Remote Monitoring And Control Of Automation System With Internet Of Things

Aravind C., Suji Prasad S. J., Ponni Bala M.

Abstract: These Remote monitoring control and automation are the most important criteria for maximizing process plant availability production. With the valuation, Industry 4.0, the wireless industrial monitoring system becomes unavoidable. The system should be able to acquire and process real-time data. It is also needed for controlling related instruments to change the environmental factors and monitoring in long distance. The development and implementation of real-time analysis of process parameters through data acquisition and status monitoring using Ethernet through Programmable Logic Controller (PLC) are presented in this paper.

Index Terms: Automation, Internet of Things (IoT), Industry 4.0, Remote Monitoring and Control, PLC

1. INTRODUCTION

The fourth industrial revolution, Industry 4.0, concentrates on the individual customer and life cycle of products rather than organization and control. Industrial internet, smart sensors, manufacturing and control with the cloud can be achieved through the Internet of Things (IoT). Focus on continuous improvement; value addition and optimization are significant concerns in Industry 4.0 [1-3]. Integration of the new technologies with existing will accomplish in high-quality Industry 4.0. The combination of interdisciplinary or transdisciplinary information industries will improve the quality of control. The success of Industry 4.0 is contributed by advanced information and communication technology tools [4]. The industry is ready to adopt wireless sensors and actuators to improve their production and quality. The IOT services already started dominating day to day life. The studies IOT are showing availability of different IoT protocols, lack of industry standards and interoperability issues [5]. With voice commands and smart phone, most of the home applications can be controlled. With dedicated App, Google assistant and microcontroller home automations systems are developed [6]. An IoT based system with standard protocols for monitoring different industrial applications. The authors developed a method for monitoring liquid level and dc motor speed control applications. The proposed system consists of MODBUS and TCP protocol for communication of data with the internet [7]. A model is developed for monitoring and control parameters in the agricultural farm which gathered data from sensors that work autonomously [8]. Through IoT the signals were transmitted and actuators were enabled through the internet. The users are also provided with farm information. Joshi et al. [9] facilitated the introduction of user interfaces for web-based IoT applications. Access to the control system is provided to the end-user through web URLs. A middleware is developed to connect the IoT systems with process automation. Kavitha and Gopakumar [10] presented various methods used to measure and record the parameters of equipment running in an industry. The temperature, power consumption, voltage and speed of rotation to gateway section using CAN protocol. The controller took control of operations by shutting down the process. Kadiyala et al. [11] presented the advancement of a modern checking system because of internet technology. The system is suitable for real-time industrial monitoring. The design is implemented on the ATmega board. The client collaborates with the system to send all the commands from various sensors over the internet and shown in the LCD. The outline was tried, actualized and the accuracy and working of the system were verified. Ferdin Joe John Joseph [12] implemented a weather monitoring system using Raspberry Pi as per the required specifications and the data insights are generated in web-based portal. The access to this data is available in the intranet with the current level of implementation and it could be made public when the information is made to store in cloud servers or other sources on the internet.

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1 METHODOLOGY

In conventional methods, the industrial parameters are monitored through individual analog displays. The industrial process parameters are measured with various types of sensors and the microcontrollers scale the measured values for the LCD. The control actions are also performed by the microcontroller or manual. The microcontrollers lack fail-safe operation and isolation from field devices The existing method requires more manual power to monitor the industrial parameters and monitoring of parameters continuously under critical conditions is difficult. The troubleshooting and unloading of programs in microcontrollers are complicated. The huge number of sensors and actuators in large scale industries lead to higher copper cost. The quality of the cable deteriorates and leads to aging. The wireless communication will be an alternative for the above-said problem [13].

2.1 Proposed Methodology

The parameters, such as temperature and pressure, are monitored and controlled in through Ethernet. The data can be accessed from one server to another server by using IoT. Temperature is through thermocouple and pressure is measured using Differential Pressure Transmitter (DPT). The measured data can be monitored by the Arduino, where the data outputs will be displayed. The temperature output will be monitored by Celsius (^{0}C) and Fahrenheit (^{0}F). The pressure output will be monitored by pounds per square inch (psi). These data were given to the PLC and the required amount of data can be controlled. The process will be handled automatically with PLC. So it reduces the manpower requirement in the industrial monitoring field. It also attains good stability at high temperatures [14], [15].

2 MATERIALS USED

This section describes the block diagram of the methodology used and detailed explanation of hardware which have been used to monitor the data.

3.1 Block Diagram of Sensor Monitoring

Fig. 1 shows the block diagram of the overall system. Two sensors are going to monitor and control the parameters like temperature and pressure respectively. Their output will be monitored and controlled by PLC's. Each Input Output Module (I/O) channel of PLC can select a variety of industrial process parameters such as temperature, pressure through sensor banks. The PLC directly supports Ethernet communication.

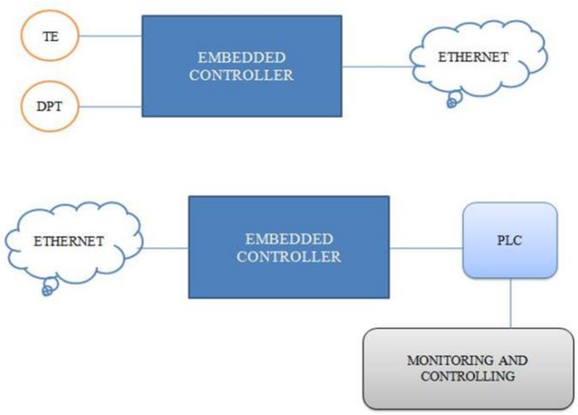

Fig. 1 *Block Diagram of Sensor Monitoring*

From Fig. 1, the temperature and pressure output data will be given through Ethernet and PLC will monitor the required data.

3.2 Hardware details

Table 1
Hardware details

S. No	COMPONENTS REQUIRED	SPECIFICATIONS
1	ESP8266 NodeMCU	128KB Memory
2	MAX6675ISA Thermocouple	-20°C to +85°C(8Pin SO)
3	Differential Pressure Transmitter (DPT)	0 to 24V
4	Arduino UNO	0 to 5V
5	Siemens PLC	24V
6	Ethernet Shield	0 to 5V

3.3 Material Description

MAX6675 thermocouple is used to measure temperature. The equivalent temperature values are obtained by compensating for the difference between the thermocouple cold-junction side (MAX6675) and a 0°C virtual reference. For a type-K thermocouple, the voltage changes by 41μV/°C, this approximates the thermocouple characteristic with the following linear equation:

$$V_{out} = (41\mu V/°C)5(T_R - T_{AMP}) \quad (1)$$

where,

V_{out} is the thermocouple output voltage (μV).

T_R is the temperature of the remote thermocouple junction (°C).

T_{AMB} is the ambient temperature (°C).

The DPT is used to measure the differential pressure between two measured pressures and produce output current for the calibrated pressure range. The output current generated is directly proportional to the pressure range of the DPT. The current range is from 4mA to 20mA. Programmable Logic Controller is an industrial digital computer that has been ruggedized and adapted for the control of industrial processes, such as assembly lines, or robotic devices, or any activity that requires high-reliability, ease of programming and process fault diagnosis. It is used for the monitoring of process parameters and adjusts accordingly. It can be programmed and operated by even an unskilled operator person. The algorithm for both temperature and pressure controller is programmed into the programmable logic controller using ladder logic programming. Necessary inputs will be obtained from the temperature transmitter and pressure transmitter. The input leads are connected to the PLC which bears specific addresses for every input terminal and so is the case with the output too. These addresses are noted down for the sake of ladder logic programming. The ladder logic program can be designed according to the specific necessary cascade control scheme. The control scheme may vary for every industrial process. The industrial process can be monitored on a computer screen, a data representation of the process to provide a control facility.

3.6 Data Logger

The Data Logger comprises of Arduino as the central controller, Ethernet shield for Ethernet communication, RS485 module for communication, GSM Modem and NodeMCU for logging the data to the network server. NodeMcu is an open-source IoT platform. The firmware in it runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. Modbus is a serial communication method used for transmitting information over serial lines between electronic devices. The Modbus Master requests the data and the devices supplying information are Modbus Slaves. In a standard Modbus network, it has one Master and up to 247 Slaves.

3 SENSOR INTERFACING

Interfacing computer systems with the outside world is an important issue in a large number of computer-related disciplines, from human-computer interaction to robotics, to interactive multimedia, to computer music. To do this, computer systems require some form of sensors. Thus this chapter shows the overall view of interfacing sensors with hardware to bring out the output data.

4.1Internet of Things (IoT)

The IoT allows the temperature to measure and monitor the output. The sensed output exists in network infrastructure and creates direct integration of the physical world into computer-based systems. It results in improving efficiency, accuracy and economic benefit in addition to reduced human intervention.

From Fig 2, the industrial parameters like temperature is sensed by the sensor like thermocouple MAX6675 and monitored by the individual microcontrollers.

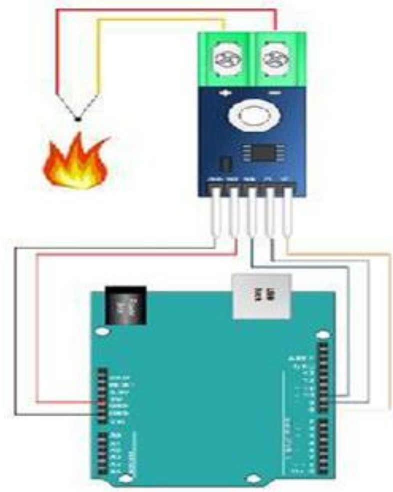

Fig. 2 *Interfacing Thermocouple with Arduino*

The signal is manipulated through the signal conditioning circuit. The manipulated signal is given to the session border controller, which transmits the network from one part to another. Then the required signal is passed through the wireless router and the output is monitored through the server from anywhere.

4.3 Configuring PLC with MODBUS over Ethernet

The measured sensors like thermocouple and DPT are connected with the proper PLC and coding has been done. The connection must be checked and the Siemens PLC has processed the monitored data output through ethernet. The data can be verified and controlled according to the user.

4.4 Interfacing PLC with ARDUINO

Interfacing PLC with Arduino using Ethernet Shield with Modbus Protocol is shown in Fig 3. In PLC, the 0-5V variable power supply is connected as Analog source using the Analog Module in Siemens S7-1200PLC. By using ladder logic programming PLC configuration, in which the analog source voltage is approximated and the value is transferred to over the Ethernet using Modbus protocol and PLC is conFigd as Modbus server. Arduino is conFigd as Modbus client using the Modbus library.

Fig. 3 *Interfacing PLC*

The float value obtained from the PLC and uploaded to the webserver shown in Fig. 4

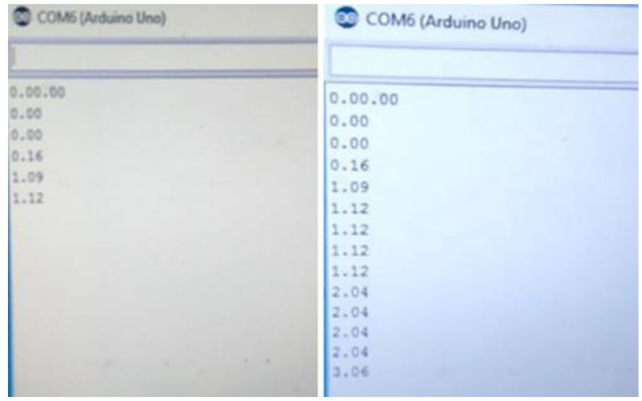

Fig. 4 *Data Received in web server*

4 DPT INTERFACING

5.1 Interfacing of DPT

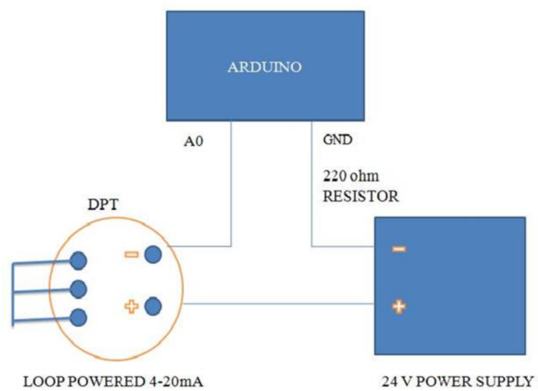

Fig. 5 *Interfacing of DPT*

From Fig 5, the sensors work based on the 4-20mA standard current loop measurement, i.e. The lowest value is 4mA and the maximum value is 20mA correspondingly to the real-time environment. The thermocouple is used for the measurement which works on the 24V DC. A 220-ohm resistance is connected in series with the current loop and the Arduino Analog port is connected in parallel with that 150-ohm resistance. Any range of resistance can be taken as reference; to get the output 220ohm is chosen. The Resistance and the parallel circuit is used to generate the voltage output corresponding to the current flow in the sensor current loop. The testing is done by connecting the circuit to the water flow model with DPT sensor and the corresponding current value is uploaded to the webserver using GSM or Wifi Module.

5.2 Interfacing of Thermocouple

A Type K thermocouple is inexpensive and reasonably accurate. Here we have a temperature range of 0 ˚C to 1024 ˚C. The MAX6675 digitizes the signal from a type-K thermocouple shown in Fig.6. The 12-bit resolution output data is SPI-compatible read-only format.

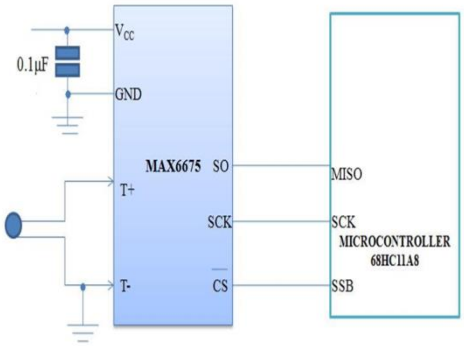

Fig. 6 *Interfacing of Thermocouple*

5 RESULTS AND DISCUSSIONS

The pressure sensor works based on the 4-20mA current loop measurement and the DPT is calibrated with HART calibrator for 0 to 2 kg/cm2. A 220-ohm resistance is connected in series with the current loop and the signal is given to Arduino. The K type thermocouple is used for the measurement and the MAX6675 module performs cold junction compensation. The digital signal is given to the Arduino module. The process measurement is done with the corresponding current value is uploaded to the webserver using the Wifi Module. The real-time experimental model is shown in Figs 7 and 8.

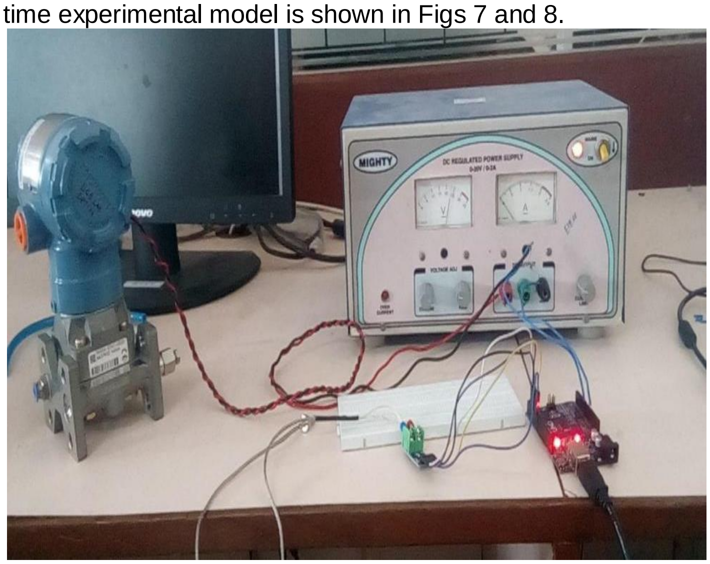

Fig. 7 *Real-Time Sensor Interfacing*

Fig 8 *Real-Time PLC Interfacing*

From the above Fig, it is evident that the pressure sensor and temperature sensor are connected to the Arduino board and the data are stored in the cloud storage. The data is also updated in the through MODBUS communications. The control actions performed by the PLC are also updated in the cloud storage. The voltage changes with respect to temperature changes as shown in Fig 9.

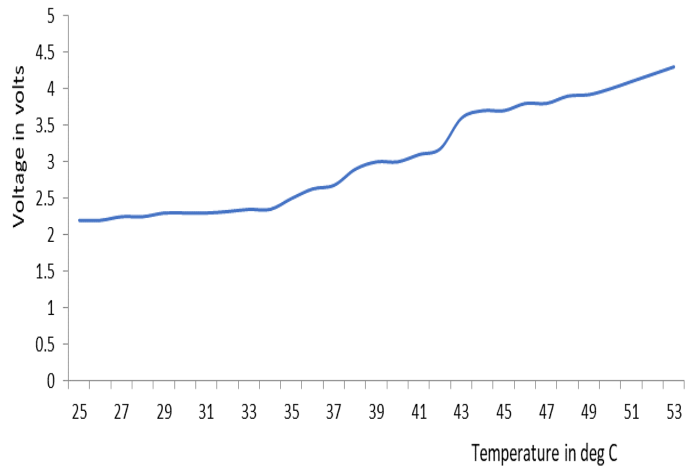

Fig. 9 *Voltage vs. Temperature*

The thermocouple senses the temperature variations and the voltage varies linearly with the temperature. There is a considerable rise in voltage after 350 C which is due to the self-heating of the vessel used. The PLC will cut off the heating system when the set temperature is reached. The current changes due to the change in pressure are shown in table 2

Table 2
Pressure vs Current

Pressure kg/cm^2	DPT output mA
0	4
0.2	5.56
0.4	7.19
0.6	8.8
0.8	10.38
1.0	12.01
1.2	13.6
1.4	15.18
1.6	16.8
1.8	18.4
2.0	20

From the above table 2, it is observed that the current output varies for the calibrated 0-2 kg/cm2 DPT. The high-pressure side of the DPT is connected to the chamber and low-pressure side is open to the atmosphere.

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