A METHOD OF MEASUREMENT AND CONTROL OF THE "V-A" CURVE OPTIMAL POINTS OF DOUBLE SPHERICAL ELECTROSTATIC PROBES. LABORATORY SIMULATION

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Keywords: space plasma, spherical Langmuir probe, quasi-static electric fields.

In the paper some problems when measuring a quasi-static electric field by using the Langmuir double probe's floating potential method are described. A high precise method for measurement and control of the "V-A" curve optimal points of double spherical electrostatic Langmuir probes is proposed. A laboratory simulation of the method is described. This simulation is realized by a multifunctional DAQ module in addition to PC system. The algorithm for measurement, computing and control of the "V-A" curve optimal points of two Langmuir probes is shown. This method ensures a maximum linear range of all measured signals and potentials of two probes close to the surrounding plasma potential.

1. INTRODUCTION

To measure a quasi-static electric field in the ionosphere-magnetosphere plasma the Langmuir double probe's floating potential method is used [1]. The satellite body potential has strong influence on the measurement. It varies in a quite wide range and takes negative or positive values due to continuously changes in surrounding environment. A local parasite electric field can be registered as result of the satellite potential existence. This is the reason why spherical Langmuir probes are installed on bars far away from the satellite body not to be influenced from [2]. From other side the parasite electric field increases when satellite potential increasing. Some authors [3] also offer an active control (decrease) of the satellite body electrostatic potential and of the conductive parts of the booms on which the probes are mounted. A spherical Langmuir probe as a body submersed in plasma is electro-statically charged to some balanced potential. There are two possibilities when measuring one vector of the quasi-static electric field by two spherical Langmuir probes:

– the spheres are charged to high positive potentials in the case of thin plasma;
– the spheres are charged to high negative potentials when crossing regions with high energy flows.

Therefore a different density of the plasma as well as the satellite body potential distorts any measurement even sometimes it is not possible. As a result of this problem a weak electric fields can not be registered.

2. HIGH PRECISE METHOD FOR MEASUREMENT AND CONTROL OF THE “V-A” CURVE OPTIMAL POINTS OF DOUBLE SPHERICAL ELECTROSTATIC PROBES

As a solution of all mentioned above problems for quasi-static electric field measurement we propose a high precise method for measurement and control of the “V-A” curve optimal points of double spherical Langmuir probes (SLP).

This method is based on three principles:

– periodically high-precise (12-bit) measurement, computing and control of the floating potential φ_{slp} of one from two SLP and corresponding current I_{pm} respective to optimal point M (Langmuir mode) from “V-A” curves (testing cycle);

– forced current injection I_{pm} to both SLP (control cycle);

– periodically high-precise (16-bit) measurement of the potential difference between two SLP (measuring cycle).

3. LABORATORY SIMULATION OF THE METHOD

The idea as proposed by new method is during the experiment periodically to inject into two SLP some current I_{pM}. Measurement, computing and control of this current are different for specific space experiments and depend from scientific tasks to be solved, from cyclogram of the scientific devices during the space flight and etc. For laboratory simulation of surrounding environment, experiment conditions and scientific instrument a National Instruments’ multifunctional DAQ module is used [4]. It is from E-series technology type with complete hardware architecture for data acquisition which leverages of the latest in electronics and computer technological innovations and advances the capabilities of PC-based DAQ solutions. An algorithm for measurement, computing and control of the M optimal point of the “V-A” curves of two SLP is further present, where Ni, T_e, M_i, φ_{slp} are set in advance, Ni is electron density, T_e – ion density, M_i – mass composition, φ_{slp} – probe floating potential, and T_{ts} , T_{cs}, T_{ms} – respectively test, control and measurement cycles.

Testing cycle:

1. Form “V-A” test characteristic – set Ni, T_e, M_i, φ_{slp} and discrete linear changing current I_{p1} (12-bit accuracy, in the range $\pm I_{pn}$). The time is T_{tc}, n – step number.
2. Compute $U_{fp} = f(I_{pi})$ where $U_{fp} = V_{slp1} - V_{slp2}$ (difference between floating potentials of two SLP).
3. Compute $\Delta I_{p1} / \Delta U_{fp}$.
4. Search $\varphi_{slp} = (\Delta I_{pi}/\Delta U_{fp})_{min}$.
5. If φ_{slp} # 0 -> search [A,B] range from the “V-A” characteristic where $\Delta I_{pi}/\Delta U_{fp}$ = const.
6. Compute point M = (A+B)/2 and the corresponding current I_{pm} .
7. If $\varphi_{slp} = 0$, $I_p= 0$.

Control cycle:

1. $V_{slp1}=f(I_{pm})$; 2.$V_{slp2}= f(I_{pm})$.

Measuring cycle:

1. Determine T_{ts} +T_{cs} /T_{ms}=1/9 for each experiment.
2. Measurement of $U_{fp} = V_{slp1} - V_{slp2}$.

The structural graph of the algorithm for measurement, computing and control of the "V-A" curves optimal points of two SLP is shown in Fig.1.

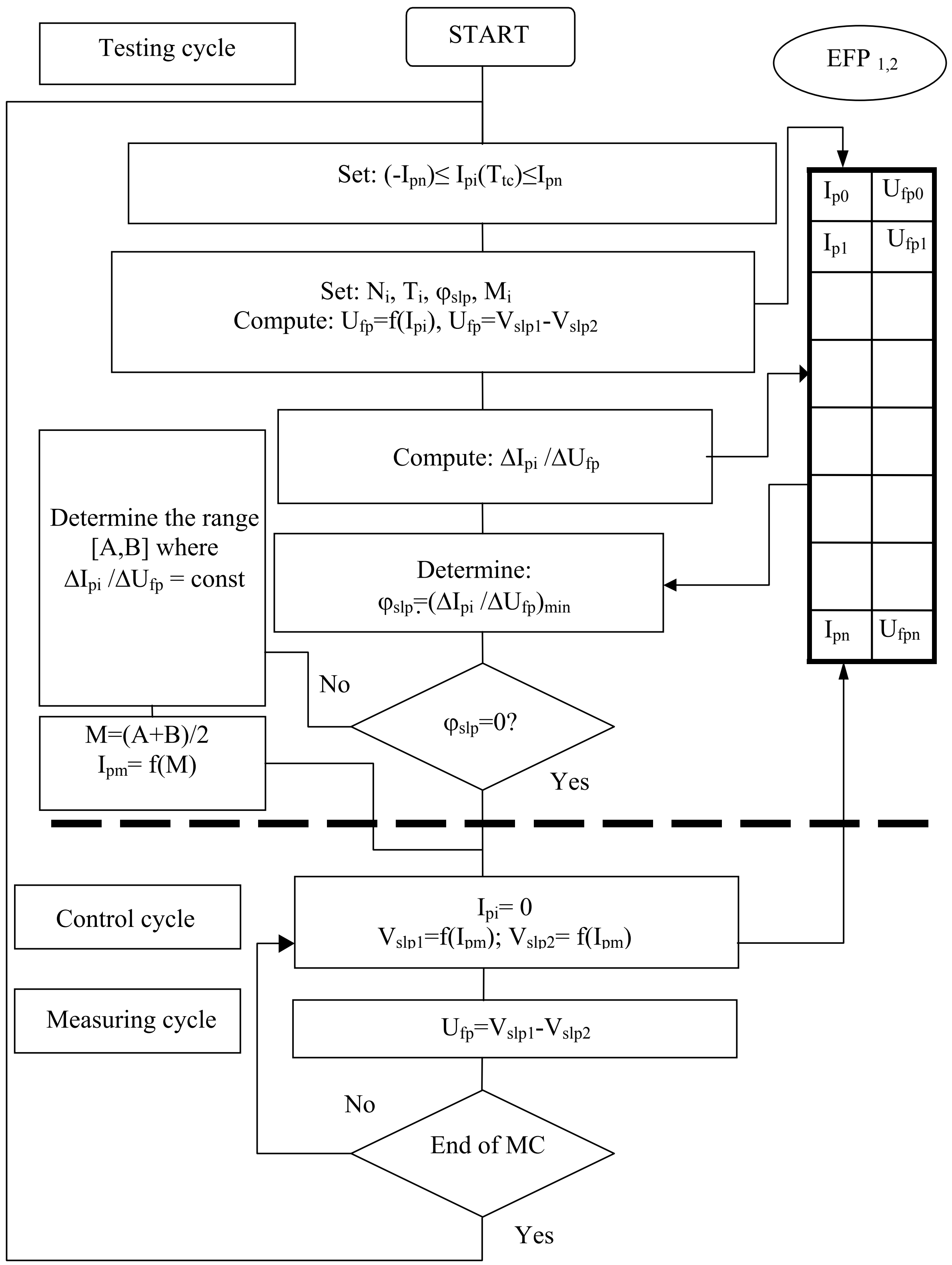

Fig.1

4. RESULTS OF LABORATORY SIMULATION

On Fig.2 a summarized "V-A" curve I = f(U), obtained during the test cycle, is shown. On Fig.3 the value of the floating potential φ_{slp} is shown (when total sum of the input and output currents are equal to 0, $\varphi_{slp} \underset{\cdot}{=} (\Delta I_{pi} / \Delta U_{fp})_{min}$)). Then the AB part of the curve, where $\Delta I_{pi} / \Delta U_{fp} \underset{\cdot}{=}$const, is determined as well as an optimal point M=(A+B)/2 and corresponding current I_{pm} (Fig. 4). Two probes are injected by this current and the difference between two potentials (U_{fp}=V_{slp1}-V_{slp2}) is determined.

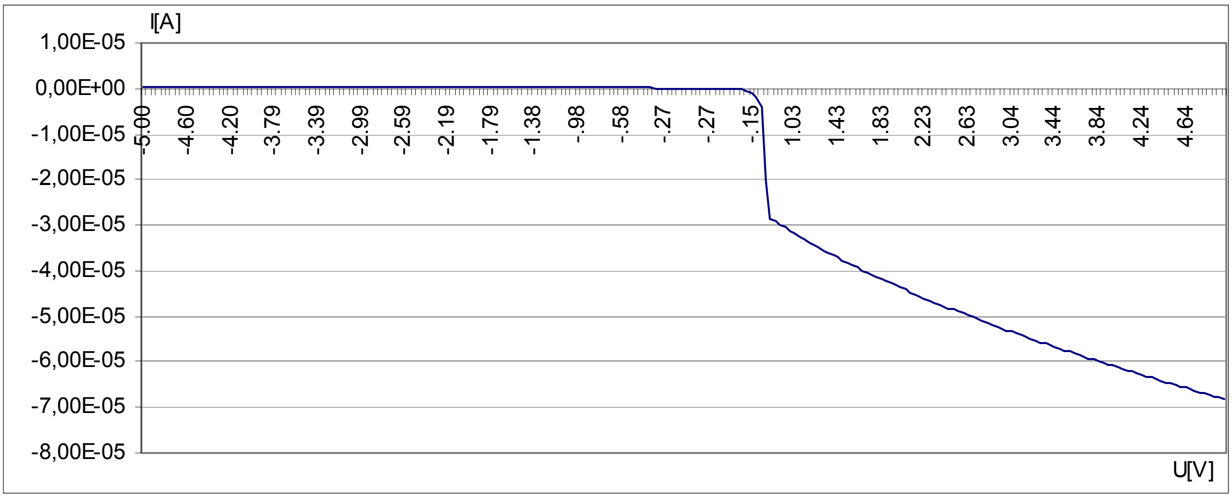

Fig. 2

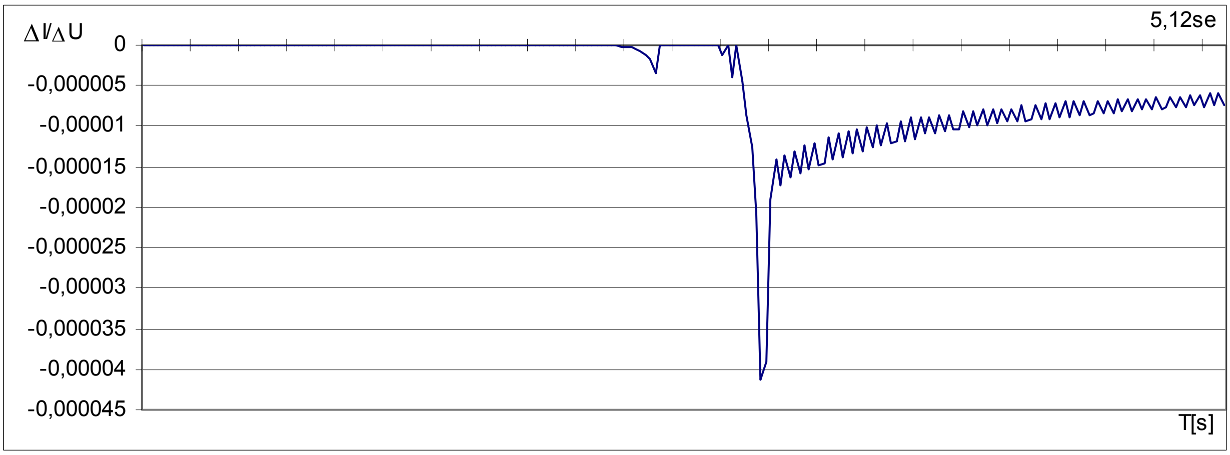

Fig. 3

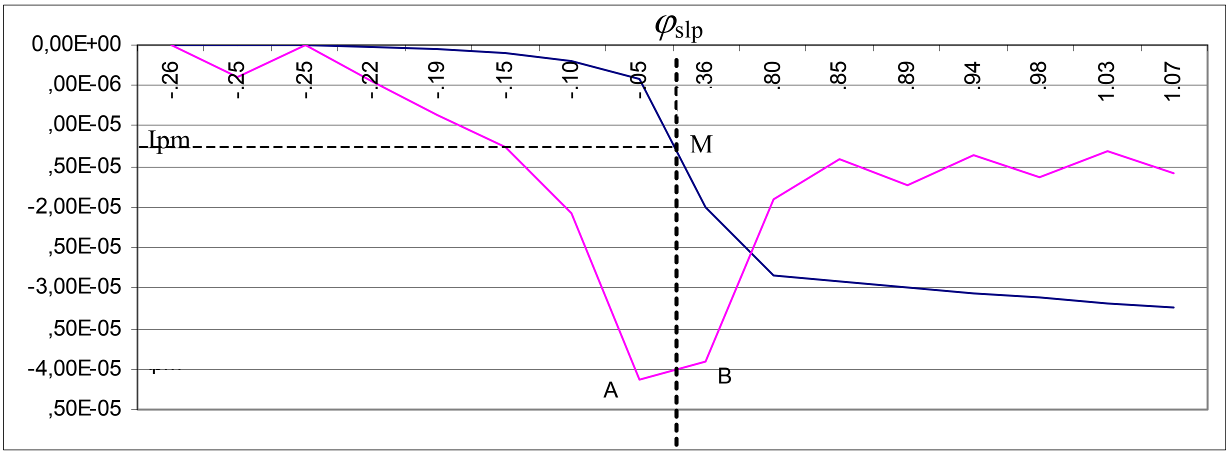

Fig. 4

5. RESULTS

A method for measurement and control of the "V-A" curve optimal points of double spherical electrostatic Langmuir probes is proposed by which:

– two SLP always have some floating potential;

– two SLP potentials are always negative even when the satellite body potential is positive.

6. CONCLUSIONS

The proposed method for measurement and control of the "V-A" curve optimal points of double spherical electrostatic Langmuir probes can be used for calibrating of two SLP in vacuum chamber and for optimizing of current source during the time of a real space experiment. The method eliminates the influence of ionosphere-magnetosphere plasma and sometimes even quite strong disturbances by satellite body potential. It gives opportunity to measure not only the quasi-static electric field but electron and ion densities and the satellite body potential. Most valuable is that the proposed method can be used in linear part of the "V-A" curve of two SLP and guarantee reliable measurement of the quasi-static electric field.

7. REFERENCES

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