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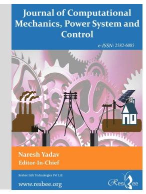

The Arduino Microprocessors in the Development by some Components of the Systems of Monitoring in the Laboratory with the Plasma-Chemical Installation

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Abstract: Plasma is often described as the fourth state of matter, distinct from solid, liquid, and gas. It consists of ionized gas particles containing free electrons and positively charged ions. The reactor chamber is where the plasma is generated and maintained. It is designed to contain and control the plasma discharge, often using vacuum systems, magnetic fields, or other confinement techniques to manipulate the plasma properties. This increases the demand for protection, warning, security, and surveillance systems. We developed a security and leak detection alarm unit, consisting of system security and alarming as well as leak alarming systems and video unit surveillance on a mobile platform (video machine).The mobility and controllability of a video surveillance system on a mobile platform (machine) allows to change the system configuration at any time remotely. The developed blocks can be used as independent devices, combined into a single, complex, or integrated into other systems. The use of this system in a plasma-chemical laboratory has shown the usefulness of these devices in ensuring the security of the premises, the protection of equipment, and the safety of students and researchers. The prospect of integrating this equipment into the general monitoring system in the laboratory lies in the possibility of using these devices as additional sources for collecting research information, including various kinds of experiments with their video recording.

Keywords: Alarm; Arduino; Laboratory; Security; System; Video Camera On Mobile Platform.

Nomenclature

Abbreviation	Expansion
WAN	Wireless Sensor Network
PPE	Personal Protective Equipment
FTP	File Transfer Protocol
MEMS	Micro-Electro-Mechanical Systems
MOX	Metal oxide
PC	Personal Computer

1. Introduction

In modern laboratories, there is often a need for timely data both on the state of the laboratory itself and on the course of experimental research. Significant assistance in these matters can be provided by the monitoring systems. From the work of [8], monitoring can be defined as a procedure control of research implementation, as well as data collection and presentation of research results according to the protocol/ plan/ program or standard operating procedure. The use of computer system monitoring in mini productions (laboratories), combined with experimental research is a serious help for the most effective use of available equipment [15].The main trends related to the development of monitoring systems for mini-productions are aimed at getting the maximum effectiveness and one that can be easily rebuilt for another product [6].The peculiarity of laboratory installations is that they are used for conducting experimental research but are also used for mini production of raw materials. At the same time, on one installation (perhaps with slight variations) technologies for obtaining various substances close to the method of obtaining [17].

We note that any chemical, food, pharmaceutical, or similar production implementsa specific complex technology and specific chemical-technological system that consist so facertain number of devices and technological connections between them.

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During this study several questions needed to be addressed:

1) Develop a system for monitoring the integrity of the premises, including windows and doors.
2) To resolve the issue of unauthorized persons being in the laboratory.
3) To remotely monitor the laboratory and the progress of experiments.
4) Organize the possibility of recording images of violators, progress of the experiment, and sending their photos to the person in charge of the laboratory and responsible for conducting experiments.
5) The ability to film from different parts of the laboratory and different angles.
6) Ensure the safety of the people during classes in the laboratory.

To solve these problems, it was necessary to develop an appropriate monitoring system. The proposed system is based on Arduino microprocessor systems for security and warning alarm units, leak alarming systems, and video surveillance on a mobile platform. The process involves selecting tools, choosing a programming environment, assembling, installing, and programming the blocks, followed by testing in the laboratory. The security and leaking alarm system utilizes Arduino Uno modules, functional sensors, an autonomous power source, and external actuators. The Arduino module processor processes signals and generates trigger commands for external actuators, enabling the sending of leaking notices to the laboratory owner via a GSM module connected to a SIM card. These developments can be used as independent units or integrated into other systems for various applications, mainly for premises protection and surveillance. The performance was assessed based on surface type of lighting and type of control, showing the ability to control the machine using a PC or smartphone.

The rest of the paper is organized as follows: Section 2 covers the literature review.

2. Literature Review

Monitoring systems for chemical, chemical-technological, etc. laboratories must be equipped with security and control systems. Quite a large number of works are devoted to this topic.

In 2017, Sun,*et al.* [25], presented the development of a wireless security monitoring system for chemistry and chemical laboratories. The system utilized a WSN to detect fire, toxic gas leaks, and abnormal sounds in the laboratory. Once an in security is detected, the system can control the corresponding devices, transmit information and images to a handheld terminal, and give an alarm to ensure the safety of laboratory personnel and minimize equipment loss. The system allowed supervisors to monitor the safety status of the laboratories in real time and take effective protection measures. The experimental results demonstrated the practical application value of the wireless security monitoring system.

In 2021, Sun,*et al.* [24]executed a wireless monitoring and automatic protection system for laboratory safety in chemistry and chemical engineering laboratories (CCEL). The system was based on a WSN and included indoor wireless security monitoring nodes, information aggregation and management nodes, portable handheld terminals, and a laboratory security information management system. The system allowed all-weather online monitoring of indoor safety information, ensuring continuous and safe scientific research experiments. It reduced the workload of laboratory managers, reported accidents accurately, and minimized losses through automatic protection devices. The system can also be used in dangerous goods warehouses and inflammable and explosive places

In 2010, Lio& Teng, [9] applieda real-time laboratory safety monitoring system called WebNet System, which used a small number of network cameras and wireless sensors for monitoring laboratory safety and personnel tracking. The system allowed remote monitoring via computer or 3G mobile phone. The results showed that the WebNet System had excellent monitoring effectiveness compared to traditional surveillance systems.

In 2022, Ali,*et al.* [2]adopted a real-time smart vision-based labsafety monitoring system to verify the compliance of students with PPE in educational labs. The system utilized YOLOv5 and YOLOv7 models trained on a self-created dataset named Students Lab Safety to detect PPE items such as masks, gloves, lab coats, and goggles. The performance of different YOLOv5 and YOLOv7 versions was compared based on evaluation metrics like precision, F1 score, recall, and mean average precision (mAP). The experimental results showed promising performance in detecting PPE in educational labs, with the YOLOv5n approach achieving the highest mAP of 77.40% for small and large instances. The proposed system aimed to enhance lab safety awareness and establish a health and safety culture among students.

In 2018, Poongothai, *et al.* [13] presented a platform that allowed devices to be connected and controlled remotely via a network. This allowed monitoring of overall laboratory activities, including energy consumption and device use, monitoring environmental parameters with the using sensors. The kits were developed using ESP8266, Arduino Uno, relays, Raspberry Pi3 current transformers, and sensors. The control was carried out using the CIT IoT laboratory device using the Node-Red panel or in the Android Studio mobile application. The dashboard and mobile app were designed to interact with IoT and MQTT brokers. The Node MCU was also used to control the temperature, humidity, and lighting of the laboratory.

In 2023, Odon, *et al*. [11] devised a laboratory management system that included recording, temperature, oxide level carbon (CO2), and the presence of smoke from open fires These parameters were controlled by corresponding sensors transmitting information to the Arduino microprocessor processed data based on the predetermined algorithms and produced solutions. Based on these decisions instructions were sent to the relay module, which triggered the necessary actions. The tests carried out showed more than 90% successful operations and only 9% false positives.

In 2023, Al-Okby, *et al.*[1]experimented with mobile detection and alarm systems for harmful gases or gaseous substances, especially in laboratory conditions. More than 40 works were considered. Was assessed of the detection technology, sensor characteristics, processors (type: microprocessor, microcontroller, etc.), and type of communication technology used (Bluetooth/BLE, Wi-Fi/RF, ZigBee/XBee, etc.). It was noted that most systems had a communication interface based on Wi-Fi, and sometimes GSM, BLE, and RF were added to them, among the processors were in the lead Arduino Uno, AT mega 3283, AT mega 1281, data access was carried out primarily via smart phone, Laptop, PC, Web, Cloud, less often Internal Memory. Execution form sprimarily were Portable devices, WSNs, robots, and drones.

In 2024, Bhuiyan & Sabina, [3] implemented a hardware implementation of a low-cost and easy-to-assemble robot for monitoring an object. Microcontroller was used Arduino Mega 2560 and Bluetooth module HC-05. The robot was equipped with various sensors for image capture and obstacle detection respectively. Microprocessors are used to control the robot's movement and process sensor data. Module Bluetooth was used to establish communication between the robot and the Android device. For movement, a platform on 4 wheels was used image fixation was carried out using a pair of mini cameras. The robot was capable of patrolling the designated territory and sending surveillance footage in real-time via Wi-Fi on an Android device.

2.1 Review Table

Author	Technology used	Detected
Sun,*et al.*[25]	WSN	Temperature, smoke, flame, toxic gases, and abnormal sound
Sun,*et al.* [24]	WSN	Fire information, toxic gas content, and abnormal sound.
Lio& Teng, [9]	WebNet	Emergencies or objects moving within the monitored areas.
Ali,*et al.*[2]	YOLOv5 and YOLOv7	Detecting personal protective equipment.
Poongothai, *et al.*[13]	IoT and mobile application technologies	Temperature, humidity, and light intensity
Odon, *et al.* [11]	IoT	Fire, temperature, and carbon (ii) oxide (CO) levels
Al-Okby,*et al.*[1]	MEMS and MOX	Hazardous gases and volatile chemicals
Bhuiyan & Sabina, [3]	Arduino Mega 2560 microcontroller	Obstacles

2.2 Research Gap

- The literature lacks detailed information on the specific challenges or limitations faced during the development and implementation of Arduino-based monitoring systems in laboratory settings.
- There is a gap in the research regarding the comparative analysis of different monitoring system configurations using Arduino microprocessors in laboratory environments.
- Limited information is available on the integration of additional sensors and actuators into Arduino-based systems for enhanced functionality and performance.
- The literature does not extensively cover the potential security vulnerabilities associated with the use of Wi-Fi connectivity in video surveillance units connected to Arduino microprocessors.

3. Methodology

3.1 General Architecture

Fig 1 shows the plasma-chemical installation located in the laboratory for monitoring purposes. The system consists of selecting tools for developing the appropriate blocks, choosing a programming environment, assembling, installing, and programming blocks, and carry in gout tests directly in the laboratory. In the development of a monitoring system in a laboratory with plasma chemistry installation, the blocks responsible for protection were developed and tested to identify leakages through video surveillance.

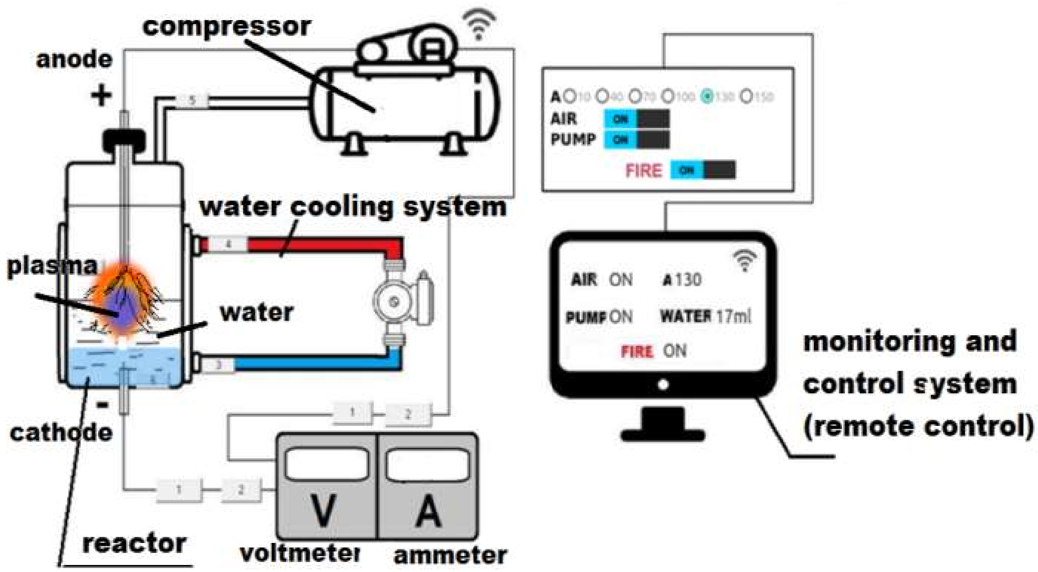


Fig. 1. *General diagram of the plasma-chemical installation located in the laboratory-5 – sensors of the installation monitoring system*

The microprocessor systems control the corresponding blocks. Initially, Arduino-based systems were selected. It includes Arduino Uno modules, sets functional sensors, movement detector HC-SR501 – infrared, gas sensor MQ-2, sensor leaking fluid (water), the relay module, connecting GSM Shield Neoway M590, sensor door opening buzzer MH-FMD, reed sensors, autonomous power supplies, and external executives devices.

The video machine is called an Arduino NANO 3.0 module. The body of the machine is framed on 2WD (platform with additional wheels). The following components used are NANO Atmega238p and cable USB, SANNCE high definition (HD) 720p, Wi-Fi camera model I21AG with charger device, machine body kit (platform with two gear motors DC3V-6V and three wheels – two main and one auxiliary), 2 ceramic capacitor 0.1 – 10 µF, motor driver L298N, 18650 battery and compartment for it, boost converter MT3608, charge controller module MH TP4056-PROTECT 5V, connecting wires and L298N motor driver for Arduino.

To connect to a PC, a CH340G chip was used (driver for it pre-installed before working with Arduino). Arduino NANO is powered by a mini-B USB connector or external power source 6–12V (pin "Vin"), or 5V stable external power supply (pin "5V"). The power automatically switched to the higher voltage source. Arduino Uno module programming is done using the Arduino IDE software and firmware in its Code Ender module. This system is very flexible, so it can be incorporated into any other alarm system. As well, if necessary, extra equipment or sensors, remote warning systems, etc.

Programming was carried out using an integrated development environment for Windows Arduino IDE [5]and its built-in Code bender module, as well as code, was written for the SANNCE HD 720p «JoyLite» camera mobile application program (sketch) with which speed and movement were controlled cars[19].The selectionofmicroprocessorsystemsbasedonArduinowasalsodonebecauseArduino is an open platform. This platform includes so-called starter kits and open-source software and is also designed for quickly creating interactive electronic devices.

3.2 Security Alarm Unit For Liquid Or Gas Leaks

The process is carried out in a room laboratory [17] and monitored through monitoring systems that use Arduino micro processors. The room itself had only one door and two windows. The main requirements for such laboratories include fire and explosion safety and protection from the entry of unauthorized persons. It needs remote control and video surveillance. The alarm unit helps to notify the breaking or entering through an autonomous power system. It is additionally able to notify the liquid leakage, gas leak, possibility of connecting and changing sensors, and indicators of hazardous substances. A separate surveillance and security system is represented in Fig. 2.

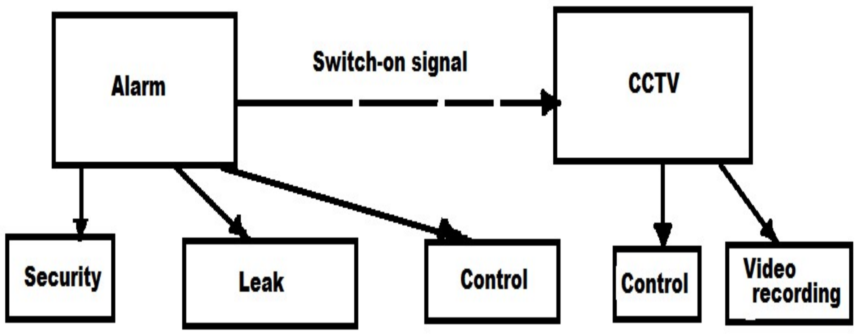


Fig.2. *Functions performed by alarm and video surveillance units in the laboratory.*

The security alarm system[26] used a microprocessor system based on Arduino Uno. It is connected to Arduino Uno modules, a set of functional sensors, an autonomous power source, and external actuators.

When one of the connected sensors is triggered, a signal is transmitted to the Arduino module processor. Using downloaded and user software, the microprocessor performs signal processing according to a specific algorithm. As a result of execution, a trigger command is generated through an external actuator. Then the leaking notices will be sent to the owner of the laboratory. This process is due to connecting a special GSM module into which a SIM card from one of the mobile communication providers is installed [16].

To create a security system [20], The following components used are an Arduino Uno board, high-contrast LCD 16 × 2, keyboard 4 × 4, 10 ~ 20 k Ohm potentiometer, 3 reed sensors, 3 2-pin screw terminals, and HC-SR04 ultrasonic sensor. Fig 3 presented a Signaling diagram based on an Arduino Unomicro processor module for a room with one door and two windows.

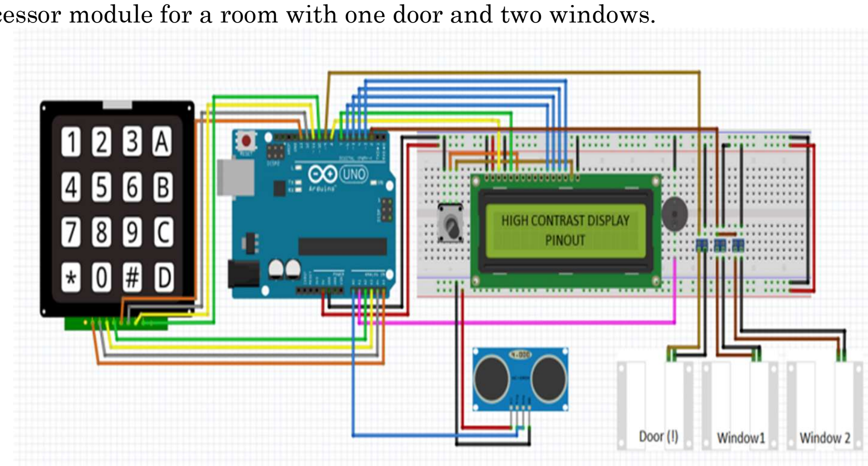


Fig.3. *Signaling diagram based on Arduino Unomicro processor module for a room with one door and two windows.*

The Arduino Uno module is programmed using the program Arduino IDE and the Codebender module built into it. This system is integrated into security alarm systems. It is also possible to connect with additional equipment with various sensors, remote control systems alerts, etc., if necessary.

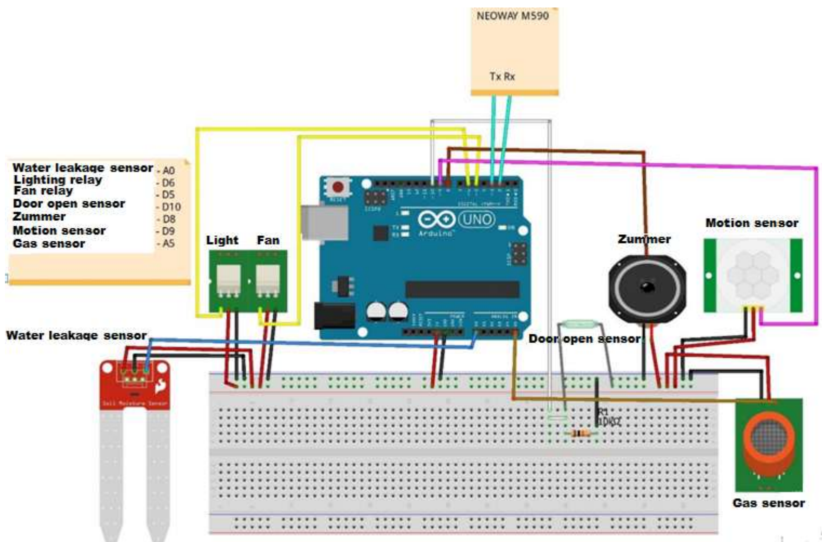
The system has two operating models an alarm (security mode) and a leak detection mode (when working in the laboratory, alarming about leaks, etc.).

To set the alarm to security mode, use the «A» button on the numeric keypad. After pressing it, the security mode was turned on after 10 seconds. If there was an intrusion into the laboratory territory, a sound signal was activated. To turn off security mode, it is necessary to enter the correct password and press the «*» button on the keypad. Also, a function was provided to change the password by pressing the button «B». This security alarm system used 3 reed switches sensor and 1 ultrasonic, for tracking movement. When the doors opened, it took 20 seconds to enter the correct password, at 21 seconds the system began to loud beep.

3.3 Detection Of Leakage Through Additional Sensors

Fig.4. shows one of the options for connecting additional sensors to operate the system in alarm of leak detection mode. Where 1 – GSM module based on NEOWAY M590 for operation under the control of a controller or computer (viaa universal serial bus (USB) / universal asynchronous receiver/transmitter (UART).Inputs for connecting to Arduino Uno: Water leakage sensor – A0;

Gas sensor – A5; Fan relay – D5; Lighting relay – D6; Zummer – D8; Motion sensor – D9; Door open sensor – D10.



*. **4.** General diagram of connecting sensors for a leak detection system.*

Connecting sensor leaking fluid (water). The sensor has 3 outputs - +, -, and S. Plus and minus outputs are connected to the breadboard for inputs. The analog output S is connected to an analog input A0 Arduino board.

3.4 Connecting Gas Sensor

Gas sensor MQ-2 has four outputs - VCC, GND, D0, and A0. VCC and GND are connected to the + and - breadboard. Yield D0 and A0 are respectively discrete and analog output sensors. This scheme used only analog output A0 A5 which connects to the analog input board Arduino UNO

3.5 Connecting The Relay Module

The relay module has 4 outputs - VCC, GND, IN2, and IN1. VCC and GND are connected to the breadboard. IN1 IN2 and outputs connected to the binary inputs D5 and D6 respectively. Module 2 has an additional input under the 220V device. This is to ensure that when any of the Arduino sensors are sending the relay signal to switch illumination or fan to ventilate the room.

3.6 Connecting GSM Shield Neoway M590

M590 module has 8 outputs - + 5V, GND, I, T, R, V, K, G. Outputs + 5V and GND are connected to corresponding inputs on the Arduino board. The outputs T and R are communication channels Tx and Rx, where Tx is the receiver and Rx is the source. They are connected to the discrete inputs D2 and D3. To turn on the output of the module, K must be connected to the output of G and therefore worth a jumper between them.

3.7 Connect The Motion Sensor

Movement detector HC-SR501 – infrared (has 3 outputs - GND, Power+, Output. Outputs Power + and GND are connected to the + and - breadboard and Output D9 output to the input board Arduino UNO
H. Connection of the sensor door opening

The door opening sensor is connected to one output + breadboard and a second output is connected to the digital input boards D10 Arduino. For proper operation of the sensor, the output D10 must be short-circuited through a 10K resistor to GND. Connecting buzzer MH-FMD buzzer has 3 outputs - VCC, GND, Input, and output VCC, and GND are connected to respective tracks on the breadboard. Output I / O is connected to a logic input on D8 Arduino.

4. Result Performance of The Video Surveillance and Recording Unit

The video surveillance unit was a Wi-Fi-controlled mobile video device based on Arduino. When developing it among Arduino modules for the system Arduino NANO 3.0is chosen for video surveillance. The advantages of this module are its small size and ATmega328 memory, with a capacity of 32 KB (2 KB allocated for the loader).Connection to a PC was made via cable mini USB.

The L298N motor driver for Arduino is used to control two low-power brushed DC motors or one low-power 4-wire two-phase stepper motor. The mounting board has one mounting hole for mounting the motor on a flat surface.

The driver is powered from an Arduino controller or a no the micro processor control device attached or from an external source power supply (power supply, battery). The supply voltage was 2-9 VDC. Control signal – 1,8 – 7 V DC. The motor's maximum connection current was 1.5 A.

The MT3608 boost switching voltage converter is designed for receiving voltage up to 28 V with load current up to 2 A from a low voltage source. The regulator on the converter board made it possible to select the required output voltage level.

TheMHTP4056-PROTECT 5V charge controller module is based on the TP4056 chip – a charge controller for 3.7V Li-Ion and Li-Po batteries with a built-in temperature sensor. The TP4056 chip automatically completes the charging cycle when its voltage reaches 4.2V and 1/10 of the programmed value. The module indicates the charging process. At the time of charging, the red LED glowed. When the battery was fully charged, the green LED was lit, and the 18650 battery.

Connecting wires PVB-3 with a cross-sectorialareaof0.75 mm^2 are power wires that consist of a monolithic copper conductor with a cross-section from 2 to 95 mm^2 in polyvinyl chloride insulation. To make it easiertodist in guish the poles in the circuit, wires of different colors were used.

The performance of the finished unit in the form of a video machine was assessed. The results are shown in Table 2. It shows the effect of surface type of lighting and type of control on the operation of the camera.

Table 2. *Test results*

Surface/ working time, hours		**Image quality**			**Control**	
Without obstacles	With obstacles	Daylight/ distance, m	twilight/ distance, m	night/ distance, m	From PC	From smartphone
6	5,12	HD/< 30	720/< 8	720/< 8	✓	✓
5,49	5,35	HD/< 30	720/< 8	720< 8	✓	✓
5,52	5,21	HD/< 30	720/< 8	720<8	✓	✓

As follows from Table 2, control of the video machine was possible using either a PC or via smartphone. The image obtained is sufficient for using the presented device as an integral part of the created system monitoring of a chemical technology system for recording and video surveillance.

To connect to a PC, a CH340G chip was used (driver for it pre-installed before working with Arduino). Arduino NANO is powered by a mini-B USB connector or external power source 6–12V (pin "Vin"), or 5V stable external power supply (pin "5V"). The power automatically switched to a higher voltages source.

The power connection was made via a standard micro-USB connector. An 18650 battery was used for an autonomous power supply. When the battery is discharged charger was used.

The SANNCE HD 720p Wi-Fi IP video camera model I21AG with night motion sensor. The main features are

- P2P technology – the ability to observe what is happening in the roomor holes, and control the camera in real-time (this requires access to Internet networks).

- Rotating camera: horizontally 350°, vertically 90°.
- Clear night shooting-Infrared illumination (visibility at night up to 8 m, during the day – upto 30m).
- Recording video and photos to a memory card, smartphone/ tablet, or FTP server (support for memory card up to 64 GB).
- Two-channel audio communication, built-in microphone, and 1W speaker.
- Supply voltage– 5 V
- Security devicemode – Alarm activation based on movement in the field of view cameras (It is possible to set a certain time after which an alert should be sent to a smartphone if motion is detected).
- Dual stream technology (Local recording is carried out separately from remote viewing).
- Special software (Joy Lite) is used to provide camera control.

SANNCE HD 720p Wi-Fi camera and motor driver are connected to Arduino NANO L298N. The camera is connected via wires A0 – A5, which were connected to the microprocessor of asynchronous motors on the camera. Motor driver L298N connected to Arduino NANO using INT1 – D3, INT2 – D9, INT3 – D10, INT4 – D11 (Fig. 5).

To connect the engines, they were connected to the MOTOR-A (right motor) andMOTOR-B (left motor on driver L298N. The driver wires were connected to the gear motors. A standard library was used to control the motors AFM ot or.h [7].

The Wi-Fi-controlled video machine (Fig. 5) was powered using a battery [10],connected to the charge control module via micro USB. An MT3608 2 A – 28 V adjustable boost converter was also installed to increase the voltage since the rotation speed of the motors is constant current when connecting the Arduino board from a computer and a power supply battery was significantly different. From the boost converter power was supplied to the SANNCE HD 720p Wi-Fi camera and Arduino NANO. The L298N motors driver, which in turn supplied power to the motors through ceramic capacitors, was connected to the charge controller module along with the wires of the «+» and «–» boost poles converter.

Considering that, to perform the functions of the movements of the machine motors, it was enough signals in the form of a vector with three Boolean variables, then connected to the controller has three wires for each motor [4].

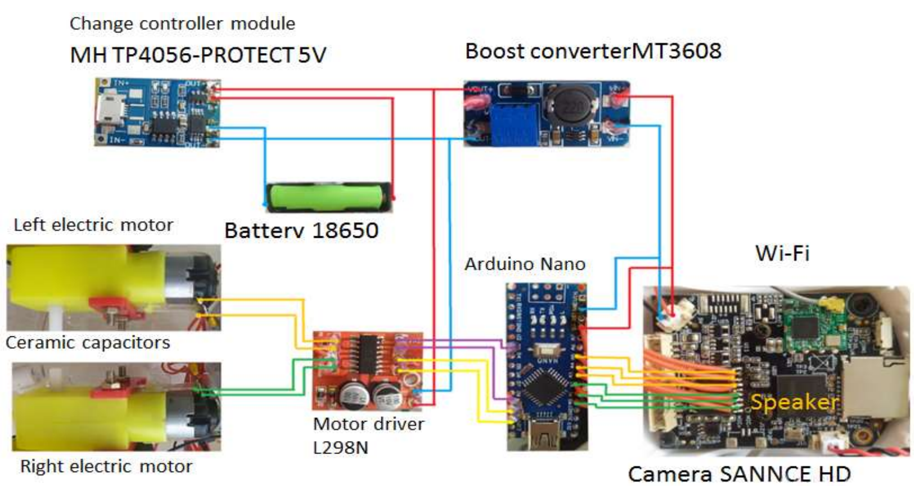


Fig.5. *The scheme of Wi-Fi-controlled video machine*

As ketch was written for the mobile application of the SANNCE HD 720p «JoyLite» camera, which was intended to decode signals from steppers camera motors, and also carried the function of transmitting signals to asynchronous motors machine and setting the speed of rotation of the machine wheels.

The algorithm for decoding camera motor signals was used during the time signals were received from the smartphone. When translating movements using this algorithm camera motors into the program code, they were written to the motors Trick function. Next, through motors Trick, signals were transmitted from the motor driver to the motors of the machine. Thus, after transmitting signals from a smartphone, it was possible to configure wheel rotation speed.

A video machine controlledvia Wi-Fi is shown in Fig. 6. Dimensions of the finished product: width to outer the sides of the wheel axle are 255 mm, length is 260 mm, height with wheels and camera is 190 mm.

To operate the SANNCE HD 720p «JoyLite»: camera mobile application: first download the «JoyLite» application from the App Store or Play Market; after downloading the application an available Wi-Fi network and a SANNCE HD 720p camera were "tied" to the smartphone. After completing the setup, the window from the «live-video» camera was connected to the «JoyLite» application.

Fig. 6. *Wi-Fi controlled video machine.*

Checking additional features of the camera (including video recording and photos to a memorycard, smartphone/ tablet of FTP server with support for memorycards 64Gb;two-channelaudio communication through the built-in microphone and speaker; security mode device; local recording separately from remote viewing) gave a positive result.

When connecting the machine to a smartphone or computer, ease was noted in the control of the machine, which does not require special skills because it is an intuitive clear interface.

Note that the use of a monitoring system consisting of three blocks, namely:

– Security and warning alarm unit responsible for the integrity of the laboratory;
– An alarm unit that notifies about leaks of various substances in liquid or gaseous form;
– A video recording unit that could move around the laboratory.

This made it possible to solve many problems of security, and safety and resolve controversial issues related to various types of violations. In addition, the use of a stationary alarm to turn on a video machine in a sleep node made it possible to significantly reduce energy consumption and extend the operating time of the machine without changing its batteries.

We also note that such projects may well be developed by students undergoing training in the relevant specialties [23].

5. Advantage And Disadvantage

Advantages

- Enhancing flexibility and convenience in surveillance and security operations.
- Easy to control without requiring specialized skills, making it accessible to various users.
- Provided a reliable and customizable platform for developing security and surveillance systems, ensuring efficiency and adaptability.
- Integration of various sensors and actuators enhances the functionality of the security and alarm systems, enabling comprehensive monitoring and alert mechanisms.
- The video surveillance unit's compact design and Wi-Fi connectivity offer mobility and ease of installation, expanding the application range for monitoring purposes

Disadvantages

- The security alarm system's reliance on a numeric keypad for operation may pose limitations in terms of user-friendliness and speed of response.
- The use of multiple components and sensors in the security and alarm systems may increase complexity and maintenance requirements.
- The video surveillance unit's reliance on Wi-Fi connectivity may introduce potential vulnerabilities related to signal interference or network security.

6. Conclusions

The presented devices based on Arduino microprocessors can be used as the basis for security alarm systems. A computer security alarm system can be used in various fields, mainly for the security of premises. They can also be used as built-in units for other systems. The mobility and controllability of the video surveillance system on a mobile platform (machine) allows you to change the configuration of the video surveillance system at any time and this can be done remotely.

The use of this system in a plasma-chemical laboratory has shown the usefulness of these devices to ensure the security of the premises, the protection of equipment, and the safety of students and researchers. The prospect of integrating this equipment into the general monitoring system in the laboratory lies in the possibility of using these devices as additional sources for collecting research information, including various kinds of experiments with their video recording. Thiscould be a topic for further research.

Compliance with Ethical Standards

Conflicts of interest: Authors declared that they have no conflict of interest.

Human participants: The conducted research follows the ethical standards and the authors ensured that they have not conducted any studies with human participants or animals.

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