

INTRODUCTION

UTC(IDN), managed by the National Measurement Standards of the National Standardization Agency of Indonesia (SNSU-BSN), is the local realization of UTC and serves as the national reference for time and frequency traceability in Indonesia. To maintain its accuracy and reliability, UTC(IDN) must be properly managed, with its correction value relative to UTC monitored monthly through Circular-T reports, ensuring deviations remain within 100 ns.

SYSTEM OVERVIEW

The system utilizes a 5071a cesium atomic clock connected to a Frequency and Phase Offset Generator (HROG-10), with the 1pps output signal from the HROG-10 serving as UTC(IDN). Monitoring and control are facilitated by connecting the 5071a and HROG-10 to a computer via an RS-232 serial cable and dedicated software. A Universal Time Interval Counter (SRS SR602) is employed to measure the time difference between the UTC(IDN) signal and the 1pps signal from a GNSS Receiver. The SR620 is connected to the computer through a GPIB-USB cable, allowing the UTC(IDN) data to be recorded. The system's configuration is illustrated in Figure 1.

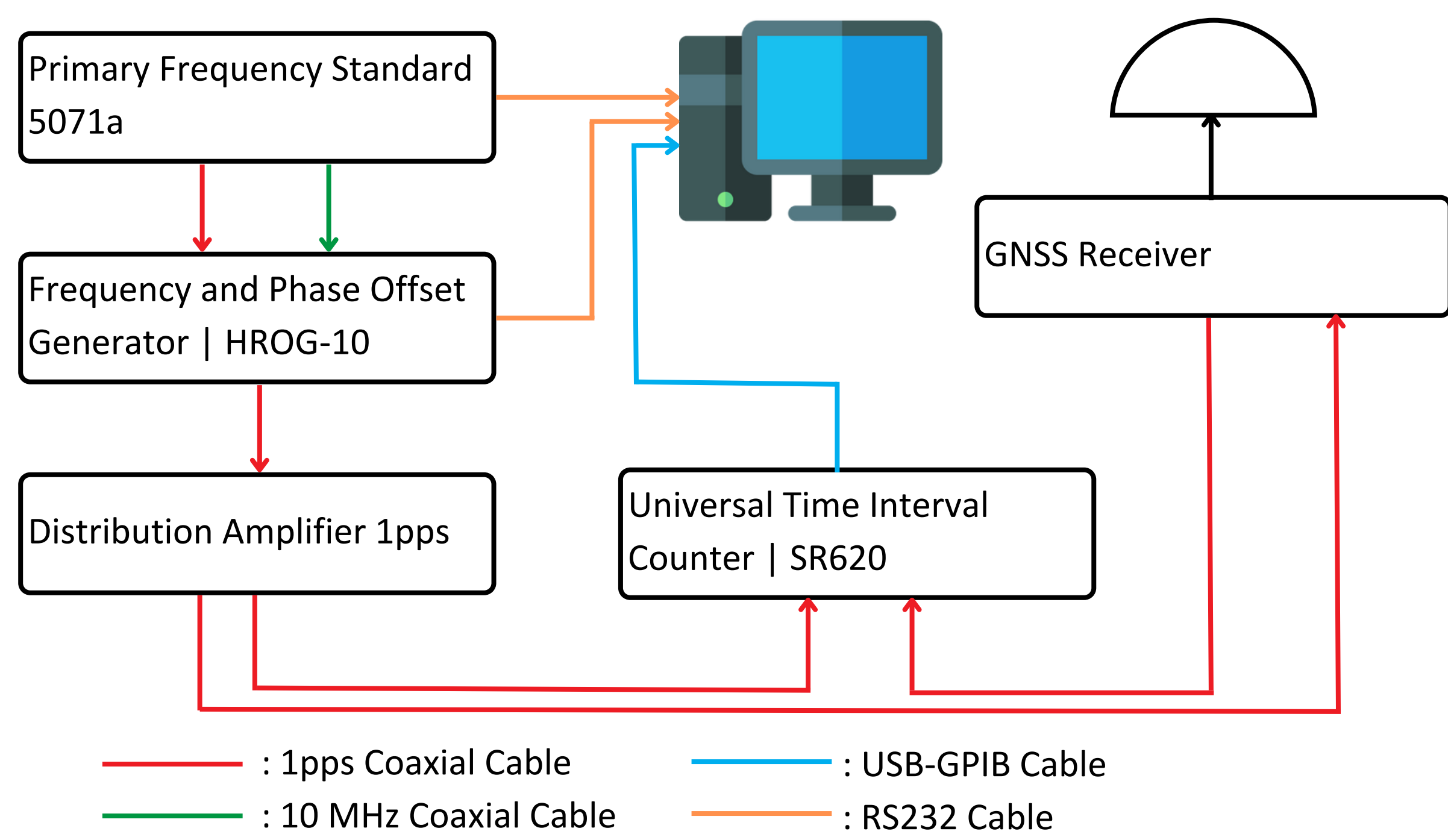


Fig 1. Hardware Diagram of Integrated System

The internal operational parameters of the cesium atomic clock are monitored by querying its data daily, with status updates recorded every 10 minutes. The collected data is stored in a spreadsheet accessible remotely and backed up locally to ensure availability in case of internet disruptions. A notification system has been implemented to alert users in the event of errors or warnings within the system.

The development of the steering system begins with monitoring the UTC(IDN) value by comparing it against the 1pps GNSS satellite signal and historical Circular-T data. This data is utilized as training input and validated using Circular-T reports. A machine learning algorithm is then selected to determine the optimal steering period and value. The calculated steering value is periodically sent to the HROG-10 to adjust the UTC(IDN) output. The effectiveness of the steering process can be directly observed through measurements recorded on the SR620.

RECENT PROGRESS ACHIEVE

A cesium atomic clock monitoring system has been developed to record and analyze its internal operational parameters and current status. These parameters are recorded daily, while the clock status is logged hourly. All recorded data is accessible in real time through a Google Sheets page and visualized with graphs, as illustrated in Figure 2. Additionally, the data is backed up locally using Microsoft Excel to ensure availability. A notification system has also been implemented to alert metrologists via WhatsApp whenever any internal parameter exceeds its specified limits or if the cesium atomic clock status deviates from "operating normally." This system ensures prompt responses to potential issues and enhances the reliability of clock operations.

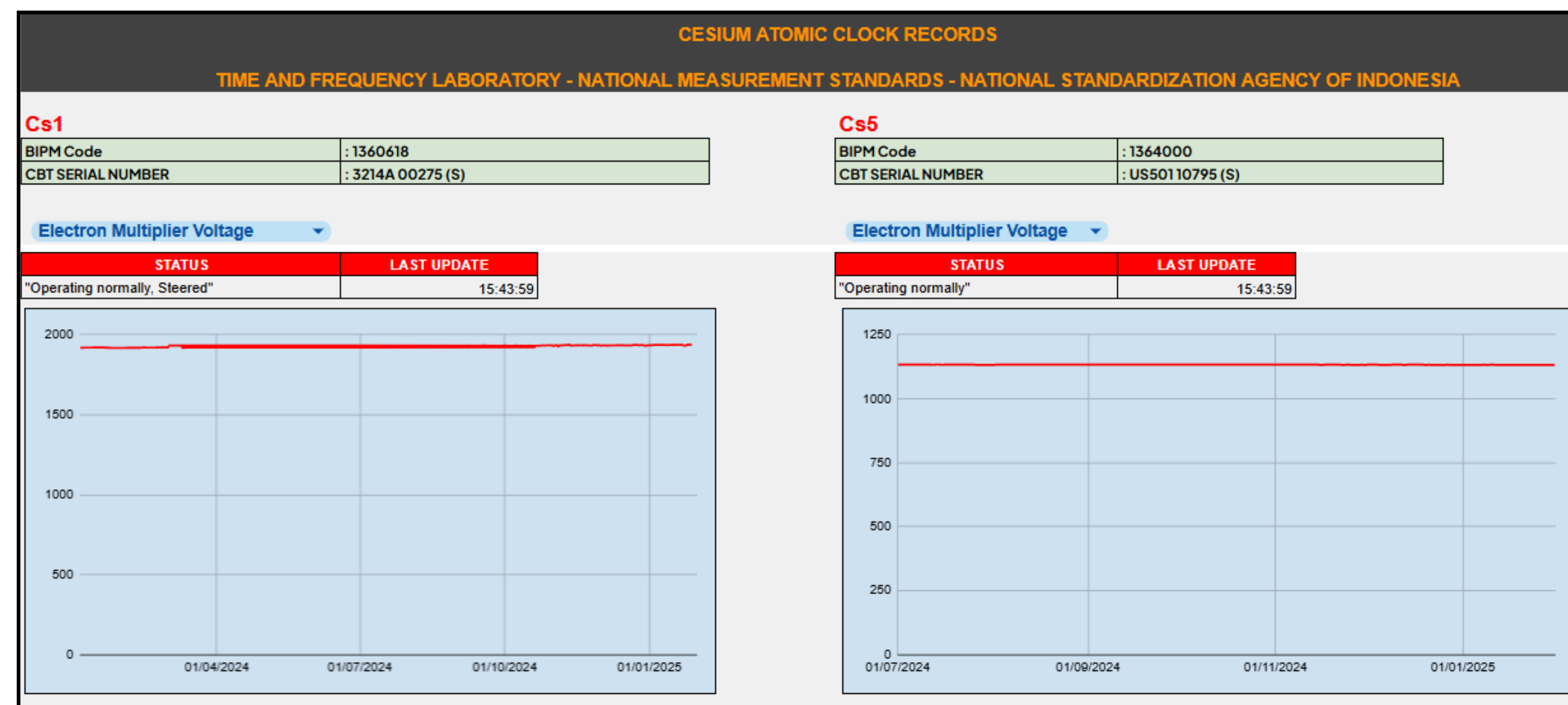


Fig 2. Cesium Atomic Clock Records

The development of the steering system began with the creation of software to compute the linear regression of UTC(IDN) corrections relative to UTC. The correction values are retrieved using the BIPM API Web Service and analyzed through the software. Users simply input the desired date range, and the software provides analysis results. The analysis outputs are automatically saved as an XLSX file for record-keeping, and data plots are generated.

The screenshot shows the UTC(IDN) Steering Calculator software interface. It includes the following elements:

- Start Date** and **Finish Date** input fields with dropdown menus.
- Analyze UTC(IDN)** button.
- ANALYZING RESULT** section with a table for Linear Regression, Slope, Intercept, and R Squared.
- Plot** button.

Fig 3. Steering Calculator Software

FUTURE DEVELOPMENT

The next monitoring system will be developed to integrate the monitoring of the environmental conditions, the backup power system for the primary time and frequency standard. Additionally, the UTC(IDN) steering system will be enhanced with automated recording of UTC(IDN) vs. GNSS Time measurements. With the collected data, the development of a machine learning model to provide precise steering values can begin. The goal is for this system to deliver accurate steering values to the Frequency and Phase Offset Generator at the correct time.

CONCLUSION

The development of the UTC(IDN) monitoring and steering system has been initiated with the establishment of a cesium atomic clock monitoring system and the creation of software to calculate steering values. Further development is required to achieve a more integrated and reliable system capable of producing a more stable and accurate UTC(IDN).

RELATED REFERENCES

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- D. Dharmappa, F. B. Singh and B. N. Ramakrishna, "Caesium Atomic Clock Behaviour Analysis Method (CSBAM) for GNSS systems," 2019 Third International Conference on Inventive Systems and Control (ICISC), Coimbatore, India, 2019, pp. 399-404, doi: 10.1109/ICISC44355.2019.9036422.
- K. G. Mishagin, V. A. Lysenko and S. Y. Medvedev, "A Practical Approach to Optimal Control Problem for Atomic Clocks," in IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control, vol. 67, no. 5, pp. 1080-1087, May 2020, doi: 10.1109/TUFFC.2019.2957650.

