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Modification of Conveyor with Monitoring of Running Hours, Current, and Voltage Based on Arduino Mega 2560 Microcontroller "Model G.A.S" at Iskandar Pangkalan Bun Airport

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Abstract

Conveyor belts are vital facilities in airport operations, but their maintenance systems are often reactive, inefficient, and high-risk. This study aims to design and build a monitoring system for conveyor modifications at Iskandar Pangkalan Bun Airport that can monitor running hours, current, and voltage in real time to support condition-based maintenance. The method used is applied Research and Development (R&D) by building a prototype based on the Arduino Mega 2560 microcontroller. This system integrates an ACS712 current sensor, a ZMPT101B voltage sensor, a DS3231 Real Time Clock (RTC) module, a TFT Display, and an SD Card module for data logging. Test results indicate that the system operates effectively with stable and accurate sensor readings. The measured current remains consistent at 1.56 A under normal load conditions, voltage fluctuates within a reasonable range (214.74 V to 222.23 V), and the RTC module demonstrates high accuracy with a time deviation of only 1-2 seconds over 24 hours. The system successfully stored historical data on the SD Card, including date, time, running hours, voltage, and current. Thus, this monitoring system has proven reliable in providing accurate data essential for improving maintenance efficiency and operational reliability of the conveyor.

Keywords: Conveyor, Monitoring, Arduino Mega 2560, Running Hours, Current and Voltage, Condition-Based Maintenance.

INTRODUCTION

An airport is an area located on land or water with specific boundaries, which functions as a place for aircraft landing and departure, as well as a point of transfer for passengers and goods between modes of transportation. To support smooth operations, airports are equipped with primary and auxiliary facilities, including supporting equipment such as escalators, travelators, elevators, passenger bridges (aviobridges), and conveyors, collectively known as Traction Equipment (TQM). This equipment plays a crucial role in enhancing the efficiency and comfort of operational systems within the airport environment (JDIH Kementerian Keuangan, n.d.).

Conveyor belts are one of the facilities found at airports, especially in the terminal area. These conveyor belts are a means of transport in the form of moving belts, designed to move passengers' luggage from the check-in area to the baggage loading area or from the baggage drop-off area to the baggage claim area (Ibad & Widagdo, 2024).

Currently, conveyor maintenance systems at a number of airports still rely on a reactive approach, where repairs are carried out after damage or disruption has occurred. This method has a number of disadvantages, such as an increased risk of delays in baggage handling, higher repair costs due to severe damage, and a reduced equipment service life. In the industrial world, one of the key components supporting operations is the electric motor, which can be used as a power source for heavy machinery, conveyors, and other equipment (Norhan, 2021). Therefore, it is necessary to plan motorcycle maintenance based on the available manual so that the maintenance process can be carried out in a more structured and optimal manner. The installation of sensors on each motor is highly necessary with the aim of enabling more planned motor maintenance and avoiding severe or fatal damage to motor equipment (Hanafi, Hunaini, & Siswanto, 2023). Continuous operation of the motor can also cause a number of problems, such as a decrease in motor performance and damage to the components of the induction motor (Sartika, 2023).

With advances in technology, the use of microcontroller-based monitoring systems has become an effective alternative for improving the efficiency and reliability of conveyor belts. Microcontrollers have the ability to integrate various sensors to automatically monitor operating duration (running hours), current, and electrical voltage. A microcontroller is a small-scale control device and essentially a computer system where most of its components are packaged into a single Integrated Circuit (IC) and form part of an embedded system (a system designed to perform one or more specific functions in real time) (Arifin, Zulita, & Hermawansyah, 2016). The information obtained from this system can be used to evaluate the condition of the conveyor, identify potential damage early on, and provide early warnings to technicians so that maintenance can be carried out before more serious damage occurs.

The implementation of a microcontroller-based monitoring system on conveyor belts at Iskandar Pangkalan Bun Airport is expected to improve the effectiveness of equipment maintenance processes. Maintenance activities are crucial as they can extend the useful life or lifespan of assets, ensure optimal availability of installed equipment for production, maximize possible investment returns, guarantee operational readiness of all required equipment in emergency situations at all times, and also ensure the safety of individuals using the facilities (Tupan, Simanjuntak, & Aditiar, 2018). This system enables airport managers to switch from time-based maintenance to condition-based maintenance, which is more efficient because it is only performed when necessary, thereby reducing costs and equipment downtime.

The microcontroller-based monitoring system enables historical data recording for accurate analysis of conveyor performance. This can improve operational reliability by predicting maintenance and component replacement before damage occurs. Technically, the system utilizes current and voltage sensors connected to a microcontroller, then presents data in real time through an interface for anomaly detection and rapid response.

Based on this background, this study is titled "MODIFICATION OF CONVEYORS WITH MONITORING OF RUNNING HOURS, CURRENT, AND VOLTAGE BASED ON ARDUINO MEGA 2560 MICROCONTROLLER AT ISKANDAR PANGKALAN BUN AIRPORT," aims to design a monitoring system as an efficient and applicable solution to support condition-based maintenance.

METHOD

1. Data Collection Methods

Methods Data collection methods describe how data is collected. In this study, I used qualitative techniques, where qualitative research data collection uses techniques such as interviews, observation, documentation studies, case studies, and focus groups. These techniques allow researchers to gain an in-depth understanding of the views, experiences, and perceptions of respondents (Jailani, Syahran, 2023).

2. Data Processing

Data processing explains how data is processed using a specific approach (qualitative/quantitative). In this study, I used a qualitative approach where data was processed through observation and documentation studies. After the data is obtained, it is analyzed, and the results are presented in the form of a narrative description of the situation being studied. The descriptive purpose of this approach is to provide a systematic, factual, and accurate description, portrayal, or depiction of the facts, characteristics, and relationships between the phenomena being investigated (Jailani & Saksitha, 2024).

3. Data Analysis

Data analysis provides an explanation of the tools used. According to Sugiyono (2019), data analysis is the process of systematically processing and organizing data obtained from observations, field notes, and documentation. This process includes grouping data into specific categories, breaking it down into smaller parts, identifying patterns, identifying important information, and drawing conclusions. The goal is to make the data easy to understand and interpret, both by the researcher themselves and by others (Sugiyono, 2019).

RESULTS AND DISCUSSION

1. Research Results

This research resulted in a design that went through several stages, starting from the component assembly process to comprehensive system testing. The mock-up conveyor developed was named G.A.S (Gede Ariandika Asrif), an innovative tool inspired by the TQM (Traction Equipment) system at airports. This tool is the result of conveyor modification equipped with current sensors, voltage sensors, and a real-time clock (RTC) module.

Figure 1. Mock Up Conveyor

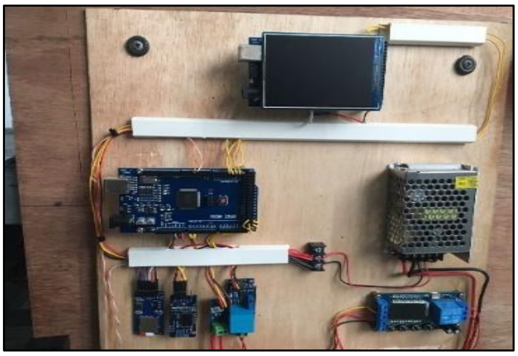

Figure 2. Control Panel Circuit for Monitoring Running Hours, Current, and Voltage

This research produced a mockup conveyor unit assembled using a 3 cm x 6 cm galvanized hollow frame with a thickness of 0.8 mm to ensure corrosion resistance and support the main components. The system consists of an NBR rubber belt 440 mm wide and 4 mm thick, galvanized rollers, pulleys, a WPA 40-type gearbox reducer, and a single-phase electric motor with a power rating of 375 Watts, sourced from a water pump unit.

The WPA 40 gearbox adjusts speed and increases motor torque to drive the conveyor efficiently. Motor rotation is transmitted to the gearbox using a 12 mm diameter pulley and M-34 type V-belt, which is ideal for light to medium loads, minimizing slippage and maintaining stability.

This system is equipped with an Arduino Mega 2560-based monitoring panel, which is integrated with a current sensor (ACS712), a voltage sensor (ZMPT101B), and a DS3231 RTC module. Data is displayed on a 16x2 LCD and automatically stored in EEPROM, enabling accurate recording of running hours.

Testing showed that all sensors worked stably and accurately, and were able to help technicians perform maintenance based on actual data, rather than just time estimates. The presence of this monitoring system was able to improve energy efficiency, detect potential disturbances early, and significantly extend the service life of the conveyor motor.

a. Test Data Verification

1) Current and Voltage Consistency Testing

The purpose of testing the consistency of the current and voltage sensors is to assess the stability of the readings while the conveyor is operating under normal load conditions. Data is recorded every 10 seconds for one minute to observe any significant fluctuations in the current and voltage values displayed by the system. The current sensor used is the ACS712 5A, while voltage measurements are performed using the ZMPT101B sensor.

Table 1. Current and Voltage Consistency Test

Time (seconds)	Voltage	Current
0	0	0
10	216,31 V	1,56 A
20	220,73 V	1,56 A
30	222,23 V	1,56 A
40	215,33 V	1,56 A
50	215,77 V	1,56 A
60	214,74 V	1,56 A

The stability of sensor readings is a crucial aspect in this type of monitoring system, as errors in detecting current or voltage can lead to incorrect decisions, such as unnecessary power cuts or the inability to detect overload. Therefore, this testing demonstrates that the system is capable of providing accurate and reliable real-time information, making it suitable for use in the demanding operational environment of an airport that requires high precision.

2) Accuracy and Synchronization Testing of the DS3231 RTC Module

The DS3231 RTC module is a real-time module known for its high accuracy because it is equipped with an internally temperature-compensated crystal oscillator. Accuracy testing was carried out by comparing the time displayed by the Arduino system with the actual time from reference devices such as laptops or smartphones that have been synchronized with internet time. Observations were made periodically for one hour.

Table 2. Accuracy and Synchronization Testing Table for the DS3231 RTC Module

No	Start Time (RTC)	Actual Time	Difference (seconds)
1	08:16:40	08:16:38	2
2	08:17:54	08:17:53	1
3	08:39:23	08:39:22	1
4	08:41:28	08:41:26	2
5	08:45:04	08:45:03	1

3) SD Card Testing

The developed system not only displays information in real-time via an LCD screen but also automatically saves important data to an external storage medium in the form of an SD card every hour, in accordance with the program embedded in the Arduino Mega 2560 microcontroller. The recorded information includes the date, time, total operating hours (running hours), and electrical parameters such as motor voltage and current. All this data is stored in a text file named log_data.txt, which can be accessed and analyzed via a computer. This data recording feature is crucial for supporting maintenance activities and evaluating the performance of conveyor systems in airport environments. With operational documentation continuously recorded in digital format, technicians can review conveyor usage patterns, identify potential issues earlier, and schedule machine maintenance based on real-time data (data-driven maintenance). This approach is more efficient than conventional methods that rely solely on manual inspections or estimated timelines.

Table 3. SD Card Testing Table

No.	Date	Time	Running hours	Voltage	Ampere current
1	2025-06-30	10:37:28	38 detik	216.25	1.56
2	2025-07-01	21:24:10	5 detik	224.84	1.56
3	2025-07-02	08:39:23	277 detik	220.09	1.56

b. Data Analysis Results

Based on the test results, the monitoring system showed stable and reliable performance. The ACS712 current sensor and ZMPT101B voltage sensor are capable of providing consistent readings over a 60-second period under normal load conditions, with voltage fluctuations within acceptable limits (214.74–222.23 V) and current remaining stable at 1.56 A. The DS3231 RTC module has also proven to be accurate, with a time difference of only 1–2 seconds compared to an internet-synchronized reference device, thanks to the use of a temperature-compensated crystal oscillator (TCXO). Additionally, the system successfully recorded data automatically to an SD Card every 10 minutes, including important information such as date, time, operational duration (running hours), voltage, and current. The data is stored in digital format (log_data.txt) and remains intact even in the event of a power outage, as it is supported by EEPROM storage. Overall, this system has proven effective in supporting data-driven maintenance for conveyors in airport operational environments.

c. Product Revision

Based on the results of data presentation and analysis, product revisions were made to ensure optimal system functionality. Testing showed that the ACS712 current sensor and ZMPT101B voltage sensor had stable and accurate readings, so no significant changes were required. The DS3231 RTC module also showed good time accuracy, supporting running hours recording without significant obstacles. Data storage to the SD Card operates smoothly, with stable data format and communication between the Arduino and the storage module. If revisions are needed, they are only minor in nature, such as connection checks, code adjustments, or error handling. Overall, this monitoring system has been functioning well and is capable of meeting its objectives for accurately monitoring running hours, current, and voltage.

2. Pembahasan Hasil Penelitian

Penelitian dan pengembangan pada sistem konveyor yang telah dimodifikasi membuktikan keberhasilan dalam menggabungkan komponen mekanik dan elektronik untuk menghasilkan sistem pemantauan yang efisien. Hasil temuan dijelaskan melalui dua aspek utama, yaitu kinerja keseluruhan sistem serta ketepatan dalam proses pengumpulan data.

Figure 3. Conveyor at Iskandar Airport, Pangkalan Bun

Figure 4. G.A.S. Conveyor

Success of Integration and System Functionality The physical assembly of the conveyor, which uses corrosion-resistant galvanized hollow structural sections and integrates a single-phase AC motor with its mechanical drive, has proven to be robust and functional. The core of this research, the centralized monitoring panel, successfully integrates the Arduino Mega 2560 as the “brain” of the system. This microcontroller effectively processes real-time data from the ACS712 current sensor, ZMPT101B voltage sensor, and DS3231 Real-Time Clock (RTC) module.

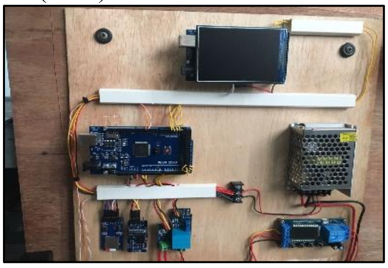

Figure 5. LCD, Arduino Mega 2560, ZMPT101B, ACS712, RTC DS3231

The system's ability to display data on the screen and save it to an SD card shows that the design and implementation have successfully met the project targets. Data monitoring accuracy and reliability are key aspects in ensuring that the information collected is precise enough to support maintenance decisions.

Figure 6. LCD display for current and voltage monitoring

The current and voltage sensors showed stable performance during testing, with very small voltage fluctuations—ranging from 214.74 V to 222.23 V—still within the normal range of AC power supply. The current remained at 1.56 A under standard load conditions, indicating that the system has reliable detection capabilities for abnormal conditions such as current surges or voltage drops, which may indicate motor malfunctions or overload conditions. Meanwhile, the DS3231 RTC module demonstrates high time accuracy, with a deviation of only 1–2 seconds over a 24-hour period compared to the synchronized reference time. This level of precision is achieved thanks to temperature-compensated crystal oscillator (TCXO) technology, making the conveyor's operational time recording a reliable reference. This accuracy supports the transition from a schedule-based maintenance system to a more effective and efficient condition-based approach.

3. Research Implications

Based on the results of the research and discussion, this study has a significant impact both in practical applications in the field and in its contribution to the development of science and technology. In the operational environment of Iskandar Pangkalan Bun Airport, the designed system enables a transition from a fixed-schedule maintenance method to a condition-based approach. Data on running hours from the RTC DS3231 module allows technicians to schedule maintenance only when needed, thereby reducing costs and avoiding unnecessary downtime. Additionally, real-time monitoring of current and voltage helps detect potential issues such as overloading or power fluctuations early on, enabling preventive actions before serious damage occurs. The system as a whole improves the efficiency and reliability of the conveyor, accelerates baggage handling processes, and supports flight schedule accuracy. The data logging feature to an SD Card also provides complete historical data for long-term performance analysis.

From a scientific standpoint, this study demonstrates the successful integration of the Arduino Mega 2560 microcontroller with the ACS712 current sensor, ZMPT101B voltage sensor, and DS3231 RTC module within an airport monitoring system. This achievement serves as a valuable reference for the development of automation and monitoring technologies in other industrial sectors, particularly in the field of aviation infrastructure. The Research and Development (R&D) approach employed in this study has proven effective in delivering practical technical solutions, encompassing problem identification, system design, comprehensive evaluation, and testing.

CONCLUSION

Based on the design, testing, and analysis results, the modified conveyor system utilizing the Arduino Mega 2560 microcontroller has been successfully developed and integrated with the ACS712 current sensor, ZMPT101B voltage sensor, DS3231 RTC module, TFT display, and SD Card module. The system effectively monitors running hours, current, and voltage in real time, delivering accurate and stable performance. The current remains consistently at 1.56 A, voltage fluctuates within the normal range of 214.74–222.23 V, and the RTC module exhibits minimal time deviation—only 1–2 seconds over a 24-hour period. Furthermore, the system demonstrates reliable and efficient operation, with an optimal daily runtime of approximately 10 hours.

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