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CONVEYOR MODIFICATION BASED ON EMERGENCY STOP INDICATORS AT ISKANDAR PANGKALAN BUN AIRPORT

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ABSTRACT

The conventional conveyor system at Iskandar Pangkalan Bun Airport has limitations in terms of operational efficiency and safety, particularly related to the lack of an integrated emergency stop indicator. This study aims to design, implement, and evaluate a conveyor modification by adding an emergency stop indicator system integrated with an Arduino Mega 2560 microcontroller, relay, contactor, buzzer, LED, DS3231 RTC module, and SD Card module. Applied Research and Development (R&D) methods were used in all stages, from design to testing. The test results showed that the emergency stop indicator system achieved a 100% reliability level in stopping the conveyor completely, with an average response time of less than 1 second. Visual and audio indicators were activated instantly (<0.1 seconds), ensuring the emergency warning was effectively communicated. Furthermore, the time-of-event recording to the SD Card functions well, providing accurate historical documentation. This modification proved effective in improving occupational safety and reducing potential damage to conveyors in the airport environment.

Keywords: Conveyor, Emergency Stop, Microcontroller, Arduino Mega 2560, Operational Safety.

INTRODUCTION

In the current era of globalization, technological development is also increasingly rapid. Almost all household appliances and industrial equipment already use electronic control systems in their operations (Bosak & Bosak, 2023). An airport is an area on land and/or water with certain boundaries that is used as a place for aircraft to land and take off, board passengers, load and unload goods, and a place for intra and intermodal transportation transfers, which is equipped with aviation safety and security facilities, as well as basic facilities and other supporting facilities (Phechsuwan, 2023). Airport operations demand high efficiency, speed, and security to accommodate ever-increasing mobility, where any delay or incident can have a broad impact on flight schedules and passenger satisfaction. Therefore, investment in operational support technology is a priority (Suwarno et al., 2023). Traction equipment is a tool that supports the operational services of aviation facilities that functions to provide comfort and smoothness for service users in the safety operations building and airport terminal (Yue et al., 2023).

The use of conveyors for aviation as operational support. With the existence of this equipment, it can assist human work in transporting goods that cannot be carried by humans. So that the process of moving or transporting goods can be done easily, quickly, and comfortably while maintaining the safety and security of industrial workers [2]. The conveyor system is one of the vital applications of Traction Equipment, being the backbone of the baggage handling system (BHS) (Bhuiyan & Sabina, 2024; Rajendran et al., 2024). Without a reliable conveyor, baggage handling will be very inefficient, time-consuming, and potentially cause significant delays. Conveyor Belts are the most common type used at airports to deliver baggage from the check-in area to the Baggage Drop area. This system is important for processing baggage quickly and accurately, as well as reducing the risk of lost or delayed baggage (Bathre & Das, 2024; Rahmaddani, 2024).

However, at Iskandar Pangkalan Bun Airport, the conveyor system is still operated manually (Poso, 2023). This manual operation is ineffective and relies heavily on human labor, which can cause delays and reduce service quality. This situation leads to baggage backlogs, which hamper security screening, increase the risk of baggage damage, and slow down distribution (Bošnjak, 2024). One important factor in the conveyor service system is the presence of an Emergency Stop (E-Stop) indicator (Manurung & Fernandes, 2023). The microcontroller functions to control device operations, take data from sensors, send data via the network One solution to overcome this problem is to integrate the emergency stop indicator system and microcontroller (Pratama & Jamaaluddin, 2024).

According to ISO 13850:2015, the emergency stop button must be easily accessible, red with a yellow background, and have a clear operating mechanism to ensure a quick response in an emergency (Putra et al., 2023). Therefore, a conveyor modification based on an Emergency Stop indicator is needed that is able to provide visual or sound in real-time when the system experiences an emergency condition. This modification is expected to be a solution to reduce the risk of conveyor damage, minimize downtime due to technical problems, and ensure that the safety system at Iskandar Pangkalan Bun Airport can run more optimally. Based on this background, the author raised the title "CONVEYOR MODIFICATION BASED ON EMERGENCY STOP INDICATORS AT ISKANDAR PANGKALAN BUN AIRPORT". This research is expected to provide solutions to the problems.

METHODOLOGY

Method Of Collecting Data

The data collection method explains the procedures for collecting data. In this study, data were collected through observation and documentation. Observation is a data collection technique that involves direct observation of participants and the context involved in the research phenomenon (Hasan & Iryani, 2024; Pehar, 2024; Prabowo et al., 2023). Observation was conducted by directly observing the conveyor system at Iskandar Pangkalan Bun Airport, noting any problems that occurred. Documentation was conducted by collecting documents related to the research, such as passenger data. This confirms that documentation is one of the main pillars in qualitative data collection (Cruz et al., 2023; Wijaya et al., 2025).

Data Processing

Data processing is a process to obtain data from each research variable ready for analysis (Efendi et al., 2023). Data processing explains the procedures for processing data using a specific approach (qualitative/quantitative). Data obtained from the test results will be processed quantitatively to calculate the level of accuracy of the emergency stop indicator and real-time data from the RTC DS3231. This study also has monitoring of quantities such as voltage and current carried out by installing a sensor (Setiawan et al., 2024).

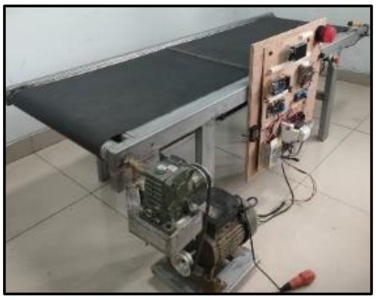
Data analysis

Data analysis provides an explanation of the tools used. Data analysis according to Sugiyono (2019) is the process of systematically searching and compiling data obtained from observations, field notes, and documentation, by organizing data into categories, breaking them down into units, synthesizing them, arranging them into patterns, selecting what is important, and drawing conclusions so that they are easy to understand (Pratama & Jamaaluddin, 2024). The stages of data analysis include: Data Reduction, Data Display, and Conclusion Drawing/Verification (Putra et al., 2023).

RESULTS AND DISCUSSION

Research Results

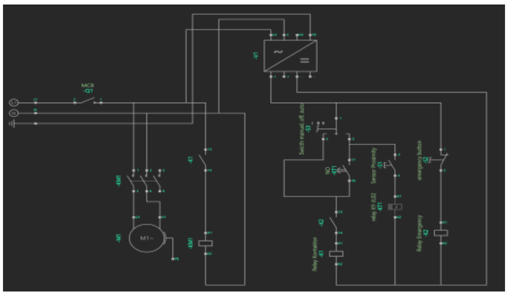
The research conducted has succeeded in achieving its main objective, namely modifying a conveyor system that has an emergency stop integrated with a microcontroller. The final product of this research is a functional conveyor that can operate if a problem occurs that requires stopping to minimize damage to the conveyor components at Iskandar Pangkalan Bun Airport. This system has been equipped with key features such as automatic and manual operation modes, a visual interface via a TFT screen for status monitoring, as well as LED lights and a buzzer.



Picture 1. Mock Up Conveyor GAS

The physical prototype developed was a single-unit conveyor mock-up, named the GAS Conveyor (Gede Ariandika Asrif). Creating a mock-up was crucial for visualizing ideas, identifying initial design issues, and facilitating communication. The GAS conveyor was assembled using galvanized hollow structural sections (3 cm x 6 cm, 0.8 mm thick) for corrosion resistance and longevity. This frame supported mechanical components such as rubber belts, galvanized rollers, pulleys, a reducer gearbox, and a single-phase electric motor. The rubber belt, a crucial element, was 440 mm wide and 4 mm thick, optimized for compatibility with the pulleys and rollers. The material, NBR (Nitrile Butadiene Rubber), was chosen for its resistance to abrasion, oil, and grease, as well as its ideal coefficient of friction to prevent slippage. A WPA 40 reducer gearbox was used to adjust the speed and increase the torque from the electric motor to the conveyor. The 1:40 reduction ratio reduced the rotational speed and increased the torque, crucial for moving luggage, especially during initial start-up. The single-phase electric motor from the water pump unit serves as the primary power source. This motor has an output power of 375 Watts (0.375 kW) with an input power of 0.68 kW, and weighs 5 kg. Two conveyor rollers are used, with a diameter of 50 mm, a length of 500 mm, an axle length of 640 mm, and an axle diameter of 12 mm. These rollers work synergistically for smooth movement.

A pulley and v-belt transmission system transfers power from the motor to the gearbox. A 12 mm diameter pulley and an M-34 type v-belt ensure efficient transmission with minimal slippage. The conveyor control circuit uses a 5 volt voltage for the microcontroller and sensors. Two Arduino Megas are used, one to display data on the TFT screen from the sensors, and the other to process the sensor data which is then sent via the TX and RX pins. The Arduino Mega microcontroller as the main control unit successfully processes input from the emergency stop indicator.



Picture 2. 12 Volt DC and 220 Volt AC Control Circuit

A schematic diagram of the control circuit specifically depicting the interconnection between the emergency stop indicator, relay, contactor, and motor. This circuit utilizes a 12-volt DC power supply as a power source to activate the 12-volt relay. The working mechanism of manual and automatic modes, as well as how the emergency stop indicator functions as a crucial safety feature, are discussed. In manual mode, DC power is directed directly to activate the relay connected to the contactor, allowing for immediate system operation. Conversely, when automatic mode is activated, the system will operate based on the established control logic. However, regardless of the operating mode, the presence of the emergency stop button is vital. When the emergency stop button is pressed, the power supply to the contactor will be immediately cut off, ensuring an instantaneous motor stop and preventing potential danger or damage. This function is supported by a relay that will operate when the emergency stop button is activated, disconnecting the main control circuit.

Trial Data Testing

TestingEmergency Stop Reliability

Emergency stop button reliability testing is a critical step in ensuring that the conveyor safety system operates optimally in the event of an emergency. The emergency stop button is designed as an input capable of halting system operation by sending a direct signal to the microcontroller, interrupting the control flow to the relay and contactor.

Table 1. Emergency Stop Reliability Test Results

Parameter Data	Test Method	Test Result	Description
Stop Response Time	Stopwatch	Trial 1: 0.80 seconds Trial 2: 0.75 seconds Trial 3: 0.82 seconds average : 0.79 seconds	success
Stopping Reliability	Count the number of success	10 out of 10 succesfull (100%)	success
Condition after stopping	Visual and tactile observations	Conveyor comes to a complete stop with no residual vibrations	Succes

Testing was performed by repeatedly pressing the emergency stop button several times while the system was active to determine whether the stop command could be executed consistently and without delay. The entire circuit was tested 10 times, and in each trial, the system was able to completely stop the conveyor, with a 100% success rate, without any delays, signal failures, or delayed responses.

Emergency Stop Indicator Performance Testing

Buzzer indicator testing was conducted to ensure the system could provide a clear and instantaneous audio warning signal when the emergency stop button was pressed. The buzzer was connected directly to the Arduino logic system and activated via a digital output when the system detected an input signal from the emergency button.

Table 2. Emergency Stop Indicator Performance Testing

Data Parameters	Test Method	Test Result	Observation result
Visual Indicator (LED) Clarity	Observation from various directions and distances	Clearly visible from a distance of approximately 20 meters	The indicator helps quickly identify emergency locations.
Clear Audio Indicator (Buzzer)	Observation from various areas	Clearly audible within a radius of approximately 15 meters	Loud but not intrusive, effective as an alarm.

Testing was conducted by pressing the emergency button while the system was active, and recording the time the buzzer sounded using a digital stopwatch and subjective observations from various positions. The test results showed that the buzzer sounded less than 0.1 seconds after the button was pressed, indicating that the signal was sent and received by the system with a very fast response. Furthermore, the buzzer sound intensity was tested from various locations around the conveyor (e.g., 5 m, 10 m, and up to 20 m). The buzzer sound was clearly audible at a distance of up to 20 meters without distortion or loss of clarity. These results indicate that the buzzer is effective as an emergency warning device, loud enough to attract attention, but does not cause excessive acoustic disturbance to the operator. Based on these results, it can be concluded that the audio indicator works responsively and communicatively, strengthening the effectiveness of the emergency stop system as a work safety measure.

Emergency Stop Log Storage Testing on SD Card Based on RTC DS3231

The designed emergency stop indicator system, tested the system's ability to automatically record emergency events into the SD Card module with a real-time time marker from the DS3231 RTC module.

Table 3. Emergency Stop Log Storage Testing on SD Card Based on DS3231 RTC

System State	Time (RTC DS3231)	Data Recorded on SD Card	File Log	Storage Status
Emergency Stop Pressed	02/07/2025 – 08:17:54	EMERGENCY ON, 2025-07-02T08:17:54	log.txt	Saved
Emergency Stop Pressed	24/07/2025 – 08:35:32	EMERGENCY ON, 2025-07-02T08:35:32	log.txt	Saved
Emergency Stop Pressed	24/06/2025 – 08:39:23	EMERGENCY ON, 2025-07-02T08:39:23	log.txt	Saved

This test ensures that every press of the emergency stop button not only stops the system immediately but is also digitally recorded for documentation and operational evaluation purposes. The system accurately records the time of the event and stores it in text format (.txt) on a memory card.

Data Analysis Results

The results of data analysis from a series of trials, several things can be concluded. Based on Table 1, the reliability of the Emergency Stop button shows a 100% success rate in stopping the conveyor, with an average response time of 0.79 seconds, proving high speed and consistency. Based on Table 2, the performance of the visual (LED) and audio (buzzer) indicators is very effective, indicated by near-instant activation (less than 0.1 seconds) after the emergency stop button is pressed. The LED indicator is clearly visible and the buzzer is clearly audible up to a radius of ±15 meters, even effective up to 20 meters. Based on Table 3, the Emergency Stop log storage on the RTC DS3231-based SD Card functions well, where every emergency stop event is successfully recorded automatically and in real-time into the SD Card using an accurate timestamp from the RTC DS3231, in an easily accessible text format.

Product Revision

Based on the test and analysis results, several product revisions are proposed for optimization:

1. Expansion of the Emergency Indicator & Zone System: Current indicators are local. Expanding the centralized indicator and the concept of an "emergency zone" with parallel buttons on different sides of the conveyor is recommended to improve safety accessibility, speed response, and mitigate risks, as per ISO 13850:2015.
2. Digital Monitoring System Integration For long-term efficiency, the system can be equipped with a wireless communication module (ESP32/WiFi) for real-time transmission of DS3231 RTC log data to a server or cloud. This revolutionizes monitoring, enabling access to operational data and emergency stop events directly from the control room, supporting rapid decision-making and preventive/predictive maintenance concepts.

Discussion of Research Results

This prototype conveyor, measuring 45 cm (75% of the minimum KP 635 2015 standard), was designed for laboratory-scale testing to ensure space and resource efficiency. While limited, these dimensions are sufficient to test the emergency stop function and its safety indicators. The prototype can carry luggage up to 35-40 cm wide, with an estimated maximum individual load of 8 kg per item, focusing on validating the emergency stop system rather than carrying capacity.

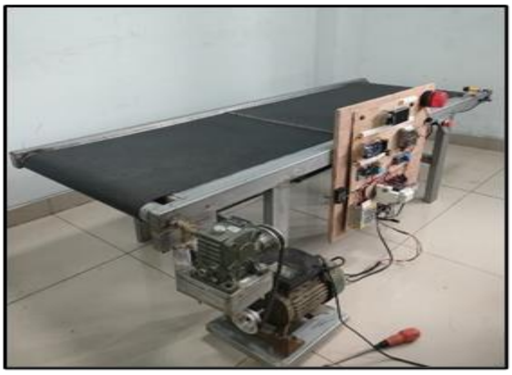


Figure 3. G.A.S Conveyor

An emergency stop indicator system was successfully developed using an Arduino Mega 2560, emergency stop button, relay, contactor, buzzer, LED, RTC DS3231, and SD Card module. This system is designed to respond quickly and automatically when the emergency button is pressed, stopping the conveyor motor, activating visual and audio warnings, and recording the event time to the SD Card. Its working mechanism shows a response of less than 1 second, with the LED and buzzer flashing simultaneously, proving real-time integration and effectiveness. Its effectiveness in preventing damage is proven by 100% success of total and stable stops without delay. Automatic time recording is also useful for monitoring and evaluation. Thus, the research objectives have been achieved through the design, understanding of the mechanism, and evaluating the effectiveness of the emergency stop indicator system.

Research Implications

The results of this research have significant dual implications. From a scientific perspective, this research enriches the field of Airport Technology through a concrete case study of automation for infrastructure efficiency. This project is also relevant as reference material and a learning tool for students exploring the application of mechatronic systems in airport environments.

Figure 4 conveyor at Iskandar Airport, Pangkalan Bun

Figure 5 Mock Up GAS Conveyor

At the implementation level, the proposed system has the potential to provide tangible benefits to Iskandar Pangkalan Bun Airport. Benefits include extended conveyor life and reduced maintenance costs. From a safety perspective, the absence of an emergency stop indicator increases the risk of workplace accidents for both personnel and the operator.

CONCLUSION

This research succeeded in achieving the main objective of modifying the conveyor based on the emergency stop indicator at Iskandar Pangkalan Bun Airport, with the following conclusions: The Emergency Stop indicator system was successfully designed using Arduino Mega 2560, emergency stop button, relay, contactor, buzzer, LED, RTC DS3231 module, and SD Card. The working mechanism shows a very fast response (less than 1 second on average), with the LED and buzzer active in real-time. The implementation of the Emergency Stop indicator is proven to be 100% effective in stopping the conveyor completely and stably, without delay. Automatic recording of event times to the SD Card using RTC DS3231 works well, providing accurate documentation. Overall, the developed system shows stable and efficient operational capabilities. This design is optimal for use of approximately 10 hours per day.

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