ASRO JOURNAL
http://asrojournal-sttal.ac.id/index.php/ASRO

Volume 15, Number 04, pp.32-41
October-December 2024
ISSN: 2460-7037
E-ISSN: 2722-5763

THE DESIGN AND BUILD CONTROL SYSTEM AND FIRING TEST ON RBU 6000 WEAPON IN KRI PARCHIM CLASS TO SUPPORT COMBAT AND OPERATIONAL READINESS

Suprayitno[1], Samsy Subahry Mokoginta[2], Bagiyo Hernowo[3]

[1,2,3] *Electrical Engineering Departement, Sekolah Tinggi Teknologi Angkatan Laut (STTAL), Jl. Moro Krembangan, Krembangan, Surabaya City, East Java 60178*

prayit.suprayitno.sp2@gmail.com

DOI: https://doi.org/10.37875/asro.v15i04.561

Manuscript received 5th November 2024, Revised 13th November 2024, Published 16th December 2024

ABSTRACT

Parchim class is a warship made in East Germany that entered Indonesia in 1996 and is equipped with AKS (Anti-Submarine) RBU 6000 weaponry. To maintain the reliability of these weapons, the Navy needs to ensure the RBU 6000 firing system is in combat ready condition. However, a number of technical problems still occur in the RBU fire control and monitoring system, such as limited firing test equipment, long test duration, use of simple measuring instruments, and unreliability of the firing button. This research aims to improve the RBU 6000 fire control and monitoring system using INA226 voltage sensors and Teensy 4.0 microcontrollers. The INA226 sensor has a wide reading range and good compatibility with the Teensy 4.0 microcontroller. This combination allows high-accuracy reading of the trigger voltage, which allows effective monitoring and analysis of firing. In addition, the Omron V-15-1C25 limit switch sensor is used as a misfire detector, which is able to distinguish launcher status and detect changes when the rocket enters and exits the launcher. In this study, software was also developed using the Windows-based Abacus Delphi7 application, which can control firing, read trigger voltage output, and monitor the status of limit switch sensors. The software is also capable of carrying out firing tests with a faster duration, firing in various modes, and moving the training angle and elevation of the RBU tower. The results of this study show that the use of INA226 voltage sensor and Teensy 4.0 microcontroller effectively improves the RBU 6000 fire control and monitoring system on KRI Type Parchim. The high trigger voltage reading accuracy and misfire detection capabilities of the Omron V-15-1C25 limit switch sensor provide significant improvements in firing reliability and safety. With the software developed, the operation of the RBU 6000 has also become more efficient and flexible. This research is expected to contribute to improving the Navy's defense capabilities in facing submarine threats.

Keywords: *KRI, RBU 6000, Control System, Shooting.*

1. INTRODUCTION

The Integrated Fleet Weapon System (SSAT) is one of the critical components in the country's defense and law enforcement at sea. In SSAT, the KRI (Battleship of the Republic of Indonesia) component is the spearhead in carrying out these tasks. The Indonesian Navy divides KRI into several divisions according to the characteristics of their respective ships, weapons, and combat capabilities. One of the important divisions is the KRI Parchim Class Division, which consists of 11 KRI stationed in Koarmada I and Koarmada II.

KRI Parchim Class type is a warship made in East Germany that entered Indonesia in 1996. One of the main advantages of this KRI is its AKS (Anti-Submarine) weaponry, namely RBU 6000 with 24 units of RBU 6000 launchers in each KRI. However, problems in the maintenance and use of this weapon still occur. Some of the problems faced by the KRI crew include the limited number of firing test kits, the long duration of the firing test time, the use of makeshift measuring instruments (Avometer), damage to the firing button that often occurs, the lack of display of the RBU firing control and monitoring system, limited firing mode settings, the absence of

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

indicators when a misfire occurs, and there is no recording of shooting results as real data reports to the leadership of the Indonesian Navy.

In the growing digital era, a tool is needed that is able to overcome these problems. The tool must be able to measure and ensure the readiness of each launcher quickly and accurately, control the firing mode, display indicators when a misfire occurs, and provide shooting data as evidence of reports to the Navy leadership. With this tool, KRI weapons can remain in a combat-ready condition, as well as facilitate and increase efficiency in the process of maintenance and execution of firing.

2. LITERATURE REVIEW

2.1 RBU 6000

RBU-6000 is a rocket-type weapon launched with a launcher system using the 90R type on a turret, with a function as an anti-submarine weapon. This rocket can activate detonation adjusted based on the depth required. When it has entered below sea level, its function will be a sea bomb that can destroy targets up to 1,000 meters deep. RBU 6000 in the ranks of the Indonesian Navy is only found in the KRI Type Parchim Class with the number of RBUs each KRI has 2 main towers and the number of each tower has 12 RBU rocket launchers . So each KRI has 24 RBU 6000 rocket launcher launchers.

2.2 Electric Voltage

Electric voltage is a measure of the potential difference between two points in an electrical circuit, measured in units of Volt (V). DC voltage is the direct voltage produced by a source such as a battery, while AC voltage is an alternating voltage that varies periodically, commonly used in household and industrial appliances. The DC voltage symbol is a positive and negative sign, while the AC voltage symbol is a round circle with a sine wave in it.

2.3 Microcontroller

A microcontroller is a small IC chip that has a CPU, memory, and programmable input/output devices. Its function is as a controller or system controller by processing incoming data and instructions. The CPU is the center of data processing, while memory is used to store data temporarily or for long periods of time. Microcontrollers also have parallel input/output ports for connecting external devices, ADC converters for converting analog signals to digital, DAC converters for converting digital signals to analog, as well as other components such as interrupt control, special function blocks, and timers/counters. All these parts work together to perform the control function of the system with accuracy and effectiveness.

2.4 Control System

Control system is a system used to control a plant through input settings. There are two types of control systems, namely open loop control systems and close loop control systems. An open loop control system is a system in which the control action does not depend on the output of the system, while a close loop control system is a system in which the output of the system is measured and compared to a set point, so the control action always depends on the output of the system. Control systems generally consist of sensors to measure controlled variables, controllers, and controlled systems or plants. Close loop control systems use feedback from system outputs to adjust inputs to achieve desired results, while open loop control systems have no feedback mechanism and are susceptible to internal or external interference.

2.5 Snubber Range

Snubber is a circuit used to protect electronic components from voltage surges that can cause damage or operational interruptions. The snubber circuit reduces or dampens voltage surges that occur during switching at inductive or capacitive loads. A snubber consists of a combination of capacitors and resistors connected in series or parallel to the component you want to protect. Its purpose is to protect components from phenomena such as voltage surges, reverse voltages, and oscillating symptoms that may occur during switching. The values of capacitors and resistors in the snubber should be selected according to the characteristics of the system and precise calculations.

2.6 Serial Communication

Serial communication is a method of communication in which data is transmitted on a per-bit basis in turn and sequentially. Although slower than parallel communication, serial communication has the advantage of requiring only one line and fewer wires. There are two types of serial communication, namely synchronous serial and asynchronous serial. In synchronous serial, the clock is sent together with the data, whereas in asynchronous serial, the data is sent without the clock and both parties must have the same clock frequency and synchronization.

3 RESEARCH METHODS

This research aims to design and develop a control system for the RBU 6000 weapon and conduct firing tests on KRI Type Parchim Class vessels. The RBU 6000 is an anti-submarine rocket launcher system that plays a crucial role in naval warfare, requiring precise control and reliable operational mechanisms. By enhancing the control system, the study seeks to improve the accuracy, efficiency, and responsiveness of the weapon

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

system, ensuring its optimal performance in various combat scenarios. The research will involve the integration of modern control technologies to refine targeting, firing sequences, and system diagnostics, ultimately increasing the weapon's effectiveness in anti-submarine operations.

Furthermore, the implementation of firing tests is essential to evaluate the performance of the improved control system under real operational conditions. These tests will assess the reliability, precision, and efficiency of the RBU 6000 in simulated combat environments, identifying potential improvements for further system optimization. Enhancing the control and firing capabilities of the RBU 6000 on KRI Type Parchim Class ships will significantly contribute to the Indonesian Navy's combat readiness, ensuring that the fleet is better equipped to handle underwater threats. This research is expected to provide valuable insights into modernizing naval weaponry systems and strengthening Indonesia's maritime defense capabilities.

4. ANALYSIS AND DISCUSSION

4.1 System Block Diagram

Hardware design there is a control system and this firing test begins with preparing the tools to be used, in the input section, namely the voltage output that comes out of the firing ballistics of each RBU launcher, then processed with two sensors, namely voltage sensors and limit switches and the output of the system made is on hardware using LEDs and buzzers while on software using delphi More details can be seen in Figure 3.3 below:

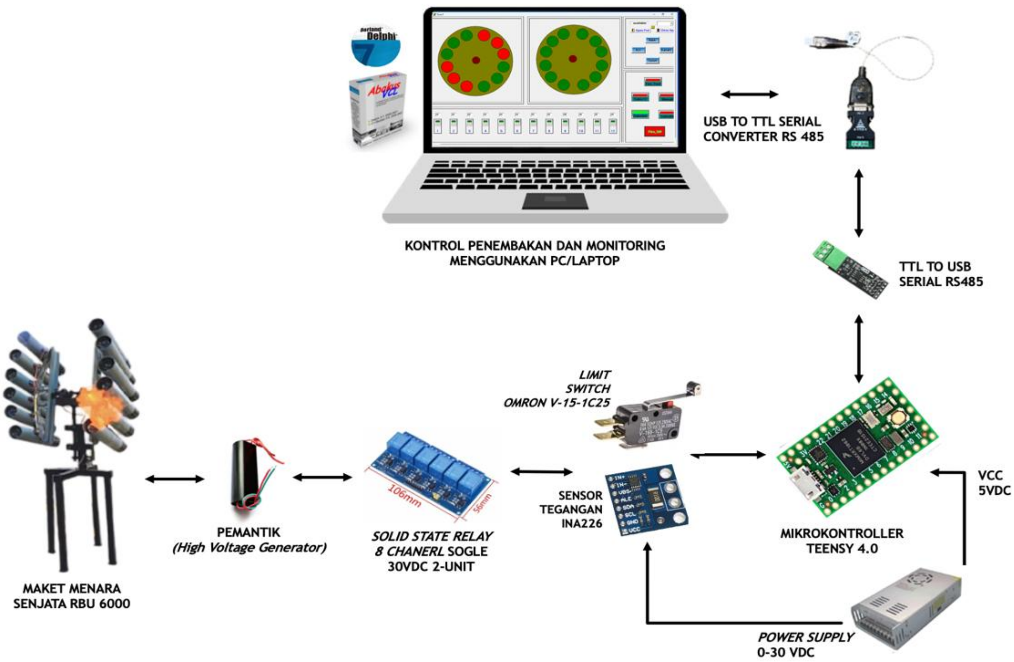

Figure 1. System Block Diagram
(Source: Processed author)

Figure 1 describes the INA226 Voltage sensor used to process firing voltage data on each RBU launcher. The data is sent via I2C communication to the Teensy microcontroller. Inside the microcontroller, data is read and processed, including voltage parameters and ON/OFF for limit switches that read the presence of rocket ammunition in the launcher. The microcontroller also sends sensor data to the user's laptop/PC via TTL to serial. When firing occurs and the voltage sensor and limit switch are active, the microcontroller activates the relay and INA sensor to read the firing voltage and provide information on the presence of the rocket in the launcher. The microcontroller also sends data to be displayed on the display that has been created.

4.2 Results and Discussion

4.2.1 INA226 Voltage Sensor

The results of testing the INA226 sensor against the 27VDC voltage input show that this sensor can be used to detect the firing voltage of RBUs on ships. In the test, the INA226 sensor was integrated with a microcontroller to read the voltage. Test results show that the INA226 sensor has an average error percentage of 1.57%, which falls into the "very low" or "relatively small" category. Thus,

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

this sensor can reliably detect the firing voltage of the RBU on the vessel.

Table 1. Ascender movement travel time

NO	Voltage		Difference Data (V)	*Error* (%)
	Voltmeter V_{in}	Sensor INA226 V_{out}		
1	27	26.95	0.5	$\frac{0.5}{27}\ x\ 100\% = 1.85\%$
2	27	26.93	0.7	$\frac{0.7}{27}\ x\ 100\% = 2.59\%$
3	27	26.96	0.4	$\frac{0.4}{27}\ x\ 100\% = 1.48\%$
4	27	26.95	0.5	$\frac{0.5}{27}\ x\ 100\% = 1.85\%$
5	27	26.98	0.2	$\frac{0.2}{27}\ x\ 100\% = 0.74\%$
6	27	26.97	0.3	$\frac{0.3}{27}\ x\ 100\% = 1.11\%$
7	27	26.95	0.5	$\frac{0.5}{27}\ x\ 100\% = 1.85\%$
8	27	26.94	0.6	$\frac{0.6}{27}\ x\ 100\% = 2.22\%$
9	27	26.96	0.4	$\frac{0.4}{27}\ x\ 100\% = 1.48\%$
10	27	26.95	0.5	$\frac{0.5}{27}\ x\ 100\% = 1.85\%$
11	27	26.96	0.4	$\frac{0.4}{27}\ x\ 100\% = 1.48\%$
12	27	26.99	0.1	$\frac{0.1}{27}\ x\ 100\% = 0.37\%$

(Source: Processed author)

Figure 2. INA226 Sensor Testing

Error data obtained from the observation of table 4.6, then calculations are carried out to determine the average error percentage, where "n" is the number of tests carried out so that it can use the following 4-2 equation:

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

Average Error Percentage (%) (4-1)= $\frac{\sum \text{eror}}{\text{n}}$

Average Error Percentage = $\frac{18.87}{12}$
= 1.57%.

4.2.2 Sensor Limit Switch

In this analysis, the author uses a high voltage generator as a voltage trigger for the active limit swich indicator by issuing a firing trigger current of 5VDC to trigger the rocket to launch on each launcher. The results of limit switch testing on 12 launchers when loading and unloading ammonition.

In this study, testing was carried out on the limit switch sensor used in the RBU launcher. The test results showed that when the ammonition rocket was loaded into the launcher, the limit switch sensor changed status from Normally Open to Normally Close. This indicates that the 5V input voltage is flowing and activates the generator's high voltage lighter to burn the propellant in the rocket. This process allows the rocket to be launched from the RBU launcher. Next, researchers tested the work of the limit switch sensor when the ammonition was fired from inside the RBU launcher. The test results show that the firing voltage output and limit switch sensor status are in accordance with the design that has been made. Here is picture 3 of the limir switch sensor test results

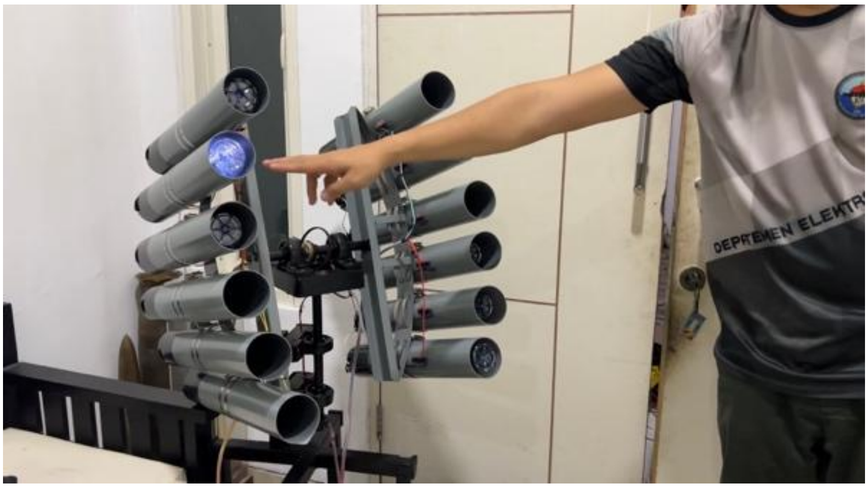

Figure 3. Testing limit switch sensors

4.2.3 Software FCS RBU 6000

The following are the results of the design of the control system software and firing tests made by the researchers, as shown in figure 4 below.

Figure 4. Software Development Results

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

a. Mode Firing Test

In the firing test mode, a trigger current voltage reading is taken before firing at the KRI. Currently, the firing test process is carried out manually using a firing test unit separate from the firing panel system. However, testing with this method takes a long time, about 22 minutes, to check the voltage in each launcher to ensure the firing readiness of the RBU. In the results of the firing test mode, it was found that using Firing_Test mode, the time needed to find out the voltage on 12 launcher units is only 15.72 seconds by pressing the firing button (Fire_On) once. This calculation was carried out using a stopwatch on the researcher's smartphone**.**

Figure 4. Firing Test Mode Testing

b. Mode Salvo 12

Salvo mode 12 testing aims to ensure that the software that has been created is able to command the controller to carry out firing on 12 launcher units in the RBU 6000 Tower. On the software display when shooting, you can see launcher 1, launcher 4 and launcher 9 indicators in red. This happens because the software receives data from the limit sensor that the ammonition rocket is still in the launcher. What the researchers did was to compare the results of the voltage output released by the relay to the switch limit with a voltage input of 27VDC in order to activate the lighter in each launcher.

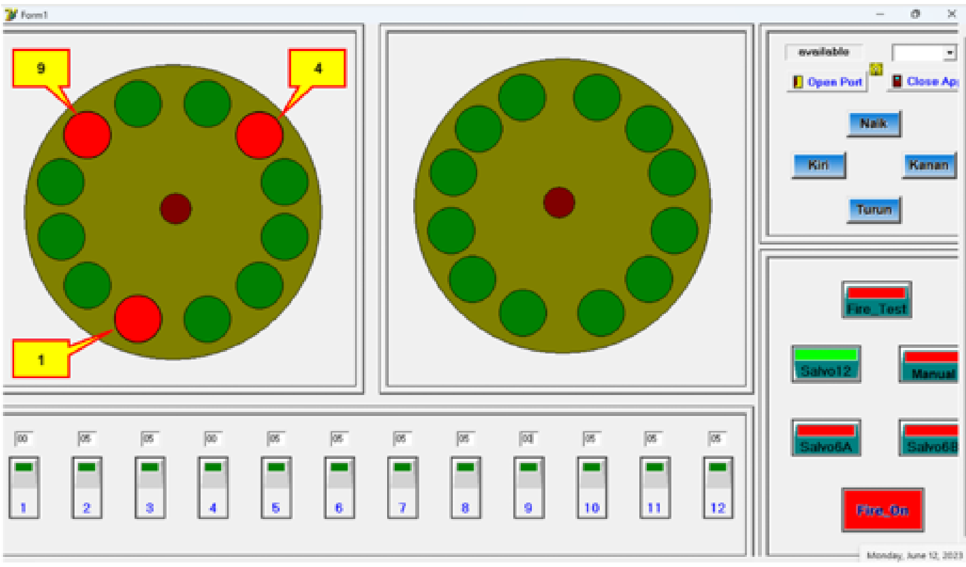

Figure 5. Display of Salvo Mode 12

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

Figure 6. Mockup Shooting Results

The results of testing the voltage sensor for salvo mode 12 showed an average error percentage of 7.16%.

c. Salvo Mode 6A

The 6A salvo mode test aims to shoot for 6 launchers only. This test is to find out the software that has been made capable of instructing the system to carry out firing on 6 launcher units in the RBU 6000 Tower. Salvo 6A consists of launchers 1, 2, 3, 4, 5, and 6.

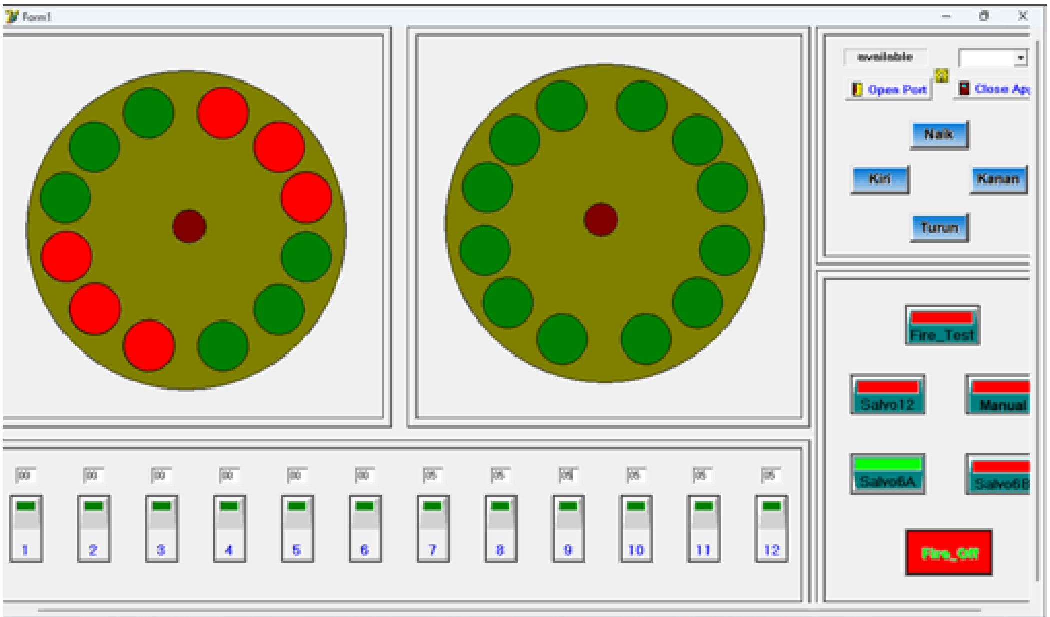

Figure 7. ModeSalvo 6A display

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

Figure 8. Mockup Shooting Results

The results of testing the voltage sensor for salvo mode 6A found that the average error percentage was 4.5%.

d. 6B Salvo Mode

The 6B salvo mode test aims to fire for 6 launchers only. This test is to find out the software that has been made capable of instructing the system to carry out firing on 6 launcher units in the RBU 6000 Tower. Salvo 6B consists of launchers 7, 8, 9, 10, 11, and 12.

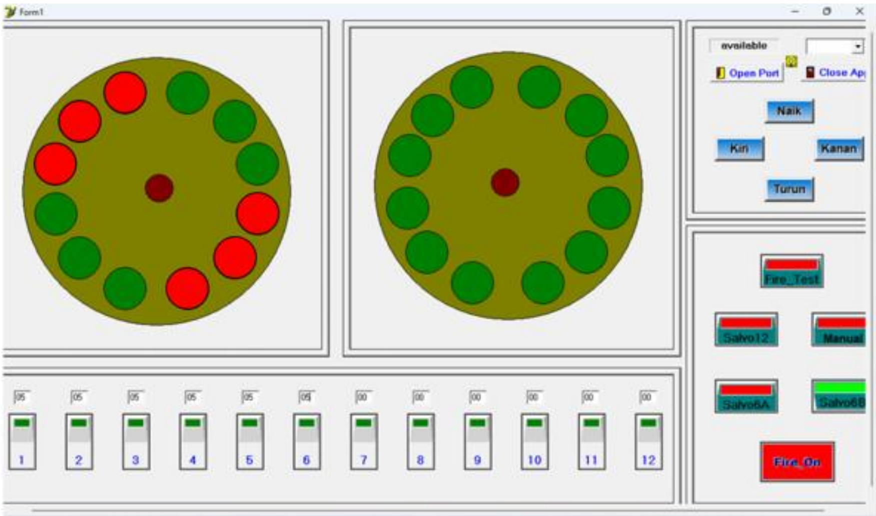

Figure 9. Display ModeSalvo 6A

Figure 10. Mockup Shooting Results

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

The results of testing the voltage sensor for salvo mode 6B found that the average error percentage was 4.5%.

e. Mode Manual

Manual mode testing aims to test firing singly. This test is to find out the software that has been made capable of instructing the system to carry out firing according to the wishes of the operator with a solo (single) system.

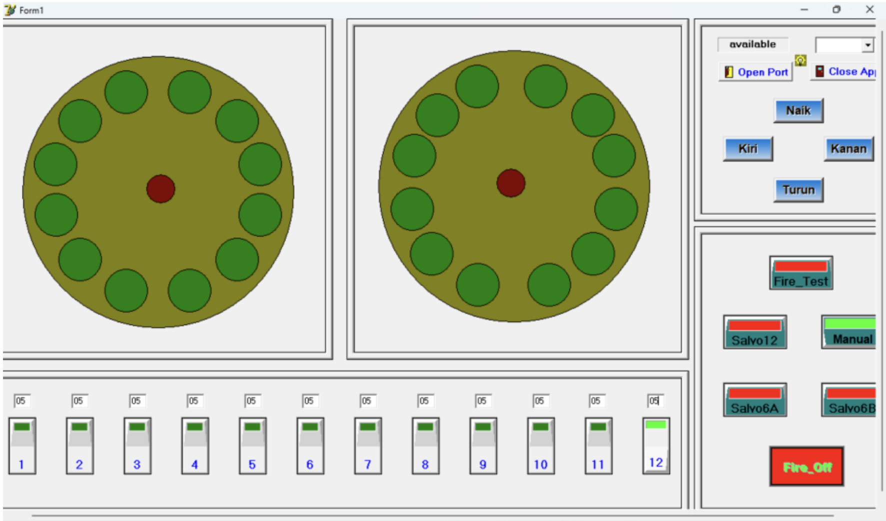

Figure 11. Manual Mode Display

Figure 12. Mockup Shooting Results

At this stage, the author chooses launcher 12 for manual shooting mode by pressing (clicking) the status button 12 to become green. Then carry out the firing as in figure 12 where you can see the ammonization rocket sliding from the launcher. Furthermore, monitoring the results of firing on the display with the results of the launcher status changing to "green" which means that the limit switch sensor does not detect a rocket in the launcher. Furthermore, it ensures that the voltage sensor reads the firing voltage output with the output read on the software, which is 27VDC.

f. Elevation Movement and Training

Motor movement testing aims to test the training angle and elevation of the RBU tower. This test is to find out the software that has been made able to command the training motor and elevation motor to move according to the commands of the software. The creation of movement control in the software with 4 directional button indicators (RIGHT, LEFT, UP, DOWN) on the display.

Volume 15, Number 4, pp.32-41
ISSN: 2460-7037
E-ISSN: 2722-5763

5. CONCLUSIONS AND SUGGESTIONS

5.1 Conclusion

The conclusions of the results of the research that has been carried out are as follows:

a. The selection of the INA226 voltage sensor and Teensy 4.0 microcontroller as part of the RBU 6000 control system and firing tests showed several advantages. The INA226 sensor has a wide voltage reading range, high accuracy with low error rates, and compatibility with a wide range of trigger voltages. The use of Teensy 4.0 microcontrollers allows for fast and efficient data processing.

b. The Omron V-15-1C25 limit switch sensor has proven effective in detecting launcher status during a misfire. This sensor can distinguish between NO and NC states well, and can work with a 5VDC firing trigger voltage. This sensor is also able to detect changes in status when rockets enter and exit the launcher.

c. The software design of the control system and firing tests using the Windows-based Abacus Delphi7 application showed a number of advantages. This software is able to communicate with the Teensy 4.0 microcontroller, control firing, read and display trigger voltage output, read limit switch sensor status, detect misfire, carry out firing tests with faster time, and move the Training and Elevation angle of the RBU tower.

5.2 Suggestion

The conclusions of the results of the research that has been carried out are as follows:

a. It is necessary to collaborate with research institutions, the defense industry, and the Indonesian Navy to share knowledge, experience, and technology related to the development and maintenance of the RBU 6000 weapon system. Synergistic cooperation will help improve the combat and operational readiness of KRI Type Parchim Class.

b. It is important to conduct further research using the RBU 6000 tool in the integrated laboratory to produce more applicable research and can be implemented throughout the KRI Type Parchim Class.

c. It is necessary to conduct comprehensive field testing and validation of proposed solutions. The collection of data from the real use of the RBU 6000 system with the implementation of improved sensors, microcontrollers and software will help to practically evaluate its effectiveness, performance and reliability.

d. It is necessary to improve the quality of sensors and components used in the design of the RBU 6000 control system and firing tests in order to achieve military specification standards. This is important so that the tool can be installed in all KRI Type Parchim Class owned by the Indonesian Navy.

e. It is necessary to ensure that the use of RBU control software and firing tests does not reduce the vigilance of soldiers during the execution of shooting. Quality improvement is needed so that this tool can support its basic functions properly

ACKNOWLEDGEMENT

The authors greatly acknowledge the support from Indonesia Naval Technology College STTAL Surabaya Indonesia for providing the necessary resources to carry out this research work. The authors are also grateful to the anonymous reviewers and journal editorial board for their many insightful comments, which have significantly improved this article.

REFERENCES

Alexandria. Delphi 11.1 (2022, 30 Juni). Embarcadero Technologies patch update.https://p2k.stekom.ac.id/ensiklopedia/Embarcadero_Delphihttp://digilib.unhas.ac.id/uploaded_files/temporary/DigitalCollection/.pdf (Retrieved June 1, 2023, at 08:00 WIB).

Ashar Arifin, (2021) Open Loop &; Close Loop Control System. Retrieved February 11, 2023. https://www.carailmu.com/2021/06/open-loop-close-loop.htmlhttps://www.yuasabattery.co.id/produk/detail/91(Retrieved November 17, 2023, at 08:00 WIB).

Grace. (2021). Design an Aircraft Front Wheel Lift and Towing System Control System at the Indonesian Navy Air Base. Surabaya.

R P Soumoki, P. E. (2023, 6 12). Analysis of the addition of slipway capacity to Pt. Dock and shipping Waiame (Persero) Ambon. Tehnik electro-engine marine informatics and science.

TNI, P. (2007, March 7). THE DUTIES OF THE TNI ARE IN ACCORDANCE WITH ARTICLE 7 PARAGRAPH (1) OF LAW NO. 34 OF 2004. Retrieved from www.tni.mil.id.

Wikipedia. (2023, November 27). Frog Squad Commando. Retrieved from https://id.wikipedia.org/wiki/Pusat_Komando_Pasukan_Katak.

Wikipedia. (2023). Kopaska. Retrieved from https://id.wikipedia.org/wiki/Pusat_Komando_Pasukan_Katak.