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EVALUATION AND IMPLEMENTATION OF WIRELESS INDUSTRIAL SUPERVISORY CONTROL SYSTEM

[1]M. MateenYaqoob,Capt Hassan Gillani, [2]Mohsin Nisar

[1]Pakistan Consortium for Advance Research in Electrical Engineering (PCAREE), Islamabad, Pakistan

[2]Safe City Project, Islamabad, Pakistan

E-mail: [1] mateenyaqoob@gmail.com, [2]mohsin714@gmail.com

ABSTRACT

The aim of this research work is to build a profound wireless supervisory system to avoid serious damages and haphazardness in industrial environment. Normally in most of the industrial system monitoring and controlling is the most pivotal parameter. In addition to controlling and monitoring in real time, we uses different sensors for transmitting and through this self-checking has been achieved. Sensors will transmit data which is received by the control office where the supervisory staff monitors and controls the performance of the environmental setup without paying visit to it. For this purpose, wireless communication is utilized in this paper. Therefore the transmitted data displayed at receiving side via Lab View. With the help of this kind of system, we can achieve continuous vigilance over the installed setup.

Keywords:*Microcontroller, UHF, Frequency Modulation, Wireless communication, Sensors*

1. INTRODUCTION

The main factor behind remarkable growth is wireless medium's capability to significantly fulfill components of telecommunications which are; any information, any place and any time. Wireless communication provides anytime and anywhere connectivity to users. Future of wireless communication relies on more rapidly, more consistent methods of transmitting data and use of voice commands and enhancements in audio-video transmission.

Nowadays as advancement taking place in technology, particularly in the field of computer as well as micro-controllers, all the daily activities have become a part of information; we find computers and micro-controllers at each and every application. Thus, the trend is directing towards computer based project works. Output of micro-controller is used to drive digital display, with the aim of the value of each parameter can be displayed. Low frequency is fed to transmitter as a modulating wave, which is super imposed over the carrier and transmitted as a modulated wave.

The idea of generating three different low frequencies is to identify the failure parameter and to transmit the failure information. Initial purpose of micro-controllers was to use as component in process-control systems. Though, due to their lesser size and economical in price, they are also used in regulators for separate control loops. The micro-controllers are outclassing their analog competitors and also economical.

Micro-controllers are utilized as tools for analyzing and designing of a control system. Control engineers have effective tools available recently as compare to proceeding. Digital communication is in a stage of improvement due to progress in very large-scale integration (VLSI). Therefore considerable technical enhancements are forthcoming.

A wireless solution improves safety and security, and ensures regulatory compliance. Industrial systems involve controlling and monitoring of various factories, plants or manufacturing conditions and transmitting data to end system. Therefore this paper explores resources how wireless communication can simplify and enhance monitoring and performance of an industrial system.

The aim of this paper is to illustrate a control theory which is relevant to the analysis and design of system with prominence on basic concept and ideas. In this paper micro-controller is used at the receiving side. The advantage of using micro-controller is efficient control of each application can be achieved. Similarly the advantage of using Lab View is to display the information effectively. In this paper for demonstration purpose Lab View software is used for the graphical display for showing any automated error in performances, if any. Thus the three sensors which are continuously sensing and transmitting signal have been carried out over the Computer at the receiving side.

The sensors used in this paper are, a) Level Detector Sensor; it detects the level of materials which flow which includes slurries, liquids, and coarse materials. b) Gas Leakage for identifying the potentially hazardous gas leaks likelihood cause fire that may result in death, injury, or property damage. c) Flow Detector Sensor; it is used for recognizing the rate of fluid flow.

The rest of the paper is organized as follows. Related workand motivation are given in section II. Section III defines the major components. Section IV describes the implementation of idea. Section V gives the conclusion and future work.

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2. RELATED WORK

Wireless is a technical term which is used to elaboratehow electromagnetic wave transmits the signal besidea communication path. Devices used for purpose of monitoring, for example intrusion alarms employ audio at frequencies exceeding the human hearable range; they are categorized as wireless. Wireless communication technology is swiftly growing, playing a vital part in the lives of people around the globe. Alsoseveral people are depending on technology either directly or indirectly [1].

Wireless communication is transmission of data over distance without any electrical conductors or wires. Rangeof communication may be short or long. Wireless communication is usually considered to bepart of telecommunication. Wireless operations authorize services, such as long range communications [2].

As there are no cables or wire to route, wireless system of monitoring is fundamentally more flexible than other network. A user is not restrictedto fixed network topology or setup in wireless communication, which leaves open possibility for additions, upgrades, extensions, and many more. The accessibility means less overhead associated whileestablishing up a network and small overhead results in taking additional measurements and applications into communication system. Also thetime required to establish a network is considerably reduced [3].

In several applications, wires are not a viable solution or option. For example, rotating equipment, such as a crane, requires the draping of cables or use of slip rings. These additions in mechanical add to the complexity of system and need consistent maintenance. Wireless solution eliminates such additions, as it allows the sensors to monitor them regularly [3].

The first wireless network was established in the pre-industrial age. They transfer information in the line-of-sight distance using torch signaling, smoke signals,flashing mirrors. An extravagant combination of set of signal was introduced to send complex messages with these elementary signals. Observatory stations were constructed on the hilltops and along roads to relay the messages over long distances. These early communication systems were substituted by the telegraphic network and then telephone replaces them [4].

Frequency modulation is category of modulation in which frequency of carrier is changed with accord to modulating wave. Whereas amplitude of carrier is constant [5].

The modulating signals change instantaneous frequency of the carrier. Meanwhile amplitude is constant infrequency modulation, so it has low noise and providesgood quality of technique for modulation which can be used for audio and musicbroadcasting [5].

A microcontroller can be thought as a small computer assimilated on an integrated circuit (IC);it consists of memory, a processor core and input/output peripherals. Microcontrollers are designed for the applications ofembedded systems, as compared to microprocessors. Microcontrollers are used for inevitably controlled devices, such as remote controls, automobile engine control, implantable medical devices, office machines, appliances, and toys. Reductionin size and cost compared to a design which used separate memory,microprocessor, and input/output devices [6].

Dual Tone Multi Frequency (DTMF) generates a composite audio signal consisting of two tones. The frequencies used for the DTMF (dual-tone, multi-frequency) system, which is also referred to as tone dialing. These frequencies are shown in figure 1.

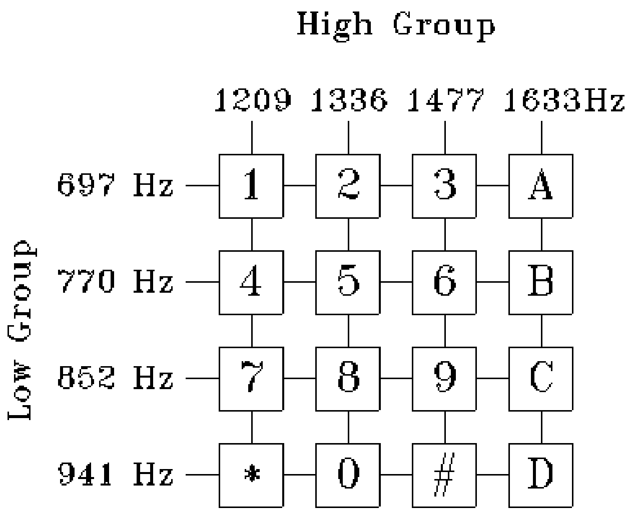

Figure 1: DTMF Frequencies [7]

Numerous companies manufacture microchips whichtransmit and receive signals in the form of DTMF. Telephony Application Program Interface (TAPI) offers a program for detection of DTMF digits. DTMF is a signal to the telephone company which generates when a user presses a telephone's key [8].

3. MAJOR COMPONENTS

The antennas which are described here were designed at 433 MHz in order to satisfy the constraints of size and bandwidth, also sensor application. The performance is characterized in terms of bandwidth, electrical size,and radiation efficiency.The constraints of sensors are in terms of battery, processing capability, life time and data rate. Sensorstransmit data over short range of distance. Antennas are immune to miniaturization, asphysical laws which determine the behavior causesantenna’s basic characteristics to be self-conflicting.Telescopic antennas are used principally in conjunction with radio receivers, radio transmitter-receivers, portable television receivers, and television receivers installed in moving objects, such as automotive vehicles; such antennas are also used as indoor television antennas.

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Henceforward the antenna miniaturization is a process of compromise. The efficiency of communication system is associated to the energy efficiency of whole node. We know mathematically gain and power are related as follows

$$\text{EIRP} = P_t G_t \text{ ---- } (1)$$

Sensor measures physical magnitude and transforms them to signalsthatare readable by a user ordevice [9]. These are utilized in daily entities for instance touch sensitive elevators, lamps which bright or dim by stirring the base. Numerous applications of sensors include car, machines, medicines, manufacturing, etc. Following sensors are being used in this paper

A. Level Detector Sensor

Level sensor identifies the level of materials which flow including liquids, and gritty materials. Thesematerials stream to convert the level, due to the gravity. The level measurement of substances is of two types; continuous and point values.

A continuous level sensor measures level only in a specific range and determines precise amount of fluid in a particulararea.Whereas the point-level only indicates the fluid is either exceeding or underneath a certain point. It detects levels that are extremely high or low. Several physical and application variables affect the selection of optimal level monitoring method for various commercial and industrial processes.

Selection criteria includes the physical: phase (liquid, solid or slurry), temperature, pressure or vacuum, chemistry, dielectric constant of medium, density (specific gravity) of medium, agitation (action), acoustical or electrical noise, vibration, mechanical shock, tank or bin size and shape. Importantly the application constraints are: price, accuracy,physical size, response rate, ease of calibration or programming, and mounting of the instrument, monitoring or control of continuous or discrete (point) levels.

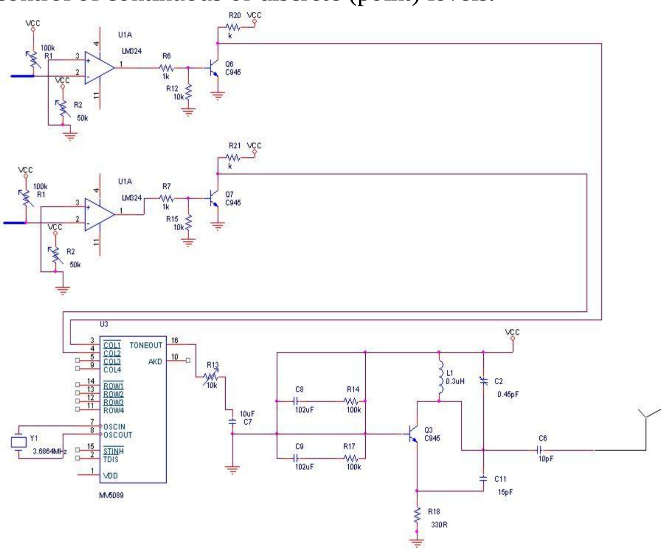

Figure 2: Circuit of level sensor

In the figure 2, the circuit has three level signals which are given to comparator's inverting input. Whenever any one of these level is available to the comparator that level signal will cause –Vcc or +Vcc to appear at the output of the comparator. As there are three level, so for them there are three different cases which are discussed below:

I. Case-1: Low level signal

For this comparator we have following configurations. Va is applied at the non-inverting terminal and Vb is applied at the inverting terminal of the comparator. Now we have two cases

1: If Va>Vb then comparator will be ON and $+V_{CC}$ (5V) is present at the output of the comparator.
2:If Vb>Va then comparator will be OFF and $–V_{CC}$(-5V) is present at the output of the comparator.

When low level signal is present at inverting terminal of comparator then difference of this signal voltage and Vcc will be applied at inverting terminal of comparator .Lets call voltage and non-inverting terminal as Va and voltage at inverting terminal as Vb. Now if Va>Vb then +5v will appear at the output of comparator and this voltage will make transistor operational and current will flow through it and hence ground of the transistor will be connected to pin 3 of U3.

After this step required frequency will be generated using standard crystal frequency of 3.68 MHz and particular frequency will be out at pin #16 of Tone generator.

II. Medium level signal

Now at the second comparator of the circuit we are waiting for the medium level signal present at the input of it .Now we have two cases

1: If Va>Vb then comparator will be ON and $+V_{CC}$ (5V) is present at the output of the comparator.
2:If Vb>Va then comparator will be OFF and $–V_{CC}$(-5V) is present at the output of the comparator.

When medium level signal is present at inverting terminal of comparator then difference of this signal voltage and Vcc will be applied at inverting terminal of comparator.Let's call voltage at non-inverting terminal as Va and voltage at inverting terminal as Vb.Now if Va>Vb then +5v will appear at the output of comparator and this voltage will make transistor operational and current will flow through it and hence ground of the transistor will be connected to pin 3 of U3. After this step required frequency will be generated using standard crystal frequency of 3.68 MHz and particular frequency will be out at pin #16 of Tone generator.

III. High level signal

For this comparator we have following configurations. Va is applied at the positive terminal and Vb is applied at the inverting terminal of the comparator.Now we have two cases

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1: If Va>Vb then comparator will be ON and $+V_{CC}$ (5V) is present at the output of the comparator.
2:If Vb>Va then comparator will be OFF and $-V_{CC}$(-5V) is present at the output of the comparator.

When high level signal is present at inverting terminal of comparator then difference of this signal voltage and Vcc will be applied at inverting terminal of comparator.Let's call voltage at non-inverting terminal as Va and voltage at inverting terminal as Vb. Now if Va>Vb then +5v will appear at the output of comparator and this voltage will make transistor operational and current will flow through it and hence ground of the transistor will be connected to pin 3 of U3. After this step required frequency will be generated using standard crystal frequency of 3.68 MHz and particular frequency will be out at pin #16 of Tone generator.

After any one of level signal is applied then that level signal will cause particular frequency to be generated in the tone encoder and this frequency will be obtained using standard reference frequency offered by crystal oscillator. This combination will be provided through mixing of standard frequency with combination of row and column input, and then resonation will be obtained at required frequency of 433 MHz using RLC combination circuit.

In the next stage Tone out will be going through RC combination circuit where capacitor is short circuited for AC frequency so this will go through this circuit shortest resistance path and this signal will be applied at the base of transistor.At the collector of this transistor Vcc is applied as it is connected through inductor which is short circuited (ideally) for DC combination.

So this applied signal at the base of transistor is then transmitted through antennas in the air. Before transmitting through antenna it is passed through capacitor.

B. Flow Detector Sensor

A flow detector sensor is used for sensing rate of flow of a liquid. Usuallyit is sensing element which is used in a flow meter, to record the flow of a liquid. Every sensor requiresabsolute accuracy of a measurement which is for functionality for adjustment.

There are severaltypes of sensor which detect the flow, they include some which have a strip, and can drive a rotary potentiometer. Other sensors are based on the transfer of heat which is resulted by moving medium. This principle is common for micro-sensors to measure flow.

Flow meters are related to devices called velocimeters that measure velocity of fluids flowing through them. Laser-based interferometry is often used for air flow measurement, but for liquids, it is often easier to measure the flow. Another approach is Doppler-based methods for flow measurement.

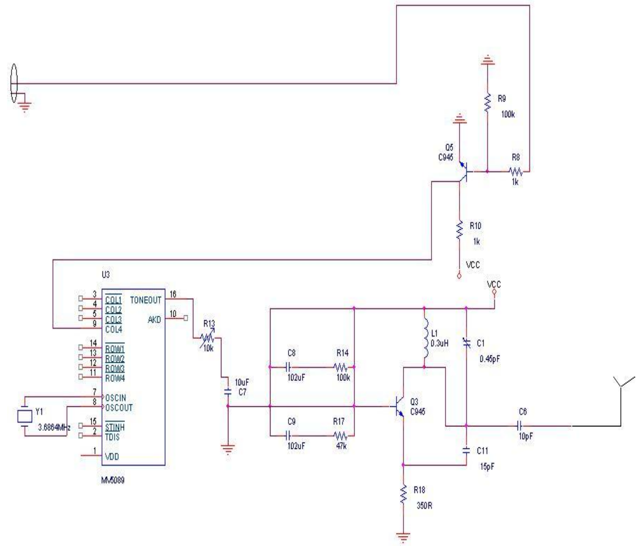

Figure 3: Flow sensor's circuit diagram

The 5V is applied at the base of the transistor given as Q5 in the figure 3.Since this voltage is applied at base terminal of transistor, so it will not be operational and current will not pass through it.So Vcc applied at collector terminal will then be applied at pin 3 of tone encoder. Corresponding selected tone will be out through this IC at pin no 16 labeled as Tone out. Rest of circuit working is same as of level sensor transmission circuit.

C. Gas Leakage Detector

Gas leak detection is the process of identifying potentially hazardous gas leaks by means of various sensors. These sensors usually employ an audible alarm to alert people when a dangerous gas has been detected. These sensors are used for a wide range of applications, and can be found in industrial plants, refineries, wastewater treatment facilities, vehicles, and around the home.Gas leak detection methods became a concern after the effects of harmful gases on human health were discovered. Since then, many technologies and devices have been developed to detect, monitor, and alert the leakage of a wide array of gases.

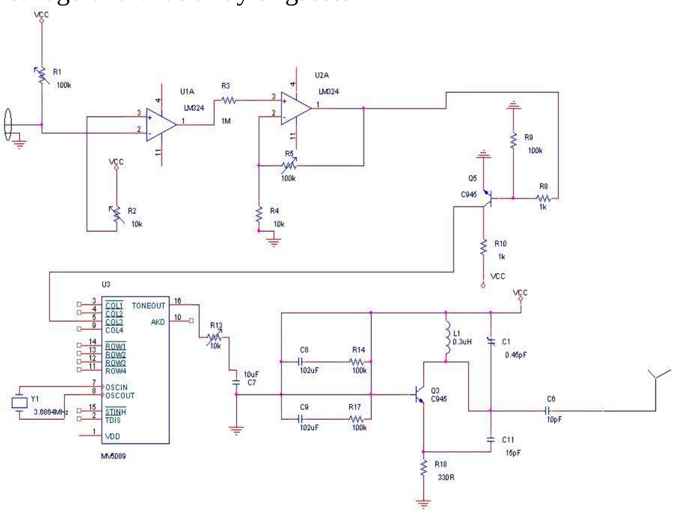

Figure 4: Circuit of gas detector

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At the transmitter side we have comparator at the first stage so when + 5V is applied to non-inverting input of comparator then this voltage is compared to the +Vcc 5V to pass through the comparator. In the next stage amplifier is used as non-inverting amplifier configuration and so this 5V will be passed through it. Gain of non-inverting amplifier can be given as

$$\text{Gain} = 1+Rf/Ri \text{ ----- } (2)$$

When 5V is passed through it then output at second stage will be given as

Output voltage at amplifier= 4.8V

This 4.8V is then applied at the base of the transistor given as Q5 in the figure 4. Since this voltage is applied at base terminal of transistor, so it will not be operational and current will not pass through it. So Vcc applied at collector terminal will then be applied at pin 3 of tone encoder. Corresponding selected tone will be out through this IC at pin no 16 labeled as Tone out.This frequency will be obtained using standard reference frequency offered by crystal oscillator. This combination will be provided through mixing of standard frequency with combination of row and column input, and then resonation will be obtained at required frequency of 433MHz using RLC combination circuit.

In the next stage Tone out will be going through RC combination circuit where capacitor is short circuited for AC frequency so this will go through this circuit shortest resistance path and this signal will be applied at the base of transistor .At the collector of this transistor Vcc is applied as it is connected through inductor which is short circuited (ideally) for dc combination.So this applied signal at the base of transistor is then transmitted through antennas in the air. Before transmitting through antenna it is passed through capacitor.

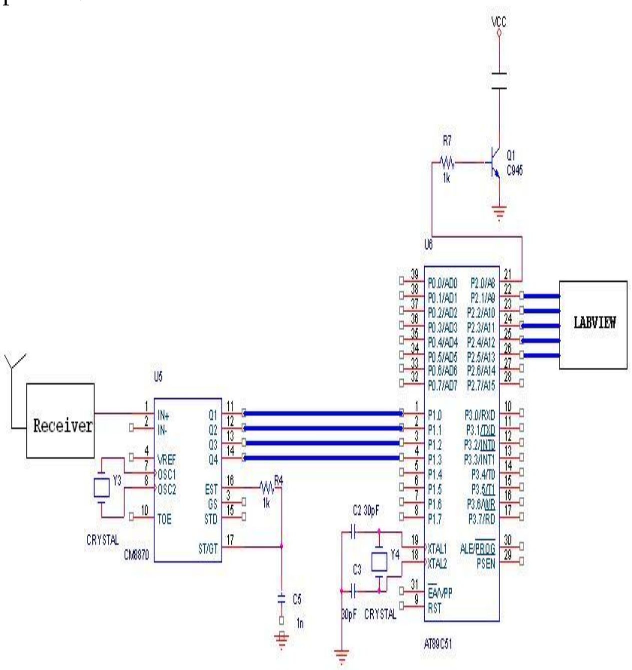

Figure 5: Receiver circuit

4. IMPLEMENTATION OF IDEA

Figure 6 and 7 describes basic idea of implementation of our proposed system for continuous monitoring of industrial activity.

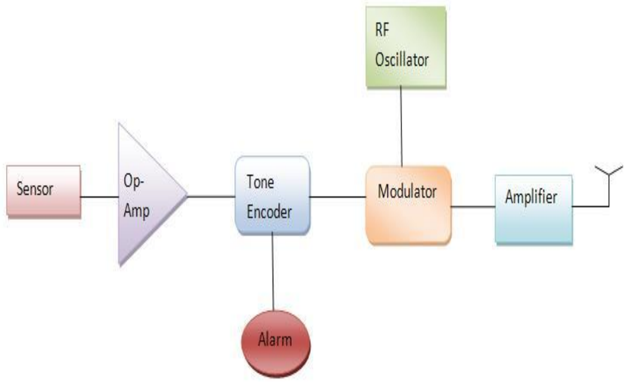

Figure 6: Frond End Panel

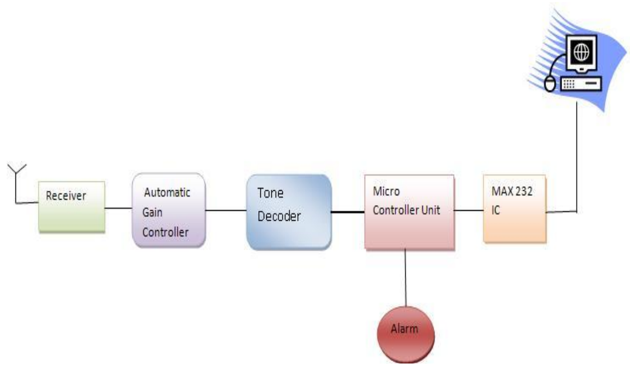

Figure 7: Control Panel

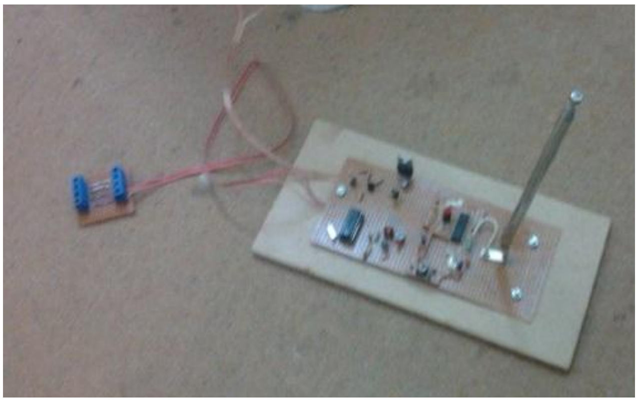

Figure 8: A prototype built from our idea by us

ITEE Journal
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Figure 9: Overall prototype of system with all three sensors and a receiver

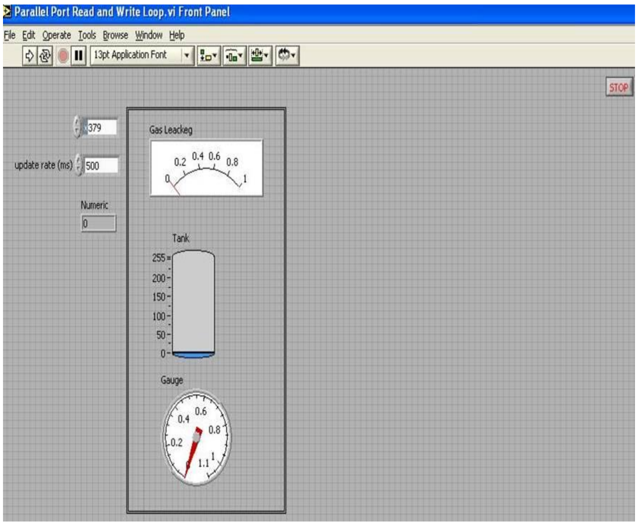

Figure 10: Lab View implementation at control panel

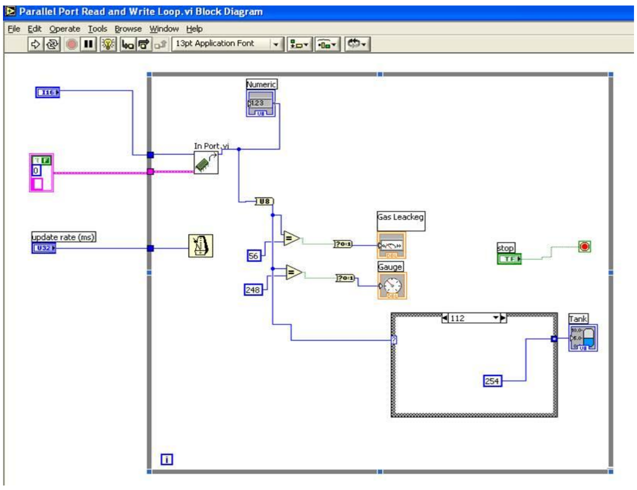

Figure 11: Block diagram of Lab View implementation

Table-1: Specifications of our system

Parameters/ Features	Specification
Operating Frequency	UHF
Power Output	18mW
Type of Antenna	Telescopic Antenna
Communication Range	10~12 meters
Technique	Frequency Modulation
Bandwidth	4 kHz

5. CONCLUSION AND FUTURE WORK

The purpose of this paper is to build a stable, reliable wireless supervisory control in industry. It allows continuous self-checking and system monitoring to alert of any degradation in performance. Therefore it will explore the resources to learn how wireless hardware and software can simplify and improve industrial control systems.

We concentrate on the type of wireless system suitable for industrial sensor monitoring. We are going to supervise and control multiple devices, and monitoring like tank level, gas leakage and flow control in pipelines. We have also use a Graphical User Interface (through Lab View) for control and monitor the devices and sensors.The oil and gas industry needs systems that can communicate wirelessly so that expanding process become simple and cost-effective. The infrastructure processes includes water treatment, gas and oil pipelines and civil defense siren systems. Future work includes adding modules configured as repeaters, the range of system can be extended.

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AUTHOR PROFILES

1. M. Mateen Yaqoob received his MSElectrical Engineering with specialization in Telecommunication from COMSATS Institute of Information and Technology, Islamabad in 2013. He completed his BS Telecommunication Engineering from Foundation University, Islamabad in 2011. He is member of research group, Pakistan Consortium of Advance Research in Electrical Engineering (PCAREE).His research area includes Wireless Networks and Communication, Improving bandwidth utilization and efficiency in Wireless Networks, Wireless Sensor Network, and Next generation networks.

2. Capt Hassan Gillani received the degree of BS Telecommunication Engineering from Foundation University, Islamabadin 2011. He is currently serving in Pakistan Army as Captain in Signals Core.

3. Mohsin Nisarreceived his BS degree in Telecommunication Engineering from Foundation University, Islamabadin 2011. He is currently employed in the Safe City Project under Government of Pakistan.