Data Acquisition System Based on Arduino Platform for Langmuir Probe Plasma Measurements

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***Abstract*—A simple data acquisition system based on Arduino Nano platform is designed. Bluetooth wireless protocol has been used for data transmission. Android OS application for data visualization and recording is developed. The system has been successfully applied for acquiring data from Langmuir probe measurements in the non-self-sustained discharge with a hollow anode.**

***Keywords*— Langmuir probe; Arduino; Bluetooth; non-self-sustained discharge; Android.**

I. Introduction

One of the most important parts of plasma diagnostics equipment is digitizing and storing data of measurements. Available commercial data acquisition systems produced by profiled companies, i.e. LabView and others, usually have rather high price. However, nowadays, there is a possibility to design and manufacture quite simple and low-cost system on the basis of independent embedded Arduino platform or similar.

Several works in different fields have been done for data acquisition using Arduino. For example, Coelho E.T. et al. [1] developed an application in the scenario of controlling the information processing and also communications between sensors and actuators onboard of an autonomous flying robot, in a "fly-by-wireless" approach. Krishnan J. et al. [2] presented application in medical field. It served as a remote monitor for measuring and analyzing along with logging of data from patients. Jenifer T.M. et al. [3] designed a mobile robot which has been used for autonomous temperature measurements, as an early detector of fire in forests and also as a sensor kit in warehouses, hospitals, etc.

Indeed, we have not found any information about application of Arduino-based wireless data acquisition system in plasma diagnostics. Also we understand that some natural limitations of this system (mainly due to low acquisition speed) could be the obstacle in applications for plasma diagnostics. However, in the case of stationary plasma, i.e. in gas discharge experiments, the system could be rather prospective.

II. Experimental Setup

A. System Diagram

The designed system consists of a Langmuir probe (or multiple probes), Arduino board, Bluetooth module and Android OS device with appropriate software (Fig. 1.). The signals, which extracted from Langmuir probe, are sent to the analog inputs of Arduino microcontroller. Then, analog signals, being converted into digital form, are further directed to the Blue-tooth transceiver for communication with Android OS device.

The application for visualization and acquiring transmitted data is installed on the Android OS device.

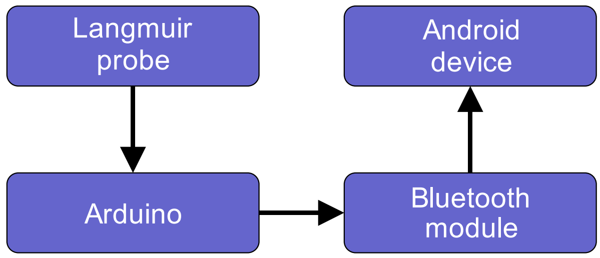

Fig.1. System block diagram

B. Langmuir Probe in Plasma of Non-Self-Sustained Gas Discharge

Non-self-sustained gas discharge, in which the additional charge carriers are produced by a vacuum-arc plasma gun, is characterized by strong-current electron and ion fluxes and high values degree of ionization [5-10]. Such type of discharge might be easily excited in well-known vacuum-arc deposition setups (Fig. 2). In such setups, as a rule, power sources between metallic cathodes and anode provide the arc current in the range from tens to hundreds Amperes at the voltage of few tens of Volts. With such experimental setup one possible to obtain a gas discharge with similar magnitudes of current and voltage. Due to the enhanced plasma density in the discharge and high degree of ionization, the processes of surface treatment in such gas discharge are much more intense in comparison with conventional self-sustained glow discharge.

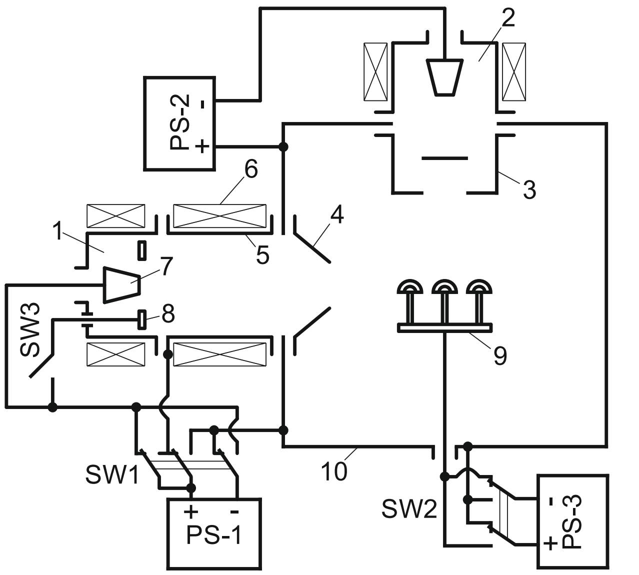

Fig. 2. Experimental setup: 1 and 2 – vacuum-arc evaporators; 3 – screen; 4 – diaphragm; 5 – anode; 6 – focusing coil; 7 – central anode (or cathode in deposition mode); 8 – additional ring anode; 9 – samples; 10 – vacuum chamber. Power sources PS-1 and PS-2 for supply of arc and gaseous discharges; PS-3 is a bias voltage source.

Langmuir probe consists of tungsten wire with 1 cm length and diameter of 0.7 mm, which is placed inside ceramic tube. The probe has been connected to measurement circuit Fig. 3. Capacitor C and coil L forms analog filter for reducing both the noise and the fluctuations vacuum-arc plasma parameters. V_B – is a varying voltage source in the region of -30 … +100 V.

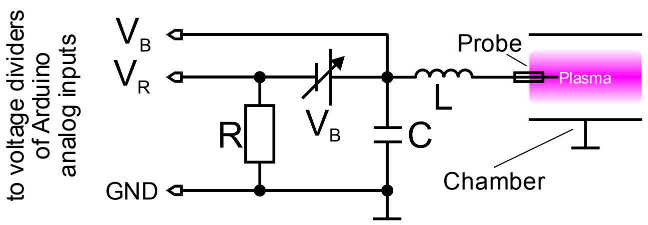

Fig. 3. Langmuir probe measurement circuit

The measuring resistor R has resistance of 100 Ohms. The output of the circuit is connected to Arduino analog inputs through the voltage dividers (Fig. 4). It has been done because of limited input voltage of Arduino analog pins by the value of 5 V.

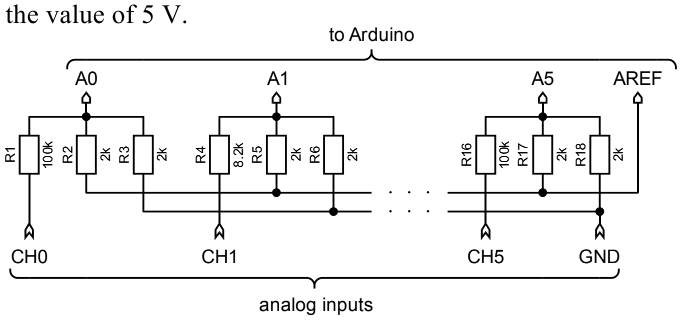

Fig. 4. Voltage dividers

C. Arduino Board

Arduino Nano V3.0 is a surface mount breadboard with integrated USB. This board is based on ATmega328 microcontroller. It supports the recommended working voltage in the range of 7…12 V. In our case, we use 9 V standard batteries. An FTDI FT232RL on the board channels this serial communication over USB and the FTDI drivers (included with the Arduino software) provide a virtual COM-port to software on the computer.

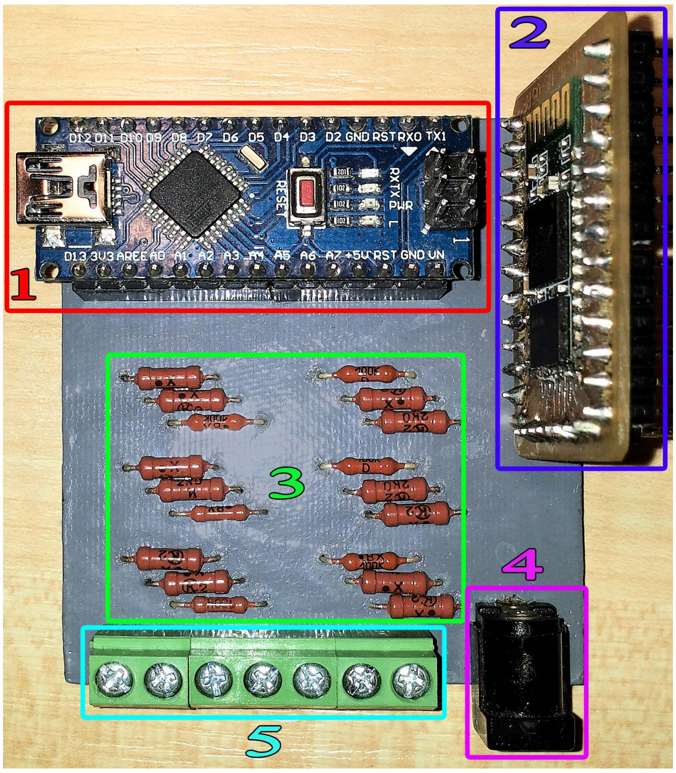

Fig. 5. Data Acquisition System mainboard: 1 – Arduino Nano V3.0; 2 – Bluetooth module HC-05; 3 – voltage dividers; 4 – power jack; 5 – probe signal inputs.

The Arduino Nano has 8 analog inputs (6 of which are used in our system), each of which provide 10 bits of resolution. The ATmega328 has 32 KB, (also with 2 KB used for the bootloader) of flash-memory and 2 KB of SRAM and 1 KB of EEPROM. The microcontroller clock speed is 16 MHz. The board has serial pins used both to receive (RX) and transmit (TX) TTL serial data. These pins in our system are connected to the Bluetooth module. Arduino Nano board, Bluetooth module and voltage dividers are mounted all together on the printed-circuit mainboard (Fig. 5.).

D. Bluetooth Module

HC-05 module is an easy to use Bluetooth Serial Port Protocol (RX-TX) module, designed for transparent wireless serial connection setup. Serial port Bluetooth module is fully qualified Bluetooth V2.0+EDR (Enhanced Data Rate) 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband. It is shown on Fig. 6.

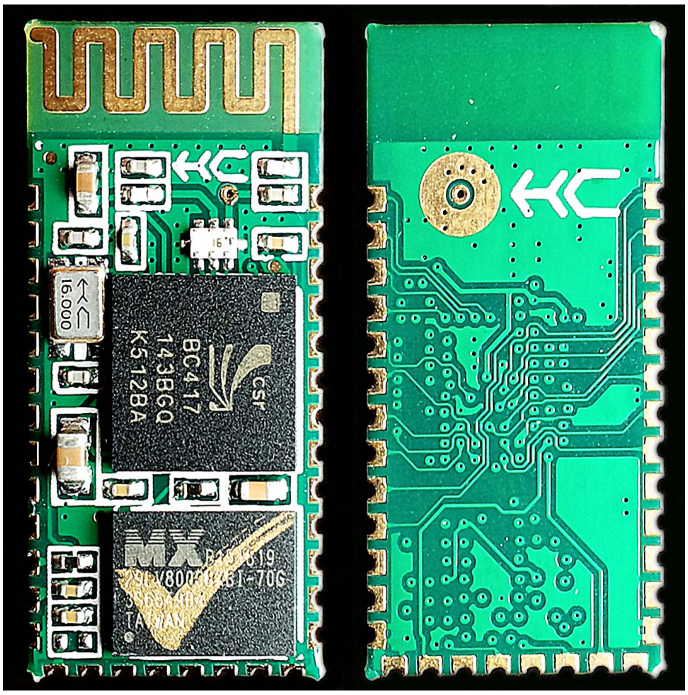

Fig. 6. Bluetooth module HC-05.

It has the size of 12.7×27 mm. The module has low power operation (3.6 V) and UART interface with programmable baud rate. In our case, baud rate is 115200.

E. *Software*

Android OS based device is used for receiving and storing the digitized data. The application for these purposes was developed using the recommendations of the tutorial [4]. All control buttons and timer counter are placed on top of the main application window Fig. 7. Six real-time graphs for monitoring each analog channel are placed under the buttons. The system provides the possibility for acquiring data with speed 28…30 samples per second ("Start Record" button).

III. Results of Probe Measurements

The main application of the developed data acquisition system is "in-situ" measurements of Langmuir probe current-voltage characteristics in such type of discharge configuration. The maximum varying voltage in our experiments does not exceed 100 V. The probe has been placed in the center of chamber on the distance 23 cm from hollow anode. I-V characteristics were recorded by slowly varying bias voltage during 1 minute. Thus, for some certain magnitude of bias voltage we recorded few values of the probe current. By averaging these probe current values we can reduce the noise which is passed through the analog filter. A typical (averaged) current-voltage characteristic is shown in Fig. 8.

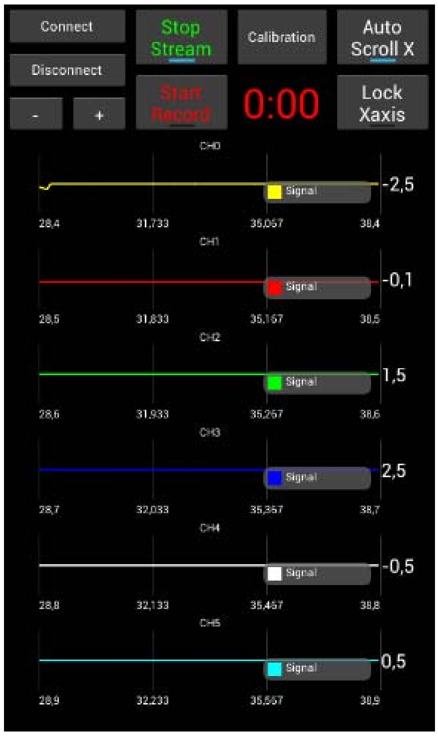

Fig. 7. Main Android application window.

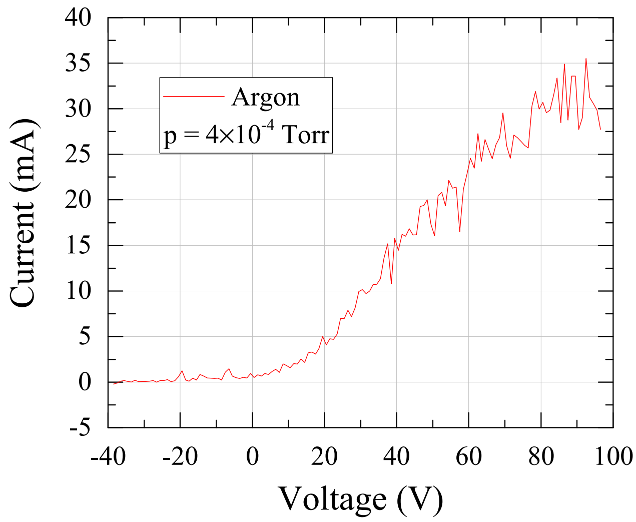

Fig. 8. Typical current-voltage characteristics of Langmuir probe.

Two different working gases were used in performed experiments: argon and nitrogen. The electron temperature was calculated from slope of the I-V characteristics in logarithmic scale. The temperature dependence on gas pressure has a following behavior as shown by Fig. 9.

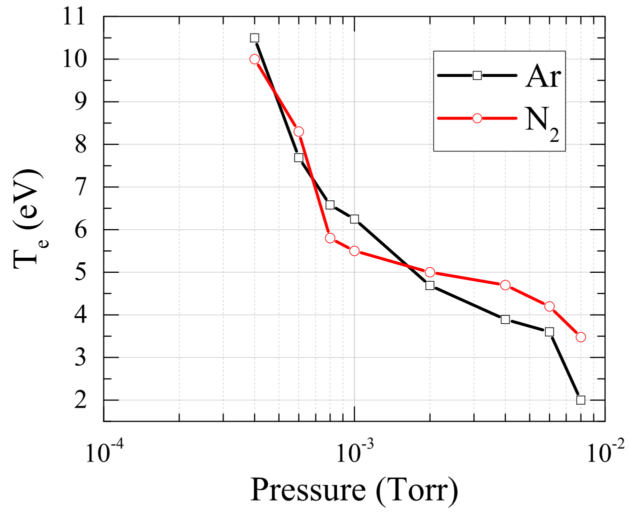

Fig. 9. Electron temperature vs. pressure for argon (black) and nitrogen (red) gas discharges.

Conclusions

Data acquisition system based on Arduino Nano platform has been proposed and designed. Bluetooth wireless protocol has been used for data transmission. The process of data visualization and recording can be done on an conventional Android OS device with the developed application. The system was successfully applied for acquiring data of Langmuir probe measurements in the non-self-sustained discharge with a hollow anode. The results of measurements showed that our system could be effectively used for data acquisition of Langmuir probe measurements in conditions of stationary plasma discharges.

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