A SIMPLE DATA ACQUISITION SYSTEM BASED ON ARDUINO PLATFORM FOR NON-SELF-SUSTAINED GAS DISCHARGE PLASMA DIAGNOSTICS

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

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INTRODUCTION

One of the most important parts of plasma diagnostics equipment is digitizing and storing data of measurements. An industrial data acquisition systems produced by many companies, such as LabView, usually have a high price. However, nowadays, there is a possibility to build 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] present an application in the scenario of controlling the information processing and communications between sensors and actuators onboard of an autonomous flying robot, in a "fly-by-wireless" approach. Krishnan J. et al. [2] present application in medical field. It serves as a remote monitor for measuring and analyzing along with logging of data from patients. Jenifer T.M. et al. [3] developed a mobile robot which is used for autonomous temperature measurement, as an early detector of fire in forest and also as a sensor kit in warehouses, hospitals, etc.

We have not found any information about application of Arduino-based wireless data acquisition system in plasma diagnostics. Also we understand that the limitations of this system (due to low acquisition speed) could be the reason for its failure in plasma diagnostics. However, in the case of stationary plasma, i.e. in our case, the system shows good results.

1. SYSTEM DIAGRAM

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

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

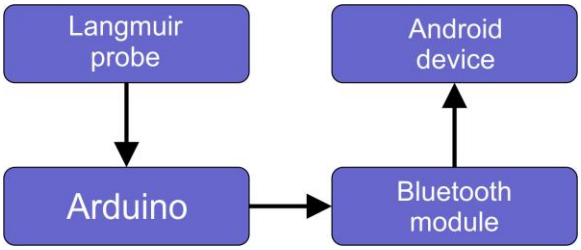

Fig. 1. System block diagram

2. LANGMUIR PROBE

Langmuir probe consists of tungsten wire with 1 cm long and diameter of 0.7 mm placed inside of ceramic tube. The probe was connected to measurement circuit Fig. 2. Capacitor C and coil L forms analog filter for reducing noise and vacuum-arc plasma parameters fluctuations. V_B – is a varying voltage source in the region from -30 to +100 V. The measuring resistor R has resistance of 100 Ohm. The output of the circuit is connected to Arduino analog inputs through voltage dividers. It is because of limited input voltage of Arduino analog pins by the value of 5 V (Fig. 4).

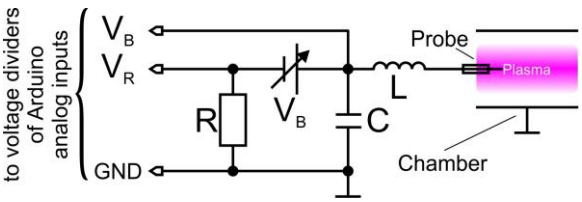

Fig. 2. Langmuir probe measurement circuit

3. ARDUINO BOARD

Arduino Nano V3.0 is a surface mount breadboard with integrated USB. This board is based on ATmega 328 microcontroller. It supports the recommended working voltage in range 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.

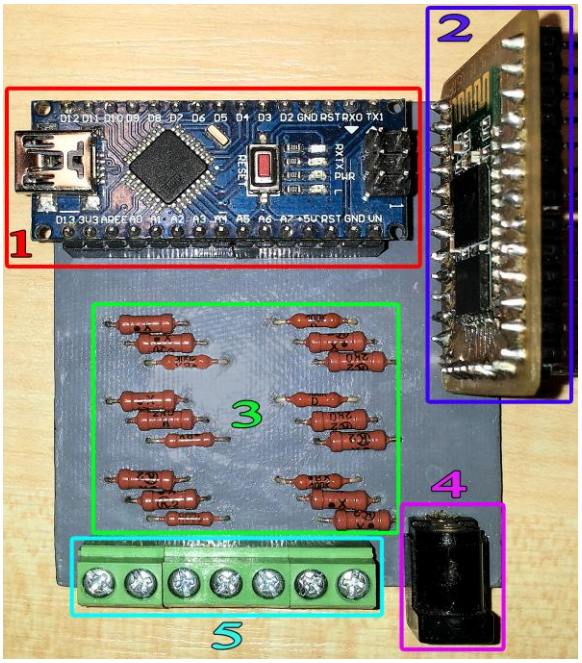

Fig. 3. Data Acquisition System mainboard: 1 – Arduino Nano V3.0; 2 – Bluetooth module HC-05; 3 – voltage dividers; 4 – power jack; 5 – probe signal inputs

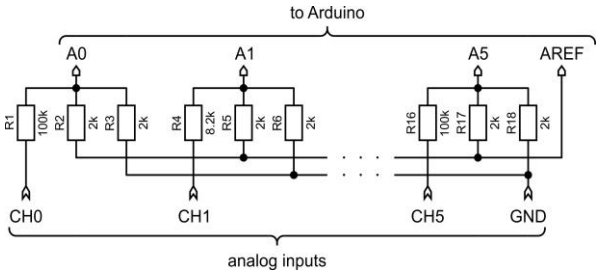

Fig. 4. Voltage dividers

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 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 all together mounted on the printed-circuit mainboard (Fig. 3.).

4. 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 2.4 GHz radio transceiver and baseband. It is shown on Fig. 5.

It has the size 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.

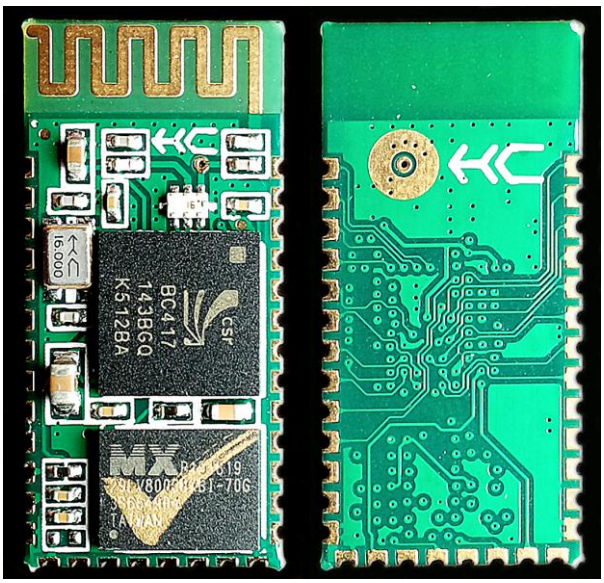

Fig. 5. Bluetooth module HC-05

5. SOFTWARE

Android OS based device is used for receiving and storing 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. 6. 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).

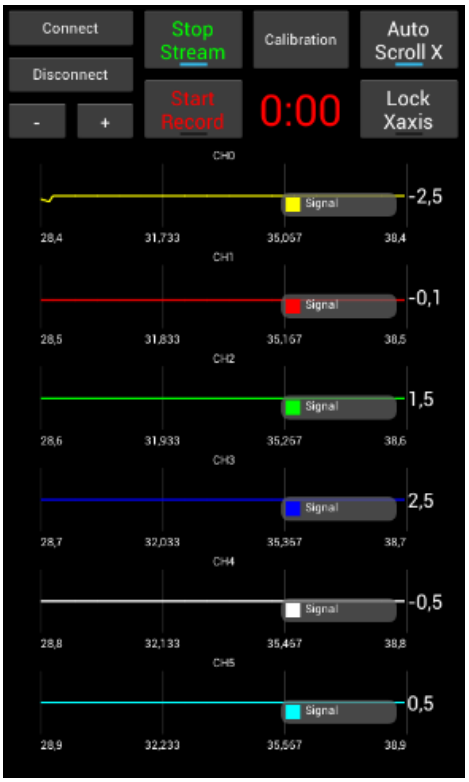

Fig. 6. Main android application window

6. RESULTS OF PROBE MEASUREMENTS

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 [5-7]. Such type of discharge may be easily excited in widely used vacuum-arc deposition setups. Between metallic cathodes and anode, power sources in such setups provide, as a rule, the arc current ranging from tens to hundreds of amperes at a voltage of a few tens of volts. With easy switching on such equipment one can obtain a discharge in a gas with almost the same values of current and voltage. Due to enhanced plasma density and degree of ionization, the processes of surface treatment in such gas discharge are much more intense than it is in a self-sustained glow discharge.

The main application of the developed data acquisition system is measurement 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 was placed in the center of the 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 value of bias voltage we record a few values of probe current. By averaging these probe current values we can reduce the noise which passed through the analog filter. A typical (averaged) current-voltage characteristic is shown on Fig. 7.

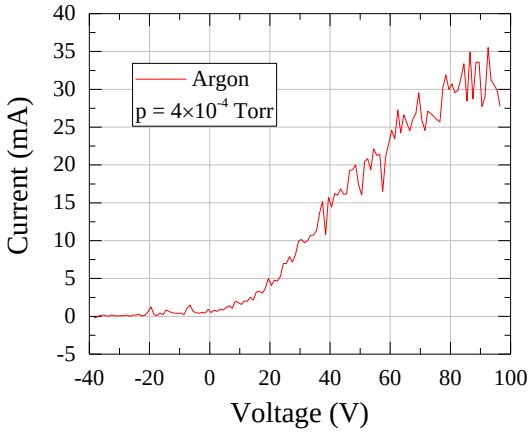

Fig. 7. A typical current-voltage characteristi

Two working gases were used in the experiment: argon and nitrogen. The electron temperature in eV was calculated from the I-V characteristics. The temperature dependence of pressure has a following behavior Fig. 8.

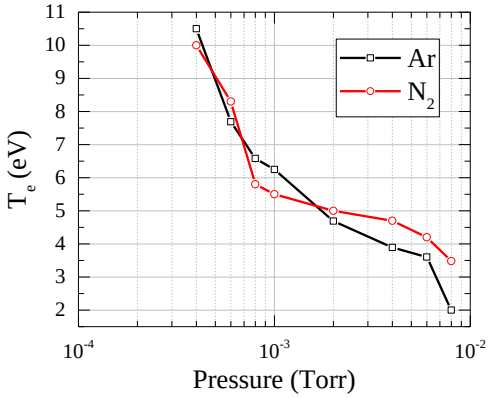

Fig. 8. Electron temperature versus pressure for argon (black) and nitrogen (red)

CONCLUSIONS

Data acquisition system based on Arduino Nano platform is developed. Bluetooth wireless protocol is used for data transmission. The process of data visualization and recording can be done on an ordinary 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 show that our system can be applied for data acquisition of Langmuir probe measurements in stationary plasma.

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СИСТЕМА СБОРА ДАННЫХ ДЛЯ ЗОНДОВЫХ ИЗМЕРЕНИЙ В ПЛАЗМЕ НА ОСНОВЕ ПЛАТФОРМЫ ARDUINO

И.А. Мисирук, А.И. Тимошенко, В.С. Таран, И.Е. Гаркуша

Разработана простая система сбора данных на основе платформы Arduino Nano. Bluetooth протокол был использован для передачи данных. Приложение для визуализации и записи данных разработано для операционной системы Android. Система была успешно применена для сбора данных зондовых измерений в несамостоятельном газовом разряде с полым анодом.

СИСТЕМА ЗБОРУ ДАНИХ ДЛЯ ЗОНДОВИХ ВИМІРЮВАНЬ В ПЛАЗМІ НА ОСНОВІ ПЛАТФОРМИ ARDUINO

І.О. Місірук, О.І. Тимошенко, В.С. Таран, І.Є. Гаркуша

Розроблено просту систему збору даних на основі платформи Arduino Nano. Bluetooth протокол було використано для передачі даних. Додаток для візуалізації та запису даних розроблено для операційної системи Android. Система була успішно застосована для збору даних зондових вимірювань в несамостійному газовому розряді з порожнистим анодом.