

MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF
KAZAKHSTAN

Non-profit joint - stock corporation
ALMATY UNIVERSITY OF POWER ENGINEERING AND
TELECOMMUNICATION named after G. Daukeev
Department of *Electronics and robotics*

«Allowed to defence»

The head of department of «Electronics and robotics»

Chigambayev T.O. c.t.s., associate professor

(Full name, academic degree, rank)

_____ « _____ » _____ 2020 year
(sign)

DEGREE PROJECT

On the topic: *Design of UAVs for the study and recording of rare animals*

Done by: *Bexultanov Madiyar* *PSa-16-3*
(Surname and initials of a student) (group)

Specialty *5B071600 Instrumentation Engineering*

Research supervisor *Balbayev G.K. PhD, docent*

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_____ « _____ » _____ 2020 year
(sign)

Consultants

on economic part: *Tuzelbayev B.I. Ph.D, associate professor*
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_____ « _____ » _____ 2020 year
(sign)

Almaty, 2020

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ALMATY UNIVERSITY OF POWER ENGINEERING AND
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Institute of space engineering and telecommunications
Department of Electronics and robotics
Specialty 5B071600 Instrumentation Engineering

ASSIGNMENT
for execution of degree project

Student Bexultanov Madiyar Makanuli
(Full name)

Topic of the work Design of UAVs for the study and recording of rare animals

Approved by the order of the rector № 155 from « 23 » october 2020 y.

Deadline of the finished work « 8 » june 2020 y.

Initial data required parameters of the results and initial data:

1. Raspberry Pi 3 B+
2. Multiwii controller
3. Raspicam v2
4. Any smartphone

List of issues to be developed in a degree project or a summary:

1. Explore the hardware component of Raspberry Pi 3 and argue the choice of this particular single-board computer
2. Describe the principle of operation of an object recognition system based on the Python
3. Program part
4. Development of life safety measures
5. Economic justification of the project

List of graphical material (with precise indication of mandatory drawings);
This degree project contains 48 figures and tables

Recommended basic literature:

1. Pavlushenko M., Evstafiev G., Makarenko I. UAV: history application, threat of proliferation and development prospects. M., "Rights person", 2005.
2. Inozemtsev D.P. Unmanned Aerial Vehicles: Theory and practice // Automated research and design technologies, 2013. No2. - S. 50-54.
3. S. Korotkiy, "Neural networks". Saint Petersburg, 2002

Consultants for work with indication of the relevant section

Section	Consultant	Date	Sign
<i>Life safety</i>	<i>Begimbetova A.S</i>	<i>16.05.2020</i>	
<i>Economic part</i>	<i>Tuzelbayev B.I</i>	<i>18.05.2020</i>	

SCHEDULE

Of degree project preparation

№	Title of section, list of issues to be developed	Deadline for submission to instructor	Note
1	<i>Theoretical part</i>	<i>29.01</i>	
2	<i>Engineering part</i>	<i>05.03</i>	
3	<i>Program part</i>	<i>15.05</i>	
4	<i>Life safety</i>	<i>16.05</i>	
5	<i>Economic part</i>	<i>18.05</i>	
6	<i>Conclusion</i>	<i>06.06</i>	

Date of issue of the assignment « 20 » 01 2020 year

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The assignment for execution is accepted by: Bexultanov Madiyar Makanuli
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Аңдатпа

Дипломдық жұмыста сирек кездесетін аңдандарды зерттеуге және оларды санақ жүргізуге арналған ұшқышсыз ұшу аппаратының (ҰҰА) прототипінің әзірленуі қарастырылады. Осындай мақсатқа арналған ҰҰА-ның негізі болып Raspberry Pi 3 B+ бірплаталы микроконтроллері келтіріледі, ал ол өз кезегінде проекттің программалық бөлігінің жұмысын қамтамасыз етеді.

Құрылымды және функционалды схемалар көрсетілген болатын, олардың негізінде ҰҰА ның әзірленуі және жобалануы жүргізілен болатын. Дипломдық жұмыстың программалық бөлігі Raspbian операциялық жүйесінде Python жоғары дәрежелі программалау тілінде жүзеге асырылған.

Дипломның құрылымы кіріспеден, төрт бөлімнен, қорытынды мен әдебиет тізімінен тұрады.

Аннотация

В данном дипломном проекте рассматривается разработка беспилотного летательного аппарата (БПЛА) для изучения и ведения учета редких животных. В основу БПЛА для подобной цели ляжет одноплатный микроконтроллер Raspberry Pi 3 B+, что в свою очередь обеспечит всю работу программной части проекта.

Были показаны структурные и функциональные схемы, на основе которых осуществлялись разработка и проектирование БПЛА. Программная составляющая дипломного проекта была создана в операционной системе Raspbian на высокоуровневом языке программирования Python.

Структура дипломной работы состоит из введения, четырех разделов, заключения и списка литературы

Annotation

This graduation project discusses the design of a unmanned aerial vehicle (UAV) for the study and recording of rare animals. The UAV for this purpose will be based on the Raspberry Pi 3 B + single-board microcontroller, which in turn will ensure all the work of the software part of the project.

Structural and functional schemes were shown, on the basis of which the development and design of UAVs was carried out. The software component of the graduation project was created in the Raspbian operating system in the high-level Python programming language.

The structure of the thesis consists of introduction, four sections, conclusion and list of references

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Introduction

Nowadays, the trend of creating UAVs for special purposes is becoming increasingly widespread. Projects for state and civil security, medicine, military weapons, modification of fees in the agro-cultural sector - everywhere the ideas of using UAVs are used or promoted.

According to the definition approved by the ICAO Assembly, “an unmanned aerial vehicle (drone) is an aircraft without a pilot, which performs flight without an aircraft commander on board and is either completely remotely controlled from another place from the ground, from the side of another aircraft, from space, either programmed and completely autonomous

The operating conditions of the UAV operator may vary depending on the field of activity. The drone operator can stand in the stadium with a remote control and direct the drone that carries the poster. UAV operators in the Air Force service work in specially equipped rooms at the air base, where several screens, sensors and vibration of joysticks allow you to monitor the situation around the device, which is located thousands of kilometers from the base.

The main advantage of UAVs is the lack of people from the inside, so that they have the opportunity to carry out the most difficult problems. UAVs can be used in chemical places. irradiation, since for the purpose of the crew, complicated life-support concepts are in no way necessary.

For the purpose of an unmanned aerial vehicle (UAV) of one of more significant issues is considered the implementation of a whole flight project, in independence from various unexpected disturbing conditions, appearing in flight. Mechanical Flight Control Issues interconnected with the task of resolving UAV research issues.

The aim of this thesis is to create software that allows you to scan the territory for the presence of animals in it for further identification of objects visually

To achieve this goal it is necessary to solve the following interconnected tasks:

- Study of the UAV control processExplore the hardware component of Raspberry Pi 3 and argue the choice of this particular single-board computer
- Develop software for subsequent work on identifying objects
- Describe the principle of operation of an object recognition system based on the Python
- Description of the hardware component of the UAV itself
- Show results of processing photos and videos using computer vision

1 Unmanned aerial vehicle and single board microcontroller Raspberry Pi.

Main part

1.1 A brief description of the UAV. Their advantages over manned aircraft.

Unmanned Aerial Vehicle (UAV) - in the aggregate case, this flying device without crew on board. Performance flying the device contains a huge number of species, any of which has its own unmanned analogue. In print, if the conversation goes about a sudden surge of interest in drones, and in this the material used to establish the UAV receives the most limited view. And directly: a flying device in no crew on board applying aerodynamic rule the formation of portal power with the support of fixed or rotating shutter (UAV aircraft and helicopter type), equipped with a motor and having the right load and duration flights satisfied with the purpose of fulfilling specialized issues.

With the support of unmanned systems, it is possible to exercise control as well as the technical provisions of the objects, as well as their security, activities, in addition to the fact that the managed objects can be at a considerable distance (extended objects). The superiority of UAVs over manned aircraft is considered, first of all, as a whole, the price of work, and in addition a significant reduction in the number of regulatory procedures. The very absence of a person on board an aircraft greatly simplifies preparatory activities for the purpose of aerial photography.

Firstly, there is no need to purchase an airfield, even the simplest one. Unmanned aerial vehicles are launched either by hand or with the support of a special take-off device - catapults. Secondly, when applying the electric motor circuit, there is no need for competent technical support for the maintenance of the aircraft, measures to ensure safety at the facility procedures are much simpler.

Thirdly, there is no or significantly increased inter-operational period of UAV operation in comparison with a manned aircraft. This fact is of great importance when operating an aerial photography complex in remote regions of our state.

Thus, the marching season of aerial photography is short-lived, any clear period should be used for the purpose of shooting. The list of issues and areas of use of UAVs noted above sets special conditions as well as for UAVs personally, and thus to targeted on-board equipment. Despite the alleged similarity of issues of combat and civilian use of UAVs, there are several basic differences, which are required to appear in basic conditions for ensembles with UAVs.

A typical unmanned aerial vehicle is made of lightweight composite materials: this helps to reduce the weight of the hull and increase the maneuverability of the device. The properties of such materials allow military drones to fly at extremely high altitudes.

Drones are equipped with various technologies, such as infrared cameras, GPS and lasers (to a greater extent, this applies specifically to military models). Unmanned aerial vehicles can be controlled by a remote system, sometimes also called a ground-based cockpit. That is, we can say that the UAV consists of 2 parts: the drone itself and its control system.

The "nose" of the drone is the place where its sensors and navigation system are located. Everything else is placed in the "body" of the device. The composite material from which the devices are made, in addition to its lightness, is also capable of absorbing vibration.

UAVs come in a variety of sizes, and the largest of them are most commonly used for military purposes, such as the Predator. This is followed by medium-sized drones with fixed wings, which require the take-off of a small runway. Such models are used to cover large areas such as reconnaissance and poaching. Example of the simple drone is illustrated on picture 1.1



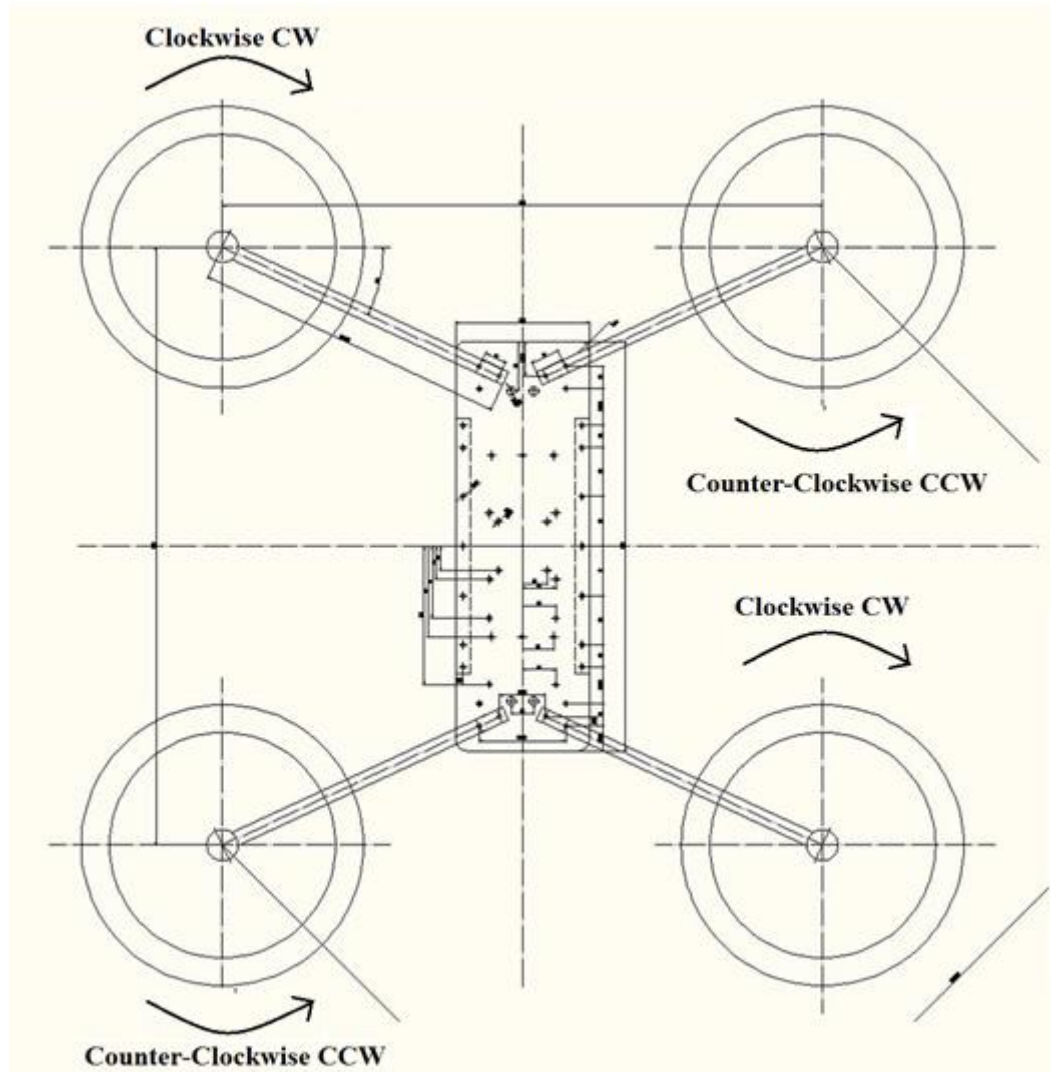
Picture 1.1 – VTOL drone model

Gyrostabilization technology allows drones to fly smoothly and accurately. Gyro must operate at lightning speed to ensure a stable flight of the device. In addition, it provides all the necessary navigation information for the pilot, i.e. joyful.

An inertial measurement unit (IMU) is used to monitor the current acceleration of the device using a combination of several accelerometers. Some IMUs also contain a magnetometer to further stabilize the device.

Gyroscope is an integral part of the IMU, which is an important component of the UAV control and measurement system. The Flight Controller is actually the central brain of a drone.

Thanks to its engines and propellers, drones are able to fly in any direction. On quadcopters, they work in pairs: 2 engines and 2 propellers rotating clockwise (CW Propellers) and a pair of engines with propellers rotating counterclockwise (CCW Propellers). Rotation direction of each motor units are illustrated on picture 1.2



Picture 1.2 - Propellers rotation direction

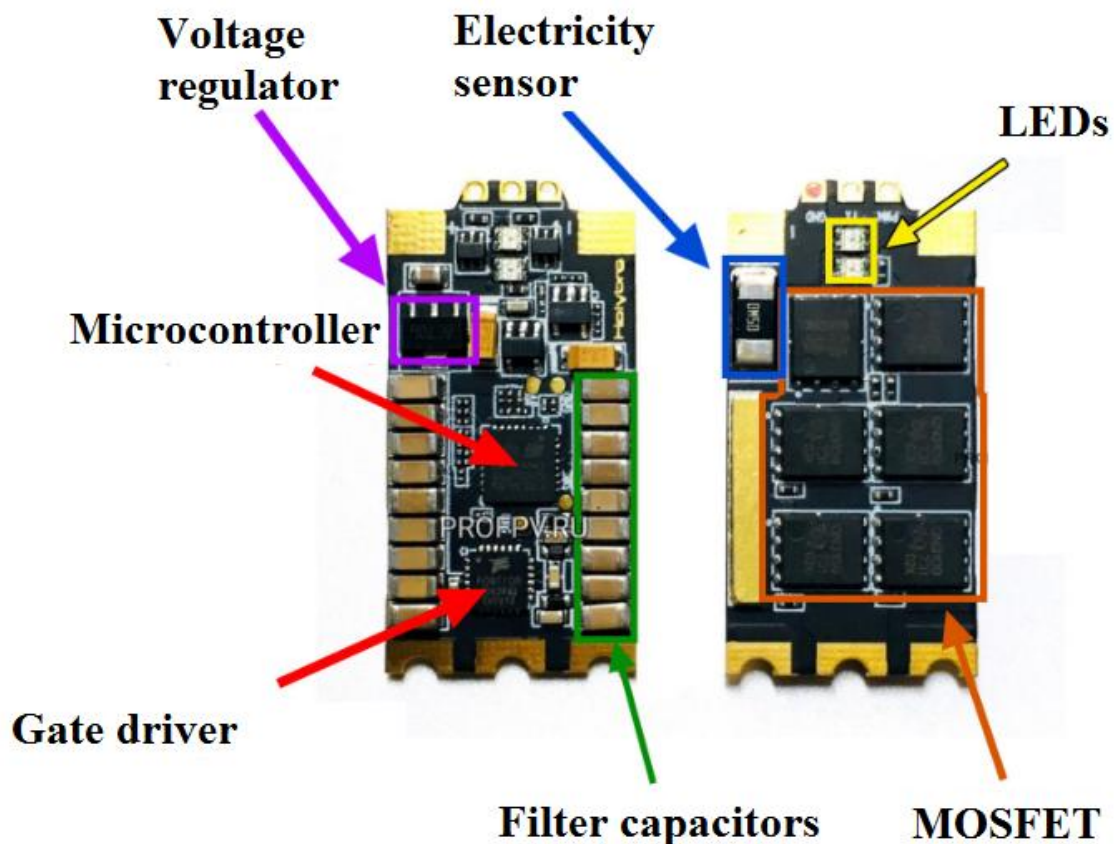
They receive data from the flight controller and from the electronic speed controller (ESC) and accordingly fly the drone somewhere or fly in the right direction.

ESC - electronic speed controller, translates as electronic speed controller. In the Russian-speaking community it is customary to call them as “speed regulators”, in the common people “regulator” or “regulators”.

What are the tasks of ESC. To understand without deepening - everything is very simple, the speed controllers, based on the name - adjust the speed of the engines based

on the commands of the flight controller. The faster the engine rotates, the more it creates traction, the faster the quadcopter flies.

How ESC speed controllers interact with engines affects the speed and traction of the aircraft, as well as its behavior in the air. At miniquadtestbench.com, QuadMcFly found in tests that the difference in traction between the best regulator and the worst is only 20%. In comparison, I can cite the choice of a car among various brands and the choice of a good regulator will give you as much power as a properly selected car engine (more precisely, a car with a good engine). Functional drawing of ESC part of the drone is shown on picture 1.3



Picture 1.3 – ESC structure

The most important part of every UAV. Accelerometers in three axes have inputs for connecting software firmware, peripheral devices and motors as well as an output for control. Without it, no drone will explode. The part is important enough to be mounted on a special shock absorbing platform to reduce the effects of vibrations and shock loads.

In order for the aircraft to be able to perform its basic functions, whether it be aerial photography, search or tracking, it must have sufficient carrying capacity to

transport all the necessary equipment. In the case of shooting, such equipment is a high-definition camera. To implement the same machine vision algorithms, it is necessary to carry a powerful computing system on board.

In addition to carrying capacity, the UAV should have a sufficient supply of energy for a flight of 10-15 minutes. During this time, you can take several pictures, shoot a short video or explore a small enclosed area. To increase flight time from above, additional development of an automatic recharging system is required.

To achieve design flight characteristics, the machine body must be made of lightweight materials such as aluminum, carbon fiber or fiberglass. Moisture protection on the experimental model is not provided.

Engines and propellers are UAV technology that raises a drone into the air and allows you to fly in any direction, as well as freeze in the air. On a quadrocopter, the engines and propellers are paired: 2 engines / propellers rotating clockwise (CW propellers) and 2 engines rotating counterclockwise (CCW propellers). They receive commands from the flight controller and electronic speed controllers (ESC) about the direction of the drone's motion either to hover in the air or fly.

1.2 Description Raspberry Pi 3 B +. Characteristics and difference from previous models

Raspberry Pi is a single-board computer, that is, various parts of the computer, which are usually located on separate boards, are presented here on one. In addition, this board has a relatively small size - approximately 8.5 * 5.5 cm.

The name of the product combines Raspberry - raspberry and Pi - the number of Pi. The image of raspberries has become the logo of the project.

Originally created as an educational project, the Raspberry Pi is great for learning the basics of electronics. Based on the Raspberry Pi, many computer classes have been created. However, today his appointment has gone beyond only educational.

The Raspberry Pi 3 Model B is a full-fledged silent card the size of a bank card, with a 64-bit quad-core ARM Cortex-A53 processor on the Broadcom BCM2837 single-chip chip.

The Raspberry Pi 3 has a 64-bit Broadcom BCM2837 processor based on the ARM Cortex-A53 architecture with a clock frequency of 1.2 GHz and a 1 GB RAM module. The processor and memory are placed on the technology of "package-on-package" directly on the processor. The BCM2837 also includes the Video Core IV® Multimedia dual-core graphics coprocessor, which provides Open GL ES 2.0, Open VG hardware acceleration, and 1080p30 H.264 decoding.

Unlike Arduino boards, the logic level voltage of the Raspberry Pi is 3.3 V. The maximum voltage that the inputs / outputs can withstand is 3.3 V and not 5 V. By applying a voltage, for example 5 V, a single-board can be disabled.

Table 1.1 – Raspberrys parts

№	Chip system	Broadcom BCM2837B0 (CPU + GPU + RAM)
1.	Processor	A 64-bit quad-core ARMv8 Cortex-A53 processor with a clock frequency of 1.4 GHz; 16 KB cache L1 and 512 KB cache L2
2.	Graphical Processor	VideoCore IV® dual-core processor (GPU) (3D GPU @ 300 MHz, video GPU @ 400 MHz) supports OpenGL ES 2.0, OpenVG, MPEG-2, VC-1 standards and is capable of encoding, decoding and outputting Full HD video (1080p, 30 FPS, H.264 High-Profil)
3.	RAM	1 GB SDRAM LPDDR2
4.	Storage	MicroSD card slot
5.	Ethernet	10/100/1000 Mbit Gigabit Ethernet (via USB 2.0) (LAN7515 controller - USB 2.0 Hub and Ethernet)
6.	Wi-Fi / Bluetooth	2.4 GHz and 5 GHz IEEE 802.11.b / g / n / ac WI-FI and Bluetooth 4.2 Low Energy (BLE) provided by Cypress CYW43455
7.	Video input	1 x CSI-2 for connecting the camera via MIPI
8.	Video output	1 x HDMI 1.3a (CEC) 1 x DSI (Display Serial Interface) for connecting a standard display; 1 x composite video output (CVBS video, PAL and NTSC) 3.5 mm jack
9.	Audio output	Jack 3.5 mm, HDMI
10.	USB ports	4 USB 2.0 ports via USB hub in Microchip LAN7515
11.	Peripherals	40 general-purpose input-output ports (GPIO), UART (Serial), I ² C / TWI, SPI with a selector between two devices; power pins: 3.3 V, 5 V and ground.
12.	Power	5 V, 2.5 A via micro-USB or GPIO port; Power over Ethernet (PoE) via separate PoE HAT (separate 4 pins)
13.	Power Management Module	(PMIC) MxL7704
14.	OS	Ubuntu, Debian, Fedora, Arch Linux, Gentoo, RISC OS, Android, Firefox OS, NetBSD,

Raspberry pi 3 B + differs from its predecessors in more improved performance, the number of innovations in the field of modules and the number of simultaneously performed operations.

The previous version in the Raspberry conveyor was a sander model pi 3 B. Both models do an excellent job, but it is worth noting that the B + model is a worthy continuation of the development branch of Raspberry microcontrollers. Below I have compared the specifications of both handheld computers on the picture 1.4

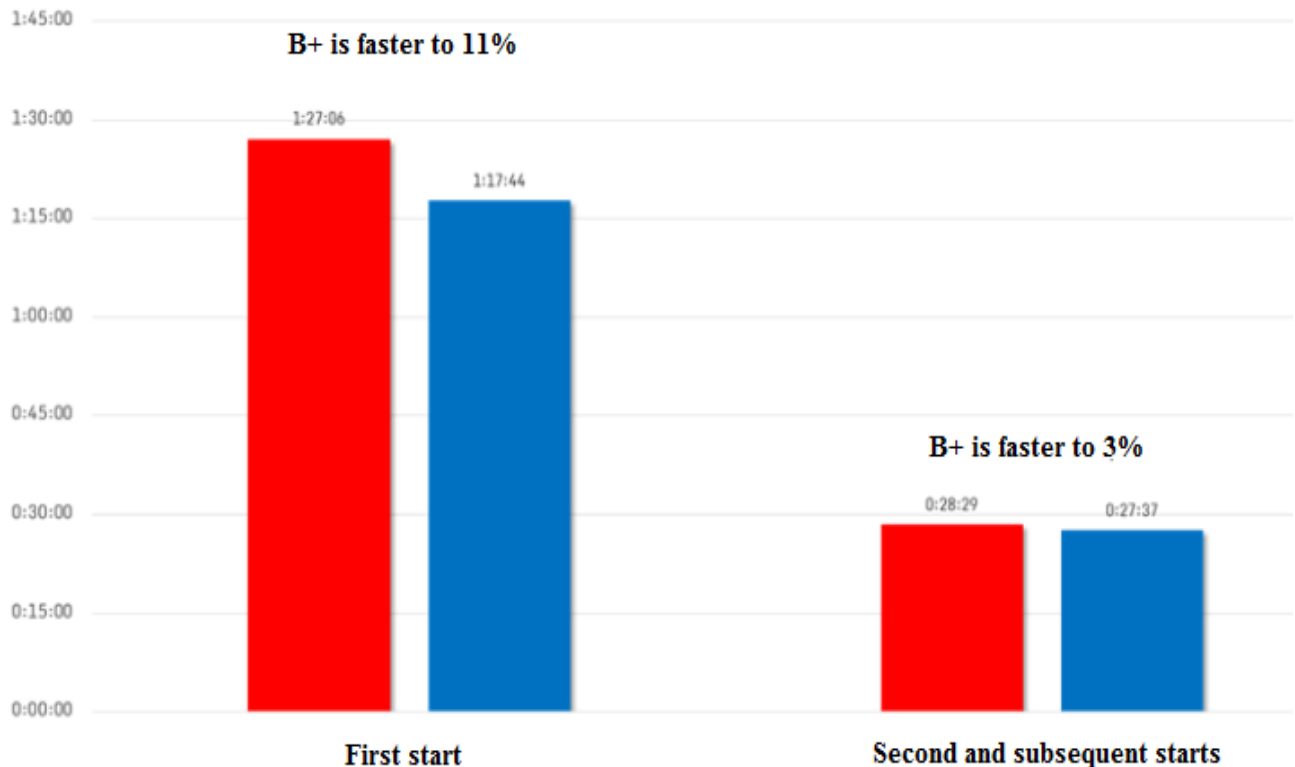
Raspberry Pi 3	
Model B (2016)	Model B+ (2018)
Broadcom BCM2837, Cortex-A53, 64-bit, quad-core SoC @ 1.2GHz	Broadcom BCM2837B0 , Cortex-A53, 64-bit, quad-core SoC @ 1.4GHz Better temperature control and higher performance
1GB LPDDR2 SDRAM	1GB LPDDR2 SDRAM
IEEE 802.11 b/g/n 2.4GHz Wireless LAN (WLAN)	IEEE 802.11 b/g/n/ ac 2.4GHz/ 5GHz Wireless LAN (WLAN)
Bluetooth Low Energy 4.1 (BLE)	Bluetooth Low Energy 4.2 (BLE)
Broadcom BCM43438	Cypress CYW43455
Microchip LAN9514	Microchip LAN7515
100 mb/s	300 mb/s (Gigabit Ethernet over USB 2.0)

Picture 1.4 – Technical characteristics of both microcontrollers

All tests are performed on the boards "as is", out of the box - without cases, radiators or other sources of active cooling. Both copies use two identical microSDHC flash cards Sony SR-16UYV 16Gb 10Class. On both flash drives, the Raspbian Stretch With Desktop 4.9 image is deployed (release 2018-04-18, with Model B + support). Power supply 5V / 2.5A.

Raspberry is more productive in comparison with its competitors. For example, you can bring Arduino. Microcontrollers which are more likely for the school curriculum and are not able to perform such a large number of operations and solving equations as the microcontroller raspberry. Arduino is more useful like a part of the working system in the head of Pi. Picture 1.5 shows the difference between each Raspberry models

Boot time



Picture 1.5 – Boot time of each Pi

The next performance test for both microcontrollers will be the calculation of π . The following operations are performed for this test, to calculate the number π , a bc calculator is used (English Basic Calculator). Before using it, you must install:

```
sudo apt-get install bc
```

```
time echo "scale=10000; 4*a(1)" | bc -l
```

Where:

- time - upon completion of the calculation, displays information about the time spent;
- scale = 10000 - accuracy, the number of decimal places - in this case 1000;
- $4 * a(1)$ - the expression for calculating the number pi - the arc tangent of 1 is multiplied by 4 (the function $a()$ calculates the arc tangent, $\arctan(1) = 45^\circ = \frac{\pi}{4}$;

- `bc -l` - the `-l` option indicates the use of a standard library of mathematical functions.

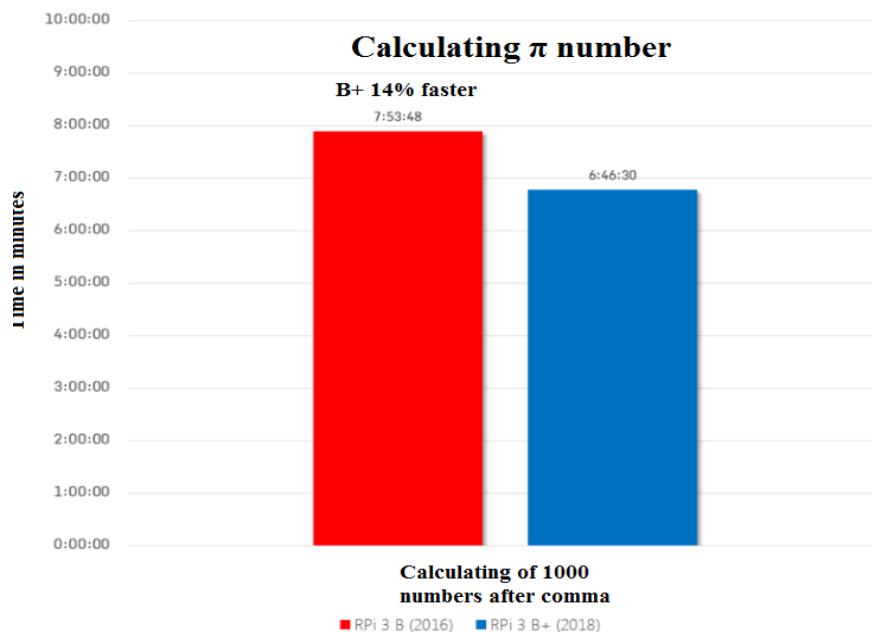
Testing is performed using the `getpi.sh` script, which starts the calculation of the π number one by one, with increasing accuracy:

```
#!/bin/bash
for scale in 10 100 1000 10000
do
    time echo "scale = $ scale; 4 * a (1)" | bc -l
    echo "_____ "
    echo ""
done
```

Script run:

```
bash getpi.sh
```

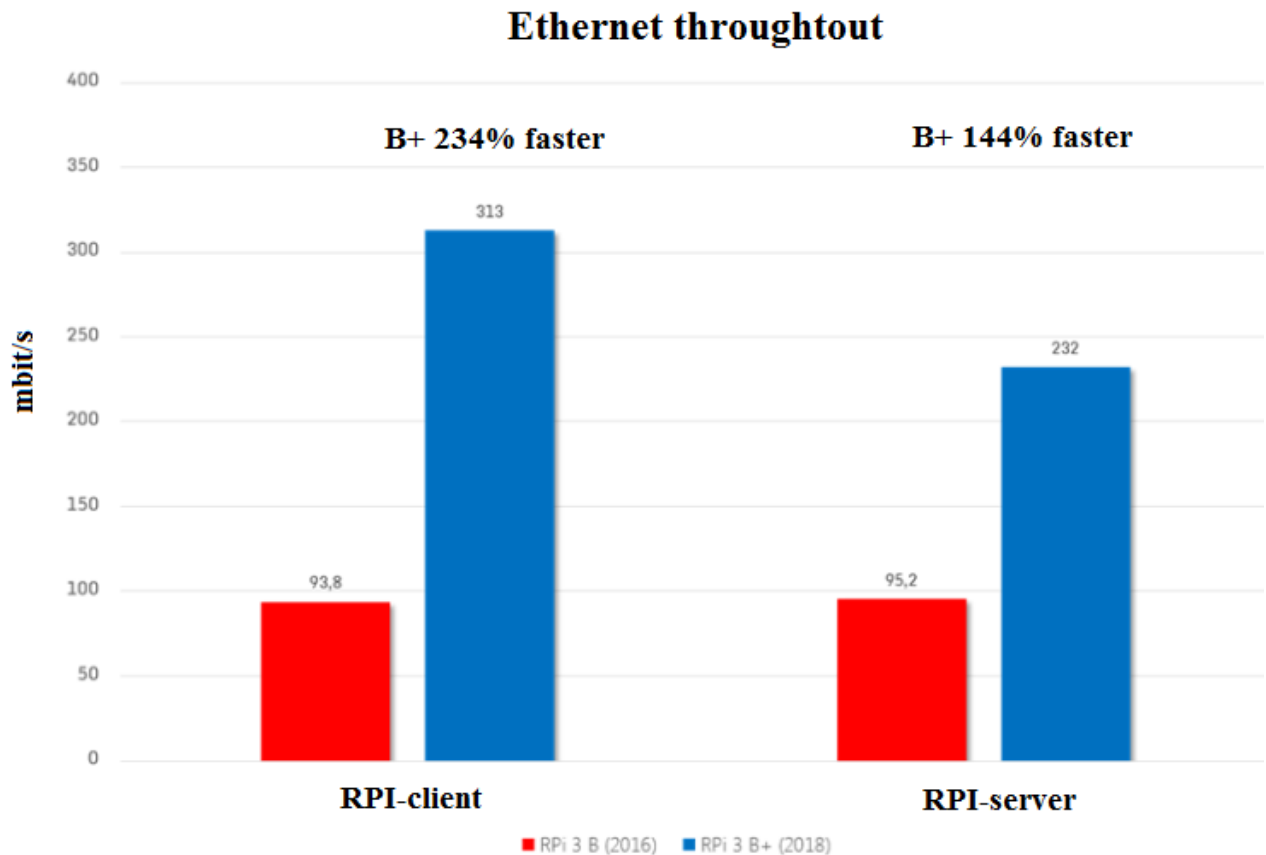
The test results again indicate that the new 3 B + burst model is better than 3 B in terms of not only the number of modules and better data transfer, but also in terms of performance and complex operations. Test results are illustrated on picture 1.6



Picture 1.6 – Calculation of π number

Gigabit Ethernet over USB bandwidth testing is performed using the iperf3 utility. For Ethernet connection, the Windows PC is equipped with the TP-Link TG-3269 Gigabit Network PCI Adapter.

Raspberry is connected via a twisted pair cable directly to a PC, bypassing routers and switches. When copying via SCP, the copy initiator is Raspberry Pi 3; when copying using FileZilla, the initiator is a Windows PC, digital data you can see on picture 1.7



Picture 1.7 – Ethernet speed test

To check out wi-fi modules of each Pi we have to install iperf3 utility and write special command, to do this we need to paste command below:

```
sudo apt-get install iperf3 -y  
  
ifwconfig
```

It's sometimes difficult to keep track of all the Raspberry Pi commands that you use, so we've created a list of the most useful and important that will greatly facilitate the use of Linux on the Raspberry Pi. Linux has two user modes that you can work

with. One is a user mode with basic access privileges, and the other is a mode with administrator privileges (superuser or root). Some tasks cannot be performed with basic privileges, so you will need to enter them with superuser privileges to perform them. After previous operations we will get information on picture 1.8

```

pi@raspberrypi ~
File Edit Tabs Help
pi@raspberrypi:~ $ iwconfig
wlan0 IEEE 802.11 ESSID:
Mode:Managed Frequency:2.422 GHz Access Point: C4:6E:1F:A4:AB:0C
Bit Rate=54 Mb/s Tx-Power=31 dBm
Retry short limit:7 RTS thr:off Fragment thr:off
Power Management:on
Link Quality=70/70 Signal level=-35 dBm
Rx invalid nwid:0 Rx invalid crypt:0 Rx invalid frag:0
Tx excessive retries:0 Invalid misc:0 Missed beacon:0

lo no wireless extensions.

eth0 no wireless extensions.

pi@raspberrypi:~ $

```

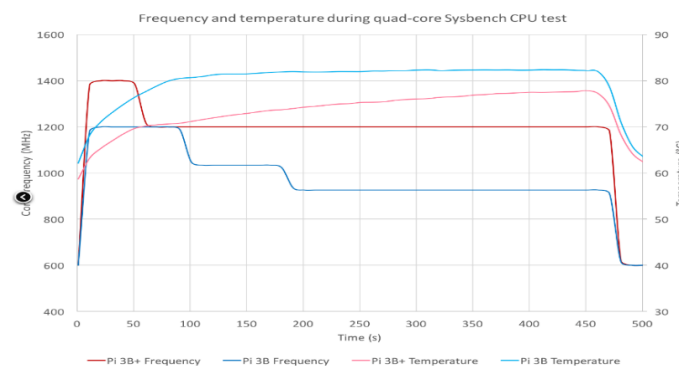
Picture 1.8 – ifconfig result

When we have checked each Pi-s wi-fi data transferring speed, we can construct the table which will show differences of Wi-Fi modules

Table 1.2 Wi-Fi modules characteristics

Pi model	Raspberry pi B	Raspberry pi B+
Link quality	70	70
Bit-rate Mb/s	54	72
Signal level, dBm	-29	-40

Thus, it was revealed that in terms of wi-fi modules, the Raspberry Pi B + model is ahead of its predecessor. In conclusion, a comparison of two pi I want to bring frequency and temperature comparison of two Raspberries on picture 1.9



Picture 1.9 – Frequency and temperature comparison

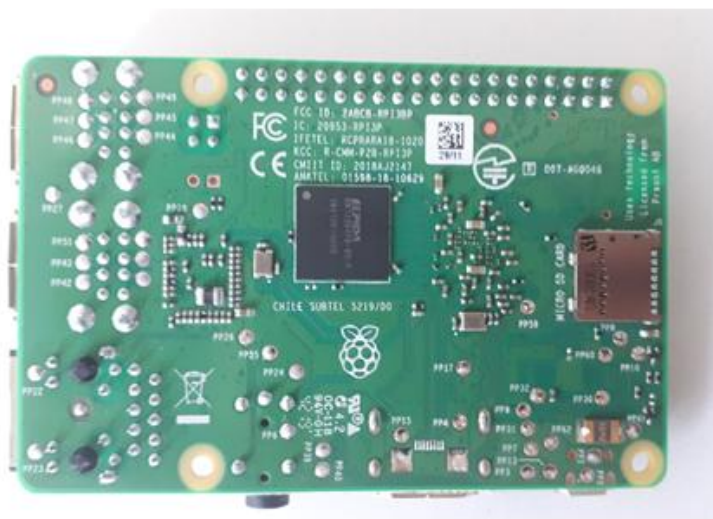
2 Technical part

2.1 Deep overview on the components and structure of the Raspberry Pi 3 B

Construction of Raspberry Pi is firstly Board or by other words System on Crystal. Special architecture of Pi gives it to operate data easily without heating itself till dangerous temperatures.

On the Raspberry Pi 3 Model B +, they improved the SoC temperature control, a metal cover also contributes to this. Below 70 ° C, enhancements are used to increase the core frequency to 1.4 GHz. At temperatures above 70 ° C, the frequency drops to 1.2 GHz, and the core voltage also decreases, thereby increasing the time until a critical temperature of 80 ° C is reached.

In order to avoid self-doubt, I have built my own prototype of working model Raspberry Pi 3 B+. On pictures 2.1 and 2.2 you can see my microcontroller at the beginning of assembly process:



Pictures 2.1 and 2.2 – Raspberry Pi 3 B+

Raspberry gets very hot when working with data in the terminal or when working with large software. The hottest nodes are a processor, an Ethernet controller and a 3.3V voltage regulator. The solution to the overheating problem is to put radiators on these microcircuits. To do this, you need a radiator from the old motherboard, saw it for metal, to cut it into pieces of the right size, sanding paper and thermally conductive glue. Here is a detailed description of the operation.

After installing the radiators, the temperature of my board dropped from 56.1 ° C to 38.8 ° C. If this is not enough, you can put a fan on top and power it from one of the GPIO ports so that you can adjust the fan speed depending on the temperature. SoC after installing aluminum radiators are given on picture 2.3



Picture 2.3 – Board after installing aluminum radiators

Two aluminum passive cooling radiators are designed to remove heat from the processor and additional chips. Cooling elements are attached with a layer of hot-melt adhesive. It is enough to remove the protective film on the back side, and then glue the large heatsink to the surface of the processor, and the smaller heatsink to the network chip, USB controller or other element. It is recommended to press the radiators with your hands for 1-2 minutes, so that the hot melt glue better grasps.

The microcontroller board is very vulnerable to external physical factors. Such as: drop, shock, pressure, careless use or elementary pollution of circuits. To avoid these factors, the best decision I made was to install a protective case around my board. The case I selected is specially printed on a 3D printer for the pi 3 model. It takes into account all the connectors for each module on the board. It is also designed to avoid overheating during active work with the microcomputer.

The Raspberry Pi 3 model B / Pi 2 model B / Pi model B + case is designed for the corresponding microcomputer model. It is made of durable, non-combustible plastic and decorated in a classic and versatile black color. Due to the high quality of the

material, the case is durable. A feature of the presented element is a screw mount, which provides a reliable and durable connection.

The case of the Raspberry Pi 3 model B / Pi 2 model B / Pi model B + is compact and light in weight. The dimensions of the case are 70x88x24 mm, and the weight is equal to 0.033 kg. The whole controller protected buy the case on picture 2.4



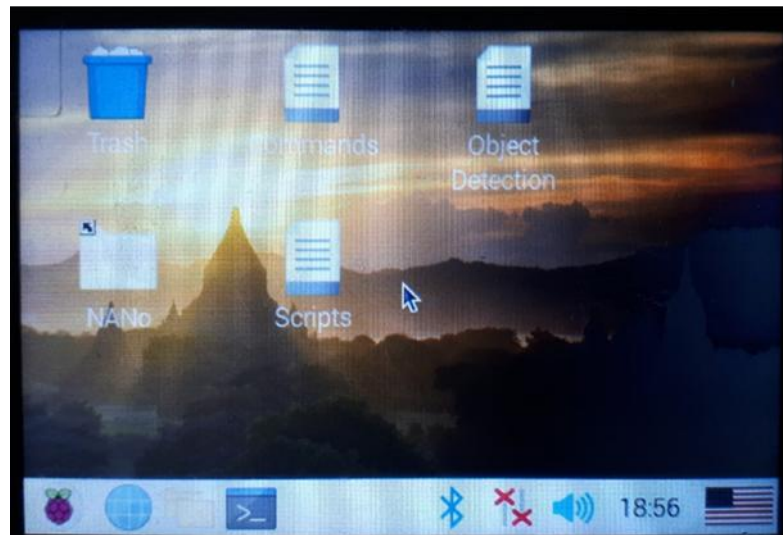
Picture 2.4 – MC with protecting body

The next important element in my assembly is the LCD screen. Thanks to it, it will be possible to connect raspberry in any place, accordingly with it the board becomes mobile. A 3.5-inch touch screen display for Raspberry Pi single-board computers (it is also compatible with some others that have the same GPIO outputs, for example, Orange Pi).

Table 2.1 LCD parts









































Model	3.5 inch Resistive Touch Screen TFT LCD
LCD type	TFT
Controller	XPT2046
Number of colors	65536
Resolution	320*480 (Pixel)
Push technology	Resistive

Designed for the Raspberry Pi, the perfect alternative solution for an HDMI monitor. Supports all revisions of the Raspberry Pi with a display resolution of 320x480, the best display. Convenient interface compatibility with Raspberry PI, anywhere, anytime. Support for systems on Raspberry PI allows you to: Watch video (support for most formats, MP4 and many others) One-touch photo processing. Support for virtual keyboards (Interaction system without keyboard / mouse). High quality workmanship. Outside and backsides of the LCD on pictures 2.5 and 2.6



Picture 2.5 and 2.6 – LCD view

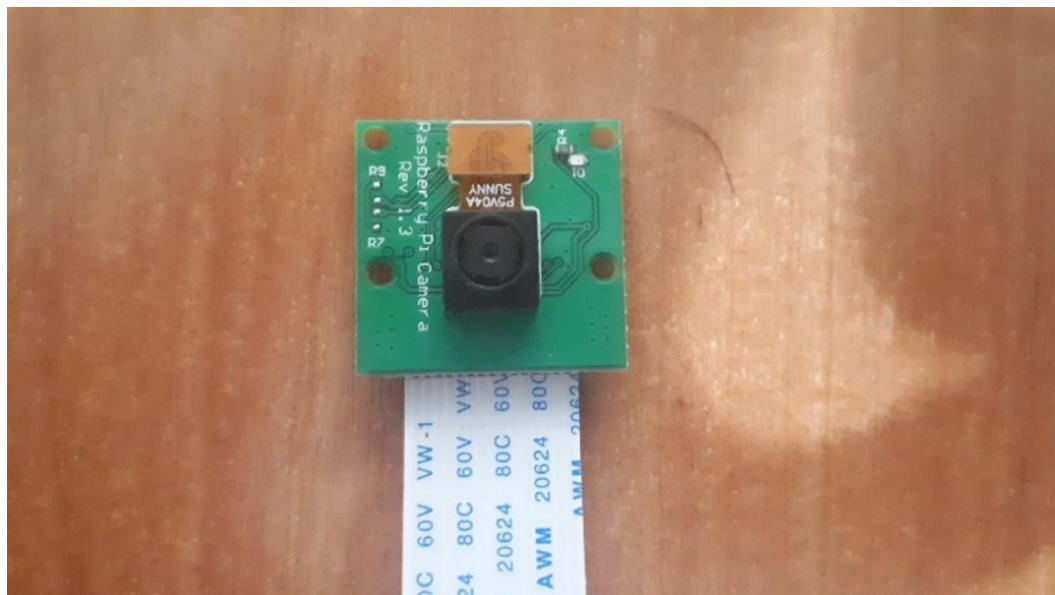
General-purpose input / output interface (GPIO) - an interface for communication between components of a computer system, for example, a microprocessor and various peripheral devices. GPIO pins can act as an input or as an output - this is usually configured. GPIO pins are often grouped into ports. The pinout of the LSD display is as follows on picture 2.7

PIN NO.	SYMBOL	DESCRIPTION	01	3.3v DC Power			DC Power 5v	02
1, 17	3.3V	Power positive (3.3V power input)	03	GPIO02 (SDA1 , I2C)			DC Power 5v	04
2, 4	5V	Power positive (5V power input)	05	GPIO03 (SCL1 , I2C)			Ground	06
3, 5, 7, 8, 10, 12, 13, 15, 16	NC	NC	07	GPIO04 (GPIO_GCLK)			(TXD0) GPIO14	08
6, 9, 14, 20, 25	GND	Ground	09	Ground			(RXD0) GPIO15	10
11	TP_IRQ	Touch Panel interrupt, low level while the Touch Panel detects touching	11	GPIO17 (GPIO_GEN0)			(GPIO_GEN1) GPIO18	12
18	LCD_RS	Instruction/Data Register selection	13	GPIO27 (GPIO_GEN2)			Ground	14
19	LCD_SI / TP_SI	SPI data input of LCD/Touch Panel	15	GPIO22 (GPIO_GEN3)			(GPIO_GEN4) GPIO23	16
21	TP_SO	SPI data output of Touch Panel	17	3.3v DC Power			(GPIO_GEN5) GPIO24	18
22	RST	Reset	19	GPIO10 (SPI_MOSI)			Ground	20
23	LCD_SCK / TP_SCK	SPI clock of LCD/Touch Panel	21	GPIO09 (SPI_MISO)			(GPIO_GEN6) GPIO25	22
24	LCD_CS	LCD chip selection, low active	23	GPIO11 (SPI_CLK)			(SPI_CE0_N) GPIO08	24
26	TP_CS	Touch Panel chip selection, low active	25	Ground			(SPI_CE1_N) GPIO07	26
			27	ID_SD (I2C ID EEPROM)			(I2C ID EEPROM) ID_SC	28
			29	GPIO05			Ground	30
			31	GPIO06			GPIO12	32
			33	GPIO13			Ground	34
			35	GPIO19			GPIO16	36
			37	GPIO26			GPIO20	38
			39	Ground			GPIO21	40

Picture 2.7 – LCD pinout description

The Raspberry Pi camera module transmits data directly to the processor on the Broadcom BCM2835 system-on-chip (SoC) through an extremely fast serial camera interface (CSI-2). This is done with a 15-pin ribbon cable (also known as a flexible cable) and is connected to a ZIF 15 surface socket.

The two data bands on the CSI-2 bus provide a theoretical bandwidth of 2 Gbps, which is approximately equal to 5 MP. Therefore, I hope that the new camera has. It is most likely to have a maximum video resolution of 1920 pixels×1080 pixels at a rate of about 30 frames per second. This is reasonable for today's technology. For normal operation of the camera you need to update the Raspian OS like on picture 2.8



Picture 2.8 – Raspicam v2

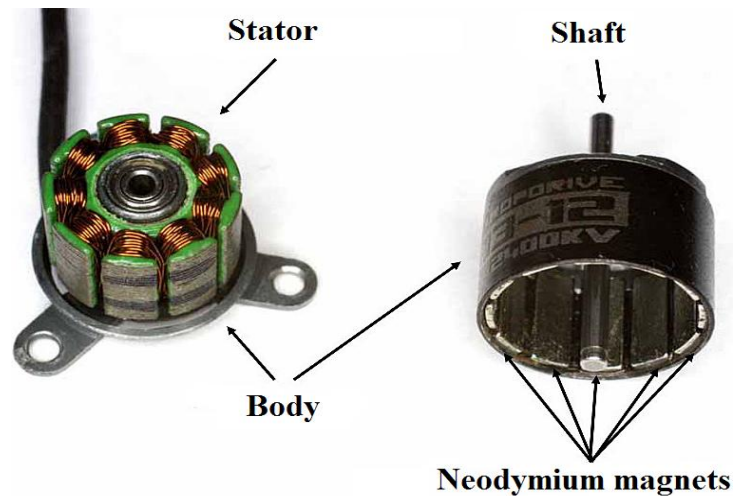
2.2 Analysis of the details of the quadrocopter and its functionality

In DPT (collector motor) special is engaged in the conversion of direct current into alternating current. product - "collector". In a brushless motor, this function is performed by the ESC controller. Why variable. But simply: in order for the engine to rotate, it is necessary to switch the current direction in time. And how do we do it - in general, in this class of enginesIn my UAV project, or in other words, the drone will consist of 5 main parts, these are:

- Motor for activate and run propellers
- ESC controllers to stabilise the flight of protorype
- Accumulator, for power supply
- Propellers
- Flight controller
- Body

Motor is the main moving part of each drone. Its main role in the project is to start and continue the flight process. Motors are connected with ESC controllers on the backgroun and with propellers on the front side. They are taking power by accumulator.

Because I am considering a quadrocopter, the motors will be 4. On the diagonal, their torsion directions will be the same. That is, 1 and 3 motors will spin clockwise, and 2 and 4 counterclockwise. This is done so that the drone can stay in one place in the coordinates x, y and z. Motor components are shown on picture 2.9



Picture 2.9 – Motor

With the Electronic Stroke Controller, the electrical power transmitted from the controller to the motor will vary smoothly. Unlike old models, new ESCs do not control

the engine by connecting in series, but have higher efficiency and do not consume battery energy when heated, which is of no use.

These controllers by other words are relaxing the voltage and on the contrary increasing it. Functionality of drone from this manipulation will grow and ensure my prototype with flexibility.

The Drone Electronic speed controller (ESC) memory card is a strong and powerful unit in the drone. ESC connection, engine, flight controller. Assuming that each brushless motor needs an ESC, the quadcopter will need four ESCs. The ESC receives a signal from the flight controller and battery and includes a brushless motor. It sounds simple, that's what it is! But there are some micro-drones that use brushes, the all-wheel-drive micro-drive used in racing and free-style swimming still depends on brushless motors. As the name suggests, a brushless motor of all contacts or "brush" inside the motor. The brush acts as a collector, using physical contact and the motor winding to turn the motor. Since there is no brush, the brushless motor uses a different way to convert electronic current (DC) to AC. This happens when you use a scarf.

All controls differ in the maximum operating current, battery voltage and the ability to work with different types of batteries.

Controls differ radically from brushless motors to brushed ones: different control of the performance of the engine hood, determination of the rules of determination for each rotor minute, specification of the three-phase supply voltage of the necessary brushless motor. These regulators are usually more expensive than the racing regulators of the same electricity collectors. The engine speed control ensures, without a brush, that only the engine does not operate with a brush, and the engine speed collector allows the activation of several assembly motors that can be converted or parallel to the controller, which is the only limit of the total power to the maximum current in this speed control.

About the navigation setting of model ships Stroke controls with automatic pattern have an advanced air cooling radiator and are able to reverse the direction of rotation of the electric motor. As a rule, this also has the task of providing energy to get and all the car boat. The power battery has a voltage of 7.4 - 48 V, while you need 5 to power tools and car boat.6, then this is built in Bec . (transfer voltage) can switch the current battery voltage to a lower voltage. The power of the built-in voltage converter is limited to 1.5-20 A. Some controls may have buttons on the body to change the parameters. Others-to be configured with a normal model control tools (via the next operation the gas knob on the transmitter of the radio control instruments). A number of companies produce special cables connect the controller to a particular control or a personal computer to adjust.

An important function of this is Not Safe. In case the model loses signal from the transmitter of the radio control system, for example, if you exceed the working radius or interfere in air, the right tune, turn off motor and car boat pass before the choice of location. Typically, plan on a smooth spiral down. This function to a lower level allows you to keep the model from an accident. The main purpose is the safety of people (especially for large aircraft), and closer to the model than in the case of a complete control of the model.

The battery must meet many conditions. Before using it in drones, check them first. The first is the size of the battery. You must understand that this is not only physical size, but also capacity.

For now, focus on weight and size. Indeed, when we seek to extend the flight time of our drone, we usually turn to the batteries with the highest capacity. But you will also need to check whether such a battery is compatible with your drone and if there will be any problems during the take-off of the drone. Battery weight is a decisive factor regarding the maximum take-off weight of the aircraft. In addition, the selected battery should fit easily in the drone. Therefore, you need to carefully measure the length and width of the battery compartment of the drone to get its exact dimensions. Finally, to make sure that you have selected the right battery for the drone, it would be wise to carefully check the maximum weight of the various drones in order to calculate the optimal battery weight for your device.

Nowadays aspectos mas importantes a considerar al elegir una batería es la cantidad de baterías o el voltaje de la batería. La razón para ignorar esta característica de la batería es un hecho simple: el voltaje es directamente proporcional a la potencia del motor. Por lo tanto, las baterías con un voltaje de voltaje suficiente o mayor pueden proporcionar más potencia a los motores electricos. Sin embargo, debe tener en cuenta que esas baterías son más pesadas de lo habitual. Si intenta quitar la batería con el voltaje de salida, fallara. Una de las formas más efectivas de elegir el voltaje correcto para un dron es comparar la eficiencia con los valores del motor del dron.Podemos decirle con seguridad que una batería con muchas baterías le dará el mejor voltaje, pero le costará mas y pesara mas.

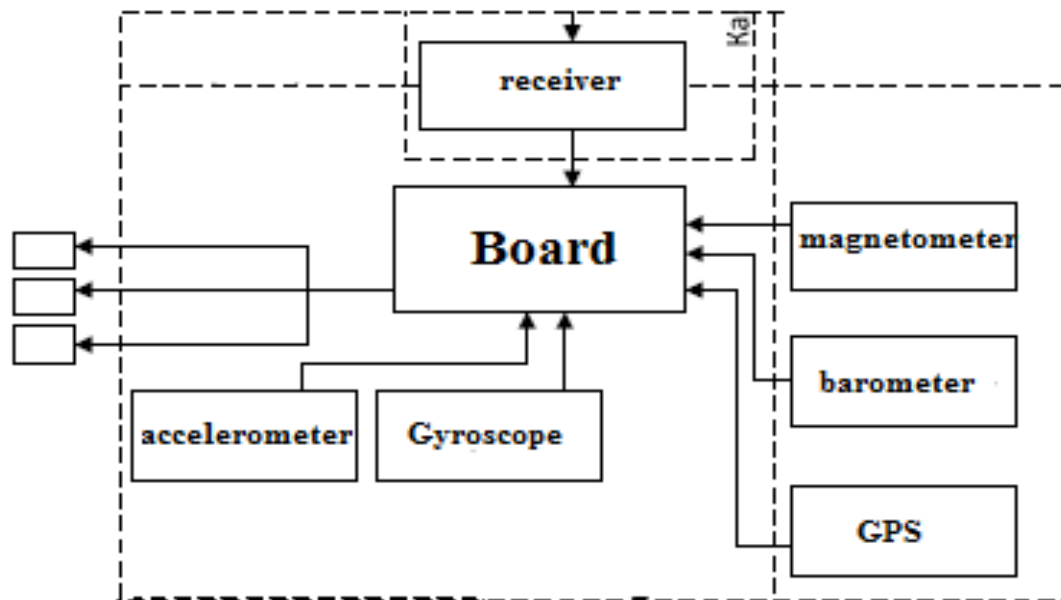
Finally, the most important point you need to consider when choosing a battery is how many motors your drone has. Moreover, you should definitely pay attention to whether the electronics and engine of your drone can maintain the voltage provided by the selected battery. It is important that you know that the engines of some drones are quite voltage-specific, and any changes can damage them.

You should be aware of the options for replacing the battery for your drone, so that if for some reason you could not find your standard batteries, you know how to replace them. In addition, such analogues are usually cheaper than branded batteries,

but despite the price, they can offer pretty good performance. However, remember all the details that we talked about above.

Propellers and engines are the most wearing parts of the drone, since during its flight the main burden falls on them. Moreover, in the event of various emergency situations, including the fall of drones, the exposed parts of the structure, to which the propellers belong, break first. Therefore, for beginners, drone developers recommend buying devices equipped with special propeller protection. It can be arcs or casings, resistant to impacts and protecting propellers from breakdowns.

Propellers are instruments of motors to run the whole UAVs body over the ground. Dependent on their rotating speed dron will get a hight. Each engine is connected to one propeller and sets it in motion with the speed generated by the speed controllers. The speed controller sets the speed based on the commands received from the flight controller. Multiwii component drowing on picture 2.10



Picture 2.10 – Multiwii scheme

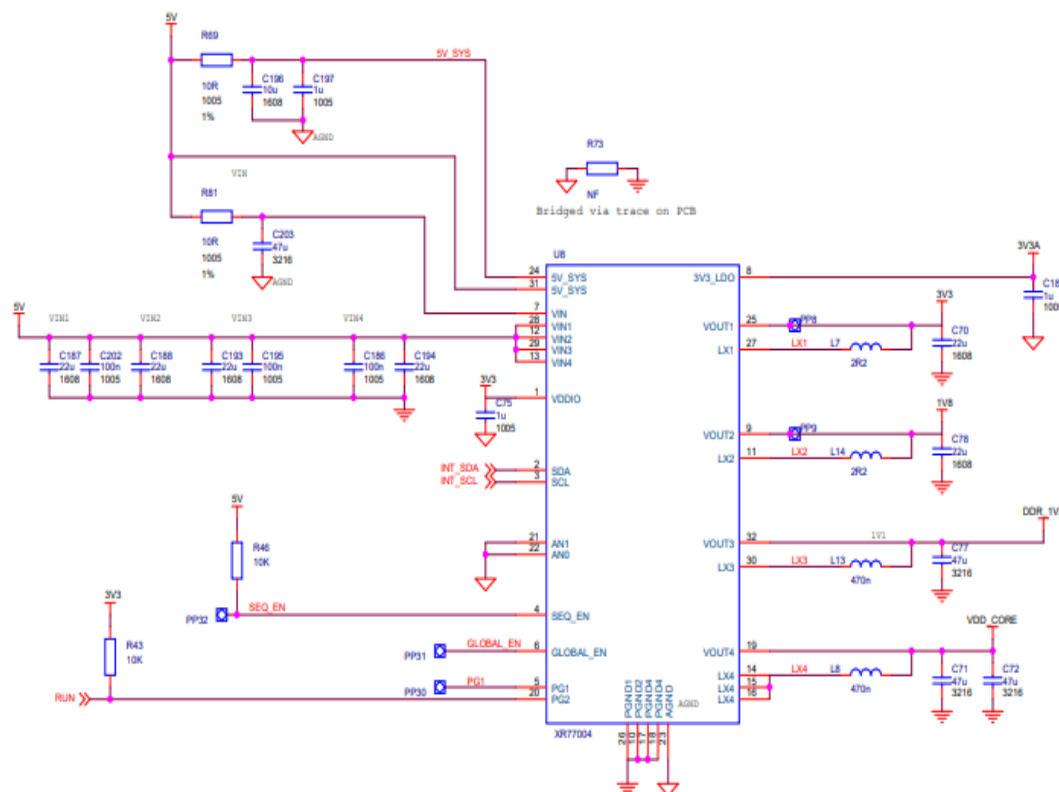
The flight controller is the brain of the drone. It is programmed to process various signals coming from the operator's remote control and the sensors installed on it. The more signals the controller can process, the more versatile the drone is. By means of a loop, the flight controller is connected to each of the four engines, which allows sending control signals (programmed commands) to them.

Since the stability of the entire flight depends on how well the pilot works, in designing drones, software developers use a variety of techniques that allow this to be as automated as possible. As a general rule, the more specific the sound, the more

drones become. Recently, high-flying pilots are diagnosed with the isolation they live on. A set of different sensors (GPS, gyros, barometer, accelerometer, etc.) are connected to the pilot, which transmits what they read. Interaction with the host is done via a special transmitter installed in the house. Depending on the readings, the agent controls the drone flight parameters. If the drone pilot is "smart" enough, then, based on the sensor readings and algorithms of the software stored in it, you can gently modify the parameters of the drone aircraft without the use of collaborators. The final design of the pilot depends on the cost of the drone. Lightweight drones can control engine configuration according to incoming commands, while high-performance drones, for example, return to the launcher themselves.

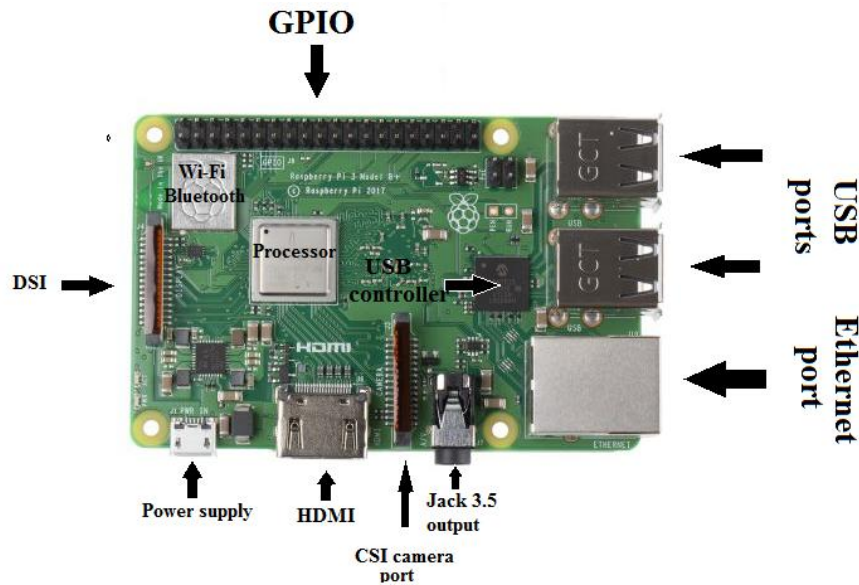
2.3 Principle of collaboration of Raspberry and quadrocopter

Any electronic product developed on a silicon crystal has a fundamental circuit. Raspberry has a non-disclosure policy for its microcontroller circuits. This can be understood since these microcontrollers are their own product on the market with their own uniqueness. Officially, they advertised only a certain part of the schemes in order to avoid copying or unscrupulous earnings on their development. On the picture 2.11 you can see the electrical schem of Pi part



Picture 2.11 – Principal drawing of 3 B+

Like the diagram above, each project has a functional diagram. It is intended to explain the components of the project modules. Functional diagram - a type of graphic model of the product. Their use and construction allows you to visually reflect the device functional (working) changes, the description of which operates with any (including non-essential) microcircuits, LSI and VLSI. Since functional schemes do not have their own system of symbols, their construction allows a combination of kinematic, electrical, and algorithmic symbols (for such schemes combined schemes are more appropriate). Main parts of Pi 3B+ are shown on picture 2.12



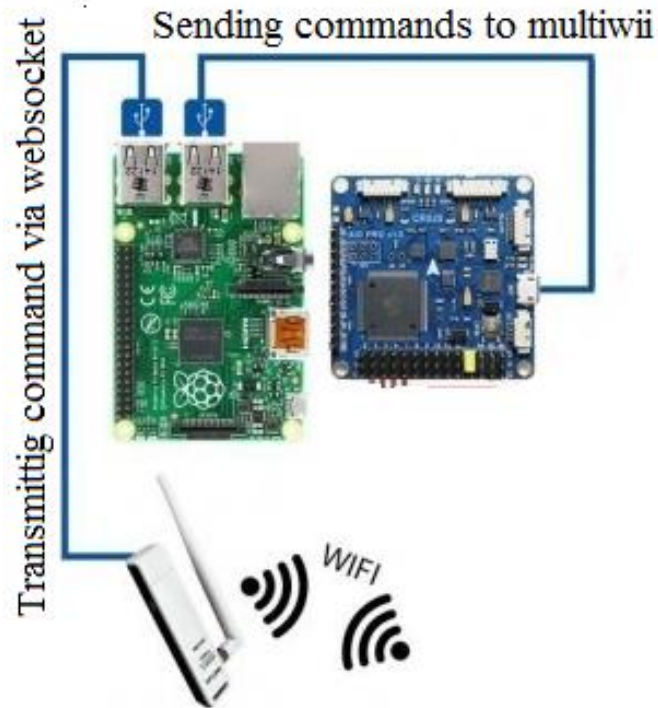
Picture 2.12 - Functional drawing of 3 B+

The principle of the joint work of Raspberry and the multiwii flight controller based on the arduino is very simple. Commands from the tablet or from the control panel will be sent to raspberry, which in turn will transmit them to the controller. The controller, in turn, will transmit the required amount of current and voltage to the ESC for further supply to the motors

The flight controller is connected to Raspberry by connecting the first to the USB port. Data packets with commands will be transferred to Wi-Fi or the Bluetooth module Pi 3rd. The wi-fi network created by the module will not be connected to the worldwide Internet. Its role is in the private connection of the burberry and the client, in other words, a smartphone or tablet. This is implemented using a DCHP server to detect IP addresses.

The second step is to run the script, which in turn leads to the activation of the WebSocket program. The web socket will provide static wireless communication by transferring data between two elements. The microcontroller here serves as a receiver

while the smartphone is a transmitter. An alternative to typing before each command is to access the root command line, which runs each command with superuser privileges. You can access root mode by typing at a command prompt. Most of the commands below have many other useful options that we don't mention. Principal of work process I left on picture 2.13



Picture 2.13 – Assembled Raspberry and flight controller

Cordova is an open source mobile app development platform. It allows you to use standard web technologies such as HTML5, CSS3 and JavaScript for cross-platform development, avoiding the native development language for each of the mobile platforms. Applications run inside a wrapper targeted at each platform and rely on standard APIs to access device sensors, data, and network status.

What we need to do to get the LCD working is install and configure the FBTFT drivers created by notro. There are two types of drivers we need to be concerned with here. One set of drivers is for the actual LCD display screen, and the other set of drivers is for the touchscreen sensors. Here is a good article explaining Linux kernel modules, devices, and drivers, which you may want to read for some background information. The standard version of Raspbian does not include the drivers for LCD touchscreens, so we will need to install and configure them manually. So just follow the steps below to get your LCD touchscreen working on the Raspberry Pi.

3 Software part

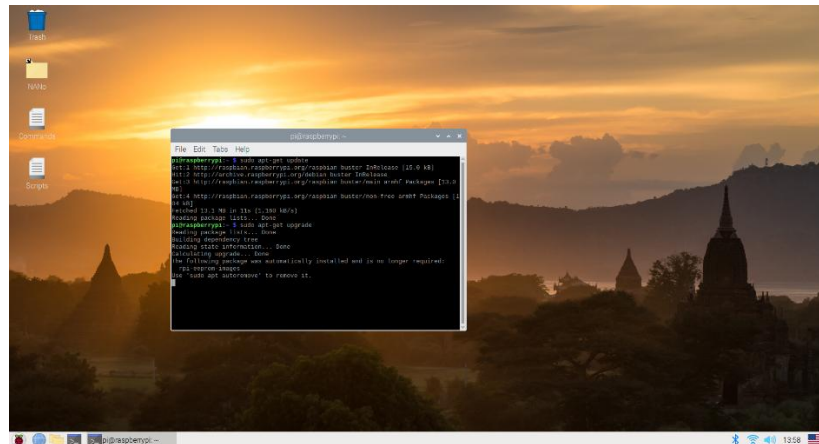
The iron base of the brain of my prototype will remain only iron if you do not implement the operating system in it. To complete this task, I needed a card reader and a 16 GB SD card. An image of the Raspbian operating system was downloaded from the Internet from the official site of the raspberry company. There are several types of operating systems for my controller:

- Raspbian;
- OSMC;
- OpenELEC;
- ArchLinux;
- Pi MusicBox;
- RetroPie;
- OpenMediaVault;
- RISC OS.

My choice fell on raspbian due to the fact that this is the only official operating system complex. At boot time, a system image offers 2 options. Raspbian Deb or Noobs. Their difference is that all sorts of utilities and entertainment programs as well as work tools have been downloaded to noobs. I would not use all of them for this reason and chose a more standard and free OS.

Raspbian is the official operating system for the Raspberry Pi, it is designed specifically for this device and has all the necessary software. Raspbian is based on the ARM version of Debian 8 Jessie and contains such programs by default - the LibreOffice office suite, a web browser, the Claws Mail email client, a lightweight desktop environment, and some tools for teaching programming.

After that, you will need to send the system image to the SD card and insert it into the raspberry. The next is to connect to the Wi-Fi and check out updates on my Desktop om picture 3.1



Picture 3.1 – Updating the system

Most LCD touchscreens for the Raspberry Pi ship with an OS image file that you can write to your SD card and get up and running pretty quickly. But what if you want to run a clean, updated version of Raspbian, without any bloatware included with the manufacturer's image. LCD touchscreen with fresh install of Raspbian Jessie Full. Raspbian Jessie Lite won't work with the touchscreen because it doesn't have X-Server and the fbturbo video driver installed. A lot of LCD touchscreens can be set up by this process, but check if your LCD is supported by the FBTFT driver. Further, for more convenient use, we download and install drivers for the LCD display on picture 3.2



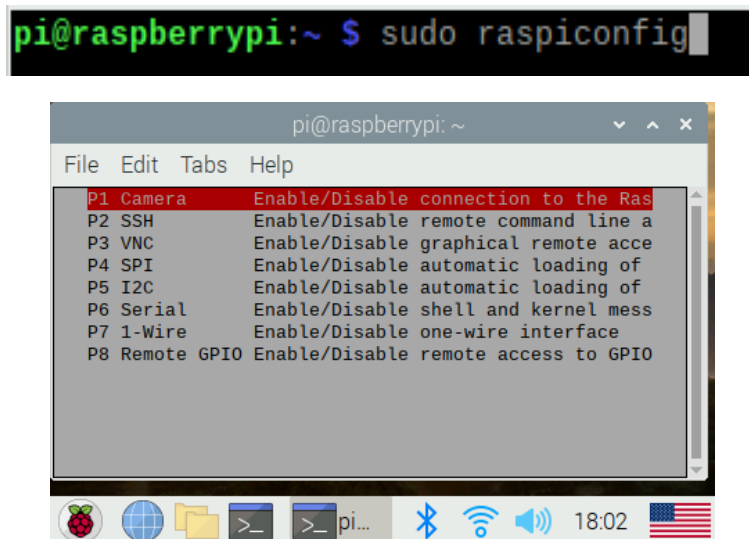
```

pi@raspberrypi: ~/LCD-show
File Edit Tabs Help
pi@raspberrypi:~$ sudo rm -rf LCD-show
pi@raspberrypi:~$ 
pi@raspberrypi:~$ git clone https://github.com/goodtft/LCD-show.git
Cloning into 'LCD-show'...
remote: Enumerating objects: 1186, done.
remote: Total 1186 (delta 0), reused 0 (delta 0), pack-reused 1186
Receiving objects: 100% (1186/1186), 753.86 KiB | 464.00 KiB/s, done.
Resolving deltas: 100% (781/781), done.
pi@raspberrypi:~$ 
pi@raspberrypi:~$ chmod -R 755 LCD-show
pi@raspberrypi:~$ 
pi@raspberrypi:~$ cd LCD-show/
pi@raspberrypi:~/LCD-show$ 
pi@raspberrypi:~/LCD-show$ sudo ./LCD35-show

```

Picture 3.2 – LCD connecting

Now we can safely work anywhere with our microcontroller anywhere. To record a video or a photo, you will need to turn on the raspicam in the settings of the peripheral devices on picture 3.3



3.3 – Turning on the camera

To record data for further processing we must use the library raspicam. This library contains all commands and executing processes which are connected with v2 camera. First of all I made a photo by the command:

```
raspistill -o Pictures/firstphoto.jpg -t 2000
```

Where

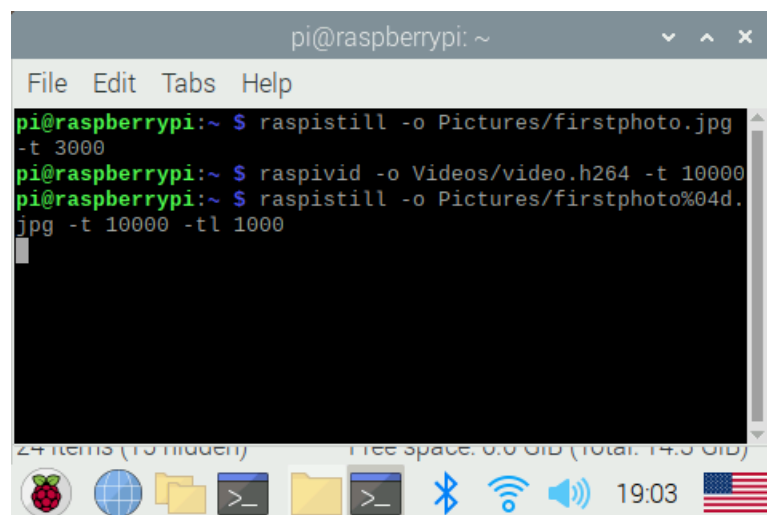
- o – means where will be saved image and in which format;
- t – is the time delay time before shot in milliseconds.

My first activation and testing of the raspberry camera is on picture 3.4



Picture 3.4 – First photo on raspicam

Thanks to library raspicam user can make photos, videos, time-lapse videos, 3d modeling of captured data etc. Commands on picture 3.5 can execute all these things



Picture 3.5 – Camera library commands

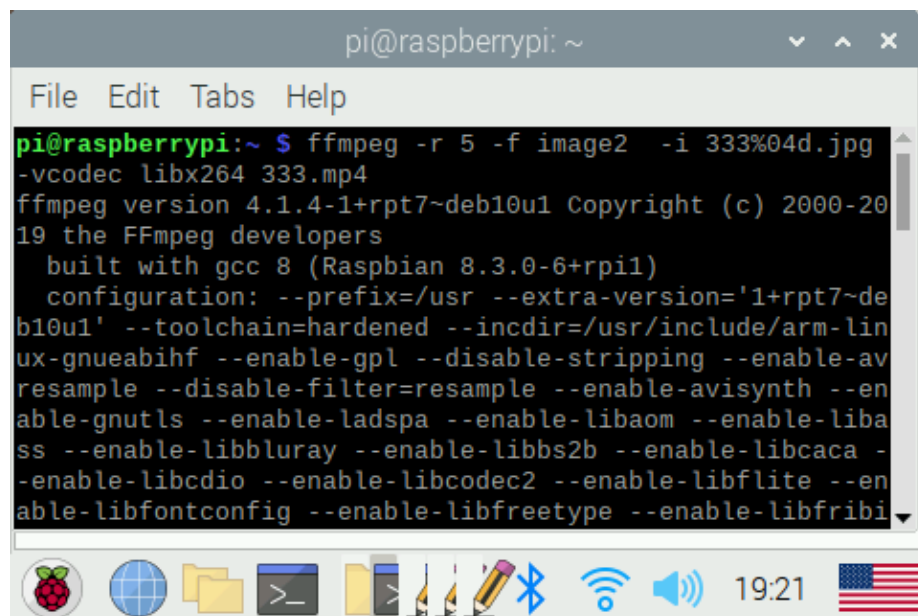
First of all, I have already told about how to make a photo, so the first command is made to take a photo. Command “raspivid” is used to shoot video files. To make a brief on this command:

- o – is again choosing the directory and format
- t – now it is a shooting time, in my instance it is 10 seconds or 10000 milliseconds

The most difficult command here is the team to create time-laps video. To do this, you first need to take a certain amount of photograph, I did this as follows:

- o – future place of file
- t – the whole time when photos will be shot 10 seconds
- tl – delay before each shot
- %04d – this is a special part which has been added by me to automatically create new files with different names in 0000 discharge.

Furthermore, I had to collect all photos in one file. I thought I could do it with “avconv” library but my OS had not it, that is why I decided to use ffmpeg. Library like on the picture 3.6



```
pi@raspberrypi: ~  
File Edit Tabs Help  
pi@raspberrypi:~ $ ffmpeg -r 5 -f image2 -i 333%04d.jpg  
-vcodec libx264 333.mp4  
ffmpeg version 4.1.4-1+rpt7~deb10u1 Copyright (c) 2000-2019 the FFmpeg developers  
built with gcc 8 (Raspbian 8.3.0-6+rpi1)  
configuration: --prefix=/usr --extra-version='1+rpt7~deb10u1' --toolchain=hardened --incdir=/usr/include/arm-linux-gnueabi --enable-gpl --disable-stripping --enable-avresample --disable-filter=resample --enable-avisynth --enable-gnutls --enable-ladspa --enable-libaom --enable-libass --enable-libbluray --enable-libbs2b --enable-libcaca --enable-libcdio --enable-libcodec2 --enable-libflite --enable-libfontconfig --enable-libfreetype --enable-libfribidi
```

Picture 3.6 – Using the ffmpeg

Where,

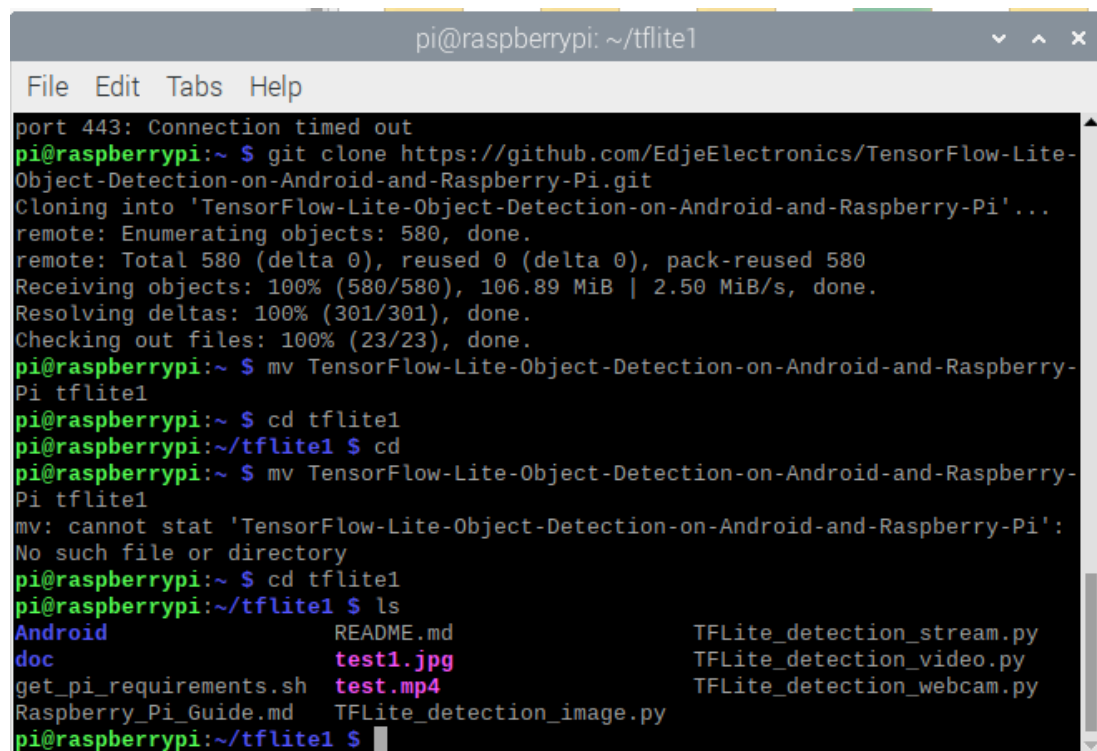
- r - frame frequency;
- f - photo processing source;

-vcodec libx264 - indicate which video codec we want to receive. In our case it is .mp4.

Ffmpeg collects all photos in one video and the result is a kind of slideshow but it will give a sense timelapse. The time has come to explain the principle of the work of my thesis. Since raspberry is the main component of my project, data will be recorded on the raspberry camera in a different format, which will subsequently either save their own form or, as in the example with timelapse, be processed and formatted in another form.

The basis of my thesis was the library of object recognition. At the moment, active research in this area of machine learning is underway around the world. The objects in my case will naturally be accepted animals. The quadrocopter in this case plays the role of nothing more than a transport for my microcontroller, which is why I did not go so deep into it.

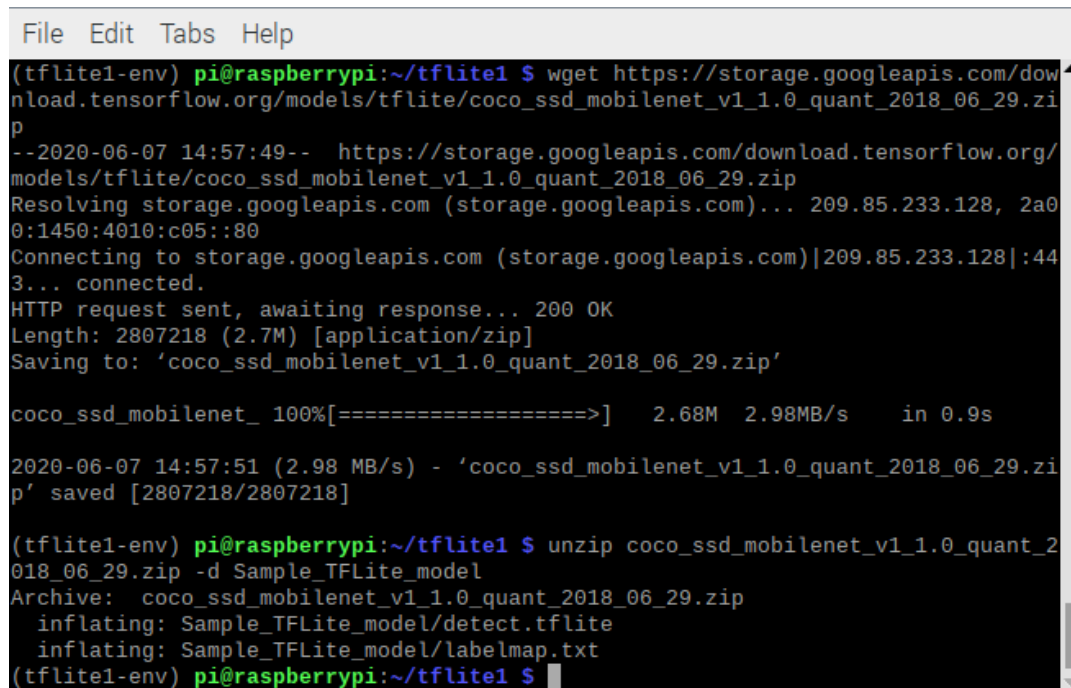
I have developed 2 working software, one works on the basis of the TensorFlow library, it works on the microcircuit raspberry as it will be difficult for the microcontroller to process video in the full version. Version Lite behaves in the same way as the full version, it just has less CPU load due to less frames per second. To accomplish this, I installed this library in my Raspbian, picture 3.7



```
pi@raspberrypi: ~/tflite1
File Edit Tabs Help
port 443: Connection timed out
pi@raspberrypi:~ $ git clone https://github.com/EdgeElectronics/TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi.git
Cloning into 'TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi'...
remote: Enumerating objects: 580, done.
remote: Total 580 (delta 0), reused 0 (delta 0), pack-reused 580
Receiving objects: 100% (580/580), 106.89 MiB | 2.50 MiB/s, done.
Resolving deltas: 100% (301/301), done.
Checking out files: 100% (23/23), done.
pi@raspberrypi:~ $ mv TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi tflite1
pi@raspberrypi:~ $ cd tflite1
pi@raspberrypi:~/tflite1 $ cd
pi@raspberrypi:~ $ mv TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi tflite1
mv: cannot stat 'TensorFlow-Lite-Object-Detection-on-Android-and-Raspberry-Pi':
No such file or directory
pi@raspberrypi:~ $ cd tflite1
pi@raspberrypi:~/tflite1 $ ls
Android          README.md        TFLite_detection_stream.py
doc              test1.jpg        TFLite_detection_video.py
get_pi_requirements.sh test.mp4         TFLite_detection_webcam.py
Raspberry_Pi_Guide.md TFLite_detection_image.py
pi@raspberrypi:~/tflite1 $
```

3.7 – tflite installing process

Machine learning models have two distinct computational components: training and inference. In this example, we're making use of Cloud TPUs to accelerate training. There are a few lines in the config file that relate specifically to TPU training. We can use a larger batch size when training on TPUs since they make it easier to handle large datasets (when experimenting with batch size on your own dataset, make sure to use multiples of 8 since data needs to be divided evenly for each of the 8 TPU cores). With a larger batch size for our model, we can reduce the number of training steps (in this example we use 2000) as on the picture 3.8

A terminal window with a dark background and light-colored text. The window title bar shows 'File Edit Tabs Help'. The prompt is '(tflite1-env) pi@raspberrypi:~/tflite1 \$'. The user enters 'wget https://storage.googleapis.com/download.tensorflow.org/models/tflite/coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip'. The terminal shows the progress of the download, including the URL, file size (2.7M), and speed (2.98MB/s). After the download is complete, the user enters 'unzip coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip -d Sample_TFLite_model'. The terminal shows the extraction process, including the file names 'detect.tflite' and 'labelmap.txt'. The prompt returns to '(tflite1-env) pi@raspberrypi:~/tflite1 \$'.

```
(tflite1-env) pi@raspberrypi:~/tflite1 $ wget https://storage.googleapis.com/download.tensorflow.org/models/tflite/coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip
--2020-06-07 14:57:49-- https://storage.googleapis.com/download.tensorflow.org/models/tflite/coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip
Resolving storage.googleapis.com (storage.googleapis.com)... 209.85.233.128, 2a00:1450:4010:c05::80
Connecting to storage.googleapis.com (storage.googleapis.com)|209.85.233.128|:443... connected.
HTTP request sent, awaiting response... 200 OK
Length: 2807218 (2.7M) [application/zip]
Saving to: 'coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip'

coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip 100%[=====] 2.68M 2.98MB/s in 0.9s

2020-06-07 14:57:51 (2.98 MB/s) - 'coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip' saved [2807218/2807218]

(tflite1-env) pi@raspberrypi:~/tflite1 $ unzip coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip -d Sample_TFLite_model
Archive:  coco_ssd_mobilenet_v1_1.0_quant_2018_06_29.zip
  inflating: Sample_TFLite_model/detect.tflite
  inflating: Sample_TFLite_model/labelmap.txt
(tflite1-env) pi@raspberrypi:~/tflite1 $
```

Picture 3.8 – Getting models for recognizing system

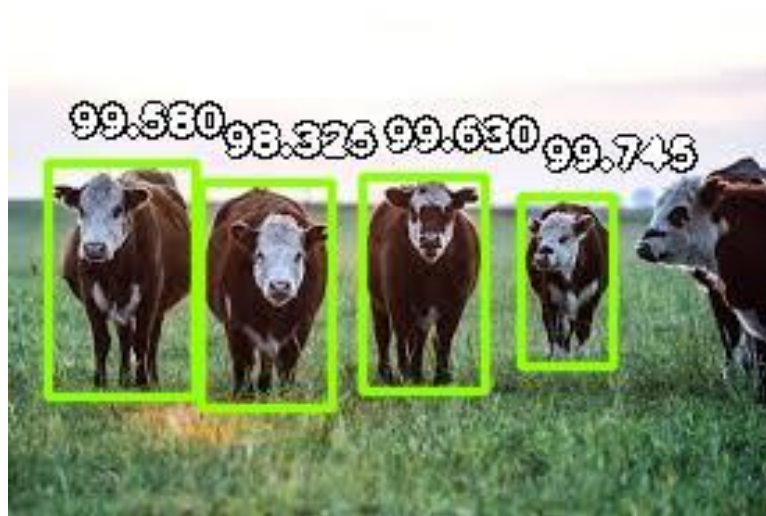
This loss function computes loss for every example in the dataset and then reweights them, assigning more relative weight to hard, misclassified examples. This logic is better suited for TPUs than the hard example mining operation used in other training jobs. You can read more about focal loss in Lin et al. (2017).

Recall from above that the process of initializing a pre-trained model checkpoint and then adding our own training data is called transfer learning. The following lines in the config tell our model that we'll be doing transfer learning for object detection, starting from a pre-trained checkpoint. By using these words we can run tflite on photo, video or real time it will recognize objects:

```
cd tflite1
source tflite1-env/bin/activate
python3 TFLite_detection_webcam.py --modeldir=Sample_TFLite_model;
```

```
python3 TFLite_detection_video.py --modeldir=Sample_TFLite_model --video=NAME OF VIDEO.mp4;
python3 TFLite_detection_image.py --modeldir=Sample_TFLite_model --image(dir)=NAME OF PHOTO.jpg.
```

First line for streaming, second for video and third for photo capturing for following animal detecting as it is shown on picture 3.9



Picture 3.9 – tflite image result

At this point you have a fully trained pet detector, which you can use to test your own images in the browser with zero setup using this Colab notebook. To run this model in real time on a phone requires some extra work - - in this section, we will show you how to use TensorFlow Lite to get a smaller model and allow you take advantage of ops that have been optimized for mobile devices. TensorFlow Lite is TensorFlow's lightweight solution for mobile and embedded devices. It enables on-device machine learning inference with low latency and a small binary size. TensorFlow Lite uses many techniques for this such as quantized kernels that allow smaller and faster (fixed-point math) models.

As mentioned above, for this section, you will need to use the provided Dockerfile, or build TensorFlow from source (with GCP support) and install the bazel build tool. Note that if you'd like to only work through this second part of the tutorial without training a model, we've made a pre-trained model available here.

On PC was set up TensorFlow's full version. Thus tensorflow is a library of a high language python, I had to install PyCharm on my Windows to avoid any system problems and for comfortable work on it.

PyCharm is an intelligent Python IDE with a complete set of tools for efficient development in Python. Available in two versions - the free version of PyCharm

4 Technical and economic project justification

4.1 Technical and economic UAV development justification

The aim of this diploma is the creation and further programming based on machine learning UAVs for the study and keeping records of rare animals.

The projected UAV will make it possible to remotely monitor a certain category of animals, tracking their movements and habitats. Like any other project on a production scale, the above project must comply with all the norms of economic standards for further payback and benefits. To achieve a return on investment and further transition to mass production, the project must go through a deep economic and financial analysis, which will be carried out in this part of the thesis.

In the technical and economic part of the thesis, the following points of capital investment will be considered to determine the payback and profitability of the project:

- investments for project development, tenge;
- equipment costs, tenge;
- assembly of a quadrocopter, tenge;
- transport services, tenge;
- purchase of materials, tenge;
- software development, tenge.

4.2 The aim of technical and economic part

The purpose of this part of the diploma is to analyze and verify the development process of the above UAV for the appropriateness and calculation of the total costs at the development stage

4.3 Calculation of capital investments for the implementation of the project

To calculate capital investments we have to use following formula:

$$K = K_{pr} + K_{ob} + K_{sb} + K_{tr} + K_m + C_n \quad (4.1)$$

where

- K_{pr} - capital investment in the development of the project, tenge;
- K_{ob} - equipment costs, tenge;
- K_{sb} - capital investments for the assembly of a quadrocopter, tenge;
- K_{tr} - capital investments in transport services, tenge;
- K_m - capital investments for the purchase of materials, tenge;
- C_n - capital investments for software development, tenge.

Project development costs are calculated by the formula:

$$K_{pr} = Z_{fot} + Z_c + Z_{ob} + Z_n, \quad (4.2)$$

where

- K_{pr} - project costs, tenge;
- Z_{fot} - general payroll fund for developers, tenge;
- Z_c - deductions for social tax, tenge;
- Z_{ob} - special equipment, tenge;
- Z_n - overhead, tenge.

The total payroll of developers (Z_{fot}) is calculated as the sum of the main and additional wages according to the formula:

$$Z_{fot} = Z_o + Z_d, \quad (4.3)$$

Where

- Z_o - basic salary, tenge;
- Z_d - additional salary, tenge.

The project involves 2 people. Project participants and their salaries are presented in table 4.1.

Table 4.1 - Basic salary for system development

№	Name of stages	Actuators (by stages)	Labor input (p./days)	Salary (tenge)	Cost 1 p.d. (tenge)	Wage (tenge)
1	Development of technical task	Design engineer	2	155000	5000	10000
2	Technical Proposal	Design engineer	1	155000	5000	5000
3	Preliminary design	Design engineer	1	155000	5000	5000
4	Development of work documentation	Supervisor	2	201500	6500	13000
		Design engineer	1	155000	5000	5000
5	Engineering analysis	Design engineer	1	155000	5000	5000
6	Verification of results	Supervisor	1	201500	6500	6500
		Total	9			49500

Thus, with the consistent implementation of all the stages of work listed in table 1, the total duration of the one-time work will be 9 working days. Additional salary of employees, which takes into account illness, holidays and other unforeseen circumstances (on average 10% of the basic salary):

$$Z_d = Z_o \times \frac{N_d}{100} \quad (4.4)$$

where N_d – coefficient of additional salaries of developers.

$$Z_d = 0,1 \times 49500 = 4950 \text{ (tenge).}$$

By the formula Z_{fon} wage will be:

$$Z_{fon} = 49500 + 4950 = 54000 \text{ (tenge).}$$

The deductions for the unified social tax are calculated based on the employee's salary and make up 9,5% (article 358 para. 1 of the Tax Code of the Republic of Kazakhstan):

$$Z_c = (Z_{fon} - PO) \times 9,5\%, \quad (4.5)$$

Where, PO – contribution to the Pension Fund in the Republic of Kazakhstan, which is calculated by the formula:

$$PO = Z_{fon} \times 10\%, \quad (4.6)$$

So,

$$PO = 54000 \times 0,1 = 5400 \text{ (tenge).}$$

$$Z_c = (54000 - 5400) \times 0.095 = 461,7 \text{ (tenge).}$$

The cost of special equipment for experimental work is 71700 tenge (table 4.2).

Table 4.2 - Costs of special equipment

№ p/p	Material name	Quantity	Price, tenge	Cost, tenge
1.	PC	1	77500	65000
2.	Screwdriver	2	350	700
3.	Soldering kit	1	6000	6000
	Total			71700

Overhead costs make up 30% of the salary:

$$Z_n = 0,3 \cdot 54000 = 16200 \text{ (tenge).}$$

Thus, according to formula 2, the cost of developing research will be:

$$K_{pr} = 54000 + 461,7 + 71700 + 16200 = 142361,7 \text{ (tenge).}$$

Capital investments in equipment amount to 105225 tenge. The list of necessary equipment is presented in table 4.3.

Table 4.3 - List of equipment necessary for the implementation of the project

Name of equipment	Quantity, units	Unit price, tg	Cost including VAT, tg	Cost without VAT, tg
Housing	1	6500	7020	6500
Propellers, RPMs and Engines	4	8700	37584	34800
Remote Control	1	12000	12960	12000
Battery	1	14000	15120	14000
Controller	1	9000	9720	9000
Raspberry Pi3 B+	1	19000	20520	19000
CSI camera 5 MP	1	5200	5616	5200
Wire set (USB, charger, etc.)	1	3000	3240	3000
SD memory card 16 GB	1	1500	1620	1500
Radiators	3	75	243	225
Total			113 643	105225

To calculate the capital investment for the assembly, we use the formula:

$$K_{sb} = K_{ob} \times 10\%, \quad (4.7)$$

In this way,

$$K_{sb} = 105225 \times 10\% = 10522,5 \text{ (tenge)}$$

Capital investments in transport services are calculated by the formula:

$$K_{tr} = K_{ob} \times 5\%, \quad (4.8)$$

So,

$$K_{tr} = 105225 \times 5\% = 5261,25 \text{ (tenge).}$$

Capital investments in materials necessary for the implementation of the project are presented in table 4.4

Table 4.4 - Material Costs

№, p/p	Material name	Quantity, unit	Price, tenge	The amount, tenge
1.	Solder	1	1500	1500
2.	Rosin	1	100	100
3.	Soldering Acid	1	400	400
4.	Connecting wires	10	10	100
5.	Ethanol	2	200	400
6.	Lacquer	5	135	675
	Total			3165

Costs (C_n) for software development can be found by the formula:

$$C_n = Z_{fon} + Z_c + P_m + P_e + P_n, \quad (4.9)$$

Where, Z_{fon} is the general payroll fund for developers, tenge;

- Z_c - deductions for social tax, tenge;
- P_m - depreciation costs of equipment, tenge;
- P_e - electricity costs, tenge;
- P_n - overhead expenses, tenge.

The size of the payroll fund for developers (PFAT) is calculated according to formula 3.3. In order to calculate the basic salary of the contractor, we use the formula:

$$Z_o = t_p \times Z_{po}, \quad (4.10)$$

Where,

- t_p - the complexity of software product development, person-days;
- Z_{po} - daily salary of the developer, (tenge).

Total labor costs are calculated as the sum of the composite labor costs according to the formula:

$$t = t_o + t_a + t_n + t_l + t_d, \quad (4.11)$$

Where,

- t_o - is the time spent on the task description, person / hour;
- t_a - compilation of the program algorithm, person / hour;
- t_n - time spent writing a program, person / hour;
- t_l - time allotted for debugging software on a PC, person / hour;
- t_d - time spent on the development of documentation, person / hour.

The conditional number of operators in the task program is determined by the formula:

$$Q = q \times c, \quad (4.12)$$

Where,

- Q is the conditional number of operators;
- q - is the estimated number of operators depending on the type of task;
- c - coefficient taking into account the novelty and complexity of the program.

Let us select the coefficient q according to table 4.5.

Table 4.5 - The values of the coefficient q

Task type	Limits of measurement of the coefficient
Registration tasks	1400 to 1500
Operational management tasks	1500 to 1700
Planning tasks	3000 to 3500
Multivariate tasks	4500 to 5000
Complex tasks	5000 to 5500

Since this project considers not only UAV control but also work with machine learning and data, we take the q coefficient equal to 4500.

Further, in order to determine the coefficient c , the first thing is to choose a group according to the degree of novelty:

- Group A - the development of fundamentally new tasks;
- Group B - development of original programs;
- Group B - development of programs using standard solutions;
- Group D - a one-time standard task.

The program will be written in a high-level language using standard algorithms. Python has a global interpreter lock (GIL) - in its operation, the main interpreter constantly uses a large amount of thread-unsafe data. Basically, these are dictionaries

in which the attributes of objects are stored, and calls to the external code, therefore, in order to avoid the destruction of this data when combined from different threads. Now, based on table 4.6, we determine the coefficient c equal to 1.08.

Table 4.6 - Labor calculation factors

Programming language	Difficulty group	Degree of novelty				Coefficient B
		A	B	C	D	
Python combined with machine learning libraries	1	1,38	1,26	1,15	0,69	1,2
	2	1,30	1,19	1,08	0,65	1,35
	3	1,20	1,10	1,00	0,60	1,5

Thus,

$$Q = 4500 \times 1.08 = 4860 \text{ (teams)}.$$

After this, it is necessary to determine the time spent on creating the software at each stage:

a) t_o is taken upon the fact: $t_o = 24$ (person / hour).

b) we find t_a by the formula: $t_a = \frac{Q}{(50 \times K)}$, (4.13)

where K is a coefficient taking into account the qualifications of a programmer (table 4.7).

Table 4.7 - Programmer qualification factors

Experience	Qualification ratio
Up to two years	0,8
2-3 years	1
3-5 years	1,1-1,2
5-7 years	1,3-1,4
More than 7 years	1,5-1,6

Thus,

$$t_a = \frac{4500}{(50 \times 1)} = 90 \text{ (p/h)}.$$

c) t_n we find by the formula:

$$t_n = \frac{Q \times 1,5}{(50 \times K)}, \quad (4.14)$$

Thus, according to formula 14:

$$t_n = \frac{4500 \times 1,5}{(50 \times 1)} = 135 \text{ (p/h)}$$

d) t_{otl} is determined by the formula:

$$t_{otl} = \frac{Q \times 4,2}{(50 \times K)} \quad (4.15)$$

According to formula 3.15:

$$t_{otl} = \frac{4500 \times 4,2}{(50 \times 1)} = 378 \text{ (p/h)}$$

e) t_d , taken on the fact and is (from 3 to 5 days for 8 hours):

$$t_d = 24 \text{ (p/h)}$$

According to the formula 3.11:

$$t = 24 + 90 + 135 + 378 + 24 = 651 \text{ (hours)}.$$

Thus, the time taken to create the software is 651 hours or 90 people / day. The daily wage is determined based on the monthly salary of the developer and the number of working days in the month (on average, 22 working days can be accepted). Information on the employees involved in the development is presented in table 4.8.

Table 4.8 - Information on the employees involved in the project.

Specialist - Contractor	Number of persons	Salary per month, tenge
Design engineer	1	118000
Total		118000

The results of the calculation of basic wages are presented in table 4.9.

Table 4.9 - Summary results of the calculation of the costs of the basic wage

Name of the content of work	Executor	Labor input, norm-hour	Salary per hour of work	Salary amount
1	1	8	625	5000

The basic salary is calculated by the formula:

$$Z_o = t_p \times Z_{po}, \quad (4.16)$$

where

- t_p - the complexity of software product development, person-days;
- Z_{po} - daily salary of the developer, tenge (table 4.9).

Thus,

$$Z_o = 90 \times 5000 = 450000 \text{ (tenge)}.$$

Additional salary (Z_d) is calculated by the formula 4.4:

$$Z_d = 450000 \times 0.1 = 45000 \text{ (tenge)}.$$

Thus, the payroll is:

$$Z_{fon} = 450000 + 45000 = 495000 \text{ (tenge)}.$$

Social tax is calculated using the formula 4.5. Where software is calculated by the formula 4.6.

So,

$$PO = 495000 \times 10\% = 49500 \text{ (tenge)}.$$

In this way,

$$Z_c = (495000 - 49500) \times 0,095\% = 42322,5 \text{ (tenge)}.$$

Depreciation costs are calculated using the formula:

$$P_m = \frac{(C_o \times N_a \times N)}{(100 \times 12 \times t)} \quad (4.17)$$

where

- N_a is the depreciation rate (25%);
- C_o - the initial cost of equipment (tenge);
- N - time of use of a personal computer (days);
- t is the number of working days in a month.

$$P_m = \frac{(71700 \times 0.25 \times 90)}{(100 \times 12 \times 22)} = 61,1 \text{ (tenge)}.$$

Electricity costs are calculated by the formula:

$$P_e = M \times k \times T \times C \text{ kWh}, \quad (4.18)$$

where

- M is the power of the computer, kW;
- k is the load factor (0.8);
- CkWh - the cost of 1 kWh of electricity, tenge / kWh;
- T - work time, hour.

In this way,

$$R_e = 0.08 \times 0.8 \times 651 \times 17.81 = 742 \text{ (tenge)}.$$

Overhead costs (P_h) make up 20% of the basic salary:

$$P_h = 450000 \times 20\% = 90000 \text{ (tenge)}.$$

Thus, according to formula 4.9, the costs of software development will be:

$$C_n = 495000 + 42322,5 + 61,1 + 742 + 90000 = 628125,6 \text{ (tenge)}.$$

Thus, according to formula 4.1, the total amount of capital investment for the project without VAT is equal to:

$$K = 105225 + 10522,5 + 5261,25 + 3165 + 146\,517 + 628125,6 = 898816,35 \text{ (tenge)}.$$

4.4 Calculation of the economic efficiency of the project

Evaluation of the economic efficiency of the project is based on the indicator of comparative economic efficiency according to the formula:

$$E_{ef} = C - K \times E, \quad (4.19)$$

where

- E_{ef} is the expected annual economic effect, tenge;
- C - price when selling the device, tenge;
- K - capital investments, tenge;
- E - normative coefficient of economic efficiency of capital investments, which is determined by the formula:

$$E = \frac{1}{T_n}, \quad (4.20)$$

where T_N is the standard payback period for capital investments, which is 15 years. Thus, according to formula 4.20:

$$E = \frac{1}{15} \approx 0.06$$

The price will be equal to 190000 tenge.

Based on the expected formula 4.19, the economic effect (E_{ef}) will amount to 136071 (tenge). The coefficient of economic efficiency of capital costs is calculated by the formula:

$$E_p = \frac{C}{K}, \quad (4.21)$$

where

- E_p is the coefficient of economic efficiency of capital costs;
- C - price when selling the device, tenge;
- K - capital investments to create a system, tenge.

$$E_p = \frac{190000}{898816,35} \times 100\% = 21,1\%.$$

The payback period of capital investments is calculated by the formula:

$$T_p = \frac{1}{E_p}, \quad (4.22)$$

and consists:

$$T_r = \frac{1}{0,21} = 4.7 \text{ (year)}.$$

The conclusion of all the above calculations is a table of indicators that will be provided below. On this, the technical and economic part will be completed. Calculations showed that this project is economically feasible and profitable in development. The summary results of the calculation of the economic efficiency of the project are presented in table 4.10

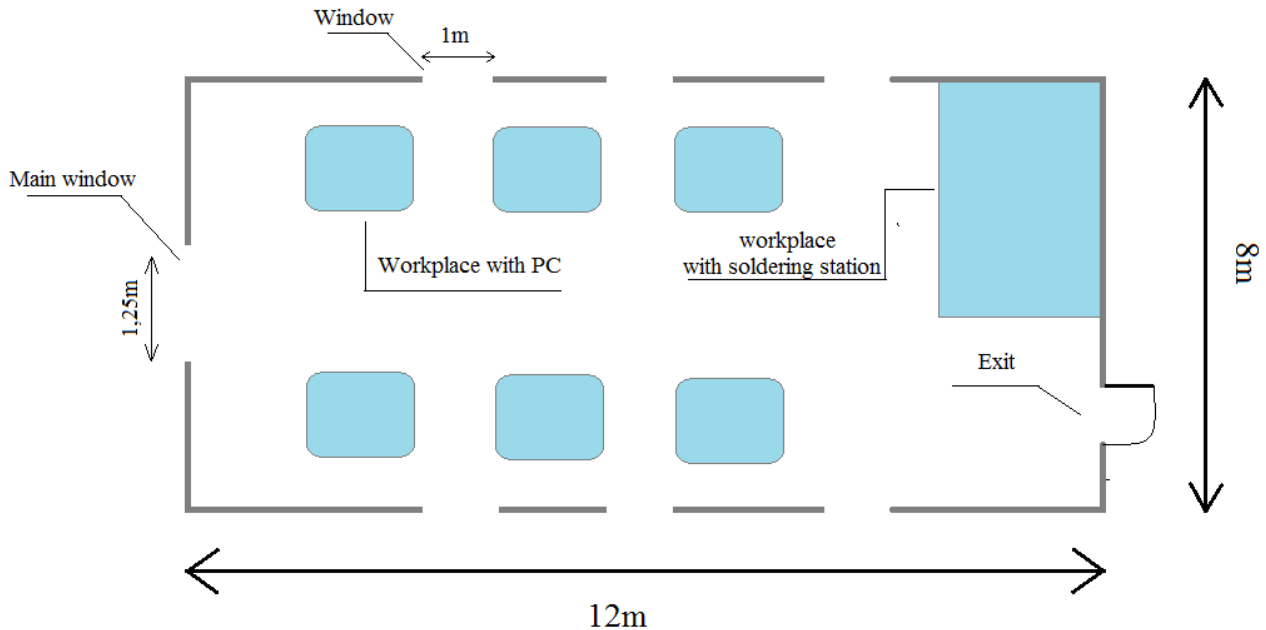
Table 4.10 - Indicators of economic efficiency

Indicators	
Capital investments, tenge	898816,35
Expected economic effect, tenge	136071
Coefficient of economic efficiency, %	21,1
Payback period, year	4,7

5 Life safety

5.1 Analysis of hazardous and harmful production factors

This diploma project deals with the development and programming of UAVs and object recognition systems, which accordingly means that most of the work will be done using computers and other electrical equipment in the room. The number of specialists is 6 people. The work will be carried out in a room 12m long, 8m wide and 3m high. Room layout on picture 5.1



Picture 5.1 – Building scheme

The occurrence of a fire in the working area in question is caused by the following factors: - the presence of flammable elements: documents, doors, tables, etc .; - the presence of oxygen as an oxidizer of combustion processes; - broken insulation of electrical wires.

In order to minimize the possibility of a fire in a building, it is necessary to carry out fire-fighting measures:

- if possible, reduce the amount of flammable substances, replacing them with analogues that are not resistant to burning;
 - eliminate possible sources of ignition;
 - have mandatory fire extinguishing means (fire extinguishers, fire tools, sand);
- conduct a fire alarm in the room;
- keep the electrical equipment in good condition, if possible using means that prevent the occurrence of a fire;

- smoking only in designated areas;
- contain the paths and passages of the evacuation of people in a free state; conduct periodic safety training;
- designate a person responsible for the fire safety of the premises.

Fire safety in the working area is ensured by the following measures:

- regular briefing of employees on safety measures;
- a plan for evacuating people in case of fire; - automatic fire alarm and telephone communication with the fire department;
- the availability of fire extinguishing means (OG-9 fire extinguishers), fire tools, sand.

According to the approved by the Decree of the Government of the Republic of Kazakhstan dated January 16, 2009 No. 14 to the Technical Regulation “General Requirements for Fire Safety” (hereinafter referred to as the Technical Regulation), buildings, structures and premises are classified according to explosion and fire hazard in accordance with Section 7 of Appendix 1 to the Technical Regulations.

The classification is used to establish fire safety requirements aimed at eliminating the risk of fire and providing fire protection to people and property in the event of a fire in buildings and structures. The separation of objects is based on the determination of their belonging to the corresponding category.

Since in the development and programming of UAVs there is no need to use flammable materials and materials that constitute an explosive threat according to the technical regulations of the Republic of Kazakhstan, the room considered in the graduation project belongs to the class “D” - non-combustible substances and materials in the cold state.

But since, as a result of possible emergency circumstances associated with electrical equipment in the room, a fire can still occur and therefore a fire in the room must have an automatic fire extinguishing system.

Having studied the fire safety rules and fire extinguishing methods, it was decided for the above fire extinguishing system to choose a carbon dioxide-chladone composition as a fire extinguishing agent. This composition copes with fires associated with electrical equipment.

In accordance with NPB 88-2001 * "FIRE FIGHTING AND SIGNALING INSTALLATIONS. DESIGN NORMS AND RULES", to extinguish fires in gas fire extinguishing systems, refrigerants 23 (CF₃H), 125 (C₂F₅H), 218 (C₃F₈), 227ea (318FH), 318Fa (C₄F₈c), as well as CO₂, sulfur hexafluoride, nitrogen, argon and the Inergen gas composition (gas mixture containing 52% (vol.) Nitrogen, 40% (vol.) Argon and 8% (vol.) Carbon dioxide) . Presented gaseous substances are low toxic and chemically inert. HFCs used as volumetric fire extinguishing agents do not contain

chlorine in the molecule, and bromine, which increase their toxicity, belong to the group of fluoroalkanes, the toxicity of which decreases with an increase in the number of fluorine atoms in the molecule. The toxicity of propane compounds (Freon 218) increases with a maximum fluorine content in the molecule (1, 2, 3, 4). HFCs used in GOTV are chemically inert, are low-toxic compounds (hazard class 4) and are excreted from the body with exhaled air and in small quantities with bile and urine (1, 2, 3, 4).

The most effective in extinguishing a fire are chemical gases - chladoxones. The physicochemical process of their action is based on two factors: chemical inhibition of the oxidation reaction process and a decrease in the concentration of oxidizing agent (oxygen) in the oxidation zone. A fire extinguishing concentration of compressed gases is higher than freons, therefore, 25-30% more gas is required and, therefore, the number of containers for storing gas fire extinguishing substances (hereinafter GOTV) increases by a third. In accordance with NPB 54-2001 and NPB 88-2001 * a gas fire extinguishing system, where compressed gas is used as the GOTV, requires complex and expensive technical weight control devices.

If GOTV is ranked by toxicity for massive leakage, compressed gases are the least dangerous. Of the listed compressed gases, the Inergen mixture should be preferred, since the carbon dioxide in its composition protects the person from hypoxia. The minimum concentrations of GOTV, at which, in short exposures (less than 5 minutes), there are minimal noticeable harmful effects (for nitrogen, argon and the Inergen mixture), are 43 and 52 volume percent, respectively.

Protective grounding. In addition to the danger of fire, the likelihood of a specialist getting an electric shock should also be considered. Due to the high amount of electrical equipment in the work area, the chance of such an event only increases. To avoid accidents, the room must also be equipped with protective earth.

For example, damage to the internal insulation (conductor, circuit) and the appearance of voltage on the metal casing of the equipment can be cited. And such a voltage can range from several volts to several tens of volts and can even be more than 100 volts.

Touching such equipment, an alternating current will pass through a person, and as you know, AC voltage with a rating of more than 24V is considered deadly. Many experienced "biting" the metal parts of the equipment, so these are small voltage potentials. To protect against such damage, grounding was invented, the main purpose of which is to reduce the magnitude of this voltage. That is, in other words, the main purpose of grounding is to minimize the voltage that appears on the body of electrical equipment to a safe value

5.2 Fire safety. Calculation of an automatic fire extinguishing system with a combined carbon dioxide-chladone composition

The estimated mass of the combined carbon dioxide-freon composition m_d , kg, for volume fire extinguishing is determined by the formula

$$m_d = k_6 q_n V \quad (5.1);$$

where,

- k_6 is the coefficient of compensation for unaccounted for losses of carbon dioxide-freon composition (Table 3.3), $k_6 = 1.25$;

- q_n is the normative mass extinguishing concentration of carbon dioxide-chladonic composition, it is taken 0.27 kg / m³ when the time of filling the room is 30 s, and 0.4 kg / m³, when the time of filling the room is 60 s

$$q_n = 0.4 \text{ kg / m}^3 \quad (5.2);$$

V is the volume of the protected space, $V = 12 * 8 * 3 = 288 \text{ m}^3$.

From this we get:

$$m_d = 1,25 * 0,4 * 288 = 144 \text{ kg}$$

The estimated number of cylinders ζ_2 is determined from the calculation of the capacity of a 40-liter cylinder of 25 kg of carbon dioxide-freon composition

$$\zeta_2 = \frac{m}{25} \quad (5.3);$$

We get
$$\zeta_2 = \frac{144}{25} = 5,76 \approx 6 \text{ balloons}$$

The internal diameter of the pipeline d_i mm, is determined by the formula

$$d_i = d_1 \sqrt{\zeta_2} \quad (5.4);$$

where

- d_1 — the diameter of the siphon tube of the cylinder (table. 3.5), $d_1 = 10 \text{ mm}$;
- ζ_2 — number of simultaneously diluted cylinders, $\zeta_2 = 2 \text{ balloons}$.

We get
$$d_i = 10 \cdot \sqrt{6} = 24,49 \text{ mm}.$$

The equivalent length of the main pipeline, l_1 m, is determined by the formula:

$$L_1 = k_7 l \quad (5.5);$$

where k_7 - the coefficient of increase in the length of the pipeline to compensate for unaccounted for local losses, (table. 3.4), $k_7 = 1,7$; l — project pipeline length, $l = 10$ m;

It means
$$l_1 = 1,7 \cdot 10 = 17 \text{ m}$$

Since the diameter of the passage of the main pipe is less than 35 mm, I can take the data from the graph on picture 5.2 for determining the consumption of carbon dioxide HFC composition Q , kg / s.

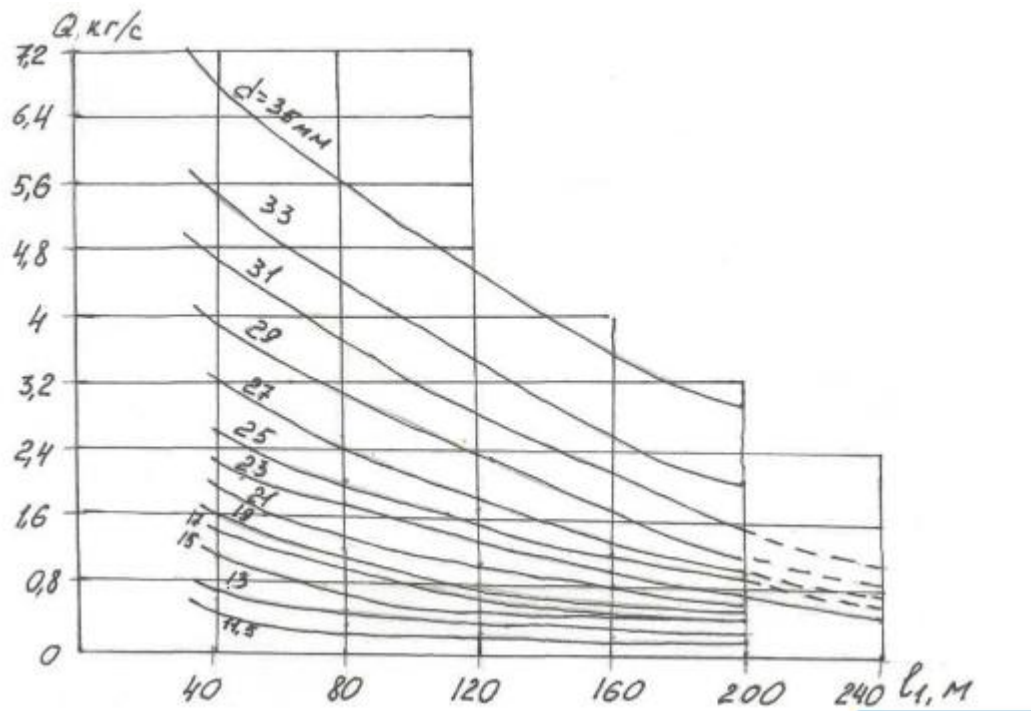


Figure 5.2 - Graph of the ratio of the length of the pipeline and the flow rate of the composition

With the equivalent length of the main pipeline $l_1 = 17\text{m}$ and its diameter $d_i = 17\text{mm}$, we obtain the value of the flow rate of carbon dioxide-chladone composition $Q = 3.1 \text{ kg / s}$

The estimated feed time of carbon dioxide-chladonic composition t , min is calculated by the following formula:

$$t = \frac{md}{60 \cdot Q} = \frac{144}{60 \cdot 3,1} = 0,77 \text{ min}$$

The mass of the main stock of carbon dioxide-freon composition m , kg, is calculated by the formula:

$$m = 1,1 \cdot m_d \cdot \left(1 + \frac{K_8}{K_6}\right) \quad (5.6);$$

Where,

- m_d - estimated mass of the combined carbon dioxide-freon composition;
- K_6 - coefficient of compensation for unaccounted losses of combined composition;
- K_8 - coefficient taking into account the remainder of the carbon dioxide-freon composition in cylinders and pipelines.

$$m = 1,1 \cdot 144 \cdot \left(1 + \frac{0,2}{1,25}\right) = 183,74 \text{ kg}$$

Based on the calculations, I calculated that the mass of the main stock of carbon dioxide-freon composition $m = 183.74 \text{ kg}$, the estimated number of cylinders $\zeta^2 = 2$ cylinders. The feed time of the composition $t = 0.77$ minutes

5.3 Protective earth Calculation

An additional measure of protection is protective grounding of metal cases of all electrical equipment of the workshop. Protective grounding is a system of higher conductivity, so that the contact voltage is reduced to a safe value. The structural element of the protective equipment are grounding conductors - metal conductors connecting the grounded equipment with grounding conductors. Protective grounding is supposed to be made of vertical rod grounding conductors with a length of $L = 3 \text{ m}$ and a diameter of $d = 0.05 \text{ m}$ buried in the ground by a length of $t_0 = 3 \text{ m}$. The resistance of a single tubular grounding conductor installed in the ground is determined from the formula:

$$R_{tr} = \frac{\rho v}{2 \cdot n \cdot L} \left(\ln \frac{2 \cdot L}{d} + \ln \frac{4t+L}{4t-L} \right) \quad (5.7);$$

where ρ - soil resistivity; L is the length of the pipe; t is the depth of laying;

$$P_v = \rho \cdot \Psi_v \quad (5.8);$$

where Ψ_b – seasonality coefficient and it is 1.1;

Ground resistivity $\rho = 100 \text{ Ohm} \cdot \text{m}$ as the foundation of the room will be made of concrete

$$P_b = 100 \cdot 1.1 = 110 \text{ Ohm} \cdot \text{m};$$

Next, calculate the depth t , m:

$$t = t_0 + \frac{L}{2} = 3 + \frac{3}{2} = 4,5 \text{ m};$$

The next step is the calculation of the resistance of a single tubular earthing switch:

$$R_{tr} = \frac{110}{2 \cdot 3,14 \cdot 3} \left(\ln \frac{2 \cdot 3}{0,05} + \ln \frac{4 \cdot 4,5 + 3}{4 \cdot 4,5 - 3} \right) = 5,4(4,79 + 0,34) = 27,702 \text{ Ohm}$$

Choose the distance between adjacent and vertical electrodes:

$$a = 2 \cdot L = 2 \cdot 3 = 6 \text{ m};$$

We determine the number of vertical electrodes n . To do this, we find the product of the utilization coefficient of vertical electrodes:

$$(\eta_v \cdot n) = \frac{R_{tr}}{R_{H \text{ add}}} \quad (5.9);$$

Since the maximum allowable value of $R_{H \text{ add}} = 4 \text{ Ohm}$, therefore:

$$(\eta_v \cdot n) = \frac{27,702}{4} = 6,925$$

According to the table, determine the number of grounding conductors $n = 10$

The resistance of the metal strip used to connect the tubular earthing is determined from the formula:

$$R_n = \left(\frac{\rho n}{2 \cdot n \cdot L_n} \cdot \ln \frac{2 \cdot L_n}{b \cdot t} \right) \quad (5.10);$$

Where, L_n – strip length;

$$L_n = n \cdot a = 10 \cdot 6 = 60 \text{ m};$$

$$\rho_n = \rho \cdot \Psi_n = 100 \cdot 1,4 = 140 \text{ Ohm} \cdot \text{m};$$

$$\Psi_n = 1.4$$

$$R_n = \frac{140}{2 \cdot 3,14 \cdot 60} \cdot \ln \frac{2 \cdot 60}{0,04 \cdot 4,5} = 0,37 \cdot 6,5 = 2,4 \text{ Ohm};$$

The ground resistance of the ground electrode system, consisting of 10 rod ground electrodes and the connecting strip, is determined by the formula:

$$R_{zp} = \frac{R_{mp} \cdot R_n}{R_{mp} \cdot \eta_z + R_H \cdot \eta_6 \cdot n} \quad (5.11);$$

When $\frac{a}{L} = 2$ and $n = 10$ from the figure 4.3 we find the coefficients of the corresponding electrodes $\eta_b = 0,74$ and $\eta_r = 0,68$. Coefficient are illustrated on figure 5.3

a/l	При размещении в ряд			При размещении по контуру		
	$\square_{\theta} n$	n	\square_{θ}	$\square_{\theta} n$	n	\square_{θ}
1	1,70	2	0,85	2,76	4	0,69
	2,34	3	0,78	3,66	6	0,61
	2,92	4	0,73	5,50	10	0,55
	3,50	5	0,7	9,40	20	0,47
	3,90	6	0,65	16,40	40	0,41
	5,90	10	0,59	23,40	60	0,39
	8,10	15	0,54	36,00	100	0,36
	9,60	20	0,48	-	-	-
2	1,82	2	0,91	3,12	4	0,78
	2,61	3	0,87	4,38	6	0,73
	3,32	4	0,83	6,80	10	0,68
	4,05	5	0,81	12,60	20	0,63
	4,62	6	0,77	23,20	40	0,58
	7,40	10	0,74	33,00	60	0,55
	10,50	15	0,70	52,00	100	0,52
	13,40	20	0,67	-	-	-
3	1,88	2	0,94	3,4	4	0,85
	2,73	3	0,91	4,8	6	0,80
	3,56	4	0,89	7,6	10	0,76
	4,35	5	0,87	14,2	20	0,71
	5,10	6	0,85	26,4	40	0,66
	8,10	10	0,81	38,4	60	0,64
	11,70	15	0,78	62,0	100	0,62
	15,20	20	0,76	-	-	-

Figure 5.3 - Coefficients of use vertical electrodes

$$R_{rp} = \frac{27,702 \cdot 2,4}{27,702 \cdot 0,68 + 2,4 \cdot 0,74} = 3,23 \text{ Ohm}$$

In accordance with the requirements, the total grounding resistance must not exceed 4 ohms. Thus, the grounding resistance $R_{gr} \leq 4 \text{ Ohms}$, which meets the requirements of PTE and PUE.

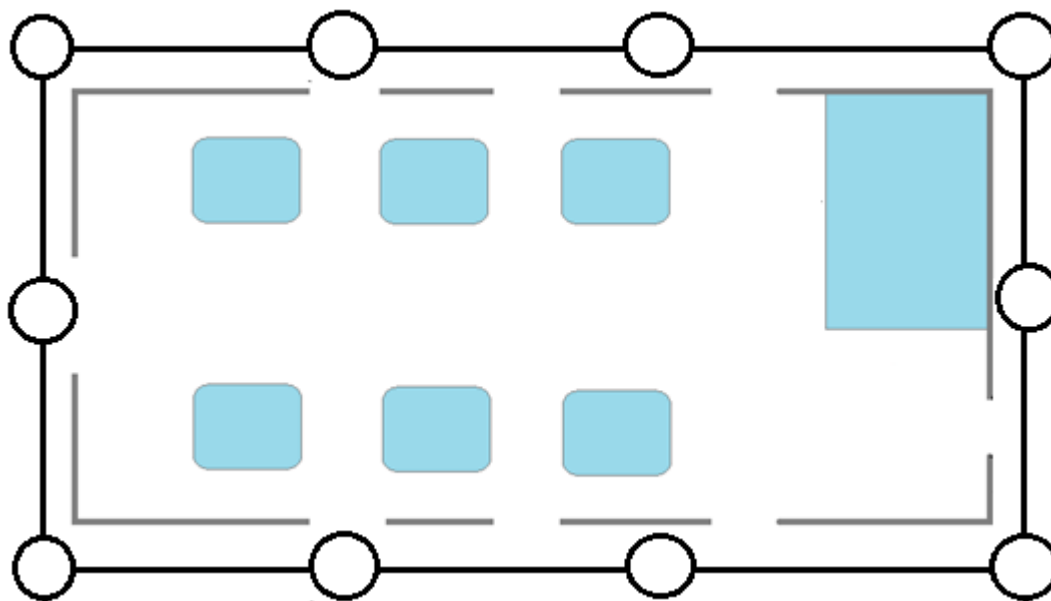


Figure 5.3 - Protective earthing circuit

5.4 Conclusion on the section of life safety

In this section of the thesis, calculations were carried out to create protective grounding systems and an automatic fire extinguishing system. In this regard, data corresponding to the standards of safe work of personnel in the working area were calculated.

The total resistance of the ground electrode / electrode is $R_{GR} = 3.23$ Ohms, which corresponds to the requirements of PTE and PUE. The number of single ground electrodes was 10 pieces, which are shown in Figure 4.3.

Then, calculations were made to supply the premises with a protective grounding system in order to avoid accidents with electrical voltage. Namely, by means of calculations, the following data was obtained that also correspond to the standards: The total grounding / electrode resistance $R_{gr} = 3.23$ Ohms, the number of single grounding conductors was $n = 10$, and the resistance of the metal strip was $R_n = 2.4$ Ohm.

Conclusion

As a result of this diploma project, skills were acquired in the study and analysis of UAVs. Moreover, the microcontroller of the Raspberry family was studied in depth and in detail, namely, the Pi 3 B + model, which was directly used in the assembly of the prototype. Using the sufficient knowledge gained at the university, a program was developed for studying and keeping records of rare animals based on OpenCV and Tensorflow. The modules of the microcontroller used have been carefully studied and reviewed. Much work has been done in the Raspbian operating environment, which has led to the accumulation of a large amount of experience working on Linux-based operating systems. The created prototype can be successfully applied in agriculture to search for lost livestock, to study a particular species without risking the lives of zoologists, to protect objects in wild zones from predators, etc.

In the future, it will be possible to create more complex control algorithms and object recognition based on the existing simulation model.

In addition, the presence of a feasibility study revealed that the financial task is cost-effective and quite cost-effective, the presence of the study of the concept has been won. Based on the calculations, it is possible to note that in the worst case the plan will pay off less than in 4 years, which is considered a good sign.

Bibliography

- 1 Pavlushenko M., Evstafiev G., Makarenko I. UAV: history application, threat of proliferation and development prospects. M., "Rights person ", 2005.
- 2 Inozemtsev D.P. Unmanned Aerial Vehicles: Theory and practice // Automated research and design technologies, 2013. No2. - S. 50-54.
- 3 Michael D. S. Simulation and control of a quadrotor unmanned aerial vehicle. URL: uknowledge.uky.edu/gradschool_theses/93 (handling date 01/12/2015).
- 4 Astha Sharma, Amol Barve. Controlling of Quad-rotor UAV Using PID Controller and Fuzzy Logic Controller // International Journal of Electrical, Electronics and Computer Engineering. - 2012. - No. 2277-2626. - pp. 38-42.
- 5 Aleksandar Rodic, Gyula Mester. Control of a Quadrotor Flight. URL: webmanage.ecust.edu.cn/picture/article/144/e1/85/1718504046598df3c004b09234_24/0cae278c-1440-47b1-acdc-9f25cd6d18.pdf (handling date 01/12/2015).
- 6 Hicham Khebbache, Mohamed Tadjine. Robust Fuzzy Backstepping Sliding Mode Controller For a Quadrotor Unmanned Aerial Vehicle // Control Engineering and Applied Informatics - 2013 - Vol. 15 - pp. 3-11.
- 7 Victoria Lopez, Franciso Morata. Intelligent Fuzzy Controller of a Quadrotor // International Conference on Intelligent System and Knowledge Engineering – ISKE 2010. - pp. 141 - 146.
- 8 Syed Ali Raza and Wail Gueaieb. Intelligent Flight Control of an Autonomous Quadrotor. URL: intechopen.com/books/motioncontrol/intelligentflight-control-of-an-autonomous-quadrotor (handling date 01/12/2015).
- 9 Bourhane Kadmiry. Fuzzy Control for an Unmanned Helicopter / Linköping Studies in Science and Technology, Sweden, 2002 - P. 122.
- 10 Francisco Jurado, B. Castillo - Toledo. Stabilization of a Quadrotor via Takagi - Sugeno Fuzzy Control // The 12th World Multi-Conference on Systemics, Cybernetics and Informatics. - Orlando, Florida, USA, 2008.6 p.
- 11 Nicoli C., Macnab C.J.B., Ramirez-Serrano A. Robust neural network control of a quadrotor helicopter. URL: academia.edu/8226428/ROBUST_NEURAL_NETWORK_CONTROL_OF_A_QUADROTOR_HELICOPTER (handling date 01/12/2015).
- 12 <https://newatlas.com/intel-winter-olympics-drones/53355/> (06.05.2018) (accessed date: 05/05/2018)
- 13 <https://www.cossa.ru/216/79896/> (accessed 05.05.2018)
- 14 <https://robo-sapiens.ru/stati/20-sposobov-primeneniya-dronov-segodnya-iv-blizhayshem-budushhem/> (accessed 05.05.2018)

- 15 Randal W. Byard, Timothy W. McLane. Small unmanned aircraft: theory and practice. Moscow: TECHNOSPHERE, 2015 .—312 c.62
- 16 Daewon Lee, H. Jin Kim, Shankar Sastry. Feedback Linearization vs. Adaptive Sliding Mode Control for a Quadrotor Helicopter. International journal of Control, Automation, and Systems, 2009. - 10 c.
- 17 University of Michigan. Control Tutorials for Matlab & Simulink, DC Motor Speed: System Modeling - [Electronic resource]. URL: <http://ctms.engin.umich.edu/CTMS/index.php?example=MotorSpeed§ion=SystemModeling> (Date accessed: 04/30/2018)
- 18 Theory of automatic control: textbook. for universities / S. E. Dushin, N. S. Zotov, D. Kh. Imaev and others; Ed. V. B. Yakovleva. - M.: Higher School, 2005. - 567 p.
- 19 Theory of automatic control: textbook. for universities / S. E. Dushin, N. S. Zotov, D. Kh. Imaev and others; Ed. V. B. Yakovleva. - M.: Higher School, 2005. - 567 p.
- 20 W Yerkeshev. Guidelines for the implementation of economic parts of theses for students of specialty 5B071600 - Instrument making. - Almaty: AUES, 2017 - 29s.
- 21 Kolmykova T.S. Investment Analysis: Textbook. - M.: INFRA-M, 2009 .-- 204 p.
- 22 Lipsits I.V. Economics: Textbook for universities. -Omega-L, 2006 .-- 656 p.
- 23 Kuznetsov, B. T. Investment analysis: a textbook and workshop for academic undergraduate / B. T. Kuznetsov. - M.: Publishing house Yurayt, 2014 .-- 361 p.
- 24 <http://kak-bog.ru/kak-pravilno-sidet-za-kompyuterom> (date of treatment 05/06/2018)
- 25 Carre F. Danger sédentarité - Cherche Midi, 2013 .-- 168 p.
- 26 Dulitsky G.A., Komarevtsev A.P. Electrical safety at operation of electrical installations up to 1000 V. Reference. - M.: Military Publishing House, 2008.
- 27 Abdimuratov Zh.S., Mananbaeva S.E. Safety life activity. Guidelines for the implementation of the section "Calculation industrial lighting "in graduation work for all specialties. Undergraduate - Almaty: AIPP, 2009. - 20 p.
- 28 SP RK 2.04-104-2012 Code of Practice. Natural and artificial lighting. State regulations in the field of architecture, urban planning and construction.
- 29 SP 52.13330.2011 Code of practice. Natural and artificial lighting.
- 30 SanPiN 2.2.4.548. Hygienic requirements for microclimate production facilities. M.: Ministry of Health of Russia, 2009.
- 31 SanPiN 2.2.2 / 2.4.1340 - 03. Sanitary and epidemiological rules and standards "Hygienic requirements for personal electronic computers and work organization".