# Designing A Monitoring and Control System for A Production Line Based on The Internet of Things (IoT)

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# تصميم نظام مراقبة وتحكم في خط إنتاج قائم على انترنت الأشياء IoT

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**Abstract:**
The monitoring stage of the industrial process within establishments is considered an essential factor in the success of these establishments, in addition to being the basis for their continuation, because of the prominent role it plays in ensuring the avoidance of problems that may accompany the production process. Therefore, it is important when designing and implementing industrial facilities to take into account the monitoring process and how it can be performed optimally without negligence. In this paper, a production line was designed and implemented to transport products, which were classified according to their color into two basic categories. ESP32 board was used to control the system, as this board provides the system with the ability to connect to the Internet for monitoring and controlling it remotely. It was tested, and the results obtained were good, as the operating status of the motors was displayed, in addition to turning the system on and off remotely through the Internet of Things technology provided by the ESP32 board.

**Keywords**: Production Line Monitoring, ESP32 Board, Internet of Things (IoT).

**الملخص:**
تعتبر مرحلة مراقبة العملية الصناعية داخل المنشآت عاملاً أساسياً في نجاح هذه المنشآت، بالإضافة إلى كونها الأساس لاستمرارها، لما تلعبه من دور بارز في ضمان تجنب المشاكل التي قد تصاحب العملية الإنتاجية. ولذلك فمن المهم عند تصميم وتنفيذ المنشآت الصناعية أن تؤخذ في الاعتبار عملية المراقبة وكيف يمكن تنفيذها على النحو الأمثل دون إهمال. في هذا البحث تم تصميم وتنفيذ خط إنتاج لنقل المنتجات والتي تم تصنيفها حسب لونها إلى فئتين أساسيتين. تم استخدام لوحة ESP32 للتحكم في النظام حيث توفر هذه اللوحة للنظام إمكانية الاتصال بالإنترنت لمراقبته والتحكم فيه عن بعد. وتم اختباره وكانت النتائج المتحصل عليها جيدة، حيث تم عرض حالة تشغيل المحركات، بالإضافة إلى تشغيل وإيقاف النظام عن بعد من خلال تقنية إنترنت الأشياء التي توفرها لوحة ESP32.

**الكلمات المفتاحية:** مراقبة خط الإنتاج، لوحة ESP32، إنترنت الأشياء (IoT).

## Introduction

The packaging industries appeared directly after the increasing need to transport and store packaged products without any damage. During the early stages of the development of the packaging industries, packaging was done using wooden boxes, plastic and paper bags, but with the increasing areas of manufacturing and production in the packaging industries, there was a necessity to automate the sorting of cartons according to their size [1]. The rate of production has expanded dramatically in today's technologically advanced world. Most often, manufacturing companies produce the same models with small differences in length, color, weight and shape, so sorting is crucial in this case. In such circumstances, industries cannot afford to sort their products through human error. Therefore, it was necessary to look for ways to design low-cost automation systems to accurately sort these products [4]. The sorting process is very important in industries, through which we can distinguish between materials easily. Sorting plays a major role in achieving greater productivity with high speed and accuracy because the automated sorting process reduces human effort in all industries, such as the food industry and other industries [5]. Companies all over the world are automating the classification and sorting process used in their organization to increase productivity, as sorting plays a major role in any industrial automation, especially in the field of packaging industries. Automated sorting saves labor costs and time, thus increasing accuracy and overall efficiency, which leads to increased productivity and profits [1, 2]. The method of classifying materials depends on several methods, all of which agree on the use of sensors that work to distinguish the type of material and classify it [3,6]. The process of classifying products and items in industrial institutions is carried out according to several criteria, including color, size and weight, where these products are compared with specific values so that the product specifications match these setpoints values previously specified by the user [5]. Many researches have appeared that are working on developing sorting systems [7] and many control technologies have emerged that provide automated control of the sorting system. Such as controlling sorting and classification systems using a programmed logic controller (PLC) [4] and also controlling sorting systems using an Arduino board [8]. The advancement of technology and digitization worldwide has led to the emergence of an innovative communication system known as Machine-to-Machine (M2M) communication, or Internet of Things (IoT). The concept of IoT revolves around the idea that everything can interact and communicate with each other through machines, where one device communicates with another to perform various functions. Following the success of IoT, its branches have started to spread across different fields [9]. With the technological development in the field of communications and information technology, more advanced designs for sorting systems have emerged that rely on Internet of Things technology. This technology develops factories that were operating in traditional ways into smart factories that operate with systems based on the Internet of Things. The main concept of smart industry is smart manufacturing and the Industrial Internet of Things, where all components of the industrial system, including the user, will exchange all the information available in this system. Since the exchange of data between different devices in real time is the main element of the smart factory, this will enable the smart factory to provide the customer with smart services and products, which will be connected to a network based on the Internet of Things [10]. This research presents an automated sorting model using a color sensor and a distance sensor (ultrasonic), where the conveyor belt transports materials from the starting point to the end of the belt. Then, once the pieces reach the end of the belt, they move in front of the distance sensor, which detects the presence of a piece in front of it moving to the place designated for classification. Immediately after that, the rotation of the conveyor belt is stopped by turning off the DC motor, and moving the moving base with a servo motor in one of two directions based on the color of the piece.

**Block diagram of the production line control system.**

Figure 1 shows the Block diagram of the production line control system presented in this research. The Block diagram shows the system's inputs, outputs, and the processing and control unit. The processing unit (ESP32) receives electrical signals through on and off switches as well as sensors, while the system outputs are control signals that are sent to the motors. In addition, all input and output signals are transferred to the graphical user interface to display the production line system data.

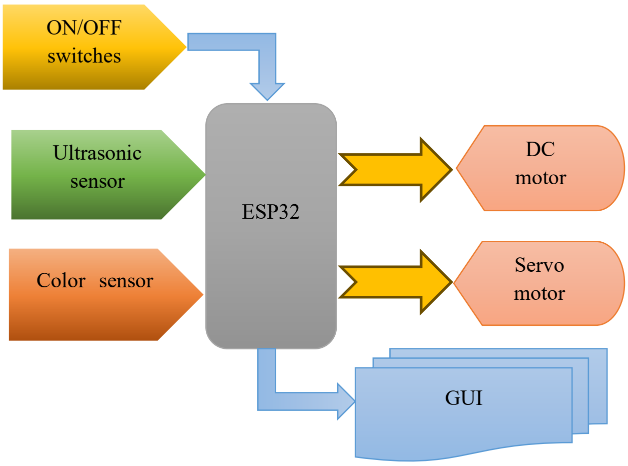


**Figure 1:** The Block diagram of the production control system.

**Proposed system architecture**

In this research, a sorting system based on the Internet of Things was designed and implemented for products transported on a conveyor belt, as shown in Figure 2, which represents the actual model of the system presented in this research. The smart sorting system presented in this research includes three main parts: the mechanical part, which consists of the mechanical parts of the system, the electronic part, which consists of the electronic and electrical parts of the system, and finally the software part, which consists of programming the system and the graphical user interface (GUI) .

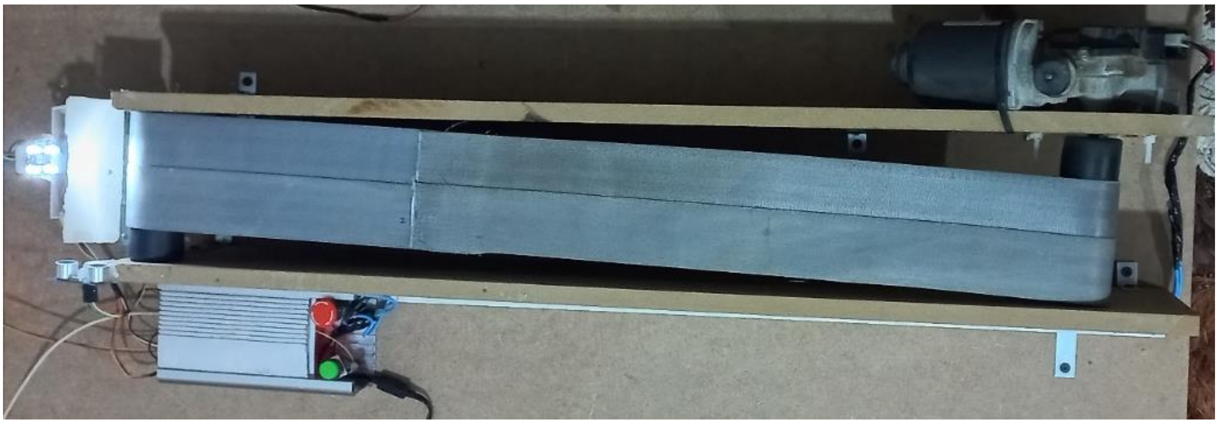

**Figure 2:** The prototype of the production line presented in this paper.

**1. Mechanical part.**

It is all the physical components that work to carry the electronic and electrical components and connect them to control the movement of the system. The mechanical part includes the production line base, the conveyor belt, the conveyor belt rollers, and the product classification base.

**2. Electronic part**

The electronic part is all the components that have a direct relationship with electrical signals, and it is responsible for turning the system on or off based on the commands to which it is set. It consists of the following parts: DC motor, servo motor, ESP32 board, on and off switches, distance sensor, color sensor

**3. Software and Programming**

- **The software parts**

The software part is the part that includes the software code in addition to the graphical user interface through which the operation of the production line presented in this research is monitored and controlled. The ESP32 featured in this paper has been programmed utilizing the Arduino software (IDE) which is illustrated in Figure 3. This open-source Arduino software simplifies the process of writing code and uploading it to the board [11].


**Figure 3:** Programming setup on Arduino IDE.

Through the graphical user interface (GUI), operating systems are also monitored and controlled, as graphical user interfaces allow displaying system information in addition to the possibility of sending control signals from the user to the operating system, thus saving a lot of time and effort for the user in terms of the ability to follow the control system. Remotely [12].

In this research, the graphical user interface shown in Figure 4, was designed using the Blynk platform. This graphical interface consists of a start button, a stop button, an indicator lamp for the operation of the conveyor belt, and indicator lamps (LEDs) showing the operating status of the classification based on the right or to the left.

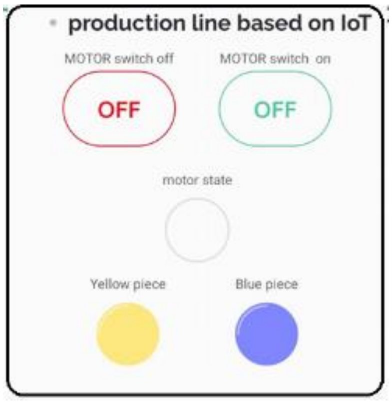


**Figure 4:** The graphical user interface.

- **Flowchart**

The flow chart shown in Figure 5, describes the stages of executing the code, starting with reading the input signals, then processing these signals and executing the necessary commands.

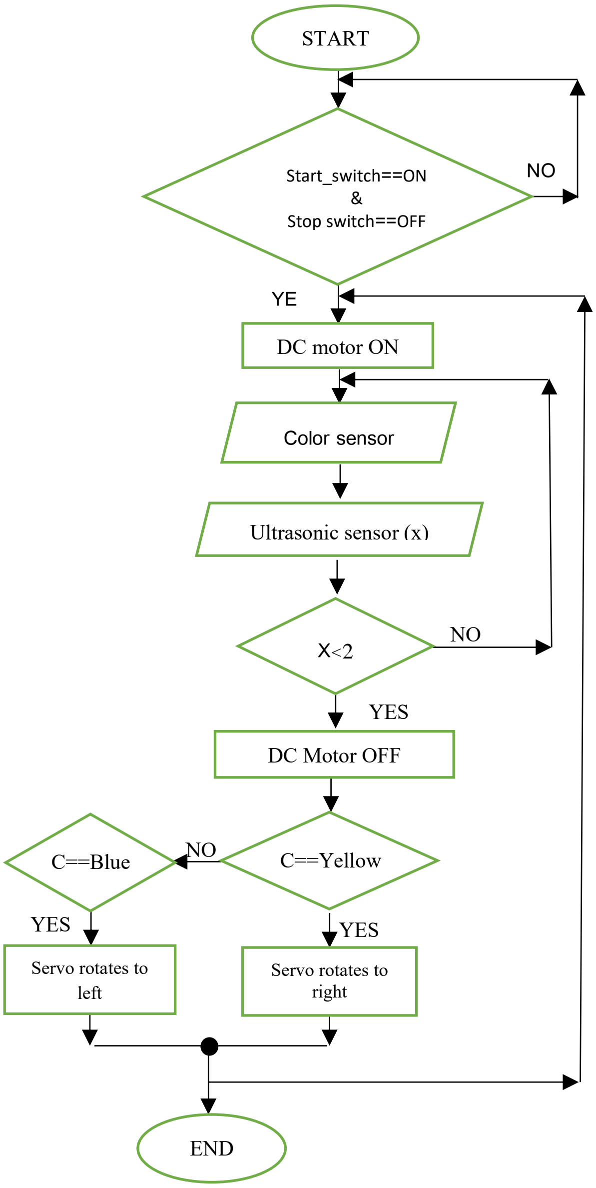


**Figure 5:** The flowchart of the proposed system.

**Implementation of the system**

The idea of the production line monitoring system and the classification process presented in this research is the process of operating a conveyor belt such that the belt carries a group of pieces of products to be classified to be transferred to a mobile base that classifies the products into two categories according to their colors through a color

sensor. The ESP32 board is considered It is the basis for controlling the production line system presented in this research, as it works to receive operating orders and sensor signals, and then appropriate orders are issued to the motors that perform the required movements.
When the start button is pressed, the direct current motor is started, which operates the conveyor belt that moves the pieces to the classification base. As soon as the product piece approaches the classification base, its presence will be notified through the distance sensor that distinguishes the approach of these pieces by the distance between the piece and the sensor. After the distance sensor senses the presence of a piece in front of it, the ESP32 board will issue a command to turn off the conveyor belt in conjunction with the fall of the product piece on the classification base, in order to ensure that other pieces do not fall when the classification base is moved. The classification base is moved at an angle of 90 degrees through the servo motor to place the product piece in its designated box. The color of the pieces is sensed by a color sensor mounted on the classification base. Also, the emergency switch is used to stop the conveyor belt from moving. The process of displaying data related to the production line, which relied on IoT technology, is also among the most important processes that were implemented in this research, as this process provides the possibility of monitoring the system in addition to the possibility of controlling its operation. This process has simplified many of the steps that the user needs to take. A graphical user interface (GUI) was designed using the Blynk platform, in which the operating status of the engines is displayed, in addition to the control buttons for turning the system on and off, as a step to provide the ability to monitor and control the production line remotely from anywhere in the world.

**Experimental results**

The production line system presented in this research has been tested under different operating conditions, which are the state of running and stopping the production line (DC motor), as well as the classification process for product parts. Figure 6, shows the graphical user interface for production line monitoring, through which the production line system is monitored and controlled.


**Figure 6**: The user interface of the proposed system.

The results obtained from testing the production line control system can be listed as follows:

1. first case: the operating status of the production line

In this case, the operation of the production line (DC motor) was tested by pressing the start button located in the control system circuit, or pressing the start button located in the graphical user interface. Figure 7, shows the graphical user interface, which shows the engine operating status by turning on the indicator lamp that shows the engine operating status.

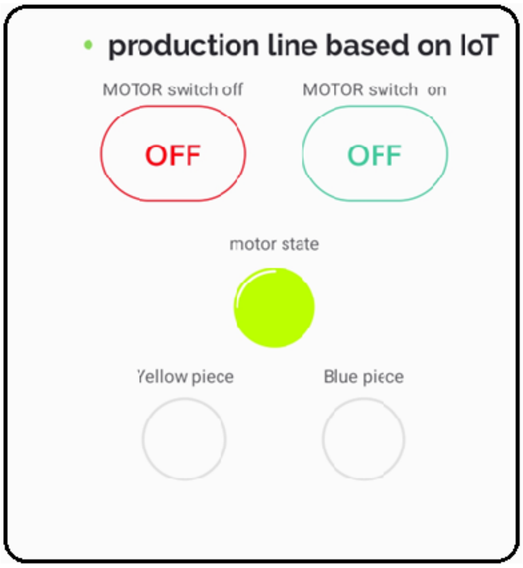


**Figure 7:** The operating status of the proposed system.

2. second case: Shut down the production line

In this case, the production line (DC motor) was turned off using the stop button in the control system circuit, or by pressing the start button in the graphical user interface. Figure 8, shows the graphical user interface, which shows the engine operating status by turning on the indicator lamp that shows the engine operating status.

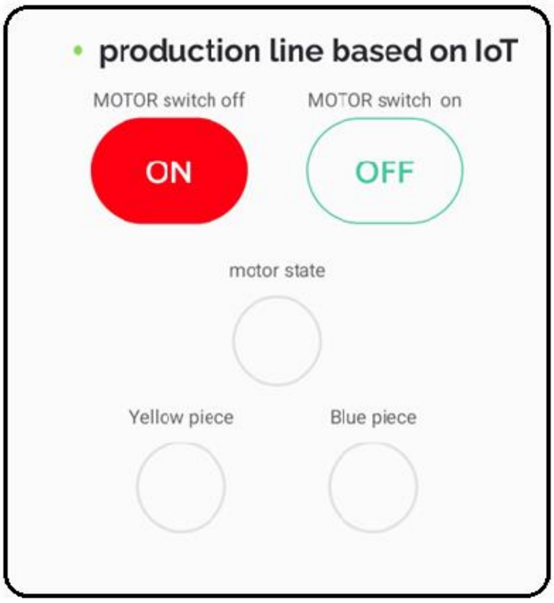


**Figure 8:** The state of stopping the proposed system.

3. third case: the process of classifying product pieces

The product classification process was tested and the results were good, by turning off the indicator lamp that shows the operating status of the production line and turning on one of the indicator lights that shows the status of the classification of product pieces. Figure 9, shows the illumination of the blue indicator lamp, which indicates the presence of a blue piece on the classification base and that it has been placed in its designated place. Figure 10, also shows the illumination of the yellow indicator lamp, which indicates the presence of a blue piece on the classification base and that it has been placed in the place designated for it.


**Figure 9:** The process of classifying the blue pieces.

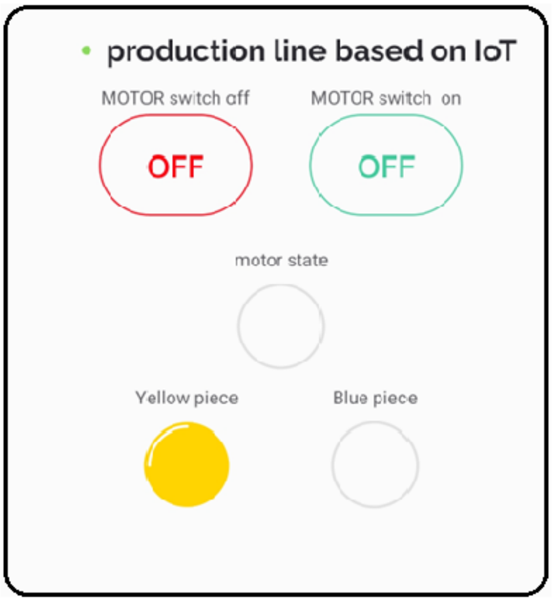


**Figure 10:** The process of classifying yellow pieces.

**Conclusion**

In this research, a control and monitoring system was designed for a production line using an ESP32 board based on the Internet of Things. This system demonstrated the effectiveness of remote monitoring systems by displaying the status of the facility on the graphical user interface (GUI), which also enables the user to remotely control the work of the facility. The results have proven the system's ability to control and monitor the production line, and this in turn provides the user with ease of monitoring and control in addition to saving effort and time, as well as the cost of reducing the number of workers in the industrial facility based on IoT technology.

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