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Research Note

MICROCOMPUTER-BASED LANGMUIR PROBE SYSTEM

C.S. WONG, S.H. SAW AND O.H. CHIN
Plasma Research Laboratory
Physics Department
University of Malaya
Kuala Lumpur 22-11
Malaysia

Abstract

A simple microcomputer-based data acquisition system is set up to obtain the I-V characteristic of the Langmuir probe. The system is ideal for extensive probe data collection in the study of steady-state plasmas.

The Langmuir probe is a simple but effective tool for the diagnostic of fairly large volume, relatively cold and low density plasmas. From the I-V characteristic of the probe, plasma parameters such as the electron temperature, electron density, space potential and electron energy distribution can be deduced. For a time-varying plasma, the pulsed Langmuir probe[1-4] must be used. In the case of a steady-state plasma, it is usually sufficient to use the point-by-point technique, although the pulsed method can also be employed. However, the process of obtaining the Langmuir probe characteristic by the point-by-point method and its analysis is tedious and time-consuming if it is done manually. This is particularly true in cases where the Langmuir probe is employed as a basic diagnostic and extensive data are required to be collected concurrently with other diagnostics of the plasma.

In this note, a simple microcomputer-based data acquisition system for the Langmuir probe is described. The system employs an Apple-II microcomputer to control the variation of the probe's bias potential as well as to monitor the probe current automatically.

The data acquisition system consists of a 64k RAM Apple-II microcomputer which is supported by a high-resolution CRT display unit; two mini floppy disk-drives and a dot matrix printer with high-resolution graphic capability (Fig. 1). Data acquisition is done via a multi-channel A/D + D/A interface card (Mountain Computer Inc.) which can be plugged directly into the expansion slot of the Apple–II. This interface card provides 16 cannels each of analog-to-digital and digital-to-analog converters. The range of its analog input/output level is −5V to +5V, with a digital equivalence of 0 to 255.

The experimental set-up of the microcomputer-based double Langmuir probe measurement of a plasma is as shown in Fig. 2. A 1 kΩ resistor is connected in place of the usual microammeter for measuring the probe current, Ip. The potential drop across the 1 kΩ resister is expected to be of the order of mV only and hence it must be amplified before it is fed into an A/D channel of the computer. This is done by using a HP2470A data amplifier.

The probe potential Vp is supplied by using the HP467A power amplifier acting as a variable power supply. The output of the power amplifier can be varied within the range of −30V to +30V by applying a voltage of −3V to +3V to its input. Thus when used in conjunction with a digital-to-analog converter, the HP467A power amplifier functions as a low voltage digitally controlled power supply. This arrangement is good enough for the present purpose. If higher voltages are required, the digitally controlled power supply described by Fanelli and Merangelli[5] may be employed.

It is the present intention to apply the above microcomputer-controlled Langmuir probe system to study the plasma of a dc glow discharge. However, in order to test the reliability of the system, a simulation experiment is first performed by replacing the plasma with a 10 MΩ resistor

(±10%). For such a simulation system, the current flow in the circuit varies linearly with voltage (Ohm's Law) This has been obtained as shown in Fig. 3. The slope of the straight line obtained is 10.5 MΩ which is consistent with the resistance of the load used.

As an example to illustrate the operation of the microcomputer-controlled Langmuir probe system, the double probe characteristic of a hot-cathode dc glow discharge is obtained as shown in Fig. 4. The feature of this probe characteristic is typical to that obtained with a contaminated and non-symmetrical double probe. It is well known[6] that surface contamination of the Langmuir probe has the effect of smoothing out the "knee" of the characteristic; whereas the intercept of the curve on the V_p-axis at point C is caused by the difference in the plasma potentials at the locations of the two probes. The electron temperature of the plasma can be determined from the slope of the characteristic at point C where $I_p=0$. This has been obtained to be $T_e=(2.0 \pm 0.2)$ eV in the above case, which is typical for the glow discharge plasma considered here.

We have illustrated above the operation of a microcomputer-based Langmuir probe system for the measurement of the electron temperature of a glow discharge plasma. As can be seen from Fig. 4, more points at small voltage increments of 0.4V have been obtained for a single characteristic, which is not possible if the same procedures are performed manually. Thus the utilisation of microcomputer in Langmuir probe measurement has greatly enhanced its accuracy and effectiveness as a basic diagnostic in the study of steady-state plasmas.

Acknowledgement

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References

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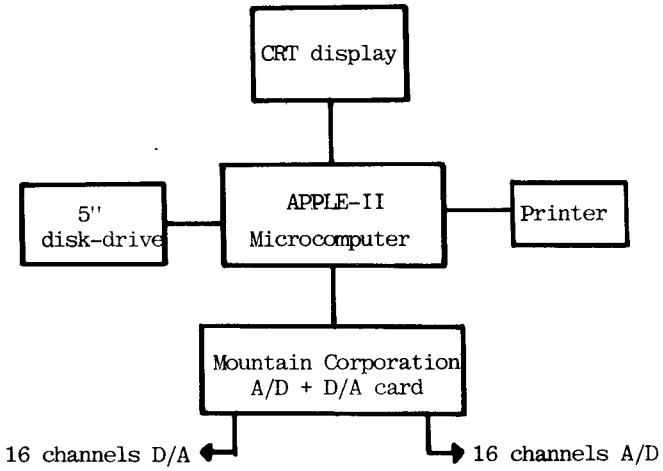

Fig. 1: Schematic of the microcomputer-based data acquisition system.

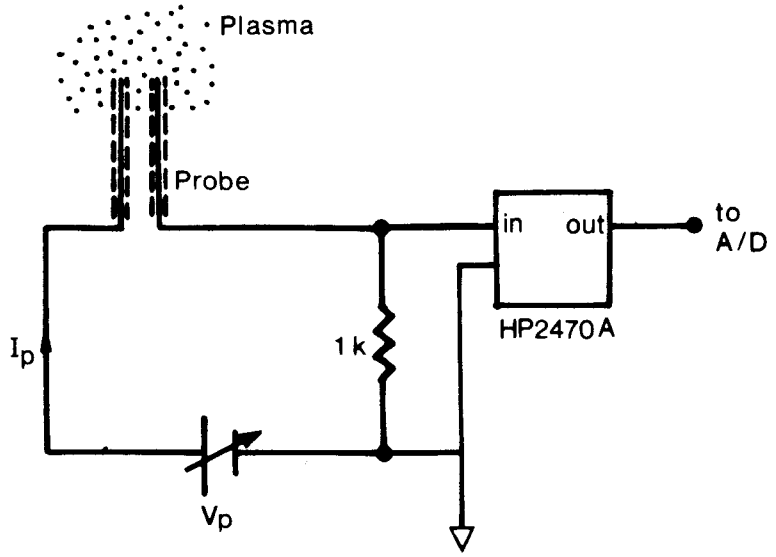

Fig. 2: Experimental set-up of the double Langmuir probe measurement of a plasma.

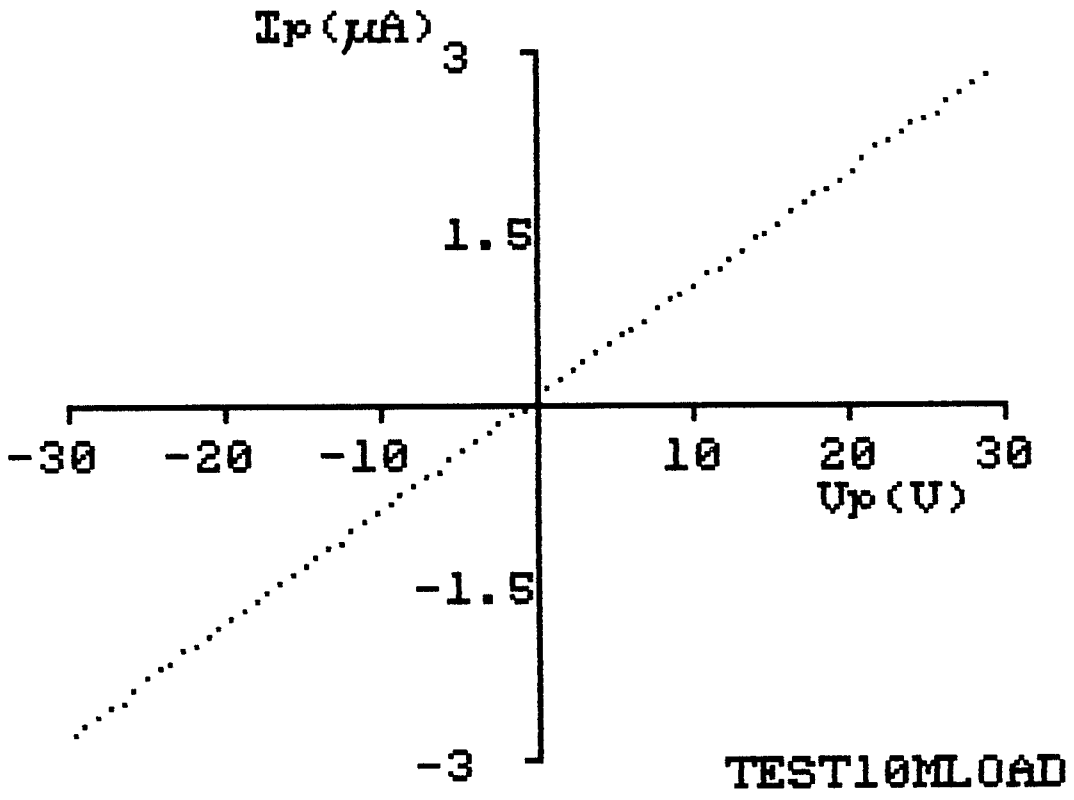

Fig. 3: Ohm's Law simulation test of the microcomputer-controlled Langmuir probe.

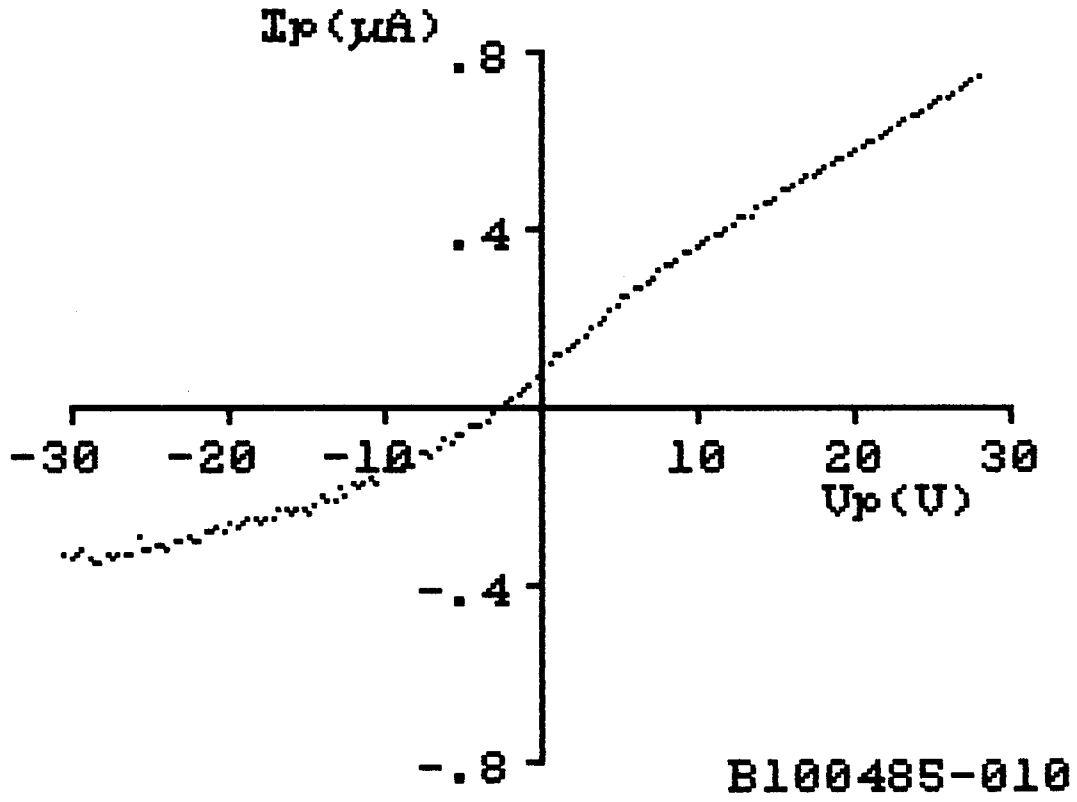

Fig. 4: A double probe characteristic of the hot-cathode dc glow discharge plasma obtained by the computer.