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Implementation of Automated Water based Level Management Model by using SCADA system and PLC

Maan M. Abdulwahid[1*], Haifat K. Abdullah[2], Wasnaa M. Ateah[3], Saja Ahmed[4]

[1,2,3,4]Ministry of Water Resources, General Commission for Operation and Maintenance Euphrates River Basin, Iraq.*

Corresponding Email: [1]engmaan.m@gmail.com*

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Abstract:** This research developed a SCADA model for water management in a tank that is utilized for regulating and controlling power production and distribution automation for energy quality. The goal of this work is to create a model for water change controlled by a motor to handle the speed of filling and discharging the water within the tank, and as a water management procedure, such procedure will be performed by using the PLC controller connected to an HMI screen to achieve reliable management. The protocol utilized is the Modbus-based TCP protocol, which is suitable for low-cost systems and models. The suggested methodology may be used in big water tank stations to manage filling operations automatically and efficiently. In the future, the management method might be done wirelessly by employing a client software application with a specialized configuration.

***Keywords:** SCADA, PLC, HMI, Water Management, Modbus.*

1. INTRODUCTION

Power systems use SCADA systems to acquire, evaluate, and monitor force system data. The system handles power age, transmission, distribution, and sustainable power source divisions, therefore checking and control are key in all of these areas. Hence, saving money and time using SCADA would boost framework production. Activity, misfortune reduction, guiding, and managing age and transmission systems may do this. SCADA work in the force framework improves framework reliability and matrix activity. Force framework computerization provides possibility-based rapid Load Shedding, Power Control, and SCADA for the electrical system [1].

SCADA systems must handle the complex distribution process and higher-level Distributed Management System applications (DMS). Smart grid SCADA systems help with distributed

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generating operations, alarms, telemetry, event logging, and remote control of outstation field equipment. Modern systems should provide power system data without requiring an operating workstation to enable engineering and financial planning. SCADA systems formerly supported power system data imports and exportation. Recent power system operating developments need a decentralized, adaptable, integrated, and open distributed control centre. Current control centers are attempting that [2-4]. SCADA technologies used in dispersed control centers are briefly examined. The Internet era has led to a movement between micro grid and grid computing and web services, or micro grid services. Micro grid service-based future control center [5].

The water industry has one of its greatest difficulties in the form of natural disasters such as droughts and floods, which occur everywhere on the planet. In contrast to drought, which may occur occasionally or on a regular basis, water shortage is a continuous and persistent problem. Water shortage is a problem that exists on every continent and affects one fifth of the population of the globe. In addition, the rising values of energy prices was another obstacle that needed to be overcome. Energy expenses account for 55-60 percent of the total life cycle cost of a pumping station; thus, this was a significant factor. In addition, according to the World Bank, leakage and other forms of non-revenue water may account for anywhere from 25 to 30 percent of a utility's total water supply being lost in the network. These losses cost water corporations significant sums of money, not only in missed income but also in the expense of cleaning and pumping water that leaks into the ground. Not only does this happen when water is lost, but it also happens when water is lost via other means. As a result, there is a need to handle the water problems with effective way and by using the power of automated systems such as SCADA and PLC [6].

This study investigates and implements a current SCADA network system for water level tank management utilizing Modbus / TCP, a common Ethernet instrumentation protocol that may be accessible by TCP/IP on the Internet or local Intranet. Because of its openness and simplicity, Modbus / TCP has been extensively used. This paper also presents a large industrial control-based wireless network solution.

Related Works

Many scientists have used the SCADA system to develop and construct many systems during the last few years. For instance, writers in [7] proposed a cheap and adaptable SCADA system. The proposed process is meant to produce sugar. In the sector, the production line is managed and controlled using a PLC Siemens S7-1200. The SCADA system's hardware was the major focus of the project's design and selection phases. The second consists of human-machine interface (HMI) design, alerts, and system trending in PLCs. Temperature, velocity, and relative humidity data were used to probe the proposed system [7]. In [8], the authors detail a low-cost, open-source SCADA framework that leverages the Internet of Things (IoT) and existing SCADA architecture. The architecture consists of a set of current and voltage sensors, a small-scale controller (ESP32) with an organic light-emitting diode (OLED) display for processing the data, and an Internet of Things (IoT) server for storing the data and facilitating communication between humans and machines. To transmit sensor data to the IoT

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server through a nearby Wi-Fi connection, the ESP32 functions as the MQTT Client and the server hub as the MQTT Broker. To ensure the safety of the stored information, the IoT server is hosted privately on a Raspberry Pi single-board computer and uses a local SQL database.The open-source SCADA framework was put to the test by connecting it to a solar-powered remote monitoring and control system, where it processed data on the system's current, voltage, and intensity. Work presents Things Board-based IoT server architecture, testing, dashboards, and alerts [8]. An HMI was designed in [9] for a PLC-packaged automated process that allowed for remote control and monitoring through mobile applications. The packaging conveyor belt is controlled by a Siemens LOGO! 230 RCE PLC. Infrared (IR) sensors drive relays on an Arduino uno microcontroller, allowing enabling product detection. The PLC takes relay statuses as inputs. Microcontrollers are used as the brains of Android-based HMIs. The proposed design is cheaper since it does not use SCADA but rather regular sensors and control using mobile apps. Many ongoing initiatives evaluate the model's presentation, which yields favourable results. Unfortunately, the researchers did not examine IOT-based service vulnerabilities and other concerns [10]. A Super SCADA system that can anticipate machine failure time was presented in [11]. The study aims to create an open-source framework that can integrate data from SCADA Systems, ERP, and other sources into Super SCADA frameworks and accurately predict machine failure and issue proactive warnings. A MySQL database, communication director, and webserver make up Super SCADA. Ubuntu 16.04.3 introduces APACHE 2.4.29 webserver. MySQL server 5.6 stores data. The model uses open-source Eclipse Neo SCADA. Sensors and actuators relay data from plant segments to RTU. RTU or PLC provide data to SCADA. Arduino connects sensors. Arduino driver reads data from Arduino Ethernet shield. Socket.IO, a JavaScript library for continuous online applications, controls and accumulates RTU data in bi-directional communication. The Super SCADA System data-based prediction model has not been verified or built. Moreover, predictive data and standard SCADA data have not been proven [11].

2. METHODOLOGY

In this section, the tools, components that are used to propose the water level tank model will be mentioned to demonstrate the most important parts to be used.

A. Human Machine Interface (HMI)

Human operators may use software and hardware to keep tabs on the status of a controlled operation, modify control parameters to alter the management target, and take direct control in the event of an emergency. Control algorithms, constants, and set points may all be entered into the controller through the HMI by a control designer or operator [12]. In addition to the process status, operators, administrators, managers, suppliers, and other approved users may also see historical data, reports, and other data on the HMI. Operators and engineers rely on HMIs to keep tabs on the controller and make adjustments to its settings, set points, and algorithms. The HMI also gives you access to process history and status updates. In contrast, a human-machine interface (HMI) is any panel or interface that allows a human to interact with a machine. Although the term "human machine interface" (HMI) is most often used in

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the context of an industrial process, it may be used to any screen that facilitates user interaction with a device [14]. Although human-machine interfaces (HMIs) and graphical user interfaces (GUIs) have certain characteristics, they are not the same. The graphical user interface (GUI) is often used in HMIs. The PLC's input and output addresses must be assigned to each indicator and button on the HMI [15]. This brings up a further concern: it is critical that the HMI and PLC be compatible with one another. This necessitates a kind of inter-communicative "talk" between them. There is a set procedure that they adhere to. distinct methods are used by distinct companies. Common protocols are Modbus, Ethernet/IP, and Profibus [16]. Figure 1 is an illustration of a human-machine interface.

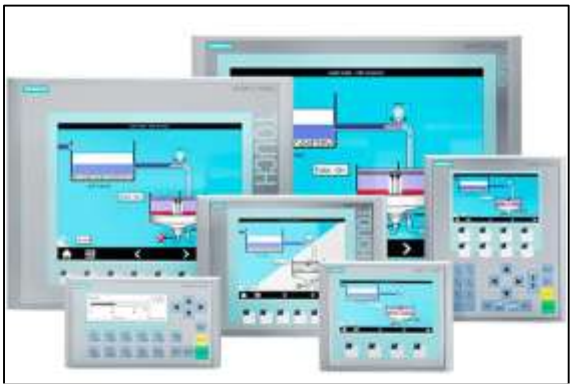

Fig. 1 Different types of HMI products from Siemens

B. PLC S7-300

Complex applications that need a high number of I/O points are best served by the S7-300 and S7-400 PLCs. Each private limited company has the capacity to grow. Modules external to the CPU handle I/O and power delivery. A decision between the S7-300 and S7-400 depends on the complexity of the project and any potential future expansion. Any more information about a Siemens PLC can be provided by your representative for Siemens agreements. Figure 2 clarifies a PLC S7-300 example [17,18]. S7-300 has proved effective millions of times and is utilized in several applications all over the world. Additionally, its Controllers have a modular design and need less room for installation. According to the work at hand, a broad variety of modules may be employed to centrally develop the system or to establish decentralized structures, and they make it easier to maintain an affordable supply of replacement parts [19].

Fig. 2 Example of PLC type S7-300 [19].

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PLC is made up of a few different parts, all of which collaborate to build the overall functionality of the system. Figure 3 demonstrates these separate parts clearly. The input module's job is to convert incoming indications into signals that the PLC can use to do its work, and then it must transmit these signals to the focal control unit [19]. A yield module is responsible for carrying out the task just opposite of this one. This converts the signal coming from the PLC into signals that are suitable for the actuators. The actual preparation of the signs is handled inside the central control unit in accordance with the program that is stored in the memory [20]. PLC programs may be written in a variety of ways, including by using assembler-type commands in a "explain list," at a higher level, using issue-arranged languages such as structured content, or as a stream graph, such as one that is spoken to by a sequential capacity graph. The use of capacity square outlines that are predicated on job schematics and that include realistic visuals for reason doors is widely employed in Europe. The stepping stool graph' is the terminology that is preferred by customers in the United States. There is a distinction that can be established between conservative PLCs (input module, focal control unit, and yield module all in one housing) and measured PLCs [21]. This distinction is based on how the focal control unit is related with the info and yield modules.

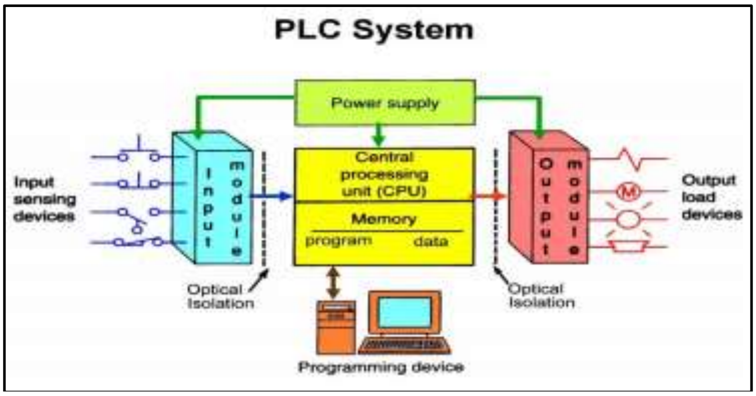

Fig. 3 Component of PLC system [22].

C. Modbus

The Modbus communication protocol has established itself as a de facto standard and is now widely used as a way of linking various electrical equipment used in industrial settings. Since it is widely released and does not need any royalties to use, Modbus is quite common in industrial settings [23,24]. It was designed to be used in industrial settings, and in comparison to other standards, it is reasonably simple to install and keep up to date. Moreover, it lays minimal limits on the format of the data that is to be conveyed. In SCADA systems, a plant or system supervisory computer is often connected to a RTU through Modbus. Several of the data types get their names from the industrial control of manufacturing equipment, such as ladder logic, which gets its name from its application in controlling relays. For example, a single-bit physical output is called a coil, while a single-bit physical input is either termed a discrete input or a contact [25-30].

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Water Management

In this work, a compact module for regulating the speed of motor by relying on the frequency for controlling its rotation speed has been constructed. This contrasts with actual stations, which would need huge and costly motors for controlling and performing various jobs. For such motors to work, there would need to be careful monitoring of both the turn-on time and the total number of rotating cycles. For this reason, there is a requirement for regulating that is both effective and efficient for such motors. In addition, the PLC system would be used to regulate the data storage as well as the scheduling of dividing it up across the various working units. PLC S7-300 was the model of PLC that was suggested to be used in our work. In addition, the Variable Frequency Drive (VFD) has been used as a regulator for the speed of the three-phase induction motor in this work, which has a rotational speed of 300 round per minute (rpm). The structure of connecting the VFD with the PLC can be seen in Figure 4.

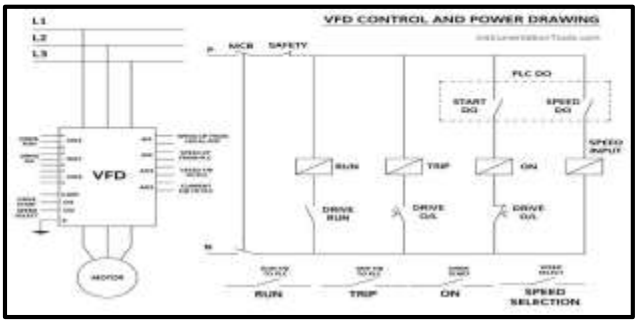

Fig. 4 Internal circuit of the VFD

Figure 5 displays the particulars of our offered programmed an approach which can be used to regulate both the beginning speed of the motor and its overall speed. The overall schematic design of the proposed system can be seen in

f / PLC_1 [CPU 314C-2 DP] / Program blocks

Main [OB1]

Main Properties							
General							
Name	Main	Number	1	Type	OB	Language	LAD
Numbering	Manual						
Information							
Title	"Main Program Sweep (Cycle)"	Author		Comment		Family	
Version	0.1	User-defined ID					

Name	Data type	Offset	Default value	Comment
▼ Temp				
OB1_EV_CLASS	Byte	0.0		Bits 0-3 = 1 (Coming event), Bits 4-7 = 1 (Event class 1)
OB1_SCAN_1	Byte	1.0		1 (Cold restart scan 1 of OB 1), 3 (Scan 2-n of OB 1)
OB1_PRIORITY	Byte	2.0		Priority of OB Execution
OB1_OB_NUMBR	Byte	3.0		1 (Organization block 1, OB1)
OB1_RESERVED_1	Byte	4.0		Reserved for system
OB1_RESERVED_2	Byte	5.0		Reserved for system
OB1_PREV_CYCLE	Int	6.0		Cycle time of previous OB1 scan (milliseconds)
OB1_MIN_CYCLE	Int	8.0		Minimum cycle time of OB1 (milliseconds)
OB1_MAX_CYCLE	Int	10.0		Maximum cycle time of OB1 (milliseconds)
OB1_DATE_TIME	Date_And_Time	12.0		Date and time OB1 started
Constant				

Fig. 5 The specification of the proposed water tank model

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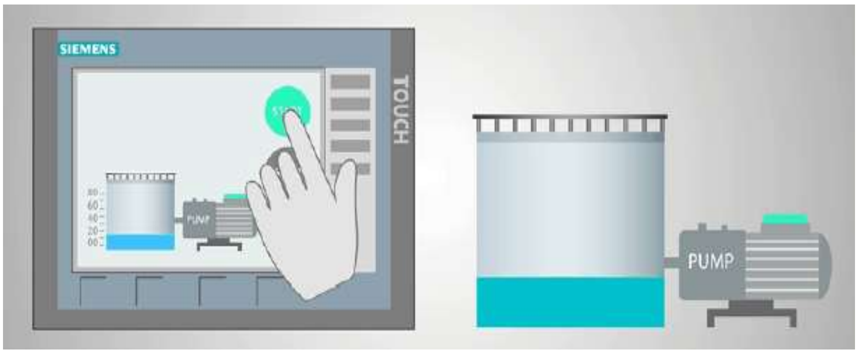

Fig. 6 The schematic design of the proposed model

The frequency used to regulate motor speed is directly related to supply power. This scenario used Tia portal. Starting with 0 Hz, like the VFD device, a three-phase order would be placed. Thus, the SCADA system would react to VFD from AC motor. Then the PLC and SCADA system would read the frequency from this signal. Increasing the frequency using the mechanism we suggested and from the HMI screen we would notice that the speed of the motor would be raised. The SCADA system screen was built using WINCC by Tia portal. Figure 7 illustrates SCADA system motor work architecture. Figure 8 shows the system representation if the motor fails. Figure 9 shows that the SCADA system would indicate system errors.

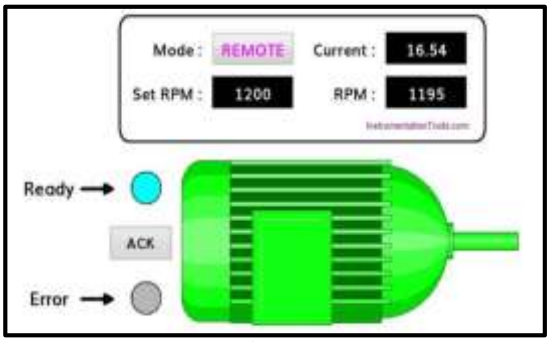

Fig. 7 The working status of the proposed water tank model

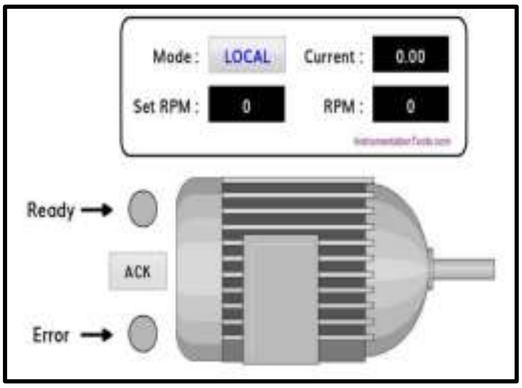

Fig. 8 The stop status of the proposed water tank model

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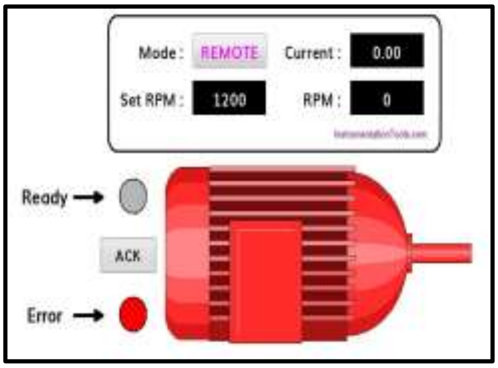

Fig. 9 The error status of the proposed water tank model

The principle of motor working within the tank level model and the overall designed system can be as seen in Figure 10. When the water level in the tank reaches the desired level, the SCADA system will send an order to fill the tank, which is accomplished by pressing the FILLING button. The system will then provide an indicator that the tank has been filled to the desired level. Figure 11 depicts the potential outcomes of the filling tank scenario. In the meanwhile, the most recent circumstance concerning the tanks is represented by the emptying of liquids. via order to do this via the SCADA system, the DISCHARGE command must be used. Figure 12 provides an illustration of this third possible outcome for the situation. Figure 12 demonstrate the management of water tank by using logic ladder coding of SCADA system

Fig. 10 The proposed water tank model

Fig. 11 Case of filling water tank by using SCADA system.

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Fig. 12 Case of discharge water tank by using SCADA system.

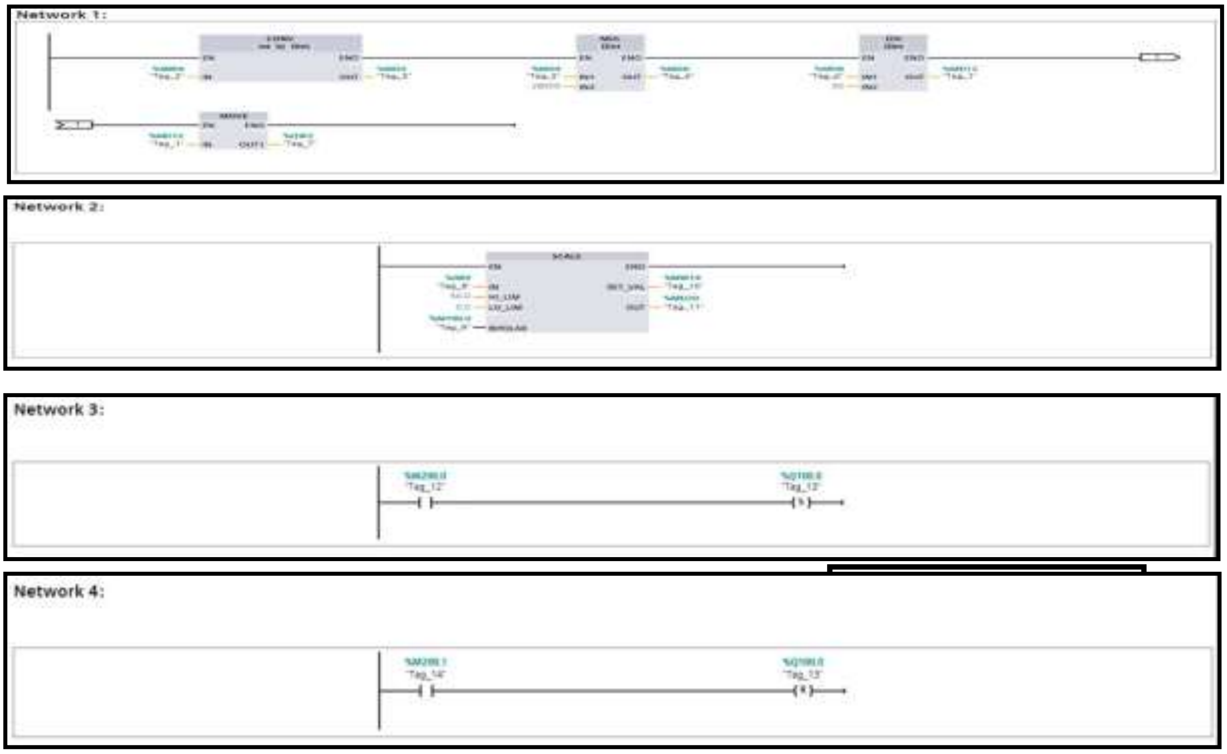

Fig. 13 logic ladder code for the proposed model

3. CONCLUSIONS

This paper proposed a SCADA model for water management in a tank to handle the most advanced automatic control system and is used for controlling and controlling power generation and distribution automation for energy quality. The aim of this work is to design a model for water change controlled by using motor to handle the speed of filling and discharging the water within the tank and as a management of water in tanks, such procedure will be performed by using the PLC controller connected to HMI screen to achieve reliable management. The protocol used is the Modbus based TCP protocol that can be used for the lower cost-based systems and models. The proposed model can be implemented in large water tank stations to handle the operation of filling automatically and effectively. For future, the management procedure can be performed in a wireless way by using a client software program with the dedicated setting.

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