

MONITORING AND CONTROL WATER NETWORK USING GIS

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ABSTRACT

In this paper general idea of full-scale realization for a comprehensive monitoring system of the drinking water distribution network has been presented by using several modern technologies such as Geographic Information System technology (GIS), PIC Microcontroller Programming, and wireless communication.

Monitoring of water networks is a system of measurements and analysis of the operational and technical state of the network in order to gain sound bases for its control and usage.

The proposed system is going to monitor the water network operation and allow remote control for critical sections in the network using GIS, because GIS is quickly becoming a critical component to develop and sustain asset management for water utilities, and GIS interfaced with Visual-Basic program to send and receive data from Microcontroller that connected with wireless device.

This program receives any changes on the network as a warning alarm and displays it on the map as exactly X and Y coordinates that will help us for identifying the problem properly. Knowing the exact location and giving quick solutions are necessary to avoid any losses and to provide a good and continuous service to the customers.

The developed system is suitable for any water network, but it is more efficient to use especially for the far places which indeed is suffering from water losses and network breakdown and furthermore, the employees are facing real danger for operating the network locally and manually that obtains as a result for the Israeli occupation.

Keywords: GIS, Microcontroller, VB, Wireless, Water, Control.

1 INTRODUCTION

Community prosperity and well-being are directly dependent upon a sufficient supply of clean water. In addition to basic human health and sanitation, a clean and adequate water supply is needed and more important benefits of clean water such as irrigation for agriculture, habitat for many plants and animals, recreational opportunities, and a symbol of vitality.

But this vital resource is stressed by multiple and sometimes competing demands.

And by studying Gaza strip network can be finding that it contains many problems that need to be studied and solved such as:

Water quality doesn't match the standard measurements around the world, Gaza strip network depends on ground water which means it is not renewable. It runs manually which mean more difficulties and problems in operating, monitoring and controlling the system, and also the service will be always under the mercy of the occupation attacks.

According to these problems and the importance of water quality and quantity, this work suggests different scenarios that might be used to solve them and improve the network's service.

This work depends mainly on operating the water network remotely also providing the municipal and the Water authority with annually , monthly , weekly network status reports which will be very helpful and useful for them.

In addition to this, looking forward to monitor and control the main hydraulic and environmental parameter Using new software and technologies such as ArcGIS programs.

But this work confronted a lot of problems such as:

- Low level of water quality which was the reason of many diseases in the city.
- Quantity of water is not enough compared to the amount of demand.
- There is no accuracy of human water meter readings.
- There is no periodic information about the network situation and what is the status of the component (if maintenance is needed or not).
- There is no exact information about damages in the network only when the people complain.
- The operators might face the risk in case of Israeli attack.
- Lack of enough amount of water in the case of fire.
- The leakage and the stolen lines of the network. This paper doesn't have solutions for all problems but it is help the water authority to solve many problems like as:
 - To Change the network operation from manual to automatic, that will be save the operator life.
 - To make a good match between the amount of demand and amount of water (water redistribution according to the hydraulic concepts) to grantee the service for each customer.
 - To Control the water's quality and quantity using suitable sensors (pressure and chloride).
 - To Detect Illegal connections by checking flow meters and consumption amounts.
 - To Use a monitoring system which enable us to avoid, find and maintain damages.
 - To give weekly, monthly reports about network situation and water quality [1].

2. METHODOLOGY

Work will be divided into three main steps: data collection, determine the network's main problems and implement system to solve the problems.

2.1 Data collection

It means punctual study to get all the information about the city and the water network including:

- Area study: the demography, climate, history, income, water resources and water quality.
- Studying the maps (contour map, streets and roads map, water network map, the city zones and blocks) as shown in Figure 1.
- Water Supply Sources and Facilities which include a certain study for the water network distribution that explain the physical condition for

the network and the network operation rules also it provides us with information about every component in the network and how it works.

- Looking for network components which are available in Gaza companies to get the cost of pumps and valves.
- Finally concentrate all the effort to discover the real problem with the network and the people suffer by making questionnaire and field visits.

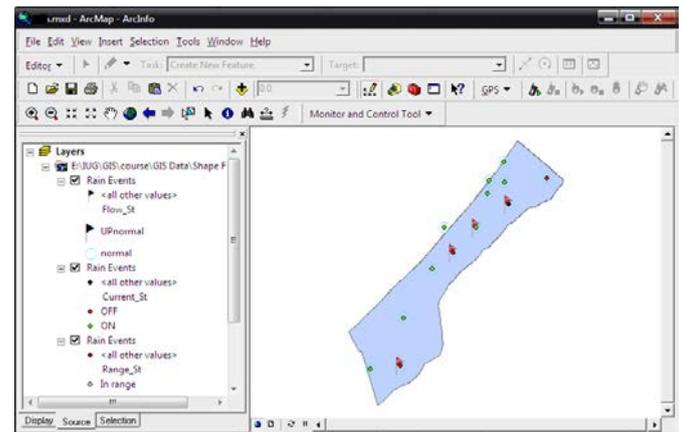


Figure 1 Temporary Map of Gaza Strip using GIS

2.2 Determine the network's main problems

From several visits to water companies and water authority in Gaza city and Dair Al Balah city, could be classify the problems into two categories as following:

First: Water network Problems those consumers suffer from:

- 1. Quality's low level:** salinity and contamination of water make it undrinkable and it is used for cleaning houses or irrigation activities only, this situation forces people to buy clean water for drinking.
- 2. Quantity is not enough:** In winter water arrives day after day and 5 hours per a day, and the problem increases largely in the summer that is in some regions such as Dair El Balah camp water arrives twice in the week that forces them to buy water for drinking and other uses.

Second category of problems is water network Problems that Operators suffer from:

1. Water quality: using different water sources to feed the network make it difficult to control the water's quality.

2. Accuracy of flow measurements: this problem appears in the zones that are not supported with flow meters also because some workers don't even measure the available flow meters.

3 SYSTEM IMPLEMENTATION

The implementation for this work is divided into two categories; each one has two steps as shown in Figure 2

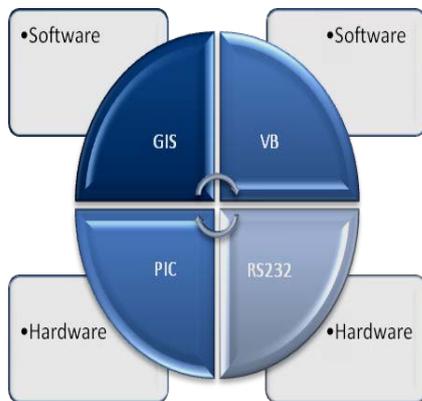


Figure 2 Software and hardware parts that is implemented

3.1 Software Implementation

In this work, two software are used to implement the system

3.1.1 GIS

GIS is a computer system for capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Typically, a GIS is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image on a map and a record in an attribute table. GIS can relate otherwise disparate on the basis of common geography, revealing hidden patterns, relationships, and trends that are not readily apparent in spreadsheets or statistical packages, often creating new information from existing data resources.

With GIS, can be explore the spatial element of the data to display soil types, track crime patterns, analyze animal migration patterns, find the best location for an expanding business, model the path of atmospheric pollution, and makes decisions for many types of complicated problems [2].

As a tool to implement this system, the GIS is used for many things:

- To display the water network map system is going to monitor and to add the database layer that buttons and menus so this facility is used to create system own tool menu containing system own used, By clicking anywhere in the program window Then select Customize, that followed by New Tool Bar to add and name the new toolbar for our work the new toolbar is named as “Monitoring & Control” as illustrated in Figure 3.

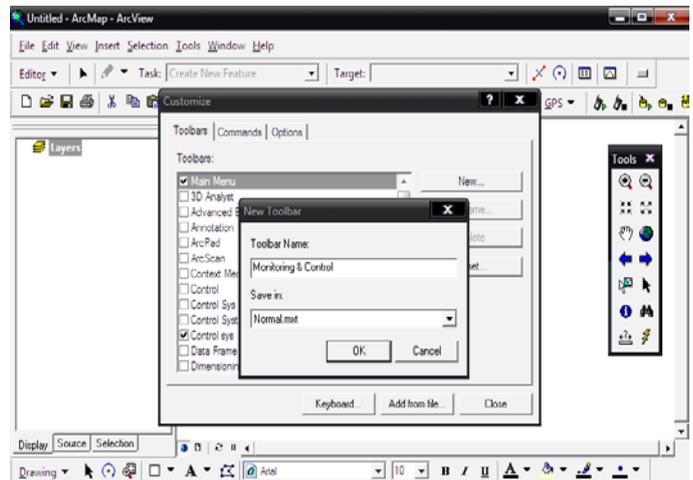


Figure 3 add a new toolbar

Created and programmed displays the x and y coordinates for the valves, tanks and pumps that the system is monitoring as shown in Figure 1. In addition, it has status, alarms and other information fields to help the user in this system.

To build the system toolbar menu because GIS supports adding special Buttons, Such as:

- Auto Refresh Button: an auto refresh button is created to support refreshing the map every 10 seconds in order to display coming alarms and map changes quickly and easily without the need to refresh the map manually.
- Serial Communication Button: this is main monitoring and control Button that allows serial communication between the GIS and the hardware

model, this button is going to open the serial ports and wait for incoming alarms to edit the map's database according to the new incoming data that will appear on the map automatically because of the use of the previous mentioned button.

- Control Button: it is where the interaction between the user "employee" and the network occurs, here this button is created to display a small control interface that allow controlling the valves and pumps status " ON/OFF" according to the current status and the network operation needs.

And to do so, add these buttons through the Commands from customize window and then select UIControl to add New UIControl that has many options, for this work, Create UIButtonControl and drag it to our own tool bar,

These Buttons are used according to the water network operation as follows:

- Pressure Changes: will appear on the network's map that will allow turning on/off the valves because of high/low pressure.

- Flow meter Changes: if water consumption exceeds the water authority given limits, an alarm will appear on the map to allow turning off the valve supporting the zone that gives the alarm for a time to avoid another zone's lack of water and to provide suitable water quantity for each zone.

In addition to the consumption, by changes in the flow meters readings may indicate that there is a breakdown on the network, and because GIS gives exact locations so maintaining the network will be easier and more quickly.

- Situation needs: if the current zone situation needs to stop supplying some zones or change some water paths this can be done by controlling the valves on the path or the pump for the supplying tank remotely to avoid water losses and also to provide continues water service during attacks or network damages.

In addition, GIS is useful to get reports of the network status periodically.

The most difficult and complex part in this system is insertion the current ARCMAP document to apply our code. Fortunately, The ARCMAP Program contains an embedded VBA (Visual Basic Application Editor) that is used to program the buttons from the ARCMAP itself.

3.1.2 Visual Basic

A programming language and environment developed based on the BASIC language; Visual Basic was one of the first products to provide a graphical programming environment and a paint metaphor for developing user interfaces. Instead of worrying about syntax details, the Visual Basic programmer can add a substantial amount of code simply by dragging and dropping controls, such as buttons and dialog boxes, and then defining their appearance and behavior.

It is software programming tool that is used to program the GIS buttons and to prepare the system to be ready for serial communication [3].

It is chosen because ARCGIS supports the use of Visual Basic Application Editor (VBA) to program additional buttons, and simplifies this work by giving embedded VBA program that is built in the GIS itself [2].

Programming using VBA allowing us to develop the previous mentioned buttons and simplifies accessing the current GIS maps and databases.

It uses mainly to allow serial communication and database connection, where the code is programmed to wait for incoming data, check it and its validity, determine the indicated database, connecting to the database and edit it according to the new data [4].

Also it's programmed to receive user's controls choices and send the suitable controls to the suitable and intended valve or pump.

3.2 Hardware Implementation

Also it is divided into two steps as follows:

3.2.1 PIC Programming

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division. The name PIC initially referred to Programmable Interface Controller, but shortly thereafter was renamed Programmable Intelligent Computer [5]. PICs are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes,

availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability.

For this work, PIC16F877A is chosen to be used because it allows Analog and Digital I/O and provide serial communication pins (TX and RX) with simple configuration steps and suitable for the system needs.

The PIC Program will do several tasks such as:

- Checks the sensors status and according to the status will send alarms to the GIS.
- Check the flow meter values and if it's larger than the expected limits, an alarm will be send to the GIS.
- Wait for serial incoming data from the GIS, Check it and take the proper action with the intended valve or pump according to the sent GIS Controls.

3.2.2 Wireless and Serial port connections

Wireless communication is used to implement the system so Bluetooth wireless communications are used as an example to view how wireless would be use and serves the system. But to implement the system for far distance, WIMAX wireless technology or Microwave is recommended.

4 RESULTS

The serial port is used to interface the software (GIS and VB) and hardware (PIC, Pump, Valve, and the sensors), but the connection not easy to implement without the driver and auxiliary circuits should be built, this section views these circuits.

Figure 4 views the small drive circuit to control the valve by PIC, if the output 1 or 0 then the valve ON or OFF, respectively.

After studying the water network operation, I found that two kinds of control must be used on the source water tank and pumps, Automatic control and remote control

- Automatic Control: this kind of control is needed when talking about tank water's level

Since pump must be off when the tank is empty and can be ON or OFF when it is not empty, so we had to use a water level's indicator that is the float switch.

- Remote Control: it is the PC control that is sends to the PIC to change the pump status when sudden problem occurs.

The automatic control using float switch and remote control with PIC are shown in Figure 5 and Figure 6, respectively.

The schematic diagram of the whole system is illustrated in figure 7

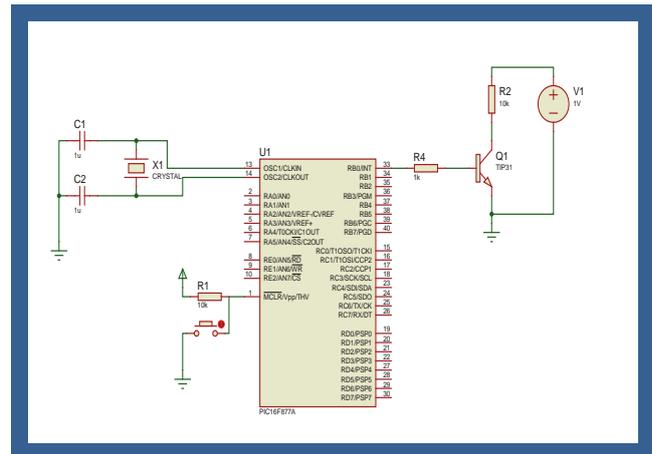


Figure 4 Valve Driver Circuit

5 CONCLUSION

In this work, can be solving many problems as follows:

Using sensors will control the water quality and quantity, and can be used to detect illegal connection.

- Automatic control will let the system solve some problems automatically without the need of human effort.
- Connecting the system with GIS wirelessly will give fast notification if an error occurs, helps in requesting reports for the network status and in some cases will be used in controlling the system remotely in order to avoid network break down in some cases.
- This system will provide enough quantity and good quantity for the human uses.

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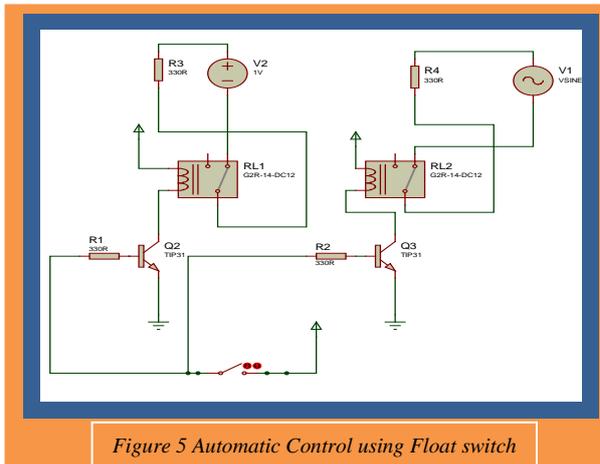


Figure 5 Automatic Control using Float switch

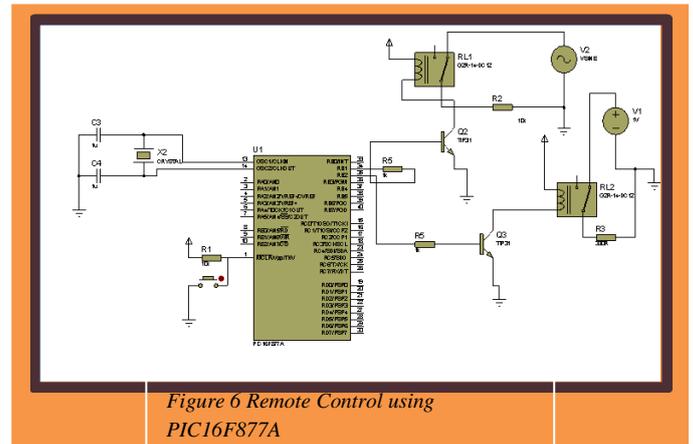


Figure 6 Remote Control using PIC16F877A

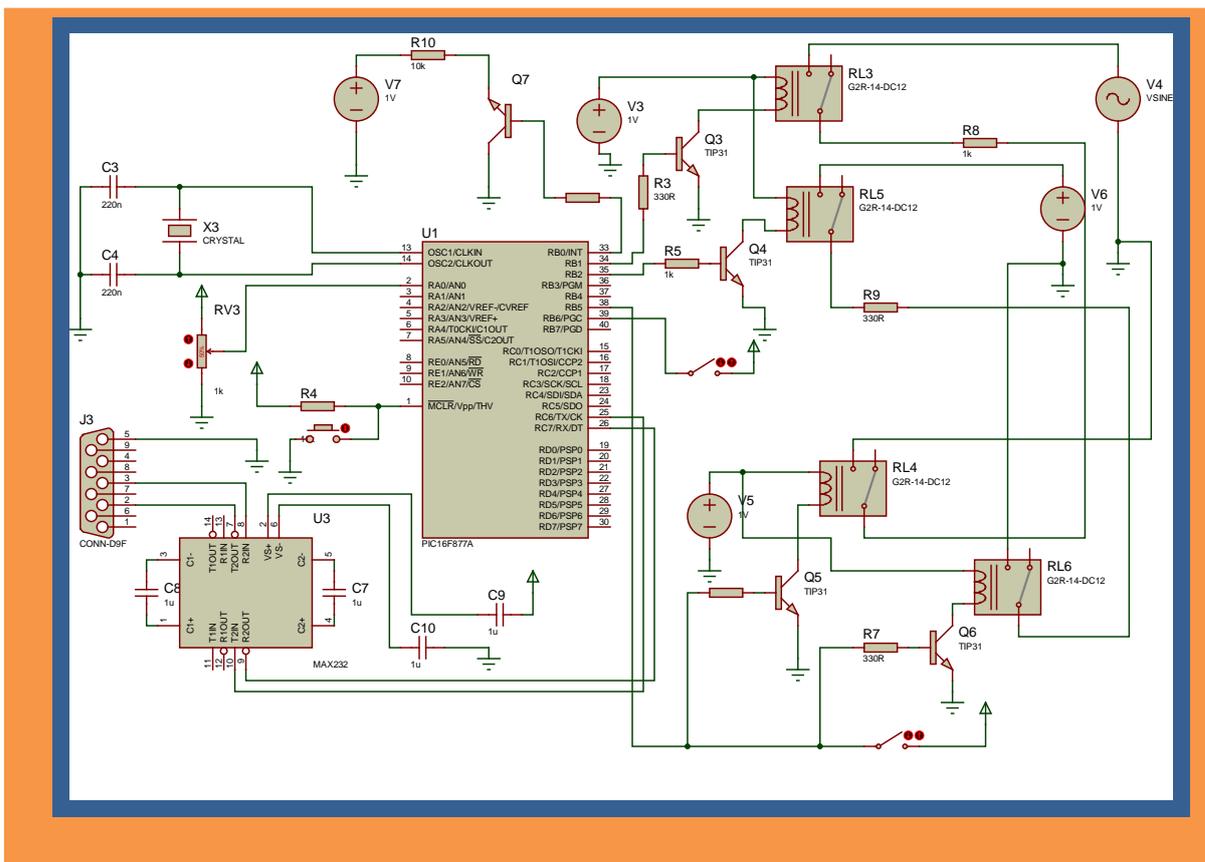


Figure 7 Schematic diagram of the whole system