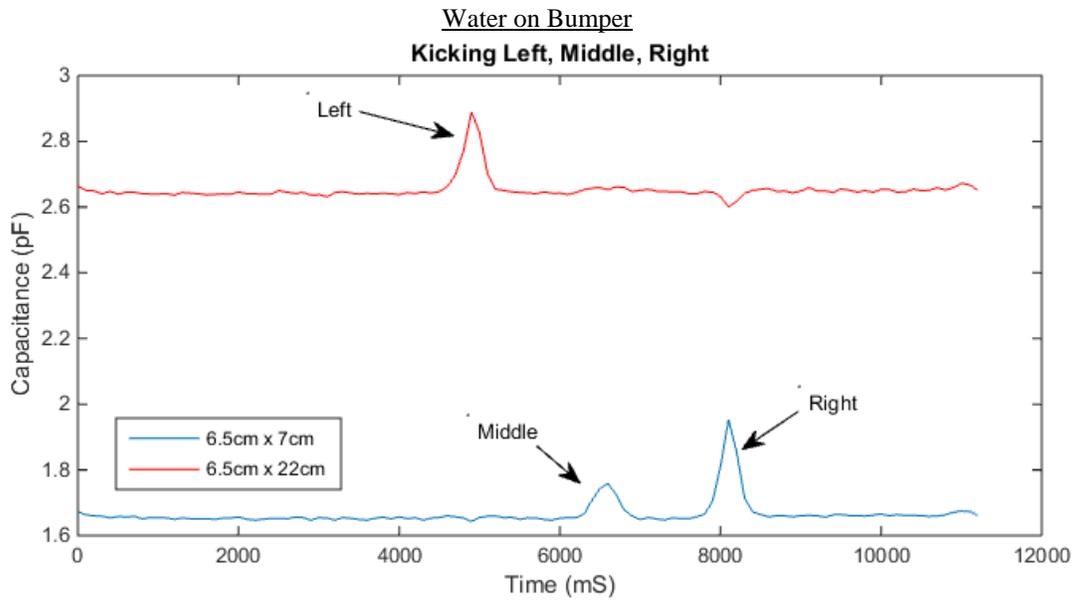
established and subtracted from the averaged plots below. Included with each proximity plot are histograms of the captured data to visually demonstrate the noise of each prolonged capture with an object introduced. From the following data, it is evident that objects within 20cm can be easily identified, whereas distinguishing an object's distance when greater than 50cm can become unreliable due to measurement noise. Additionally, the presence of water and mud on the bumper presented few, if any, negative effects on the measurements, as all three conditions had similar slopes within 20cm indicating similar detection sensitivities.





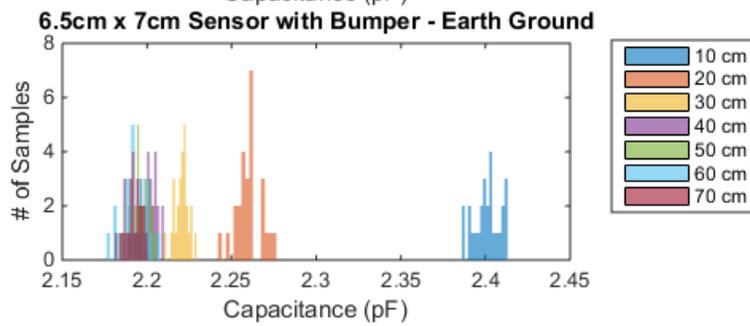
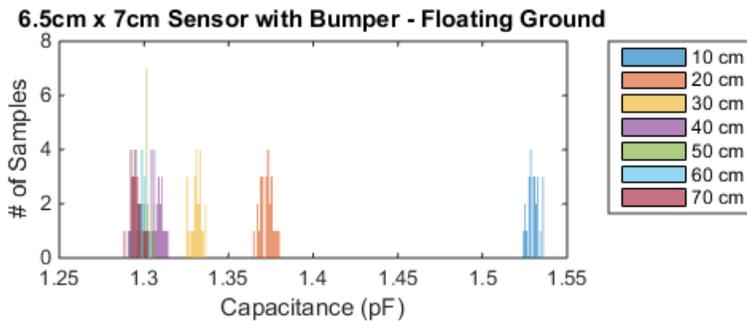
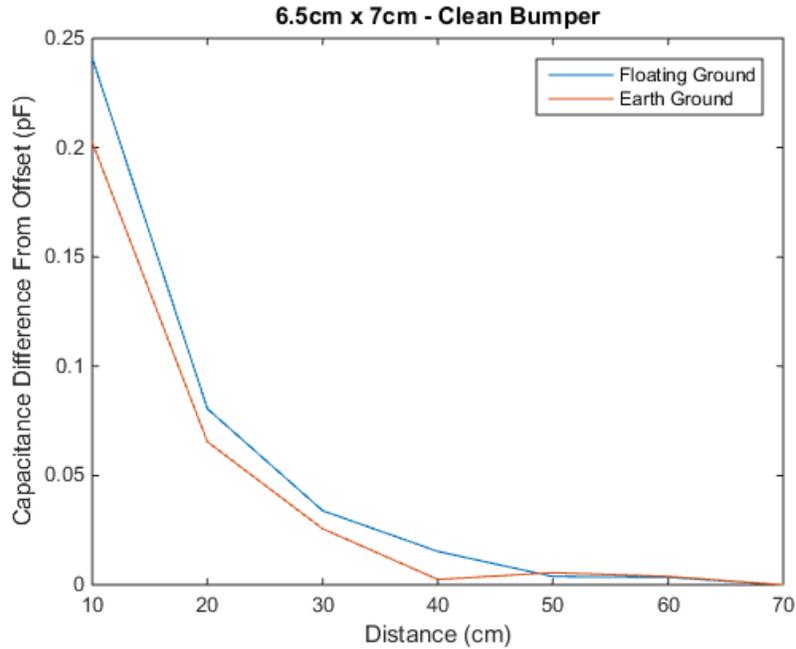
**H. Transient Captures of Kicks – Single Ended**

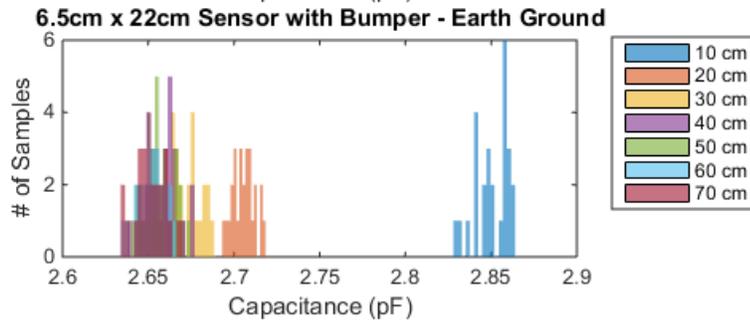
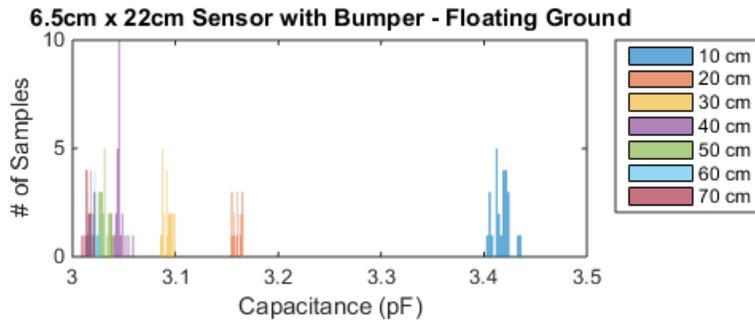
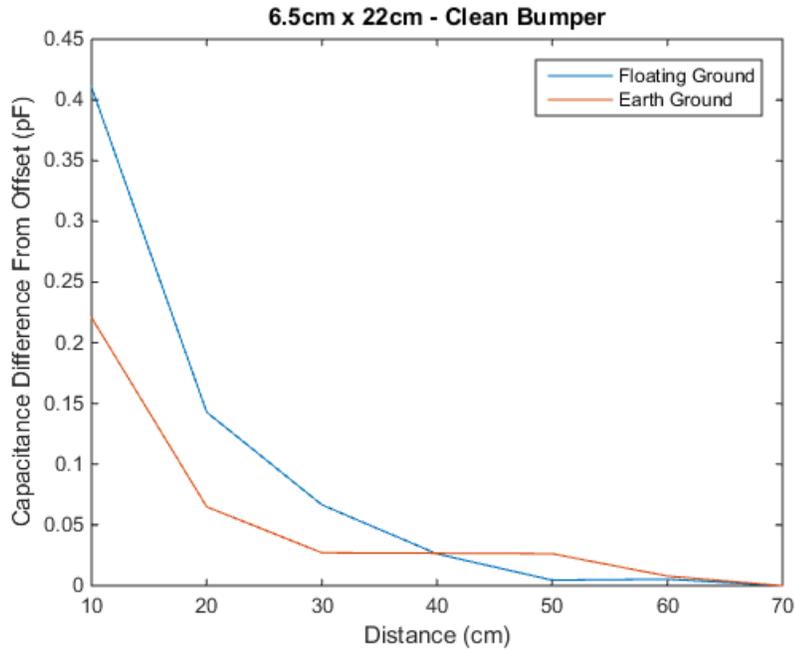
For this test setup, three kicks are measured in real time without contacting the bumper surface, with water introduced on the bumper exterior. The first kick aims toward the left of the license plate mount, nearest to the large sensor (pictured on the right in the interior photo below), the second aims below the license plate mount with the absence of a sensor, and the third aims for the right of the license plate mount nearest to the small sensor pad (pictured on the left of the interior photo below).



**I. Earth Grounded Vs. Floating Measurements**

The following demonstrates the effects measuring capacitance with respect to an earth ground (through laptop dock) and a floating ground (laptop running off battery) for both the small and large directional sensors. For both sensors the floating ground provided slightly larger sensitivity to nearby objects.





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