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ASSEMBLING AND TESTING AN AMATEUR RADIO RECEIVER

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ABSTRACT

American artist Samuel Morse (Samuel Finley Breese Morse, 1791.04.27-1872.04.02) conceived and documented his concept for a communication device that could transmit information over long distances based on the principle of electromagnetic induction, which was discovered by the renowned physicist M. Faraday in 1832 during his voyage back to the United States from England aboard the ship "Sally".
In 1837, he constructed his first telegraph and created the Morse code the following year. On September 4, 1837, Morse showcased his invention at New York University, where he met his future assistant Alfred Weil, from a distance of 1,700 feet.
The inaugural telegraph message was sent by S. Morse from Washington, D.C. to Baltimore, D.C. on May 24, 1844, at 8:45 a.m. The message, "What Hath God Wrought," traveled over a 37-mile (60 km) wire between the two cities and was received by A. Weil. The message was transcribed as dots and dashes on a paper strip at the receiving end using an ink pen connected to an electromagnet. Morse code was later transmitted audibly using a sound generator.
Therefore, Morse code is utilized globally, including by the Armed Forces and military organizations of various countries, as the primary method of communication, information exchange, and transmission.
In recent times, amateur radio and radio sports have emerged as a competitive activity, with its origins traced back to Northern and Eastern Europe in the late 1950s. The inception of radio sports in Mongolia dates back to April 15, 1958, with the formation of the Radio Central Club.

KEYWORDS

Radio, Receiver, Frequency, Amateur, Test

CITATION

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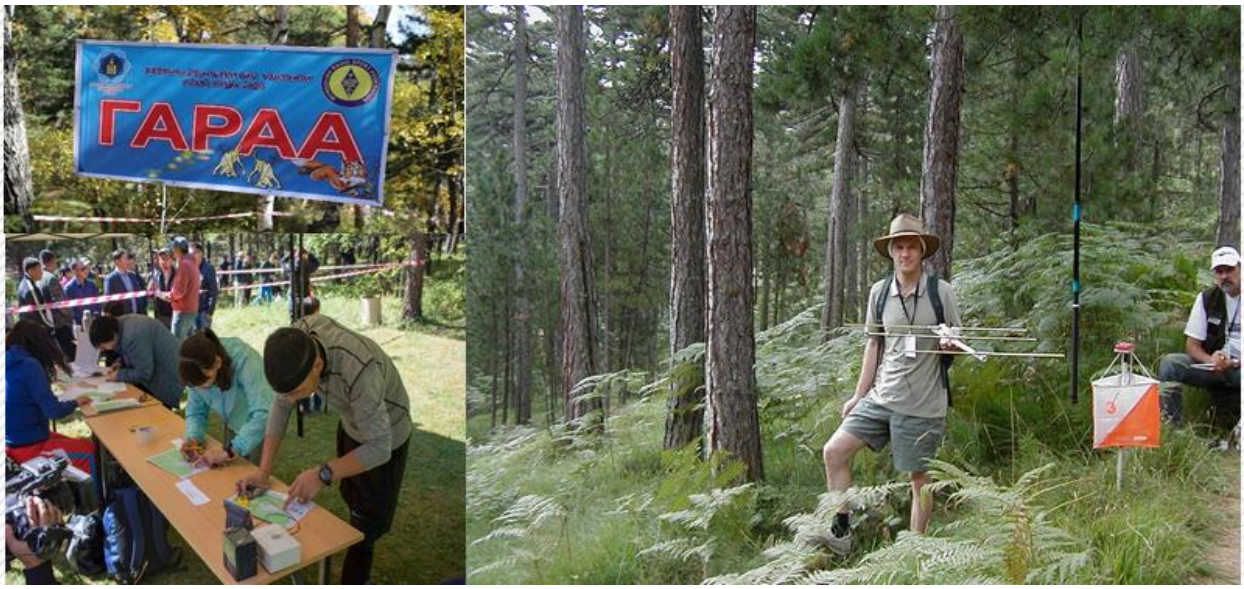
Introduction.

There are two types of amateur radio receivers: ultra-short wave and short wave. In amateur radio transmitter-finding competitions, athletes in categories such as 144 MHz, Foxoring, Sprint, and Traditional 3.5 MHz must locate 5-10 low-power transmitters hidden in the forest using a map, compass, and receiver to reach the finish line. The goal of receiving Morse code signals from the transmitters is to pre-determine their locations, establish the detection order, plan the route, and locate the transmitters. Figure 1 depicts athletes using an ultra-short wave receiver to detect transmitters.

Engaging in this competition offers numerous advantages, including enhancing physical fitness, honing map-reading skills, improving navigation abilities, progressing in one's career, and assessing agility. Many students and audience members at our school are eager to take part in the competition, but are unable to do so because of the limited availability of resources and the high expenses associated with acquiring equipment not readily available in Mongolia. As a result, we have committed to constructing and evaluating the equipment ourselves using the resources at our disposal.



a. Athletes preparing for the race *b. The location of the transmitter*

Fig. 1. *The discovery of the hidden point on the ground*

ULTRA-SHORT WAVE RECEIVER

The amateur receiver design was analyzed, the components were identified, and the necessary parts for the receiver were sourced from both international and local suppliers as per the design. The receiver's structural layout is illustrated in Figure 2. An amateur ultra-short wave receiver designed to operate within the 144 MHz frequency band is constructed based on the provided structural diagram.

Studying the amateur receiver scheme presented some challenges, so the scheme utilized in the Republic of Korea was implemented.

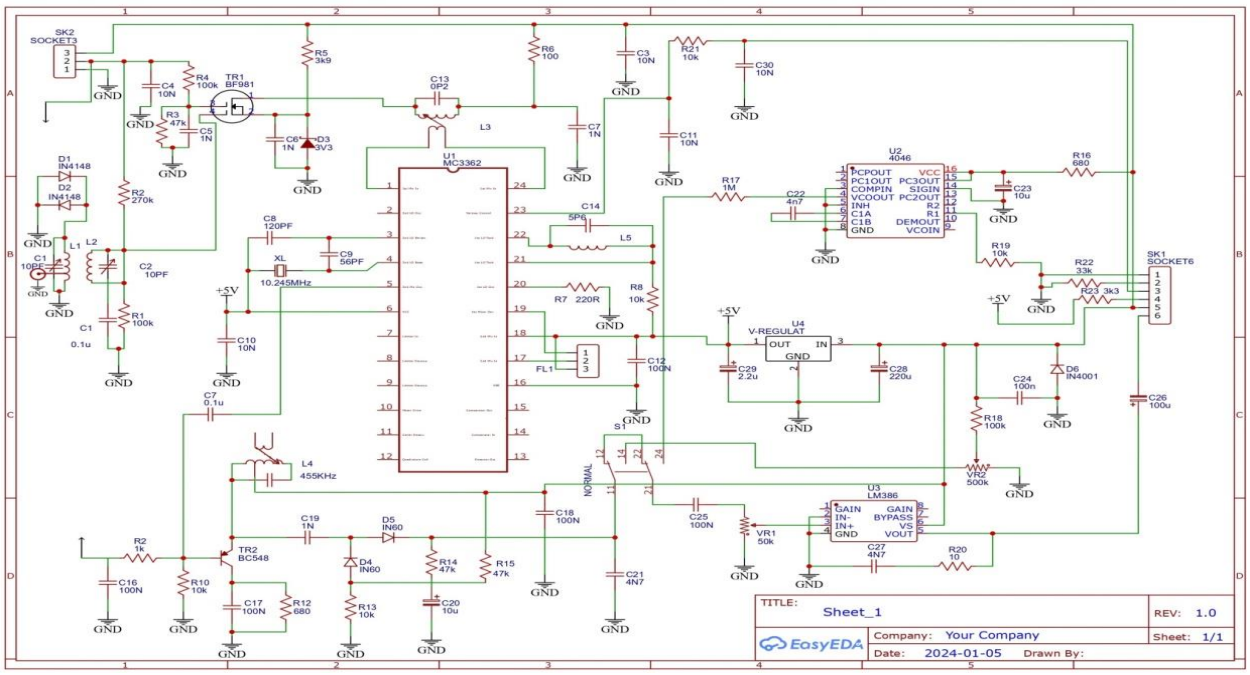


Fig. 2. *The diagram of the receiver structure.*

To recreate the factory motherboard, a board was manually crafted (Figure 1), components were soldered, and after thorough practice and testing, the receiver was powered on and functioned.

USING "SPRINT LAYOUT"

Sprint-Layout is a highly efficient software package designed for creating small to medium-complexity printed circuit boards. Its intuitive interface makes it easy to design PCBs up to 300x300mm in size, with the ability to work on both sides of the board. The program supports exporting designs to Excellon and Gerber formats, as well as creating HPGL files for the circuit board.

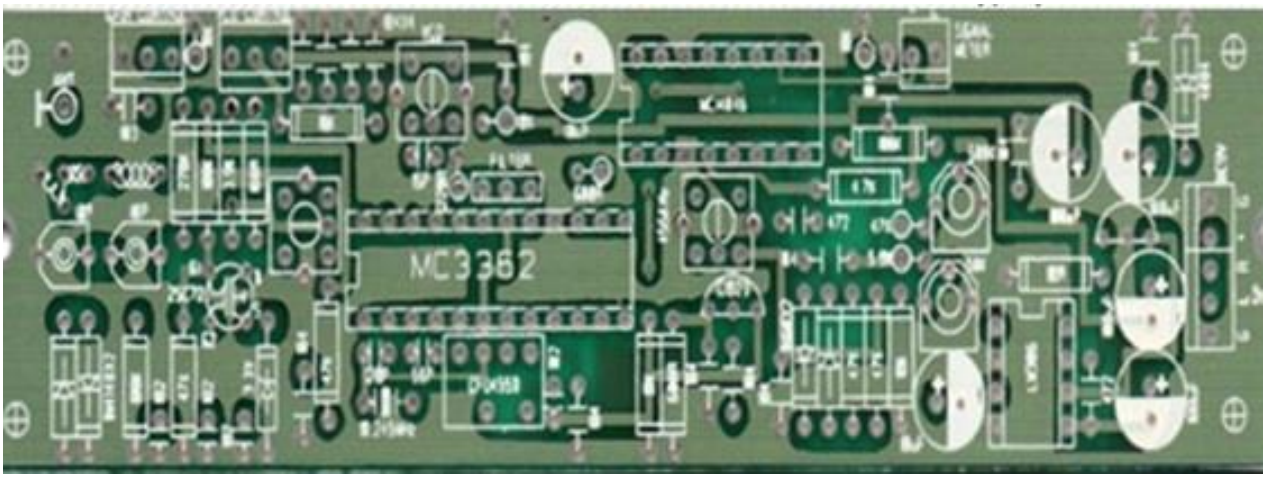
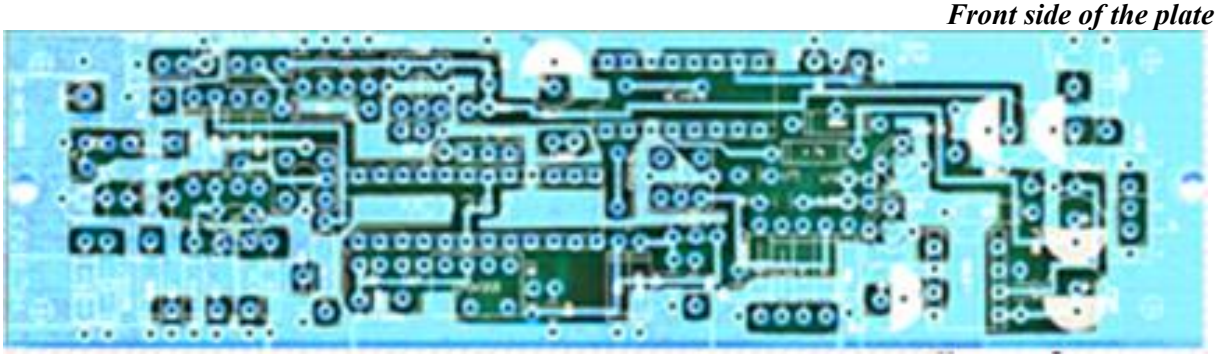


Fig. 3. *Factory motherboard*

Front side of the plate



Back side of the plate

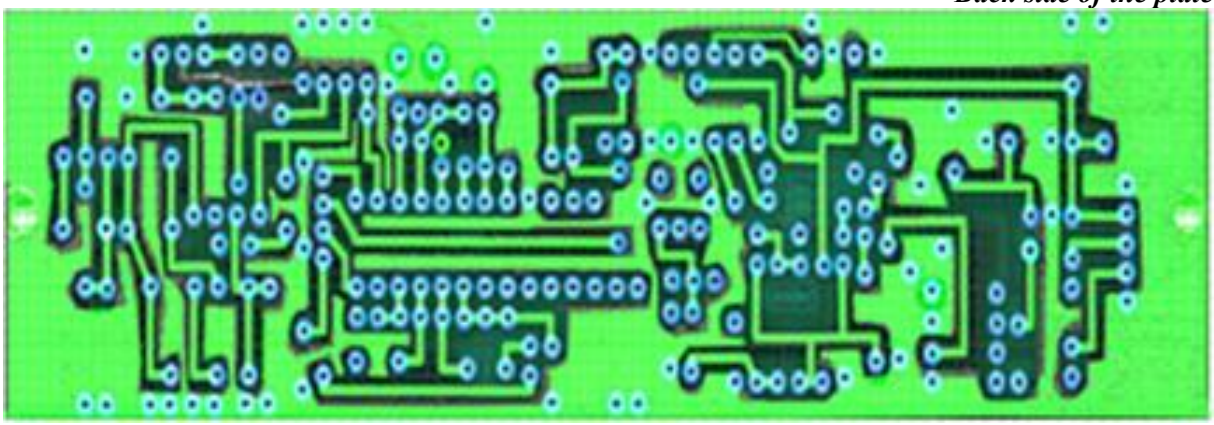


Fig. 3. *A handmade motherboard.*

The program Sprint-Layout 6, developed by domestic enthusiasts, is a fully functional Russian version that has been modified for user convenience. It includes changes to the interface, additional electronic components, and compatibility with all previous versions of Sprint-Layout up to version 5. Version 6 of Sprint-Layout includes several new features and improvements.

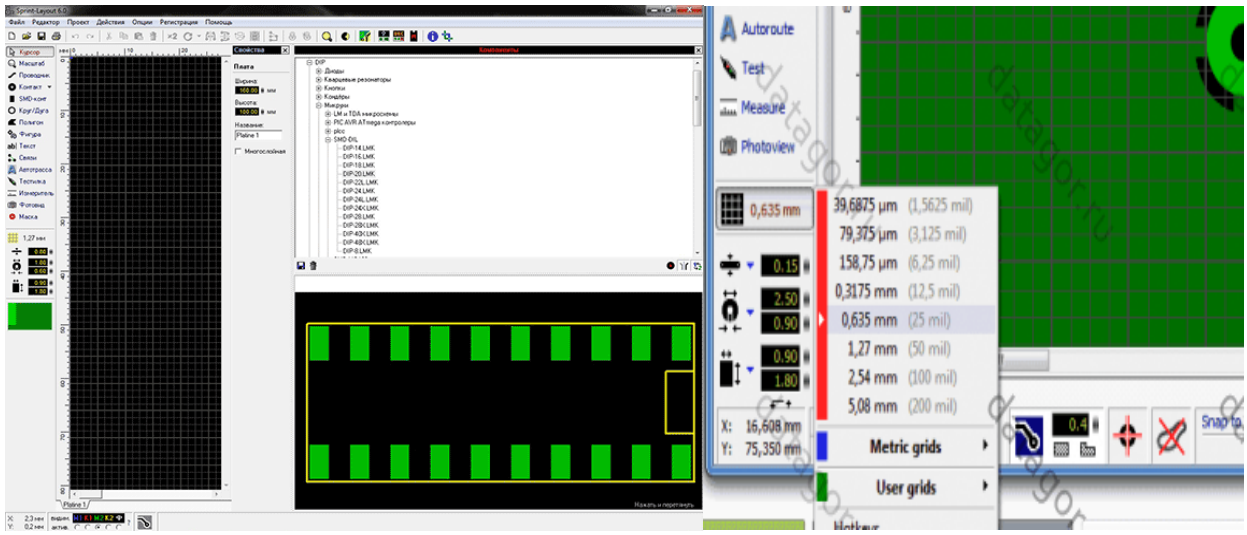


Fig. 4. *The program home page and program menu.*

Sprint Layout is a software designed for creating double-sided printed circuit boards, offering all the essential features for this task. It supports Excellon file export format for professional manufacturing processes like punching and drilling. With Sprint-Layout, users can design paths, schematics, and complete diagrams, choosing from a variety of pre-made elements or creating custom ones. An Example.LAY file is available in the Sprint Layout directory for reference.

A software tool utilized by engineers for designing objects in both 2D and 3D formats. It is commonly used in engineering graphic design projects and offers a variety of features.

THE RADIO RECEIVER ASSEMBLY

Antenna

The amateur receiver antenna consisted of 6 antennas of varying lengths: long (55cm), medium (50cm), and short (45cm) as shown in picture 5a. The metal meter was too thin to be wrapped with electrical tape on the outside, so it was covered with cambric material. This covering process, along with heating, eliminated the brittleness of the iron, making it sufficiently hard for a person to hold.

Outer box

I utilized the SOLIDWORKS software on a 3D printer to create the box by designing the dimensions, placing the mold in the printer, and using a spool of wire. The box was completed in approximately 11-12 hours /Figure 5b/. Due to size constraints, I split the box into two parts and printed the lid in two separate pieces.

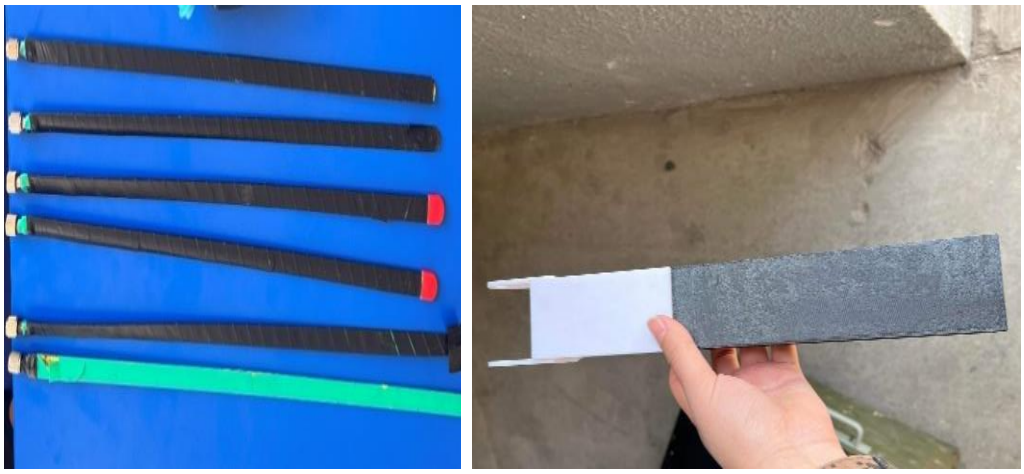


Fig. 5. *Antenna and outer box*

Main body

The receiver is made up of various components including an antenna, headphones, a box, a power supply, a motherboard, a headphone jack, and a switch. In the image provided, the components on the motherboard are arranged according to the board and schematic. The power supply is powered by a 9V battery to supply full power to the device. When the receiver is turned on using the on/off button, a light on the side illuminates, indicating that power has been supplied to the device. The headphone input has three poles: ground, plus, and minus. By connecting power wires to each pole and soldering the appropriate wire to the headphone input on the board, the signal from the transmitter is received by the antenna, filtered and processed through the device, and output as a signal or Morse code that can be heard through the headphones.

THE RADIO RECEIVER'S APPEARANCE

External design

A basic receiver includes a body, 6 antenna inputs, frequency and volume controls, a headphone input, an on/off switch, and a power supply (Figure 6).

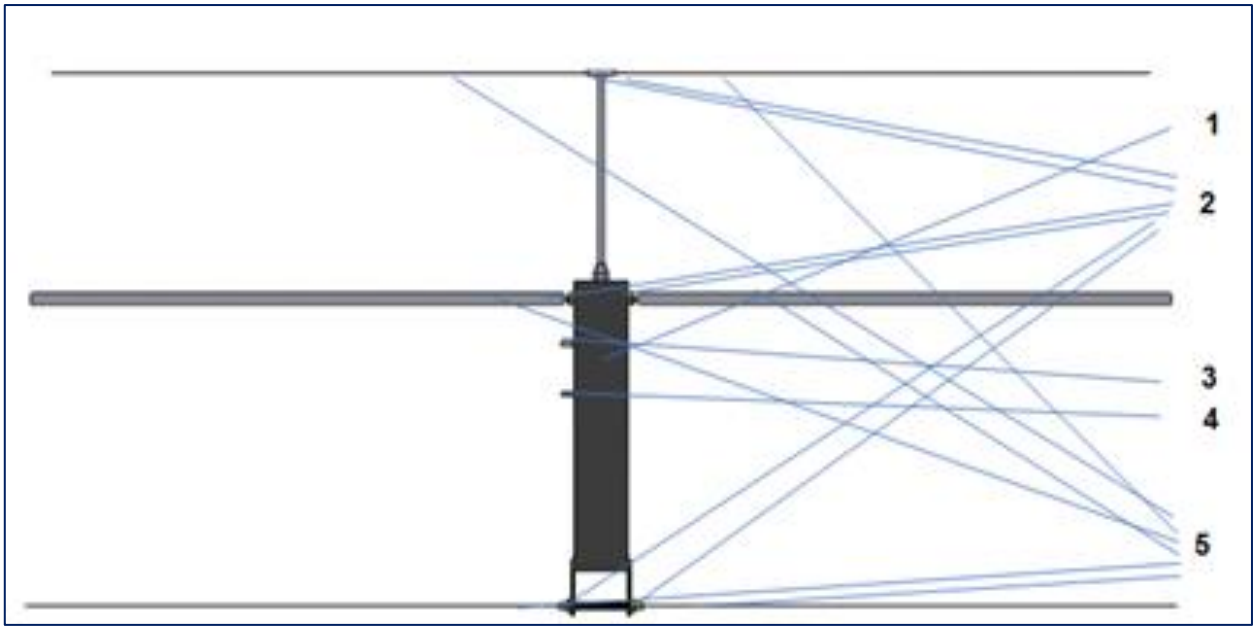


Fig. 6. *The external design of the receiver.*

1- Main body
2- Antenna base
3- Frequency control
4- Volume control
5- Antenna

Internal design

To construct the receiver base plate, the measuring units and specified elements are assembled and welded into their designated slots as shown on the plate /Figure 7/.

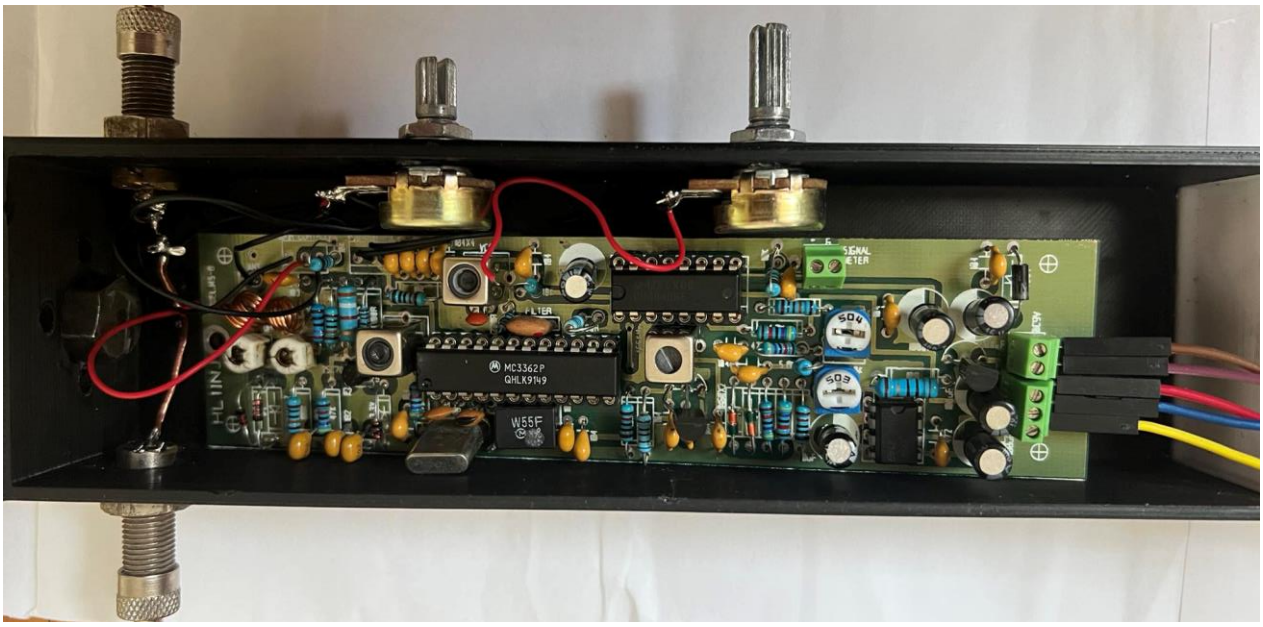


Fig. 7. *The internal structure of the receiver.*

The power, volume, frequency adjustment (potentiometer), and antenna wires were inserted from the outside, and the positive, negative, and grounding wires were connected and soldered to their respective sockets.

ADVANTAGES FOR THE RECEIVER

The receiver was successfully put together for the first time in Mongolia, and the Morse code signal is crystal clear and free of noise. It also offers the following benefits.

1. Manual assembly allows for the replacement and repair of damaged, burnt, or non-functional elements and components.
2. Using the "Sprint Layout-6" program to replicate the motherboard from the Republic of Korea manually offers a hands-on learning experience for participants.
3. Self-assembled receivers have become more affordable. By purchasing components and elements separately, you can save money compared to ordering a pre-assembled unit from abroad.
4. The necessary components for assembling a receiver are readily available and cost-effective.
5. Once you have all the materials, assembly is quick. It takes approximately 30-45 days to order, manufacture, and ship from abroad, but a team of 3-4 experienced engineers can assemble a receiver in 7-10 days.

If you purchase components and elements from foreign countries totaling 600,000–1,200,000 MNT, you can now assemble them yourself for 216,000–300,000 MNT.

CONCLUSIONS

1. The structural diagram of the ultra-short wave amateur receiver was carefully examined, calculated, and successfully assembled and tested, showcasing the innovative aspect of this research project.
2. The necessary parts and components for assembling the amateur receiver were sourced in Mongolia based on the schematic, with some components acquired locally and most ordered from the Republic of Korea. The two students from the Military Joint School who assembled the receiver initially handcrafted the board to enhance the factory board provided with the schematic.
3. The Intellectual Property Office of Mongolia officially granted a "Utility Model Patent" for the "Amateur Receiver" on February 29, 2024. The patent documentation is included.
4. Moving forward, there is great potential to incorporate this technology into practical lessons at the federal vocational school, enabling students to assemble, enhance, and utilize it as a fundamental skill in preparing for competitions aimed at determining the broadcaster's direction.

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Appendix

MONGOLIA

INTELLECTUAL PROPERTY DEPARTMENT

UTILITY DESIGN PATENT

According to the Order No. A/26 of the Head of the Department of Intellectual Property of Mongolia dated February 29, 2024, the exclusive right to own a utility model was approved and a patent was issued.

Useful pattern names:	Receiver of interest
State registration number:	**20-0003523**
Notification registration number:	**20-2023-0004727**
Default date:	**2023.09.27**
Name of creator:	Luvsan ODMAA
Owner Name:	Luvsan ODMAA
Validity period:	**2033.09.27**

CHIEF • Of age G. ELBEGSAIHAN

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