УДК 621.865.8
Pavlo Reznychenko[1], Svitlana Voitenko[2]
[1] student of group SC-615m NU “Zaporizhzhia Polytechnic”
[2] senior teacher NU “Zaporizhzhia Polytechnic”

DESIGN OF A MULTI-FUNCTIONAL AUTOMATED ROTARY PLATFORM

P.O. Reznychenko, S.V. Voitenko

Introduction and Relevance. The full-scale invasion of 2022-2025 proved that technological superiority can compensate for a lack of numbers. Some of the most effective units in the ZSU are specialists in electronic intelligence and electronic warfare, as well as UAV operator support units. One of the urgent but still unfulfilled needs of such units is a compact and lightweight device for rotating a payload with both manual and automatic control. Modern developments should focus on practical use, which is why the idea of creating such a device became the basis of my 2025 bachelor's thesis.

Analysis and Problem Statement. Based on the analyzed payload, a rotary device intended for use in combat units must meet the following requirements:

1. minimum weight and dimensions (the team often moves on foot with the equipment over the last kilometer);

2. environmental protection (against dust, moisture, wind, temperature, and UV radiation);

3. operational modes (ability to switch between automatic and manual rotation modes);

rotational speeds (automatic mode 360° rotation in 24 or 72 seconds, manual mode 360° rotation in 16 or 48 seconds);

4. remote Zero Point (setting the 'Zero' point remotely with protection against accidental reset);

5. feedback (indication of the current payload angle on the operator's remote relative to the set Zero point);

6. operator must be able to work from a shelter at a distance of up to 50 meters;

7. compatibility with standard ¼' or 3/8' tripods and the ability to mount the device on pipes or local objects using a "dovetail" attachment;

8. simple modular system for payload mounting should allow the user to 3D print new modules for new types of equipment using radio-transparent plastics and PVC pipes;

9. a simple and intuitive user interface;

10. protective coloring without elements that reflect light or emit signals in the microwave range.

Analysis of Existing Solutions. An overview of available rotary platforms allowed us to systematize current practical approaches.

Two-axis systems proved to be too massive, power-consuming, and difficult to manufacture. In field conditions, they are mostly used stationary.

Single-axis solutions, on the other hand, show better mobility and sufficient functionality for 360° observation tasks. however, most of them need improvements in ergonomics and weight.

The design of the most successful devices still has potential for improvement: miniaturization, weight reduction, increasing efficiency, and adding more control scenarios.

The plan is to use a stepper motor with a compact gearbox, a four-wire interface, a splash-proof remote with a display, and a customized mount for a payload weighing up to 1 kg. Additionally, the power unit (battery and converter) will be placed in a separate block. This minimizes the weight of the remote and makes it easier to replace batteries in the field.

Technical Specifications and Hardware. The main hardware components for the prototype were selected:

1. Arduino Nano as the main control platform;
2. NEMA17 stepper motor with a 5.18:1 planetary gearbox;
3. DRV8825 stepper motor driver;
4. Seven-segment display, indicators, and control buttons;
5. HW-519 interface converter for signal transmission;
6. LM2596 step-down converter for power management.

All components were chosen based on their stability, compatibility, and simplicity of integration for field use.

Technical Implementation and Hardware Design. The development process involved designing and manufacturing a functional prototype of an automated rotary platform. The system consists of three primary functional units: a control unit, a central power distribution hub, and the rotary platform itself.

The structural components of the system were engineered in Autodesk Fusion 360, focusing on modularity and ergonomics. A key design feature is the unified 'dovetail' mounting system, which enables rapid reconfiguration of the payload, such as antennas, cameras, or auxiliary devices. The chassis components were fabricated using additive manufacturing (3D printing) on a Creality K1C printer. While PET-G filament was utilized for the functional prototype, ASA-CF composite is recommended for field operations due to its superior mechanical strength and UV resistance.

The assembly process included the integration of electronic components into the 3D-printed enclosures, followed by the sealing of critical nodes. To ensure environmental protection, a splash-proof system was implemented, featuring sealing grooves, waterproof G16 connector gaskets, and a protective hemispherical cover for the control unit joystick. The resulting mobile complex has a total weight (including cables and batteries) starting from 5 kg, depending on the specific configuration, fully meeting the project's technical specifications.

Software Architecture and Control Algorithms. The system architecture implements distributed logic: the primary computational center is integrated into the operator's control unit, while the rotary platform's software functions as an executive module, effectively minimizing the risk of critical failures. Data exchange between the control unit and the turret is facilitated via the UART protocol, converted to the industrial RS-485 standard to ensure stable operation over long distances. To optimize data transmission, a simplified single-byte command system was developed, significantly enhancing response speed and communication reliability.

The implemented control algorithm supports two primary modes: manual, utilizing an analog joystick, and automatic, for cyclic space scanning within a ±180° range. The system features four speed modes tailored to the operational requirements of Tiny SA Ultra and SA6 spectrum analyzers. Additionally, a remote "Zero Point" calibration and homing function is provided.

The software framework is built using the AccelStepper library for non-blocking motor control and the TM1637Display library for real-time azimuth visualization. To ensure energy efficiency and hardware protection, a dynamic power management logic was implemented, activating the driver only during active maneuvers.

The final stage of the project involved a comprehensive review of the developed prototype and performance testing under conditions simulating real-world operations. The evaluation confirmed the correct functionality of all operational modes, command processing, real-time display accuracy, and system response to varying payload loads. An in-depth analysis of the software logic and hardware performance identified several potential limitations related to the prototype's components; subsequently, specific recommendations were formulated to eliminate these issues in the final production model.



Figure 1 – Prototype review and testing

The research also included an economic feasibility study, highlighting the use of cost-effective materials and off-the-shelf components for the functional prototype. Furthermore, the study assessed the practicality of replacing certain elements with high-grade, more reliable alternatives for the final system iteration. Overall, the prototype demonstrated consistent performance, confirming its readiness for scalability and further engineering refinement.

Conclusion. This work presents the design and development of a multifunctional automated rotary turret prototype tailored for the operational needs of the ZSU. Through the analysis of electronic warfare and UAV units' requirements, a single-axis structural scheme was justified as the optimal balance between weight, energy efficiency, and deployment speed in field conditions.

The project resulted in a fully functional system consisting of custom-engineered enclosures, specialized firmware for manual and automated scanning modes, and a robust communication interface. Field tests confirmed that the prototype achieves the target objectives: a user-friendly interface, expanded functionality, reduced overall mass compared to existing analogs, and high cost-effectiveness.

The practical significance of this research lies in the creation of a scalable solution built from off-the-shelf components, allowing for rapid mass production and adaptation to various payloads. Theoretically, the study contributes a methodology for engineering calculations and the unification of structural components for specialized hardware in high-demand environments. The successful integration of these elements proves the system's readiness for further modernization and practical application.