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## Programmable Irrigation Control System Using Li-Fi

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**ABSTRACT:** Li-Fi based irrigation system mainly consists of wireless sensor networks and the monitoring center. The sensors in the monitoring area collect the information of soil moisture and temperature together with the growth information of different crops in different periods. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller based gateway to control water quantity. Automating the data acquisition process of soil moisture and temperature that govern plant growth allows information to be collected at high frequency with less labor requirements. The system has a reliable duplex communication link and irrigation scheduling to be programmed through a web page which achieves real-time monitoring of soil on crop growth.

**KEYWORDS:** Automation, measurement, water sources, Internet, irrigation, wireless sensor networks (WSNs)

### I. INTRODUCTION

Irrigation by help of fresh water resources in agricultural areas has a crucial importance. Because of highly increasing demand for freshwater, optimal usage of water resources has been provided with greater extent by automation technology and its apparatus such as solar power, drip irrigation, sensors and remote control. Traditional instrumentation based on discrete and wired solutions, presents many difficulties on measuring and control systems especially over the large geographical areas.

Integrating modern technologies in irrigation management systems is one of the ways of enhancing the irrigation process to optimize the use of water, and labor costs. The success of irrigation management systems however, depends on the timely application of the water required to meet the water needs of the crops. Another important factor that is critical to irrigation management system is the scheduling or timetable system, which is mostly developed to maximize crop production with minimal water wastage. The data packet coming from wireless sensor unit is received, identified, recorded and analyzed by the microcontroller and perform the corresponding irrigation action and these data's are transmitted to the computer using wireless communication unit, Li-Fi module for data inspection and irrigation scheduling to be programmed through a webpage.

### II. LITERATURE SURVEY

Agriculture uses available freshwater resources worldwide. There are many systems to achieve water savings in various crops, from basic ones to more technologically advanced ones. For instance, in one system plant water status was monitored based on Canopy temperature measured with infrared thermometers or other remote infrared sensors. Canopy temperature is a direct measure of the energy being released by a plant. It can provide continuous information on water status, water use and how a plant is functioning metabolically. There can be significant difference between the air temperature and canopy temperature. Target area consists of dark areas or stem parts between leaves. Thermometer can view only leaves. Thermometer can be harmed by direct solar radiation entering its lens. Reading should be made with the sun at the back of the operator similar to the rule of photography. Several measurements should be taken during a drying cycle and depending on the data and the stress level, the final evaluation can be based on average data or data from a selected date [1].

Time Domain Transmission sensor (TDT) is an electromagnetic sensor to measure soil moisture was the basis for developing an irrigation system to control water quantity. The TDT sensor was designed to directly connect to a custom irrigation controller or to interface a small display/control box with a conventional irrigation timer where irrigation

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scheduling is based on threshold water content. The sensor circuitry controlled the irrigation schedule by allowing the reprogrammed schedule to operate whenever the sensor-estimated water content dropped below U Threshold. But TDT sensor is very expensive [2].

An automated irrigation system was developed to optimize water use for agricultural crops. The system has a distributed wireless network of soil-moisture and temperature sensors placed in the root zone of the plants. In addition, a gateway unit handles sensor information, triggers actuators, and transmits data to a web application. An algorithm was developed with threshold values of temperature and soil moisture that was programmed into a microcontroller-based gateway to control water quantity. The system was powered by photovoltaic panels and had a duplex communication link based on a cellular-Internet interface that allowed for data inspection and irrigation scheduling to be programmed through a web page [3].

Rice cropping farms are significant loads in power systems due to the large amount of electrical energy required by the irrigation system. In Brazil, power companies invest in research to improve energy efficiency of this type of load. This article presents an automated irrigation system based on supervisory control (SCADA) and wireless communication. The main objective of the project is to monitor and control the level of water in the crop, which represents an important impact on energy efficiency and water consumption. Specific characteristics of rice cropping irrigation were taken into account, such as large distances involved and different working schemes of water pumps. A complete solution is presented and it includes equipment description for reliable communication and supervisory features [4].

Distributed in-field sensor-based irrigation systems offer a potential solution to support site-specific irrigation management that allows producers to maximize their productivity while saving water. This paper describes details of the design and instrumentation of variable rate irrigation, a wireless sensor network, and software for real-time in-field sensing and control of a site-specific precision linear-move irrigation system. Field conditions were site-specifically monitored by six in-field sensor stations distributed across the field based on a soil property map, and periodically sampled and wirelessly transmitted to a base station. An irrigation machine was converted to be electronically controlled by a programming logic controller that updates geo referenced location of sprinklers from a differential Global Positioning System (GPS) and wirelessly communicates with a computer at the base station. Communication signals from the sensor network and irrigation controller to the base station were successfully interfaced using low-cost Bluetooth wireless radio communication. Graphic user interface-based software developed in this paper offered stable remote access to field conditions and real-time control and monitoring of the variable-rate irrigation controller [5].

An intelligent irrigation system based on wireless sensor networks and fuzzy control. This system has wireless sensor networks and the monitoring center. All of the nodes in Monitoring area use solar power collect the information of soil moisture, together with the growth information of different crops in different periods. Soil moisture content deviation and the rate of change of deviation are taken as input variables of fuzzy controller, and the fuzzy control regular database is established for the fuzzy irrigation control system. The monitoring center receives the data transmission from wireless sensor network node, and output information of irrigation water demands to the relay via a wireless sensor network to control opening and closing time of the valve in crop areas. The experimental results show that the system has a stable and reliable data transmission, which achieve real-time monitoring of soil on crop growth, give a right amount of irrigation based on crops growth information, which has broad application prospects [6].

Ambient intelligence has acquired great importance in recent years and requires the development of new innovative solutions. A distributed tele-monitoring system, aimed at improving healthcare and assistance to dependent people at their homes. The system implements a service-oriented architecture based platform, which allows heterogeneous wireless sensor networks to communicate in a distributed way independent of time and location restrictions. This approach provides the system with a higher ability to recover from errors and a better flexibility to change their behavior at execution time [7].

Visible-light communications (VLC) is a technology for wireless communication using light that can be perceived by the naked eye. VLC uses frequencies other than radio, and they are unrestricted and licence free. The urgent need of VLC is to overcome the problems faced in RF communication. Unlike existing methods of wireless communication, the visible light portion of the electromagnetic frequency spectrum is used in VLC to transmit information. Visible light communication refers to the communication technology which utilizes the visible light source as a signal transmitter, the air as a transmission medium, and the appropriate photodiode as a signal receiving component [8].

VLC can support high data rates beneath the water, where other wireless technologies like RF do not work [9]. A smart parking information system exploiting visible light communication technology to help drivers getting the real-time

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parking information as well as direction guide. By providing accurate information on available parking spaces, drivers save time and fuel and increase efficiency of the parking process [10].

### III. LI-FI BASED IRRIGATION SYSTEM

Irrigation system that consists of a distributed wireless network of soil moisture and temperature sensors deployed in plant root zones. Each sensor node involved a soil-moisture probe, a temperature probe, a microcontroller for data acquisition. The microcontroller permits the automated activation of irrigation when the threshold values of soil moisture and temperature are reached. The microcontroller sends data to the computer via Li-Fi transceiver. The receiver unit also has a duplex communication link using Light Fidelity technology, which is a new technology in optical wireless communication. The Internet connection allows the data inspection in real time on a website, where the soil-moisture and temperature levels are graphically displayed through an application interface and stored in a database server. This access also enables direct programming of scheduled irrigation schemes and trigger values in the receiver according to the crop growth and season management.

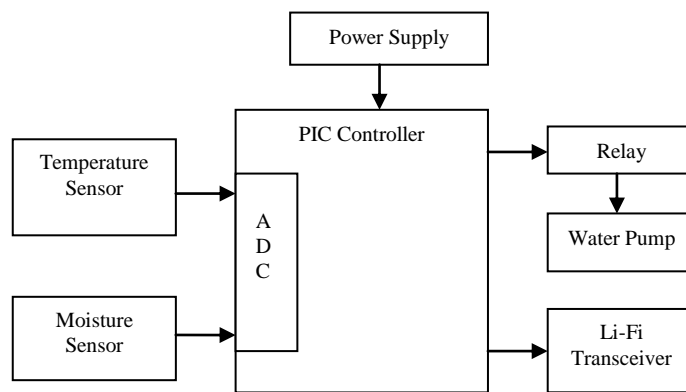


Fig. 1. Block Diagram of Irrigation System-Transmitter part.

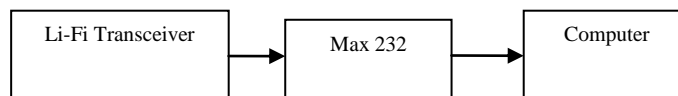


Fig. 2. Block Diagram of Irrigation System – Receiver Part

#### A. TEMPERATURE MEASUREMENT

The LM35 series is precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as it is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of  $\pm 1/4^{\circ}\text{C}$  at room temperature and  $\pm 3/4^{\circ}\text{C}$  over a full  $-55$  to  $+150^{\circ}\text{C}$  temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only  $60\mu\text{A}$  from its supply, it has very low self-heating, less than  $0.1^{\circ}\text{C}$  in still air. The LM35 is rated to operate over a  $-55^{\circ}$  to  $+150^{\circ}\text{C}$  temperature range, while the LM35C is rated for a  $-40^{\circ}$  to  $+110^{\circ}\text{C}$  range ( $-10^{\circ}$  with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also

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available in an 8-lead surface mount small outline package and a plastic TO-220 package. Using this LM35, the soil temperature is monitored and recorded in the microcontroller to irrigate the field.

## 1) LM35 Features

LM35 is Calibrated directly in ° Celsius (Centigrade). It has linear + 10.0 mV/°C scale factor and 0.5°C accuracy. It is rated for full -55° to +150°C range and suitable for remote applications. The cost is low due to wafer-level trimming and operates from 4 to 30 volts. It requires less than 60 µA current drain and hence low self-heating.

## 2) Block Diagram

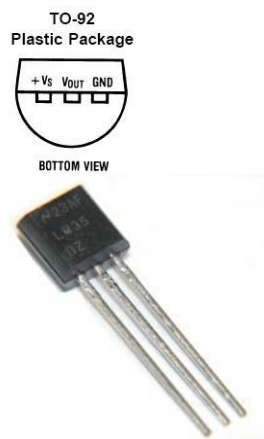


Fig .3. Block diagram of LM35 temperature sensor.

## B. MOISTURE MEASUREMENT

Soil Moisture Sensor is used to measure the volumetric water content of soil. It can

- Measure the loss of moisture over time due to evaporation and plant uptake.
- Evaluate optimum soil moisture contents for various species of plants.
- Monitor soil moisture content to control irrigation in greenhouses.

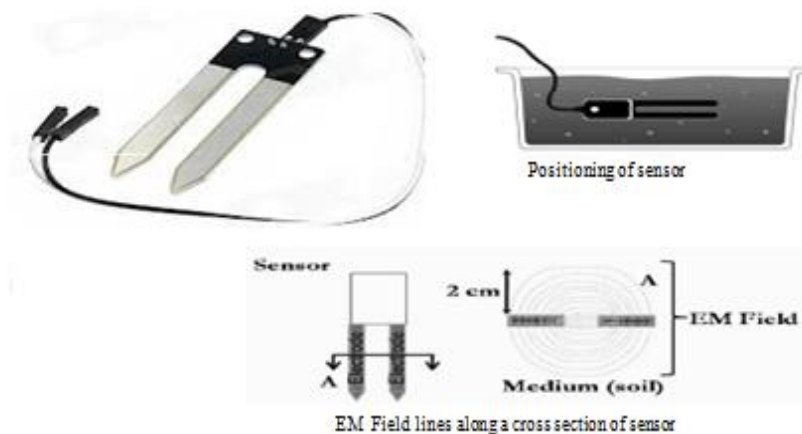


Fig. 4. Moisture plate sensor, Positioning of sensor and EM Field lines along a cross section of sensor.

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### *Positioning the sensor*

Figure 4 shows the proper placement of the Soil Moisture Sensor. The prongs should be oriented horizontally, but rotated onto their side – like a knife poised to cut food – so that water does not pool on the flat surface of the prongs. The horizontal orientation of the sensor ensures the measurement is made at a particular soil depth. The entire sensor can be placed vertically, but because soil moisture often varies by depth, this is not usually the desired orientation. To position the sensor, a thin implement such as a trenching shovel to make a pilot hole in the soil. Place the sensor into the hole, making sure the entire length of the sensor is covered. Press down on the soil along either side of the sensor with our fingers. Continue to compact the soil around the sensor by pressing down on the soil with our fingers until we have made at least five passes along the sensor. This step is important, as the soil adjacent to the sensor surface has the strongest influence on the sensor reading. By using this soil moisture plate sensor, the volumetric water content of soil is measure and recorded in the microcontroller to irrigate the field.

### **C. PIC (16F877)**

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877.

#### *Special Features Of PIC Microcontroller*

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
- Processor read/write access to program memory
- Wide operating voltage range: 2.5V to 5.5V
- High Sink/Source Current: 25mA

Microcontroller reads data from the temperature and moisture sensors and once these sensors exceed the threshold values, the field will get irrigated. The values like time, date, sensor readings and the time the field will get irrigate is transmitted to the computer through Li-Fi transceiver, where the computer will display all these readings in graphical format using Visual Basic.

### **D. LI-FI**

Wi-Fi technology becomes more popular today. Every public spots and private offices have wifi because of this wireless spectrum is blocked very frequently. Due to maximum utility RF interferences are getting more common to overcome this problem light fidelity (Li-Fi) technology was introduced in the year 2011. Li-Fi is similar to other wireless communication which uses the communication medium as light. Visible light is used to transfer data between the systems instead of radio signals. Li-Fi uses LED light source to transmit the data wirelessly this method is widely called as VLC (visible light communication). A stream of data transmitted in the way of pulses of light that cannot be detected by the naked eye.

Visible Light Communication is a category of optical wireless communication. It is only a small portion of the electromagnetic spectrum. The data communication medium which uses visible light between 400 and 800 THz (780 – 375 nm). The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbit/s, or LEDs for up to 500 Mbit/s. Low rate data transmissions at 1 and 2 kilometres (0.6 and 1.2 mi) were tried. RONJA achieves full Ethernet speed (10 Mbit/s) over the same distance. Visible Light requires low power for their operation and has very high switching speeds. For the communication to be full duplex it requires a downlink and an uplink.

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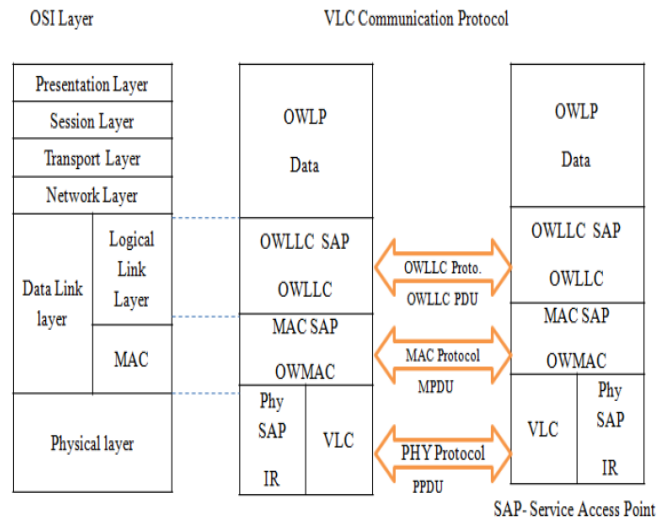


Fig. 5. VLC communication protocol.

The PHY defines the electrical and hardware specifications for devices. It defines the relationship between a device and a physical channel. Media Access Control has three physical layers with different data rates.

- PHY I is designed for outdoor applications and data rate is in the range 12 to 267 kb/s.
- PHY II is designed for indoor applications and data rate is in the range 1.25 to 96 Mb/s.
- PHY III is designed for data rates in the range 12 to 96 Mb/s and for applications in which RGB sources and detectors are used.

The Data Link Layer is divided into two sub-layers as an Optical Wireless Logical Link Control (OWLLC) and Optical Wireless MAC (OWMAC). OWLLC refers to the functions required for the establishment and control of logical links between local devices on a network. OWMAC is referred to as a Medium Access Controller. This channel provides half duplex, full duplex or broadcast communication service.

Upper layer comprises Internet Protocol (IP) and the Application layer. These are common to OSI architectures. These layers can be modified depending on the applications.

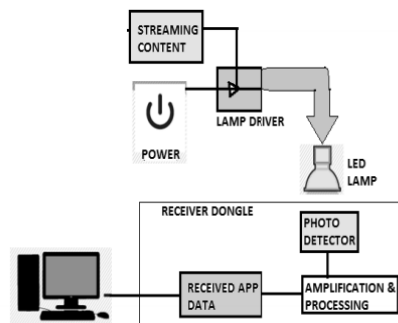


Fig. 6. Working of Li-Fi.

The streaming content from the microcontroller is connected to the driver module which drives the led light source based on the data transmitted through it. The data has been transmitted in form of light beam. The receiver segment detects the changes in the light beam and separates the data from the light source and generates the electrical signal based on the intensity of the light fall on it. The converted signal was transmitted to the computer.



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TABLE I  
Comparison of VLC with RF

Attribute	VLC	RF
Wave length	400-700nm	3-300nm
Data Rate	Advanced techniques almost 500 Mb/s	GPRS-112 Kb/s, Bluetooth-2.1 Kb/s, GSM- 9.6 Kb/s
EMI	No	High
Hazard	No	Yes
Power Consumption	Relatively Low	Medium
Security	Yes	No
Line of Sight	Both LOS and NLOS is possible	No
Distance	Maximum 1.24Km	100Km
Cost of additional Bandwidth spectrum	None	Very high when available
Path Redundancy	Achieved with multiple LEDS	Achieved with multiple access points
Available bandwidth capacity	Light can be directed and tuned to adapt to different environments	Signals at same frequency can interfere with one another and thus be limited by contention, signals degrade from peak
Multipath Fading	Interference appears as noise. No signal cancelling	Destructive interference. RF waves bounce off surfaces and can be out of phase
Regulation	No, except eye safety standards	yes
Health	Harmless	Harmful

## IV. SIMULATION RESULTS

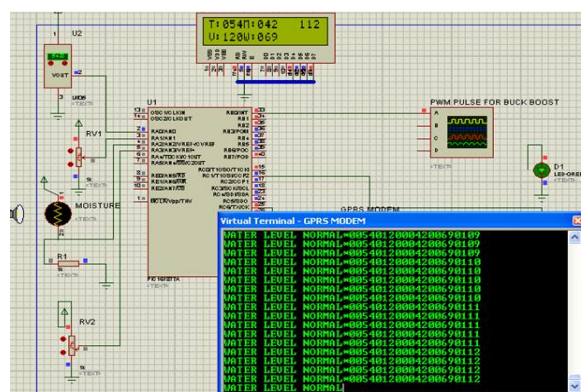


Fig. 7. Simulation result of Irrigation system as the water level is normal.

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Figure 7. Shows the simulation result of Irrigation system as the water level is normal. PIC controller will send the following parameters to the Phone via GPRS

- 1) Water level status-Normal or Low
- 2) Temperature
- 3) Voltage
- 4) Moisture
- 5) Water level
- 6) Time it irrigates the field

As the water level goes above 50% PIC will send the water status as “Water level normal”. If the water level is normal and if the temperature goes above 30 or the moisture level goes below 50 the PIC will irrigate the field by showing that LED is ON and it will also transmit the time it will irrigate the field.

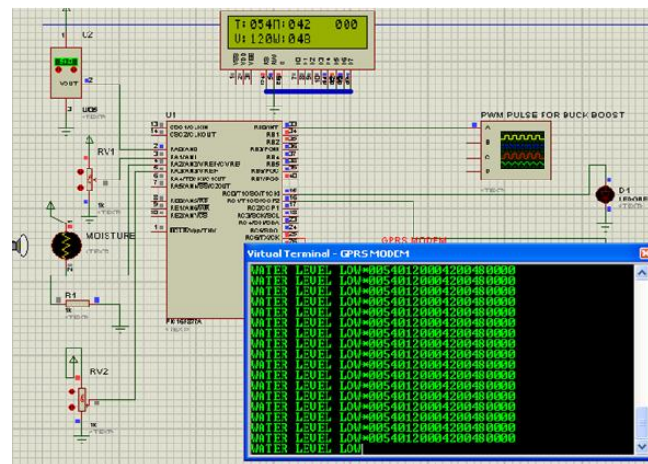


Fig. 8. Simulation Result of Irrigation system as the water level is low

As the water level goes below 50% PIC will send the status to Phone as “Water level low” and it will also stop the timer and the LED will be in OFF condition.



Fig . 9. Snapshot of the hardware kit



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## V. CONCLUSION

The automated irrigation system implemented was found to be feasible and cost effective for optimizing water resources for agricultural production. This irrigation system allows cultivation in places with water scarcity thereby improving sustainability.

The automated irrigation system developed proves that the use of water can be diminished for a given amount of fresh biomass production. The irrigation system can be adjusted to a variety of specific crop needs and requires minimum maintenance. The modular configuration of the automated irrigation system allows it to be scaled up for larger greenhouses or open fields. In addition, other applications such as temperature monitoring in compost production can be easily implemented. The LI-FI communication and Internet connection allows the data inspection in real time on a website.

## REFERENCES

- [1] G. Yuan, Y. Luo, X. Sun, and D. Tang, "Evaluation of a crop water stress index for detecting water stress in winter wheat in the North China Plain," *Agricult. Water Manag.*, vol. 64, no. 1, pp. 29–40, Jan. 2010.
- [2] J. M. Blonquist, Jr., S. B. Jones, and D. A. Robinson, "Precise irrigation scheduling for turfgrass using a subsurface electromagnetic soil moisture sensor," *Agricult. Water Manag.*, vol. 84, nos. 1–2, pp. 153–165, Jul. 2009.
- [3] Joaquin Gutierrez, Juan Francisco Villa-Medina, Alejandra Nieto-Garibay, and Miguel Angel Porta-Gandara, "Automated irrigation system using a wireless sensor network and GPRS Module" *IEEE Transactions on Instrumentation and Measurement*, Vol.63, No. 1, Jan 2014.
- [4] Gunjan Pandey, Ratnesh Kumar, and Robert J. Weber, "An Automated Irrigation System for Rice Cropping with Remote Supervision" *International Conference on Power Engineering, Energy and Electrical Drives 2011*.
- [5] Y. Kim, R. G. Evans, and W. M. Iversen, "Remote sensing and control of an irrigation system using a distributed wireless sensor network," *IEEE Trans. Instrum. Meas.*, Vol. 57, No. 7, pp. 1379–1387, Jul. 2008.
- [6] Liai Gao, Meng Zhang, Geng Chen, "An Intelligent Irrigation System Based on Wireless Sensor Network and Fuzzy Control" *JOURNAL OF NETWORKS*, Vol. 8, NO. 5, May 2013.
- [7] J. M. Corchado, J. Bajo, D. I. Tapia, and A. Abraham, "Using heterogeneous wireless sensor networks in a tele-monitoring system for healthcare," *IEEE Trans. Inf. Technol. Biomed.*, Vol. 14, No. 2, pp. 234–240, Mar. 2010.
- [8] Jacqueline, Mohammed hayder and Hashim Ahmed, "A survey on visible Light Communication" *International Journal of Engineering and computer science* Feb 2014.
- [9] Periasamy and Vimal, "LED Lamp Based Visible Light Communication in Under water Vehicles" *International Journal of engineering Trends and Technology*, Jul 2014.
- [10] Namon, Changqiang and Kim, "Smart Parking Information System Exploiting Visible Light Communication", *International Journal of Smart Home*, Apr 2014.