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ASPECTS REGARDING THE ELECTRICAL RESISTIVITY SOFTWARE MEASUREMENTS ON INSULATING MATERIALS USING 6517A HI-R SWEEP TEST PROGRAM

BY

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Abstract. The software measurements of electrical resistivity on insulating materials are studied. We used in our studies the 6517A Hi-R Sweep Test program from Keithley model 6524 High Resistance Measurement software, in connection with the 6517A Electrometer and 8009 Resistivity Test Fixture. The Alternating Polarity test method was used in these software applications to sweep some basic parameters such as alternating voltage values with a fixed measure time or a few measure time values with a fixed alternating voltage.

Key words: software measurements; insulating materials.

1. General Background

Electrical materials, as regards their electrical resisitivity, can be grouped into three main classes: conductive materials, insulating materials and semiconductors. The insulating materials (with electrical resistivity greather than 10^{12} Ω), according with the aggregation state, can be

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a) solid insulating materials, such as natural organic materials, inorganic materials or synthetics;

b) liquid insulating materials, such as mineral and vegetable oils, naturals or synthetic resins;

c) gaseous insulating materials.

Composite materials represent an important category of insulating materials successfully used in electrical and electronical industry, for electromagnetic compatibility measurements and applications, mostly in electromagnetic shielding problems.

Surface resistivity represents an important parameter of these insulating materials, used to evaluate and determine dissipation factor, dielectric breakdown, mechanical continuity and other basic material aspects and properties. Surface resistivity, ρ_S, is defined in the literature as a characteristic of a material which can be determined as the ratio of DC voltage, U, per unit of length, L, to the surface current, I_S, per unit of width, l.

In this paper we have performed a few software applications regarding the surface resistivity measurements of these insulating materials. The computational program used for simulations was the 6517A Hi-R Sweep Test from the model 6524 High Resistance Measurement Software (developed by Keithley Instruments, Inc), in connection with some dedicated equipments and devices. The basic measurement method of this software tool is the Alternating Polarity test method to sweep a series of important and specific material parameters.

2. Technique and Measurement Instrumentation

The measurement block diagram used for our computational applications is presented in Fig. 1, where surface resistivity software measurement on choosed materials will be tested through some dedicated instrumentation (6517A electrometer and 8009 fixture), which are briefly illustrated below.

The equipments used in our software measurements and simulations are

A. *6517A Electrometer*, with DC voltage measurements (from 1 μV to 210 V), DC current measurements (from 10 aA to 21 mA), electrostatic charge measurements (from 10 fC to 2.1 μC), resistance and resistivity measurements - surface or volume resistivity (from 10 Ω to 210 TΩ). The model 6517A include Built-in V-Source (the 100 V range provides up to 100 V at 10 mA and the 1,000 V range provides up to 1,000 V at 1 mA), data storage, built-in math functions, filtering and built-in test sequences.

B. *8009 Resistivity Test Fixture*, designed for measuring the surface and volume resistivity of solid electrical materials. This model is designed to ensure complete electrostatic shielding and can support samples from 64 mm to 102 mm in diameter. The working voltage for this model is max. 1,000 V and the test current is max. 0.1 A.

For connections between computer and 6517A electrometer we used an IEEE-488 Interface Board for PCI Bus (GPIB board) model KPCI-488A from Keithley.

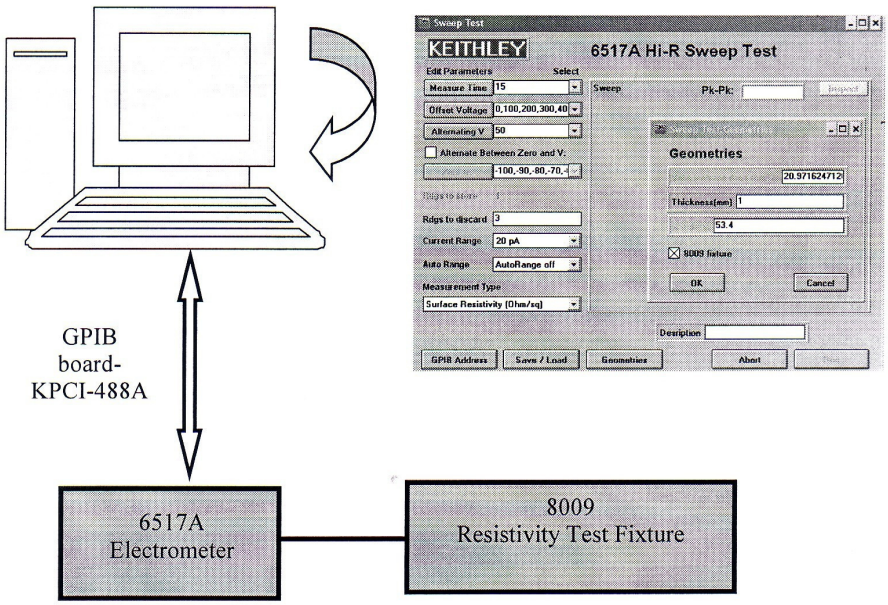

Fig. 1 – General measurement system set-up.

Model 6524 High Resistance Measurement software package includes four programs namely

1. 6517A Hi-R Sweep Test program.
2. 6517 Hi-R Test program.
3. 6517A Hi-R Temp and RH program.
4. 6517 Hi-R Step Response program.

The *Keithley 6517A Hi-R Sweep Test* represents a computational program used in software measurements and simulations of resistances, currents, volume or surface resistivities which uses, generally, the Alternanting Polarity technique to sweep some alternating voltage or measure time values with a fixed specific parameter. The main configuration controls for our software studies are Alternating Voltage, Offset Voltage (defined as the center level that voltage alternates around) and the Measure Time (parameter who sets the time the voltage is held at every polarity).

In our tests, we used four different types of insulating material samples, such as

1. Textile material from cotton 100% (with 2.80 mm thickness).
2. Textolite (with 0.58 mm thickness).
3. Polystyrene PS (with 2.00 mm thickness).
4. Plastic material with polyethylene (with 1.00 mm thickness).

All these material samples were prepared in accordance with the design requirements of the model 8009, with specific dimensions (the samples were prepared with 24…48 h before taking measurements and with a maximum thickness of 3.2 mm and a range of 64…102 mm diameter). The measurements were performed in adequate conditions of temperature and relative humidity.

3. Software Measurement Results

The software measurements and simulations were performed with high precision, according to the requirements of the specific standards. The parameters used in these applications and test setup control settings are presented in Table 1, namely: Readings to Discard, the Current Range, GPIB address, the Measure Time, the Offset Voltage and the Alternating Voltage. Fig. 2 shows the system for surface resistivity software measurement, using the instrumentation presented above. The GPIB address used in our software exemplifications was set on 27.

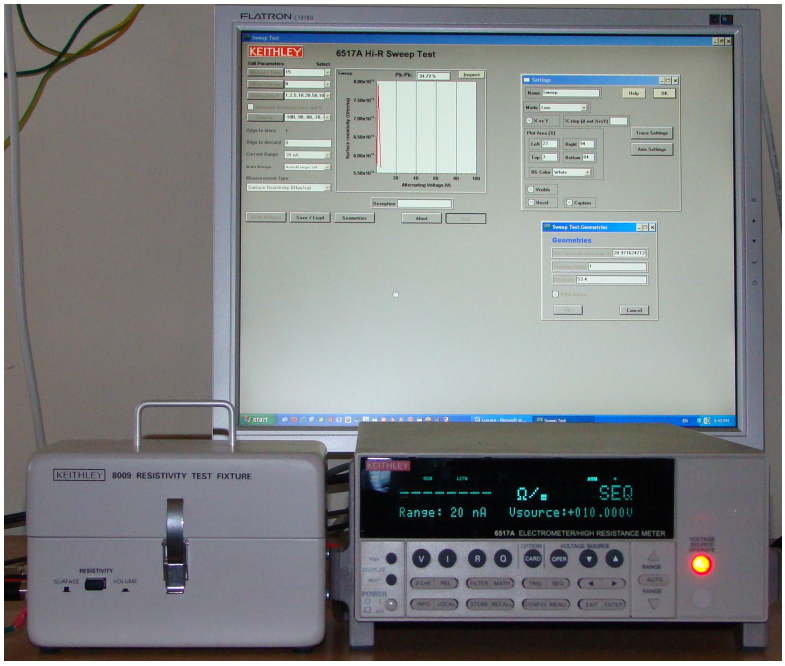

Fig. 2 – Software measurement of electrical resistivity

6517A Hi-R Sweep Test program uses two voltage alternation options: the Offset Voltage-Alternating Voltage option or the Alternate between Zero and Voltage option. For our applications we used the Ofset Voltage/Alternating Voltage where a specified and defined voltage is alternately added to and the substracted from a specific offset voltage. The current measurement will be performed at each alternation.

Table 1

The Measurement Configuration Controls

Measurement configuration controls	Set Values			
	Textolite	Textile material with cotton	Polystyrene PS	Plastic material with PE
The Measure Time, [s]	15	15	20	30
The Offset Voltage, [V]	0	0	10	10
The Alternating Voltage, [V]	1; 2; 5; 10; 20; 50; 100	1; 2; 5; 10; 20; 50; 100	10; 30; 50; 70; 90; 110; 130;150	1; 2; 5; 10; 20; 50; 100
The Current Range	20 nA	2 μA	200 nA	20 nA
Readings to discard	3	3	3	3

In Figs. 3,…,6 are presented graphically the obtained results for the choosed sample materials: textolite, textile material with cotton, polystyrene and plastic material with polyethylene. The diagram from Fig. 3 shows the surface resistivity *vs*. alternating voltage graph for textolite sample. The offset voltage is set for 0 V, the current range is of 20 nA and the measure time is of 15 s. The surface resistivity results and readings for this material are plotted at the 1; 2; 5; 10; 20; 50; 100 alternating voltages points. For the second material

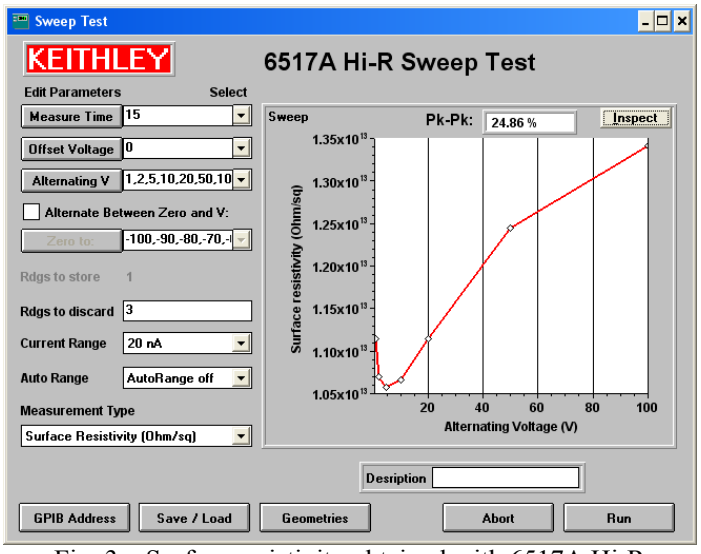

Fig. 3 – Surface resistivity obtained with 6517A Hi-R Sweep Test program for textolite sample.

(textile material with cotton 100%) the surface resistivity *vs*. alternating voltage graph is displayed in the Fig. 4, where the offset voltage is set on 0 V and the

current range is of 2 μA. The alternating polarity test method to sweep a series of alternating voltage values (1; 2; 5; 10; 20; 50 and 100 V) was used. The diagrams from Figs. 5 and 6 represent the results obtained (surface resistivity *vs*. alternating voltage) for the last two materials (polystyrene and plastic

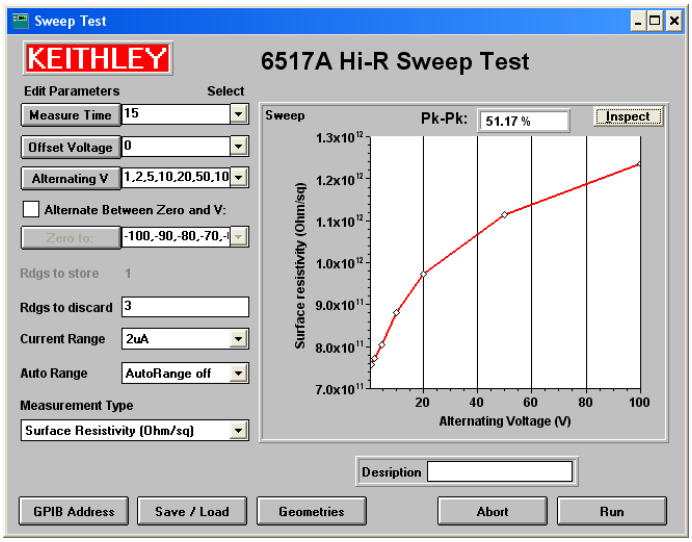

Fig. 4 – Surface resistivity obtained for textile material sample.

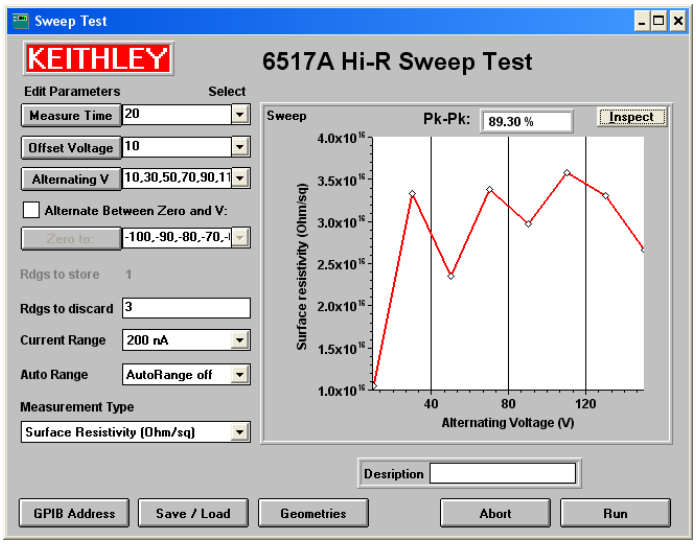

Fig. 5 – Surface resistivity obtained for polystyrene sample.

material with PE), with a range current and offset voltage set on 200 nA, respectively 20 nA and 10 V. The surface resistivity readings for PS and plastic material are plotted at the 10; 30; 50; 70; 90; 110; 130; 150 V, respectively 1; 2; 5; 10; 20; 50; 100 V sequences.

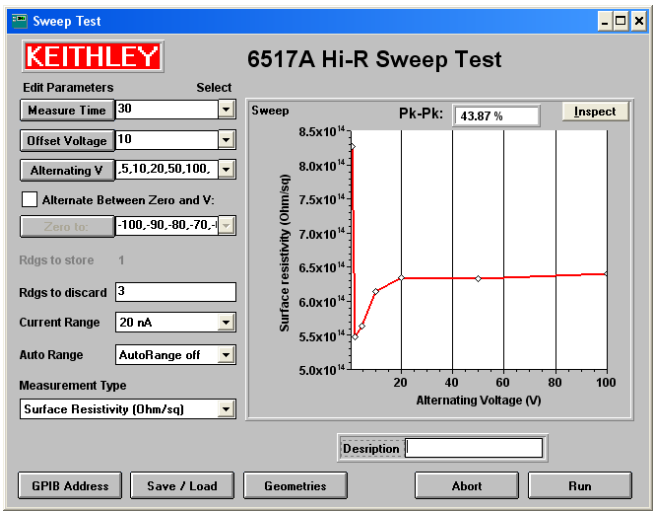

Fig. 6 – Surface resistivity obtained for plastic with PE sample.

4. Conclusions

Some interesting studies based on surface resistivity software measurements and simulations of four different kinds of insulating materials are presented. The computational program used in our studies was the Keithley 6517A Hi-R Sweep Test software from the model 6524 High Resistance Measurement Software, in connection with an electrometer, model 6517A and a 8009 Resistivity Test Fixture. Our researches present and display the results obtained for this parameter (surface resistivity) on some insulating materials through the Alternating Polarity test method to sweep a few alternating voltage values, to compare the surface resistivity readings performed at diverse alternating voltages. These studies and exemplifications are important and useful for characterization and evaluation of insulating materials, in the electrical materials research area.

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STUDII PRIVIND MĂSURAREA SOFTWARE A REZISTIVITĂŢII ELECTRICE A MATERIALELOR ELECTROIZOLANTE CU AJUTORUL PROGRAMULUI 6517A HI-R SWEEP TEST

(Rezumat)

Se prezintă rezultatele unor studii şi analize cu privire la testarea şi măsurarea software a rezistivităţii de suprafaţă a unor materiale electroizolante. Programul software utilizat în aceste aplicaţii a fost 6517A Hi-R Sweep Test, dezvoltat de compania Keithley Instruments, Inc., împreună cu o serie de echipamente specifice de testare precum electrometrul 6517A şi celula de măsură 8009 Keithley. Metoda polarităţii alternante reprezintă metoda de bază folosită de acest software, pentru consideraţii de alternare a parametrilor specifici de măsurare, testare şi simulare.