Simulation study on multi-electrode structure of large-scale capacitive sensor

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ABSTRACT

In this brief, six large-size multi-electrode planar capacitive sensor (PCS) structures are designed for small target detection. Firstly, the six different sensors were simulated using the boundary element method in COMSOL Multiphysics. Secondly, we compared the performance of the six sensors in terms of sensitive field distribution, sensitivity and initial capacitance, and the results show that the triangular comb-shaped sensor performs the best. Lastly, the effect of the ratio of the electrode spacing to the electrode width of the triangular comb-shaped electrode on the sensitivity distribution of the sensor is discussed. The simulation results demonstrate that the larger the ratio is, the better the consistency of the sensor sensitivity distribution.

SIMULATION MODELS AND RESULTS

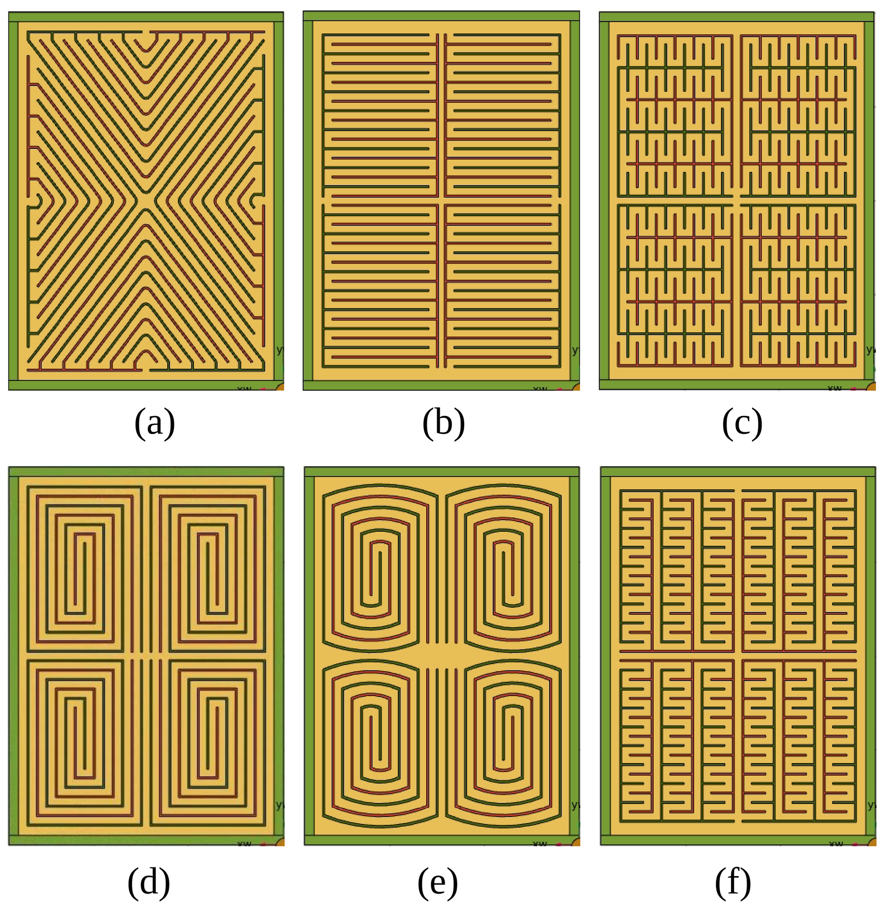


Fig. 1. Electrode structures: (a) triangular comb-shaped;(b) comb-tooth I; (c) comb-tooth II; (d) spiral I; (e) spiral II;(f) comb-tooth III.

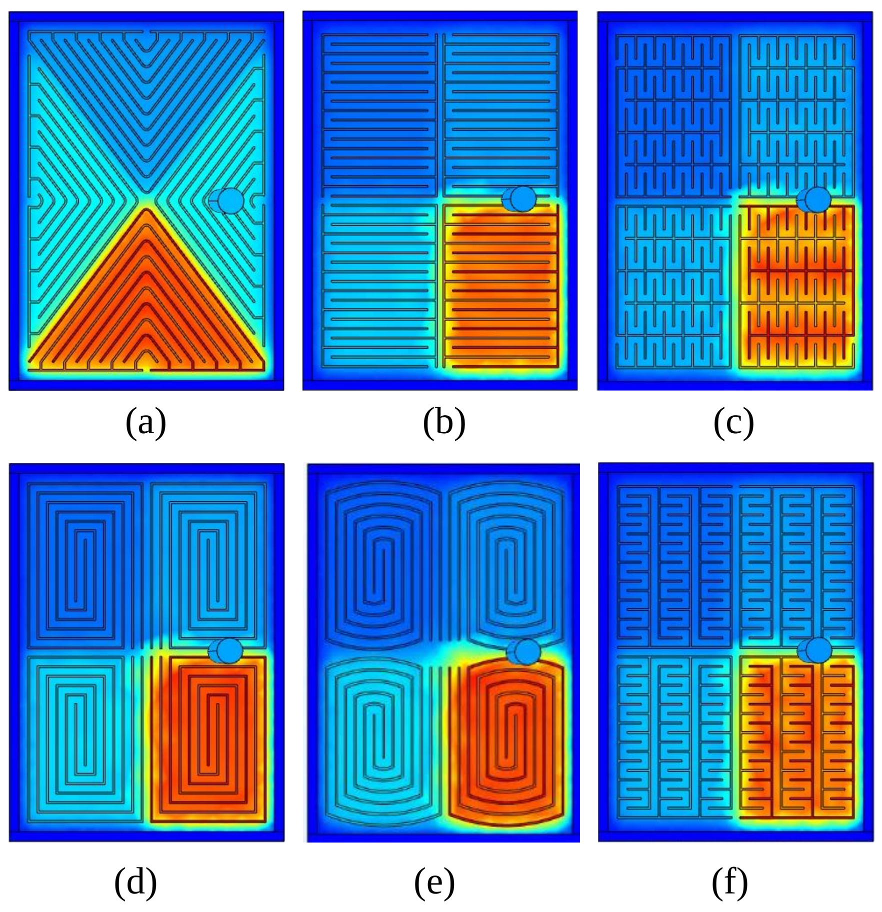
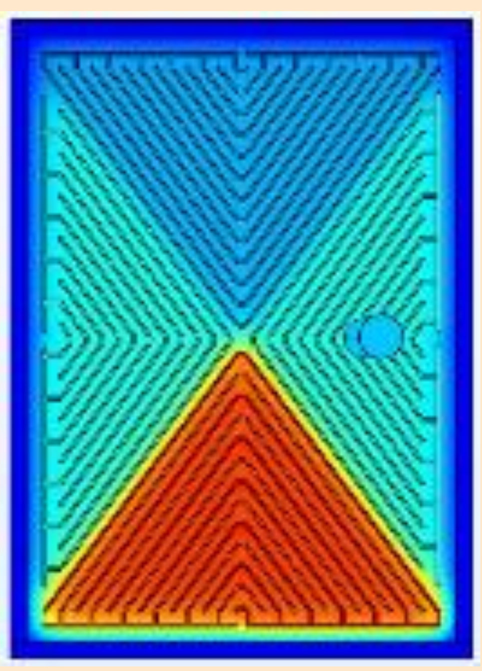
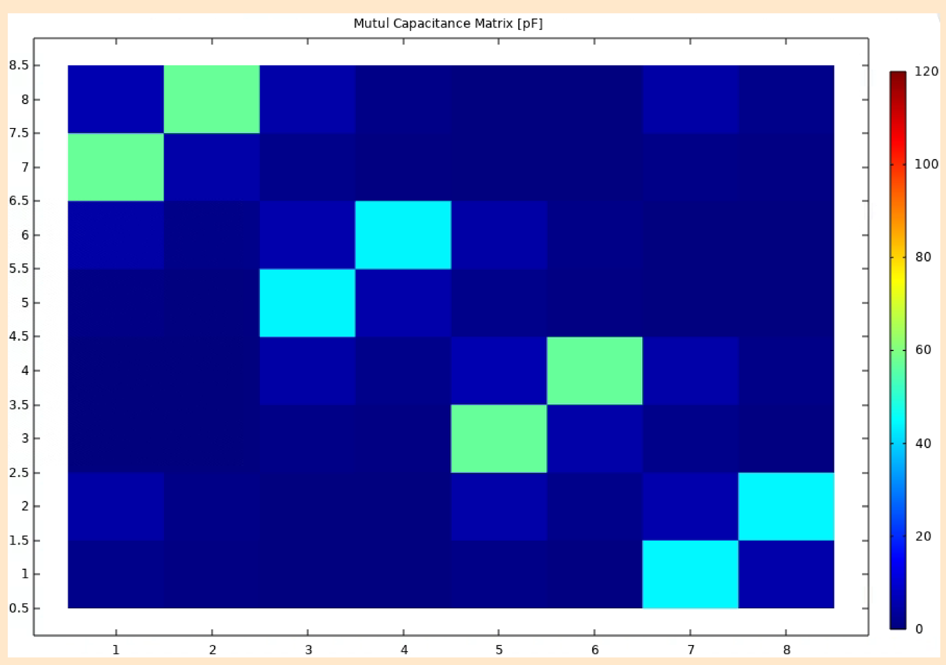
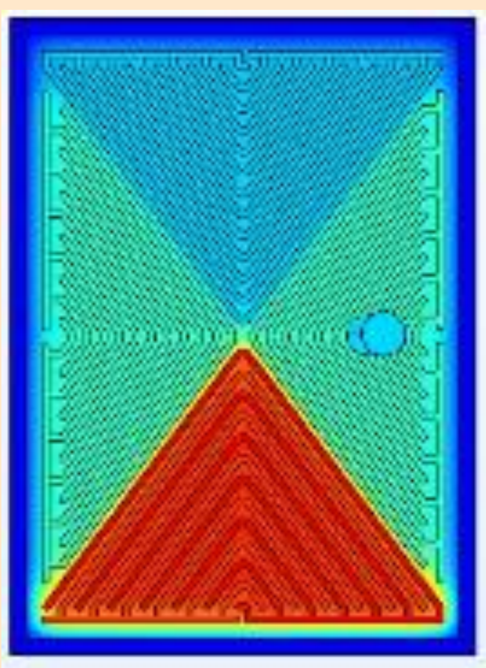
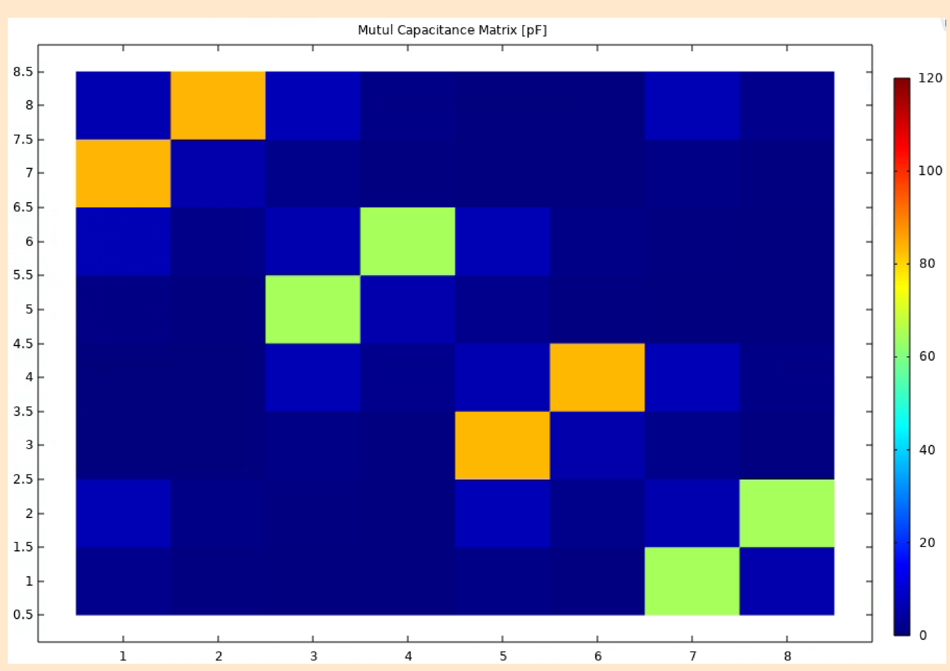
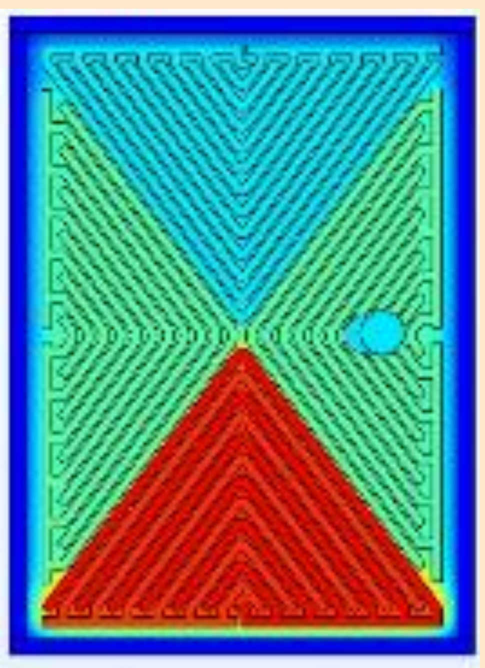
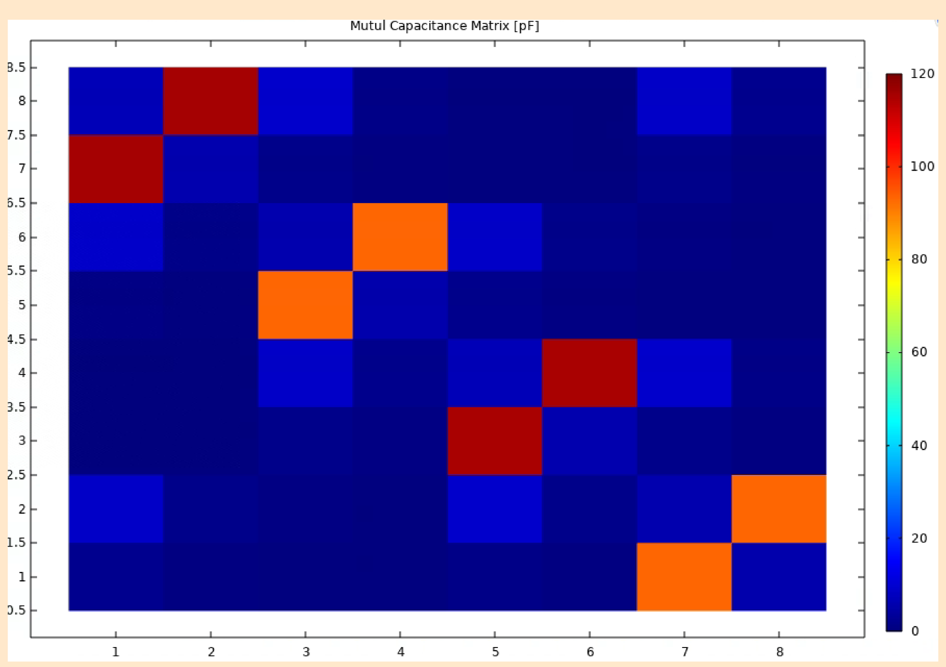


Fig. 3. Electric potential distribution: (a) triangular comb-shaped; (b) comb-tooth I; (c) comb-tooth II; (d) spiral I; (e) spiral II; (f) comb-tooth III.

TABLE I. CHANGE THE RATIO (a) OF ELECTRODE WIDTH (b) TO ELECTRODE SPACING (d)

Electric potential distribution	Initial capacitance matrix
	
Triangular comb-shaped I, b=2mm, d=6mm, a=1/3	
	
Triangular comb-shaped II, b=4mm, d=4mm, a=1	
	
Triangular comb-shaped III, b=6mm, d=2mm, a=3	

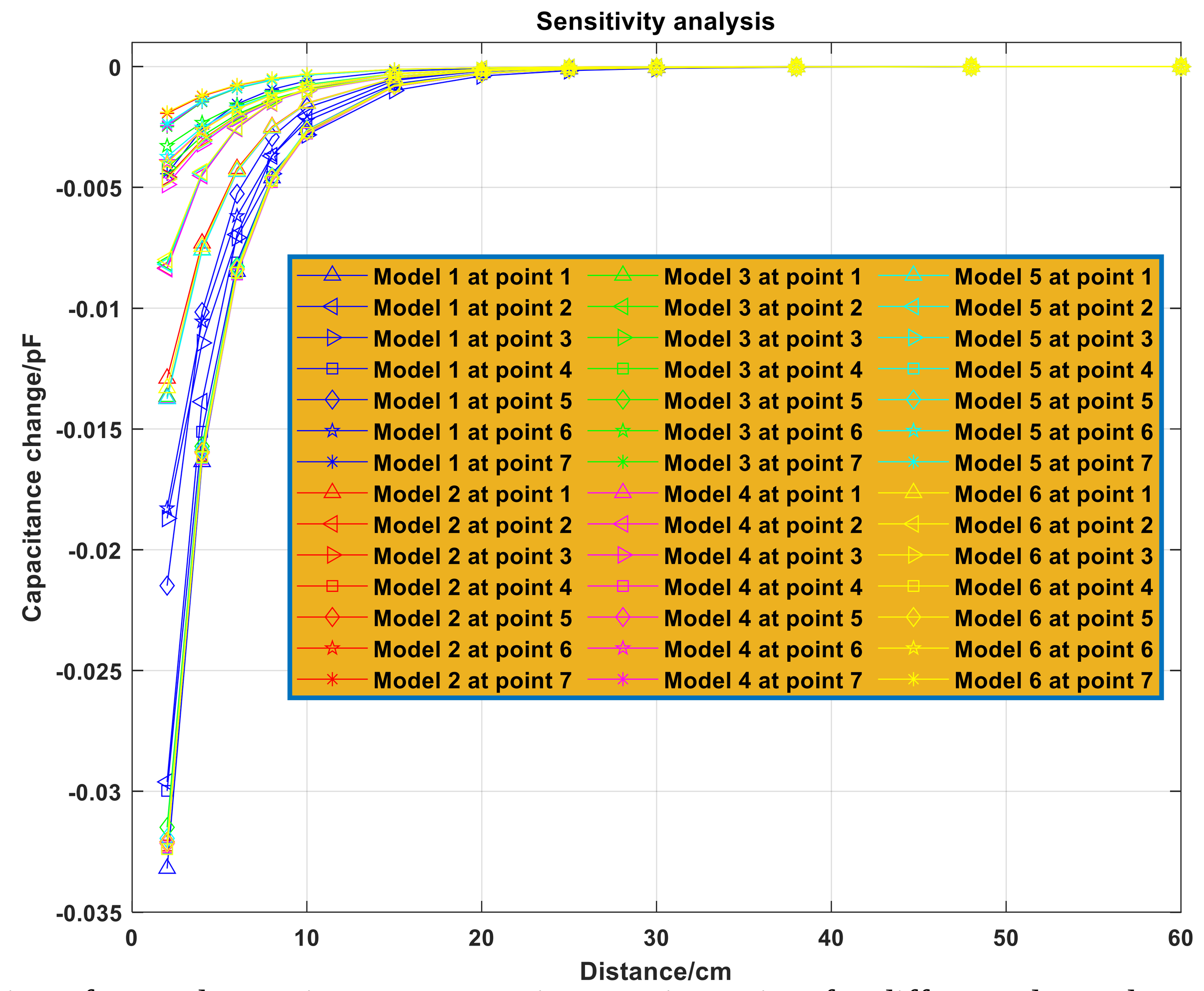


Fig. 4. Variation of mutual capacitance at seven intersection points for different electrode structures (Model 1-6 are triangular comb-shaped, comb-tooth I,comb-tooth II, spiral I, spiral II and comb-tooth III.)

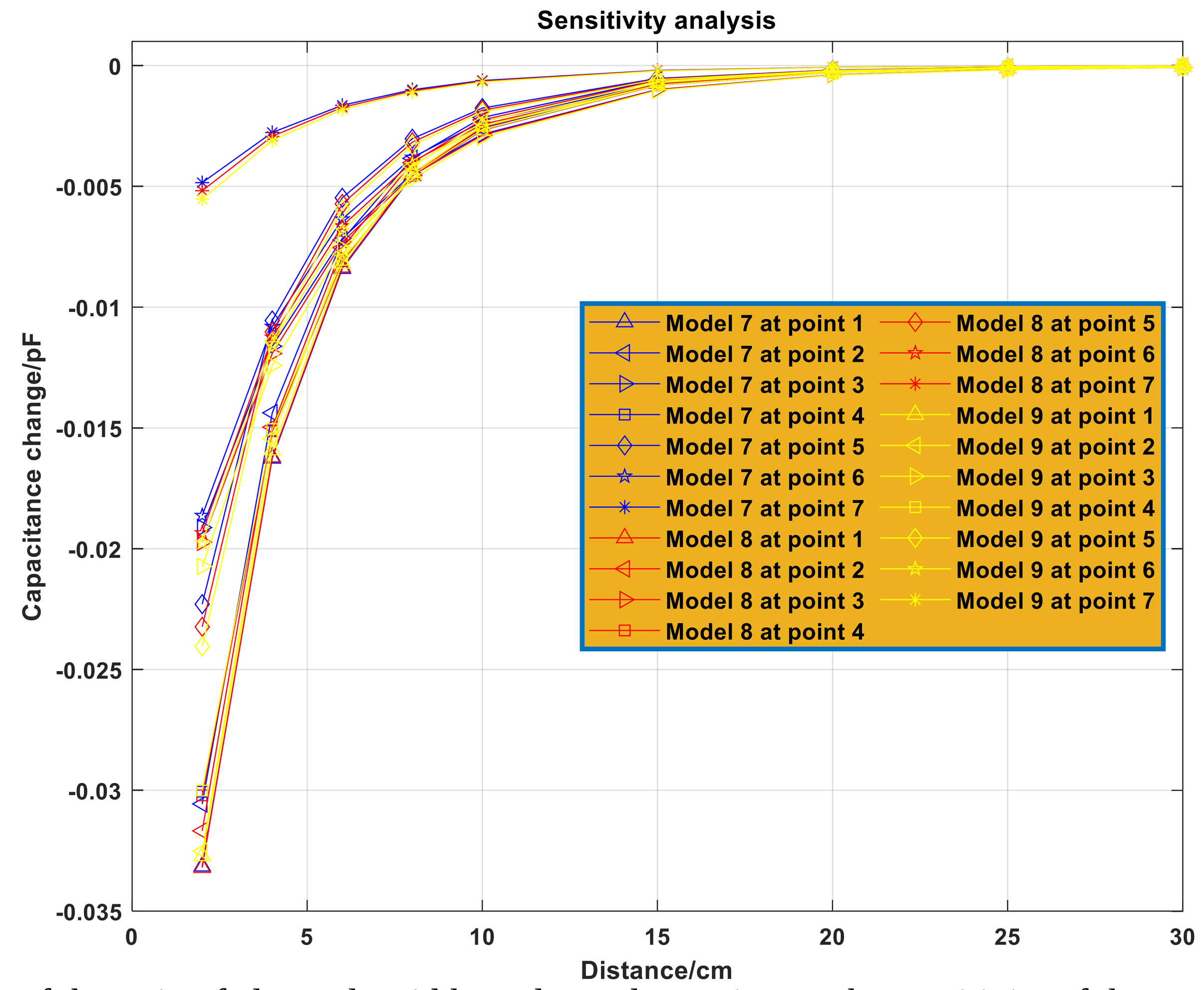


Fig. 5. Effect of the ratio of electrode width to electrode spacing on the sensitivity of the sensor (Model 7-9 are triangular comb-shaped I-III.)

CONCLUSION

In this report, the triangular comb-shaped PCS structure is designed as a novel and complex spiral and comb-tooth electrode structure based on the spiral and comb-tooth electrode structure. Firstly, the six different sensors were simulated using the boundary element method in COMSOL Multiphysics. Secondly, we compared the performance of the six sensors in terms of sensitive field distribution, sensitivity and initial capacitance, and the results show that the triangular comb-shaped sensor performs the best. Lastly, the effect of the ratio of the electrode spacing to the electrode width of the triangular comb-shaped electrode on the sensitivity distribution of the sensor is discussed. The simulation results demonstrate that the larger the ratio is, the better the consistency of the sensor sensitivity distribution.

In summary, the performance of the PCS is studied, and the optimal electrode structure model is finally determined for the multi-electrode plate large capacitance sensor for small targets, which can provide guidance for the subsequent design and application of PCSs. In this simulation study, the intersection of the measured object and the sensor are vertical intersection, and the intersection surface does not change during the movement of the measured object. The disadvantage is that the target does not necessarily intersect vertically when the multi-electrode plate large capacitance sensor for small targets is applied in practice.

AKNOWLEDGMENT

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