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Implementation of Wireless SCADA System for Al-Tahady ESP

Rawnaq Maher Afram[1] **Anas Ali Hussein**[2] **Mehdi J. Marie**[3]
[1&2]Al Nahrain University / College of Engineering/Computer Engineering Department, Baghdad, 00964, Iraq
[3]Ministry of Industry and Minerals, Baghdad, 00964, Iraq
rawnaqmaher@yahoo.com anasali78@yahoo.com mehdijelo@gmail.com

Abstract

Wireless technologies are rapidly being adapted from simple monitoring and control to supervisory control and data acquisition (SCADA) systems. Wireless provides highly reliable data communications in the hard and interference-heavy conditions. In this article, a new wireless SCADA system has been built to control the electrostatic precipitator (ESP) in Al-Tahady site/Al-Zawraa state company wirelessly. Two wireless devices are used Rocket M5 and AirLive_WHA-5500CPE which utilize the Wi-Fi wireless technology and the IEEE802.11/b standard was used. They used as a transceiver for sending and receiving the information between the master station (MS) and Programming Logic Controller (PLC). A more detailed focus on Iraq cement plants using wireless technologies for monitoring and control of the whole process as an application also was presented.

Keywords : Wireless SCADA systems, WiFi, PLC, MS, Rocketm5, AirLive_WHA-5500CPE

تنفيذ نظام سكادا لاسلكي للمرسب الكهروستاتيكي لموقع التحدي

رونق ماهر افرام [1] **أنس علي حسين** [2] **مهدي جلو مرعي** [3]
[2&1]جامعة النهرين / كلية الهندسة / قسم هندسة الحاسوب، بغداد، 00964 ، العراق
[3]وزارة الصناعة والمعادن، بغداد، 00964، العراق
rawnaqmaher@yahoo.com anasali78@yahoo.com mehdijelo@gmail.com

الخلاصة

شهدت التقنيات اللاسلكية تكييفا سريعا في مجال المراقبة والتحكم البسيط وصولا الى نظام السكادا. توفر الشبكة اللاسلكية اتصالات موثوقة للغاية في الظروف الصعبة وشديدة التداخل. في هذه المقالة، تم تنفيذ نظام سكادا لاسلكي جديد للتحكم في المرسب الكهروستاتيكي في موقع التحدي / شركة الزوراء العامة لاسلكياً. حيث تم استخدام جهازين لاسلكيين Rocket M5 و AirLive_WHA-5500CPE اللذان يستخدمان تقنية (الواي فاي) اللاسلكية و (استخدام معيار IEEE802.11 / b.) كجهازي إرسال واستقبال لإرسال واستقبال البيانات بين المحطة الرئيسية ووحدة التحكم المنطقية . كما تم التركيز على مصانع الأسمنت في العراق باستخدام تقنيات لاسلكية للتحكم ومراقبة تطبيق العملية.

الكلمات المفتاحية : انظمة سكادا اللاسلكية، واي فاي، وحدة التحكم المنطقية، المحطة الرئيسية، Rocketm5، AirLive_WHA-5500CPE

1. INTRODUCTION

SCADA is a process control system that enables a site operator to monitor and control processes that are distributed among various remote sites. A properly designed SCADA system saves time and money by eliminating the need for service personnel to visit each site for inspection, data collection/logging, or make adjustments. SCADA systems are computers, controllers, instruments; actuators, networks, and interfaces that manage the control of automated industrial processes and allow an analysis of those systems through data collection. They are used in all types of industries, from electrical distribution systems to food processing, to facility security alarms[1].

The electrostatic precipitator (ESP) is a filtration device that removes fine particles, such as dust and smoke from the gas stream using the power of the electric charges and electrostatic principles.

The cement plants are considered as hazardous places that contain a lot of dangerous materials and emits huge quantities of air pollutants such as Cox, Nox, Sox, and dust. These elements cause a lot of diseases and affect the sanitary in general. There are many ways by which they treat these emissions, such as bag filters, wet scrubbers, and dust filters (ESPs) as Al-Tahady ESP shown in Figure 1. The ESP efficiency is approximately 99.8% which is the best one between other types[2]

The motivation of this paper is "to build new monitoring of the pollution system by environmental agencies. The use of the wireless SCADA network will serve to monitor and control the pollution inside and outside the plant the experiment is addressed the use of Rocket M5 as a transceiver and AirLive_WHA-5500CPE as a receiver for control and monitoring in the SCADA systems. The characteristic is a medium distance communication (200m), medium speed, low power dissipation, and low cost. Application wireless communication technology makes that uncomfortable wire repeat can be avoided in the area of a home, factory, hospital, etc[1].

Figure 1. Al-Tahady ESP

2. Related Work

In 2014, Rishabh Das, Sayantan Dutta, Anusree Sarkar and, Kaushik Samanta. [3] presented a Practical experience that helps in controlling the Features and ON/OFF states of three types of control valves: Linear Valve, Equal Percentage Valve, Quick Opening, or On-Off Valve. Utilizing SCADA and PLC, SiemensS7-300 is used, the ladder logic was written in Siemens SIMATIC manager, The PLC is connected to the computer by Interface Module (IM). HMI has built via Siemens WinCC V5.5. The task promptly accomplishes the point of automating and controlling the valve attributes. It requires less human liberality and works effectively to create better findings.

In 2014, J. Li et. al. [4] developed a measurement and control system based on Siemens PLC S7-300 for this Helium Liquefier. The HMI is accumulated utilizing Siemens design programming WinCC V7.0. The PC linked with the PLC by methods of industrial Ethernet.

In 2015, Ahmed KH. et. al. [5] gave a solution to plan the application process by utilizing SCADA system and deal with another system determined in the organization of process, Figure the record and make supply chain report, and expecting of accomplishment or failure of the system. The manufacturing process is designed by using SCADA simulator which is WINCC v6.0, the management system of the operation is done via an open ERP v7.0 simulator. The integration between the two systems accomplished by the OPC server.

In 2017, V. B. Kumbhar et al. [6] managed the implementation of SCADA system using PLC, the designed Visual Basic (VB) based SCADA is commensurate with: A real-time view of the industrial process, reduction in the downtime and troubleshooting time for faults, the safety of operating personals. This paper is an effort to show that VB can be successfully implemented for the Packaging machine as a SCADA alternative.

In 2018, V. Gupta [7] showed a motor speed controlled by the driver as an open-loop control system. To make a more accurate closed-loop control of motor speed a tachometer was used (revolution-counter, tach, rev-counter, RPM gauge) to measure the speed and feed it back to the PLC, which compares to the desired value and take a control action, then the signal is transferred to the motor – via driver – to increase/ decrease the speed. We will measure the speed of the motor using an incremental rotary encoder by adjusting parameters (PLC, driver), and also, we need to reduce the overall cost of the system. Our control system will be held using the available Siemens PLC.

3. Wireless Communication

Wireless technologies are increasingly being developed to be used in simple applications to large SCADA systems. Wireless networks can provide highly reliable data communication in hazard and interference-heavy environments. Figure 2 illustrates a schematic diagram of wireless SCADA system. Compared with traditional cable-based circuits, wireless technology offers advantages, including increased flexibility, easy installation and cost savings. All wireless systems operate on some frequency, communicate some distance and offer some data rate. These factors affect each other, so it is important to find a compromised method to satisfy the requirements for a certain application[8].

The identifier for radio is the frequency. There are three frequencies, 900MHz, 2.4MHz and 5GHz represent the Industrial, Science and Medicine (ISM) bands. In radio network, once a signal has left the antenna and communicated over the air, energy continues to be lost over the communication path which is a function defining lost energy at frequency over a distance. As the frequency and distance increase, then free space loss does[9].

Another aspect of communication is the data rate. A radio does not operate at one frequency; instead, it does in a band of frequencies. This band can be used in its entirety or in smaller sections, typically called channels. The spectrum that the radio operates in (weather it is an entire band or specific channels) is considered radio's channel bandwidth. A high-speed radio uses a wider channel bandwidth regardless of the transmission method. Channel bandwidth refers to the amount of data that can be transmitted by radio signal. It is measured in bytes transferred over a period of time (Kbps or Mbps). Higher speed communication requires a wider bandwidth making high speed radios more susceptible to interference.

There are different data transmission modes. They have various unique characteristic. These variations result in the ability to communicate different amount of data at varying distances. Table 1 shows wireless technologies used by SCADA system. One or more of the following transmission methods can be used in each of the wireless technologies[2]:

- Fixed frequency
- Frequency hopping spread spectrum (FHSS)
- Orthogonal frequency- division multiplexing (OFDM)

- Direct sequence spread spectrum (DSSS)

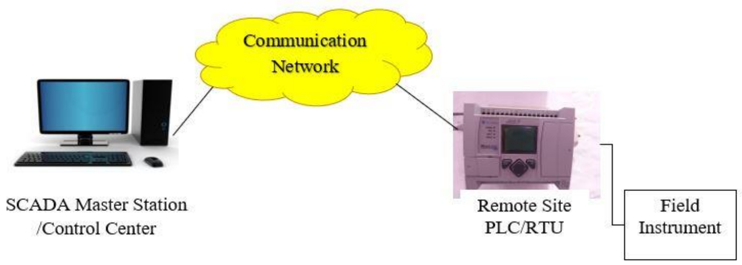


Figure 2. Wireless connection between MS and PLC/RTU

Table 1. Short-range wireless SCADA

Property	WUSB[1]	BLUETOOTH	Wi-Fi[2]	WiMAX	Zigbee
Range(m)	10	10	50 a-100 b/g	up to 2000	10-100
Frequency GHz)	24	24	2.4-5.4	5.8	2.4
Rate (Mbps) **Power** **Complexity** **Application** **SCADA suitability**	0.62 Low Low PC[3] Low	1 Medium Low PDA[4] Low	11-54 High High PC, Security Medium	75 High High ---- Medium	20 0.2 - 0.4- 2.5 Very Low Low High

[1]: Wireless universal serial board

[2]: Wireless - Fidelity

[3]: Personal computer

[4]: Personal digital assistant

4. Implementation of SCADA Wireless System

The system is composed of the power supply, transforming unit and controlling unit. The system components are connected together by a network. There are many types of sensors that are used to detect the ESP functionalities, position and transmit the status of the ESP to PLC. PLC is the controller that receives the status of the sensors and makes a decision according to its program. This decision is used to drive the sequence of operations of the ESP.

The implemented system will control and monitor ESP operations and will ensure that sufficient monitoring is maintained. This system can be used everywhere in industrial applications. Failures can also be monitored. The Block diagram of the system is shown in Figure 3.

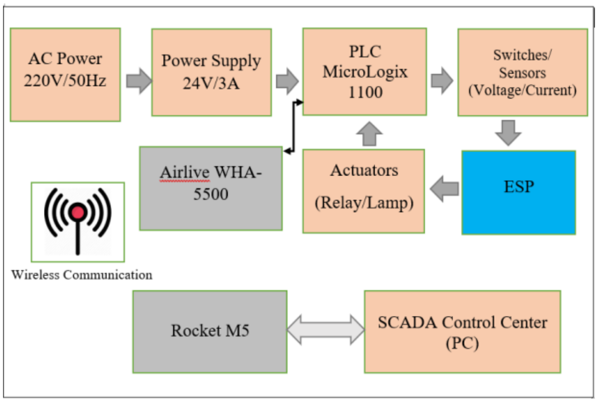


Figure 3. Block Diagram of the System

4.1 PLC CONTROLLER

The system implementation of smart control and monitoring for ESP wirelessly involves both hardware and software components. The hardware components include PLC as a controller, input, and output hardware interface modules. Allen Bradley MicroLogix 1100, 1763-L1BBB PLC[10] is used as a programmable controller which uses Rockwell Software (RS) Logix 500 as control logic software, running on the host computer terminal. The development of the software program and its implementation using PLC.

The MicroLogix 1100 controller provides flexibility and power to control a wide variety of devices. The compact design, flexible configuration, and powerful instruction set combine to make the MicroLogix 1100 a good solution for controlling the implemented system.

PLC serves as the major controlling unit of the presented work, As shown in Figure 4, Allen Bradley MicroLogix 1100 PLC consists of the digital and analogue input port, output port, power port, and communication port.

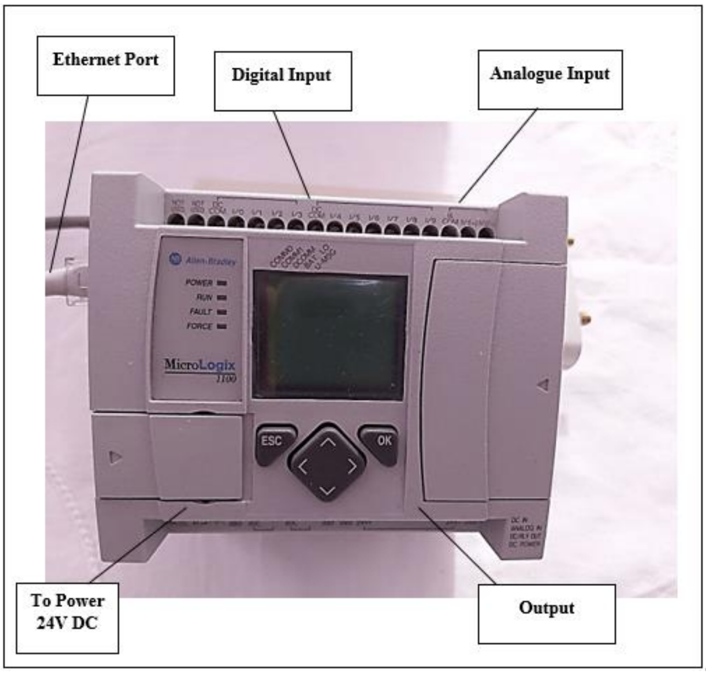


Figure 4. MicroLogix 1100 PLC

5. SYSTEM OVERVIEW

The system consists of PLC and wireless communication devices that connected the field instrument (ESP) with the SCADA wirelessly. PLC can be programmed by RSLogix 500 MicroLogix via either RS-232 port or Ethernet port on a PLC processor. This software comes with

RSLinx ™ which provides a connection between PLC and PC as shown in Figure 5.

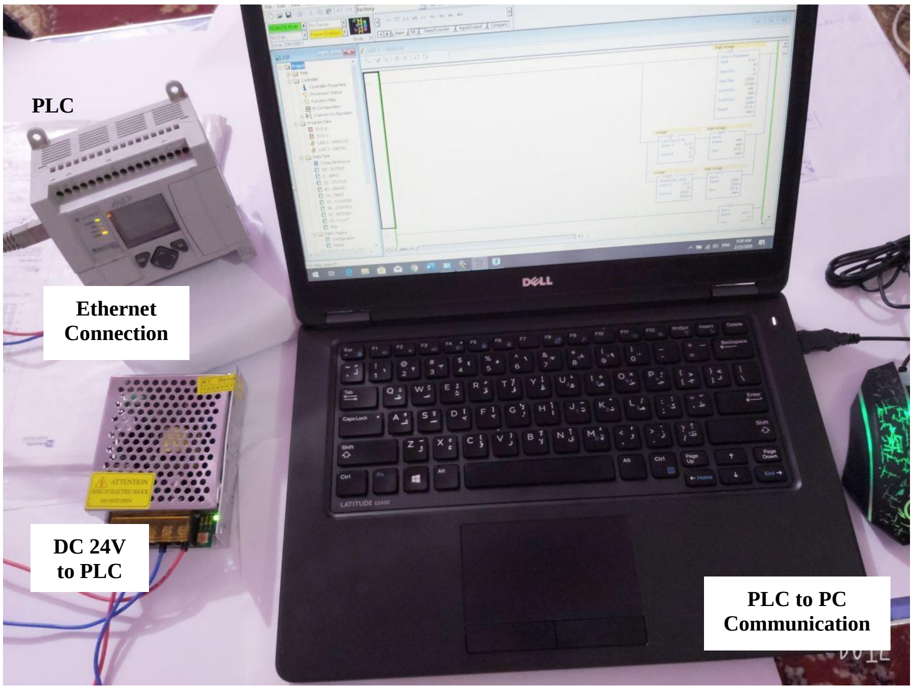


Figure 5. PLC to PC Communication

After the program is started, the new project is created to select the devices. and then open RSLinx to provide the real connection between PLC and the computer with Ethernet cable with IP address 192.168.1.45, when the connection established, The Ethernet / IP in RSLinx selected to activate PLC connection with the program in RSLogix500. RSLogix 500 software was used to control and monitor some units of ESP. In the first step the tags of all digital and Analogue inputs, outputs were added. Then the ladder diagram (main) was built to do the required actions for this project.

5.1 BUILDING THE SCADA SOFTWARE

This part presents the collected data from the ESP to build SCADA components (HMI, operating, alarm, and other components).

After preparation, the field instrument unit, process control unit, and the master terminal unit, The SCADA components were represented by using FactoryTalk View software to form a control panel screen. The control panel screen was used to help to visualize the values that were generated in the process. So, when any sensors and actuators operated, the figure that represented it on the screen would turn on as shown in Figure 6.

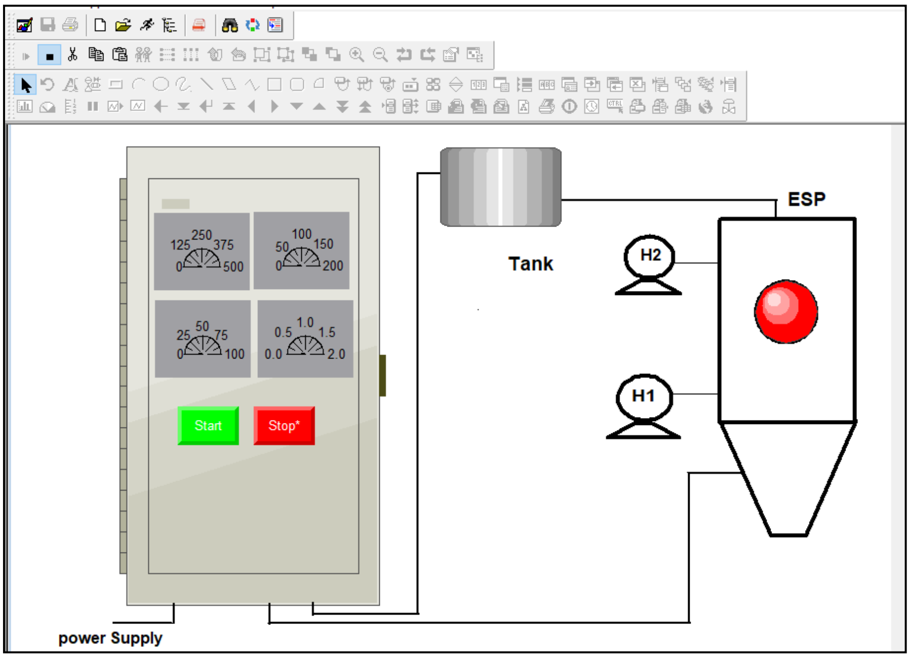


Figure 6. SCADA in RSLogix 500 MicroLogix

6. Wireless Communication Implementation

The first step of the communication is implemented by using OPC protocol in FactoryTalk view to creat communicate between the Hardware and Software (PLC with Program in PC) OPC service was used to enable MicroLogix 1100 PLC software (RSLogix 500 MicroLogix) to communicate with FactoryTalk view, OPC service configuration can be described below.

A- Established the connection by choosing an Ethernet / IP driver in RSLinx Classic Late and insert the IP for PLC [192.168.1.45].

B- DDE/OPC in RSLinx is used to create the connection to OPC in the FactoryTalk view by creating the new topic connected to PLC activated.

C- After then the OPC Data server connection in FactoryTalk view is created by choosing the same topic name and RSLinx OPC server to enable the PLC and activated the tags connection between the RSLogix 500 MicroLogix and the control panel screen.

Figure 7 show the hardware components and devices used to set up and to create a wireless connection to control and monitor ESP wirelessly.

The control room of the ESP in the Al-Tahady site contains the main components (sensors and actuators) that connected to PLC to control the operations in ESP as shown in Figure 8.

Figure 7. Hardware Components

Figure 8. ESP Control Room

7. The Steps for connecting PLC and SCADA are as follows: -

First Step: - The AirLive_WHA-5500CPE Connected to PLC via Ethernet cable after setting up the wireless setup in AirLive, the access point wireless operation mode selected and configure the wireless and WAN settings, The IP address set to [192.168.1.5] and the network name SSID is (airlive), Radio mode 11a (the IEEE standard for

Wi-Fi operating in the 5GHz frequency band) was chosen because 11a is the most stable mode and guarantee Less packet loss and connection.

The required distance 200 and the best output of power is about 14dBm for 200 meters and 11a [11]. The settings show in Figure 9. The airlive acts as an access point to distribute the IPs to the stations.

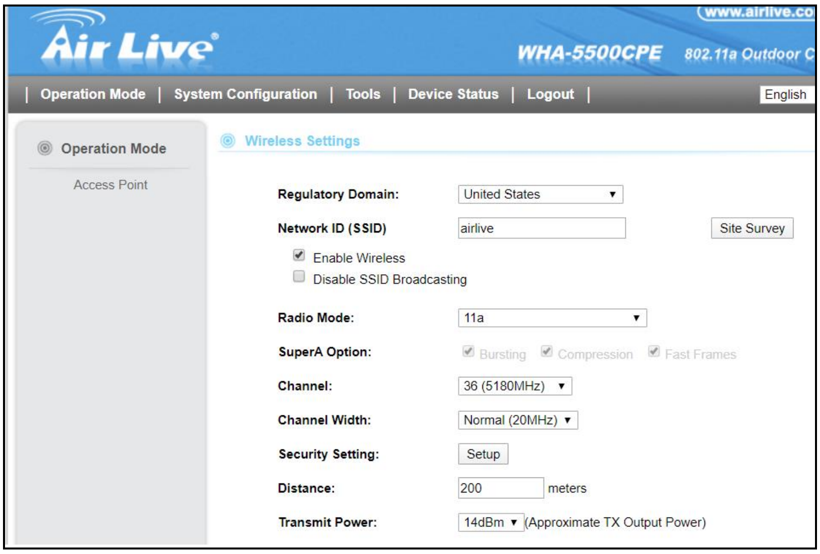


Figure 9. Airlive Settings

Second Step:- The rocket m5 is connected with the master PC that represents the SCADA via Ethernet to control and monitor the ESP operations wirelessly. The rocket m5 set to IP address [192.168.1.20] and as a station to send and received the signal from the airlive that connected with PLC. The wireless configuration in the rocket m5 is shown in Figure 10.

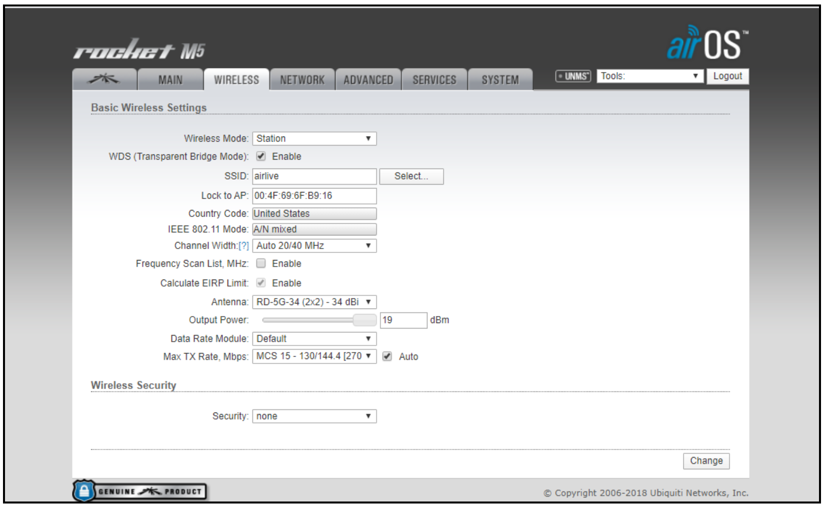


Figure 10. Rocket m5 Wireless Settings

Third Step:- Test the connection quality by monitoring the strength and speed of the transmitted and received signal, as well as checking the speed of PLC response to the signals sent to it as shown in Figure 11.

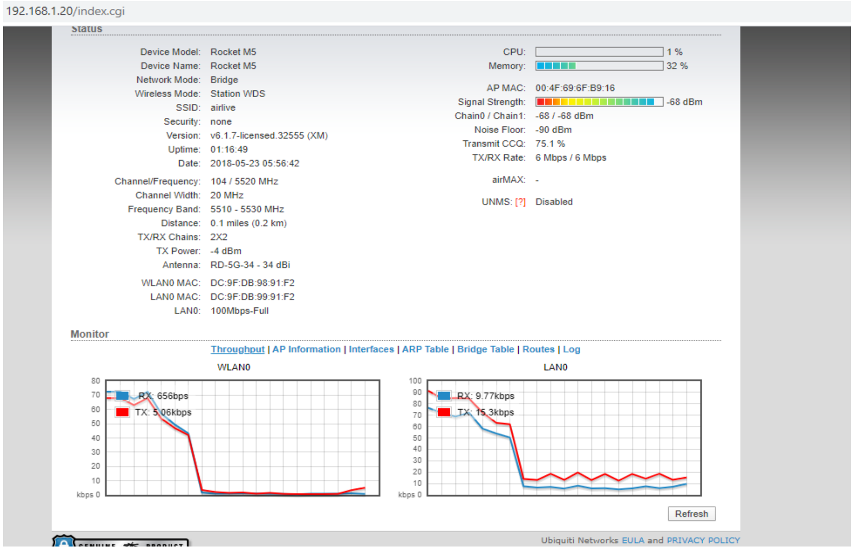


Figure 11. The Wireless Connection

When the SCADA starting to operate the ESP, it sends the signal via Rocket m5, on the other side the airlive receives the transmission signal and transmits it to PLC, PLC starts the process of operating the ESP according to the instructions and then return the signals to SCADA for monitoring its work. Figure 12 shows the inputs and outputs of PLC according to Instructions.

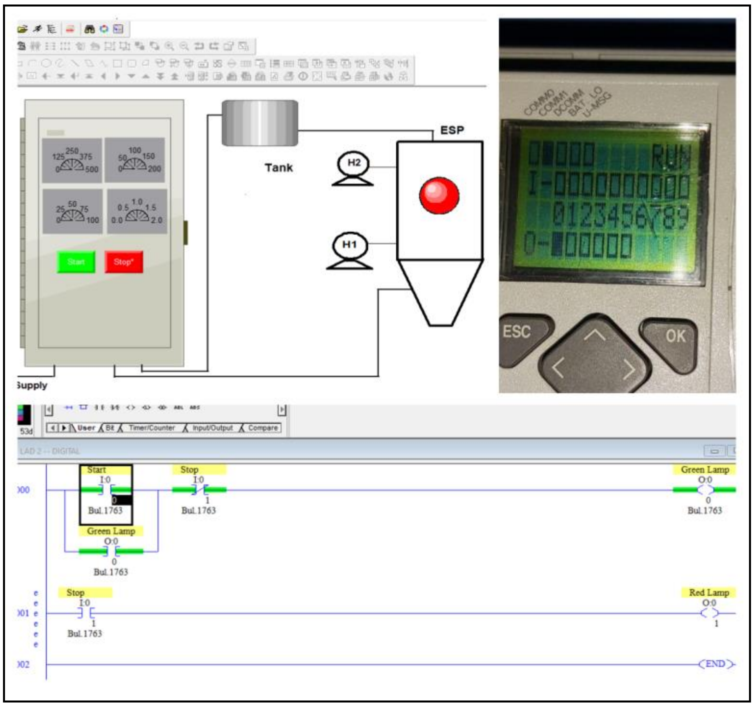


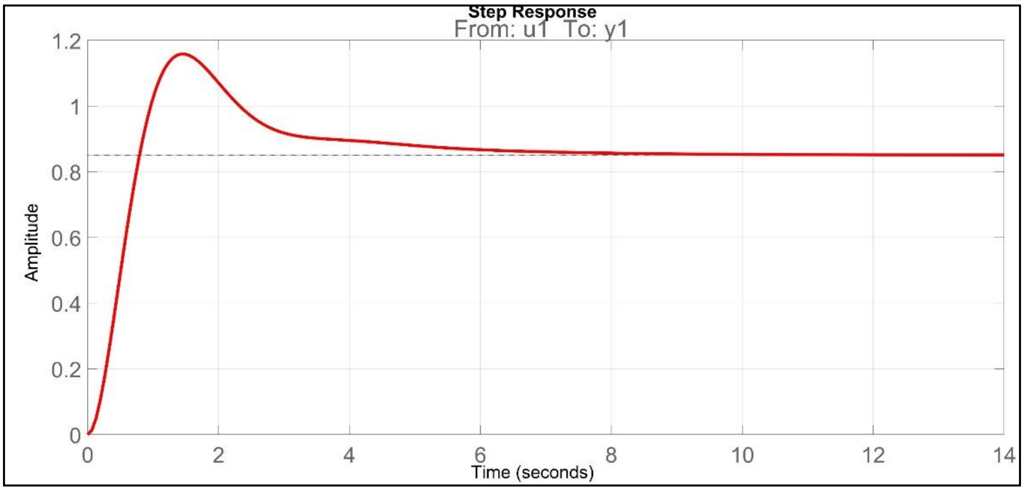
Figure 12. Switching ON of ESP

The results obtained from the practical experiments are the responses of the control system for a reference input as shown in figure 12. The simulation results are obtained using the Truetime 2 simulator [12]. Figure 13 (a) represents the wireless control system for ESP using WiFi network, while (b) is the step response for the closed system. The transfer function of the closed loop control system is:

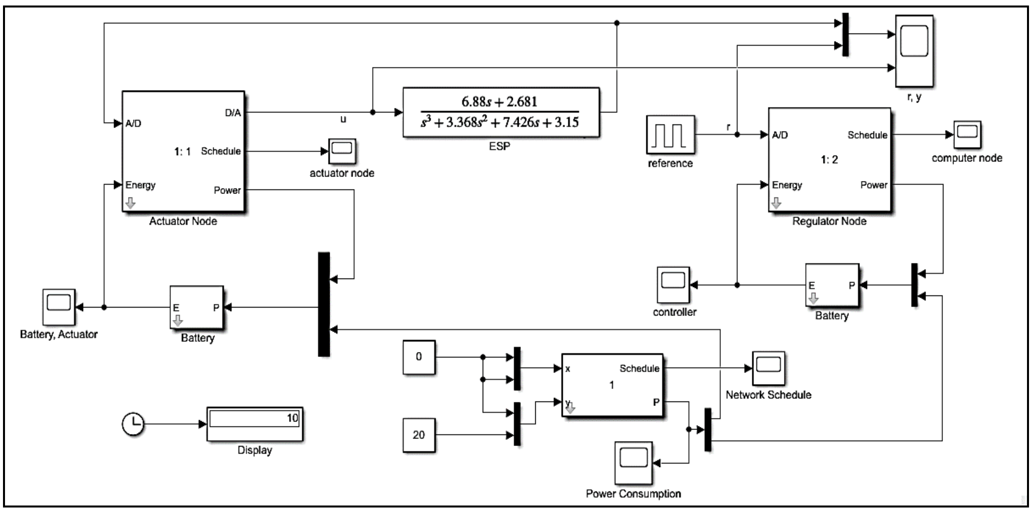
$$T(s) = \frac{Y(s)}{U(s)} \frac{6.88s+2.681}{s^3+3.368s^2+7.426s+3.15}$$

and of PID controller as

$$\frac{U(S)}{E(s)} = k_P \left(1 + \frac{1}{T_i S} + T_d S\right)$$



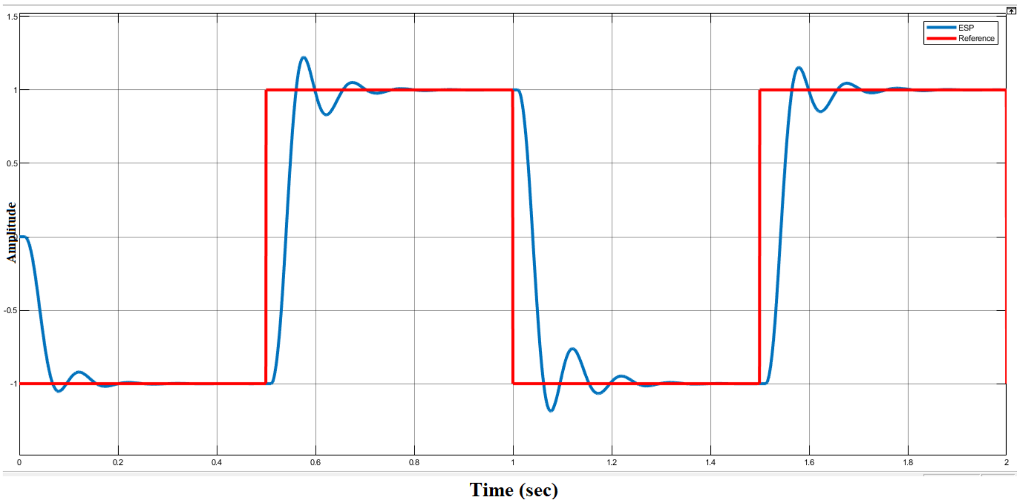
(a)



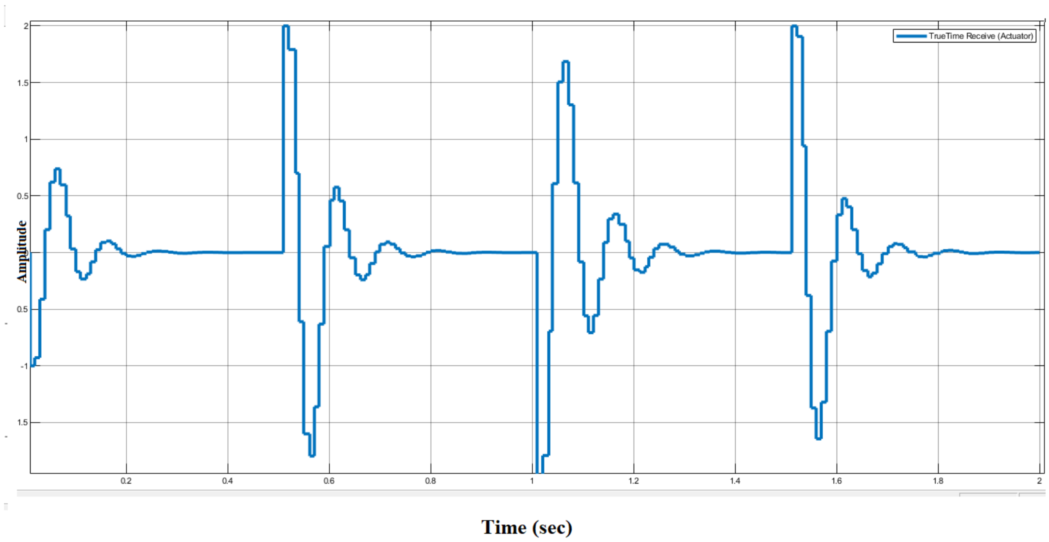
(b)

Figure 13. Implementation of PID Controller through Wireless SCADA system; (a) ESP wireless control system using Truetime 2.0 simulator; (b) Step response of the system.

The simulation results are identical, and we can see, that the approach with the standalone interface block is good for modelling of simple control strategies and sensor data acquisition. A close-up of the network traffic (network schedule) of the wireless network is shown in Figures 14(a) and 14(b).



(a)



(b)

Figure 14 (a)Wireless simulation results (a) Wireless simulation with time delay

8. CONCLUSIONS

In this article, we tried to solve the problem of controlling ESP remotely. The wireless control system is suitable for our environment because there is always dusty weather and a lot of pollutants were there, so the maintenance is very difficult. The wireless SCADA system if it is decided to be used will be very useful to overcome problems and it can be regarded as the best solution. The use of nanostation5 for data transmission between the MS and RTUs is implemented practically for controlling the operating the ESP and controlling the high voltage. The practical and theoretical results are compared. The quality and quantity of the product will be enhanced accordingly using wireless SCADA system.

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