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A SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA) FOR WATER PUMPING STATIONS OF GAZA

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Abstract: Gaza has scarce water resources. At present, there are more than 40 wells that are supposed to supply adequate water from the aquifer to the public through the water distribution network. However, the pumping stations at these wells along with the distribution network are managed manually by operators in a primitive manner. During peak consumption periods, which may last for weeks, water is not delivered to wide areas and resources are not distributed evenly to public. Operators try hardly to achieve fairness by manually controlling gate valves along with pumping stations. The aim of this research is to design a Supervisory Control and Data Acquisition (SCADA) system for managing the water pumping stations in Gaza. This system is expected to increase customer satisfaction, reduce water distribution cost and provide an accurate overview of the plants' operations. Moreover, SCADA stores valuable information about the water system performance. This data is necessary for efficient development of the existent distribution system in a way that meets population growth.

KEYWORDS: SCADA, Automation, Pumping stations, Networks.

تحكم إشرافي و اكتساب بيانات لنظام توزيع المياه في مدينة غزة

الملخص: تعتبر مدينة غزة من المناطق الفقيرة في مصادر المياه، فهي تعتمد على استخراج المياه من باطن الأرض لتلبية احتياجات السكان. في الوقت الحالي يوجد أكثر من 40 بئرا جوفيا تغذي المدينة بالمياه الخاصة بالشرب والاستخدام المنزلي. يتم ضخ المياه المستخرجة من هذه الآبار مباشرة في شبكة توزيع المياه. تدار وتنظم هذه العملية عن طريق المشغلين بطريقة يدوية وبدائية تعتمد على خبرة ونظر المشغل. خلال فترات الذروة التي قد تستمر لأسابيع، تنقطع المياه ولا تصل مناطق واسعة وكذلك عملية توزيع المياه لا تكون منتظمة وعادلة بالرغم من اجتهاد وكفاءة المشغلين ومحاولاتهم توزيع المياه بطريقة عادلة على جميع السكان في جميع المناطق. الهدف من هذا البحث هو تصميم نظام تحكم إشرافي واكتساب بيانات لإدارة محطات أبار المياه في مدينة غزة. المتوقع من هذا النظام العمل على تقليل تكلفة توزيع المياه وتزويد المختصين بمعلومات دقيقة عن عمل الآبار للمساعدة في وضع الخطط اللازمة لإدارة وتنظيم عملية استخراج وتوزيع المياه والوصول إلى إرضاء وارتياح المواطنين. كذلك يقوم هذا النظام بتخزين المعلومات المهمة عن كفاءة وفعالية عمل محطات أبار المياه، وتعتبر هذه المعلومات ضرورية عند وضع خطط تطوير فعالة تواجه الزيادة المستمرة في احتياجات المياه نظرا للزيادة المستمرة في الكثافة السكانية. اعتمدت عملية التصميم على الحفاظ على الوضع الحالي في التحكم بأجهزة المحطة مع إضافة ما يلزم لتتوافق عملية التحكم مع نظام التحكم الإشرافي و اكتساب البيانات. كما تم التوصية استخدام نظام اللاسلكي في ربط محطات الآبار مع غرفة التحكم الرئيسية التي يفضل بأن تكون في لدية غزة نظرا لموقعها المتوسط و المرتفع.

1. BACKGROUND

The existing supply of potable water in Gaza is generally dependents upon well sources abstracted from the aquifer [1]. The water utility supply system in Gaza city consists of 40 water wells located in different regions in Gaza strip as illustrated in Figure 1 and summarized in Table 1 using Palestinian Grid Coordinates (GCS_Palestine_1923). Part of these wells has been constructed with submersible [2] water pumps and others having vertical turbine [3] pumps with a production rate varies between 50 and 220 m^3/hr. The pumping set is protected against low level water in the aquifer by means of dedicated sensors. The water wells are conventionally comprises of a pump, a chlorine dosing unit, a water manifold, an electrical switchboard, a sand trap and a standby diesel generating set.

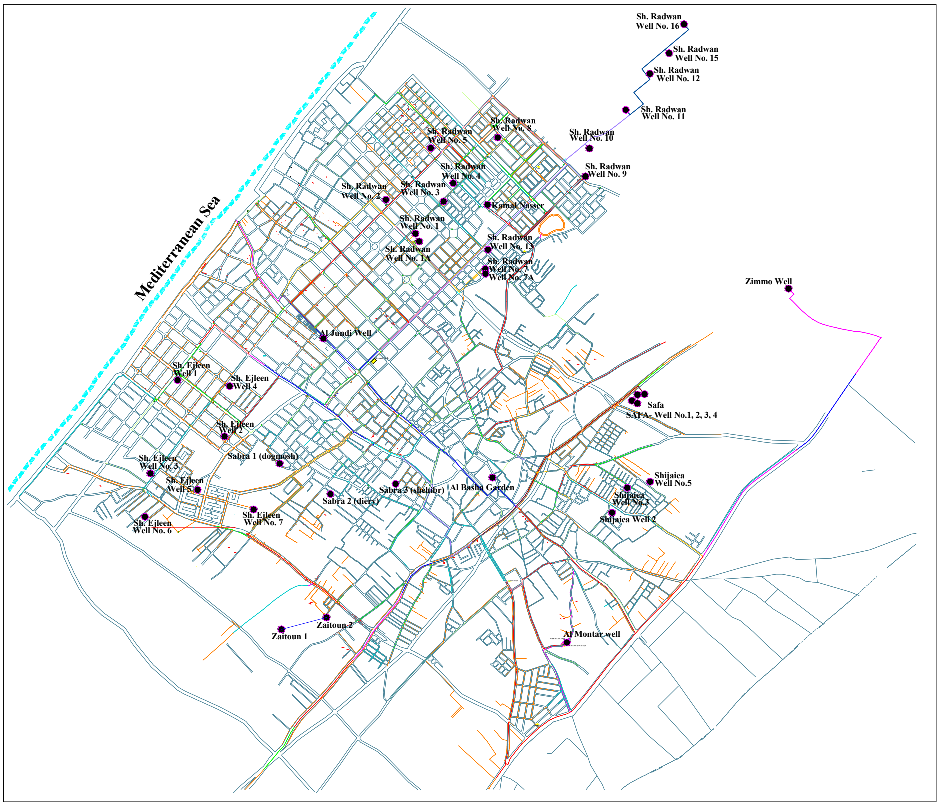


Figure (1): Gaza well pumping stations location

The distribution system depends mainly on direct pumping from the wells to the distribution network. These pumping stations are managed manually through operators who are located as three consecutive 8-hour shifts along the day. Decisions are made according to observations and feedback which is delivered through phone calls between humans. An operator is allocated for each pumping station and he is in charge of running the station according to phone call orders from the responsible department in Gaza municipality, or according to a predefined time schedule. There is no automated centralized management and there is no computerized alarm logging and handling.

2. SCADA SYSTEM

SCADA stands for Supervisory Control and Data Acquisition [4, 5]. As the name indicates, it is not a full control system, but rather focuses on the supervisory level. It is a software package installed on networked computing platforms, like personal computers (PCs) or small dedicated devices which are hardened for industrial environments [6]. SCADA provides a high level layer on top of the Programmable Logic Controllers (PLCs) [7, 8] layer which is positioned over the plant hardware devices. Thus, we have a functionally modular platform in which there are three layers interacting with each other in a hierarchical manner as sketched in Figure 2.

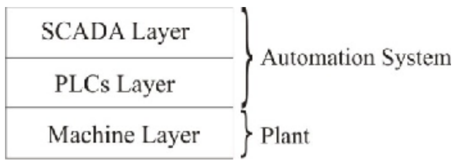


Figure (2): Functional decomposition of an automation system

2.1 Hardware Architecture

Well stations are the remote sites that should be connected to the main control room which is proposed to be at Gaza Municipality. The main reason of selecting this location is the fact that it is located in the middle of the city and characterized by a high altitude. This feature is preferable for possible wireless communications.

Well stations contain field instruments and equipments connected to devices being controlled and monitored. They convert physical parameters to electrical signals, which are the lower layer of the automation system. Then these devices are connected to process controllers, PLCs and Remote Terminal Unit (RTU) [9]. Process controllers control the field devices, operate the station automatically, gathering data from the field devices and provide data to the main control room. Main control room contains SCADA servers that store data from PLCs and RTUs, regulate the control system, provide human machine interface (HMI) for the operators and send SMS messages (Alarms) to the operator.

Table (1): Gaza well pumping stations coordinates

No.	Well Name	Coordinates X	Coordinates Y	No.	Well name	Coordinates X	Coordinates Y
1	Sh. Radwan 1	98457	104108	21	Safa 1	100779	102497
2	Sh. Radwan 1A	98480	104049	22	Safa 2	100702	102494
3	Sh. Radwan 2	98168	104435	23	Safa 3	100647	102436
4	Sh. Radwan 3	98739	104413	24	Safa 4	100701	102410
5	Sh. Radwan 4	98846	104605	25	Shijaiea 2	100444	101316
6	Sh. Radwan 5	98611	104965	26	Shijaiea 3	100598	101566
7	Sh. Radwan 7	99158	103710	27	Shijaiea 5	100829	101626
8	Sh. Radwan 7A	99155	103751	28	Almontar	099987	100017
9	Sh. Radwan 8	099303	105059	29	Zaitoun 1	97100	100149
10	Sh. Radwan 9	100175	104681	30	Zaitoun 2	97552	100272
11	Sh. Radwan 10	100202	104975	31	Sabra 1	97076	101802
12	Sh. Radwan 11	100596	105332	32	Sabra 2	97607	101504
13	Sh. Radwan 12	100825	105709	33	Sabra 3	98263	101596
14	Sh. Radwan 13	99179	103956	34	Sh. Ejleen 1	96054	102650
15	Sh. Radwan 15	101010	105926	35	Sh. Ejleen 2	96524	102080
16	Sh. Radwan 16	101186	106191	36	Sh. Ejleen 3	95774	101709
17	Remal 1	97524	103059	37	Sh. Ejleen 4	96560	102585
18	Remal 2	99176	104395	38	Sh. Ejleen 5	96253	101546
19	AL Daraj	99242	101666	39	Sh. Ejleen 6	95719	101275
20	Zimmo	102233	103555	40	Sh. Ejleen 7	96819	101348

The connection between the process controllers and the SCADA servers may be established using different techniques. It is our main objective in this research to highlight these techniques along with their features and limitations. Figure 3 illustrates most common communication scenarios, nearby well stations may be connected using direct cables (RS232, RS485 or Ethernet) while faraway stations may be connected through PSTN (Public Switch Telephone Network), cellular system or wireless private connection.

2.2 Software Architecture

There are many software packages in today's Information Technology (IT) market which enables engineers with moderate programming experience to build SCADA applications [10].

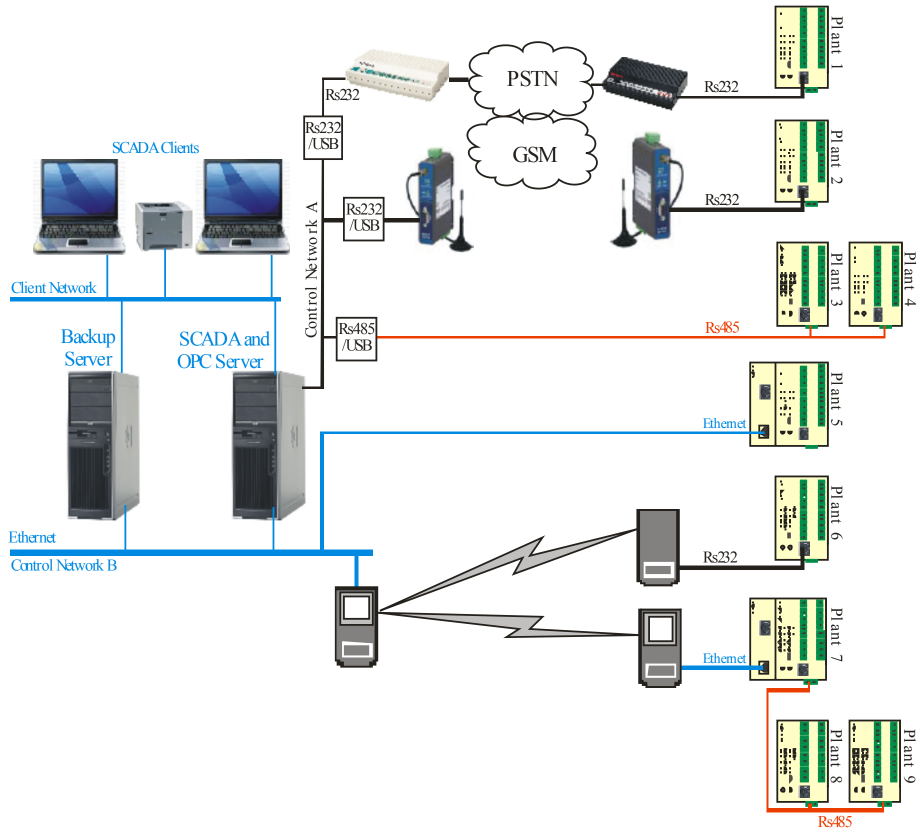


Figure (3): Hardware architecture

SCADA server applications handle data archiving, alarm processing and events logging. Main parts of the SCADA system are the device driver (PLC/RTU drivers) and the database servers. OPC (OLE[1] for Process Control) [11] is an open standard designed to bridge process control hardware and software applications. An OPC server is simply a PLC device driver which enables programmers to communicate with the PLC through a standard interface. SQL server from Microsoft Company is widely used for data archiving, alarm processing and events logging. SMTP server from Microsoft Company may be used to build email and SMS alarm messages to alert the operators about unacknowledged alarm events happened for longer time than adjustable set delay time. SCADA systems include a HMI which uses graphical interface to visualize the state system variables, change set points, alerts operators of critical condition and generate data trends.

[1] OLE stands for Object Linking and Embedding which is a technology that allows embedding and linking to documents and other objects developed by Microsoft.

There are several software packages used for designing HMI and SCADA. WINCC from Siemens, Cimplicity HMI from General Electric, and Lookout from National Instruments are well known examples for efficient commercial SCADA packages. However, professional computer programmers are biased to standard programming languages and tools in building SCADA applications. This lower level programming approach offers them more freedom to configure their project with highly reduced restrictions which are associated to these higher level packages. Moreover, while using standard programming languages allows SCADA developer to put their own character in the final product, the cost of extra programming efforts is fairly compensated by savings in software packages expenditure. Figure 4 illustrates the traditional relational connection between the plants and SCADA server along with the software relations between the SCADA server components. GSM and dialup plants connect to OPC server through the USB port by using RS232/USB converter, but they are defined as modems, and OPC server use dialing to connect to the PLCs to read and write data. RS485 direct connection bus connected to the OPC server through USB port by using RS485/USB converter [12]. The OPC server uses Modbus protocol [13, 14] in communication between the RS485 PLCs bus. Wireless plants connect to the SCADA server through Ethernet network and has software package used as communication driver between the wireless remote sites and the SCADA server. Direct Ethernet connection connects to the OPC driver through Ethernet port. Plants 8 and 9 use the same communication driver that is used with plants 7 as the main communication is between plant 7 and the OPC, plants 8 and 9 communicate with plant 7 only and has no direct connection with The SCADA server.

3. SYSTEM ANALYSIS

Gaza water well stations vary between new and old stations. All stations have almost the same components and instruments. Old stations components need maintenance and replacement, where new stations components are good.

3.1 System Components

Atypical station consists of a pumping station, a dosing chlorine pump, a chlorine tank, a pressure meter, a non return valve, a sand trap, an electrical generator, a soft starter and a main electrical distribution board. There are two types of pumps as shown in Figure 5; vertical turbine pumps and submersible pumps. Vertical turbine pumps have high capacity as it pumps for 100-200 m^3 per hour, where submersible pumps used for 40-60 m^3 per hour. Vertical turbine pumps need lubrication unit that splash water before starting the pump operation. Soft starter used at start operation to limit the high starting current of the water pump motor. After an adjustable period around (20 sec), by-pass contactor connects the pump station motor directly with the power supply and disconnects the soft starting.

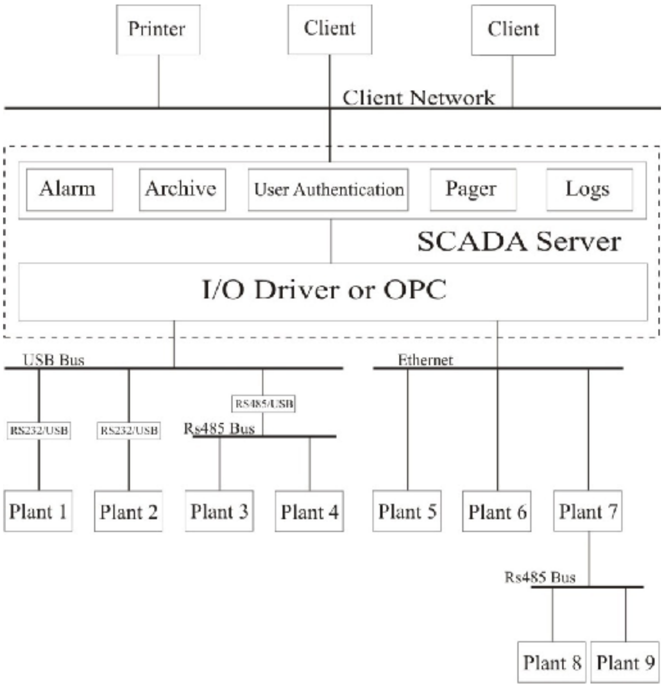
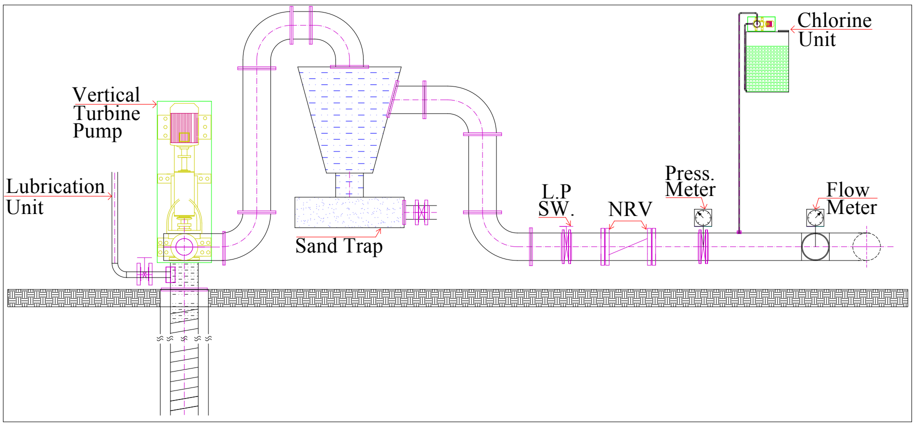


Figure (4): Software Architecture

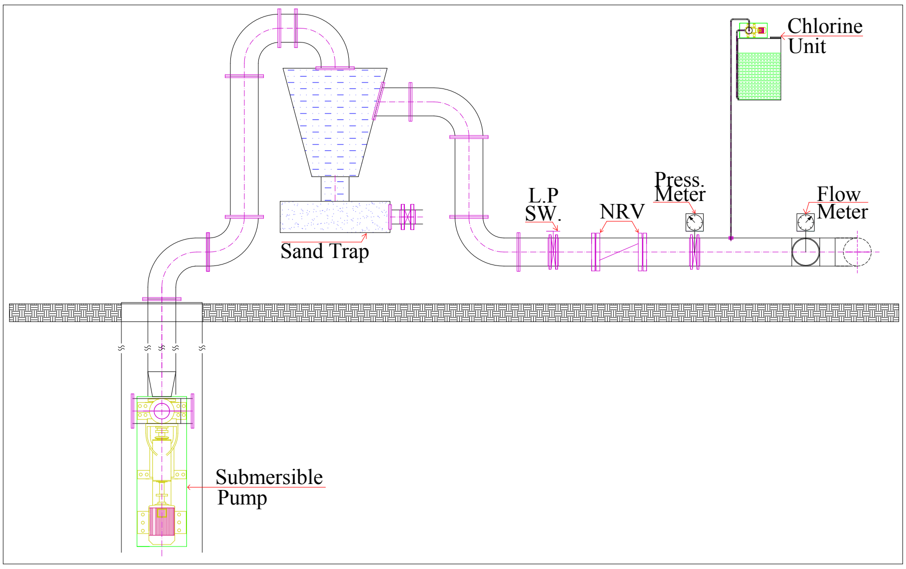
3.2 Control System Operation

The present controllers of well pumps are based on hardwiring using relays and timers. Submersible pump control is simpler than vertical turbine pump control since it has no lubrication unit. The process control of a vertical turbine pumping station is shown in Figure 6, and it may be described as follows:

1. There are two options to operate the station, *Automatic* run that depends on preprogrammed clock timer and *Manual* run that depends on the operator.
2. Starting the system runs Timer 5 (T5) for 60 sec, during this time lubrication unit splash water on the rubber shaft of vertical turbine pumps.



(a) Well station with vertical turbine pump



(b) Well station with submersible pump

Figure (5): Well station with vertical turbine and submersible pump

3. After the set time of T5, and if there is not any fault in the control system, soft starter [15] runs the motor pump in acceleration speed for 20 sec.
4. Then, by-pass contactor (C1) runs the motor pump station through by-pass.
5. Pumped water opens the NRV and its timer (T2). T2 is NRV timer and preset for 20 sec. if the NRV remain close.T2 will stop the system after this preset time.

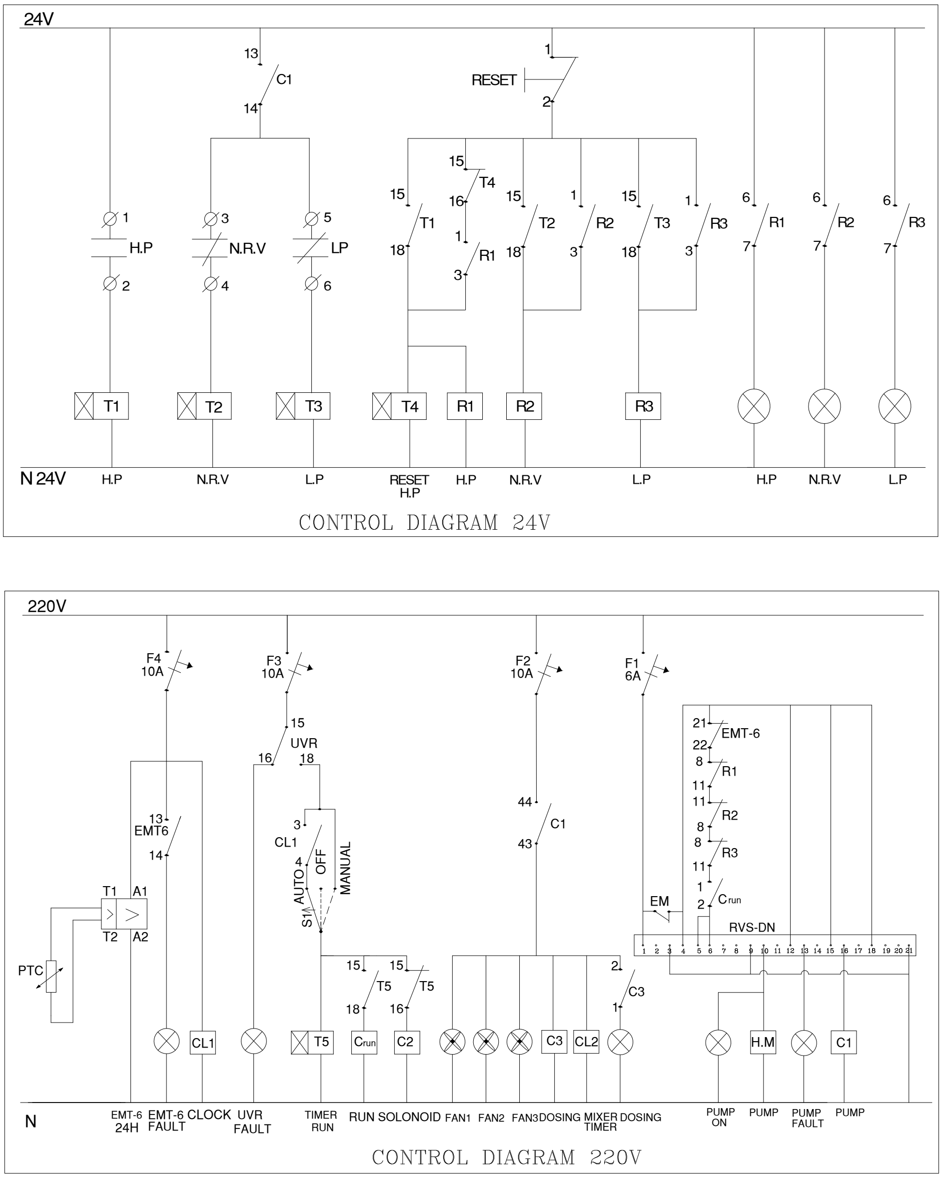


Figure (6): Well station control system diagram

6. T1 and T3 timers for high and low pressure switches respectively. If pressure reached the preset threshold value (high /low) for 60 sec, these timers will stop the system.
7. T4 timer used to reset T1 timer after specific period to prevent hysteresis.

A remote terminal unit should be installed to integrate the plant with the SCADA system. Therefore, a simple upgrade is required to allow handling the I/O signals summarized in Table 2.

Table (2): I/O System Signals

NO.	Signal	Type	NO.	Signal	Type
1.	Is Remote	Digital input	9.	Fuel low level	Digital input
2.	Is Manual	Digital input	10.	Generator Fault	Digital input
3.	Soft starter fault	Digital input	11.	Flow meter	Analog input
4.	Pump in operation	Digital input	12.	Pressure meter	Analog input
5.	NRV	Digital input	13.	Pump operation	Digital output
6.	Chlorine level	Digital input	14.	Lubrication valve	Digital output
7.	Moist. /Over temp.	Digital input	15.	RS-VDN (RS485 bus)	Data bus (I/O)
8.	Power Fall	Digital input			

Upgrade of the system depends on adding new components that are needed for the SCADA system while keeping the previous control system components. The new upgraded system will have the ability to run the new control system with all its original options, along with the additional supervisory and data acquisition features. Figure 7 illustrates the connection of the upgraded part of the control system.

3.3 Alarms, Reports and Trend Displays

Alarms and reports are main parts of the SCADA system functions [16]. The control system generates several alarms that are used to alarm the controller if the system interred in danger state. These alarms are: Pump faller (Pressure, ENT6, NRV), Soft starter faller (NZM), Chlorine level switch, Fuel level switch, and Generator fault.

Previous alarms are archived with another data (flow meter, pressure meter and RS485 bus data of the soft starter) in the SCADA system and used for analyzing and developing the systems. Important reports that may be generated are: time of pumps operation, Current of the motor pump, pressure level of the distribution line and the flow rate.

3.4 Supervisory Control

Control system of the well station recommended divide to remote and local. Remote control will be through the SCADA system. This system needs a PLC to be as its process controller. Local will be two parts, local automatic and local manual. Local control will be monitored through the SCADA system also. Remote control will help in blocking and deblocking pumps and generators remotely in addition in monitoring and archiving the system processes.

3.5 System Upgrade

Updating of the system depends on remaining the previous hardwiring control system. Adding a process controller PLC from Delta Company as it is familiar in Gaza market and its prices are relatively low. New control system will depend on:

1. PLC input signals will be from the present control system devices (switches, valves, NZM, ENT6, soft starter, and generator).
2. Output signal will used to run the soft starter.
3. The PLC will be programmed to control the pump using previous signals.
4. New control system will has three operation methods: manual depending on the operator and monitored with the PLC, automatic depending on clock timer, relays and timers and also monitored with PLC, the third method of operation is supervisory control depending on the PLC and supervisory by the SCADA system.
5. UPSs are added to operate the PLC and the communication unit for nearly 1 hour, when the main electrical current cut off.
6. RS485 card for SOLCON soft starts may be added to connect the soft starter with the PLC through RS485 port, to reed soft starter parameters.
7. Switch sensors for chlorine tank and fuel tank.
8. Electrical pressure meter, to send signals to the PLC to calculate the pressure in the water distribution network.
9. Flow meter, to calculate the quantity of the water pumped from the station.

4. COMMUNICATION NETWORK

In this part we will illustrate most common communication scenarios, suggested network topology and cost for each communication scenario.

4.1 Communication Scenarios

Designing the communication network of the SCADA system is one of the main parts of our research. That will specify the way of connecting the water well stations with the main control room. There are several scenarios that depend on communication technology exist in Gaza strip [17]. It includes direct connection through (RS232, RS485 and Ethernet), Public Switching Telephone Network (PSTN), Global system for Mobile (GSM)

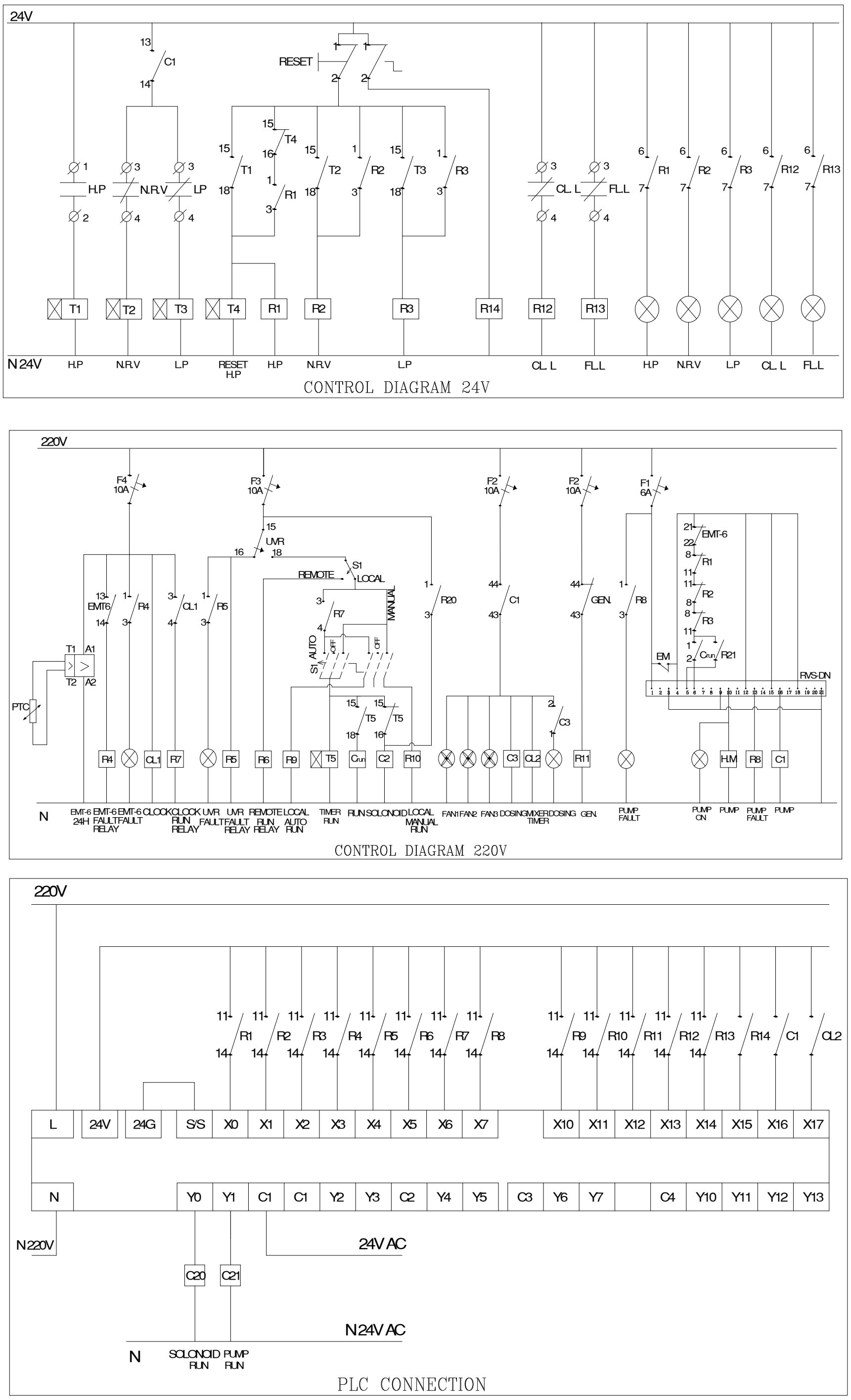


Figure (7): Well station control system with PLC cellular system, and wireless LAN. Every connection has advantages and disadvantages. We can use mix of these techniques to reach to the optimum connection.

4.1.1 Direct Connection

Direct connection usually uses RS232, RS485 or Ethernet port to connect a process controller (PLC) with SCADA servers. This is the cheapest and most preferable connection method. But this is suitable for small distances that are less than 20 m for RS232, less than 100 m for Ethernet and less than 1200 m for RS485[2][18]. So this connection is used when the well station near the main control room as shown in plants 3, 4 and 5 in Figure 3; or when there are several well stations near each other and connected with master PLC controller as the case of plants 8 and 9 in the same figure.

4.1.2 Dial up Connection Using PSTN

Connecting far process controller (PLC) with the SCADA servers using PSTN [4] needs external dial up modem with serial port at each well station. At the other side, at the main control room, the SCADA server connects to the PSTN through dial up modem as illustrated in the case of planet 1 in Figure 3. This scenario implies a relatively low cost running cost that composed of the monthly fixed charges and the dial up calls. There is no online data connections, data will be collected several times through the station work period, and collecting data through dialup takes a time, as every call need 1 minute. On line connection will be expensive. Also, getting data at urgent actions will take time until dialing the modem and connecting to PLC. Well stations that have already dialed up phone line can use this scenario for connecting with the main control room.

4.1.3 Cellular Phone System

Connecting the PLC with the SCADA server through the cellular phone system need GSM modem with serial port at each well station to connect to at the process controller PLC with the RS232 serial port. At the other site, pool of GSM or dial up modem used to connect the control system with the cellular system as shown in plant 2 of Figure 3. Gaza cellular phone system, JAWWAL, has good service that is called GPRS; this service is used for internet connection. The user is assigned an IP number which allows him to connect online with internet. Charging depends on the size of download packets not on the calling time. When using this service the PLC is

[2] Using fiber optic technology may reach to 3 km distance but the infrastructure is difficult and expensive.

connected online with the SCADA server. The problem of this service is assigning dynamic IPs to clients. This forces us to program the PLC to send data to the SCADA server but this is not a professional solution. On the other hand, requesting static IPs is much expensive.
One promising advantage of cellular phone system is the availability of using RTUs from SOLCON Company. Resent well stations soft starters are from SOLCON so, using SOLCON RTUs [19] reduces the required upgrade equipments and cost.
Cost of using cellular phone system is more expensive than PSTN although there are no monthly fixed charges. Calling charges of cellular system are more expensive. It is good to benefit from the prepaid system by using it at well stations modem and use it for alarms and emergency cases only. At main control room, it is recommended to buy a big package of calling to benefit from the discount on big packages. Cellular system used in stations that has good GSM signals. Cellular system has some problems in calling as network busy, lack of the signal in some locations and change of the signal strength.

4.1.4 Wireless Private Connection

Wireless communication has evolution every day; all instruments and devices try to use this connection. It has many different types as Bluetooth, VHF/UHF [4], Microwave [4] and others. These types depend on frequency band that has ranges from 30 MHz to 300 GHz. each rang of frequency band has its special use that depends on the transmission distance, the data transmission and the system cost.
Microwave: Microwave transmits at frequencies of 30 to 300 GHz through parabolic dishes mounted on towers or on top of buildings. This media uses point-to-point, line-of-sight technology and communication may become interrupted at times due to misalignment and/or atmospheric conditions. Microwave technology used for direct line-of-site systems for distances of tens of kilometers with relatively huge power requirement.
VHF / UHF: VHF/UHF transmission ranges from 30 MHz to 3000 MHz through special antennas. A license from the ministry of communication must be obtained and coverage is limited to special geographical boundaries. Commonly used VHF/UHF frequencies in radio modems for environmental monitoring or SCADA includes frequencies of the range from 66 MHz to 960 MHz. These ranges locate in the ISM (Industrial Scientific and Medical) band frequencies that are unlicensed.
Many companies manufacture industrial wireless devices compatible with SCADA system and used to connect far industrial devices to central

SCADA system. One of these industrial devices is SATELLAR [20] system that is shown in Figure 8, which is wireless communication system in unlicensed frequency range 380-520 MHz, and has point to point link communication range reach to 10 km in urban area.

Figure (8): SATELLAR system

4.2 Network Topology

According to the above description of network connections and according to the well water stations distribution in Gaza, we can connect these water well stations as classified below:

4.2.1 Connection Using RS485 Bus

We recommend using this connection for stations that have a distance less than 1200 m between each other and have the practical ability of connection using RS485 cable. Also, stations in the same location will be connected using RS485. Stations which are recommended to be connected with RS485 listed below:

1- Well stations Sh. Radwan wells 12, 15 and 16. The central PLC connection will be at Sh. Radwan well 15.
2- Well stations Sh. Radwan wells 10 and 11. The central PLC connection will be at Sh. Radwan well 10.
3- Sh. Radwan wells 1 and 1A .
4- Sh. Radwan wells 7 and 7A
5- SAFA-wells 1, 2, 3 and 4.
6- Zaiton wells 1 and 2.

4.2.2 Connection Using Private Radio Channels (WIRELESS)

We will use wireless radio signals to connect far stations with the main control room. Table 3 summarizes the line-of-site distance between the proposed main control room and remote locations. It is remarkable that this distance is less than 5Km for all remote locations.

4.3 Communication and System Costs

Table 4 illustrates the cost of the previous communication scenarios. We calculate the price of the hardware devices with its installation and the running cost for 5 years. For dialing systems we make our cost on making 10 calls per a day, with calling charges of 2 cents for dialing and 20 cent for cellular. Also Table 5 illustrates the system total estimated cost [21] which also includes stations upgrading, hardware and software implementing and engineering consultant.

Table (3): Gaza well pumping stations groups and distance to main control room

No.	ID	Well Name	Dis. to Main Room	No.	ID	Well Name	Dis. to Main Room
1	WG1	Safa well 1	2026	12	WS6	Sh. Radwan 2	2667
		Safa well 2		13	WS7	Sh. Radwan 3	2568
		Safa well 3		14	WS8	Sh. Radwan 4	2753
		Safa well 4		15	WS9	Sh. Radwan 5	3111
2	WG2	Sh. Radwan 1	2176	16	WS10	Sh. Radwan 8	3262
		Sh. Radwan 1A		17	WS11	Sh. Radwan 9	3171
3	WG3	Sh. Radwan 7	1908	18	WS12	Sh. Radwan 13	2137
		Sh. Radwan 7A		19	WS13	Remal	1688
4	WG4	Sh. Radwan 10	3435	20	WS14	Remal 2	2581
		Sh. Radwan 11		21	WS15	AL Daraj	550
5	WG5	Sh. Radwan 12	4657	22	WS16	Sh. Ejleen 1	2791
		Sh. Radwan 15		23	WS17	Sh. Ejleen 2	2221
		Sh. Radwan 16		24	WS18	Sh. Ejleen 3	2949
6	WG6	Zaitoun 2	1971	25	WS19	Sh. Ejleen 4	2256
		Zaitoun 1		26	WS20	Sh. Ejleen 5	2496
7	WS1	Shijaiea 2	1811	27	WS21	Sh. Ejleen 6	3063
8	WS2	Shijaiea 3	1900	28	WS22	Sh. Ejleen 7	1965
9	WS3	Shijaiea 5	2135	29	WS23	Sabra 1	1638
10	WS4	Almontar	2231	30	WS24	Sabra 2	1170
11	WS5	Zimmo	3911	31	WS25	Sabra 3	529

SATELLAR system proposed to be the main connection between these stations and main control room. Some of important stations will have backup connection, it is recommended to use the dialing up connection as an alternative and backup connection. Meanwhile, nearly all big and important well stations already have a dialup phone line.

Table (4): Communication scenarios cost for first 5 years

#	Communi-cation Method	Method parts	Setup Cost		Running Cost /Year	Total cost for first 5 years
			Remote Unit Cost	Central Unit Cost		
1	Direct	-	0	0	0	0
2	Dial Up Connection (PSTN)	Modem	70*31 =2170$	70*4=280$	10 calls per day 2 Cent per call 10*30*12*.02*31= 2232$ Fixed charges: 5$ 5*12*35= 2100$	26210$
		Phone Line	60 *31= 1860$	60*4=240$		
3	Cellular phone System (GSM)	Modem	300*31= 9300$	300*4= 1200$	10 calls per day 20 Cent per Call 10*30*12*0.20*31 = 22320$	123150$
		Phone Line	2*31= 62$	30*4= 120$		
4	Radio wireless connection	-	3000*31= 93000	5000*2= 10000	0	103000$
5	RTU (SOLCON)	Unit price	3500*31= 108500	1200$	10 calls per day 6 Cent per Call 10*30*12*0.06*35 = 7560$	147562$
		Phone Line	2*31= 62$	0		

Table (5): The system total estimated cost

Item	Estimation Cost
Stations upgrade	160,000$
Main control room hardware components	30,000$
Software implementation	70,000$
Communication	110,000$
The engineering consultant	30,000$
Total Cost	400,000 $

5. EXPERIMENTAL RESULTS

The experimental platform comprises four well plant modules which are equipped with Delta DVP28SV PLCs as shown in Figure 9. Many experiments are designed to evaluate and demonstrate the communication scenarios described in the previous section. Our experimentation challenges along with practical remedies are detailed in reference [22].

Figure (9): Experimental platform

6. RESULTS AND CONCLUSIONS

The importance of water in our region pushes us to try to use the new world technology in controlling our little resources of water supply. This research presents a framework for building a SCADA system to control Gaza well water supply. Upgrade of the system depended on adding new components that are needed for the SCADA system with keeping the previous control system components, so the upgraded system will have the ability to run the new control system with all its original options. Wireless communication system is more suitable for the running time. Near stations are connected with others through RS485 bus then connected with the main control room through wireless unit. SATTELLAR wireless system is recommended to be used for wireless system. It is good to use backing communication system for main well pumping stations using PSTN system for well stations that has dialup line, and cellular system may be used for stations that have problems with PSTN network.

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