Design of PLC Timer System Based on FPGA For Industrial Automation System

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***Abstract*—Our project is a device which allows a user to control the motion of a Conveyor belt with the help of an ESP32 and FPGA. Our project is a designed system which offers a flexible and reconfigurable platform capable of controlling complex processes and is optimized for real-time control. The FPGA based PLC is based on a parallel processing mechanism, so the proposed design works significantly faster as compared to a conventional PLC. This project involves designing and implementing a PLC system which can be remotely controlled through a wireless control. The board uses a FPGA to control the motor , which is programmed by providing the timer to the motor.**

Keywords - FPGA, Esp32, IR sensor, Motor, conveyor belt, FPGA Programming.

I. INTRODUCTION

FPGA (Field Programmable Gate Array) is a versatile programmable logic device that can be configured to perform complex logic functions and interface with other electronic components, making it an ideal choice for designing our FPGA based PLC. An FPGA is a programmable device that can be configured to perform specific functions using digital logic.

A programmable logic controller (PLC) or programmable controller is an industrial computer that has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, machines, robotic devices, or any activity that requires high reliability, ease of programming, and process fault diagnosis. There are various FPGA based PLC that are used in industrial automation automation based systems . PLCs have established a critical important place as control elements for logic control of manufacturing systems.

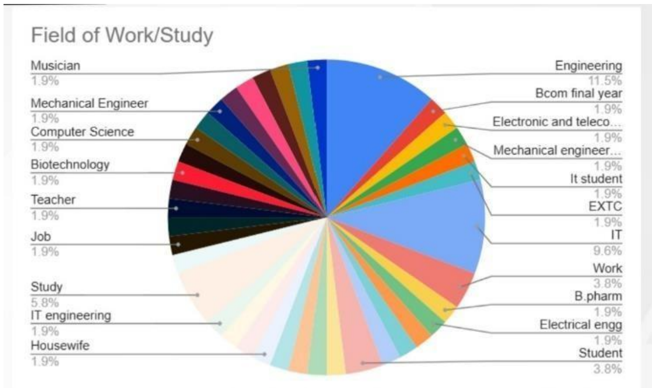
The main difference from most other computing devices is that PLCs are intended-for and therefore tolerant-of more severe conditions (such as dust, moisture, heat, cold), while offering extensive input/output (I/O) to connect the PLC to sensors and actuators. PLC input can include simple digital elements such as limit switches, analog variables from process sensors (such as temperature and pressure), and more complex data such as that from positioning or machine vision systems

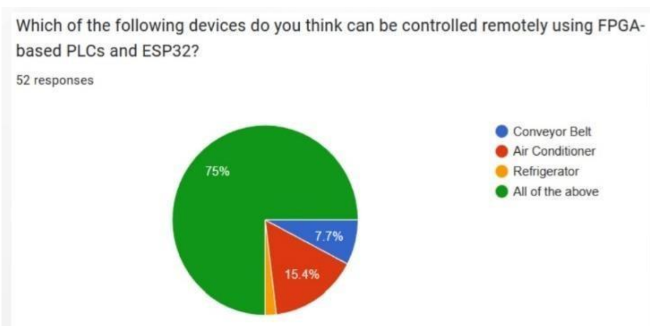
Purpose :- While there are many softwares already available in the market which can help in automating a process , a FPGA based design has various advantages such as parallel processing, reprogrammability and is cost-effective. These advantages of FPGA makes it a good alternative for implementation of a project which helps automate a process as some processes can require multiple inputs without compromising on processing speed.

II. PROBLEM STATEMENT

Design and implement a timer system which can be used into PLC's using FPGA board. The development should be such that the PLC could be controlled by the client remotely based on wifi. The final implementation should include a prototype of the PLC application and it must have the wireless control and the user - friendly configurations.

III. LITERATURE SURVEY



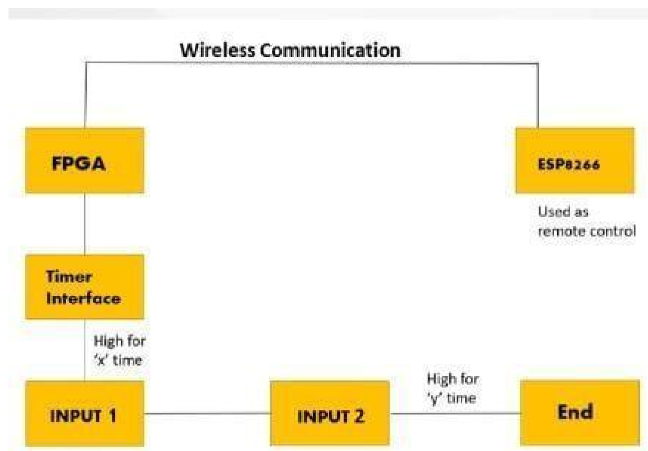


IV. RELATED WORKS

"A Low-Cost FPGA-Based Programmable Logic Controller for Industrial Applications" by S. S. D. Dharan and S. R. Jino in International Journal of Engineering and Technology (IJET), 2018..
"Development of a High-Speed FPGA-Based Programmable Logic Controller for Industrial Applications" by M. O. Balogun, F. S. Oladosu, and A. O. Ogunlade in IEEE Transactions on Industrial Electronics, 2019.
“An FPGA-Based Programmable Logic Controller for Industrial Automation" by M. A. Mohamed, A. M. El-Sayed, and M. I. Abdou in 2016 13th International Conference on Computer Engineering and Systems (ICCES)..
"A Novel Programmable Logic Controller Based on FPGA" by X. Zheng and J. Yang in 2018 IEEE 3rd Advanced Information Technology, Electronic and Automation Control Conference (IAEAC).
“A Hybrid CPU-FPGA Approach for Programmable Logic Controller" by H. Yan, C. Huang, and J. Wu in 2019 IEEE 7th International Conference on Advanced Computational Intelligence (ICACI).
“FPGA-based Programmable Logic Controller for Smart Grid Applications" by A. B. Chatterjee, K. Mishra, and A. K. Sharma in IEEE Transactions on Industrial Informatics,
“An FPGA-Based Programmable Logic Controller for Real- Time Control of Industrial Processes" by M. A. Salam

and S. Hossain in 2019 IEEE 6th International Conference on Industrial Engineering and Applications (ICIEA).
"FPGA-Based Programmable Logic Controller for High-Speed Control of Industrial Robots" by X. Yan, Z. Li, and L. Li in 2019 IEEE 15th International Conference on Automation Science and Engineering (CASE).

V. BLOCK DIAGRAM



VI. HARDWARE DESCRIPTION

A. FPGA

FPGA Spartan 6 Board: The FPGA Spartan 6 board is a programmable logic device that serves as the central processing unit of the energy meter. It has a field-programmable gate array (FPGA) that can be programmed to perform various functions, including data acquisition, signal processing, and control. The FPGA board contains a 12-bit analog- to-digital converter (ADC) that is used to measure the AC voltage and current of the power signal. The board also includes programmable digital input/output (I/O) pins that can be used to interface with other hardware components.

B. ESP32 wifi module

ESP32 is a low-cost System on Chip (SoC) Microcontroller from Espressif Systems, the developers of the ESP8266 SoC. It is a successor to ESP8266 SoC and comes in both single-core and dual-core variations of the Tensilica's 32-bit Xtensa LX6 Microprocessor with integrated Wi-Fi and BluetoothThe good thing about ESP32, like ESP8266 is its integrated RF components like Power Amplifier, Low-Noise Receive Amplifier, Antenna Switch, Filters and RF Balun. This makes designing hardware around ESP32 very easy as you require very few external components.Another important thing to know about ESP32 is that it is manufactured using TSMC's ultra-low-power 40 nm technology. So, designing battery operated applications like wearables, audio equipment, baby monitors, smart watches, etc.,.

C. *Breadboard*

LCD Display: The LCD display is a user interface that displays energy consumption data such as voltage, current, power, and energy usage. It also displays the Wi- Fi connectivity status and other system messages. The LCD display is connected to the output pins of the FPGA board and can be controlled by the FPGA software to display different types of data. The LCD display typically includes a backlight, which can be controlled by the FPGA software to adjust the brightness of the display.

D. *IR Sensor*

An infrared (IR) sensor is an electronic device that measures and detects infrared radiation in its surrounding environment. Infrared radiation was accidentally discovered by an astronomer named William Herchel in 1800. While measuring the temperature of each color of light (separated by a prism), he noticed that the temperature just beyond the red light was highest.

IR is invisible to the human eye, as its wavelength is longer than that of visible light (though it is still on the same electromagnetic spectrum). Anything that emits heat gives off infrared radiation.

There are two types of infrared sensors: active and passive. Active infrared sensors both emit and detect infrared radiation. Active IR sensors have two parts: a light emitting diode (LED) and a receiver. When an object comes close to the sensor, the infrared light from the LED reflects off of the object and is detected by the receiver. Active IR sensors act as proximity sensors, and they are commonly used in obstacle detection systems (such as in robots).

VII. WORKING

The project is focused on developing an integrated system that involves using an FPGA-based PLC and a conveyor belt. This is because conventional PLCs are typically sequential due to the use of microcontrollers or ASIPs at their core, and the implementation of a PLC on an FPGA is a potential solution for this limitation.

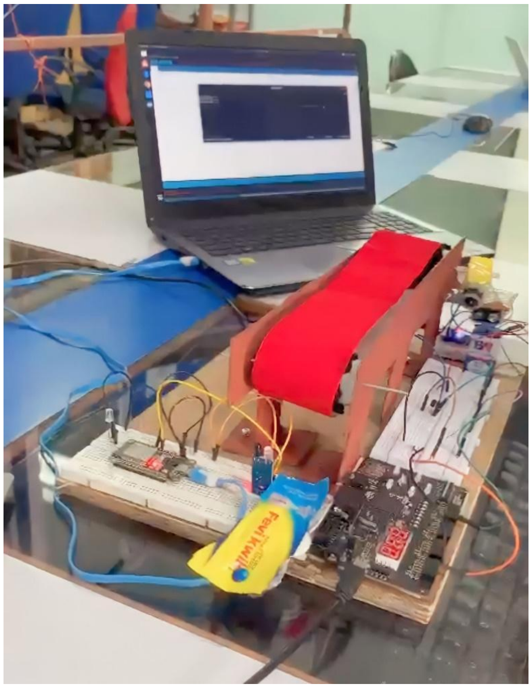
FPGAs contain an array of programmable logic blocks and reconfigurable interconnects that allow blocks to be connected together. These logic blocks can be programmed to perform complex combinational functions or act as simple logic gates like AND and XOR. Additionally, most FPGAs include memory elements, such as flip-flops or memory blocks, that can store data.

The conveyor belt is a critical component of the project, as it is used to move products through various stages of development in manufacturing. The conveyor belt is connected to a motor, which is linked to the FPGA and a timer-based system. This timer-based system provides motor commands that stop the process for a specific period of time. After that, the same process resumes, and the conveyor belt moves the product through various stages of development.

This system has several potential industrial applications, as it can be used to move products through different stages of manufacturing, such as assembly or packaging. Additionally, the entire model can be remotely controlled using an ESP32 WiFi module, which allows for greater flexibility and ease of use.

Infrared (IR) sensors are used in the project to keep track of the number of products passing through the conveyor belt. These sensors use different types of media, such as vacuum, atmosphere, or optical fibers, to transmit the IR signals. Optical components, such as lenses, are used to focus the IR radiation and limit the spectral response. The IR sensors are critical in ensuring that the products are moving through the conveyor belt correctly and that the entire system is functioning as intended.

VIII. IMPLEMENTATION



In order to implement an FPGA-based PLC industrial automation system, we will first need to design and program the FPGA using hardware description languages (HDLs) such as VHDL or Verilog. This programming will require expertise in the domain-specific knowledge of FPGA programming.

Once the FPGA has been programmed, it can be integrated with other electronic components such as sensors, actuators, and motor controllers to create a complete automation system. In our proposed system, the FPGA-based PLC will work in coordination with a conveyor belt that is connected to a motor.

The FPGA will provide commands to the motor controller based on a timer-based system, allowing the motor to stop the process for a certain duration. The PLC will be designed to handle complex automation tasks in real-time, ensuring maximum uptime and minimal maintenance.

The implementation of an FPGA-based PLC offers many advantages over traditional PLC systems, including high processing power, programmability, and flexibility. This makes them ideal for implementing large-scale complex automation tasks in real-time, saving time and money for companies that use them.

In conclusion, the implementation of an FPGA-based PLC industrial automation system offers a cost-effective, efficient, and reliable solution for complex automation tasks in large-scale manufacturing. With the right expertise and programming, an FPGA-based PLC can offer many advantages over traditional PLC systems and can help companies improve their production processes while reducing downtime and maintenance costs.

IX. APPLICATIONS

1. Industrial Automation: Your system can be used to control various industrial machines and equipment remotely, such as conveyor belts, assembly lines, and robotics.

2. Home Automation: Your system can be used to control various devices in a home remotely, such as lights, fans, and other appliances.

3. Healthcare: Your system can be used to control medical equipment remotely, reducing the need for healthcare workers to be in close proximity to patients.

4. Agriculture: Your system can be used to control irrigation systems and other farm equipment remotely, allowing farmers to monitor and control their crops from a distance.

5. Smart Cities: Your system can be used to control streetlights, traffic signals, and other devices in a city remotely, improving the efficiency of public services.

X. CONCLUSION

In conclusion, we have successfully developed a remote control system for industrial machines using an ESP32 and FPGA board. By connecting to an IoT cloud, our system allows users to control and monitor machines from a safe distance, improving efficiency and safety in the manufacturing process. With its potential to revolutionize industrial automation, we hope that our project will inspire further innovation in the field and contribute to making manufacturing processes more cost-effective and efficient.

XI. REFERENCES

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XII. FUTURE SCOPE

1. Integration with other IoT devices and platforms: In the future, the project can be expanded to integrate with other IoT devices and platforms to enable more complex actions and functionalities.

2. Development of advanced control algorithms: The project can be improved by implementing advanced control algorithms to optimize energy consumption and improve efficiency.

3. Integration with more advanced hardware: The project can be further developed by integrating with more advanced hardware to enhance its capabilities and functionality.

4. Expansion to other applications: The project can be expanded to other applications beyond controlling a conveyor belt, such as controlling other industrial machinery or home appliances.

5. Development of a mobile app or web-based interface: A mobile app or web-based interface can be developed to provide users with easy access and control of the system remotely.