Development of Solar Powered Irrigation System

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Abstract. Development of a solar powered irrigation system has been discussed in this paper. This system would be SCADA-based and quite useful in areas where there is plenty of sunshine but insufficient water to carry out farming activities, such as rubber plantation, strawberry plantation, or any plantation, that requires frequent watering. The system is powered by solar system as a renewable energy which uses solar panel module to convert Sunlight into electricity. The development and implementation of an automated SCADA controlled system that uses PLC as a controller is significant to agricultural, oil and gas monitoring and control purpose purposes. In addition, the system is powered by an intelligent solar system in which solar panel targets the radiation from the Sun. Other than that, the solar system has reduced energy cost as well as pollution. The system is equipped with four input sensors; two soil moisture sensors, two level detection sensors. Soil moisture sensor measures the humidity of the soil, whereas the level detection sensors detect the level of water in the tank. The output sides consist of two solenoid valves, which are controlled respectively by two moistures sensors.

1. Introduction

The irrigation system is defined as a system that distributes water to targeted area. Basically, it is meant for agriculture purposes. The efficiency of the irrigation is based on the system used. Since antiquity, the human life is based on agriculture and the irrigation system is one of the tools that boost agriculture. There are many other types of irrigation system all over the world but these irrigations are encountering many problems. In fact, there are few modern systems but they mostly fail in one way to another. The automation plays an important role in the world economy; therefore, engineers struggle to come out with combined automatic devices in order to create complex systems that help human in its activities so that the system automatically processes itself without any human intervention. So we would like to develop an automatic irrigation system.

Basically, the paper consists of electrical part and mechanical part. The electrical part consists of photovoltaic, which is meant to generate power and the power is stored in the rechargeable battery. The mechanical part consists of pump to pump out the water from the water source. There are two solenoid valves that are used to control the water flow. Additionally, Programmable Logic Controller (PLC) is interfaced with SCADA (Supervisory Control Data Acquisition) system developed in a personal computer (PC) using LABVIEW. SCADA system is used for controlling the automation system via computer so there is a need to develop HMI human-machine interface employed to communicate with automation

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device like PLCs and other computers, like water computers. Water is recognized as a source of human life, as well as plants and animals. Therefore, the water needs to be managed properly without any waste. The proper management of any liquid is very significant, especially in our case of water management of the irrigation system. The best liquid management is provided by SCADA.

The parameters in the project are soil humidity condition, water level condition, the position of the Sun and SCADA system. Humidity of the environment plays a major role in agriculture development. Due to the high cost and the effectiveness of the system, that has yet to be proven, watering process based on these parameters is not widely used in the World, as it is still a very new technology that tends to post modernize the agriculture. Most of the existing systems are manual system. The manual system needs labor for monitoring the productivity and health crop. Considering labor's salary, the system will cost much more than the automatic system, in which there is no assistance to the system. The solar system is used to generate the power to the entire system and the solar system is much cheaper than the electrical system. It is suitable to the rural area that is why the solar system is used as a power supplier to replace DC motor electricity source. In fact the initial cost of solar installation is higher than use of DC electrical motor but the solar system has no bill compared to electrical which has bill to pay every month. It is a versatile source of renewable energy that can be used in any application. Solar power is also clean and pollution free.

As it is stated in the paper, the discussion is about the development of an intelligent irrigation system, which can be used in plantation. The utilization of greenhouse concept is used in the paper for reducing atmosphere pollution. The system consists of hardware and software and, finally, the integration of the two parts to provide the results. The hardware system consists of the sensors, actuators, drivers and PLC. The software is all about designing SCADA system, in which, it has the ability to read from the automatic system and write into the system. In software design, there is a need for full development of NI instruments, such as DSC module, OPC server, MODBUS server. In hardware design, we need all the components that are necessary to accomplish the project, and these components are PLC, DC water pump motor, actuators, sensors and some minor components like tank and reservoir.

2. Related Work

In this section, we are going to review papers and books related to SCADA based irrigation system. The system is divided in three different branches, as SCADA, PLC and Solar Panel, and the literature review consists of the aforementioned three independents parts.

SCADA, which is known as the supervisory control and data acquisition, happens to be a computer system for assembling and analysing real time data. Furthermore, SCADA is frequently regarded as the central system that controls and monitors an entire system that is expansively distributed over an extended distance. Remote Terminal Unit (RTU) and Programmable Logic Controller (PLC) are responsible for performing automatically in regards to the size of the site. However, there is always a restriction by the host control functions towards the central site over-ride or supervisory level capability. Essentially, the SCADA system consists of hardware and the software parts.

Remote Terminal Unit (RTU) gathers information from the inputs devices such as sensors, valves, motors, alarms and many more. RTU can be a programmable logic controller (PLC) as well as computer. RTU collect all the system information and keep it the memory until the master terminal unit (MTU) send the request to transmit data [9].

MTU collects all the data stored and sends information to the device for interference operation. MTU can be a computer consisting of Human Machine Interface (HMI) as medium of communication for processing data and information. HMI human machine interface provides a centralized monitoring and controlling system for the various inputs and outputs [10].

The communication is very important part of SCADA system, as it is a way of establishing connection between MTU and RTU. Through communication server the device send the signal from the site to the server device so that the data can be processed and the system can make decision based on the processed data. The basic communication types are LAN local area network, wireless and radio signal [12].

NI LABVIEW software can communicate with a Programmable Logic Controller (PLC) in a variety of ways. In order to make a successful communication with PLC, Modbus serial communication protocol was made available by Modicon in 1979, and it was then expanded to the TCP protocol. Modbus turned into one of the regular communications medium in the industry, as it included real-time and historical trending, tools for logging data to a networked historical database, organization of events and alarms. Modbus also assists in networking Lab-VIEW Real-Time targets and Modbus devices into a whole system, and, lastly, Modbus adjoins security into the user interfaces [13]. The second part is for the Solar Irrigation system.

a) Rain harvesting b) Solar powered system

Figure 1. Solar powered irrigation system.

Figure 1 describes the component of irrigation system, which consists of solar power and rain harvesting. A solar powered agricultural system is used for sustaining the availability of food production; it is powered by a solar system, which is recognized as the most suitable source in case of irrigation [11]. The system is based on time that is to say from 7.30 to 3pm is peak watering demand time. And from Sunrise to Sunset is called peak energy production time or the time in which the battery is charged. The energy charged in the battery will power up the engine when the specified time comes [1].

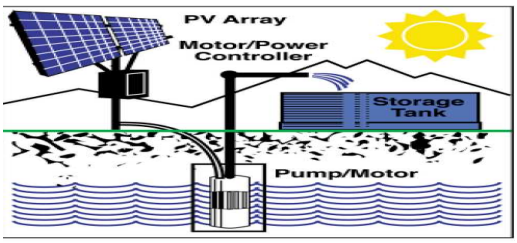


Figure 2. Photovoltaic system [2]

The system function is based on time and it has a system that predicts the weather condition but it fail to predict sometime due to climate change. It is quite difficult to forecast the weather condition due to climate change. The area happens to be in a condition of deficiency of water, which rationally contains negative irregularity in the watering pattern that may be over watered. The release of water to the seedlings in trays, by means of watering hoses, has resulted in dislodged seedlings from trays, thus lowering the production and augmented the cost linked with weekend employment of labour [1]. The developed system in [1] is not intelligent system. Additionally, the weakness of the system is outnumbered, and one of the biggest weaknesses is about failure of predicting the weather. Furthermore, there is no sensor used in the system. It is advisable to use rain sensor as well, as soil moisture sensor is in work by [1]. Figure 2 below shows a solar powered irrigation system which consists of photo voltaic, controller and storage tank.

The paper provides a preface to solar-powered livestock watering systems, as well as the discussions of price, mechanism, and terms, with some suggestions for the installment and design of these systems. The potency and flaw of the solar pumping system are evaluated in contrast to the key options for pumping in far-flung locations: mechanical windmills [2].

The system utilized solar panels, mechanical windmills, and portable generators. The objective is to pump water from the water source for livestock areas, where there is an unavailability of electricity from the power lines. These systems bestow livestock with immense access potential of investigation by encouraging the animals to leave from watercourse and lakes. Livestock pressure is reduced on stream banks, avoiding nutrient loading, damaging streamside erosion, vegetation, and pollution [2].

Solar powered systems have high initial cost and low maintenance cost compared with other remote systems. There are two mounting structures, such as fixed and tracking mounting structures. For fixed mounts, there is a tolerance for high wind and it is less expensive but the tilt angle needs to be adjusted to the south. Tracking arrays follow Sun across the sky. Batteries are not used because tanks are so big enough to keep water for few days, hence reducing the maintenance and installation cost [2].

Partially, it is a good initiative to omit the batteries which reduce the cost. The tracking mount system for photovoltaic is better idea since it follows Sun across the sky. There is an important controller which helps the pumps from low and high harmful voltage and maximizing the water pumped [2]. Some great ideas are present in the system, such as using tracking mount system and reducing the cost by omitting the batteries, even though the system is not intelligent enough [2].

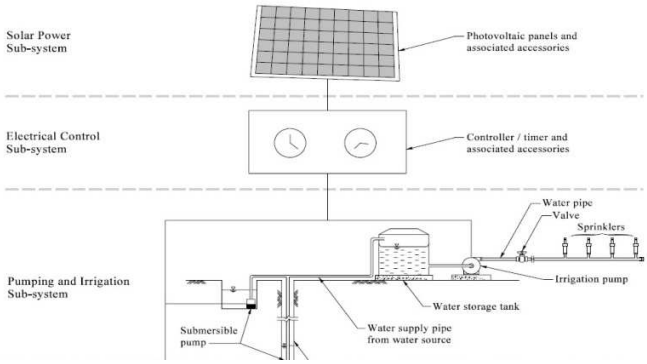


Figure 3. Solar Installation System [2]

Figure 3 displays the simulation of solar powered irrigation system. This system is to help the organization of freshly planted vegetation on man-made slopes, where man-made vegetation slopes green during the dry seasons; an automatic irrigation system, utilizing solar power for watering vegetation, is applied. Photovoltaic panels are utilized to generate electricity to produce electricity, that is later stored in rechargeable batteries. Power is supplied by the batteries for operating the system. Water is pumped from a submersible pump from a natural watercourse to a storage tank and the water is then drawn by an irrigation pump to the sprinklers installed at the slope toe for watering the vegetation on the slope [11]. Initially, there were some quandaries involved with the solar powered automatic irrigation system. Improvements to the system were instantly executed to develop the efficiency of the system.

Therefore, it is learnt that the utilization of an automatic irrigation system, which is functioned by solar power, is the best option in designing the irrigation system. In fact the greatest problem that is facing the system is due to the defection of batteries. It is necessary to come up with great idea about batteries.

The system happens to be in a very adequate position as it is nicely structured with all the equipments of the solar powered automatic irrigation system, where a control unit controls the control relays, electrical timers, an inverter and a charge controller [3].

The period for the operations is maintained by the control of relays and timers, which influences the pumping and the irrigation system as well. The charging of the batteries is controlled by the charge controller, with the assistance of the PV panels. For the pump operations, rechargeable batteries help the inverter to convert direct current (DC) into alternating current (AC).

For the rainfall detection, rain detector sensor is connected to the control unit of the system for the detection, and if there a detection of rain within a range of three hours before a scheduled irrigation, the system will skip the irrigation function for that day [3].

The topic is about generating electricity using solar system. It is known as photovoltaic system. This form of system is the most important especially in rural [4]. Areas where there is luck of foil. It is found better system compare to other system such as motor and so on. The Sun's rays are able to generate energy by making the rays strike onto the surface of the panel, thus releasing energy in the form of heat. Special materials also influence the release of energy from the surface of the panels.

This material is used by the Solar Panels to transform the light energy from the Sun directly into electricity, with the assistance of the photovoltaic process. The power produced by the solar panels is directly proportional to the intensity of Sunlight striking the Solar Panel. Furthermore, bigger Solar Panels are able to seize more rays, thus producing more power. Four different components are able to be found in a Solar Electric System and they are: Solar panel, battery, regulator (controller), and one or more lights or other [4].

However, solar electric systems in [4] comparisons to other lighting systems are:

1. Vivid and Stable Light
2. Radio and TV is able to run with it
3. Monthly Electricity Bill is not required
4. Secured; No Fire Hazards required
5. No Pollution and Noise
6. Lifelong

Using photovoltaic to generate power or electricity is the best idea because it is found that it has many advantage such less expensive. It is good for rural areas. One of the good points is about how to increase the power of photovoltaic; just it is simply to put in parallel in parallel to each other [4].

The function of solar powered water pumping system is the crucial aspiration of this paper, as well explaining the differences with the other energy sources [5]. Two fundamental types of solar powered water pumping systems are found and they are: Battery-Coupled and Direct-Coupled. These two fundamental types help us to determine the optimum system for a particular application, and they are explained briefly below [5]:

2.1 Battery-Coupled Solar Water Pumping System:

Battery-coupled solar water pumping system is composed of charge-control regulator, photovoltaic panels, and batteries, pump controller, pressure switch and tank, and DC water pump. During the daytime, the batteries are charges with the electric current produced by the PV panels, and the batteries in return supply power to the pump whenever water is required.

2.2 Direct-Coupled Solar Pumping System:

Electricity from the PV modules is sent directly to the pump in this pumping system, and the electricity helps the water to pump water through a pipe to where it is required. This water pumping mechanism is designed to be executed only in the daytime, as the quantity of water pumped is entirely dependent on the type of pump used and the amount of Sunlight striking the PV panels [5].

- Battery-Coupled Solar Water Pumping System:
  Using battery is the most trusted since there might be a day where the radiation coming from the Sun will not be available. For better precaution it is advisable to use batteries in solar system in order the store energy for future use.

- Direct Coupled Solar Pumping System:
  Direct connection is not advisable because there will be a day without storage and radiation coming from Sun.

The configuration, which is battery-coupled solar water pumping system, is accepted in our case. The coupled battery is to be used again if it becomes necessary [5].

The system is really pertinent, because we are going to use photo voltaic system to generate electricity to our irrigation system. This article is consecrated only for the Photovoltaic system, therefore we will implement the points that we have learned from this article. Photovoltaic cells are capable of transforming

the energy from the solar radiation into electricity due to the energy transfer transpiring at the sub-atomic level [6].

Small packages, called photons, make the very nature of solar energy. Open circuit voltage and short circuit current capabilities make the relevant analysis required for a photovoltaic cell.

The advantage of utilizing a direct solar radiation is also found in [7]. There is an importance in the article due to the cost competitiveness of photovoltaic power for irrigation with conventional energy sources for petite, remote applications. Lastly, if the entire system designs and utilization timing is circumspectly considered and organized, there is always a presence of opportunity to utilize the solar energy as efficiently [7].

3. Methodology

The system consist of hardware and software. The harware part involves PLC (Programmable Logic Controller), smart solar tracker, motors, sensors and valves. The software part is about building SCADA (Supervisory Control and Dada Aquisation) system which is the interface medium between hardware and computer.

Hardware

The solar tracker system is equipped with LDR (light detecting resistor), gear box and charger. System tracks the direction of the radiation reflected from the Sun. LDR varies the voltage value based on the intensity of the light. There are two LDR circuit positioned on end- right and end- left of the solar panel. The microcontroller receives the reading of the voltage from the LDRs, then it will give instruction to the drivers of the motor to rotate in direction of the LDR that has the highest voltage. The system charges the baterries as the other parts of the system utilizes it.

Figure 4. Solar Tracker

Fig.4 shows the solar tracker system. The solar tracker system is monitored by using the DC motor in which it rotates the panel according to the desired location**.** The PLC is used as the brain of the system. Fig.5 shows the PLC that has been used in the experiment for acquiring the data. It takes the input from the sensors and gives instructions to the output side devices to operate.

Basically, for this system there are four input sensors and three outputs actuators. The four input sensors are two level sensors and two moisture sensors. The outputs are motor (water pump DC motor) and valves (l2 VDC valves).

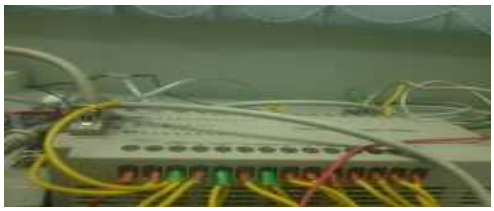


Figure 5. PLC

Software

Supervisory Control and Data Acquisition, also known as SCADA, is a computer system for the congregation and analysis of real time data. SCADA is also referred to as the central system that scrutinizes and controls an entire set of a system, which is extended over a long distance. The bulk of the site is usually executed involuntarily by a remote terminal unit, RTU, or by PLC, which is known as the Programmable Logic Controller. Furthermore, there is a constraint present in the host control functions towards the supervisory level capability [8].

For instance, the control of cooling water flow is done by the PLC during the industrial process but the SCADA system might permit a machinist to alter the control set point for the flow and will permit any alarm conditions, such as flow loss. However, the feedback control loop is congested through the PLC or RTU; the monitoring of the total performance of the loop is executed by the SCADA system. The system overview has been shown in Figure 6. The system consists of hardware (data acquisition card) and the software parts. SCADA consists of many components such as RTU, MTU.RTU, remote terminal unit gather information from the inputs devices such as sensors, valves, motors, alarms and many more [8].

RTU collect all the system information and keep it the memory until the MTU (Master Terminal Unit) send the request to transmit data. MTU collects all the data stored and sends information to the device for interference operation. MTU can be a computer consisting of Human Machine Interface (HMI) as medium of communication for processing data and information. HMI interface provides a centralized monitoring and controlling system for the various inputs and outputs. NI LABVIEW software can communicate with PLC in a variety of ways. Modbus is a serial communication protocol published by Modicon in 1979 to communicate with PLC, and was then extended to the TCP protocol. Modbus became one of the standard communications in the industries. Thus Modbus communications server is used as medium of communication between RTU (PLC) and MTU.

The SCADA system is protected and requires password to access, according to Fig.7. There are two types of account, the administrator account and the operator account.

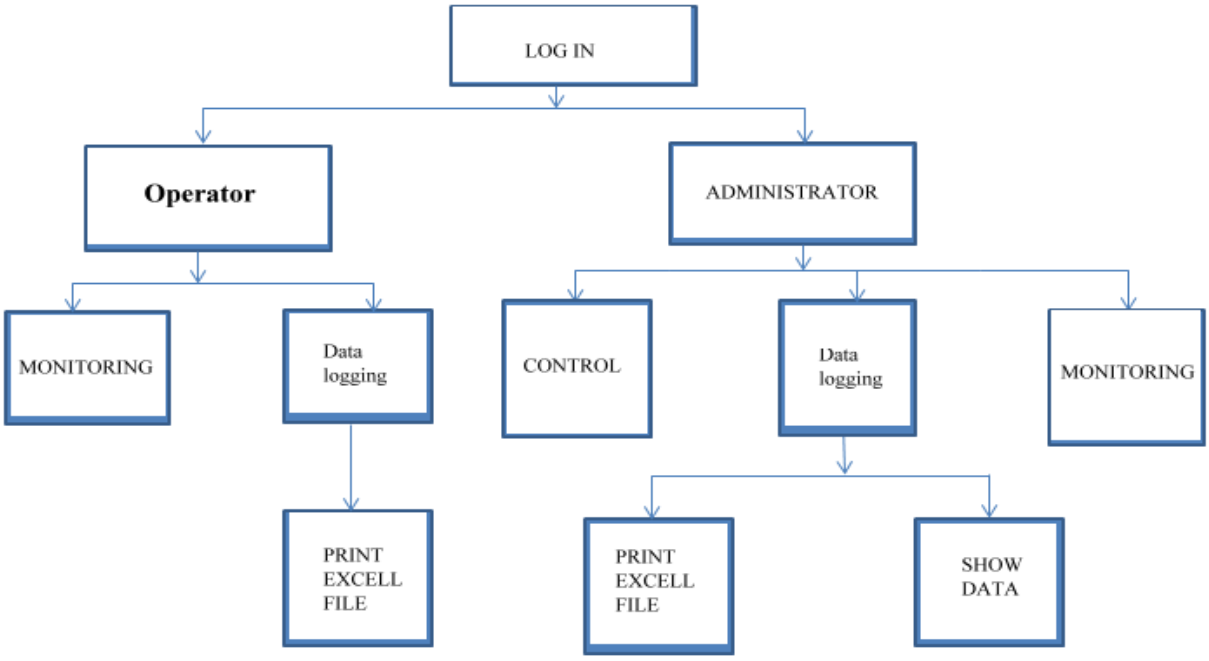


Figure 6. SCADA System Overview

The operation principle as shown below in Figure 4, there is a need to enter the password to the provided NI security login system.

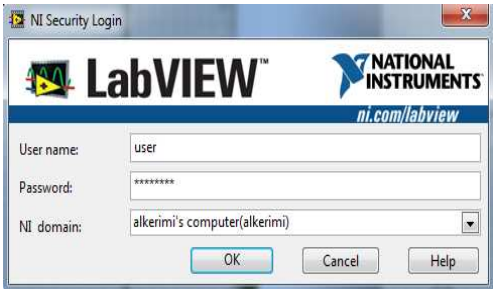


Figure 7. SCADA Operating Principle

Upon entering a valid password, the interface will take us to project explorer (Fig.8) where there are many components of the project under the named folders. Furthermore, the user has anoption of selecting any kind of project folder according to the objective of the user.

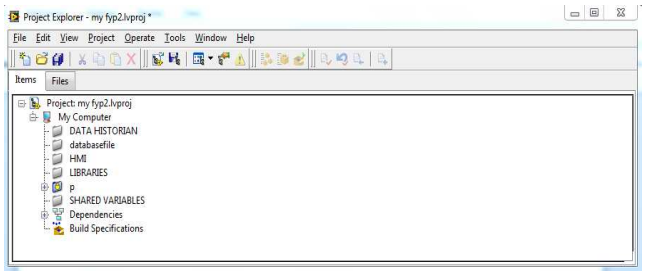


Figure 8. Project explorer

If the user selects the HMI folder, the following Fig.9 is displayed. The HMI is configured and connected with the RTU (PLC). This HMI shows the state of the variables in PLC and from the HMI there is a possibility of changing the value read from the PLC, since PLC acts like slave and HMI acts like the master. Firstly, the system displays the values in the PLC (RTU) and secondly the value can be changed.

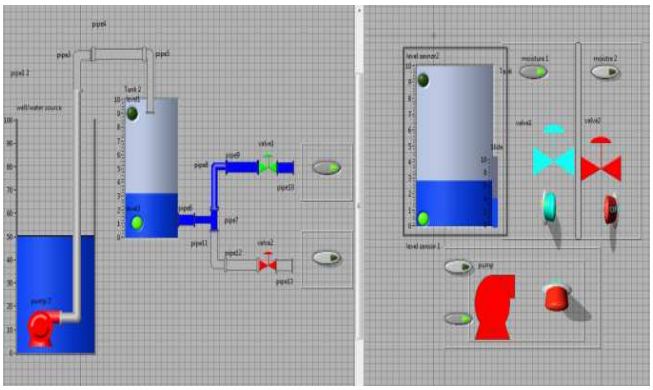


Figure 9. HMI

4. Results and Discussions

The process of recording proceedings with an automated computer is known as data logging. Furthermore, data logging is also used to provide an audit trail that can be utlized to comprehend the actions of the system and to analyze the qaundaries. Data logging tends to be constructive when it comes to the combination of log file entries from mutiple different sources. Correlations between seemingly dissimilar occurrences on different servers happen to capitulate from the earlier mentioned approach, in amalgamation with the statistical analysis. Other solution employ network-wide quering and reporting. The function of the datalog is to record all the parameters value measure durring each operation. The datalog can save file in the project explorer under the database file in form of notepad, according to Fig.10.

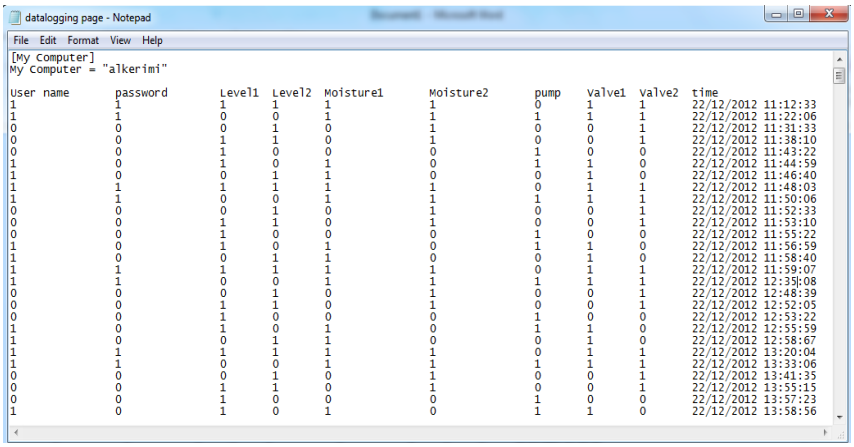


Figure 10. Data log

Upon saving the data in database for every specified cycle, the system uses the recorded data in database in order to plot the behavior of the variables. It helps to monitor the system status by displaying the real status of the control variable. In addition to this, the system is able to display graphically the status of controlled variable for previous days or hours as long as in the scope of database. In order to provide an everlasting log of facility performance, graphing is used as the data storage capability in the SCADA system.

However, most of the significant system parameters, such as moisture sensors, level sensors, pump and valves, happens to be stored in every fixed cycle of time. The system have the capability to record critical all the state of operation of all defined variable. Furthermore, data storage uses a separated server from that which is utilized for the primary system control software and is backed up sporadically.

Fig.11 represents the behavior of inputs and outputs variable for a specified cycle of time. Here the variables are two level sensors, two moisture sensors, two solenoid valves and water pump motor. The graph is based on the data on database. The inputs and outputs are digital signals.

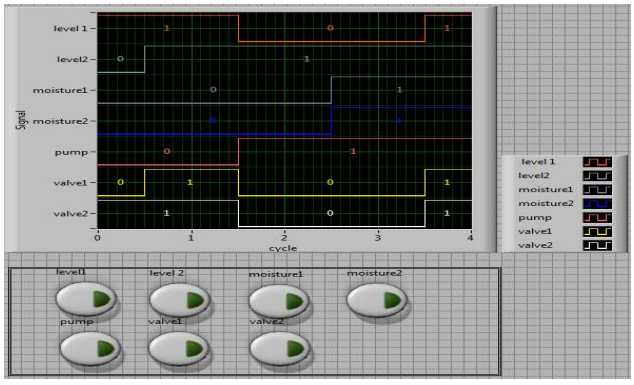
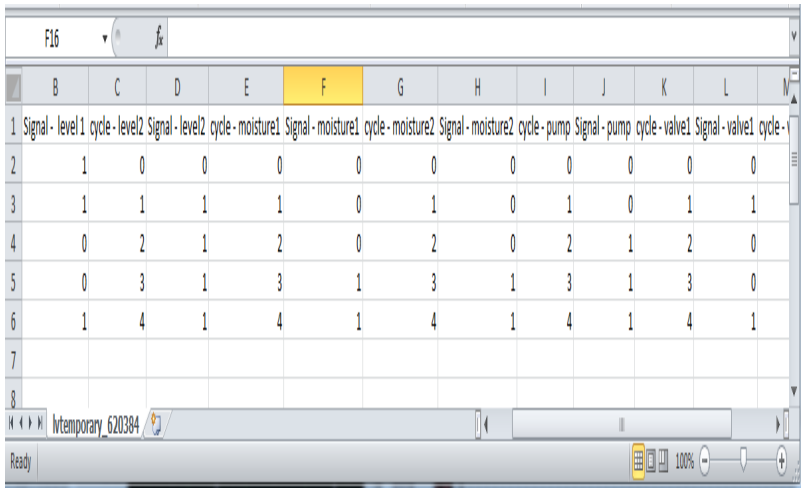


Figure 11. Behaviour of inputs &outputs

The above graph can be converted into excel data sheet on order to observe clearly for monitoring purpose (Table 1). In excel format the values are seen clearly for every cycle**,** in reference to the table shown below-

Table 1. Excel Data Show, representing the Graph of Input & Output behavior.



	B	C	D	E	F	G	H	I	J	K	L
1	Signal - level1	cycle - level2	Signal - level2	cycle - moisture1	Signal - moisture1	cycle - moisture2	Signal - moisture2	cycle - pump	Signal - pump	cycle - valve1	Signal - valve1
2	1	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	0	1	0	1	0	1	1
4	0	2	1	2	0	2	0	2	1	2	0
5	0	3	1	3	1	3	1	3	1	3	0
6	1	4	1	4	1	4	1	4	1	4	1
7											
8											

5. Conclusion

This paper managed to stumble upon the fact that the largest advantage of solar energy is its attribute as being free and unlimited source of energy. We have also found out that the research of the development of solar irrigation system requires vast knowledge and familiarity about renewable energy, as well as other parameters of control. The parameters of the system that have been used in the project are soil moisture sensor, light detecting sensor and level sensors. The design of SCADA system is meant for adding an operator on automatic irrigation system. Through SCADA system, the operator can read and write data from the controller (PLC) in addition to this there is a report of the system in excels form and that can be printed. After continuous work and effort, it was manageable to test the system by making it function properly. This project is very vital for all systems that deal with liquid monitoring and controlling specially in the irrigation field. The SCADA system helps administrators to control and monitor irrigation system. As stated, the project can be expanded to oil and gas monitoring system and greenhouse implementation system. Based on the result obtained from measurement, the system performance is quite reliable and accurate. The system has successfully overcome quite a few failings of the existing system by reducing the power consumption, maintenance and automatic system interface with SCADA system.

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