**I J C T A**, 9(14) 2016, pp. 6471-6476


# An IoT Enabled Architecture for Programmable Logic controllers

**R. Sasikala[1], Rahul Ramesh[2], Sidharth Vohra[2] and Shreyasi Chakraborty[2]**

**ABSTRACT**

PLCs are used essentially in each and every factory for automating any task such as a car assembly line, or a bottle filling operation etc. PLCs are responsible for collecting data and performing an action based on it. Multiple PLCs in a distributed control system communicate with each other and setting up the communication is a tedious process. This paper addresses the use of IoT as a communication mode for PLCs and also enables powerful data analytics to improve factory output and efficiency.

## 1. INTRODUCTION

PLCs are an essential part of an industry. It can define the efficiency, quality and operating time of any factory with automated processes. Each PLC collects data about the process its working on and acts accordingly. This data can be shared with other PLCs creating a distributed control system, hence enabling a better work flow and higher efficiency. The communication channel setup is tedious but critical for any factory. This paper defines IoT as a communication channel for each PLC allowing PLC to talk to each other wirelessly and also controlled by operators in the same fashion causing reduced setup costs, maintenance expenditure and floor space occupied by physical wires. Internet being the single channel where data from all PLCs are dumped can also be used for performing various BIG data analytics for improving the factory output and efficiency by manifolds.

This paper proposes a new model of PLC which can communicate over the internet incorporating industrial IoT features and also covering tasks which are performed by conventional PLCs.

## 2. DESIGN

Since the PLC designed here is also required to be more cost effective than the regular PLCs, the components chosen were such that they satisfy the latter overall criteria.

The PLC designed was aimed to have the below necessary features:

2.1 A Central Microcontroller

2.2 An Input section responsible for reading various kinds of inputs.

2.3 An output sections of different characteristics for versatile control operations.

2.4 Communication channels for communicating with other devices like other PLCs or computers etc.

2.1 The Microcontroller chosen for the board was the Atmel Mega 2560 because of its high number of input and output pins and it is easy to use Arduino IDE based programming.

[1] Asst. Professor, SRM University, SRM Nagar, kattankulathur, Kancheepuram District, Tamil Nadu – 603203, *E-mail: sasikala.r@ktr.srmuniv.ac.in*

[2] B.Tech graduate, SRM University, SRM Nagar, kattankulathur, Kancheepuram District, Tamil Nadu – 603203, *E-mail: rahulr94@gmail.com*; *sidharthvohra@gmail.com*; *shreoc1212@gmail.com*

2.2 The Input section consists of three parts:

- The analog Voltage Input: This unit measures the analog Voltage from a range of 0 to 12V.
- The 4-20mA current input: This unit is used to measure the analog current of 4 to 20mA current from a current -loop commonly used in industries.
- The selectable gain inputs: This unit has a selectable gain of up to 10,000 for amplifying weak signals from various sensors like strain gauges, thermocouples etc.
- The 24-bit ADC section for obtaining sensor signals with high precision.

2.3 The Output section is further divided into the following sections:

- The relay section for controlling heavy duty appliances.
- The MOSFET section for controlling heavy duty appliances at a high frequency and for generating PWM signals
- The 4-20mA current transmitter for industrial current loops.

2.4 Communication channels for communicating with other devices are as follows:

- CAN controller for inter PLC communication
- Ethernet controller for connectivity over Ethernet cable.
- I2C communication port for communicating over I2C protocol with other devices supporting I2C.
- The Wi-Fi card for connectivity over Wi-Fi for IoT access.
- ZigBee transceiver for wireless data transmission at close ranges for remote access and debugging at a faster rate.

2.2 Some other components were also used such as an inbuilt RTC which can hold up the current time value up to 10 years.

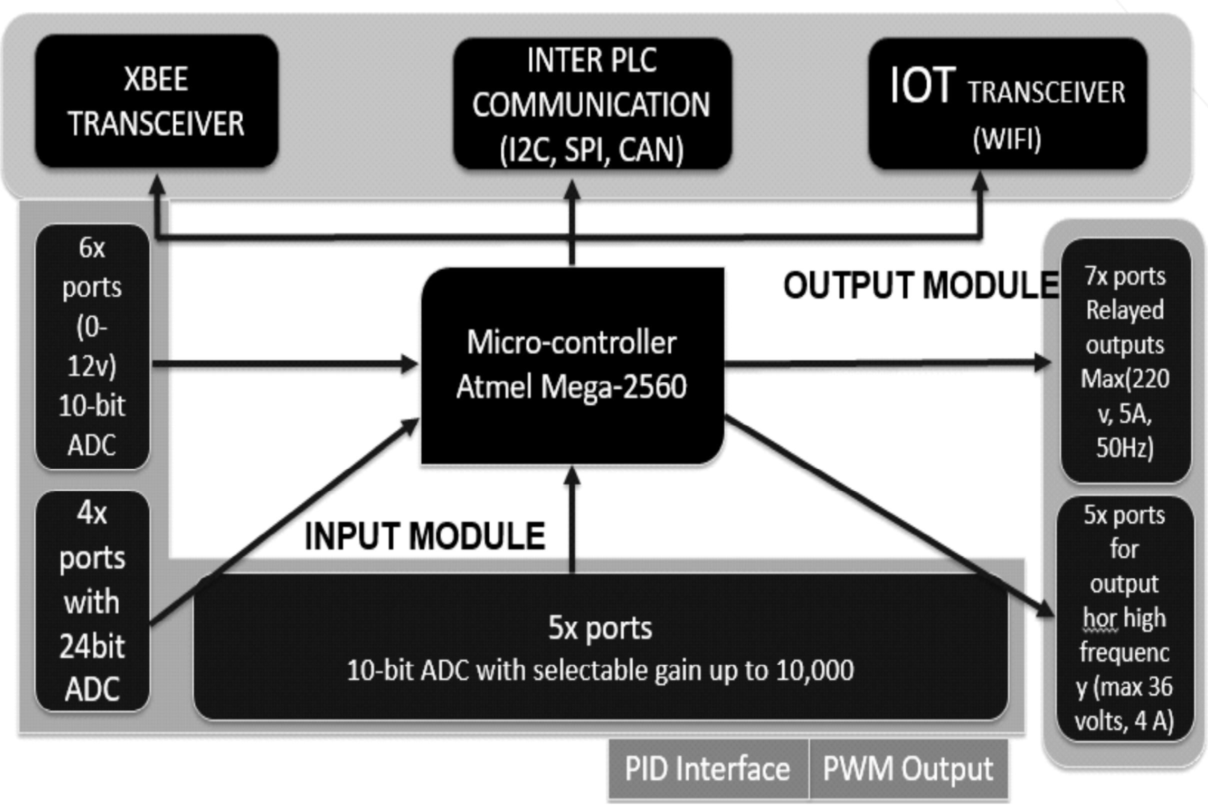



**Figure 1.1: Block diagram of all components**

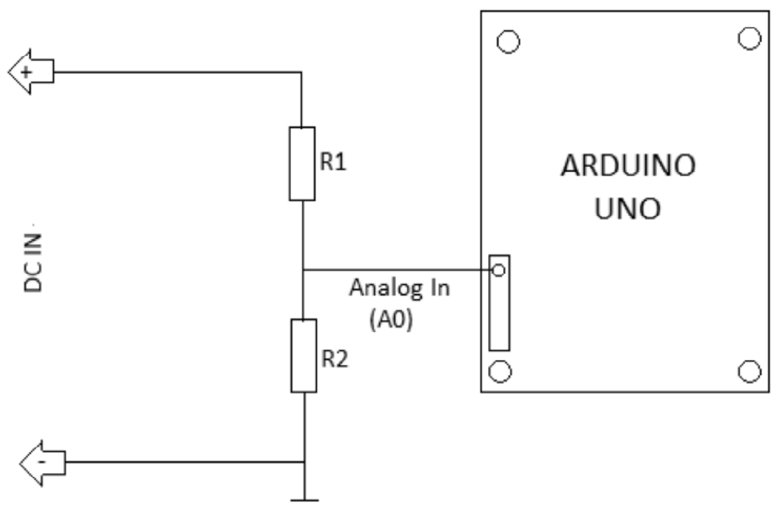
## 3. HARDWARE IMPLEMENTATION

### 3.1. Choice of Microcontroller

The microcontroller chosen was the Atmel Mega 2560 programmed using the ATMEGA 16u2 IC which converts the USB data to Serial data. Atmel Mega 2560 was specifically chosen because of its huge number of I/O pins (52 digital and 16 analog) and its AVR architecture making it compatible to program it using the easy to use Arduino IDE.

### 3.2. Input Modules

*3.2.1* 0-12V Input pins: These pins are connected to a voltage divider circuit which converts the 0-12V range to 0-5V accepted by the microcontroller.




3.2.2 4-bit ADC ports: An external ADC is used to convert the analog Input to a 24-bit digital number which is fed to the microcontroller. The 24-bit ADC used here is the HX711 module manufactured by AVA semiconductors with 3 programmable gain amplifiers.

3.2.3 Selectable Gain amplified Ports: This section consists of AD620 instrumentation amplifiers whose gain value can be changed by choosing an appropriate resistor. Its gain can be set up to a value of 10,000.

3.2.4 Current Input ports: This section consists of just a load resistor converting the input current to a proportional voltage. The resistor used is an uncommon 250ohm resistor. A wire wound resistor was made specifically for this purpose.

### 3.3. OUTPUT Modules

3.3.1 Relay Section: This section consists of relays which are triggered by the microcontroller. Standard relays have a coil current pull of 25mA, hence making it unsuitable for multiple relay triggering. A Darlington pair transistor array IC was used for current amplification hence isolating the microcontroller from the relay section. The IC used here is ULN2003.

3.3.2 4-20mA current output: This section converts the 1-5V signal from the microcontroller to 4-20mA. Since the microcontroller outputs a PWM signal, it was converted to a DC signal using a decoupling capacitor.

3.3.3 High frequency output: Since relays have an operating frequency of 50Hz, a MOSFET section was used for switching powers at high frequency capable of providing PWM outputs.

### 3.4 Communication Channels: The various communication protocols accepted by this PLC is given below

3.4.1 Controller Area Network: CAN protocol is widely used in an industrial level for communication between multiple devices using just two interfacing wires. The CAN protocol was interfaced busing the TJC1010 controller.

3.4.2 I2C port: I2C, like CAN is also capable of interfacing multiple devices under 2 wires, also known as two wire interfaces. Many sensors use I2C protocol to communicate with the microcontroller.

3.4.3 Zigbee wireless protocol: ZigBee is known for its reliability in close range used for its high data transmission rate converting the serial signals to other devices. This was made for wireless debugging and can also be configured for wireless programming.

3.4.4 Ethernet section: The Ethernet controller WS1000j was used to enable Mega2560 in order to access Ethernet channel to transmit and receive data. This can also be used to connect to an ISP for wired internet access.

### 3.5. Miscellaneous Components: Some other features were also added features

3.5.1 An external RTC module was used to store the real time data for a period of 10 years, powered by a CR2032 battery. The RTC is used here is the DS1307 IC for the above operation

3.5.2 GPIO Section: Some pins of the microcontroller were directly accessible to the user for their own applications. As a safety measure, a Zener diode was placed parallel to each pin hence providing ESD protection to each pin.

## 4. SOFTWARE IMPLEMENTATION

The Arduino IDE was chosen to program the PLC because of its ease in operation. A new library was made for simplifying commands keeping in mind that any user can use it.

The IoT interface was designed in HTML using the jQuery library for interfacing the page with the IP address allotted to the IoT module. To divert the traffic from the Internet to the local network of the Wi-Fi Module, a web server was created.

## 5. CONCLUSION

This paper was intended to show how a PLC can be made to communicate over the Internet and how this would change the working of any process. Each and every aspect of the design can be changed based on the user's requirements.

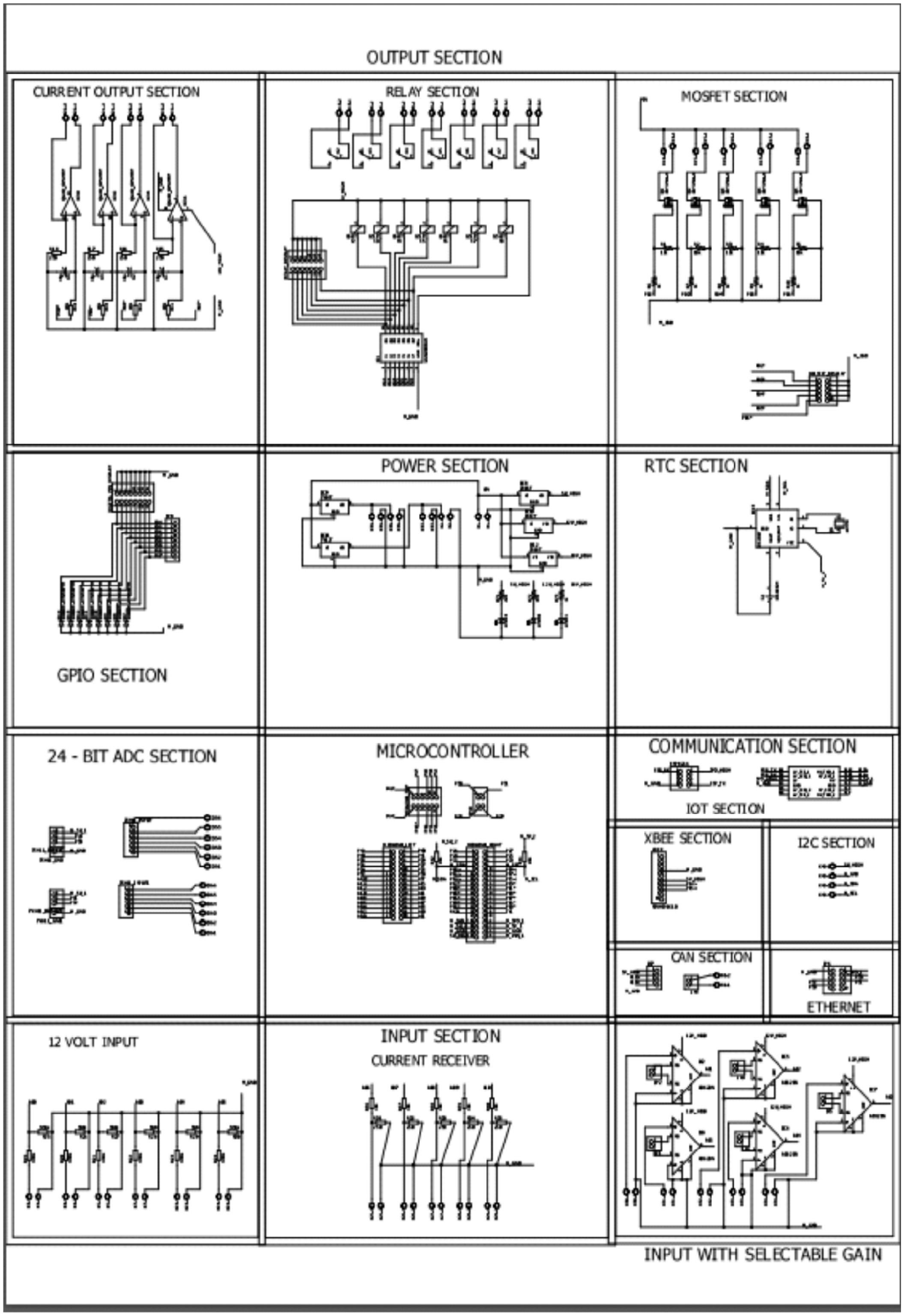
The designed PLC was tested by carrying out simple operations such as water level controlling process, 2-way traffic light control and was also used as a data logger for a jet propulsion test stand. The PLC was also easily integrated in LabView for better GUI designs.

This type of PLC can change how industries work by bringing all bits of data under a single channel, "The Internet", hence providing infinite possibilities of data analytics for improving plant operation.

## 6. SCOPE FOR IMPROVEMENT

There can be many changes made in the physical design for improving the PLC's capabilities, starting with improving the microcontroller like making a 32-bit microcontroller instead of the present 8-bit microcontroller. The PCB design itself can be changed to a much smaller version by adding more number of layers to reduce the overall size of the PLC.

Upcoming trends in inter PLC communication such as Field-Bus and Hart communications are yet to be added to the PLC.




## REFERENCES


[1] Hsieh, Han-Chuan, and Chi-Ha Lai. "Internet of things architecture based on integrated plc and 3g communication networks." Parallel and Distributed Systems (ICPADS), 2011 IEEE 17th International Conference on. IEEE, 2011.

[2] Tao, Fei, *et al*. "CCIoT-CMfg: cloud computing and internet of things-based cloud manufacturing service system." Industrial Informatics, IEEE Transactions on 10.2 (2014): 1435-1442.

[3] Kim, HyungJun. "Security and vulnerability of SCADA systems over IP-based wireless sensor networks." International Journal of Distributed Sensor Networks 2012 (2012).

[4] Moller, Dietmar PF, and Hamid Vakilzadian. "Ubiquitous networks: power line communication and Internet of things in smart home environments."*Electro/Information Technology (EIT), 2014 IEEE International Conference on*. IEEE, 2014.

[5] Houyou, Amine M., *et al*. "Agile manufacturing: General challenges and an IoT@ Work perspective." *Emerging Technologies & Factory Automation (ETFA), 2012 IEEE 17th Conference on*. IEEE, 2012.

[6] Corso, Felipe, Yeison Camargo, and Lina Ramirez. "Wireless Sensor System According to the Concept of IoT-Internet of Things." *Computational Science and Computational Intelligence (CSCI), 2014 International Conference on*. Vol. 1. IEEE, 2014.