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# Designing and Implementing the Remote Control and Monitoring System for Industrial Automation

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Abstract— Abstract— This paper presents design and implementation of a human machine interface (HMI) for a programmable logic controller (PLC) based automated packaging process that can be remotaely controlled and monitored using mobile application. A conveyor belt moving the products to a destined place for packaging, is controlled by Siemens LOGO 230 RCE PLC. Microcontroller operates the relays according to the output of IR sensors, which are used to sense the products. States of relays are taken as the input of the PLC. An HMI is designed with an android application and the microcontroller establish a communication path between the operators and PLC based plant. The interface provides remote controlling and monitoring feature. The proposed design minimized overall cost by replacing the widely used supervisory control and data acquisition (SCADA) system with normal sensors and mobile application based control. The performance of the implemented prototype is evaluated through several real-time operations, it shows satisfactory results.

## I. INTRODUCTION

Industrial automation is one of the most global trends that enhances the quality of production, safety and proper utilization of plant and resources. From the economic view, mass production is the main goal of any industry to stay ahead in the recent competitive market [1]. The production are often eased through the method automation. In any kind of industry, packaging is a widely used process. Packaging is done for providing protection and safety of products from dust, moistures and other objects that are harmful to the products. The packaging also provides better handling, transporting and, stable storage capability, company branding and many more [2]. The manual packaging process is toilsome work and costly, as a large number of workers is required for it. Therefore, many companies switching to industrial automation for cost-effective and uninterrupted production. Automation of the packaging process with remote control and monitoring system will provide more reliable and developed packaging with less error and less probability of hazards [3]. In industry, an essential equipment of product processing is the conveyor belt. Conveyor belt performs the functions include rotation, accumulation, flipping, stacking, and diversion of products depending upon the application. There are several conveyor belt systems are used in industries. In Table I, numerous conveyor belt systems are enlisted with their working domain [4].

TABLE I
CONVEYOR BELTS AND WORKING DOMAIN

| Types | Working Domain |
|---|---|
| Roller | Belt, rings or chains powered rollers |
| Sortation | Diverts product one region to another or one belt to another. Mainly used for sorting. |
| Accumulation | Holds products for a fixed time or for a fixed quantity gathering. |
| Screw | Consist of helix pushes loose products forward such as powdered or mixed products. |
| Carousel Indexing | Conveyed products to upward. |

In the area of industrial automation, programmable logic controller (PLC) found

greater interest for its robustness and low-cost implementation. PLC is a kind of small computer specially designed for industrial purpose, performs several functions including logical operations, counting and arithmetic functions to control various process or machinery through digital or analog modules [5]. Various automation of packaging using PLC and supervisory control has been proposed and implemented by numerous researchers around the world. Each automation has its own pros and cons. A brief discussion has been made on the various automation of packaging processes in Section II. It is found that most of the automation is applicable for large industries, complex in nature, expensive and not affordable for small industries. To overcome the aforementioned limitations, an affordable, less- costly and simple packaging process is proposed. The main contributions of this paper are:

i. For lower capital industries, SCADA and other supervisory devices are used for feedback and monitoring, which are costly to implement. In this paper, an HMI is implemented with low-cost equipment and easier accessing technology
ii. Implemented a mobile-based user interface i.e. an android application that is user-friendly and easy to operate and learn.
iii. Developed a platform for improvising and innovation in mobile-based industrial automation with low cost, robustness, and reliability.

In this paper, a prototype of two conveyor belts is considered, one for products carrying to the destined box and another for carrying filled and unfilled boxes. PLC is designed as the controller for a constant speed geared DC motor, which rolls the conveyor belt. An interface is designed based on android platform, arduino uno and bluetooth module to control and monitor the packaging process. The novelty of the proposed system is that it has been found suitable and cost-effective for small industries where capital is small. This work can also be implemented for large industries considering the requirements of robustness and application field.

## II. Related Works

In recent years, many works on automation and remote monitoring and control of packaging process have been done. Several papers are studied and the contribution have been enlisted, in Table II.

TABLE II
Related Works on Automation of Packaging Process and Remote Control and Monitoring

| Author | Contribution |
|---|---|
| Marie M. Baroro, Joanna & Alipio et al. [6] | Implemented packaging and material handling using PLC and recommended an HMI for controlling purpose. |
| Abueejela, Yousef & A. Algitta et al. [7] | Implemented automatic packaging machine by controlling the conveyor belt using PLC. |
| P.Thirumurugan et al. [8] | Implemented metal separating and packaging machine using PLC and a metallic sensor for detecting metals and non-metals. |
| Gupta, T & Kamboj, S et al. [9] | Proposed a design of packaging process using PLC and SCADA for remote control and monitoring with a software interface to visualize the process. SCADA and PLC inter-connection has been proposed for re-programming the PLC. |
| Shyr, Wen-Jye, Te-Jen Su and Chia-Ming Lin et al. [10] | Developed and implemented a methodology for remote controlling and monitoring of plant using PLC. A web-server based computer system and Web-Cam are used to remote monitoring and connected computer through the internet can control the plant from the remote place. |
| J. Garcia et al. [11] | Using SCADA and TCP/IP developed a platform using Motronic software interface for real-time remote monitoring and controlling of the plant and configure new device to add with, re-configure the existed device. |

From Table II, It have be seen that, powerful and more costly remote controlling and supervisory systems are used or proposed for industrial applications. However, for small industries or industries where hardiness is not required, these above-mentioned proposed designs seems unnecessary. For this, the purpose of this paper is to find alternate technology and reduce cost of automation. Moreover, an automation system

has been designed which can be easily implemented for low cost industries and for large industries where only monitoring is required rather than robustness.

## METHODOLOGY

### A. Start Packaging System

Tapping the "Start" button on android application, a specific data (e.g. "a") sent from mobile. Bluetooth module (HC-05) receives the transmitted data, which are processed by a microcontroller (arduino uno). Arduino uno makes a particular pin as logical "High" for one second, which will control the switching of relay switch (four-array relay switch 5v DC). This will make arduino uno to send a link e.g., "packaging starts" through bluetooth module to the mobile. This relay switch provides logical information to the respective PLC input (e.g. I1). PLC module then operates its logical operations to close or open respective output relay. Electrical dc motor can be used as an output actuator to move box or sample conveyor belt, as shown in Fig. 1.

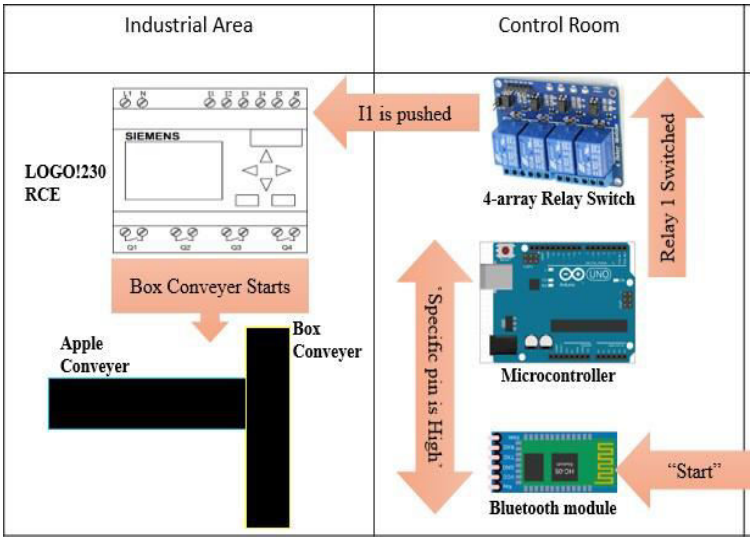


Fig. 1 Proposed procedure of start packaging system

### B. Box Sensing and Counting

Box conveyor run until a box is sensed by the IR sensor. Sensing of a box makes arduino uno to make another pin logical "High" for one second and send another string e.g., "1 box is sensed" to mobile phone including the number of boxes. That pin also controls the switching of a relay switch providing logical information to the respective PLC input (e.g. I4). PLC module stops the box conveyor belt and begins to move sample conveyor belt.

### C. Sample Sensing and Counting

Samples (e.g. apple) on the running sample conveyor belt are passed before the IR sensors (mounted on the sample conveyor structure). IR sensors senses and arduino uno process this signal to make a pin logical "High" for one second. Moreover, arduino send a string to mobile e.g., "1 sample is sensed" and a counter is started to count the sample. The logical "High" pin provides logical information to the respective PLC input (e.g. I3). PLC module stops the sample conveyor belt when three samples have been counted and begin to move box conveyor belt. In such a way, every box is filled with three samples.

### D. Stop Packaging System

Box sensing, apple sensing, and counting will be continued until an interruption command is sent from the mobile application. When the "stop" or "exit" button is tapped on the mobile application, the PLC module stops the packaging system and initializes the number of boxes and samples.

## II. SOFTWARE IMPLEMENTATION

Software implementation includes implementation of PLC ladder diagram, developing an android application and configuring necessary programs (remote control and monitoring system) for arduino.

### A. PLC Ladder Diagram

For programming and operation of the presented prototype, a PLC ladder diagram is applied by using LOGO! Soft V8. For a faster, uncomplicated and space-saving solution, LOGO! is a perfect choice. LOGO! Soft Comfort makes possible of easier installation with a minimum wiring effort

[14]. This ladder diagram, as shown in Fig. 2 provides two stages of the packaging operation. The input, output, relay switch and counter configuration are shown in Table III.

TABLE III
INPUT, OUTPUT AND RELAY CONFIGURATIONS OF PLC

| Input | | | | Output | |
|---|---|---|---|---|---|
| I1 | I2 | I3 | I4 | Q1 | Q2 |
| PLC starts | PLC stops | Apple or sample sensed | Box sensed | Apple or sample conveyor belt | Box conveyor belt |
| Relays | | | | Counter | |
| M1 | | M2 | | C001 | |
| Relay contacts | | Relay contacts | | Apple Counter | |

*1) Carrying Empty Boxes to Desired Location*

Flag "make contact" M1 is connected with "make contact" I1 (packaging starts) to provide an OR gate operation. The output of the OR gate and "break contact" I2 (packaging stops) provides an AND logic gate operation to operate flag output coil M1. Flag "make contact" M1 and flag "break contact" M2 provide an AND logic gate operation to operate relay output coil Q2 (box conveyor). Flag "make contact" M2 is connected with "make contact" I4 to provide an OR gate operation. The output of the OR gate and "break contact" C001 provide an AND logic gate operation to operate flag output coil M2. Therefore, once packaging starts (I1 logically high), box conveyor (Q2 relay output coil energies) starts to move unless "packaging stops" (I2 logically high) command is applied or a box is detected (flag M2 is logically high).

*2) Packaging Samples into Boxes*

Relay output coil "make contact" Q1 is connected with "make contact" I4 and provides an OR gate operation. The output of OR gate, relay output coil "break contact" Q2, the flag "make contact" M1 and sample counter "break contact" C001 provide an AND logic gate operation to operate relay output coil Q1 (apple or sample conveyor). An apple or sample counter C001 is introduced. C001 will be reset if relay output coil Q2 (box conveyor) is logically high. Flag make contact M1, relay output coil make contact Q1 (apple or sample conveyor) and "make contact" I3 provide an AND logic gate operation to count the number of samples.

*B. Developing an Android Application*

Android-based PLC remote control and monitoring application is developed using Android Studio (emulator) [15]. This application provides a single row display for wireless monitoring and three control buttons, as shown in Fig. 3.

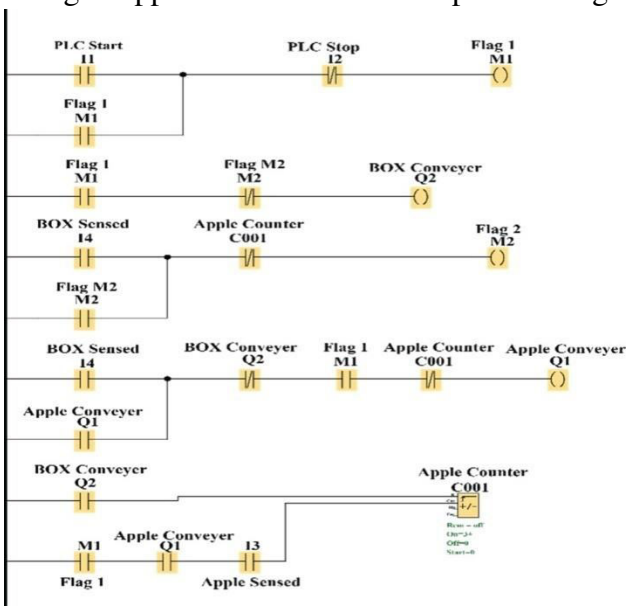


Fig. 2 Ladder diagram of the automatic packaging system.

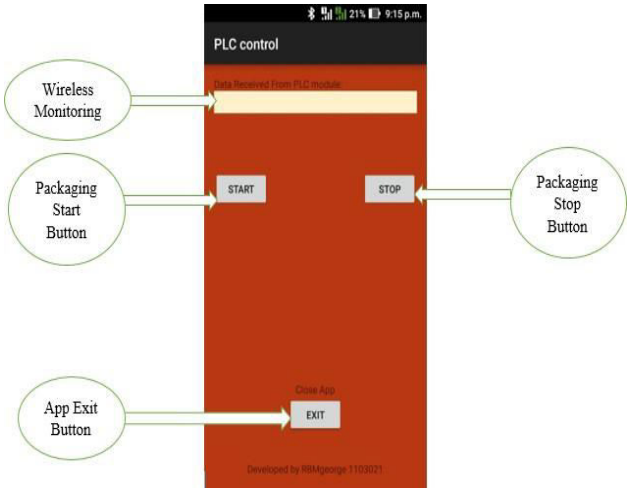


Fig. 3 An android application of automatic packaging & monitoring system.

### C. *Configuring Remote Control and Monitoring Programs to Arduino*

Arduino, an open-source electronics prototyping platform that is based on flexible, easy-to-use hardware and software. Arduino is a tiny computer system that can be programmed with specific instructions to interact with various forms of input and output and can be reprogrammed as many times depending on the microcontroller used [16]. Arduino uno performs a various function including data exchange between mobile and PLC, counting, calculate and monitor samples and provides necessary data string to the mobile application.

## V. HARDWARE IMPLEMENTATION

The required equipment for complete hardware implementation of automatic packaging and monitoring system is shown in Fig. 4.

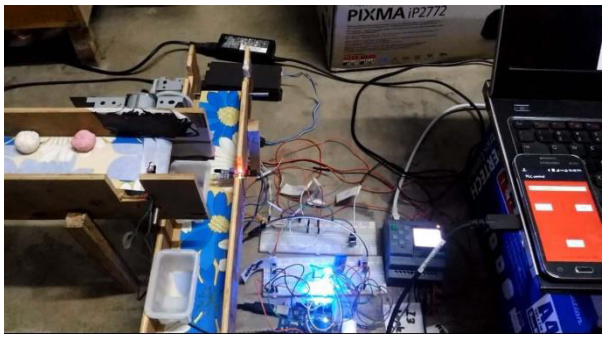


Fig. 4 Overall view of automatic packaging & monitoring system.

The major hardware equipment of the automatic packaging system are the following:

### A. *LOGO! 230 RCE PLC Module*

LOGO! 230 RCE is a small PLC module that is made for home appliances. It provides higher system stability and performance rather than a microprocessor. It comes with easy programming features i.e. ladder diagram that can be programmed using the installation software LOGO! Soft V8. The inputs (220V AC pulse) are provided by a four-array relay switch to the PLC according to the command of arduino uno and the outputs (relay switch) that are connected with the conveyor motor circuits.

### B. *Arduino, Bluetooth Module and Android phone*

Arduino uno is used to communicate between mobile phone and PLC (LOGO! 230 RCE) via bluetooth module. Moreover, IR sensors are directly connected to the arduino uno to generate respective logical input of the PLC module. Data strings provided by arduino uno are shown in Table IV.

TABLE IV
DATA STRING PROVIDED BY ARDUINO UNO

| Operations in android phone and IR sensors | Data String | |
|---|---|---|
| | Data send by arduino | Data receives by arduino |
| "Start" button | "Packaging Starts" | "a" |
| "Stop" or "Exit" button | "Packaging Stops" | "b" |
| Box is sensed | "X box is sensed" | |
| Sample is sensed | "X sample is sensed" | |

### C. *Conveyor Belts*

Two conveyor belts are made from wood, dc motors with proper gearing, belts, and sensors. Belts are used for transporting samples from one location to

another, which would be packaged into a specific plastic box later. Through the entire process, dc motor is used as actuators to move in conveyor belts. Proper gearing structure is included for high torque with moderate speed. Two IR (infrared receiver) sensors are used, one for box detection another for sample detection. Detection timing of IR sensors is modified by arduino programming. Even arduino sends necessary data strings to the mobile phone via bluetooth module for every detection of box and sample. The conveyor belt system making procedure is shown in Fig. 5.

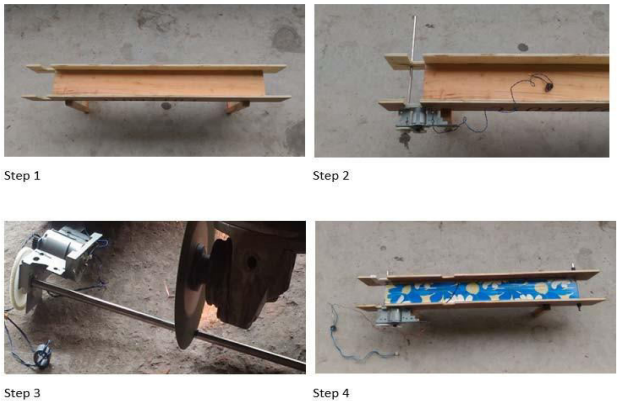


Fig. 5 Making procedure of conveyor belt.

## COST ANALYSIS

An approximate analysis of the cost of equipment used in the proposed design and existed automation is represented in this section. DC motor, conveyor belt are the common equipment in both proposed automation and existed automation. Therefore, their cost is not considered in the analysis.

TABLE V
COST COMPARISON

| Proposed Automation | | Existed Automation | |
|---|---|---|---|
| Equipment | Cost (USD) | Equipment | Cost (USD) |
| PLC (LOGO! 230 RCE) | 243 | PLC (LOGO! 230 RCE) | 243 |
| Arduino Uno | 24 | SIEMENS HMI | 700 |
| Bluetooth Module | 9 | Network Module/ Communication System (TCP/IP, Internet, GSM) | 800* |
| Mobile with Android OS | 70 | Computer | 300 |
| IR sensors | 10 | CAM/ Sensors | 50* |
| Total | 356 | Total | 2093 |

*Approximate cost of Network Module and CAM

## VII. CONCLUSION

An automated packaging process with remote control and monitoring capability has been implemented. The main purpose of this design implementation is the reduction in the cost of automation. For lower capital industry or small industries, large automation or high-configured devices are not economical. A reduction of almost 1700 USD become possible using the proposed design. The proposed design provides low-cost HMI to interact with the machine from remote places using the mobile. A warning or alert system and conveying path have been developed that monitoring and control of plant can be done from a distant place from the plant. This ensures the reliability and errorless process of the plant. The proposed design has successfully tested using numerous trial and get a satisfactory result with greater performance of reliability, robustness, and less-error in packaging. This design is feasible for low-capital industries as well as can be implemented for large industries.

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