MINISTRY OF EDUCATION AND SCIENCE OF THE REPUBLIC OF KAZAKHSTAN
Non-profit joint-stock company
"ALMATY UNIVERSITY OF POWER ENGINEERING AND TELECOMMUNICATIONS NAMED AFTER G. DAUKEYEV»
Institute of Space Engineering and Telecommunications
Department of Electronics and Robotics

Head of the Department
associate professor Chigambayev T. O.
___________ "___" _________2021

DEGREE PROJECT

On the topic: "Developing a Bluetooth-controlled robot turtle"
Specialty: "6B071600-Instrument Engineering»
Performed by: Abuov A.D.   Group: PSa-17-4
Scientific supervisor: Associate Professor T.O. Chigambayev
Consultants:
on the economic side:
associate professor Tuzelbayev B. I.

_____________ "___" __________2021
(signature)

on life safety:
associate professor Begimbetova A. S.

_____________ "___" __________2021
(signature)

Normcontroller:
lecturer Fazylova A.R.

_____________ "___" __________2021
(signature)

Reviewer:
senior lecturer Espayev B.A.

_____________ "___" __________2021
(signature)

Almaty 2021

Non-profit joint-stock company
"ALMATY UNIVERSITY OF ENERGY AND COMMUNICATIONS NAMED AFTER GUMARBEK DAUKEYEV»
Institute of Space Engineering and Telecommunications
Department of Electronics and Robotics
Specialty “6B071600-Instrument Engineering”

TASK
to complete a graduation project (work)

Student Abuov Alyas Dzhamilevich

Topic of work (project) " Developing a Bluetooth-controlled robot turtle "

Approved by University order № 44 of 05.04.2021

Deadline for delivery of the completed work (project) «30» June 2021

Initial data for work (required parameters of research (design) results and initial data of the object):

1. Components for the robot-turtle;
2. Mathematical model for caterpillar chassis;
3. Assembly of the Bluetooth-controlled robot turtle;
4. Configuration and health check.

A list of questions to be developed in the thesis, or a summary of the thesis:

1. Development of robotics;
2. Private sector security;
3. Selection of components for developing the robot-turtle.

Main recommended literature:

1. Jack J Purdum. Beginning C for Arduino: learn C programming for the Arduino. — 2015.
2. Wesley L. Stone. The History of Robotics // Robotics and automation handbook / Thomas R. Kurfess. — Boca Raton, London, New York, Washington, D.C.: CRC PRESS, 2005.
3. Belov A.V. Designing devices on microcontrollers. Saint Petersburg: Nauka i Tekhnika Publ., 2005, 256 p.

Consultations on the work (project) with an indication of the relevant sections of the work (project)

Section	Consultant	Deadlines	Signature
Life safety	Begimbetova A. S	12.04-25.05.2021	
Economic part	Tuzelbayev B. I.	12.04-25.05.2021	

Schedule of preparation of the diploma project (work)

Name of sections, list of questions to be developed	Terms of submission to the scientific supervisor	Note
1. Description of the robotics	22.02.2021	
2. Management Strategies	08.03.2021	
3. Building a mathematical model	22.03.2021	
4. Control block diagram	29.03.2021	
5. Equipment selection	05.04.2021	
6. Assembly of the robot-turtle	19.04.2021	
7. Software	30.04.2021	
8. Life safety	06.05.2021	
9. Economic part	21.05.2021	

Date of issue of the task «_____»__________2021

Head of the Department____________(T. O. Chigambayev)
(signature)

Scientific supervisor of
the work (project) _____________ (T. O. Chigambayev)
(signature)

The task was accepted by
the student ____________ (Abuov A. D.)
(signature)

Аннотация

В данной дипломной работе рассмотрены вопросы о создании робота предназначенного для обеспечения безопасности дома. Описаны микроконтроллер Arduino ATMega328, различные датчики, среда программирования Arduino IDE и другое оборудование, относящееся к данному проекту, на данных устройствах был спроектирован робот, позволяющий в режиме реального времени наблюдать за происходящим в доме при помощи управления по Bluetooth. Рассмотрены вопросы безопасности жизнедеятельности, составлен бизнес–план и рассчитан срок окупаемости данного проекта.

Summary

This thesis deals with the creation of a robot for home security. Arduino ATMega328 microcontroller, various sensors, Arduino IDE programming environment and other equipment related to this project are described, the robot was designed on these devices, allowing in real time to observe what is happening in the house by means of Bluetooth control. The issues of life safety were considered, a business plan was made and the payback period of this project was calculated.

Андатпа

Бұл тезис үйдің қауіпсіздігін қамтамасыз етуге арналған робот жасау туралы. Arduino ATMega328 микроконтроллері, әр түрлі датчиктер, Arduino IDE бағдарламалау ортасы және осы жобаға қатысты басқа жабдықтар сипатталған, осы құрылғыларда Bluetooth басқаруды қолдана отырып үйде болып жатқан оқиғаларды нақты уақыт режимінде бақылауға мүмкіндік беретін робот жасалды. Тіршілік қауіпсіздігі мәселелері қаралды, бизнес-жоспар құрылды және осы жобаның өзін-өзі ақтау мерзімі есептелді.

Content

Introduction

A robot is a machine equipped for doing a muddled arrangement of exercises consequently, particularly one that can be customized by a PC. Robots can be directed by an outside control gadget or by control that is worked inside the actual robot. Albeit a few robots are worked to take after people, most of robots are utilitarian machines intended to do an assignment without worry for feel. There are a few assortments of robots, including: The SWORDS robot, which is currently conveyed in ground-based fighting, is an illustration of military mechanical technology. It can discharge a wide scope of weaponry, and there is discussion of allowing it extensive independence in battling conditions [1].

Mining robots are planned to address an assortment of issues presently tormenting the area, including work deficiencies, expanding usefulness notwithstanding lessening mineral evaluations, and meeting ecological objectives.

Particular robots are another age of robots created to amplify robot use by modularizing its engineering. When contrasted with conventional robots, a secluded robot's ability and adequacy are easy to grow [2]. These robots are comprised of a solitary kind of indistinguishable module, numerous particular sorts of indistinguishable modules, or likewise formed modules of different sizes. Measured robots might be made with in excess of 8 levels of opportunity because of their building structure, which takes into account hyper-repetition (DOF).

Actual robots and virtual programming specialists are both alluded to as bots, however the last are generally alluded to as bots. In spite of the fact that there is no all inclusive concession to whether gadgets qualify as robots, researchers and the overall population accept that robots will in general have a few or the entirety of the accompanying abilities and capacities: assimilate and measure electronic programming, information, and actual insights electronically, move about, work actual bits of themselves or actual cycles, see and deal with their environmental factors, and show astute conduct, especially conduct that imitates people or different creatures. Engineered Biology, which looks at things whose nature is more similar to creatures than machines, is intently attached to the idea of a robot.

The piece of advancement that courses of action with the arrangement, improvement, movement, and use of robots, similarly as PC systems for their control, material analysis, and information getting ready is progressed mechanics. These advances oversee automated machines that can supplant individuals in dangerous conditions or gathering measures, or appear as though individuals apparently, lead, or understanding. An extensive part of the current robots are animated normally adding to the field of bio-roused progressed mechanics. These robots have furthermore made a more current piece of cutting edge mechanics: fragile progressed mechanics. In this work, a robot planned to ensure prosperity in the homes of ordinary occupants is considered.

1 Technological part

1.1 Purpose and objectives of the thesis

The purpose of the thesis is to create a robot designed to ensure the safety of the house using a camera installed in it, which will allow the owner to observe what is happening in real time, as well as send commands to the robot remotely. During development, you should consider the latest modern robots and study them to further create your own robot. You should also consider the various sensors required for the robot to operate.

1.2 Development of robotics

Robotics is an applied science that spotlights on the making of computerized innovative frameworks and is the main mechanical establishment for assembling progress.

Gadgets, mechanics, artificial intelligence, remote-controlled machinery, mechatronics, informatics, radio and electrical designing all have a job in mechanical technology. Development, mechanical, buyer, clinical, aeronautics, and outrageous (military, space, and undersea) advanced mechanics are among the advanced mechanics classifications [1]. With the development of robotics there are also various prostheses and the like, one of these is shown in figure 1.1.

Figure 1.1 – Robot hand

A portion of the thoughts that later turned into the premise of advanced mechanics date back to the old period, some time before the previously mentioned terms were presented. Stays of moving sculptures made in the primary century B.C. have been found. Homer's Iliad says that the god Hephaestus made working house keepers out of gold, giving them insight (that is - in current language - man-made reasoning) and force. The antiquated Greek specialist and designer Architus of Tarentus is credited with the formation of a mechanical pigeon that could fly (c. 400 BC). More than 2,000 years prior Heron of Alexandria made the Singing Bird water machine and various frameworks of portable figures for old sanctuaries. In 270, the antiquated Greek innovator Ctesibius created an exceptional water clock called the klepsidra (or "taking time"), which by its cunning gadget stimulated extensive interest among his counterparts. In 1500, the incomparable Leonardo da Vinci planned a mechanical gadget as a lion, which was to open the escutcheon of France when the lord entered the city. In the eighteenth century, the Swiss watchmaker P. Jacquet-Droz made a mechanical doll "Copyist" that could be customized with cam drums to compose instant messages containing up to 40 letters.

In 1801, the French vendor Joseph Jacquart presented a high level plan for the hour of the loom, which could be "customized" with extraordinary cards with openings to replicate rehashing beautiful examples on the woven textures. Toward the start of the nineteenth century this thought was acquired by the English mathematician Charles Babbage to make one of the main programmed ascertaining machines. By about the 1930s, androids had gave the idea that carried out rudimentary developments and were equipped for expressing basic expressions at the order of a human. One of the primary such improvements was the plan by American specialist D. Waxley, made for the New York World's Fair in 1927.

In the fifties of the twentieth century, mechanical controllers showed up for working with radioactive materials. They were fit for impersonating the hand developments of an administrator who was in a protected area. By the 1960s, far off controlled wheeled stages with a controller, telecamera, and amplifier were being created for assessment and test assortment in spaces of high radioactivity.

The far reaching reception of mathematically controlled modern machines was the catalyst for the advancement of programmable controllers utilized for stacking and dumping machine device frameworks. In 1954, the American designer D. Devol has licensed the technique for controlling the stacking and dumping controller through inconsistent punched cards, as an outcome in 1956 along with D. Engelberger he made the main modern organization on the planet "Unimation" (Unimation from Universal Automation) for the creation of mechanical advanced mechanics.

In 1962, the principal U.S. mechanical robots Versatran and Unimation were dispatched, and some of them are as yet in activity today, having passed the 100,000 hour working life limit. While in these early frameworks the proportion of expenses for gadgets to mechanics was 75% to 25%, this proportion has now turned around. Simultaneously, the last expense of gadgets keeps on declining consistently. The approach of cheap chip based control frameworks during the 1970s, which supplanted specific robot control units with programmable regulators, assisted with lessening the expense of robots by about a factor of three. This was the catalyst for their mass conveyance across all parts of mechanical creation [2].

A great deal of comparative data is contained in the book "Advanced mechanics: History and Prospects" by I.M. Makarov and Y.I. Topcheev, which is a mainstream and point by point tale about the job robots played (and still will play) throughout the entire existence of human progress advancement.

A few methodologies can be utilized to characterize robots, e.g., by application, by reason, by method of development, and so on As indicated by the extent of the fundamental application we can recognize mechanical robots, research robots, robots utilized in preparing, uncommon robots.

The main classes of broadly useful robots are manipulative and portable robots (figure 1.2).

A control robot is a programmed machine (fixed or versatile), comprising of a leader gadget as a controller having a few levels of portability and a product control unit, which serves to perform engine and controlling capacities in the creation interaction. Such robots are created in floor, suspended and gantry renditions. They are most broadly utilized in mechanical designing and instrumentation enterprises.

A versatile robot is a modified machine that has a moving underside with thusly controlled actuators. Such robots can be wheeled, walking and followed (there are in like manner crawling, floating and flying adaptable mechanical frameworks). The most basic robots in this class are four-haggled robots. Robots with an alternate number of wheels are additionally made; for this situation it is frequently conceivable to improve on the development of the robot, and to enable it to work in spaces where four-wheeled development isn't useful.

Two-wheeled robots commonly utilize some sort of gyroscopic gadget to decide the point of tendency of the robot body and create the fitting control voltage applied to the robot drives (to keep up equilibrium and make the vital developments). The issue of keeping a two-wheeled robot in balance is identified with the elements of the backwards pendulum. Some such "adjusting" gadgets have been created. Such gadgets incorporate the Segway, which can be utilized as a robot segment; for instance, the Segway is utilized as a transportation stage in the NASA-created Robonaut robot.

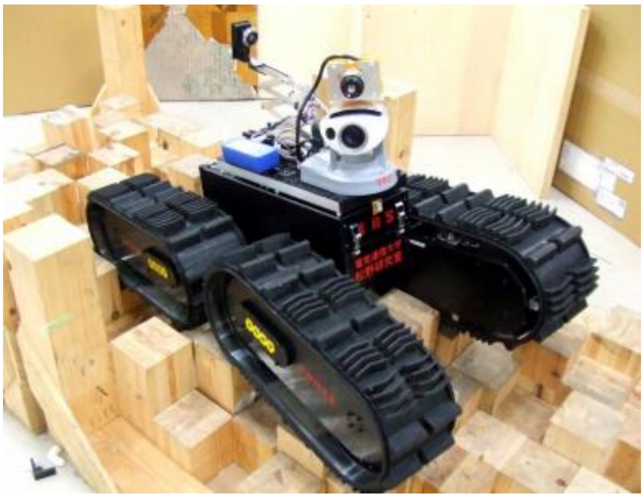

Figure 1.2 - Camera robot on tracked chassis

Single-wheeled robots are according to different perspectives a progression of musings related to two-wheeled robots. To move in 2D space, a ball driven by a couple of actuators can be used as a singular wheel. A couple of enhancements of such robots as of now exist. Models are the ball robot made at Carnegie Mellon

University, the BallIP ball robot made at Tohoku Gakuin University, or the Rezero ball robot made at the Swiss Higher Technical School. Robots of this sort appreciate a couple of advantages due to their extended shape, which may allow them to organize liked into a human environment over is useful for some various kinds of robots.

There are different models of round robots. Some of them use inside mass unrest to assemble improvement. Robots of this sort are called round circle robots, circle bot and ball bot.

Different convenient wheeled robot plans use "omnidirectional" moving wheels; such robots are especially adaptability.

For moving over disproportionate surfaces, grass and stony scene, six-wheeled robots are being made, which have really balance differentiated and four-wheeled ones. Significantly more balance is given by the tracks. An enormous number of the current fight robots, similarly as robots proposed to move over terrible surfaces, are arranged as followed robots. All the while, it is difficult to use such robots inside, on smooth surfaces and covers. Cases of such robots are the Urban Robot ("Urbie") made by NASA (figure 1.3), the Warrior and PackBot robots made by iRobot.

The employments of robots in space are gigantic. The devices assemble soil tests and examine new districts in unsafe conditions where individuals can't reach.

Figure 1.3 – NASA space robot

Robots are fit for supplanting people in numerous spaces of action. The functional use of mechanical technology has become an available reality. Current innovation has made it conceivable to make an assortment of robots, the order of which should be perceived [3].

The dynamic utilization of robots in different everyday issues has driven a few group to need their own automated "companion. Today, notwithstanding various toys for youngsters, there are robots on store retires that can fly, sing, tell stories, and considerably more. Such gadgets are additionally sold for grown-ups.

Perhaps the most striking models is the robot Thespian (figure 1.4), a gadget made for correspondence. He is capable not exclusively to impart, yet in addition understands sonnets, performs dramatic plays, signals and shows striking feelings all over.

The zenith of robot improvement in the field of amusement is humanoid-type gadgets. They can chat on different subjects and make jokes.

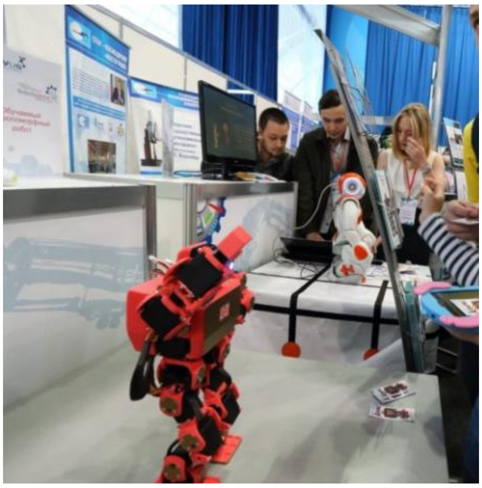

Figure 1.4 – Thespian robot

1.3 Advantages and disadvantages of robotization

1.3.1 The Disadvantages of robotization:

— Robotization is an irreversible interaction that prompts the rearrangements of specific everyday issues. Be that as it may, as well as expanding efficiency and decreasing expenses, robotization likewise has unfortunate results;

— Expanded joblessness. Since robots will possess most positions, experts will be jobless. Physical work will be supplanted by computerized reasoning, which will prompt radical staff decreases all over;

— Reliance on an unmistakable PC framework. The quality and effectiveness of robotization relies upon robots being obviously modified for specific assignments. Later on, a disappointment or change in the program can prompt work stoppages;

— Complex control in outrageous circumstances. In case of breakdowns, power floods or different possibilities, it will be hard to rapidly reestablish the work process. Creation would need to stop or HR would need to be utilized;

— Troubles in enhancement. Most robots are equipped for playing out close to 1 or 2 activities all at once;

— Difficulty of use in innovativeness. Man-made brainpower can't be trusted with autonomous item improvement or different assignments that require inventiveness. Robotics process is shown in figure 1.5.

Figure 1.5 – Robotics process

1.3.2 Advantages of utilizing robots:

— Expanded nature of items created. Robots are profoundly exact and useful, so they can create great quality items. The gadgets can do the work regardless of whether it would require tedium or genuine exertion;

— Minimization of rejects. Robots can work indefatigably to build the quantity of items delivered. Movement sensors and vision frameworks can limit scrap;

— Exactness and repeatable machining. Robots can perform assignments that are outside human ability to control;

— Cost decrease. By utilizing mechanical technology, costs for worker pay rates, pay and advantages, and extra security are diminished;

— Diminished dangers of wounds and wounds. Robots, in contrast to people, can work in unsafe regions;

— As an example of a robot designed to collect microchips is shown in figure 1.6.

Figure 1.6 – ABB robot

1.3.3 Future of robotization

Robotization will make it conceivable to make a modified item for every buyer.

A few callings will vanish and individuals will lose their positions. There will be no more experts like clerks, movers, archive agents, and so forth In any case, there will be more consideration callings for the older, and more close to home mentors.

Robotization will assist the world adapt to the issue of a maturing populace. What's more, the missing common will be supplanted by robots.

Robotization is an irreversible cycle for what's to come. It will carry huge advantages to humankind, and yet it will essentially change the development of cycles in all businesses. It is as of now conceivable to turn out to be essential for this cycle and gain crucial information in the field of mechanical technology. Indeed, even youngsters can dominate a promising and fascinating calling. At Roboschool, kids effectively ace the "claim to fame of things to come" in a perky way [4].

2 Constructive part

2.1 Comparison of Arduino versions

The Arduino Uno (figure 2.1) is the standard Arduino board and is seemingly the most well-known. It depends on the ATmega328 chip with 32KB blaze memory, 2KB SRAM and 1KB EEPROM memory. On the fringe, it has 14 discrete (computerized) input/yield channels and 6 simple information/yield channels, these are flexible valuable gadgets that permit you to cover most beginner undertakings in the field of microcontroller innovation. This regulator board is one of the least expensive and most regularly utilized. When arranging another undertaking, in the event that you are new to the Arduino stage, we suggest beginning with the Uno [5].

Figure 2.1 – Arduino UNO

Arduino Leonardo (figure 2.2) a similar Arduino Uno, yet with another microcontroller that is in a similar class, however has some certain distinctions. More simple information sources (12 versus 6) for sensors, more PWM channels (7 versus 6), additional pins with equipment intrudes on (5 versus 2), separate free sequential interfaces for USB and UART. The Arduino Leonardo can profess to be a console or mouse (HID gadget) for your PC. This makes it simple to make your own information gadget. Due to the pinout is marginally unique in relation to the Arduino Uno, there might be contrary qualities with some extension sheets.

Figure 2.2 – Arduino Leonardo

Arduino Nano (figure 2.3) is a practical simple of Arduino Uno, yet positioned on a little board. The thing that matters is the shortfall of its own attachment for outer force, utilizing FTDI FT232RL chip for USB-Serial change (or CH340G, you need to introduce the suitable drivers) and utilizing small USB link for collaboration rather than the standard one. Something else, the substance and specialized strategies are equivalent to the essential model. The stage has pin contacts, which makes it simple to introduce on the breadboard. Utilize the Arduino Nano where minimization is significant and the capacities of the Arduino Mini are either insufficient or you would prefer not to do patching.

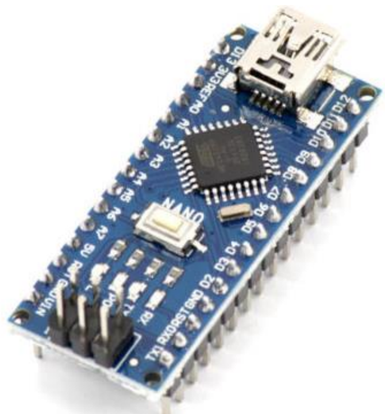

Figure 2.3 – Arduino Nano

Like Arduino Uno, however dependent on an all the more impressive microcontroller of a similar engineering. An incredible decision for "growing up" or if the Arduino Uno has quit working. Times as much memory: 256KB versus 32KB lasting and 8KB versus 2KB RAM. Ordinarily more ports: 60 of them 16 simple and 15 with PWM. Somewhat more than the essential Arduino Uno: 101×53 mm versus 69×53 mm.

Figure 2.4 – Arduino Mega

One of Arduino's best Cortex-M3 microcontroller sheets, comparable in structure factor to the Arduino Mega. 84 MHz processor and 512 KB memory. 66 I/O pins, of which 12 can be simple information sources, 12 help PWM and every one of the 66 can be arranged as equipment intrudes. An incorporated CAN transport regulator permits organizing or interfacing with car hardware. Two DAC channels permit you to integrate sound system sound with 4.88 Hz goal. The local voltage for the board is 3.3V, not the conventional 5V. It is important to ensure that the chose peripherals support activity with this level or to put voltage level converters.

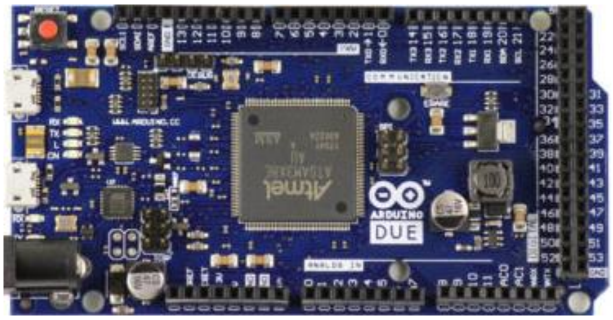

Figure 2.5 – Arduino Due

Same Arduino Uno, however in an alternate structure factor. It is minimal: just 30×18 mm. Due to the structure factor, it is preposterous to expect to introduce Arduino development sheets without stunts. It should be associated with extra modules with wires or potentially through a breadboard. The board has no USB port, so you need to streak through a different USB-Serial connector.

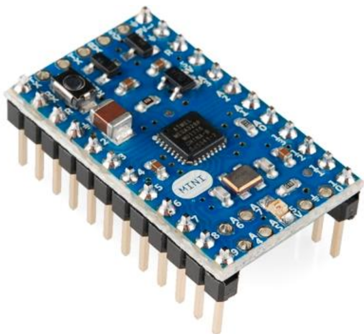

Figure 2.6 – Arduino mini

Arduino Micro (figure 2.7) is an Arduino Leonardo on a conservative board. The thing that matters is that it doesn't have its own attachment for outer force, however it tends to be associated straightforwardly to the Vi pin. Something else, the stuffing and collaboration techniques are equivalent to the Arduino Leonardo. It additionally has a solitary ATmega32u4 microcontroller for both USB glimmering and program execution; it can likewise go about as a console or mouse; and gives a similar measure of memory, advanced, simple and PWM ports [5].

Figure 2.7 – Arduino Micro

Disregard saving project memory and assets on the Arduino Uno. With the Arduino M0 board (figure 2.8), you can perform complex numerical computations, get more exact simple qualities, and still tune in to music straightforwardly from the microcontroller. The Arduino M0 depends on Atmel's 32-digit ATSAMD21G18 ARM processor with the Cortex® M0 handling center. The microcontroller runs at 48 MHz. On account of its 32-digit engineering, it performs most whole number tasks in a solitary clock cycle. Not at all like most Arduino sheets, the local voltage of Arduino M0 Pro is 3.3V, not 5V. Likewise, the yields for the sensible one yield 3.3V, and in input mode hope to get close to 3.3V. The Arduino M0 looks towards USB through the virtual sequential port, not the equipment port. This implies that pins 0 and 1 of the equipment port stay free and you can utilize them simultaneously as speaking with the PC. The virtual sequential port is available through the SerialUSB object and the equipment port is open through the Serial1 object.

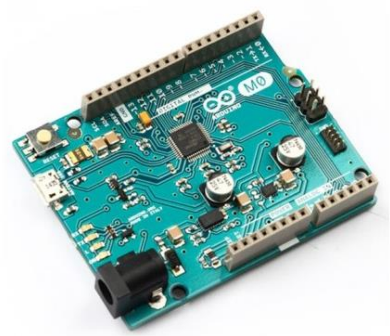

Figure 2.8 – Arduino M0

2.1.1 The benefits of the Arduino board:

— Cross-stage. Arduino programming (IDE) works in Windows, Macintosh OS X, and Linux family working frameworks, while most IDEs that have practical experience in microcontrollers, like Keil uVision, Atollic TrueSTUDIO, obscure, are restricted to Windows;

— Ease of utilization. Clear programming climate - Arduino Software (IDE) is not difficult to use for novices, yet adaptable enough for experienced clients;

— Open source and extensible programming. The product is accessible as open-source apparatuses that can be stretched out by experienced software engineers. The language can be reached out with C++ libraries and individuals who need to comprehend the specialized subtleties can change from Arduino to the AVR C programming language on which it is based;

— Price. Arduino sheets are generally modest contrasted with other microcontroller stages. The least expensive rendition of the Arduino module can be amassed by hand.

2.2 Description of the components of the turtle robot

The Arduino Uno board was picked to collect the turtle robot by correlation. The AtmelATmega328p microcontroller dependent on the ArduinoUno board (figure 2.9) was picked as the processor for the robot. This was picked due to the specialized qualities and accessibility of the microcontroller. Qualities of the Arduino Uno microcontroller. Also here is shown the circuit diagram of Arduino UNO board (figure 2.10). The specifications of Arduino Uno are in table 2.1 [6].

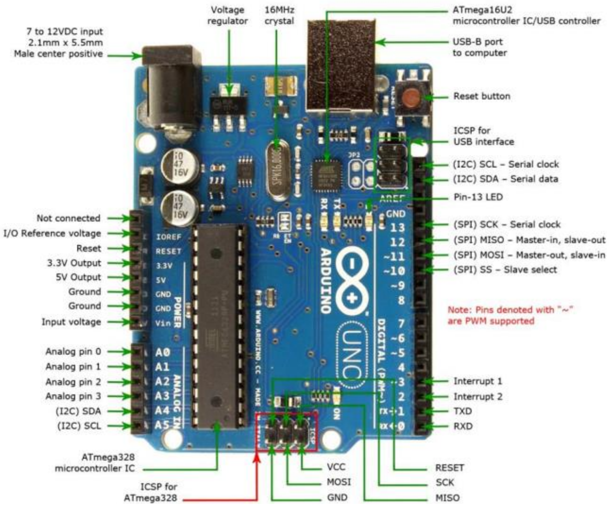

Figure 2.9 - Arduino Uno board

Table 2.1 - Arduino Uno microcontroller specifications

Microcontroller	AtmelATmega328p
Input voltage	7-12V
Operating voltage (logic level)	5V
Analog input	6
Digital input and output	14 (6 PWM)
RAM	2 Kb (AtmelATmega328p)
Memory (flash)	32 Kb (AtmelATmega328p)
Tactile frequency	16 MHz
Current voltage	50 mA
EEPROM	1 Kb (AtmelATmega328p)
Length	68.6 mm
Width	53.4 mm
Mass	25g

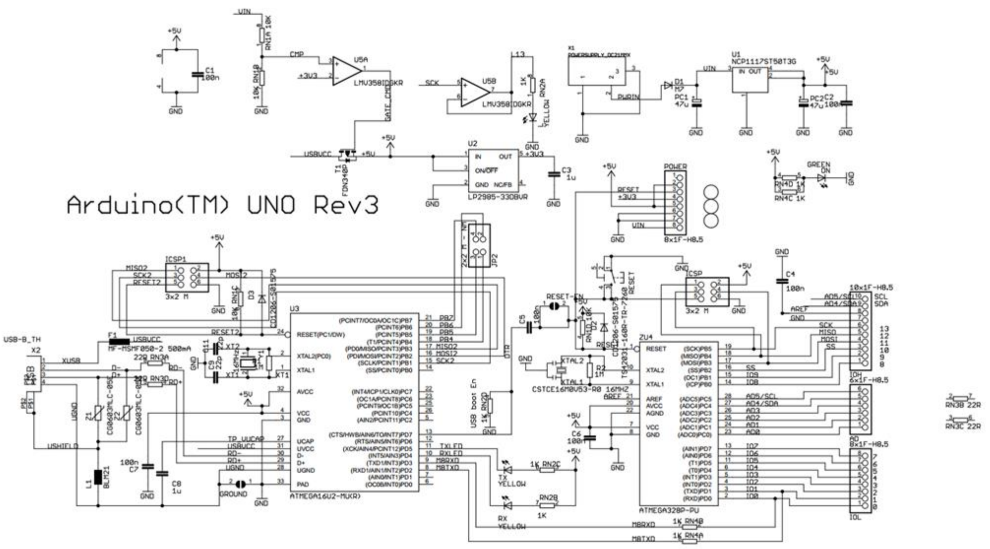

Figure 2.10 - Circuit diagram

The 14 advanced yields of the control board can be utilized as information sources and yields shown in figure 2.11. What's more, a few expenses have explicit capacities. 0 (RX) and 1 (TX) can be utilized to get yield signals (RX) and to send data by means of the sequential interface (TX).

On the off chance that the second and third information sources get a sign or assuming low, the rest source. With yield input sources 3, 5, 6, 9, 10 and 11, 8-digit simple qualities can be changed over into a PIM signal. Yield inputs 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK) can be associated by means of the SPI interface. There is a LED that illuminates when you send a high worth from yield source 13, and goes out likewise when you send a low worth.

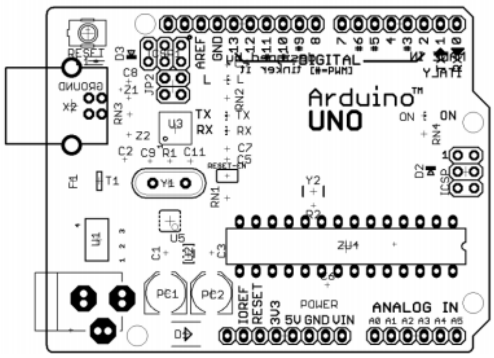

Figure 2.11 – Arduino UNO board contacts

The Arduino Uno board contains 6 simple data sources (A0-A5), any of which can show a simple voltage like 10-bit (1024 distinct qualities). The standard voltage is estimated from 0 to 5 V. The Arduino Uno is fueled by USB or other outer force supply. The stock voltage can be from 6 to 20 V.

On the off chance that you use voltages higher than 12 V, the voltage controller can overheat and may not work due to the board. The Arduino Uno has a blaze memory limit of 32 Kbytes (of which 0.5 Kbytes is utilized by the bootloader). The microcontroller likewise has 2 KB RAM and 1 KB EEPROM. The Arduino Uno can speak with a PC just as with one Arduino microcontroller or other microcontrollers. The UART recipient on the ATmega328p gives sequential correspondence through advanced yield 0 (RX) and 1 (TX). The microcontroller ATmega16U2 on the control board interfaces the UART association with the USB port of the PC and when associated it is distinguished as a virtual COM port.

Bluetooth is potentially the most generally perceived short-range distant correspondence shows for individual electronic contraptions. Distinctive information and control devices and sound devices work with it.

Against the establishment of various shows Bluetooth stands separated over all assurance from deterrent and ease. From not any more exceptional Wi-Fi Bluetooth differentiates regardless low power use, which makes it available for free contraptions. Thusly, BT has gotten inescapable.

The HC 05 and HC 06 modules are the most generally utilized and are the most ordinarily found monetarily accessible. The guideline of activity of these modules is comparable, the two modules depend on a similar chip, yet there are likewise significant contrasts. Above all else, the HC 05 module can work in two methods of activity - both as an expert (ace) and as a (slave) [6].

The two modules are two welded sheets. One of them is a production line one with a microcircuit, the other is required for independent gadgets, it is outfitted with GPIO legs with a standard pitch of 2.54 mm and a voltage controller.

For fostering the robot was choosed the HC-06 FC-114 bluetooth module it is appeared in figure 2.12.

Figure 2.12 – HC-06 bluetooth module

The created robot will be constrained by a cell phone, It was important to figure out how to oversee. Robot distant and any the choice to utilize a Bluetooth association that can be controlled without interference acknowledged. You can add extra modules to the ArduinoUno board, including a Bluetooth module. In such manner, secluded and You can interface with ArduinoUno, which improves the control framework and makes it simpler. The HC-06 module was chosen as the Bluetooth module.

Bluetooth modules work at 3.3V rationale levels, and utilizing five-volt rationale can be problematic. In any case, as a rule, the board has all you require to coordinate with the levels.

There are circumstances where voltage coordinating is required between an Arduino TXD and a Bluetooth RXD. Utilizing a divider is an assurance of solid activity [6].

On the privilege is a schematic of the least difficult divider it is shown in figure 2.13. Also there is the scheme of connecting Bluetooth module to the Arduino UNO board shown in figure 2.14.

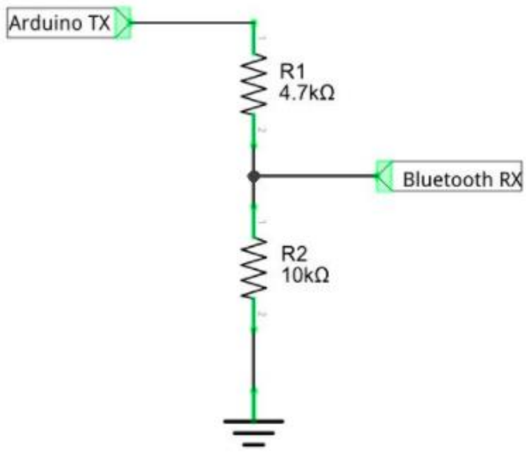

Figure 2.13 – Divider scheme

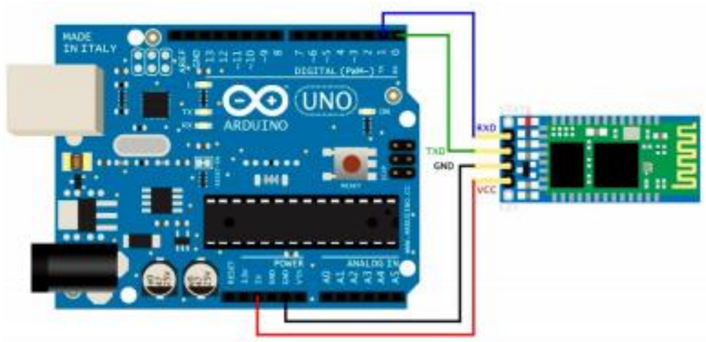

Figure 2.14 - Module connection diagram to the board

The lithium-particle battery (Li-particle) is a kind of electric battery that is broadly utilized in current purchaser hardware and is utilized as a fuel source in electric vehicles and energy stockpiling frameworks in energy frameworks. It is the most famous kind of battery in gadgets, for example, cells, workstations, computerized cameras, camcorders and electric vehicles.

Lithium-particle batteries (figure 2.15) have a powerful limit, light weight, and high limit. The voltage of the chamber type is 3.7V, the pellet type is 3.6V. With their high energy limit, no memory impact and low self-release, lithium-particle batteries are among the most famous sorts of battery-powered batteries for compact hardware.

Present day Li-particle batteries have high explicit qualities: 100-180Wh/kg and 250-400Wh/L. Working voltage is 3.5-3.7V.

Present day little measured batteries are usable at release flows up to 2 C, incredible - up to 10-20 C. Working temperature range: from - 20 to +60 ° C. Nonetheless, numerous producers have effectively evolved batteries fit for working at - 40 ° C. Extension of the temperature reach to higher temperatures is conceivable.

Self-release of Li-particle batteries is 4-6% in the primary month, at that point essentially less: in a year the batteries lose 10-20% of the put away limit. Asset 500-1000 cycles.

Figure 2.15 – 18650 batteries

2.2.1 There is some advantages and disadvantages of Li-Ion batteries:

Advantages:

- High energy thickness (limit).
- Low self-release.
- High current effectiveness.
- Countless charge-release cycles.
- Maintenance free.

Disadvantages:

- The broadly utilized lithium-particle batteries are regularly incredibly combustible when cheated, when charging conditions are not followed, or when precisely harmed.
- Flammable
- Lose effectiveness when overdischarged
- Lose limit exposed

Driver module for bipolar stepper engine on chip MX1508 (present day simple of L298N or L9110 with assurance circuits in reduced plan). It utilizes the imported unique chip MX1508 (figure 2.16 – 2.17), which has low opposition MOS switches, insignificant warmth dispersal, permitting the driver without heat sinks, little size, low force utilization, making it ideal in convenient gadgets for battery power [7].

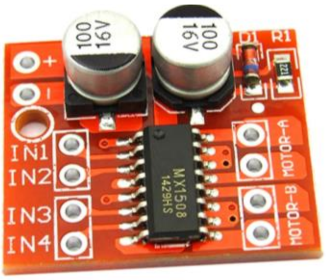

Figure 2.16 – MX1508 driver

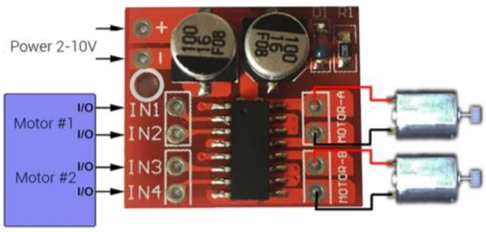

Figure 2.17 – Exterior view of MX1508

Driver pinout:

— Motor A - sockets for connecting the first brush motor or the first winding of the stepper motor;

— Motor B - sockets for connection of the second brush motor or the second winding of the stepper motor;

— GND - common wire

— Vs - input for +5V logic power. In this case only motor power (Vss) is supplied to the connector, the Vs contact remains unconnected and a regulator jumper is installed on the board which limits the supply voltage to an acceptable 5V.

— IN1, IN2 - control contacts of the first brush motor or the first winding of the stepper motor.

— IN3, IN4 - control contacts for the second brush motor or the second winding of the stepper motor. All this pins are shown in circuit diagram in figure 2.18.

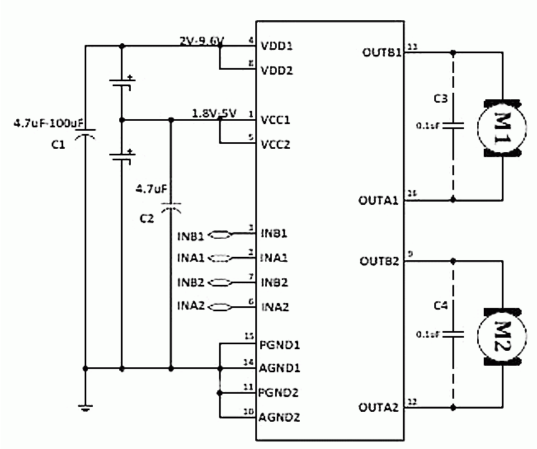

Figure 2.18 – Circuit diagram of MX1508 driver

Technical specifications:

— Dual H-bridge motor driver, can control two DC motors or a 4-wire two-phase stepper motor.

— The supply voltage of the module is 2 V to 10 V.

— Input signal voltage 1.8 - 7V.

— Operating current 1.5A per channel, peak current up to 2.5A, low standby current (less than 0.1mA).

— Built-in thermal protection circuit with hysteresis.

— Dimensions: 24.7 x 21 x 5 mm

— Diameter of mounting hole: 2mm

A tracked chassis was used as the basis for assembling the robot, which will allow this robot to bypass various obstacles that are difficult to pass. In this case, a Mini T100 tracked chassis was used (Figure 2.19).

A tracked mover is a mover of self-propelled vehicles in which the tractive force is created by rewinding the caterpillar belts.

The tracked mover (figure 2.20) provides increased cross-country capability. The large area of contact of the tracks with the ground allows for a low average pressure on the ground - 11.8 kPa, that is less than the pressure of a human foot. This protects the tracked mover from sinking deep into the ground.

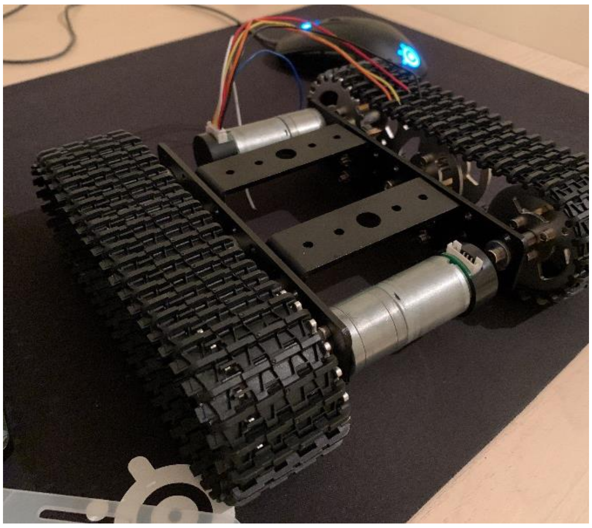

Figure 2.19 – Mini T100 chassis

Types of tracked mover:

- With caster rollers, rear drive wheel and free slats;
- Without caster rollers and with rear drive wheels;
- With support rollers, front drive wheel and track links;
- Without support rollers with front driving wheel.

Disadvantages of tracked propulsion:

- Rapid wear of wearing parts (lugs, pins);
- Track breaks under uneven load;
- Snow and stones between tracks and rollers.

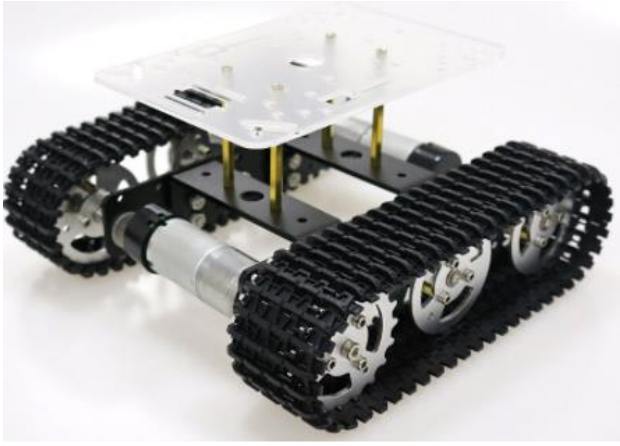

Figure 2.20 - Robot crawler chassis

In creating of the project was used HC SR 04 Ultrasonic Sensor (figure 2.21). The operation of the module is based on the echolocation principle. The module sends an ultrasonic signal and receives its reflection from the object. By measuring the time between sending and receiving the pulse, it is not difficult to calculate the distance to an obstacle.

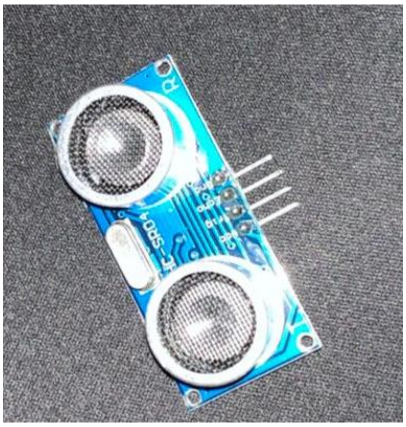

Figure 2.21 – HC SR04 sensor

The HC SR04 Ultrasonic Rangefinder has the following technical parameters:

- The supply voltage is 5V;
- Operating current parameter is 15 mA;
- Current in passive state < 2 mA;
- Viewing angle - 15 °;
- Sensing resolution - 0.3 cm;
- Measuring angle - 30°;
- Pulse width - 10-6 s.

The sensor is equipped with four pins (standard 2, 54 mm):

- Positive type power contact - +5V;
- Trig (T) - input signal output;
- Echo (R) - output signal output;
- GND - ground output.

To connect the ultrasonic distance sensor to the Arduino board is quite simple. The connection diagram is shown in the figure 2.22.

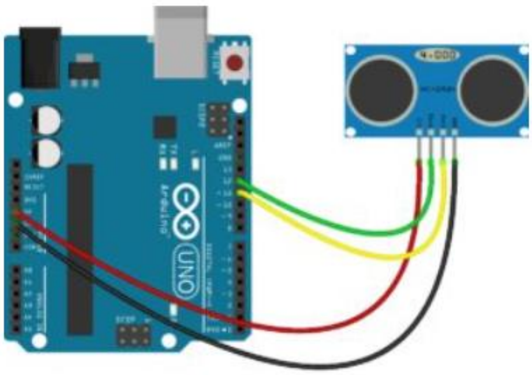

Figure 2.22 – HC SR04 connected to Arduino

The accuracy of the sensor depends on several factors:

- temperature and humidity of the air;

— the distance to the object;
— location relative to the sensor (according to the radiation diagram);
— quality of execution of the sensor module elements.

Standard of activity of any ultrasonic sensor depends on the marvel of impression of acoustic waves proliferating noticeable all around. Be that as it may, as we probably are aware from physical science, the speed of sound proliferation noticeable all around relies upon the properties of the actual air (fundamentally on the temperature). The sensor, radiating waves and estimating the time until their return, doesn't figure in which climate they will proliferate and takes for computations some normal worth. In genuine conditions because of the factor of air temperature HC-SR04 can make a mistake from 1 to 3-5 cm [8].

Factor of distance to the article is significant, on the grounds that the likelihood of reflection from adjoining objects increments, other than the actual sign weakens with distance.

Additionally, to expand the exactness it is important to coordinate the sensor accurately: ensure that the item is inside the cone of the radiation design. Basically, the "eyes" of the HC-SR04 should gaze straight toward the item.

When collecting a robot, it is vital to pick an engine that will permit it to move uninhibitedly without stress, just as foster great speed. Thusly, it is vital to pick an engine prior to beginning turn of events, since this component is quite possibly the main components of the entire framework. On the off chance that the microcontroller is the "heart" of the robot, the engine will be the "legs" of the robot that will permit it to move.

An electric engine (DC engine) is a gadget that believers electrical energy into mechanical structure. That is, power is applied to this gadget, which, thusly, makes the engine shaft pivot. In unfamiliar writing, the term is spelled direct current engine, henceforth the name. The engine is appeared in Figure 2.23.

Figure 2.23 – DT25-370 engine

The DC engine is associated with two wires. Also, appropriately, all the force dispersed in this interaction is communicated through these two wires. Most DC engines have an extremely high velocity of pivot - around 5000 rpm. In any case, the speed of such engines can be controlled, and the force level can be changed all the more decisively by beat regulation. This guideline of force control is to turn it on and off for brief timeframes. Be that as it may, the significant idea for this situation is the obligation cycle idea - the level of time the engine isn't running, which is identified with the time it isn't charging. Assuming just a large portion of the force is provided, the engine will just run at a large portion of its force.

On the off chance that you turn the force on and off, the speed of the engine will be shown at a moderately low speed, or all the more precisely, no development. The low rotational speed is on the grounds that the engine draws just a little part of the complete force. The motor wiring diagram is shown in the figure 2.24.

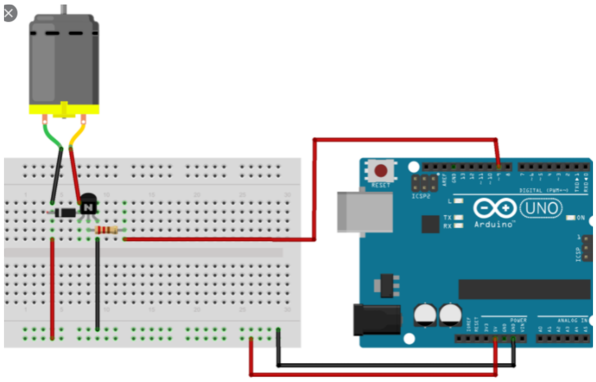

Figure 2.24 – Motor connected to the Arduino scheme

The DT25-370 engine was chosen as the engine for this project. The DT25-370 engine was purchased for the robot it's technical characteristics is shown in table 2.2. This machine is developed and made in China. Due to its technical characteristics and relatively affordable price, the electric 20 motor has become well-known and sold independently. Since this machine produces 281 revolutions per minute, which fully satisfied the tasks assigned to the robot, it was decided to use this engine for robot development [9].

Table 2.2 Technical characteristics

Output rate:	150 ± 10% rpm
Load current:	200 mA (max.)
Stall current:	4500 mA (max.)
Stall torque:	9,5 kgNaN
Load speed:	100 ± 10% rpm
Load torque:	3000gNaN
Load noise:	56 dB
Working voltage:	9 V
Shaft extension size:	14,5 mm
Axial clearance:	0,05-0,50 mm
Screw day small:	M3.0
Shaft diameter:	Phi4mm, D3.5
Code wheel parameters:	2 pulses/round
Sensor working voltage:	3-5 V

2.3 Mathematical model of a robot-turtle

This project presents a kinematic analysis of the motion of a tracked robot-turtle equipped with two independent tracked motors.

Description of the design and principle of motion of the tracked robot-turtle. The design of the tracked robot is shown in Figure 2.25.

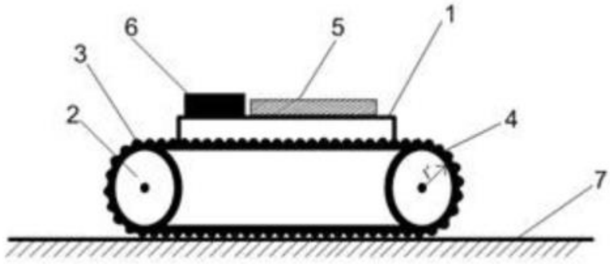

Figure 2.25 - Schematic diagram of a tracked robot-turtle

A tracked robot-turtle consists of the following main parts: 1 - body, 2 - leading roller, 3 - track, 4 - slave roller, 5 - automatic control system of the device electric drives, 6 - batteries, 7 - surface on which the robot moves.

The robot moves due to the friction forces generated between the supporting surface (ground) and the robot's crawler. The leading roller is connected via a gearbox to a DC motor controlled by an automatic control system. There is no slip between the leading rollers and the track, so the angular rotation speeds of the rollers (leading and trailing) are equal.

Depending on the travel algorithm and information from the sensors, the automatic control system generates control voltages for the electric drives of the device. To amplify low-current signals from the control system controller, power transistor switches - motor drivers - are used.

For turning in the horizontal plane, the control system forms different supply voltages for each of the crawler motors. The navigation system of the robot can include both ultrasonic distance sensors, optical rulers for moving along the contrasting line, and contact sensors for obstacles.

The position of the robot is uniquely determined by the coordinates of the center of mass of the body C and the rotation angle of the body φ. The kinematic analysis of the motion of a tracked robot solves the problem of determining the position, velocity of the center of mass of the robot and the velocity of points Ci, and Ki. Calculation scheme of the tracked robot-turtle shown in figure 2.26.

Within the scope of this study, the motions of the robot along a circle and a spiral trajectory were considered. The MathCad package was used to obtain the numerical result for the simulation of the motion.

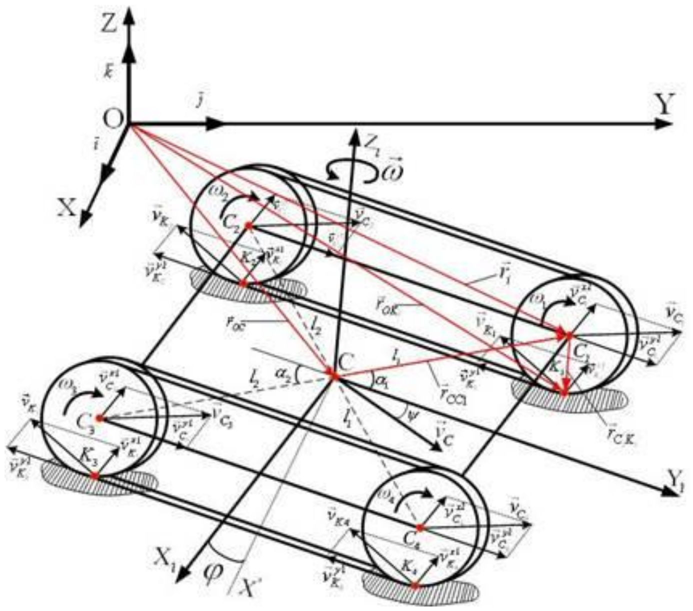

Figure 2.26 - Calculation scheme of the tracked robot-turtle

This scheme uses the following designations: XOYZ - fixed coordinate system, CX1Y1Z1 - moving coordinate system, C1, C2, C3, C4 - attachment points of the track rollers; K1, K2, K3, K4 - contact points with the surface; $\overrightarrow{v_{C_1}}, \overrightarrow{v_{C_2}}, \overrightarrow{v_{C_3}}, \overrightarrow{v_{C_4}}$ - velocities of the center attachment points of the track rollers; $\vec{v}_{C_1}^{x1}, \vec{v}_{C_2}^{x1}, \vec{v}_{C_3}^{x1}, \vec{v}_{C_4}^{x1}$ - velocity projections of the track roller centers on the CX1 axis; $\vec{v}_{C_1}^{y1}, \vec{v}_{C_2}^{y1}, \vec{v}_{C_3}^{y1}, \vec{v}_{C_4}^{y1}$ - velocity projections of the track rollers center attachment points on the axis CY1; $\overrightarrow{v_{K_1}}, \overrightarrow{v_{K_2}}, \overrightarrow{v_{K_3}}, \overrightarrow{v_{K_4}}$ - speeds of the contact points of the track rollers with the surface; $\vec{v}_{K_1}^{x1}, \vec{v}_{K_2}^{x1}, \vec{v}_{K_3}^{x1}, \vec{v}_{K_4}^{x1}$ – velocity projections of the contact points of the track rollers with the surface on the axis CX_1; $\vec{v}_{K_1}^{y1}, \vec{v}_{K_2}^{y1}, \vec{v}_{K_3}^{y1}, \vec{v}_{K_4}^{y1}$ – velocity projections of the contact points of the track rollers with the surface on the axis CY_1; ω1, ω2, ω3, ω4 – angular velocities of the supporting rollers, I_1 - distance from the center of mass to the 1st and 4th rollers, I_2 - distance from the center of mass to the 2nd and 3rd rollers, φ - angle of rotation of the robot body around CZ1. α_1, α_2– the angle between the line CC1 and the axis CY1 (α_1 for i=1,4; α_2 for i=2,3 respectively).

Determine the radius-vector describing the motion of the robot body in a stationary coordinate system:

$$\vec{r}_{OC} = \begin{bmatrix} x_c \\ y_c \\ 0 \end{bmatrix}, \tag{2.1}$$

where $x_c$and y_c – projections of the vector radius in the absolute coordinate system.

To determine the velocity of the center of mass, we differentiate the following expression:

$$\frac{d\vec{r}_{OC}}{dt} = \begin{bmatrix} v_c\cos(\psi) \\ v_c\sin(\psi) \\ 0 \end{bmatrix} = \begin{bmatrix} v_c^{x_1} \\ v_c^{y_1} \\ 0 \end{bmatrix}, \quad (2.2)$$

The velocity of the center of mass in the coordinate system $CX_1Y_1Z_1$ will have the form:

$$\vec{v}_C^{(1)} = \begin{bmatrix} v_c\cos\psi \\ v_c\sin\psi \\ 0 \end{bmatrix} = \begin{bmatrix} v_c^{x_1} \\ v_c^{y_1} \\ 0 \end{bmatrix}, \quad (2.3)$$

and in the coordinate system $XOYZ$:

$$\vec{v}_C^{(0)} = \begin{bmatrix} v_c\cos(\varphi + \psi) \\ v_c\sin(\varphi + \psi) \\ 0 \end{bmatrix} = \begin{bmatrix} v_c^{x} \\ v_c^{y} \\ 0 \end{bmatrix}, \quad (2.4)$$

Angular velocity of the robot body $\vec{\omega}$ is defined as follows:

$$\vec{\omega} = \begin{pmatrix} 0 \\ 0 \\ \dot{\varphi} \end{pmatrix}, \quad (2.5)$$

Let's define the radius-vector of the tracked robot's roller fixation points as:

$$\vec{r_\iota} = \overrightarrow{r_{OC}} + \overrightarrow{r_{CC_\iota}}, i = 1\ldots4, \quad (2.6)$$

The velocities for these points can be obtained as:

$$\overrightarrow{v_{C_\iota}} = \frac{d\vec{r_\iota}}{dt} = \frac{d\overrightarrow{r_{OC}}}{dt} + \frac{d\overrightarrow{r_{CC_\iota}}}{dt}, \quad (2.7)$$

or

$$\frac{d\vec{r_\iota}}{dt} = \frac{d\overrightarrow{r_{OC}}}{dt} + \vec{\omega} * \overrightarrow{r_{CC_\iota}}, \quad (2.8)$$

$$\overrightarrow{v_{C_\iota}} =; \overrightarrow{v_C} + \vec{\omega} * \overrightarrow{r_{CC_\iota}}, \quad (2.9)$$

Similarly, we can write for the points of contact with the surface:

$$\overrightarrow{r_{K_\iota}^{(0)}} = \vec{r_\iota} + \overrightarrow{r_{C_\iota K_\iota}}, \quad (2.10)$$

$$\frac{d\overrightarrow{r_{K_\iota}}}{dt} = \frac{d\vec{r_\iota}}{dt} + \frac{d\overrightarrow{r_{CK_\iota}}}{dt}, \quad (2.11)$$

$$\overrightarrow{r_{K_i}^{(0)}} = \overrightarrow{v_{C_i}} + \vec{\omega}_i * \overrightarrow{r_{C_iK_i}}, \quad (2.12)$$

$$\vec{v}_{K_i}^{(0)} = \begin{bmatrix} \dot{x}_{K_i} \\ \dot{y}_{K_i} \\ 0 \end{bmatrix} = \begin{bmatrix} \dot{x}_{C_i} \\ \dot{y}_{C_i} \\ 0 \end{bmatrix} + \begin{bmatrix} \bar{\imath} & \bar{\jmath} & \bar{k} \\ \omega_{1x} & \omega_{1y} & 0 \\ 0 & 0 & r_{c_ik_i} \end{bmatrix}, \quad (2.13)$$

where $\vec{v}_{K_i}^{(0)}$– point speed K_i in the absolute coordinate system.

$$T_{10} = \begin{bmatrix} cos\varphi & -sin\varphi & 0 \\ sin\varphi & cos\varphi & 0 \\ 0 & 0 & 1 \end{bmatrix} T_{10}^{-1} = \begin{bmatrix} cos\varphi & sin\varphi & 0 \\ -sin\varphi & cos\varphi & 0 \\ 0 & 0 & 1 \end{bmatrix}, \vec{v}_{K_i}^{(1)} = T_{10}^{-1}\vec{v}_{K_i}^{(0)}, \quad (2.14)$$

where $\vec{v}_{K_i}^{(1)}$ – point speed K_i in the relative coordinate system.

The position of the points of the roller centers of the robot is given by the following projections:

$$\begin{cases} x_{C_1} = x_c + l_1\cos(\varphi + \alpha_1) \\ y_{C_1} = y_c + l_1\sin(\varphi + \alpha_1) \end{cases}; \begin{cases} x_{C_2} = x_c + l_1\cos(\varphi - \alpha_1) \\ y_{C_2} = y_c + l_1\sin(\varphi - \alpha_1) \end{cases}$$
$$\begin{cases} x_{C_3} = x_c - l_2\cos(\varphi + \alpha_2) \\ y_{C_3} = y_c - l_2\sin(\varphi + \alpha_2) \end{cases}; \begin{cases} x_{C_4} = x_c - l_2\cos(\varphi - \alpha_2) \\ y_{C_4} = y_c - l_2\sin(\varphi - \alpha_2) \end{cases}, \quad (2.15)$$

where, x_{C_i}, y_{C_i}– center coordinates i- of that rink ($i = 1,2,3,4$), x_{C_i}, y_{C_i}– coordinates of the center of mass of the tracked robot.

Let the center of mass of the robot body move on a circle, the coordinates of which are given by the equations: $\begin{cases} x_C = R\cos(\omega t) \\ y_C = R\sin(\omega t) \end{cases}$, where R – is the radius of curvature of the circle along which the robot's center of mass moves, ω – is the angular velocity of the robot body. Let's assume that when $\omega = \dot{\varphi}$, the movable axis CY1 is always tangential to the trajectory, and the angle φ changes according to a given law, i.e. $\varphi = \omega t + \varphi_0$, where φ_0 – initial angle that determines the position of the robot body on the trajectory it is shown in figure 2.27.

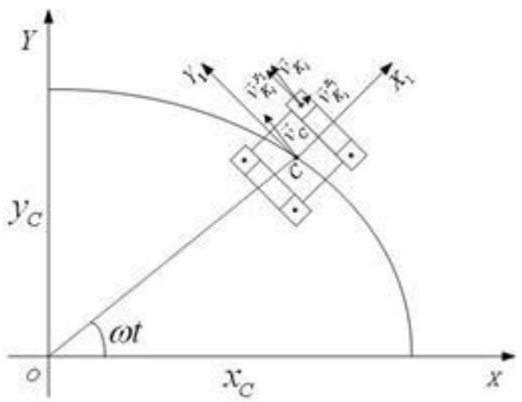

Figure 2.27 - Diagram of the robot's movement along the trajectory

Let us simulate the motion of the robot and determine the trajectory. The results of the simulation are shown in figure 2.28-2.29.

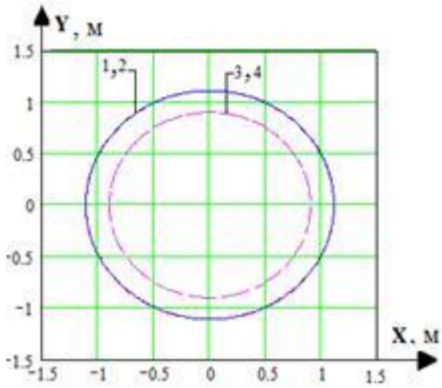

Figure 2.28 - Trajectory of the robot when moving on a circle: 1, 2 - speeds of the running track rollers; 3, 4 - speeds of the lagging track rollers

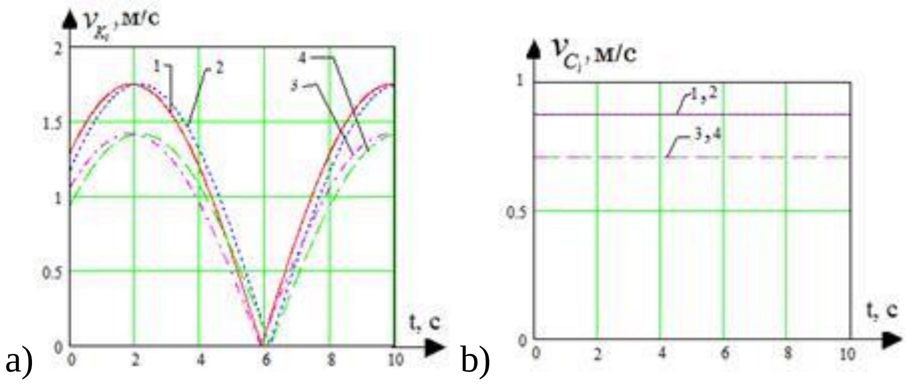

Figure 2.29 - Time diagrams of parameters of robot's circle motion 1, 2 - speeds of the running track rollers; 3, 4 - speeds of the lagging track rollers; a – time dependence of the speed of robot's points of contact with the surface; b – time dependence of the speed of the robot's rollers centers

Note that when moving along a curvilinear trajectory, longitudinal slippage occurs at the contact point of the track rollers with the surface. To estimate the amount of slippage, let us simulate the motion of the tracked robot along a spiral trajectory, in which the radius of the circle will vary over time, i.e. $R = R(t)$.

In this case, the coordinates of the center of mass will be given by the equations:

$$\begin{cases} x_C = R(t)\cos(\omega t) \\ y_C = R(t)\sin(\omega t) \end{cases}, \qquad (2.16)$$

Let us perform numerical calculation of the robot's motion in MathCAD and obtain a graph of the robot's trajectory. Also, we plot the time dependence of the velocities of the points of contact with the surface. The results of the simulation are shown in figure 2.30-2.31.

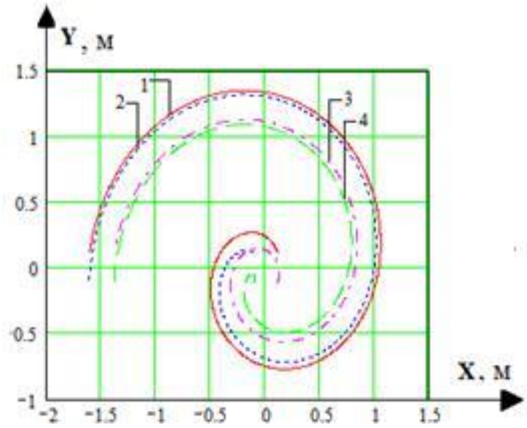

Figure 2.30 - Trajectory of the robot rollers in spiral motion: 1, 2 - speeds of the running track rollers; 3, 4 - speeds of the lagging track rollers

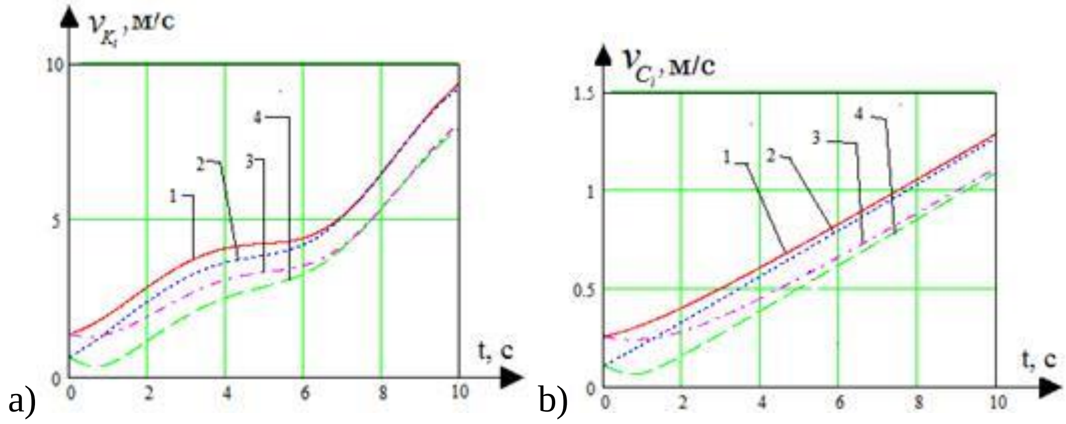

Figure 2.31 - Time diagrams of spiral motion parameters of the robot: 1, 2 - speeds of the running track rollers; 3, 4 - speeds of the lagging track rollers; a - time dependence of the speed of robot's contact points with the surface; b - time dependence of the speed of robot's rollers centers

Let us determine the value of longitudinal slip of the robot rollers. To do this, calculate the normal component of the velocity of each roller using the formula:

$$v_{K_i}^{x_1}(t) = v_{C_i}(t) * \cos(\alpha), \quad (2.17)$$

By performing the necessary calculations in MathCad, we obtain slip graphs for each of the robot rollers. As can be seen from the graph, the value of longitudinal slip nonlinearly depends on the radius of curvature of the curvilinear trajectory. The characteristic point is the one marked in figure 2.32, where R=0.18 m, and t=1.18 s.

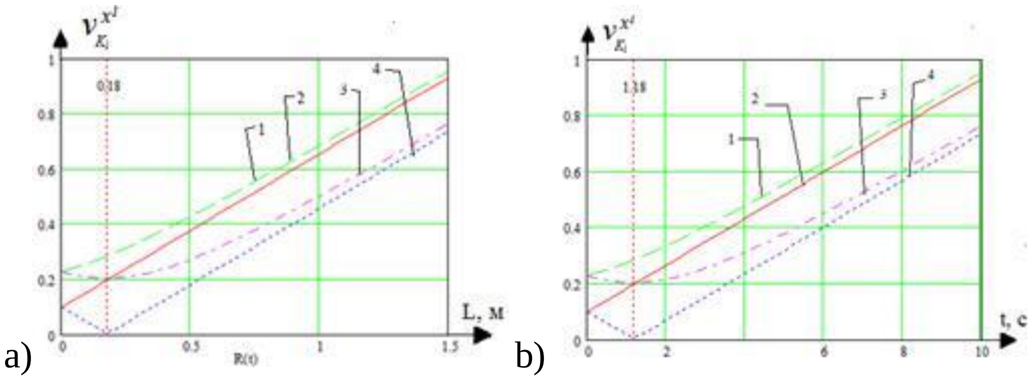

Figure 2.32 - Dependence of slip on radius of curvature:1, 2 - speeds of the running track rollers; 3, 4 - speeds of the lagging track rollers

At this point, the speed of the second track roller of the robot, which is slave in the outer track pair, becomes zero. In fact, at this point in time the robot begins to rotate relative to this roller. After this moment, when R>0.18 m, the speed of all the rollers looks like an increasing straight line, since the radius of curvature changes linearly in time.

In this project analyzed the kinematics of motion of a tracked robot turtle, identified the basic laws of its motion at a given radius of curvature trajectory, the results will be further used in the study of the dynamics of motion of the robot, in particular, the value of slip and velocity along the axis CY1 will be considered in determining the dry friction forces acting at the points of contact of the robot with the surface.

2.5 Assembly of the chassis and robot components

The robot turtle allows you to move quickly and avoid obstacles. After a detailed study of all materials, it was decided to use circuits reliably, as this would allow the robot to move evenly. The wiring diagram of all the components of the robot is shown in Figure 2.33.

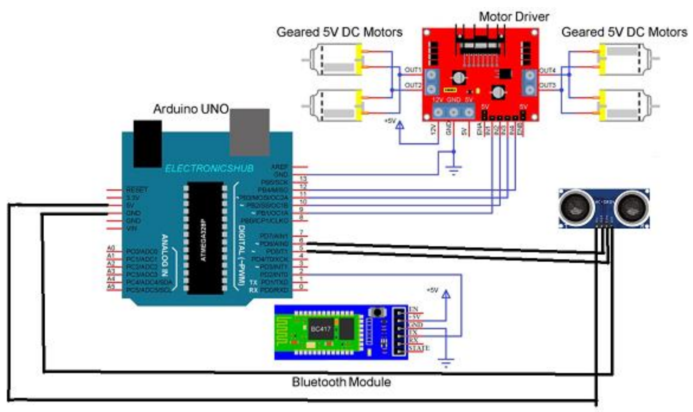

Figure 2.33 - Wiring diagram of all the components

As a matter of first importance the caterpillar undercarriage was gathered. Introduced the heap bearing wheel in the yellow roundabout opening. Bolted the copper section of the bearing wheel with M3x8 hexagon attachment screws on the two sides. The focal openings on the two sides of the bearing wheel are placed into the bearing.

Bolted the connector (figure 2.34) through the orientation on the two sides with M2 screw, note the connector to the top and base. Imprint the circle where the heap bearing wheel. And it was mounted on the section. Spot the gasket on top of the connector and pass the short M4 hex attachment screw through the opposite side of the section. The M4 screws lock the connector and fix the heap bearing wheel. Introduce a drive wheel material rundown. Note that the two focal openings of each drive wheel are not the equivalent [11].

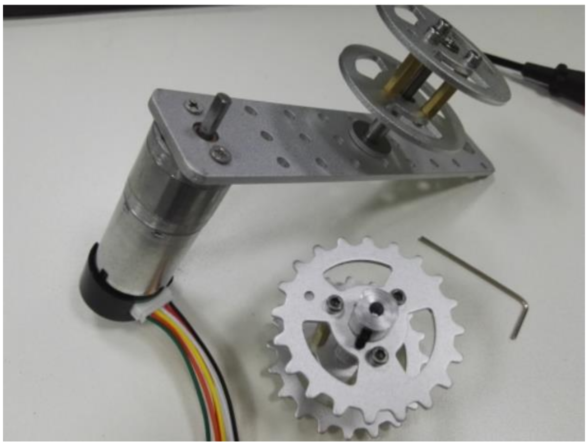

Figure 2.34 – Bolted connector

Likewise with the heap bearing wheel, first pass the M3x8 hexagon attachment screw on each drive wheel to bolt the copper segment of the drive wheel. Locked the copper (figure 2.35) segment with M3 hex attachment screws on the two sides.

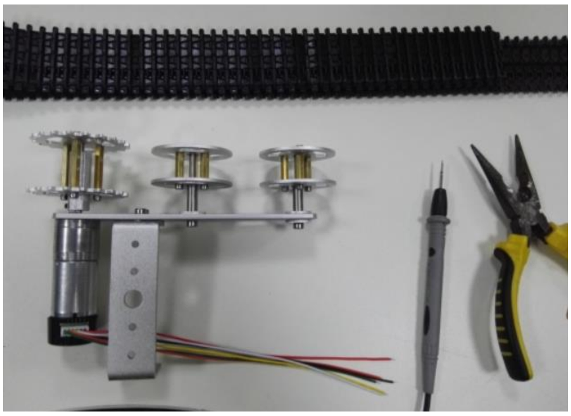

Figure 2.35 - Locked the copper

Ensure that the situating openings of the two pieces are coordinated, in any case the pinion wheels on the two sides will be faulty. Pass the coupling through the huge side of the focal opening of the drive wheel piece, embed the other piece into the long M4 inward hexangular screw and lock it. Utilize a little spanner to briefly fix the top wire to the little circular opening of the coupling. Then was assembled as it’s shown in figure 2.36.

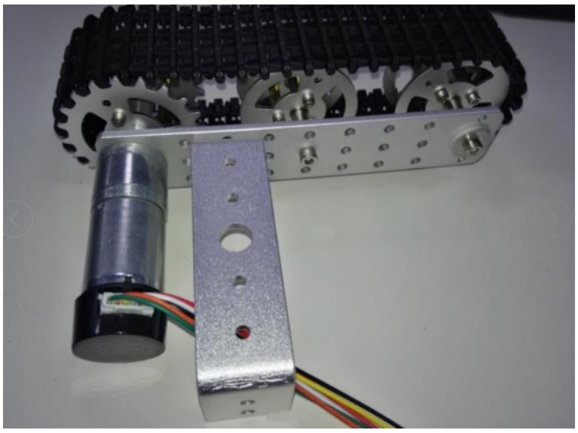

Figure 2.36 – Assembled left part of the chassis

Rundown of establishment materials of engine. Introduce the engine cap on the engine and plug in the engine wire likewise. Pass the engine shaft through the circular opening toward one side of the section (the more modest one). Passed two short M4 hexagon attachment screws through the circular openings of the section and the circular openings of the shaft separately, and afterward lock them with M4 nuts. Locked in the relating opening of the renderings. The assembled mini T100 is shown in figure 2.37.

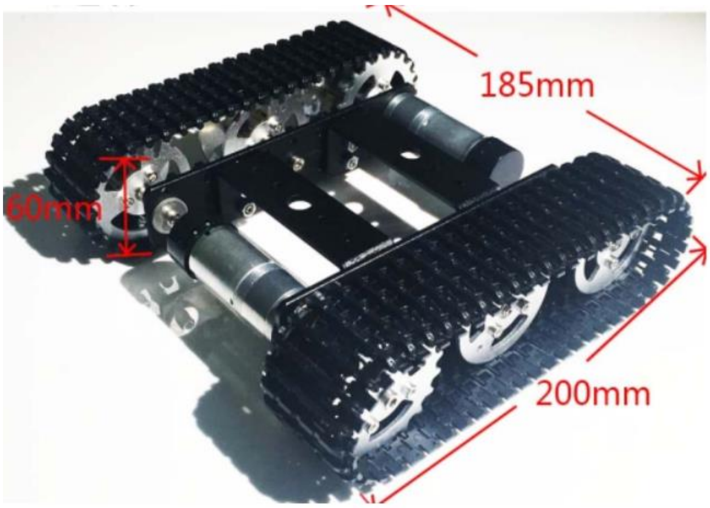

Figure 2.37 – Assembled mini T100

After marking out the length of one wheel on the broken track sleeve, insert the meter into the position you want to cut off. Lift the caterpillar pin out from the concave end with the electric watch pen to cut the caterpillar band. Cut off after the track and track needle.

Covered the track, then insert the track needle into the hole through the protruding end. Note that the rough end of the track needle remains outside. Align the holes in the track, insert the track needle from one end until the whole thing is inside, and finally bang it. The installation of the other half is the same as above. After assembling the chassis was built the robot-turtle with all components on it as shown in the figure 2.38.

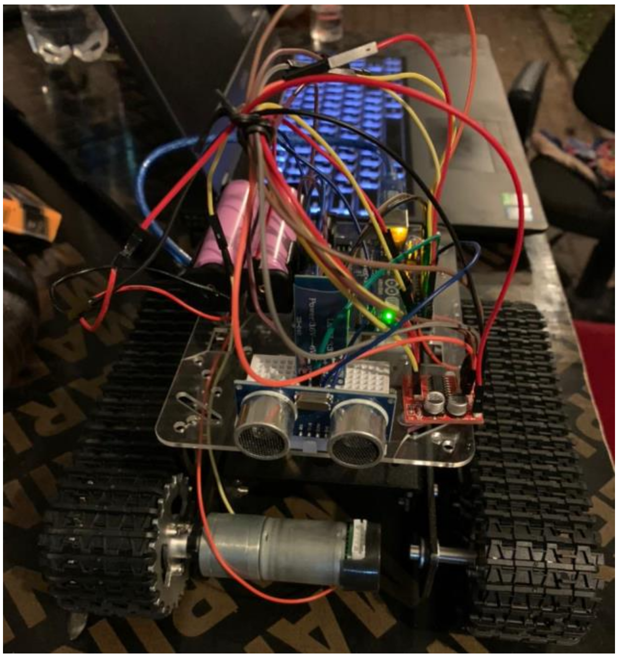

Figure 2.38 – Assembled robot-turtle

3 Software part

3.1 The program part with Arduino IDE

The Arduino Integrated Development Environment (IDE) is a cross-platform application (for Windows, macOS, Linux) that is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of third-party cores, other vendor development boards [12].

The "File" menu is the menu thing that characterizes the stacking, everything being equal. Naturally ArduinoIDE (figure 3.1) stores the sketch in discrete cells. The name of these cells is equivalent to the name of the document showed when you compose the code. Be that as it may, you can change the location of the cells where the put away projects are put away.

The "Edit" menu contains the necessary controls for working with code. This menu also has convenient combination settings for quick access to the commands provided.

If you open the "Thumbnail" menu, the "Check / Compile" control, which can be found on the toolbar, appears. This administrator will alert you in case of an error and allow you to check the written code 41 if there is no error, the code will be generated. All written programs are saved in the "Show Thumbnail Folder" menu, which can be opened the next time you click on this box.

The "Tools" menu shows the model of the Arduino card, as well as its connection to the COM port. When you enter the main menu, the "AutoFormatize" control command appears, which makes the programming language look comfortable and readable.

The "Help" menu lists all the instructions you need to work comfortably in the program. It should be noted, however, that all references are in English and will be registered on the official site of the program.

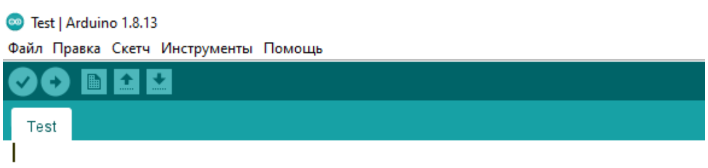

Figure 3.1 – Arduino IDE program

The Arduino code for Bluetooth Controlled Robot project is given below (figure 3.2, 3.3, 3.4). This code portrays the activities that this robot can perform, principally the different developments of the tomahawks just as the code for associating with the robot by bluetooth.

Figure 3.2 – First page of sketch

Figure 3.3 – Continuation of the sketch 1

Figure 3.4 - Continuation of the sketch 2

3.2 Management System of the robot

The robot in my task was furnished with a Bluetooth module, so it needed to consider an administration framework. These days, numerous projects have been fostered that permit you to control various sorts of robots with a Bluetooth module. There are even applications that transform your Android cell phone into a game regulator. After this was completed the connection between phone and HC06 (figure 3.5).

Subsequent to examining the accessible alternatives, I chose to pick an Android/IOS stage as my robot control application, so I utilized an application called "GyverJoy" (figure 3.6).

Figure 3.5 – Available devices for the phone

GyverJoy is a novel application that permits you to interface your cell phone to your game regulator. It interfaces by means of Bluetooth and you can without much of a stretch set up this application. The Android application permits the client to choose one of the joysticks, including the controlling wheel or the track. Furthermore, with this regulator, you can associate with a PC and the PC will see the cell phone as a USB joystick. Since the cell phone upholds the accelerometer, you can handle the catches on any cell phone without looking forward and in reverse. Of late, engineers have been utilizing a Wi-Fi association.

Plans to add joystick control too, which will incredibly build the ubiquity of the program. Right now, just 32-bit working frameworks are upheld, and later on there are plans to help 64-cycle working frameworks. For the time being, the use of this program is as yet being refreshed because of the little size of the application.

Figure 3.6 – GyverJoy application

The program is used on Android / IOS platforms as well as 32-bit Windows XP / 7/8. The principle of its use is very simple. When you open the program, three types of game controllers are displayed on the main screen. When choosing a controller, keep in mind that you need to write a program for these controllers. Was used the Bluetooth controller application (figure 3.7).

Also was used the app called “Bluetooth controller” then I have used 5 keys as Forward, Reverse, Left, Right and Stop. The corresponding data associated with each key is as follows:

- Forward – 1
- Reverse – 2
- Left – 3
- Right – 4

— Stop – 5

When a key is pressed, the corresponding data is transmitted to the Bluetooth. Module from the Phone over Bluetooth Communication (figure 3.8).

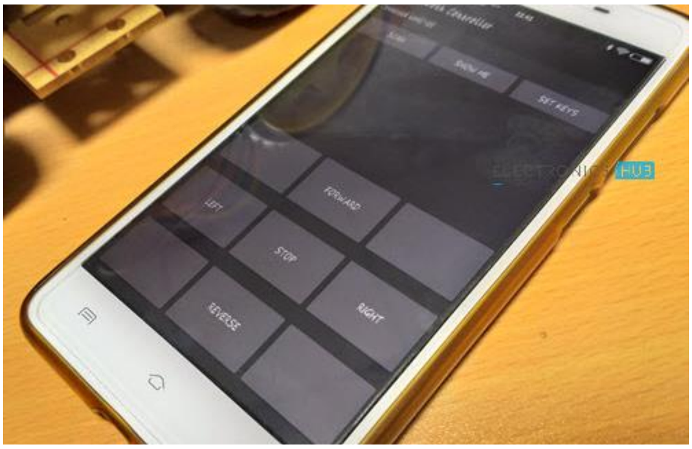

Figure 3.7 – Bluetooth controller application

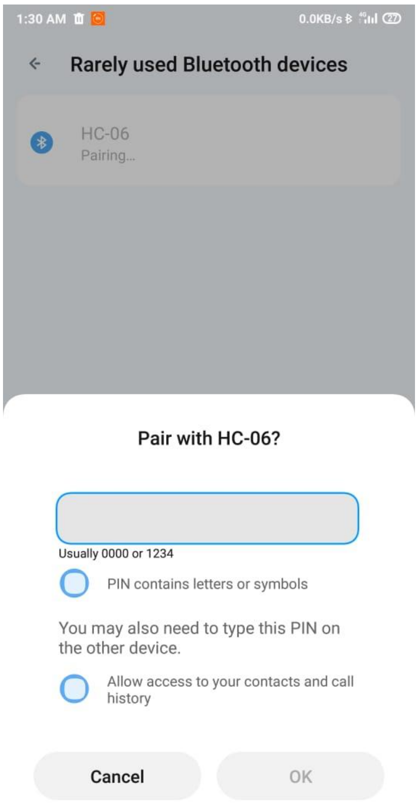

Figure 3.8 – Pairing with HC-06

4 Life safety

4.1 Analysis of working conditions with a floor plan

Representatives of the creation and specialized office are at their work environments furnished with PCs all through the functioning day. During the time spent work, the client and the PC structure an arrangement of connection between man, machine and the climate. In view of this communication framework, it is feasible to recognize risky and hurtful elements influencing the PC client.

The accompanying actual elements can contrarily influence an office representative: air temperature, residue and gas substance of the air, air moistness, lacking light of the work environment, commotion surpassing admissible norms, expanded degree of electromagnetic fields and radiation. Artificially dangerous variables incorporate the event of dynamic particles because of air ionization during PC activity, just as the presence of destructive compound ignition items noticeable all around when a fire breaks out in the workplace. Additionally, the worker can be impacted by psychophysical factors, which incorporate neuro-enthusiastic over-burden, mental pressure, overstrain of the visual mechanical assembly.

When working with a PC screen, a visual channel of data input is utilized, lacking light of the work environment prompts eye strain, debilitates consideration, and prompts untimely exhaustion. Simultaneously, exorbitantly brilliant lighting causes visual deficiency, bothering and torment in the eyes. The recorded reasons can prompt word related illnesses of workers [13].

Very much planned and top notch creation lighting decidedly affects office laborers. As indicated by building regulations and guidelines, a room with a PC should have regular and counterfeit lighting. Characteristic lighting ought to be given through light openings and give a coefficient of regular light suitable for working conditions.

Along these lines, it is important to figure out what coefficient of common light in the room where the client assistance representatives work, and to build up whether it meets the conditions at the working environment and the necessities of the principles. Counterfeit lighting in rooms where PCs are worked ought to be completed by an arrangement of general uniform lighting. Given the significance of this creation factor, it is likewise important to compute the fake lighting framework in the client support division.

Crafted by representatives of the creation and specialized division is related with a significant degree of mental and distressing work, an undeniable degree of psychoemotional work. The strain of the work cycle can cause deviations in the condition of wellbeing of different organs and frameworks of the worker. And furthermore irritate the impact of different components on the human body. Hence, it is imperative to screen the condition of the pointer of work force at the work environment to forestall the event of deviations in the condition of wellbeing and the improvement of word related infections.

The specialized staff comprises of two workers: the main specialized trained professional and the programmer.

Crafted by representatives is straightforwardly identified with the PC, and, as needs be, with the hurtful extra impact of an entire gathering of components, which essentially decreases the efficiency of their work.

These variables include:

1) mistaken enlightenment;

2) infringement of the microclimate;

3) the presence of voltage.

As per GOST 12.1.005-88 SSBT "Ideal and admissible microclimate principles, contingent upon the class of work", crafted by individuals in the room alludes to light work (1a), since the gear is controlled distantly utilizing PCs

To make typical conditions for workers of the ventures of the Communications, guidelines of the modern microclimate have been set up. In rooms when working with a PC, the accompanying climatic conditions should be noticed:

Cold season

- the ideal temperature is 22-24 C, the admissible temperature is 18-26C˚;
- relative mugginess 40-60%, admissible stickiness 75%;
- air speed is relative and admissible 0.1 m/s;

Warm season

- the ideal temperature is 23-25 C˚, the allowable temperature is 20-30C˚;
- relative dampness 40-60%, passable mugginess 55%;
- velocity relative 0.1 m/s and allowable 0.1-0.2 m/s.

The room has measurements: length (L) = 6.5 meters, width (B) = 4.5 meters, tallness (H) = 4 meters. The room is situated in a structure on the third floor, intended for 2 working environments.

The design of the premises picked for the arrangement of gear and specialized work force is appeared in Figure 4.1.

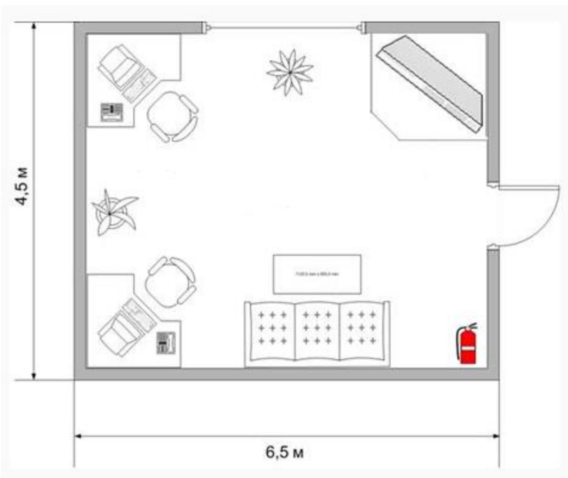

Figure 4.1 - Workroom plan

The workplace consists of the following components:

- two tables;

— two ergonomic chairs;
— two personal computers;

4.2 Calculation of parameters of a protective shield against electromagnetic radiation

For the protected activity of hardware with electromagnetic fields, you ought to: ascertain the limit of the enlistment and radiation zone; decide the normal distance to the radiation source; compute the energy thickness at a given separation from the source and contrast the outcome and the standard information; figure the thickness of the defensive screen; pick individual defensive gear [14].

Initial data:

Table 4.1

EPM source power (R), W	240
Frequency (f), Hz	104
Directionality of EMF	300
Distance from the workplace to the source, m	10

Let's calculate the boundary of the zones of induction and radiation. The radius of the induction zone (near zone) is determined by the formula (4.1):

$$R = \frac{\lambda}{2a}, \quad (4.1)$$

where λ - is the wavelength of electromagnetic radiation.

The wavelength of electromagnetic radiation is determined by the equation (4.2):

$$\lambda = \frac{c}{f * (\sqrt{e_r * \mu_r})}, \quad (4.2)$$

where $c -$ is the speed of light in vacuum (air), equal to 3.108 m / s,

$f -$ frequency of electromagnetic radiation, s-1,

e_r, μ_r –respectively the relative dielectric and magnetic constants, for air equal to 1.

Let's calculate the radius of the induction zone (near zone):

$$R = \frac{(\frac{c}{f * (\sqrt{e_r * \mu_r})})}{2\pi} = \frac{(\frac{3 * 10^8}{10^4 * (\sqrt{1 * 1})})}{2 * 3.14} = \frac{3 * 10^4}{6.28} = 4{,}78 * 10^3 m, (4.3)$$

Consequently, the boundary of the induction and radiation zone is located at a distance of 4.78 km from the radiation source. The near zone is located at a distance of 0 <R <4.78 km from the radiation source. The far radiation zone is located at a distance R> 4.78 km from the radiation source. Then the workplace (r = 10 m) is located in the near zone.

Determine the safe distance to the radiation source. In the induction zone, an electromagnetic wave is not formed, therefore, the strength of the electric and magnetic fields acts independently on a person.

The remote control for electric and magnetic fields when exposed during the entire shift is 500 V / m and 50 A / m, respectively. The remote control for the intensity of electric and magnetic fields with a duration of exposure no more than 2 hours per shift is 1000 V / m and 100 A / m [4]. Let's calculate the distances from the installation, corresponding to the EPDU and NAPU. Since the electric field has a greater effect on the human body than the magnetic field, the safe distance is calculated based on the obtained value of the EPDU.

Since the condition of the problem does not indicate the type of the EMF source and the length of the conductor, then we carry out further calculations, taking the operating voltage of the EMF emitter equal to the industrial voltage of 220 V. The magnetic field strength (N) of this installation is determined by the laws of total current:

$$H = \frac{\mathrm{I} * \mathrm{G}}{2\pi R} = \frac{\mathrm{P} * \mathrm{G}}{\mathrm{U} * (2\pi R)}, \qquad (4.4)$$

where I = P / U is the current in the conductor, P is the power of the EMF source, U is the voltage in the conductor, G is the amplification factor (directivity) of the electromagnetic field, R is the distance from the observation point.

From (4.5), we define Rmin for NPDU:

$$R_{min} = \frac{\mathrm{P} * \mathrm{G}}{2\pi * U * N_{PDU}} = \frac{240 * 300}{2 * 3.14 * 220 * 50} = 1.05, \qquad (4.5)$$

The electric field strength in accordance with the Poynting equation is:

$$\bar{S} = \frac{1}{2}[E * H^*], \qquad (4.6)$$

Consequently, equation (4.5) for Rmin for EPDU takes the form:

$$R_{min} = \frac{377 * \mathrm{P} * \mathrm{G}}{2\pi * U * \ E_{PDU}} = \frac{377 * 240 * 300}{2 * 3.14 * 220 * 500} = 39m, \qquad (4.7)$$

Since Rmin (EPDU) >> Rmin (NPDU), the distance at which the strength of the electric and magnetic fields does not exceed the MPL is Rmin (EPDU) = 39 m.

Therefore, the workplace is located within the range of the electric field, the intensity of which exceeds the MPL (Figure 4.2).

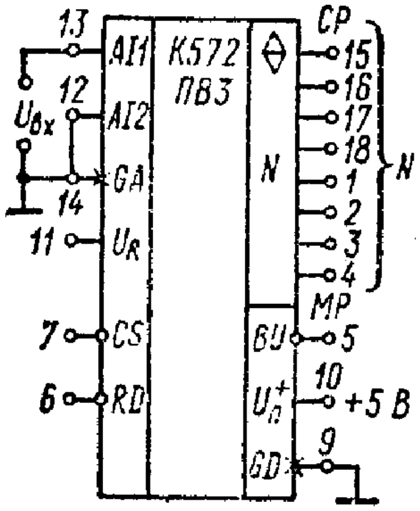

Figure 4.2 - Diagram of the boundaries of the zones of exposure to EMF

where r is the distance from the radiation source to the workplace (r = 10m),

R_{min} is the distance at which R_{min} (EPDU) of the remote control (R_{min}= 39m),

R - border of near and far radiation zones

Let's calculate the strength of the electric and electromagnetic fields at a given distance from the source.

In accordance with the formula (4.4) we get:

$$H = \frac{\text{P} * \text{G}}{\text{U} * (2\pi R)} = \frac{240 * 300}{220 * 2 * 3,14 * 10} = 5,2A/m, \quad (4.8)$$

Let's compare the obtained result with the normative data.

H = 5.2 A / m does not exceed NPDU equal to 50 A / m (5.2 <50).

E = 1964.17 V / m significantly exceeds the maximum permissible value of the EPDU, equal to 500 A / m at L = 1964.17 / 500 = 4 times. Let's calculate the thickness of the protective screen.

Since the values of the remote control are exceeded only by the electric field strength, and the value of the magnetic field strength is within the permissible values, the workplace must be shielded from the effects of the electric component of the EMF. The effectiveness of shielding electromagnetic radiation for the calculated shield is calculated by the formula (4.9):

$$L = 20\log_{10}\left(\frac{E}{E_{PDU}}\right) = 20\lg\left(\frac{1964.17}{500}\right) = 12.04dB, \quad (4.9)$$

The resulting field very quickly decreases in the screen, penetrating into it by an insignificant value δ, determined by the formula (4.10).

$$\delta = \frac{lnL}{\sqrt{\frac{\omega\mu\gamma}{2}}}, \tag{4.10}$$

Where L is the angular frequency of the field, Hz;

μ - magnetic permeability, H / m (for aluminum μ = 4.10-9 H / cm = 4.10-7 H / cm);

γ - electrical conductivity, S / m (for aluminum 3.54.105 Ohm-1 / cm = 3.54.107 S / m).

Let us calculate δ by the formula (4.11):

$$\delta = \frac{ln12{,}04}{\sqrt{3{,}14 * 4 * 10^{-7} * 3{,}54 * 10^{7}}} = \frac{2{,}49}{\sqrt{44{,}46}} = 0{,}373, \tag{4.11}$$

m = 37.3 cm .

Therefore, in order to reduce the electric field strength at the workplace to the level of the remote control, the workplace must be shielded with sheets of aluminum 37.3 cm thick. To exclude the reflection of electromagnetic waves, the floor of the workplace should be covered with rubber mats that absorb radiation.

The choice of personal protective equipment.

To protect workers from the electric field of low and very low frequency generated by industrial installations, a shielding suit (overalls or jacket with trousers) is used. The set of the suit also includes: metal or plastic metallized helmet, mittens (gloves) covered with conductive fabric and safety shoes [15].

All components of the suit are interconnected by conductors in order to ensure reliable electrical connection in order to prevent the penetration of radiation through the fabric of the suit (grounding is required to protect against EMP).

To protect the eyes of employees, protective glasses Z5-80 (GOST 12.4.013-75) are used. The glass surface facing the eye is covered with a colorless transparent film of tin dioxide, which attenuates the electromagnetic energy by 30 dB with a light transmission of at least 75%.

4.3 Calculation of the number of fire extinguishers

Even in ultra-modern buildings, built taking into account the latest achievements of architectural and planning ideas, equipped with integrated security engineering systems, including stationary fire extinguishing installations, alarms, fire-fighting water pipes that protect each room from the basement floor, underground parking to the upper technical floor / attic, there is always a place for hand-held (portable) fire extinguishers.

Why do we need fire extinguishers? Such means of operational fire extinguishing invented more than a century ago, having undergone significant modification / modernization taking into account the development of science, technology, the emergence of new principles of fighting fire, types / types of devices, effective fire extinguishing agents, not only have not lost their relevance; but they have also become a self-sufficient means, allowing, in a matter of seconds, at least to localize, and with skillful actions, to eliminate the source of fire in the premises or on the territory at the very beginning of development.

Along these lines, in every single public structure: shopping, office, sports and amusement focuses; managerial; clinical foundations; remembering for the shops of mechanical ventures, there should be a spot for compact fire dousers in the containers of fire hydrants or ablaze safeguards; and for versatile (movable) gadgets - in the city or in the premises of fire-perilous enterprises, with the assistance of which it is feasible to kill or limit fire sources, for instance, pouring combustible fluids over a huge region [16].

The final say regarding science and innovation in this matter is freon and air-emulsion fire quenchers. Makers publicize their astounding presentation attributes, high effectiveness in smothering most classes of flames; But clients, addressed by the administration of ventures/associations, and surprisingly more so common shoppers - vehicle proprietors, mortgage holders, little workplaces, shops, are so far frightened away by the excessively significant expense of these fairly straightforward in specialized terms gadgets, particularly in the event that we talk about imported items.

The calculation for ascertaining the quantity of fire dousers needed by the standards for the space of secured objects is as per the following:

Establishment of the utilitarian motivation behind a structure, floor, fire compartment or a different room in it, for example it is important to unmistakably characterize whether it is a stockroom, creation or public office.

Assurance of the classification of an article for blast and fire risk for mechanical ventures/singular businesses, distribution center bases/edifices; for public structures - this isn't needed.

Investigation of the design of a structure/structure dependent on the way that each floor or its part, isolated by clear fire parts, is furnished/outfitted with compact fire dousers independently.

Simultaneously, notwithstanding the complete space of the premises on the floor, the distances/radii of administration/security by one gadget are significant. They should be close to 20 m from the areas to the proposed fire source - out in the open, authoritative structures/structures, 30 m - in unstable and fire risky premises of classifications A - B of modern/distribution center ventures/associations, 40 and 70 m - for objects of classes G and D separately.

Assurance of the fire class, the greatest conceivable fire load anywhere nearby dependent on briefly/forever put away flammable substances - crude materials, merchandise, consumables, just as ignitable completing components, furniture, distribution center and other gear.

Subsequent to gathering, breaking down this data, it is not difficult to pick both the sort/type, brand, and the necessary number of fire quenchers. For this situation, the decision among compact and cell phones is resolved relying upon the assessed (determined) space of the fire place in the room, for instance, pouring combustible fluids/burnable fluids during depressurization of the mechanical compartment, the crude material/completed item supply pipeline, fuel.

On the off chance that the space of the proposed hearth can surpass 1 m2, versatile (movable) fire quenchers ought to be picked, with the assistance of which it will be feasible to limit/douse the fire, and the utilization of compact ones is unfeasible.

All in all, inclination ought to be given to fire quenchers that are more flexible in the field of utilization, remember about the need to have versatile gadgets for powerful dousing of different electrical gear - from electronic gadgets to switchboards.

It ought to be borne as a top priority that the quantity of fire dousers on each floor, as per the security principles in structures/constructions of any practical reason, should be at any rate two items.

Significant: frequently the proprietors/administrators and people liable for the determination, buy, command over the activity of fire quenchers fail to remember that the necessary number of fire dousers from the determined one can legitimately be decreased considerably; if singular rooms, floors or the structure all in all are furnished with fixed establishments/fire smothering frameworks that are in programmed activity [16].

A significant regular circumstance - it is important to prepare one story of the structure with fire quenchers. As referenced before, in any event 2 fire dousers are situated in open structures and constructions on each floor.

For instance, the elements of the floor in the arrangement are 48 x 16 m. The entryways of ten rooms involved by the administrations of the proprietor of the structure and the occupants go into the normal hall in the public structure, finishing with the foundation of flights of stairs planned for departure.

Fire stacking - furniture, inner flammable beautification of workplaces, office rooms, announcing documentation in printed copy, remembering for the chronicle room of the association with a space of 20 m2, for example strong flammable materials (fire class A); processing, office hardware, wiring, switchboard, establishment gear - switches, attachments, lighting conceals (class E).

All premises, including the chronicle, are outfitted with an APS, there is no AUPT framework. Obviously, it ought to consistently be borne as a main priority that the computation for each situation is individual and much will rely upon the format inside the room. Surmised chart with estimation (fire focus is a warning, snap to augment).

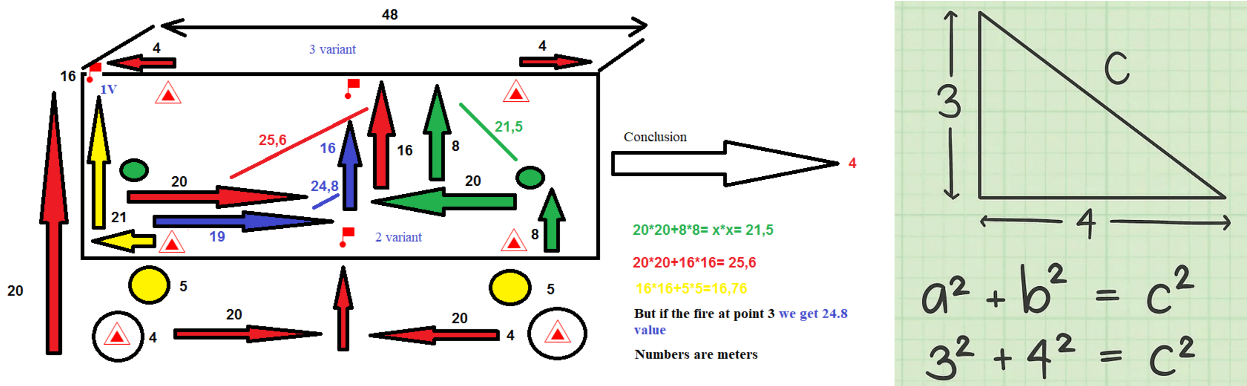

Figure 3 - An example of calculating fire extinguishers in a building and a room

The 4 red triangles marked inside the diagram are the correct locations for the extinguishers.

Three variants of the fire are given, marked in different corners of the administrative and public premises with the size of 48x16m. (ITEM 474. - no more than 20 meters):

— Option 1 (1V);
— Option 2;
— Option 3.

A green circle, a yellow circle, as well as the designation of fire extinguishers (a triangle circled in a black circle) is the location of the fire extinguishers themselves and the distance to the walls in numbers. Red arrows are attached to triangles within the diagram.

The numbers next to the arrows and fire extinguishers are the distance in meters, from the fire extinguisher to the fire. If we look, for example, at the Yellow circle, we will see the number 5 - this is the distance from the wall to the left and right (2 circles), but the number 21 on the arrows indicates 21 meters to the variant of the fire at point 1B, from the fire extinguisher (if we mirror the hearth and place it conditionally in the upper right corner, we get the same for the fire extinguisher on the right).

Fire extinguishers located 4 meters to the left and right of the walls of the room (circled in black), that is, if the hearth is at point 1B, option 2 and option 3, then we get a permissible value of 20 meters or less. Accordingly, if you mirror the fire options, the location of the extinguishers will remain the same [17].

The formula on the right is given as an example for calculating the diagonal distance, since in any variant of the location of the fire extinguisher, it should be no more than 20 meters to it.

Red arrows indicate the correct location of the extinguishers. With a building size of 48 x 16 m and a fire option at 3 different points.

If we look at the (figure 3), we will see 2 arrows and a diagonal value of 25.6 meters (when extracting the root from the obtained value, since the formula is C2 squared) for fire option 3 - this means that only 2 fire extinguishers are below in the diagram we will not have enough, respectively, we place 2 more mirrored on top.

The yellow arrows make it clear that when ONLY 2 fire extinguishers are located 5 meters to the left and right in the lower part of the premises, it is not suitable according to the PPR, since the distance to the fire source, for example 1B, is over 21 meters [18].

Green arrows are a variant of the location of fire extinguishers 8 meters in the center (16/2) and 4 meters to the right and left (inscription on arrow 20). At the same time, we see that up to 3 variants of the fire, respectively, and mirrored to 2 variants, we do not have enough distance, since we get a value of 21.5, which is more than 20.

Conclusion on life safety part

The making of good working conditions and the right stylish plan of work environments underway is vital both to work with work and to build its appeal, which positively affects work efficiency. Shading of rooms and furniture ought to add to the production of ideal conditions for visual insight and positive temperament. In office premises, in which repetitive mental work is performed, requiring critical apprehensive pressure and incredible focus, the shading ought to be quiet tones - low-immersed shades of cold green or blue tones.

The work environment is the piece of the space where the specialist works and invests a large portion of his functioning energy. A work environment all around adjusted to crafted by a designer, effectively and practically coordinated, as far as space, shape, size, furnishes him with an open to working position and high work usefulness with the most un-physical and mental pressure.

With the right association of the working environment, the usefulness of the specialist increments by 8 - 20 percent.

Consequently, tackling the issue of guaranteeing solid and safe working conditions for an architect developer is perhaps the main assignments during the time spent creation movement. By making sound working conditions, weakness when working with a PC diminishes, and the danger of mechanical wounds diminishes. Along these lines, the proficiency of the creation cycle is expanded.

Obviously, the satisfaction of just the prerequisites recorded here isn't yet an assurance of protected and agreeable human action. While sorting out the work cycle, it is basic to consider such boundaries as the association of the right brightening of the work environment, the guideline of the commotion level in the room, the degree of electromagnetic radiation. Furthermore, control of the fire and electrical security of the functioning room is obligatory.

Notwithstanding the actual parts of crafted by a PC client, mental viewpoints merit extraordinary consideration, including the issues of human mental movement, the cycle of weakness and methods of managing it.

The estimation of the quantity of fire dousers per secured region should be drawn closer mindfully, since these computations can save property at the office, yet in addition lives.

Follow the administrative documentation, just as other information of the room: region, format, its utilitarian reason and different subtleties depicted in the article.

5 Economic part

5.1 Business plan

A feasibility study of the theses related to the development of a software product (SP) was made.

The feasibility study of the development should contain:

- determination of the complexity of the development of the SP;
- calculation of the costs for the development of the SP;
- determination of the possible price of the developed SP.

5.2 Determination of the complexity of the development of the SP

The complexity of developing a software product for a specific task (t_p) can be considered as the sum of labor costs for the stages of development:

- preparation of the task description – to t_d, man-hour;
- development of the algorithm for solving the problem - t_a, man-hour ;
- drawing up a flowchart of the algorithm - t_f, man-hour;
- programming - t_p, man-hour;
- debugging the program on a computer – t_{deb}, man-hour;
- preparation of documentation for the task – t_{doc}, man-hour.

The basic indicator for determining the complexity is the conditional number of operator commands in the developed software (software). The conditional number of operators in the task program is determined by the formula:

$$Q = q \times c, \tag{5.1}$$

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 5.1.

Table 5.1 - 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

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. C++ is a general-purpose programming language created by Bjarne Stroustrup as an extension of the C programming language, or "C with Classes". The language has expanded significantly over time, and modern C++ now has object-oriented, generic, and functional features in addition to facilities for low-level memory manipulation. Now, based on table 5.2, we determine the coefficient c equal to 1.26.

Table 5.2 - Labor calculation factors

Programming language	Difficulty Group	Degree of novelty				Coefficient B
		A	B	C	D	
High-level	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
Low level	1	1,58	1,45	1,32	0,79	1,2
	2	1,49	1,37	1,24	0,74	1,35
	3	1,38	1,26	1,15	0,69	1,5

Thus,

$$Q = q \times c = 1700 \times 1{,}15 = 1955.$$

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

1) t_d is taken upon the fact:

$$t_d = 24\ man - hour.$$

2) we find t_a by the formula:

$$t_a = Q/(50 \times K), \tag{5.2}$$

where K is a coefficient taking into account the qualifications of a programmer (table 5.3).

Table 5.3 - 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,

$$t_{\text{a}} = \frac{Q}{50 \times K} = \frac{1955}{50 \times 1} = 39.1\ man - hour.$$

3) t_f we find by the formula:

$$t_f = Q/(50 \times K).$$

Where,
K – coefficient of programmer qualification factors.

$$t_f = \frac{Q}{50 \times K} = \frac{1955}{50 \times 1} = 39{,}1\ man - hour.$$

4) t_p is determined by the formula:

$$t_p = Q \times 1{,}5/(50 \times K), \quad (5.3)$$

Where,
Q is the conditional number of operators;
K is a coefficient that takes into account the programmer's qualifications.

$$t_p = Q \times \frac{1{,}5}{50 \times K} = 1955 \times \frac{1{,}5}{50 \times 1} = \frac{2835}{50} = 58{,}65\ man - hour.$$

5) t_{deb} is determined by the formula:

$$t_{deb} = Q \times 4{,}2/(50 \times K), \quad (5.4)$$

Where,
Q is the conditional number of operators;
K is a coefficient that takes into account the programmer's qualifications.

$$t_{deb} = Q \times \frac{4{,}2}{50 \times K} = 1955 \times \frac{4{,}2}{50 \times 1} = \frac{7938}{50} = 164{,}22\ man - hour.$$

6) t_{doc} taken on the fact and is (from 3 to 5 days for 8 hours):

$$t_{doc} = 24\ p/h, \quad (5.5)$$

The total labor costs are calculated as the sum of the composite labor costs according to the formula, man-hour:

$$t_p = t_d + t_a + t_f + t_p + t_{deb} + t_{doc}.$$

Where,
t_d - preparation of the task description, man-hour;
t_a - development of the algorithm for solving the problem, man-hour ;
t_f - drawing up a flowchart of the algorithm, man-hour;
t_p - programming, man-hour;
t_{deb} - debugging the program on a computer, man-hour;
t_{doc} - preparation of documentation for the task, man-hour.

$$t_p = t_d + t_a + t_f + t_p + t_{deb} + t_{doc}, \quad (5.6)$$

$$t_p = 24 + 39.1 + 39.1 + 58{,}65 + 164.22 + 24,$$

$$t_p = 349{,}07\ man - hour\ or\ 43\ man - days.$$

5.3 Calculation of the costs for the development of the SP

In works that require the development of a software product (software), the costs (C_{sp}) are determined by the following formula:

$$C_{sp} = G_f + S_t + \text{M} + C_s + C_d + C_e + C_o, \quad (5.7)$$

Where,
S_f - the general fund of remuneration of developers, tenge;
S_t - social tax deductions, tenge;
M - cost of materials, tenge;
C_s - the cost of special software tools necessary for the development of the project solution, tenge;
C_d - the cost of depreciation of equipment, tenge;
C_e - electricity costs, tenge;
C_o - overhead costs, tenge.
The size of the developer's salary fund (G_f) is calculated using the formula:

$$G_f = S_b + S_a.$$

Where,
S_b is the basic salary, tenge;
S_a is additional salary, tenge.
The basic salary of performers for a specific software is calculated using the formula:

$$S_m = t_p \times S_d, \quad (5.8)$$

Where,

t_p is the complexity of software development, man-days;

S_d – the daily salary of the developer, the i-th performer, (tenge).

The daily salary is determined based on the monthly salary of the developer and the number of working days in the month (on average, you can take 22 working days). Information on the employees involved in the development should be presented in table (table 5.4).

Table 5.4 - Salaries of specialists

Specialist	Number, person	Salary, tg.
Programmer	1	125 000
Total		125 000

Thus, the daily salary of a programmer is:

$$S_d = \frac{125000}{22} = 5682\ tenge.$$

The basic salary is:

$$S_b = t_p \times S_d = 43 \times 5682 = 244326\ tenge.$$

The additional salary is 10% of the basic salary and is calculated according to the formula:

$$S_a = S_b \times \frac{C_a}{100} = 244326 \times \frac{10}{100} = 24432\ tenge.$$

where C_a is the coefficient of additional salary for developers.

Thus, the general fund of remuneration of developers will be:

$$G_f = S_b + S_a = 244326 + 24432 = 268758\ tenge.$$

The social tax is 9,5% (Article 358 p. 1 of the Tax Code of the Republic of Kazakhstan) of the employee's income, and is calculated according to the formula:

$$S_t = \left(G_f - P_c\right), \quad (5.9)$$

Where,

P_c - pension contributions, which make up 10% of the FOT and are not subject to social tax:

$$P_c = G_f \times 0{,}1 = 268758\ \times 0{,}1 = 26876\ tenge.$$

Based on the above calculations and using the formula for the social tax is equal to:

$$S_t = \left(G_f - P_c\right) \times 9{,}5\% = (268758 - 26876) \times 0{,}095 = 22978{,}79\ tenge.$$

The value of the cost of materials based on the source data is determined by the formula:

$$\text{M} = \frac{(S_b \times R_{mc})}{100\%}.$$

where R_{mc} is the rate of material consumption from the basic salary (3-5%).

$$\text{M} = \frac{(S_b \times R_{mc})}{100\%} = \frac{244326 \times 5\%}{100\%} = 12216\ tenge.$$

This project uses the programming environment "Arduino IDE" and Raspberry Pi which is freely distributed, therefore, the cost of special software tools (Pc) is 0.

Depreciation costs include depreciation deductions from the cost of the equipment used for the development of the software product and are calculated using the formula:

$$C_d = \frac{\text{C}_{eq} \times R_d \times N}{100 \times 12 \times t}. \tag{5.10}$$

Where, R_d is the depreciation rate (25%);
C_{eq} - initial cost of equipment;
N – personal computer usage time;630000/26400
t – the number of working days in the month.

$$C_d = \frac{\text{C}_{eq} \times R_d \times N}{100 \times 12 \times t} = \frac{60000 \times 0{,}25 \times 42}{100 \times 12 \times 22} = 23{,}86.$$

The cost of electricity is calculated using the formula:

$$C_e = \text{M} \times l_f \times T \times C_{\text{kWt*h}}.$$

Where,
M is the computer power, kW;
l_f - load factor (0.8);
$\text{C}_{\text{kWt*h}}$ - cost of 1 kWh of electricity, tenge/kWh;

T – working time, hour.
Using the formula above, the energy costs were determined and shown in table (table 5.5):

$$C_{e1} = \mathrm{M} \times l_f \times T \times C_{kWt*h} = 0{,}12 \times 0{,}8 \times 349 \times 17{,}79 = 596,$$

$$C_{e2} = \mathrm{M} \times l_f \times T \times C_{kWt*h} = 0{,}1 \times 0{,}8 \times 349 \times 17{,}79 = 497.$$

Table 5.5 - Electricity costs

Equipment name	Passport power, kW	Load factor	Operating time of the equipment for the development of SP, hour	Price of el., tenge/kW-hour	Amount, tenge
Laptop	0.12	0.8	349	17.79	596
Lamp	0.1	0.8	349	17.79	497
Total electricity costs					1093

Overhead costs, (C_o) and account for 40 to 60% of the basic salary:

$$C_o = O_{ss} \times S_o / 100\%, \quad (5.11)$$

Where,
C_o is the overhead for a specific software (tenge);
S_o – the standard of overhead costs, (%).

$$C_o = 244326 \times 50\% / 100\% = 122163\ tenge.$$

Thus, the cost of developing the software product was:

$$C_{sp} = G_f + S_t + \mathrm{M} + C_s + C_d + C_e + C_o,$$

$$C_{sp} = 268758 + 22978 + 12216 + 0 + 23.86 + 1093 + 122163,$$

$$C_{sp} = 427232\ tenge.$$

The estimated cost of developing a software product is presented in table (table 5.6).

Table 5.6-Summary table of costs for the development of the SP

Cost items	Amount, tenge
Payroll fund	268758
Social tax	22978,79
Materials	12216
Depreciation	23,86
Electricity	1093
Overhead costs	122163
Total:	427232

5.4 Determination of the possible price of the developed SP

The value of the possible (contractual) price of the SP should be set taking into account the efficiency, quality and timing of its implementation at a level that meets the economic interests of the customer (consumer) and the contractor.

The contract price (C_p) is calculated using the formula:

$$C_p = \left[C_{sp} \times \left(\frac{\text{P}}{100}\right)\right] + VAT, \tag{5.12}$$

Where,

C_{sp} is the cost of developing the SP, tenge;

P - the average level of profitability (accepted in the amount of 20-30%);

VAT - value added tax,%.

The value added tax rate in the Republic of Kazakhstan for 2021 is 12% of the selling price of R&D and is calculated according to the formula:

$$VAT = \left[C_{sp} \times \left(\frac{\text{P}}{100}\right)\right] \times 12\%, \tag{5.13}$$

$$C_p = \left[427232 \times \left(1 + \frac{25}{100}\right)\right] + \left(\left[427232 \times \left(1 + \frac{25}{100}\right)\right] \times 12\%\right),$$

$$C_p = 598125\ tenge.$$

Conclusion on economic part

When calculating the cost of developing this project, it was found that certain knowledge in the field of programming is required as well as knowledge in the basics of electronics. In addition, calculations were made indicating the costs of component parts.

After the calculation, taking into account all the factors, the total cost of the development of this project, that is, a turtle robot with Bluetooth control based on the Arduino Uno microcontroller, was derived.

Conclusion

According to the analysis of existing robots, this robot is complex and available only for the services of large countries whose budgets allow to buy and store such robot.

In writing the thesis, the following tasks were solved:

- the choice was made for each type of component;
- assembled a robot-turtle;
- the system of self-management was developed;
- health and safety issues, technical and economic.

The first chapter was devoted to the concept of robotics and its modern implementations.

In the second chapter, the selection of components for the robot assembly was carried out, and the different advantages and disadvantages of these components were described. Also in this chapter, the assembly of the robot turtle was performed.

The third chapter describes the code as well as the programs to connect to the robot using bluetooth.

In the fourth and fifth chapter life safety and economic part were calculated. In the health and safety department, was analyzed working conditions in the laboratory, calculated the emissions of harmful substances during welding and the fire extinguishers in the room were calculated. In terms of feasibility study the cost of project development was 598125 tenge. In this work, capital costs, payroll and social efficiency of all equipment were calculated. The social impact of the project was also determined, which is as follows:

- ensures the safety of homes;
- allows you to control the robot via bluetooth.

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