WATER LEVEL MONITORING AND CONTROLLING OF WATER TREATMENT PLANTS USING WIRELESS SENSORS IN LABVIEW

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For my beloved mother, father, wife, sons, brothers, sisters, family

For my beloved Iraq

For my beloved supervisor Dr. Khairun Nidzam Bin Ramli

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ABSTRACT

Monitoring and controlling systems are taken as the main entity of any field which can ensure for the effective performance, hence its importance is rising exponentially in industry field. There can be many factors which can bring variations in those systems. This may cease the efficiency of the industry and destruction of industrial equipment. Therefore, monitoring, evaluation and controlling of the variables of any system is significantly important. The main objective of this research is to investigate the process of combining monitoring and controlling of the water level in the distribution tanks of water treatment plants by using wireless sensors network. The design and developed prototype of remote monitoring and controlling system of water levels in various tanks can be used in different parts of the water treatment plants. We have proposed, developed and tested hardware module based on two Arduino Mega2560 boards linked wirelessly by using two NRF transceivers. Remote Arduino is designed to monitor the water flow and the level of the distribution tank besides controlling the water level whenever is necessary. The real time sensors readings obtained are observed by specially designed LabVIEW application using graphical user interface running on a PC connected directly to the local Arduino. The application displays and analyses sensors reading on the front panel. Water level is controlled based on preset values entered by the user. The experimental result and percentage error curve endorse the reliability and feasibility of the proposed system to provide a solution for similar problems in industrial liquids treatment process applications.

ABSTRAK

Sistem pemantauan dan pengawalan diambil sebagai entiti utama bagi mana-mana bidang yang boleh memastikan prestasi berkesan, menyebabkan kepentingannya meningkat secara eksponen dalam bidang industri. Terdapat banyak faktor yang boleh membawa perubahan dalam sistem tersebut. Ini boleh menghentikan kecekapan dan kerosakan peralatan perindustrian. Oleh itu, pemantauan, penilaian dan pengawalan pembolehubah sesuatu sistem adalah penting. Objektif utama kajian ini adalah untuk menyelidik proses menggabungkan pemantauan dan pengawalan paras air di dalam tangki pengedaran rawatan air dengan menggunakan rangkaian pengesan wayarles. Contoh sulung rekabentuk dan pembangunan pemantauan jarak jauh dan sistem pengawalan paras air dalam pelbagai tangki boleh digunakan di bahagian yang berlainan di loji rawatan air. Kami telah mencadangkan modul perkakasan yang dibangunkan dan diuji berasaskan dua papan Arduino Mega2560 yang dikaitkan secara wayarles dengan menggunakan dua pemancar terima NRF. Arduino jauh direka untuk memantau aliran air dan tahap tangki pengedaran selain mengawal paras air apabila diperlukan. Bacaan pengesan masa sebenar yang diperolehi diperhatikan oleh aplikasi LabVIEW yang direka khas menggunakan antara muka pengguna grafik pada PC yang disambungkan terus ke Arduino tempatan. Aplikasi ini memaparkan dan menganalisis bacaan pengesan di panel hadapan. Tahap air dikawal berdasarkan nilai praset yang dimasukkan oleh pengguna. Lengkungan ralat hasil percubaan dan peratusan menyokong kebolehpercayaan dan kebolehlaksanaan sistem yang dicadangkan bagi memberikan penyelesaian masalah yang sama dalam aplikasi proses rawatan cecair industri.

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LIST OF SYMBOLS

GUI	Graphical User Interface
WSN	Wireless Sensor Network
WTP	Water Treatment Plant
RF	Radio Frequency
IDE	Arduino Integrated Development Environment
SMS	Short Message Service
GSM	Global System Mobile Communications
LCD	Liquid Crystal Display
AM	Amplitude Modulation
RFID	Radio Frequency Identification
FM	Frequency Modulation
LAN	Local Area Network
GPS	Global Positioning System
PC	Personal Computer
PWM	Pulse-Width Modulation
DAC	Digital to Analog Conversion
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

1.1 Introduction:

Currently, Wireless Sensor Network (WSN) is the most standard administrations utilized in business and modern applications, because of its specialized advancement in a processor, communication, and low-power of inserted computing devices. The WSN worked with nodes that are used to monitor the surrounding environment such that temperature, pressure, position, humidity and sound. These nodes can be worked in different real-time applications to perform different jobs like smart detecting, data treatment, data collection and storage also target tracking, synchronization, node localization, node confinement and successful directing between nodes and base station [1].

A Wireless Sensor Network is one kind of wireless network includes a large number of circulating, self-directed, minute, low powered device sensor nodes called motes. These systems unquestionably cover an enormous number of spatially appropriated, pretty much nothing, battery-worked, inserted devices which are arranged to caringly gather process and transfer data to the operators, and it has controlled the capabilities of computing and processing. Nodes are the modest PCs, which work mutually to frame the systems.

The sensor node is a multi-functional, energy efficient wireless device. The applications of motes in industrial are across the board. An accumulation of sensor nodes gathers the information from the surroundings to accomplish particular application targets. The correspondence between motes should be possible with each other utilizing handsets. The quantity of motes sometimes can be in the request of hundreds.

1.2 Wireless Sensor Network Review

Wireless sensor networks may comprise of numerous different types of sensors like low sampling rate, seismic, magnetic, thermal, visual, infrared, radar, and acoustic, which are clever to monitor a wide range of ambient situations. Sensor nodes are used for constant sensing, event ID, event detection and local control of actuators .The applications of wireless sensor network mainly include health, military, environmental, home, and other commercial areas as Figure 1.1 [2].

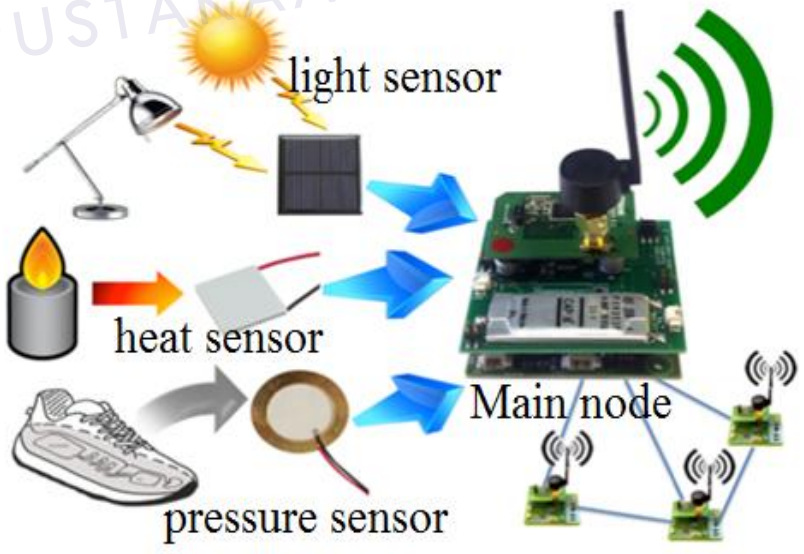

Figure 1.1: Wireless sensor network [2]

These are ideally the main characteristics:

1. Low energy consumption.
2. Low cost nodes that use cheap and commonly available batteries.
3. Small physical size to facilitat deployment.
4. Compliance to standards and regulations.
5. Single design for interntional markets.
6. Ability to maintain time synchronzation with other nodes.
7. Operate over wide temperature values especially for military uses.

The advantages of WSN include the following

1. Network arrangements can be carried out without immovable infrastructure.
2. Appropriate for the non-reachable places like mountains, over the sea, rural areas and far forests.
3. Flexible if there is a casual situation when an additional new station works.
4. Execution pricing is suitable.
5. It avoids wrongs of wiring.
6. It provide accommodations for the new devices at any timing.
7. It can be operate by using a centralized monitoring.

Some of the key technology and standards elements that are relevant to sensor networks are as follows [3]:

Sensors:

1. Intrinsic functionality.
2. Signal processing.
3. Compression, error correction, encryption.
4. Control/actuation.
5. Clustering and in-network computation.
6. Auto-assembly.

Wireless radio technologies [4]

1. Software-defined radios.
2. Transmission range.
3. Transmission impairments.
4. Modulation method.
5. Network technology.

Standards:

1. IEEE 802.11a/b/g together with ancillary security protocols.
2. IEEE 802.15.1 PAN/Bluetooth.
3. IEEE 802.15.3 ultrawideband (UWB).
4. IEEE 802.15.4/ZigBee (IEEE 802.15.4 is the physical radio, and ZigBee is the logical network and application software).
5. IEEE 802.16 WiMax.
6. IEEE 1451.5 Wireless Sensor Working Group.
7. Tiny DB.
8. Tiny OS (Tiny OS is being developed by the University of California–Berkeley as an open-source software platform; the work is funded by DARPA and is undertaken in the context of the Network Embedded Systems Technology [5].

Software applications:

1. Operating systems.
2. Network software.
3. Database connectivity .
4. Middleware.
5. Data management.

1.3 Problem statement

Water, one of the great natural resources should be utilized in proper form. During the last years the necessity to use water resources such as rivers, ground water and rain water efficiently has increased rapidly. Population growth, rapid urbanization and climate change have stressed water resources on the planet. But a huge amount of water is being wasted during daily life especially in water treatment plants due to lack of monitor or control [6].

i- The application of wireless water leveling sensor networks can utilize water resources very efficiently.

ii- Lack of control in processing tanks in water treatment plant WTP will not only affect the component and equipment but also the process and the operators comfort, all ultimately leading to loss in production and to avoid overflow in very high water level or problems of pump working in very low water level.

iii- To avoid human wrongs, manual control disadvantage and wiring connection problems.

1.4 Objectives

The main goals of this project are:

i- To investigate the process of combining monitor and control of the water level in distribution tanks in water treatment plants by using wireless sensors network.

ii- To design and develop prototype of remote monitoring and controlling system of water levels in various tanks that can be use in different parts of the water treatment plants and provide a solution for similar problems in liquids treatment process of industrial applications.

1.5 Scope of Work

The project will be built on microcontroller (Arduino AT Mega 2560), it needs two microcontroller for two nodes of wireless sensor network in the system. The first Arduino A will be programmed as a gate way for the water level sensor and water flow sensor. The second Arduino B used for controlling the water pumps according on the data signal has received from Arduino A. Besides that, there will have ultrasonic level sensor HC-SR04 to measure the water level readings and water flow sensor YF-S201 and send it to Arduino A . for this prototype project, the RF communication model that being used is 2.4 GHz NRF24L01+ transceiver. Also we need a pair of Nrf24L01+ in order to work as transceiver1 and transceiver2. It also allow the Arduino A to wirelessly communicate with other Arduino B which connected with PC has LABVIEW software for distance less than 10 meters at indoor area. In addition, there will have two water pump with electrical drive circuits and suitable energy source unit [2].

CHAPTER 2

LITERATURE REVIEW

2.1 Historical Survey

During the cold war, broad acoustic systems were created in the United States for submarine reconnaissance; a portion of these sensors are as yet being utilized by the National Oceanographic and Atmospheric Administration (NOAA) to screen seismic action in the sea. Additionally, systems of air resistance radars were sent to cover North America; to deal with this, a battery of Airborne Warning and Control System planes worked as sensors.

The real force to investigate on sensor systems occurred in the mid 1980s with programs supported by the Defense Advanced Research Projects Agency (DARPA). The dispersed sensor systems (DSN) work went for deciding whether recently created TCP–IP conventions and ARPA net's (the ancestor of the Internet) way to deal with correspondence could be utilized as a part of the setting of sensor systems. DSN proposed the presence of some minimal effort spatially appropriated detecting hubs that were intended to work in a community oriented way, yet be independent. The objective was for the system to course data to the hub that can best use the data [1].

First-generation commercial products based on the results generated by the DARPA–DSN research, military organizers set out in the 1990s to receive sensor arrange innovation, making it a key segment of system driven fighting. An exertion was set aside a few minutes to begin utilizing business off the rack innovation and normal system interfaces, along these lines decreasing expense and improvement time. A case of system driven fighting incorporate the helpful commitment ability, a framework that comprises of numerous radars gathering information on air targets. Other sensor organizes in the military field incorporate acoustic sensor clusters for antisubmarine fighting, for example, the settled appropriated framework and the progressed deployable framework, and self-sufficient ground sensor frameworks, for example, the remote war zone sensor framework and the strategic remote sensor framework [8].

In the 2000s have brought about another age of sensor arrange innovation. Developing sensor systems speak to a critical change over conventional sensors [9]. Reasonable conservative sensors in view of various high-thickness advancements, incorporating MEMS and in the following couple of years nanoscale electromechanical frameworks (NEMS), are showing up.

Institutionalization is a key to wide-scale sending of any innovation, including WSN (e.g., Internet– Web, MPEG-4 advanced video, remote cell, VoIP). Advances in IEEE 802.11a/b/g-based remote systems administration and different remote frameworks, for example, Bluetooth, ZigBee and WiMax are presently encouraging solid and pervasive availability. Modest processors that have low power-utilization necessities make conceivable the organization of sensors for a plenty of uses. Monetarily engaged endeavors are presently coordinated at characterizing network, distributed, and group tree organize topologies with information security highlights and interoperable application profiles. Table 2.1 [9] condenses these ages of business items and insinuates to a next-generation set of products [10].

Table 2.1 Commercial generations of sensor networks

	First Generation 1980s	**2nd Generation** 1990s	**Third Generation** 2000s
Size	Larger	Paperback book	small
Weight	Pounds	Ounces	Grams
Node	Separate sensing	Integrated sensing	Fully integrated sensing
Protocol	Proprietary	Proprietary	Wi-Fi, ZigBee,...etc
Topology	Point to point ,star Multihop	Client-server and Peer to peer	Fully peer to peer
Power supply	Large batteries or Feed line	AA batteries	Solar or possibly Nanotechnology
Life span	Hours and days	Days to weeks	Months to years

2.2 Wireless Sensor Networks

2.2.1 Overview of WSN

A sensor network consists of a number of sensor nodes that are deployed in a wide area with little powered sensor nodes. The wireless sensor networks, can be utilized as part of different information and telecommunications felids . they are so small devices with the capability of wireless communication, which collects information about sound, light, motion, temperature humanity and processed them before transferring it to the other nodes[1].

2.2.2 Sensor node architecture

A wireless sensor node is composed of four basic components, processing unit (microcontroller), sensing unit, transceiver unit and power unit[1].

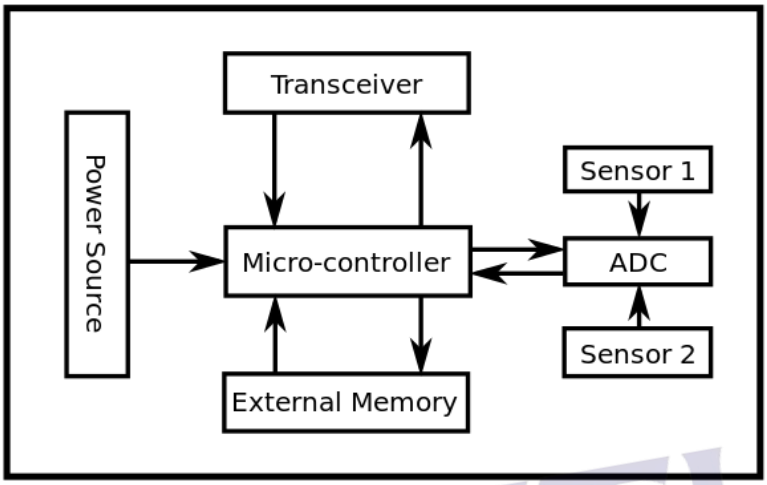

Figure 2.1 Typical sensors node[1]

Figure 2.1 shows the average development of a sensor node, Notwithstanding the above units, a remote sensor hub may incorporate various application-particular segments, for instance, an area identification framework or mobilizer. Consequently, numerous business sensor hub items incorporate extension spaces and bolster serial wired correspondence. Depictions of the essential segments are given below:

• **Microcontroller**: A microcontroller gives the handling capacity to, and facilitates the action of, a remote sensor hub. Not at all like the preparing units related with bigger PCs, a microcontroller coordinates handling with some memory arrangement and I/O peripherals. Such joining lessens the requirement for extra equipment, wiring, vitality and circuit board space. Notwithstanding the memory gave by the microcontroller, it isn't unprecedented for a sensor hub to incorporate some outside memory [3].

• **Sensing Unit**: A sensor is a gadget that measures some physical amount and changes over it into a flag to be prepared by the microcontroller. An extensive variety of sensor composes exists, including seismic, warm, acoustic, visual, infrared and magnetic[1].

condition to detect information, e.g. radar) and might be directional or omnidirectional. A remote sensor hub may incorporate different sensors giving reciprocal information. The detecting of a physical amount, for example, those depicted, commonly brought about the generation of a ceaseless simple flag. Therefore, the sending unit is commonly made out of various sensors and a simple to computerized converter (ADC) which digitizes the signal.

• **Transceiver**: A transceiver unit permits the transmission and gathering of information to different gadgets associating a remote sensor hub to a system. Remote sensor hubs ordinarily convey utilizing a RF (radio recurrence) handset and a remote individual territory arrange innovation, for example, Blue-tooth or the 802.15.4 agreeable conventions ZigBee and MiWi. The 802.15.4 standard indicates the physical layer and medium access control for low-rate, minimal effort remote correspondences, while proto-cols, expand upon this by building up the upper layers of the OSI Reference Model. The Bluetooth determination crosses all layers of the OSI Reference Model and is likewise intended for low-rate, minimal effort remote systems administration..

• **Power Supply**: All wireless sensor must be bolstered by a power unit which is regularly some type of capacity (that is, a battery) however might be upheld by control searching parts (for instance, sun oriented cells). Vitality from control rummaging procedures may just be put away in rechargeable (auxiliary) batteries and this can be a helpful mix in remote sensor hub conditions where support tasks like battery changing is unreasonable. To moderate vitality, a power unit may also bolster control preservation systems [3].

2.3 Water treatment plant review

In order to get a clear picture about how does water treatment plant, a brief information regards every stage will be quite useful. A water supply system typically includes the following [6]:

1. A raw water collection point, where the water accumulates such as a lake, river or groundwater. Raw water may be transferred using uncovered ground-level channels, covered tunnels or underground water pipes to water purification facilities.
2. Water purification facilities; undesirable chemicals, biological contaminants, suspended solids and gases will be removed from water at this stage. Treated water is transferred using water pipes (usually underground).
3. Water storage facilities such as reservoirs, water tanks or water towers. Smaller water systems may store the water in cisterns or pressure vessels. Tall buildings may also need to store water locally in pressure vessels in order for the water to reach the upper floors.
4. Additional water pressurizing components such as pumping stations may need to be situated at the outlet of underground or above ground reservoirs or cisterns.
5. A pipe network for distribution of water to the consumers and other usage.
6. Connections to the sewers such as underground pipes or aboveground ditches are generally found downstream of the water consumers, but the sewer system is considered to be a separate system, rather than part of the water supply system.
7. The water in the supply network is maintained at positive pressure to ensure that water reaches all parts of the network, that a sufficient flow is available at every take-off point and to ensure that untreated water in the ground cannot enter the network. The water is typically pressurised by pumps that pump water into storage tanks constructed at the highest local point in the network as shown in Figure 2.2 [7].

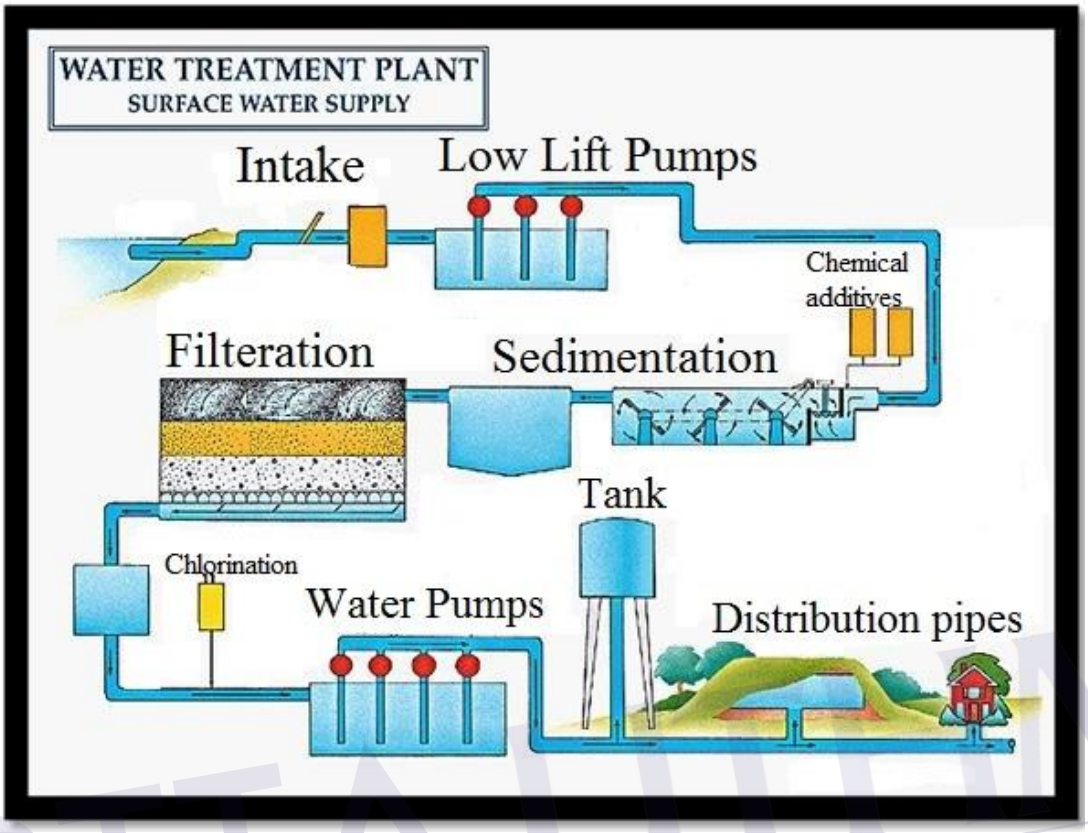

Figure 2.2 Diagram of WTP [7]

a) Water tanks

Water tanks are used to provide storage of water or water answers for use in manyapplications, , water system agribusiness, fire concealment, rural cultivating, both for plants and domesticated animals, synthetic assembling, sustenance arrangement and additionally numerous different employments. Water tank parameters incorporate the general outline of the tank, and decision of development materials. Different materials are utilized for influencing a water to tank, for example for plants and domesticated animals, synthetic assembling, sustenance arrangement and additionally numerous different employments [14].

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