A Simple Platform to Establish Supervision, Monitoring, and Control using Arduino/ Ethernet Shield and SCADA via Industrial Modbus TCP/IP Communication Protocol

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Article Info

Article history:

Received , 12/12/2023
Revised , 16/04/2023
Accepted , 25/05/2024

Keywords:

Supervision
Control
Ethernet Shield
SCADA
Modbus TCP/IP

ABSTRACT

In numerous academic and industrial fields, supervision, monitoring, and control are critical tasks for ensuring the proper handling and optimal application of data acquired or extracted from various sensors, as well as for controlling various actuators. The objective of this study is to demonstrate a straightforward approach to developing a supervision and control system using Arduino/Ethernet and a Siemens human machine interface (HMI) through the industrial Modbus TCP/IP protocol. The Modbus TCP/IP protocol establishes a connection between the Arduino master and the Siemens slave SCADA-based Wincc Flexible via RJ 45 Ethernet wire. Using the analog input of the Arduino microcontroller to the analog-to-digital converter (ADC), the supervision and real-time display of the variable voltage values (0 to 5 V) in the HMI interfaces were ensured. Additionally, the Arduino digital output was utilized to test the On/Off LED control from the HMI button.

I. Introduction

In the dynamic realm of industrial automation, the pursuit of seamless and efficient supervisory, monitoring, and control systems is a driving force behind innovation [1]–[3]. This paper delves into a comprehensive exploration of a sophisticated integration framework that harmonizes the capabilities of Arduino, Ethernet Shield, and Supervisory Control and Data Acquisition (SCADA) systems. The cornerstone of this integration is the Industrial Modbus TCP/IP communication protocol, recognized for its standardized and non-proprietary nature, fostering fluid information exchange within industrial networks [4], [5].

The imperative for real-time monitoring, precise control, and data-driven decision-making in industrial processes has fueled the development of integrated solutions. In response to this need, we present a cohesive platform that leverages the strengths of Arduino, a versatile open-source electronics platform, in tandem with the connectivity prowess of the Ethernet Shield. This integration provides a robust foundation for data acquisition and processing, laying the groundwork for advanced supervisory and control functionalities [6]–[8].

At the heart of this integration lies the SCADA system[9], [10], a powerful interface renowned for its ability to oversee and orchestrate industrial processes. The synergy of Arduino, Ethernet Shield, and SCADA forms a symbiotic relationship, enabling enhanced human-machine interaction and centralized control. However, the linchpin of this collaborative architecture is the Industrial Modbus TCP/IP communication protocol, a protocol that has withstood the test of time since its inception in 1979. Operating at level 7 of the OSI Model and adopting a master/slave mode, Modbus TCP/IP provides a standardized approach to communication, ensuring interoperability across diverse industrial environments.

This paper aims to provide a comprehensive understanding of the scientific and practical underpinnings of integrating Arduino, Ethernet Shield, and SCADA systems via the Industrial Modbus TCP/IP communication protocol. Through a meticulous exploration of relevant literature and an examination of the scientific foundations, we seek to unveil the potential of this integrated platform in addressing the complex demands of contemporary industrial automation. As industries continue to evolve, this integration represents a promising stride towards achieving enhanced efficiency, intelligent control, and adaptive responsiveness in industrial processes.

I.1. Modbus overview

Modbus is an industrial communication protocol that was first presented by Modicon in 1979. Typically, it is employed in conjunction with programmable logic controllers or industrial-grade machinery. It has now emerged as a widely adopted "open protocol" standard in the realm of automation and industrial communication, serving as the predominant method for facilitating communication among industrial equipment. One of the benefits of the Modbus protocol is its versatility, as well as its simplicity in implementation. The majority of devices and embedded systems, such as microcontrollers, PLCs, and smart sensors, are equipped with a Modbus interface and possess the capability to interact via the Modbus protocol. Initially, Modbus was primarily intended for use with wired serial communication lines. However, there have been further additions to the standard to include wireless communications and TCP/IP networking. The Modbus protocol facilitates communication across several devices interconnected inside a shared network. For instance, a system responsible for measuring the temperature and humidity of an oven might transmit its findings to a process computer using the Modbus protocol. Modbus connections can be conducted using the following physical media: •

- RS-232 • RS-485
- RS-422 is a communication standard.
- Ethernet TCP/IP (Modbus Ethernet) is a communication protocol that allows devices to communicate over an Ethernet network using the TCP/IP protocol.

I.2. Arduino/SCADA Modbus application

In this paper, the Modbus TCP/IP protocol (Fig .1) is used to give the connexion as a communication protocol between the SCADA based Wincc Flexible as a slave of Siemens and the Arduino as master using RJ 45 ethernet wire that are detailed below.

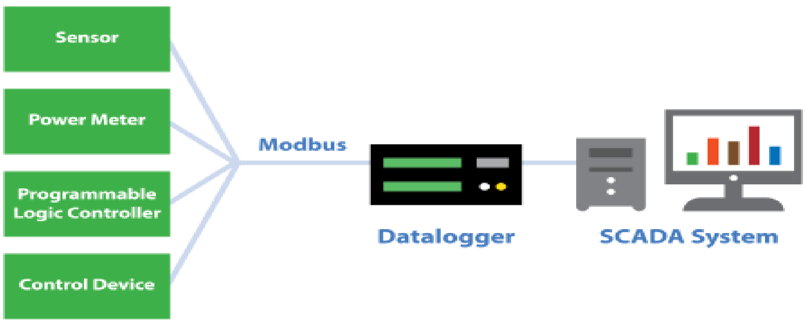

Figure 1. Modbus/SCADA Interface [11].

Before passing on the detail of this section, it is suitable to give an overview of the used software and hardware.Wincc Flexible is a software fabricated by Siemens Company which allows establish a human-machine interface (HMI) as a SCADA system or panels[12] . The Arduino /shield (see Fig. 2) is used as embedded controller for data aquision and control via analog input and digital output resepectevly , The following libraries in arduino

IDE are used for the master :

#include <SPI.h> : serial communication Between Arduino Mega and Ethernet shield

#include <Ethernet.h>:Ethernet communication #include "MgsModbus.h" Modbus protocol

The HMI salve (Wincc Flexible) and Arduino master configuration (Modbus TCP/IP protocol) with the hardware configuration of Arduino shield IP address are given below :

- IP Address (192, 168, 0, 5) for Arduino master.
- IP Address (192, 168, 0, 6) for Arduino master.

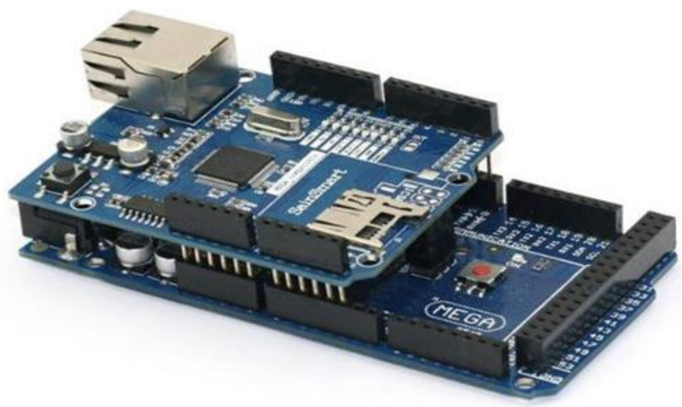

Figure 2. Arduino mega 2560 with Ehield/Ethernet [13].

The connexion beween those using Modbus communication in Wincc Flexible are configured as presented in Fig.3.

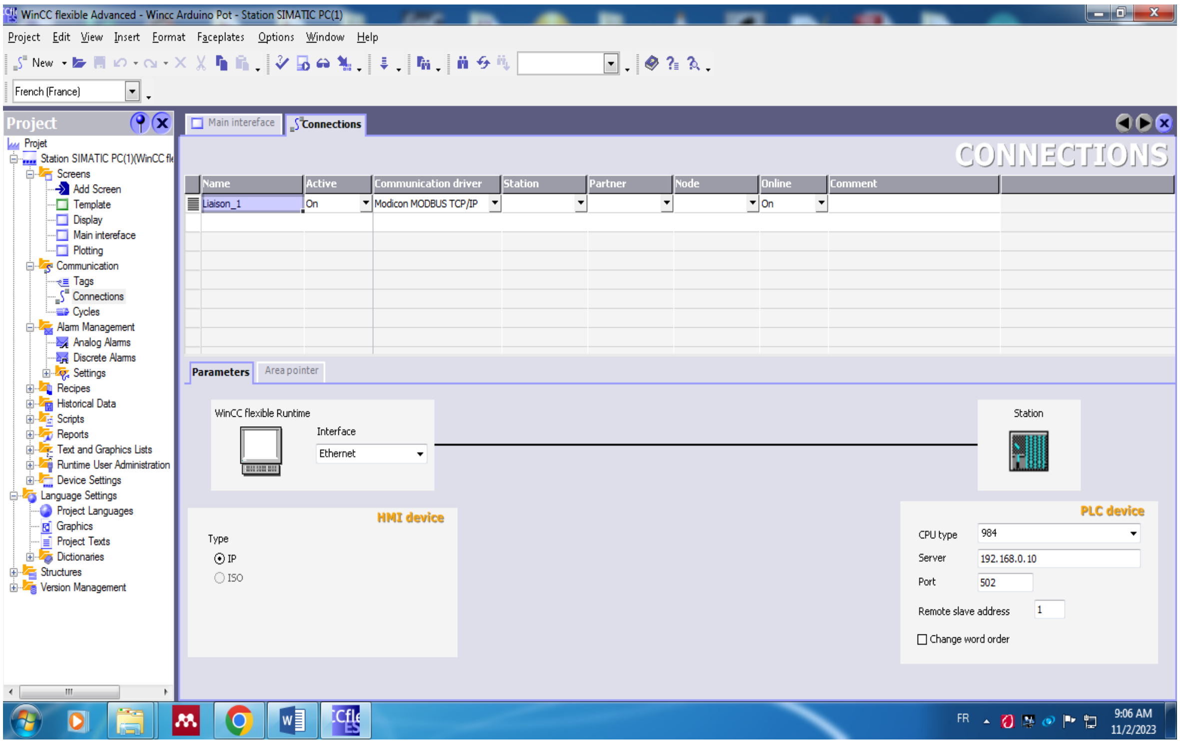

Figure 3. Modbus TCP/IP configuration beween Arduino and HMI on Wincc Flexible window.

The used tags (variables) in HMI for monitoring and supervision Wincc Flexible are illustared in Fig. 4.

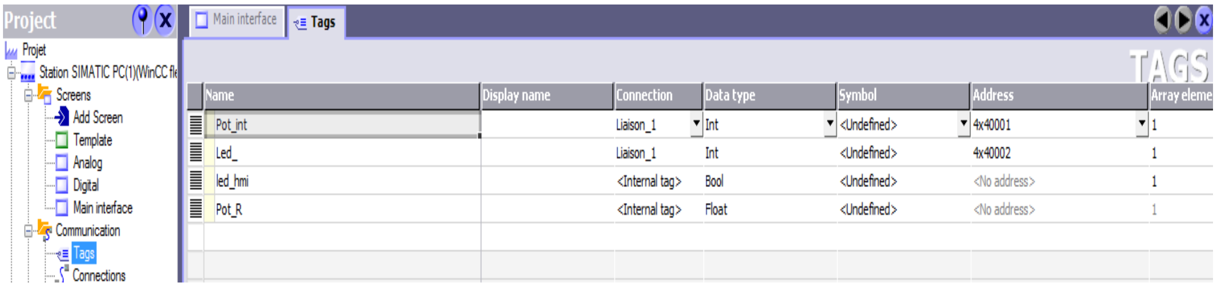

Figure 4. Tags (variables) in Wincc Flexible.

III. Results

The experimental platform of the test is presented in Fig.5.

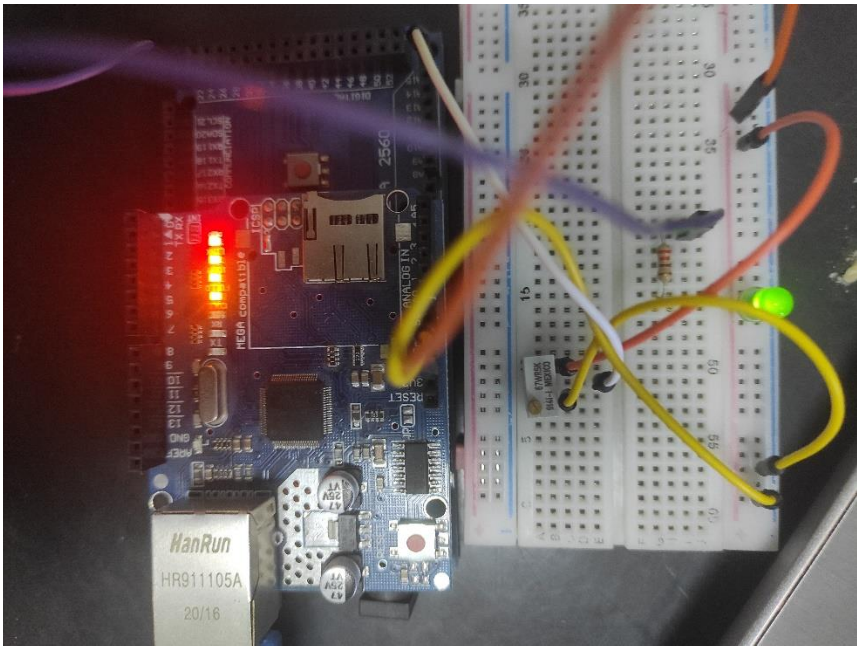

Figure 5. The experimental platform

The platform formed from the above Arduino/Shield card and SCADA HMI interfaces detailed below permits real-time LED control and voltage supervision/plotting via a variable resistor.

The HMI consists of 3 interfaces:

- Main interface (Fig 6)
- Analog (Fig 7)
- Digital (Fig 8)

The first one allows for moving between them, and the second allows voltage display in two forms (Digital values, and real-time plotting) for the analog inputs, while the third interface permits control of the led from two buttons On/Off in SCADA HMI.

Figure 6 .Main interface.

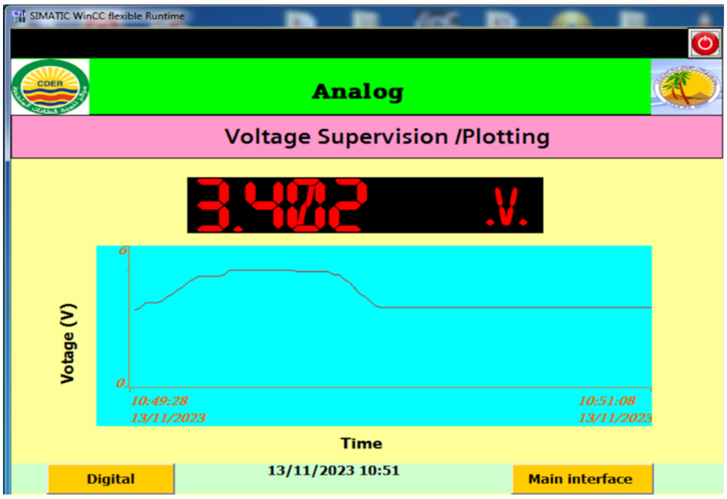

Figure 7. Analog view.

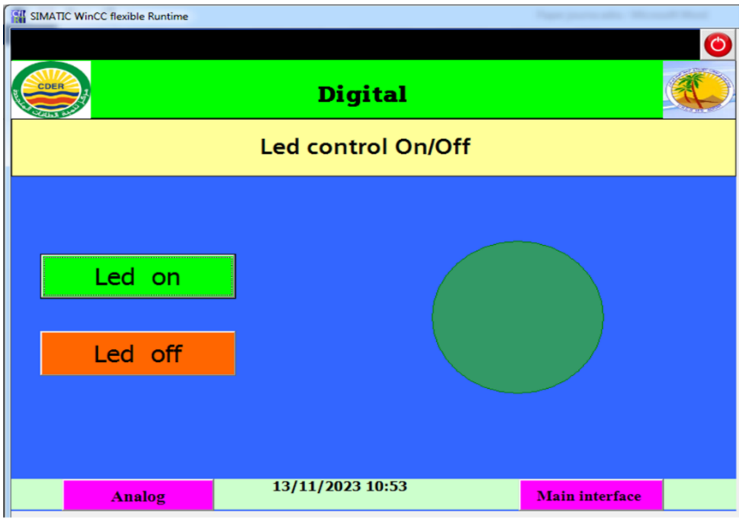

Figure 8. Digital view.

III. Conclusion

This article presents a straightforward platform that can be used to establish supervision, monitoring, and control by utilizing Arduino/ Ethernet Shield and SCADA through the Industrial Modbus TCP/IP communication protocol. The purpose of this presentation is to demonstrate the possibility of developing additional monitoring, supervision, and datalogger platforms for a variety of systems, including power plants, renewable energy centrals, as well as pedagogical and research stations.

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