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Floating Measurements In Relation to a New Laboratory Ionospheric Simulator (Ionospektroskop)

Hui Tang

Department of Geodesy and Geoinformation Science,
University of Technology Berlin, Berlin, Germany

ABSTRACT: Due to the fact that the ionosphere can affect the passage of radio waves, it plays a very important role as a part of the atmosphere. The ionosphere contains different ionized regions (D region, E region, F1 and F2 region). Each region has its own properties and shows distinct influence on the entering radio signals. The importance of the ionosphere is represented by its utilization for communication systems and its effect on satellite communications and navigation systems. There are different kinds of techniques for studying the ionosphere (Ionosonde, incoherent scatter radar, beacons, in situ measurements, etc.) that provide valuable information about the ionosphere. Because the ionosphere has a dynamic and direct response to solar activities, the patches of ionization in the ionosphere are irregular. As a consequence, ionosphere is greatly variable and quite random in its effects. With the help of a new laboratory ionospheric simulator (a so called Ionospektroskop) close studying and investigation of the characteristics of the ionosphere become possible. Ionosphere-like plasma created by the Ionospektroskop has a similar characteristic (no earth connection and no reference point) as the ionosphere holds. In order to investigate this kind of free-floating plasma, a measuring technique called floating measurement is required. With the help of the configuration of the Ionospektroskop and based on this kind of measuring technique, measuring the electrical properties (such as voltage) of the free-floating plasma gets easier. In this paper, an example of a floating measurement related to the Ionospektroskop is given.

KEYWORDS: Ionosphere, laboratory simulation, free-floating plasma, probes, oscilloscopes.

1 INTRODUCTION

1.1 IONOSPEKTROSKOP

The Ionospektroskop is thought of as a new measuring arrangement that provides a laboratory partial simulation of the ionosphere surrounding; it has to handle the adaptation to the ionospheric conditions which must be reproduced in the laboratory. In comparison with the ground-based and satellite-based ionospheric observations, the Ionospektroskop investigations take lower costs and can be considered for supporting other ionospheric observations for the case that intense solar events occur. (Radio wave propagations and satellite communications can be disrupted as consequences of this.) This kind of laboratory partial simulation of the ionosphere shows the advantages of reproducibility and relative stability compared to the actual ionosphere. A simplified schematic view of Ionospektroskop is given in figure 1: 1) Acrylic glass discharge tube (75 cm long and 15 cm in diameter), 2) Upper pencil/needle electrode, 3) Lower pencil/needle electrode, 4) Copper-zinc disk electrode, 5) Copper-zinc spherical electrode, 6) pair of Helmholtz coil in X direction, 7) pair of Helmholtz coil in Y direction, 8) pair of Helmholtz coil in Z direction.

Corresponding Author: Hui Tang (tang.hui@hotmail.de)

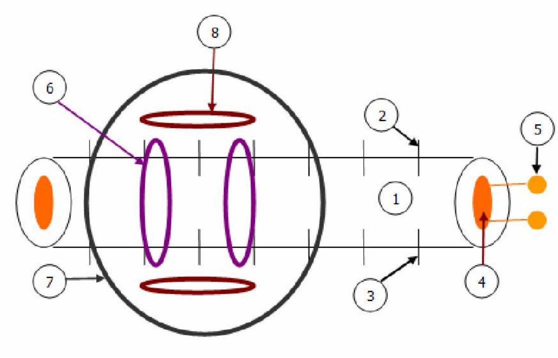

Fig. 1. A simplified schematic view of Ionospektroskop

1.2 BACKGROUND OF FLOATING MEASUREMENTS

Voltage measurements can be categorized into two sub-categories: differential measurements and floating measurements. They are distinguished whether the measurements are ground-referenced or non-ground-referenced. A differential measurement is to determine the voltage difference between two separate points. The floating measurement is a differential measurement where neither point is at ground potential. Floating measurements are mostly needed in power control circuits (such as motor controllers, uninterruptible power supplies, and switching DC power supplies) and industrial equipment. The foremost issue is that--if the measured currents or voltages are high enough--measuring devices could be damaged and the safety of the operator might be at risk. Different techniques for performing high-voltage floating measurements exist. They can be distinguished into Isolated-input Oscilloscopes, Differential Probe Measurement Technique, Voltage Isolator Measurement Technique, “A minus B” Measurement Technique, and “Floating” the Oscilloscope Technique. Each of them has its advantages and disadvantages [1].

Moreover, for the floating measurement techniques, probes also play a very important role. A probe can be considered as a kind of device, network or sensor that physically and electrically connects the test point or signal source to the oscilloscope. It probes or senses signals such as voltage signal (most cases), current, light power, etc. and transmits them to the input of the oscilloscope. Probes are generally made up by probe head, probe cable, and compensation box or other signal conditioning network. Various types of probes exist. They can be mainly distinguished into passive and active probes based on their constructions. A passive probe is constructed of wires, connectors, and according to the needs for compensation or attenuation, resistors and capacitors. In contrast to an active probe a passive probe includes no active components such as transistors or amplifiers. Therefore, there is no requirement for supplying power to passive probes. Due to the relative simplicity of use, passive probes are the most widely applied probe type. Depending on the probing target (signal type), probes can be categorized into standard or common probe types such as voltage probes, current probes, optical probes, etc., and specialty probes such as environmental probe, temperature probes, etc. These probes can be passive or active [2], [3].

Different oscilloscopes demand different probes. Therefore there is a broad selection of probes. Indeed, it is quite easy to become confused by selecting probes without the presence of sufficient professional knowledge and experiences about probes and oscilloscopes. Thus it is better to follow the oscilloscope manufacturer’s recommendations for probes. Furthermore, the usage of probes should have minimum influence on the test points or the circuit; the signal (sensed by the probe tip, transmitted by the head and cable to the oscilloscope input) should possibly keep its fidelity, and the signal loading caused by probes (probing loading) should be minimized. These requirements ask for the appropriate selection of probes as well. The right selection of the probe provides the first step for reliable measurements [2], [3], [4].

2 FLOATING MEASUREMENTS RELATED TO THE IONOSPEKTROSKOP

Due to the fact that the ionosphere has no earth connection and no reference point, the generated plasma has to be free floating in the present case as well. Generating the free-floating plasma is accomplished with the help of a new plasma generation method and the configuration of the Ionospektroskop (seven pairs of symmetric needle electrodes, number 2, 3 in figure 1). Pairs of symmetric needle electrodes are partly inserted in the acrylic glass discharge tube; they are not earth-fixed in voltage and have a direct connection with the created plasma. Their external part can be attached to devices. In other words, needle electrodes provide a kind of measuring bridge between the created plasma and the measuring devices.

In the present case, with the help of appropriate measuring devices such as high voltage probes, which are respectively attached to the external part of the needle electrodes, the voltages at these positions can be sensed. This kind of measurement is considered as *floating measurement*. New measuring methods based on this kind of technique are developed which enable measuring floating potential at each needle electrode pair. With different devices (such as suitable high-voltage passive probes, various oscilloscopes), there are different options available for achieving the floating measurement. Due to the dangerousness for both devices and operators when taking floating measurements, if traditional oscilloscopes are in use, the first choice is combining robust oscilloscopes with less sensitivity (such as HM Analog Digital Scope) with appropriate probes (10 kV high-voltage probes). However, because of the limitation of the HM digital scope, the combining high-end four-channel LeCroy oscilloscope with a suitable high-voltage probe (10 kV or 30 kV) are preferred due to its better measurement accuracy and advanced storage possibility. Figure 2 illustrates an example of a floating measurement setup (left-side) and the measuring results (right-side).

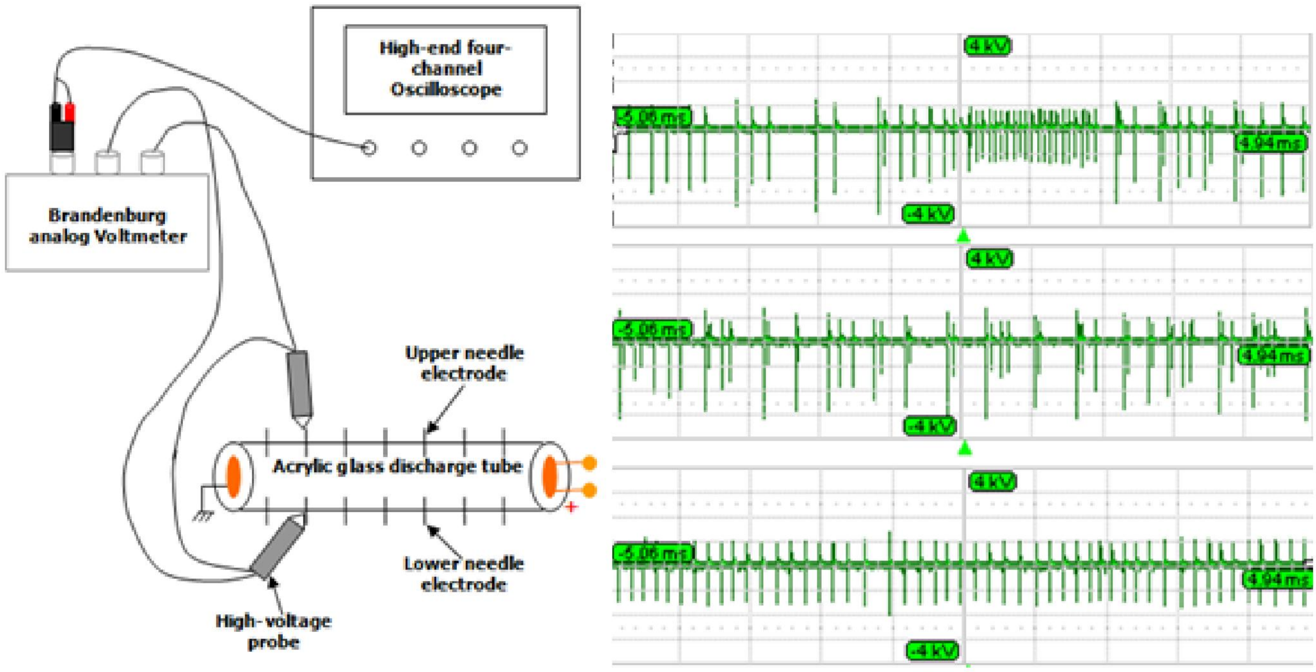

Fig. 2. Example of measurement setup and results

The analog voltmeter in the current setup gives a direct indication for the sensed high-voltage values. They show a voltage fluctuation range from 1 kV to 6 kV (with the choice of positive polarity and with a reading error of ±0.25 kV). The measuring results are taken from three different days. They are collected from one symmetric pair of needle electrodes (one upper, one lower). After the data analysis process, the analyzed results are as follows: the measured maximal positive voltage is 728 V. The measured maximal negative voltage is 128 V. The measured minimal positive and negative voltage shows 1 V respectively. Most of the voltage values in these three days are positive. In other words, the measured floating potential tends to be positive. The polarity of the sensed values depends on the numbers of electrons or positive ions collected by the tip of the needle electrode.

3 Conclusion

The analyzed measuring results of the floating measurements represent not only the sensed voltage values at the attached position, but also a repeatability of the ionizing process for generating plasma. The ionizing process should be repeated within an approximate time range from 0.1 to 0.3 ms to reproduce a similar state of the plasma. Seven pairs of the needle electrodes using the same method can be measured one after another. The first needle electrode pair locates in the vicinity of the anode of the acrylic glass discharge tube. The seventh needle electrode pair is in the vicinity of the cathode. Their distance is increased with ascending number of needle electrode pairs. The results follow an approximately inverse linear relationship between the increased distance and the amplitude. Seven pairs of the needle electrodes can also be measured simultaneously using the same method; as a result, an accurate voltage gradient may be determined.

Furthermore, the floating measurement in the current case may be combined with additional devices to determine the electron temperature of the created ionosphere-like plasma.

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