Synthsizer Audio Generator Analysist (Saga) DVOR Maru 220 Menggunakan Arduino Uno

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ABSTRACT

This study aims to design and implement a portable device based on the Arduino Uno ATmega328P microcontroller that is able to read and analyze the output signal from the DVOR Maru 220 Modulation Signal Generator (MSG) MODULE. This tool was developed to detect three main types of frequency signals, namely 30 Hz (reference signal), 720 Hz (blending signal), and 1020 Hz (ident signal), which play an important role in DVOR navigation systems. Data acquisition is done via an Arduino analog input and displayed in real-time via a desktop-based PyQt5 interface. The research method used is Research and Development (R&D) with the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model approach. The test results showed that the SAGA system was able to display frequency data with a fairly good level of accuracy, with the lowest deviation of 0.3973% at the frequency of 720 Hz. This system was considered effective in assisting technicians in the process of diagnosis, maintenance, and calibration of MSG Modules without having to use conventional equipment that was not portable. This innovation provides an efficient and economical solution in supporting DVOR-based navigation device maintenance activities.

Keywords: *DVOR MARU 220, MSG Module, Arduino, PyQt5.*

1. INTRODUCTION

Doppler VHF Omnidirectional Range (DVOR) based navigation systems play a crucial role in flight navigation, providing accurate azimuth and directional information for aircraft (Sanjaya, Sirait, Caesar, & Lumban Gaol, 2024). With the basic principle of using the Doppler effect on electromagnetic waves, DVOR serves to measure and provide important data to aircraft during travel, especially in the terminal area or when approaching an airport (Yang et al., 2018;). DVOR has been accepted globally in aviation navigation systems, but the main challenge lies in the accuracy of the signals emitted. External factors, such as interference from buildings or wind turbines, can cause deviations in the signal radiation pattern, ultimately affecting the accuracy of azimuth measurements by aircraft receivers (Sandmann & Garbe, 2019). This shows the importance of continuous monitoring and maintenance to ensure stable signal quality and avoid interference, so that flight safety is maintained (Xu et al., 2021)

The DVOR Maru 220 Modulation Signal Generator (MSG) MODULE is a device used in flight navigation systems to generate signals with specific frequencies, such as 30 Hz, 720 Hz, and 1020 Hz, which are used in the process of measuring and calibrating aircraft navigation signals. However, maintenance and calibration of these devices is often done with large and expensive tools, which hinders the efficiency and mobility of technicians, especially in the field. The main challenge faced by technicians is the reliance on measuring equipment that requires manual calibration and cannot be used practically in remote locations (Sari, 2022;). Additionally, although the 30 Hz, 720 Hz, and 1020 Hz frequencies are the primary frequencies generated by the MSG DVOR MARU 220 module, engineers need efficient and affordable tools to accurately analyze these signals. Microcontroller-based systems such as Arduino Uno offer a more efficient and portable solution compared to existing conventional tools. The use of the Arduino Uno ATMEGA 328P CH340 allows for more accessible signal measurement by using digital techniques to accurately analyze frequency signals, while speeding up the calibration and maintenance process of equipment. This Arduino-based system can help technicians to perform signal analysis in real-time, which improves maintenance efficiency and minimizes the potential for errors that can occur during signal testing (Sajadah et al., 2023;).

This study aims to design a frequency signal measurement tool based on Arduino Uno ATMEGA 328P CH340 which can be used to analyze and measure the signals generated by the Modulation Signal Generator (MSG) DVOR MARU 220 Module. Using a microcontroller-based device that is inexpensive, portable, and easy to use, the study aims to provide an efficient solution for technicians in performing 30 Hz, 720 Hz, and 1020 Hz signal frequency measurements, which are essential to ensure optimal performance of DVOR-based navigation systems (Sajadah et al., 2023;). The main objective of this study is to create a system that not only facilitates measurement, but also ensures high accuracy in signal analysis which is critical to the safety and operational efficiency of flights. In addition, another goal of this study is to show how Arduino-based systems can improve efficiency and precision in the maintenance and calibration of navigation devices in the field. By designing more portable tools, this study hopes to reduce reliance on large and expensive conventional equipment, as well as facilitate signal testing and maintenance in harder-to-reach areas (Sari, 2022;). By using this approach, it is hoped that the results of this study can be a reference for the development of better measurement technologies in the aviation industry, which can improve the performance of navigation systems around the world.

The method used in this study is an experimental approach that combines hardware based on the Arduino Uno ATMEGA 328P CH340 microcontroller with software to measure and analyze the frequency signal from the Modulation Signal Generator (MSG) DVOR MARU 220 Module. This approach is designed to provide an efficient and portable solution in analyzing the 30 Hz, 720 Hz, and 1020 Hz main frequency signals generated by the MSG DVOR MARU 220. Measurement tools designed using Arduino Uno allow programming to detect and process signal data in real-time, as well as display the results of frequency signal measurements through a computer-based user interface (Sajadah et al., 2023;). Using basic components such as Arduino and signal booster modules, the research aims to create a portable tool that can be used by technicians in the field, improving the efficiency of maintenance and calibration of DVOR-based navigation devices. This Arduino-based measurement system is designed to provide high accuracy in analyzing the frequency signals emitted by the MSG DVOR MARU 220 Module. The Arduino Uno will be programmed to read the frequency signal through the signal detector module and display the measurement results using a tested digital method. In addition, the system is also equipped with software to visualize measured signals in the form of graphs that can be analyzed by technicians to validate the performance of the navigation system. This method introduces a more cost-effective approach than conventional tools often used in signal calibration in the field, as well as providing a more flexible and transferable solution, allowing technicians to efficiently perform signal testing and analysis (Sari, 2022;). This Arduino-based system is expected to replace the use of larger and more expensive calibration tools, as well as allow for faster and more accurate measurements under a wide range of field conditions.

This research makes an important contribution in developing a more efficient and portable system for analyzing frequency signals used in flight navigation systems, particularly in applications on the Modulation Signal Generator (MSG) MODULE DVOR MARU 220. By designing an Arduino Uno ATMEGA 328P CH340-based microcontroller-based tool, this study simplifies the process of measuring the 30 Hz, 720 Hz, and 1020 Hz frequencies that are critical in the operation of navigation systems. The success in designing this tool not only helped technicians in analyzing signals more efficiently, but also reduced reliance on expensive and non-portable devices commonly used in signal testing. This Arduino-based system allows technicians to perform on-site calibration and testing more easily, making it an indispensable tool in the field (Sari, 2022;).

The main contribution of this study is in terms of improving the efficiency and accuracy in the calibration process of DVOR-based navigation devices. Using microcontroller-based technology, this research provides a solution to reduce the time and cost required in the maintenance of navigation equipment. In addition, these tools can provide faster and more accurate measurement results than larger, more expensive traditional measurement tools, which are not always practical to use in field locations. This research also contributes to the development of technologies that can be used by the aviation industry to improve flight safety and operational efficiency, as well as open up new opportunities for the application of microcontroller-based portable devices in the testing of other frequency signals in various industries (Sajadah et al., 2023;).

2. RESEARCH METHODS

This research adopts the *Research and Development* (R&D) method with the ADDIE model approach, which involves five main stages: *Analysis*, *Design*, Development, *Implementation*, and *Evaluation*. In accordance with the needs of technicians as a support for integration in technical testing at Airnav Maintenance Facility Yogyakarta effectively which aims to make simple measurements in order to be able to analyze the performance of the MSG DVOR MARU 220 Module.

This research was conducted at the Airnav Maintenance Facility Yogyakarta, especially in the improvement of the navigation field. The time for the implementation of the research takes place from the analysis stage to evaluation in a span of several months according to the applicable academic schedule. The subject of this study is an Air Navigation Engineering student, while the research is a Signal *Modulation Signal Generator Reading Tool.*

3. TOOL DESIGN

The first step in designing this Interactive Signal Modulation Module Signal Reader with Arduino Uno is to compile a block diagram, which provides a basic overview of the system. This block diagram illustrates how the circuit works to produce a tool that can function according to the research objective. The block diagram of the system can be seen in the following image:

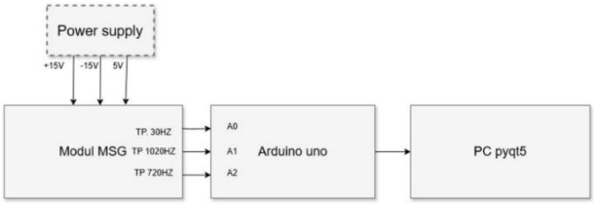

Figure 1 SAGA System Flowchart

Figure 1 illustrates the workflow of the Synthesizer Audio Generator Analysis (SAGA) designed to analyze the audio signals from the MSG DVOR MARU 220 module. The system obtains voltage supply from an external power supply with three main outputs: +15V, -15V, and 5V. These three voltages are used to turn on and stabilize the work of the MSG module which produces three test signals in the form of fixed frequencies, namely 30 Hz, 1020 Hz, and 720 Hz. The three signals are transmitted through the test point on the module and forwarded to the Arduino UNO analog input through pins A0, A1, and A2 respectively.

Once the signal enters the Arduino, this microcontroller processes analog data to be sent via a serial connection to the computer. On the computer side, the PyQt5 interface is used as a platform for visualization and analysis of data captured by Arduino. With this system, users can monitor and evaluate the characteristics of the audio signal generated by the MSG DVOR MARU module in real-time, as well as develop software-based analysis methods to support the reliability of DVOR-based navigation systems

4. RESULTS

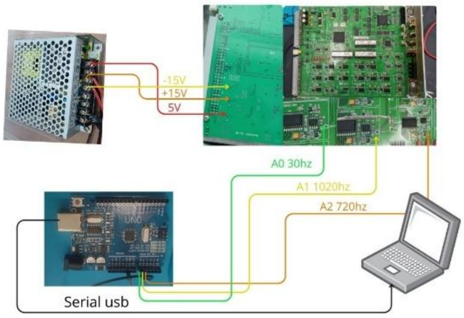

Figure 2 SAGA System Diagram Block

The system starts from the power supply component which functions to provide three main output voltages, namely +15V, -15V, and +5V. These three voltages are crucial to activate and stabilize the work of the MSG DVOR MARU module, which is part of a DVOR (Doppler VHF Omnidirectional Range) based radio navigation system. This module will generate three types of audio reference signals with different frequencies through test points, namely 30 Hz, 1020 Hz, and 720 Hz. These frequencies are used as signal simulations for the testing of frequency-based navigation systems.

The signal generated by the MSG DVOR MARU module is then transmitted to the Arduino UNO microcontroller board through three analog pins, namely A0 for 30 Hz signals, A1 for 1020 Hz signals, and A2 for 720 Hz signals. Because the frequency of the signal is in a range that can be recognized as periodic voltage changes, the Arduino processes the input as a digital representation of the analog waves, which are then sent to the computer for further analysis.

Next, Arduino UNO sends the data from the signal reading to the computer via USB serial communication. This serial communication facilitates continuous and real-time data transfer. The data sent contains information on the amplitude or voltage change of the input signal, which describes the waveform of each test frequency. Using program code embedded in Arduino, these signals are formatted and arranged in the form of data packets so that they can be recognized by the interface software.

On the computer side, a visual interface based on PyQt5, a Python-based GUI framework, is used to display data interactively. This interface will read the data from the serial port, then visualize it in the form of a graph or numerical display as needed. Through this interface system, users can observe signal characteristics directly, such as waveform, frequency stability, and possible interference. Thus, this system can be used for the analysis and monitoring of synthetic audio signals from DVOR devices, both for research, teaching, and testing of radio frequency-based navigation devices.

Table 1 Comparative Results of SAGA Measurements

Yes	Variable Singkatan	Oscilloscope	SAGA	Deviation
1	30 Hz	30.0051Hz	28.62 Hz	4.615%
2	1020 Hz	1019.95Hz	10.64Hz	4.32%
3	720 Hz	719.953Hz	717.09Hz	0.3973 %

The results of the comparison between frequency measurements carried out using oscilloscope measuring instruments with the SAGA (Synthesizer Audio Generator Analysis) system developed based on Arduino UNO and the PyQt5 interface. There are three test frequencies analyzed, namely 30 Hz, 1020 Hz, and 720 Hz. Measurements using oscilloscopes are used as a reference because this tool is a standard device with a high level of precision in signal analysis. For example, the 30 Hz frequency measured by the oscilloscope shows a value of 30.0051 Hz, while the SAGA system records a value of 28.62 Hz. The difference between the two results in a deviation of 4.615%, which is still reasonable for a simple microcontroller-based system like Arduino. For the second frequency, which is 1020 Hz, the oscilloscope measurement result is 1019.95 Hz, while the SAGA system records a value of 10.64 Hz which is seen to have a significant decrease, which is most likely due to the limited resolution of the Arduino ADC or the misreading of the signal periodicity. The deviation in this measurement was recorded at 4.32%, still within the initial tolerance limit of the experimental measurement system. As for the 720 Hz frequency, the SAGA measurement result of 717.09 Hz showed better accuracy, with the lowest deviation of 0.3973%, which indicates that the system works more optimally at medium frequencies than very low and very high frequencies.

Based on the results of the measurement and deviation analysis shown in Table 1, it can be concluded that the SAGA system is able to carry out the frequency signal measurement process with a fairly good level of accuracy, especially at the medium frequency (720 Hz). The smallest deviation was recorded at the frequency of 720 Hz, which indicates that the system is relatively stable in that frequency range. This indicates that the Arduino UNO-based signal acquisition system combined with the PyQt5 interface is capable of capturing signal characteristics with a fairly accurate digital representation, provided that the signal is within the optimal working range of the Arduino ADC. However, there are indications of decreased accuracy at low (30 Hz) and high (1020 Hz) frequencies, which need to be followed up through the development of signal reading algorithms or the use of digital filtering techniques to reduce noise or errors in the sampling process. In addition, it is also necessary to pay attention to external factors such as the stability of the power supply voltage and the quality of the input signal from the MSG DVOR MARU MODULE. In general, despite the deviation in measurements, the SAGA system can be considered successful as an early prototype in detecting and displaying microcontroller-based audio signal frequencies, with deviations that are still tolerable in the context of software and hardware development for educational and initial research purposes in the field of electronics and navigation systems.

5. DISCUSSION

Based on the results of the tests that have been carried out, it can be concluded that the SAGA system developed using Arduino Uno and the PyQt5 interface shows quite promising performance in the reading of audio signals from the MSG DVOR MARU 220 Module. The measurement results shown in Table 1 show that the system is able to detect three main frequencies namely 30 Hz, 1020 Hz, and 720 Hz even though there is a certain deviation compared to the readings using an oscilloscope as a standard measuring instrument. The highest deviation was recorded at the 1020 Hz signal with a value of 4.32%, while the lowest deviation was at the 720 Hz signal with only 0.3973%. This fact shows that the system works more stable and accurate at medium frequencies. Some of the factors that affect this deviation include the limitation of the ADC resolution on the Arduino, external interference in the signal reading process, and the quality of the input signal from the MSG module. However, the results obtained remain relevant and can be used for the purposes of initial monitoring and field calibration processes, especially in the context of maintenance and troubleshooting of DVOR navigation devices.

Overall, the application of the ADDIE model-based Research and Development (R&D) method on this system has proven to be effective in producing a prototype of a signal reader device that is practical, portable, and economical. The integration between Arduino and PyQt5 not only provides flexibility in data processing, but also simplifies the process of visualizing measurement results in real-time. This is very helpful for technicians in identifying signal interference without the need to use an oscilloscope or manually disassemble the module, which often requires additional time, effort, and equipment. In addition, the tool's ability to display a graph of the signal directly provides ease in performing signal stability and accuracy analysis. With improvements in measurement resolution and software enhancements, the system has the potential to be further developed as a standard MSG testing aid device in navigation equipment maintenance environments. Going forward, the addition of features such as log data storage and automatic calibration can also be a further innovation to improve the reliability and functionality of these tools in aviation industry practices.

6. CONCLUSION

This research successfully designed and implemented a portable device based on the Arduino Uno microcontroller to analyze the signals generated by the Modulation Signal Generator (MSG) DVOR MARU 220 Module used in flight navigation systems. The system is designed to detect three main frequencies (30 Hz, 720 Hz, and 1020 Hz) that are essential in DVOR operation. The use of Arduino Uno and the PyQt5 interface allows for real-time signal measurement with a fairly good level of accuracy.

The test results showed that the system was effective with the lowest deviation at the frequency of 720 Hz (0.3973%), which indicated that the system was more stable and accurate at the medium frequency. Despite the deviation at lower and higher frequencies, the tool can still be considered adequate for use in the field. The system is also more portable, economical and practical compared to conventional calibration tools that are large and expensive, and can be used to analyze signals more quickly and efficiently. Overall, this tool can be a good solution for technicians in maintaining and calibrating DVOR navigation devices in the field. The research also opens up opportunities for further development, such as the addition of automatic calibration features and log data storage, to improve the reliability and effectiveness of these systems in the aviation industry.

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