XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

CALIBRATION OF ELECTROSTATIC FIELD METERS

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Abstract – A method for electrostatic field meters calibration is presented in the article. A workplace for this measurement is also described and calibration results for two different electrostatic field meters are given.

Keywords: electrostatic field meter, calibration

1. INTRODUCTION

Several methods are used for the electrostatic field measurement in the air. Mostly used are these methods when an electric charge on a capacitance induced by a measured field is indicated. One typical method uses a time variable capacitance on which a measured field brings an induced alternating voltage or a special semiconductor element MOSFET type by which an indicated charge caused an impedance variation of a semiconductor channel.

Semiconductor capacitive sensors for electrostatic field

measurement consist of a flat electrode (see Fig.1) that, together with the surface generating a measured field, forms a capacitor, which charge Q can be expressed in the form

$$Q = U C, \qquad (1)$$

U is DC voltage on the surface of a source electrode against earth; C is capacitance between sensor electrode and source electrode.

In a simple case the capacitance C can be expressed as

$$C = \varepsilon_0 S/d, \qquad (2)$$

$\varepsilon_0 = 8{,}85.10^{-12}$ F m^{-1} is dielectric constant, S is cross-section area of sensor electrode, d is distance between electrodes.

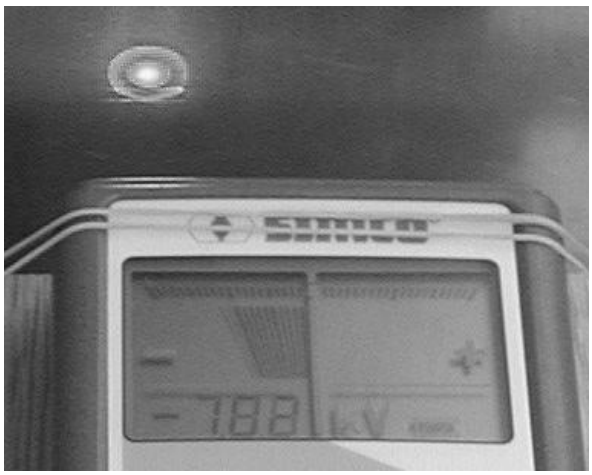
According to Equ. (1) and (2) it is possible to express the induced charge Q, in the form

$$Q = U \varepsilon_0 S/d. \qquad (3)$$

As in this case the distribution of electrostatic field is changing with the electrode distance, the Equ. (3) is not ideally valid. The meters based on this principle are calibrated for a certain exactly given distance of both electrodes. Then their reading is expressed in the voltage on the source electrode, in volts.

2. DESCRIPTION OF THE WORKPLACE

A workplace for testing (see Fig.2) of described electrostatic field semiconductor meters was developed in cooperation the Czech Metrology Institute and CTU Faculty of Electrical Engineering in Prague. The base is a conductive board 1 with dimensions (1 x 1) m on which is connected an adjustable DC voltage source U_M with the range up to 7 kV. The voltage is measured by means of a standard resistance divider consisting of 10 resistors 10 MΩ and a standard resistor 10 kΩ and a multimeter HP 34401A. The electrode



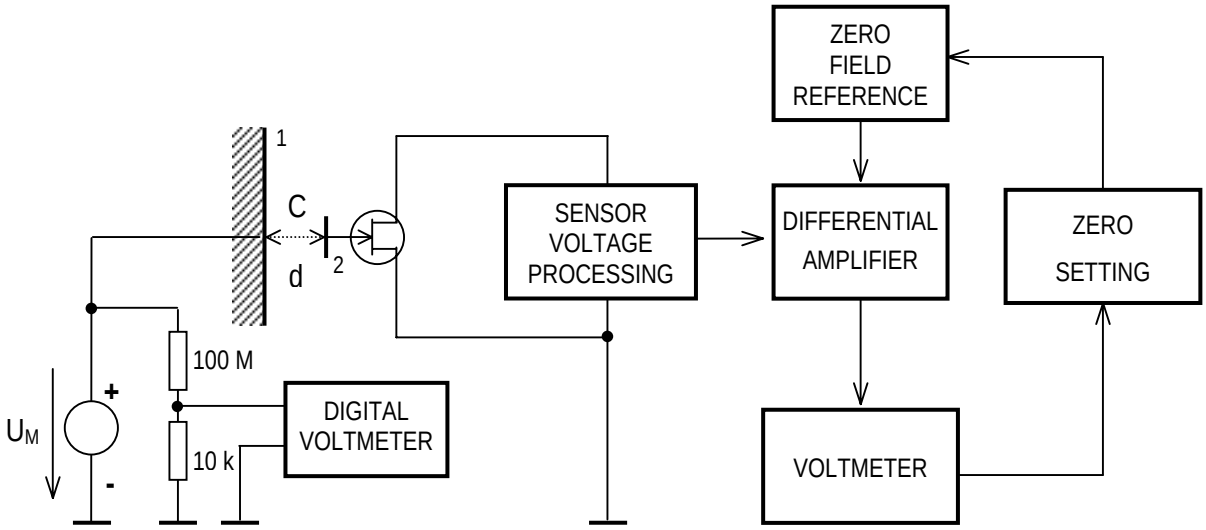


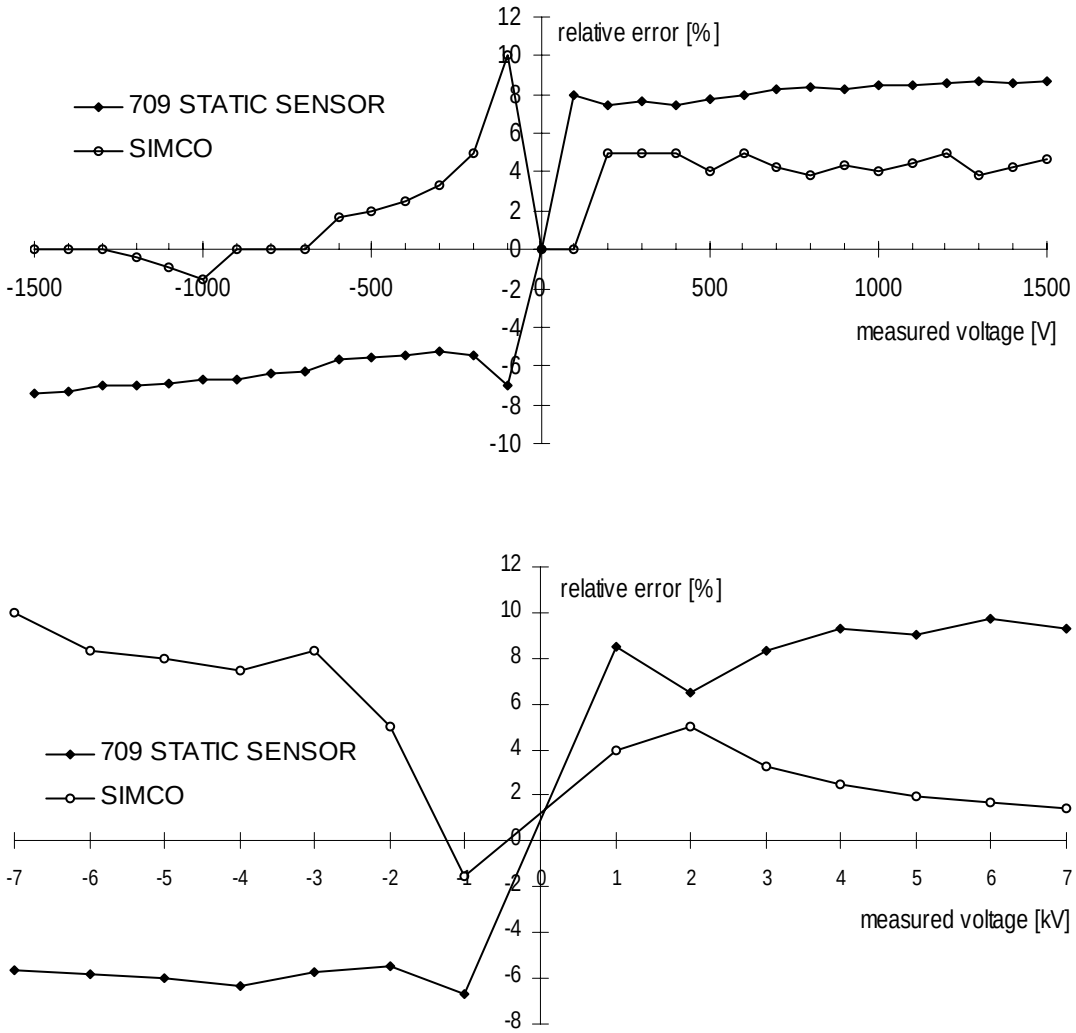
Fig. 2. Arrangement of electrostatic field meter with MOSFET sensor

2 of calibrated electrostatic field meter is placed on a sliding table with an ability to set precisely a distance d from the source board.

Two electrostatic field meters 709 STATIC SENSOR, man. 3M Electrical Specialties Division, USA and FMX-002 Handy Digital Electrostatic Fieldmeter, man. SIMCO B.V., the Netherlands were calibrated by means of this device. They are small portable battery operated instruments with digital display. Both meters have two ranges: 2 kV and 20 kV and the accuracy ± 10 % RDG. Their dimensions are approximately (11 x 7 x 4) cm. Their front panel with dimensions (7 x 4) cm forms a measuring electrode. Both instruments are calibrated for the distance 1 inch (25,4 mm) from a tested surface. For the SIMCO meter the proper position is indicated by means of LED diodes. The correct position is indicated by an overlap of two concentric luminous circles (see Fig.3). In both cases it is necessary to set zero of reading by means of the zero button in zero electrostatic field. The ground clamp of meter is during the measurement connected to one pole of measured voltage. Results of measurement are given in Table 1 and in Graph 1 and 2.

TABLE 1. Results of calibration for meters 709 STATIC SENSOR and SIMCO

true value U_T [V]	709 STATIC SENSOR		SIMCO		true value U_T [V]	709 STATIC SENSOR		SIMCO	
	measured value U_M [V]	relative error δ_U [%]	measured value U_M [V]	relative error δ_U [%]		measured value U_M [V]	relative error δ_U [%]	measured value U_M [V]	relative error δ_U [%]
-100	-107	-7,0	-90	+10,0	+100	+108	+8,0	+100	+0,0
-200	-211	-5,5	-190	+5,0	+200	+215	+7,5	+210	+5,0
-300	-316	-5,3	-290	+3,3	+300	+323	+7,7	+315	+5,0
-400	-422	-5,5	-390	+2,5	+400	+430	+7,5	+420	+5,0
-500	-528	-5,6	-490	+2,0	+500	+539	+7,8	+520	+4,0
-600	-634	-5,7	-590	+1,7	+600	+648	+8,0	+630	+5,0
-700	-744	-6,3	-700	+0,0	+700	+758	+8,3	+730	+4,3
-800	-851	-6,4	-800	+0,0	+800	+867	+8,4	+830	+3,8
-900	-960	-6,7	-900	+0,0	+900	+975	+8,3	+940	+4,4
-1000	-1067	-6,7	-1015	-1,5	+1000	+1085	+8,5	+1040	+4,0
-1100	-1176	-6,9	-1110	-0,9	+1100	+1193	+8,5	+1150	+4,5
-1200	-1284	-7,0	-1205	-0,4	+1200	+1303	+8,6	+1260	+5,0
-1300	-1391	-7,0	-1300	+0,0	+1300	+1413	+8,7	+1350	+3,8
-1400	-1502	-7,3	-1400	+0,0	+1400	+1521	+8,6	+1460	+4,3
-1500	-1611	-7,4	-1500	+0,0	+1500	+1630	+8,7	+1570	+4,7
-2000	-2110	-5,5	-1900	+5,0	+2000	+2130	+6,5	+2100	+5,0
-3000	-3170	-5,7	-2750	+8,3	+3000	+3250	+8,3	+3100	+3,3
-4000	-4250	-6,3	-3700	+7,5	+4000	+4370	+9,3	+4100	+2,5
-5000	-5300	-6,0	-4600	+8,0	+5000	+5450	+9,0	+5100	+2,0
-6000	-6350	-5,8	-5500	+8,3	+6000	+6580	+9,7	+6100	+1,7
-7000	-7390	-5,6	-6300	+10,0	+7000	+7650	+9,3	+7100	+1,4



3. CONCLUSIONS

From given results it is obvious that both calibrated instruments fulfil the given accuracy of measurement. It is necessary to connect their ground clamp with one pole of measured source. These results are not essentially affected by the dimensions of a source electrode up to the dimensions comparable with the dimensions of the meter electrode. It is recommended to place the instrument on a non-conductive pad during a measurement. It is not proper to hold the instrument in hand to prevent a charging of measured electrode by a spurious charge. By a variation of measured voltage on source electrode it is necessary to take in to account a time constant of several seconds needful for the meter reading stabilization.

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ACKNOWLEDGMENTS

This research work has been supported by the research program No. J04/98:210000015 "Research of New Methods for Physical Quantities Measurement and Their Application in Instrumentation“ of the Czech Technical University in Prague (sponsored by the Ministry of Education, Youth and Sports of the Czech Republic).