Cloud-Based SCADA Ship Alarm Monitoring system

Diono[1], Nabyl Choirul Muna[2]

Politeknik Negeri Batam
Jurusan Teknik Elektro
Jl. Ahmad Yani, Batam Centre, Batam 29461, Indonesia
E-mail: diono@polibatam.ac.id.ac.id, nabylcm55@gmail.com

Abstract

Ship Alarm Monitoring System based on Cloud SCADA was designed and developed to monitor critical parameters on a vessel, such as engine temperature, pressure, electrical voltage, and the operational status of other onboard equipment. The system integrates sensors installed on the ship's systems, a PLC as the main controller, and a cloud-based SCADA HMI platform for visualization and alarm notification. Data from both digital and analog inputs are collected by the PLC and transmitted to the cloud server through industrial communication protocols. The Cloud SCADA system then processes, stores, and displays the information in the form of analog monitoring, data processing, and real-time alarm status. In addition, the system provides alarm notification features through an online cloud dashboard, allowing responsible users to monitor the ship's condition remotely as long as an internet connection is available. System testing was conducted under several alarm scenarios, including equipment failure and rapid parameter changes. The results show that the system is capable of transmitting and displaying alarms with high accuracy, within a response time of 0–5 seconds, and an average data transmission delay that remains within safe limits for ship monitoring applications. The cloud SCADA dashboard visualization is also considered easy to understand and supportive of the decision-making process for responsible users. Therefore, the Ship Alarm Monitoring System Based on Cloud SCADA can improve monitoring efficiency, accelerate responses to critical conditions, and support the implementation of more modern and centralized ship maintenance systems.

Keywords: Cloud SCADA, Alarm Monitoring system

1. Introduction

The Cloud SCADA-based Alarm Monitoring System is a system designed to supervise and monitor the status and conditions within a specified area. This system functions to detect potential threats, failures, or abnormal conditions in real time and subsequently transmit commands or notifications to responsible users. By utilizing cloud technology, the system enables remote data access, enhances monitoring reliability, and supports faster and more accurate decision-making.

SCADA systems are designed with security considerations and prioritize reliability, availability, and speed in their development [1]. The Cloud SCADA-based Alarm Monitoring System aims to monitor the technical condition of a vessel in real time, detect potential disturbances or failures, and provide early warnings through alarm notifications. With the implementation of an effective monitoring system, operational risks can be minimized, system performance can be improved, and timely corrective actions can be taken to prevent more severe failures.

The Cloud SCADA-based Alarm Monitoring System on a vessel consists of various types of sensors and monitoring devices connected to a central control unit, such as the control room or engine room. When monitored parameters exceed predefined thresholds, the system automatically triggers alarms to alert the ship's crew. In addition, the system is capable of automatically transmitting warning notifications to users, prompting immediate attention [3].

To enhance the effectiveness and convenience of monitoring, the Alarm Monitoring System integrates cloud technology and the Internet of Things (IoT). This enables broader system accessibility and allows responsible personnel to monitor conditions remotely, even when they are not physically present on-site. Consequently, real-time monitoring can be achieved through cloud-based platforms and IoT connectivity, improving responsiveness and overall operational efficiency.

2. General Method

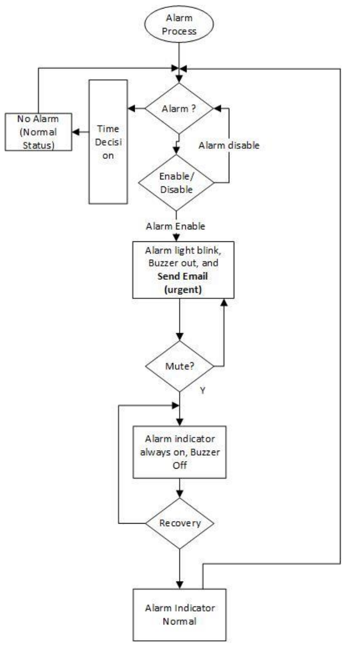

Figure 1. Flowchart system

The flowchart illustrates the operational workflow of an alarm monitoring system used to observe critical ship conditions in real time through a PLC and Cloud SCADA. The process begins with the *Alarm Process*, in which the system continuously acquires data from onboard sensors, including temperature, pressure, voltage, equipment status, and other relevant parameters.

1. **Alarm Condition Evaluation (Alarm?)**
   The system first evaluates whether the measured parameters exceed predefined safety limits (set points):
   a) If no alarm condition is detected, the system remains in a *No Alarm Status*, where all indicators are normal and no notifications are generated.
   b) If an alarm condition is detected, the system proceeds to the next stage.

2. **Time Decision (Alarm Validation)**
   At this stage, the system performs time-based validation to ensure that the detected alarm condition is persistent and not caused by transient disturbances such as noise or signal spikes. This mechanism helps prevent false alarms in the ship monitoring system.

3. **Alarm Enable/Disable Check**
   The system checks whether the alarm function is enabled or disabled. If the alarm is disabled, it will not be processed further even if an abnormal condition is detected. If enabled, the system proceeds to activate the alarm. The disable feature is typically used for simulation or maintenance purposes, allowing operation without triggering safety responses.

4. **Alarm Activation (Alarm Enable)**
   When the alarm is activated, the system performs the following actions:
   a) Activates a blinking alarm indicator
   b) Triggers a buzzer as an audible warning integrated into the general alarm system
   c) Sends urgent alarm notifications via Cloud SCADA, such as online dashboards or direct messages to responsible personnel
   This stage ensures that critical conditions are promptly identified both locally and remotely.

5. **Mute or Alarm Acknowledgment**
   The system provides a mute function that allows users to silence the buzzer without clearing the alarm condition:
   a) If mute is activated, the visual alarm indicator remains active while the buzzer is turned off, enabling the crew to focus on corrective actions without audible disturbance.
   b) If mute is not activated, both the buzzer and indicator remain active.

6. **Recovery**
   After corrective actions are taken and the monitored parameters return to normal limits, the system enters the recovery stage. At this point, the system verifies that the condition has stabilized and confirms that the alarm has been properly cleared.

7. **Normal Alarm Indicator State**
   Once recovery is complete, the alarm indicators return to normal conditions, the

buzzer remains off, and the alarm status in the Cloud SCADA system is updated accordingly. The system then resumes its continuous monitoring cycle.

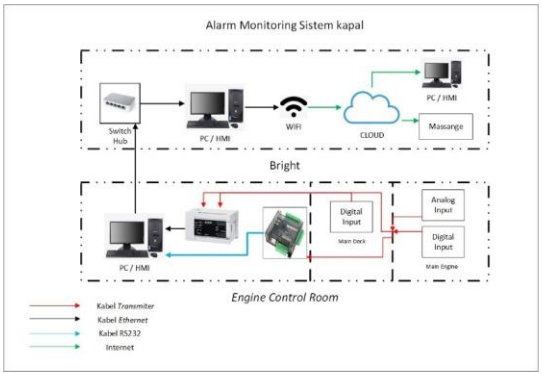

Figure 2. Single Diagram System

The system design, as illustrated in the single-line diagram, represents an integrated Alarm Monitoring System for ship applications based on PLC and Cloud SCADA. The system consists of various field devices, including analog and digital sensors installed on the main engine and deck, which continuously acquire operational parameters such as temperature, pressure, and equipment status. These signals are transmitted to a PLC located in the engine control room, where data processing and alarm evaluation are performed based on predefined set points. The processed data are then communicated to a local Human Machine Interface (HMI) via serial communication for on-site monitoring and control. Furthermore, through Ethernet-based networking and internet connectivity, the system transmits data to a cloud platform, enabling real-time remote monitoring and alarm notification delivery. This architecture allows users to access system information from any location, thereby improving operational efficiency, enhancing situational awareness, and ensuring timely response to abnormal conditions.

3. Result and discussion

In this study, a series of testing procedures are conducted to evaluate whether the measured values from temperature and pressure sensors correspond accurately with the readings displayed in the SCADA system. The testing stages are structured as follows. First, calibration of the temperature and pressure sensors is performed in accordance with their respective specifications to ensure measurement accuracy. Second, program calibration is carried out through appropriate scaling within the PLC to align raw sensor signals with engineering units. Third, functional testing is conducted to verify the consistency between sensor outputs and SCADA readings. Fourth, data acquisition is performed to obtain measurement results, from which correlation equations are derived and implemented into the program. Fifth, linearity testing is conducted to ensure that SCADA readings exhibit a linear relationship with actual sensor values, enabling accurate configuration of alarm monitoring thresholds. Finally, system validation includes testing the transmission of alarm notifications to cloud-based platforms or via email, ensuring reliable remote alerting functionality.

3.1. Calibration sensor temperature and pressure

$$T = \frac{(mA - 4)}{16}\ x\ (Tmax - Tmin) + Tmin$$

T = (mA -4) x 12.5

Penjelasan:

- 16 = Rentang mA (20 - 4)
- 200 = Tmax
- 0 = Tmin
- 12.5 = 200 / 16

Figure 3. Sample of value calibration

The calibration of the 4–20 mA signal is performed by evaluating measurement accuracy and precision based on the comparison between observed values and reference standards. The calibration process uses the output values from temperature and pressure sensors as the measured variables. A calibrated reference instrument, namely the Fluke 789 ProcessMeter, is utilized as the standard due to its high accuracy and reliability. The measured current signals are then converted into engineering units through a linear scaling method. Accuracy is determined by comparing the measured values with the ideal reference values, while precision is assessed based on the consistency of repeated measurements.

The linear scaling of a 4–20 mA signal into engineering units is defined as:

$$y = \frac{(I-4)}{16}(y_{max} - y_{min}) + y_{min}$$

Figure 4. Formula calibration

where I represent the measured current (mA), y is the converted value in engineering units, and Y_{min} and Y_{max}

denote the minimum and maximum measurement range of the sensor, respectively.

Table 1. Value of true sensor temperature

%	mA	Steps	Ohms
0%	4mA	0°C	100.00 Ω
25%	8mA	50°C	119.40 Ω
50%	12mA	100°C	138.51 Ω
75%	16mA	150°C	157.33 Ω
100%	20mA	200°C	175.86 Ω

The development of a truth table for the temperature sensor serves as a reference in the calibration process of the temperature measurement system. The obtained results are presented as a comparison against the standard reference table of the PT100 temperature sensor. Based on this comparison, the measured values demonstrate a close approximation to the actual or theoretical values. This indicates that the calibration process has been performed effectively, resulting in measurement outputs that are consistent with the expected characteristics of the PT100 sensor.

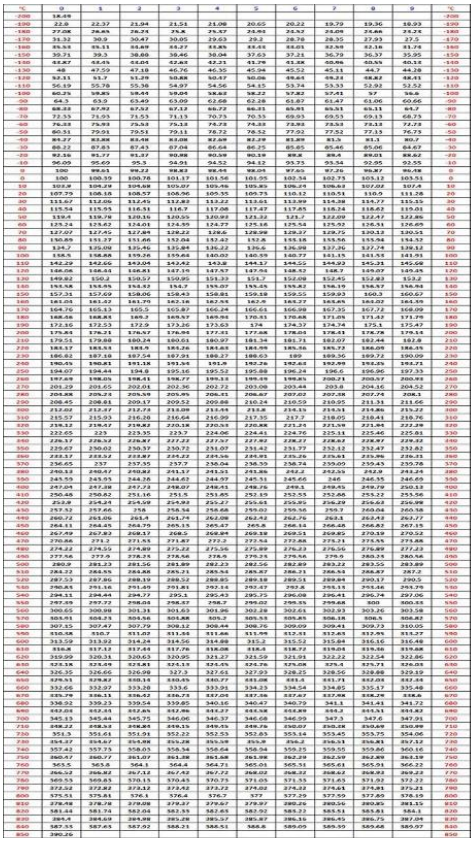

Figure 5. Temp PT100 Table of true.

Table 2. Value of true sensor pressure

%	Steps Bar	mA
0%	0 Bar	4mA
25%	0,25 Bar	8mA
50%	0,50 Bar	12mA
75%	0,75 Bar	16mA
100%	1 Bar	20mA

In the pressure sensor evaluation, the output signal is represented in the form of a 4–20 mA current loop generated by the sensor. This output value is used as the primary parameter for analysis and calibration. The measured current values are then compared against a predefined truth table, which is divided into five discrete steps across the sensor's operating range. This stepwise comparison enables verification of the sensor's linearity and accuracy, ensuring that the output signal corresponds proportionally to the actual pressure values within the specified measurement range.

3.2. Scaling data program

This calibration process produces a linear relationship by incorporating sensor data that have been previously calibrated. As a result, the system is able to generate accurate and representative values for display within the SCADA interface. This approach ensures that the readings observed in SCADA closely reflect the actual measured conditions, thereby improving the reliability and accuracy of the monitoring system.

$$S_{Value} = \frac{S_{Max} - S_{Min}}{D_{Max} - D_{Min}} \times (Data_{in} - D_{Min}) + S_{Min}$$

Figure 6. Formula scaling data PLC

1. Svalue: Scaling Value
2. Smax: Signal Maximal
3. SMin: Signal Minimum
4. DMax: Data Signal Maximal
5. DMin: Data Signal Minimal
6. Datain: Data Masuk

The acquired data are utilized as a reference to improve the accuracy and precision of the measurement system by implementing zero and span adjustments on the sensor. These parameters define the minimum and maximum output signals, corresponding to the lower and upper limits of the measurement range. By applying calibrated input signals and comparing them with the sensor output, the system enables proper scaling of measured values to match the actual physical quantities, such as pressure and temperature. Consequently, the adjusted data provide measurements that are both accurate and precise, ensuring reliable representation within the monitoring system.

3.3. Access level user security

The SCADA system provides role-based access to its menu interface, allowing different levels of users to interact with the system according to their assigned permissions. Authorized users are granted access to specific monitoring menus, enabling them to observe system conditions and operational data in real time. This access control mechanism ensures that only designated personnel can view or manage certain functionalities, thereby enhancing system security and maintaining proper supervision of monitoring activities.

Table 3. Level user security

No	Pengguna	*Maker*	*Chief Engineer*	*Admin*	*Operator*	*Guest*
	Access level	Level 20	Level 15	Level 10	Level 5	Level 1
1	Monitoring Home	✓	✓	✓	✓	✓
2	Accept Alarm	✓	✓	✓	✓	✓
3	Setting ME	✓	✓	✕	✕	✕
4	Setting AE1	✓	✓	✕	✕	✕
5	Setting AE2	✓	✓	✕	✕	✕
6	Setting General	✓	✓	✕	✕	✕
7	Calibration Data Engine	✓	✓	✕	✕	✕
8	Aux Engine 1 Menu	✓	✓	✓	✓	✓
9	Aux Engine 2 Menu	✓	✓	✓	✓	✓
10	Main Engine Menu	✓	✓	✓	✓	✓
11	Analog AE1	✓	✓	✓	✓	✓
12	Analog AE2	✓	✓	✓	✓	✓
13	Data Real-time AE1	✓	✓	✓	✓	✕
14	Data Real-time AE2	✓	✓	✓	✓	✕
15	Access Cloud	✓	✓	✓	✕	✕
16	*Update system*	✓	✕	✕	✕	✕

3.4. Alarm Buzzer

The alarm buzzer testing is conducted to ensure that the system is capable of providing automatic audible warnings when alarm conditions are detected by the PLC. The buzzer functions as an early warning indicator, enabling operators and responsible personnel to promptly recognize abnormal conditions in machinery or sensor parameters.

During the testing process, the buzzer receives direct control signals from the PLC when any monitored parameter exceeds its defined threshold. Both analog and digital alarm signals detected by the sensors are processed within the PLC and combined into a single logical output that determines whether the buzzer should be activated. The test results indicate that the alarm processing mechanism operates effectively, as every detected alarm condition successfully triggers the buzzer automatically.

The buzzer remains active until the alarm is acknowledged or muted by the operator. The mute/acknowledge feature is designed to silence the buzzer without clearing the alarm status displayed in the monitoring system. This ensures that operators can still identify the type of alarm even after the audible alert has been silenced. If the alarm is not acknowledged, the buzzer continues to sound repeatedly as a reminder that an abnormal condition persists and requires attention.

The results of this testing confirm that the alarm buzzer system performs in accordance with its design specifications, delivering responsive and clear audible warnings while providing effective control through the mute/acknowledge function. This capability is essential for enhancing operational safety and ensuring timely operator response during ship machinery operations.

Table 4. Signal PLC and status alarm

No	Nama Alarm	PLC Signal	Status Buzzer	Tindakan	Result test
1	AE1 ECR EMG STOP	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
2	AE1 FRESH WATER HIGH TEMP ALARM	SETT/NO/NC (High temp alarm)	Buzzer active	Accept	Buzzer stop alarm steady
3	AE1 LUBE OIL	NO/NC (low pressure	Buzzer active	Accept	Buzzer stop alarm steady

	LOW PRESS STOP	shutdown alarm)			
4	AE1 LUBE OIL LOW PRESS ALARM	SETT/NO/NC (low pressure alarm)	Buzzer active	Accept	Buzzer stop alarm steady
5	AE2 ECR EMG STOP	No/no	Buzzer active	Accept	Buzzer stop alarm steady
6	AE2 FRESH WATER HIGH TEMP ALARM	SETT/NO/NC (High temp alarm	Buzzer active	Accept	Buzzer stop alarm steady
7	AE2 LUBE OIL LOW PRESS STOP	NO/NC (low pressure shutdown)	Buzzer active	Accept	Buzzer stop alarm steady
8	AE2 LUBE OIL LOW PRESS ALARM	SETT/NO/NC (low pressure alarm	Buzzer active	Accept	Buzzer stop alarm steady
9	AE1 FUEL OIL PIPE LEAK ALARM	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
10	ME ECR EMG STOP	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
11	ME FUEL OIL PIPE LEAK ALARM	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
12	ME FRESH WATER HIGH TEMP STOP	NO/NC (High temp Shutdown)	Buzzer active	Accept	Buzzer stop alarm steady
13	ME FRESH WATER HIGH TEMP ALARM	NO/NC (High temp shutdown)	Buzzer active	Accept	Buzzer stop alarm steady
14	ME LUBE OIL LOW PRESS STOP	NO/NC (Low pressure shutdown)	Buzzer active	Accept	Buzzer stop alarm steady
15	ME LUBE OIL LOW PRESS ALARM	NO/NC (Low pressure alarm)	Buzzer active	Accept	Buzzer stop alarm steady
16	BILGES STBD	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
17	BILGES PORT	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
18	BILGES AFT	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
19	BILGES FORE	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
20	WATER TIGHT DOOR S1	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
21	WATER TIGHT DOOR P1	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
22	WATER TIGHT DOOR S2	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady
23	WATER TIGHT DOOR P2	NO/NC	Buzzer active	Accept	Buzzer stop alarm steady

3.5. Sending alarm messages into the cloud SCADA

The alarm transmission testing on the Cloud SCADA platform is conducted to ensure that every alarm detected by the system can be transmitted and displayed in real time through an internet-based interface. This feature enables authorized users, such as Admin, Chief Engineer, and designated vessel owners, to remotely monitor ship conditions using devices connected to the internet.

Based on the conducted tests, the system is capable of automatically transmitting alarm data to the Cloud SCADA whenever abnormal conditions are detected in sensors or machinery. Each alarm received by the PLC is processed into a notification and subsequently sent to the cloud server. Registered users with valid login credentials can access and view these alarm messages through the cloud dashboard in the form of text notifications, alert lists, or historical log data.

The test results demonstrate that alarm messages are delivered to the Cloud SCADA platform clearly and without significant delay. Any alarm generated at the local system level is immediately reflected in the cloud interface, enabling real-time monitoring of machine conditions. This allows responsible personnel to promptly identify critical situations, such as engine temperature increases, pressure drops, or other system disturbances.

The ability of the Cloud SCADA system to present alarms remotely provides significant advantages for ship operational monitoring. Technical personnel can analyze alarm types, identify potential causes, and determine appropriate corrective actions without being physically present on the vessel. Consequently, the alarm transmission feature plays a crucial role in enhancing operational safety and preventing severe engine damage.

Furthermore, only critical alarms—those with significant impact on vessel operation—are prioritized for notification delivery. These selected alarms are immediately visible to authorized users, ensuring focused attention on high-priority conditions that require prompt response.

Table 5. Sending alarm into the cloud SCADA

NO	Nama Alarm	the time the alarm appears	notification alarm time	Result
1	ALARM ERROR PLC 1	2025-12-7 22:18:42	2025-12-7 22:18:42	Sent successfully
2	ALARM ERROR PLC 2	2025-12-7 22:18:42	2025-12-7 22:18:42	Sent successfully
3	AE1 EMERGENCY STOP	2025-12-7 22:26:15	2025-12-7 22:26:15	Sent successfully
4	AE1 LUBE OIL PRESS STOP	2025-12-7 22:29:35	2025-12-7 22:29:35	Sent successfully
5	AE2 EMERGENCY STOP	2025-12-7 22:31:05	2025-12-7 22:31:05	Sent successfully
6	AE2 LUBE OIL PRESS STOP	2025-12-7 22:32:12	2025-12-7 22:32:12	Sent successfully
7	ME EMERGENCY STOP	2025-12-7 22:34:23	2025-12-7 22:34:23	Sent successfully
8	ME FRESH WATER HIGH TEMPERATURE STOP	2025-12-7 22:34:37	2025-12-7 22:34:37	Sent successfully
9	ME LUBE OIL LOW PRESSURE STOP	2025-12-7 22:34:50	2025-12-7 22:34:50	Sent successfully
10	GENERATOR 1 OFF	2025-12-7 22:18:40	2025-12-7 22:18:40	Sent successfully
11	GENERATOR 2 OFF	2025-12-7 22:18:40	2025-12-7 22:18:40	Sent successfully

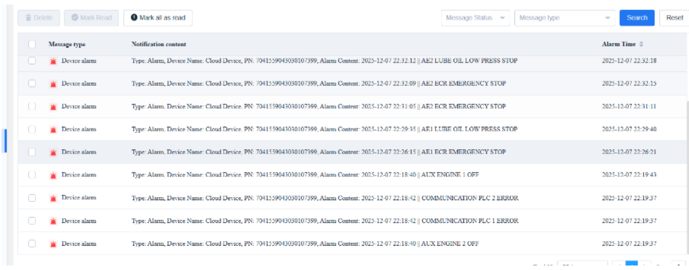

Figure 7. Result actual cloud

Figure 8. Actual Alarm monitoring system Cloud SCADA

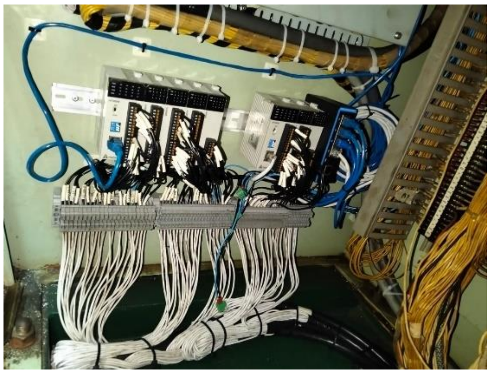

Figure 9. Wiring PLC CLOUD SCADA

4. Conclusions

Based on the results of the design, implementation, and testing processes, the Cloud SCADA-based Alarm Monitoring System has been successfully developed and evaluated. The system is capable of transmitting alarm signals in real time and performs according to its intended objectives, namely monitoring critical ship parameters such as temperature, pressure, generator speed, and the status of various onboard equipment with full operational functionality. Furthermore, the integration between sensors, PLC, and the Cloud SCADA platform operates effectively, where the PLC acquires data from both analog and digital inputs, processes the information, and transmits it to the cloud server.

The conducted testing demonstrates that a total of 23 alarm data points were successfully transmitted to the cloud server with a response time ranging from 0 to 5 seconds, which meets the requirements for ship operational monitoring. Alarm notifications are displayed without significant delay, and the monitoring of analog parameter readings is performed accurately and reliably.

In terms of system security, access control has been properly implemented to restrict unauthorized usage. User roles are categorized into several levels, including Maker, Chief Engineer, Admin, Operator, and Guest, with additional authority privileges assigned to the Chief Engineer. The system enables comprehensive monitoring of alarm events, including the duration from alarm occurrence to recovery. Testing results confirm that all 23 alarm events and their corresponding 23 recovery states were successfully monitored and recorded.

The alarm buzzer testing, conducted across 23 alarm scenarios, indicates that the system responds accurately to alarm conditions and allows configurable timing for alarm activation. All test results demonstrate consistent and expected system behavior, achieving a 100% success rate. This confirms that the buzzer system functions effectively as an audible warning mechanism.

Overall, the implementation of the Cloud SCADA-based Alarm Monitoring System significantly enhances the ability to detect and respond to critical conditions on the vessel. This contributes to preventing equipment failures, minimizing potential damage, improving operational safety, and facilitating more efficient ship operations.

For future development, the system can be enhanced by incorporating wire break detection mechanisms, adopting more advanced communication protocols such as CAN bus or Profibus, and expanding the system into a more complex and scalable architecture to support additional functionalities.

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