Exposure to Auto-Irrigation System of Pakistan Using Solar PV Power

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Abstract- Pakistan is a nation of agribusiness. Right now, farmers routinely deluge land physically. A late influx of water causes the desiccation of the harvests and as a result, the generation of yields gets affected while the nation endures a major misfortune in its income. This paper proposes an advanced and efficient way for Pakistan's irrigation system by detecting the soil moisture content via the level of water. The designed irrigation pump adjusts the water level automatically using moisture sensors. It is organized into two modes; manual and automatic. The moisture content of the soil is sensed by controlling the pump motor ON/OFF, which is intended in this effort to promote an Auto Irrigation system. Based on the moisture sensor rate, the water pump is transferred ON and OFF in an automatic tactical scheme. After predetermining the onset values of soil moisture, temperature, and water level, a software function was exclusively developed to be commanded using Arduino Nano. Furthermore, the water pump can be established ON and OFF in physical mode by the farmer via referring to a message at his own preference without essentially progressing to the ground. Moreover, this procedure now and then disburses more water, thus due to moisture sensors programmed to control water tapping, agribusiness generation is better. Human intervention will be lessened as an improvement using this practice via developing a substantiated irrigation system in Pakistan.

Index Terms- Sensing Moisture Content in Soil, Auto Irrigation, GSM.

I. INTRODUCTION

The expanding demand for energy, the progressing reduction of the flow in wellsprings of petroleum products, and the developing worry about pollution of the climate have driven the world to investigate new non-traditional, sustainable, power-source assets; for example, sun-based vitality, wind power, and so forth for electrical energy manufacturing [1]. Daylight is quite common in the Subcontinent and especially in Pakistan; it is subsequently a savvy thought to pay to utilize it in the different zones. An appropriate technique of irrigation is essential in the field of agriculture. [2]

Transmission of information to a website is handled by the database that takes values from the sensor of soil dampness, the temperature sensors in the root zone of the plant, and the opening unit. A Power Photovoltaic board was utilized. Measurement of edge estimations of the temperature sensor and soil dampness sensor has been arranged into a microcontroller for the scheming of water sum through design.

Owing to its energy autonomy and low price, the scheme has the potential to limit water being appreciated in purely inaccessible zones. In this study, the content of soil moisture was detected using acoustic techniques. The main principle of this technique is growing in the real-time soil moisture measurement method.

In this job, design has been anticipated for an automatic irrigation arrangement model based on a microcontroller, while solar power is only used as a power source. There are several sensors in the paddy field. Sensors are constantly sensing the water level and providing farmers with the data via cell phones. Without going into the paddy field, the farmer controls the engine. If the level of water reaches a high level, then the pump will be OFF without taking any command from farmers. [3], [4]

The purpose of this system has the following objectives:

- It uses power from solar when sunlight is available and solar panels are working.
- It can also take power from service mains if sunlight is not available and solar panels are not working.
- It reduces the farmer's efforts for giving water to fields as when to ON the pump and when to OFF the pump so it will toggle the pump spontaneously.
- The system contains multiple sensors that perform their work independently and give feedback to perform further actions.
- Water can be saved and can be given to fields according to the requirement by using this proposed application.

II. PROPOSED METHODOLOGY

A. Background

Solar energy is the basis of more or less all energies in the world that exist today and it is found sufficiently. It tenders expansive energy in a lime fashion for power generation, and solar power is there to answer all energy crisis in the world [5], [6]. The emergence of power electronic converters have made possible the use of this energy to generate bulk electricity for commercial applications [7]-[9]. This scheme utilizes astronomical power that pushes water from a tiny canal or lake and then passes through a water pump to areas. It also regulates the water drift frequency and improves it with a moisture sensor for the use of water. It must therefore be used with the accessible technology of linkages. Automation of agricultural fields that monitors and controls climatic constraints for plant growth and their creation.

For an investigational measure, in this paper, a vast disposition of irrigation structure, which is executed using hand control and wireless communication has been depicted. The primary purpose of this application was to show that water usage can be

optimized/reduced by the automatic irrigation system as represented in Figure 1.

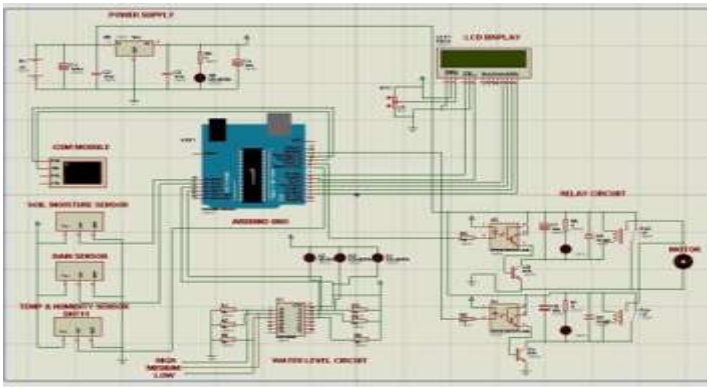

Figure 1. Circuit Diagram of the Adaptive Irrigation System.

It can also be a solar-powered photovoltaic irrigation arrangement, i.e. the soil moisture instrument and warmth sensor positioned beneath the topsoil where plant bases are reached which is a dispersed system. The scheme as depicted in Figure 2 has a sensor of water level, indicating the existence of water level in the tank. A software function has been developed by designing the soil moisture aquatic level edge values that have been programmed into a microcontroller.

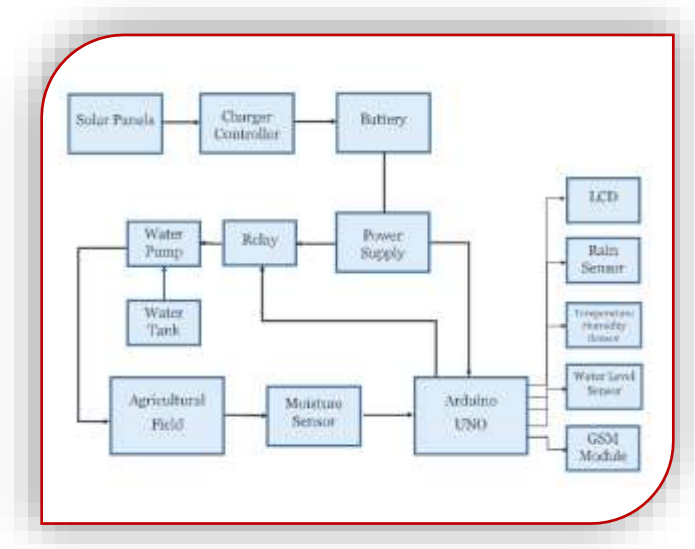

Figure 2. Block Diagram of the Proposed System.

B. Components of the project

The main components used in the project are as follows:

1. **Solar Panel**

The solar panel is specially planned to absorb the sun's radiation as a foundation of energy to generate electricity. The Photovoltaic cell converts sunlight into electricity. This cell is a source of energy for many electronic devices, i.e. calculators, lights, pumps, etc.

The solar system is a photovoltaic cell that changes the energy of the sun into electrical energy. In this analysis, poly-crystalline panels of solar panels are exploited.

Table 1: Solar Panel Specifications.

Maximum power output	150 W
Tolerance	3%
Open circuit voltage	22.5 V
Maximum output voltage	18.5 V
Short circuit current	8.56 A
Maximum output current	8.1 A
Weight	12 kg
Fuse	12 A

2. **Arduino UNO**

Arduino UNO is a board based on the ATmega328P microcontroller. By sending commands, it interfaces with the parts of device. Arduino UNO has a USB link, Power Jack, ICSP header & Reset Button.

It is attached via USB cable to a laptop & powered by an AC-DC adapter or battery. [10]

Table 2: Arduino UNO Specifications

Microcontroller	ATmega328P
Rated voltage	5 V
Input voltage	7 to 20 V
Clock speed	16 MHz
No. of Digital I/O pins	14 (6 provide PWM output)
Analog input pins	6
I/O pin DC current rating	20 mA
EEPROM	1 kB
Flash memory	32 kB
SRAM	2 kB
UART	1
I2C	1
SPI	1

3. **5 Volt Relay Module**

5-V relays are exhausted in this task. If the operator selects his/her charging time, the relay circuit will receive signals from the Arduino to turn on chargers and when the charging period is over, then the relay gets turned OFF and stops charging by obtaining the Arduino signal again [11].

4. **555 Based Charge Controller**

In this exertion, 555-based charge control is expended, in which 555 is not used as a timer, but is used for its basic schematics. It has a voltage divider, two comparators, and an S-R flip flop which is the heart of this charge control. So, instead of using all these components separately, a 555 IC is used, which will simplify the circuit. In this regulator, the usage of a 5-volt regulator is deployed to supply a regulated supply to a controlled circuit. The transistor used in this circuit is 2N2222, NTE 123, 2N2904, or another general-purpose NPN transistor. Furthermore, to deal with the high current MOSFET, IRFZ44 is exploited. All resistors are of

1/8-watt rating. Variable resistors are used in this circuit having values of 10 kΩ. This variable resistance is used as a set value for cutting off voltage. [12]

5. **Lead Acid Battery**

This battery is the oldest rechargeable battery form that is mostly used. It has the capacity to provide elevated surge currents, which implies the cells have a comparatively higher power-to-weight ratio. When a battery is discharged, the electrolyte depletes sulfuric acid. The electron resembles water in this way. Acid sulfate coats the plates simultaneously and reduces the surface area on which the chemical reaction occurs. Lead and lead dioxide in the electrolyte respond to form the lead sulfate with sulfuric acid. The lead sulfate is created in a finely amorphous state and when the battery recharges, it can readily turn to lead, lead dioxide, and sulfuric acid. AC is converted into DC and purified by means of filters. The battery is charged via a solar panel which produces DC voltages. In grid supply, when AC is converted into DC with the help of a DC converter, then the battery will provide DC voltages for chargers. Car chargers need DC voltages from the battery, which were adopted in this study. So, there will be no conversion from AC to DC and constant voltages are provided by the battery to the connected chargers. Also, 1 Amp chargers to charge mobile devices like tablets and smartphones, etc. are used in machines for charging purposes. [13]

Table 3: Battery Specifications

Manufacturer	Exide
Voltage Range	12 V
AH	72
Plates	13

C. Software Implementation

The whole program for the system has been broken down into various portions below for the sake of explanation. Indication variables will be used to indicate that the soil moisture level and other sensor combination is ON. At the Void, the setup section runs only once at the start of the program, as shown in Figure 3.

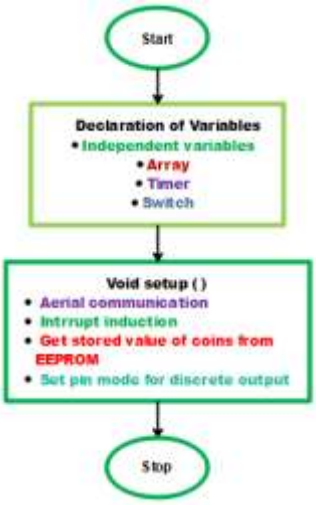

Figure 3. Initialization of Variables

In the subsequent Flowchart of Figure 4, whenever there is a signal on the interrupt pin, Arduino will run commands written in the interrupt service routine first & then resume the mains.
Each interrupt signal from the sensor is in the loop & the value of soil moisture is incremented by one & updated value is stored into EEPROM.

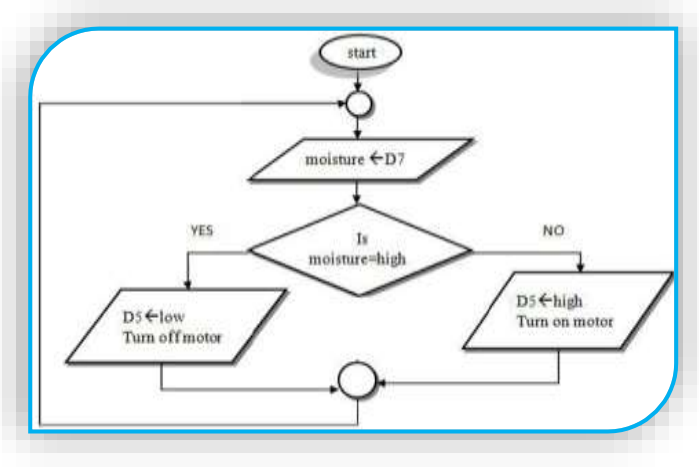

Figure 4. Flowchart for Soil Moisture

The following algorithm in Figure 5 is used at the start of a system that has been turned ON previously. This portion is repeated at every stage to make the Arduino continuously monitor the soil moisture that has been turned on while receiving new data from the soil moisture sensor.
This type of task is not possible to accomplish by just using a delay command to turn on a charger for a specified time and then turning it off as a delay command will cause the program to pause for that specified irrigation time. The Arduino will not process data from sensors during that time, so multitasking would not be possible.

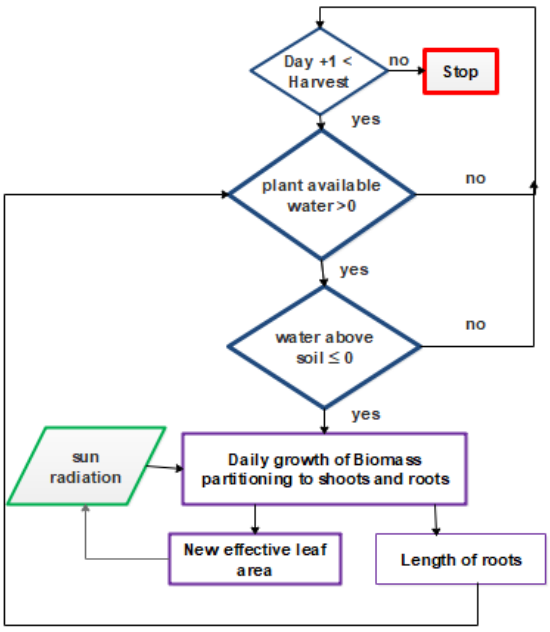

Figure 5. Availability of Water Flowchart

The execution of the sequencer will run if the plant's available water is zero. The Water Pump will get off as soon as the water level goes high.

After monitoring for irrigation that stayed switched on previously, it will move on to check for data from the soil moisture sensor. If there is no data from the soil moisture sensor database, it would jump back to the start of the section. If the button is pressed, the Arduino will jump back to the code in the first section to obtain a new value for the port number.

The Arduino will store the time that has elapsed since the Arduino was powered by that timer variable using the Millis command. Later on, that value of time could be subtracted from a new value for Millis to find the time difference. If that difference exceeds the pre-set charging time, then the charger would be switched off and a 0 would be moved to the specific indication variables.

III. RESULTS & DISCUSSION

Solar based automatic irrigation system strategy is basically the means of engineering design. A system is made up of many mechanisms that should work together to satisfy the basic requirements of what the scheme needs to do. In system designing, the main focus is on the strategic components which are to be set in it. In Table 4, Global Horizontal Solar Radiation for Sindh Province throughout the year has been collected. In Figure 6, the average insolation per year for the same province of Sindh has been graphed where the y-axis shows isolation values and the x-axis displays the month of the year. The highest peaks are achieved in the month of May and June.

Table 4: Global Horizontal Solar Radiation

									(Unit: kWh m-2 day-1) Annual				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Sindh Province													
Average	4.09	4.84	5.57	6.36	6.70	6.60	5.82	5.53	5.53	4.99	4.22	3.80	5.34
Minimum	3.61	4.36	4.77	5.90	6.19	5.97	4.93	4.91	5.10	4.49	3.86	3.40	
Maximum	4.68	5.26	6.14	6.87	7.15	7.14	6.32	6.06	5.91	5.41	4.59	4.24	

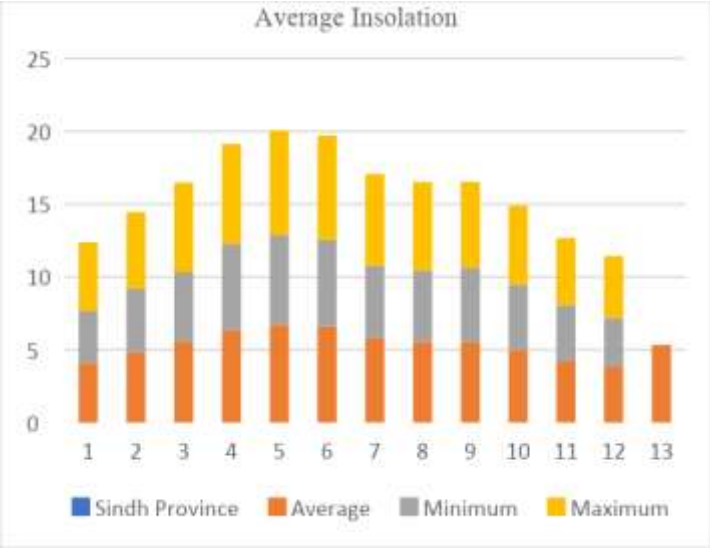

Figure 6. Average Insolation

In Table 5, Earth Mean Temperature for Sindh Province throughout the year has been gathered. In Figure 7, the average temperature per year for a similar province of Sindh has been diagrammed where the y-axis shows the temperature (Celsius) values & the x-axis displays the month of the year. The average assessment is ascertained throughout the year.

Table 5: Earth Mean Temperature

				Table 5 Earth Mean Temperature					(Unit: OC) Annual				
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Sindh Province													
Minimum	4.8	7.2	12.3	17.7	22.3	25.2	26.4	25.3	22.3	16.5	11.4	6.7	
Max imum	39.0	43.1	50.2	53.7	57.4	57.3	52.2	49.6	52.2	49.5	45.2	40.0	
Average	21.9	25.1	31.3	35.7	39.9	41.3	39.3	37.3	37.3	33.0	28.3	23.3	26.3

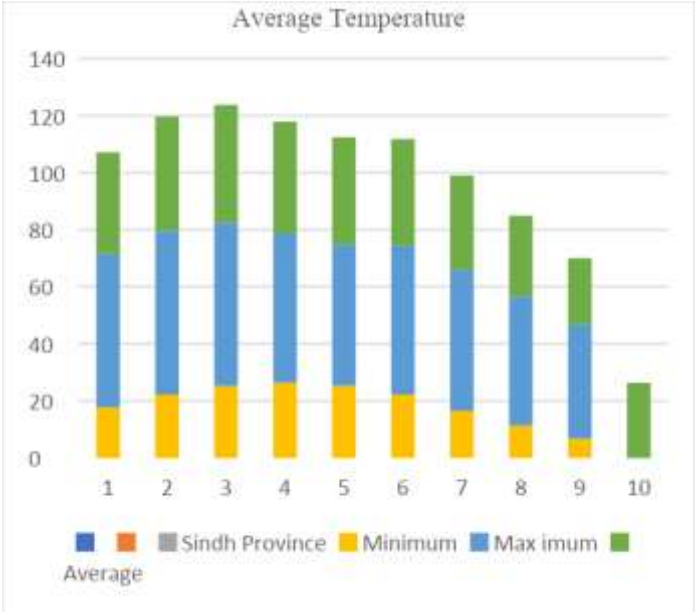

Figure 7. Average Temperature

An innovative and beautiful machine is designed to contain all the electronic parts within it. The solar panel is attached to the right side of the project table that can be portable and adjusted to any angle for easy placement & to increase the efficiency of solar. LCDs are grooved on the front side of the table.

In Table 6, percentage moisture by volume is analyzed through Eq. (iii) for Sindh Province throughout the year. In Figure 8, the moisture content in soil per year for a similar province of Sindh has been charted where the minimum values are found for the months of December and January.

Table 6: Moisture by Volume in a Year for Sindh Province

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average	3.42	4.25	5.09	6.03	6.67	6.78	6.00	5.60	5.31	4.70	3.80	3.20	5.07
Minimum	2.84	3.80	4.37	5.41	5.96	5.90	5.38	5.09	4.75	4.08	3.46	2.83	
Maximum	3.95	4.81	5.89	6.70	7.24	7.37	6.78	6.31	5.85	5.19	4.15	3.67	

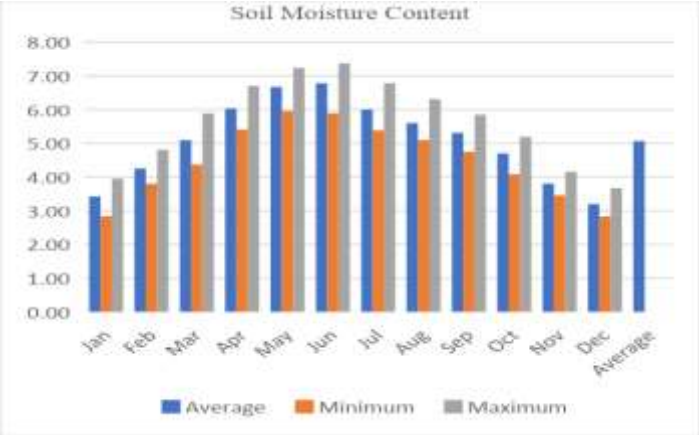

Figure 8. Soil Moisture Content

Figure 9 shows the % Moisture calculated using Equation (iv). In this project, a solar-based automatic irrigation system is signified as a unique technique for the agriculture field.

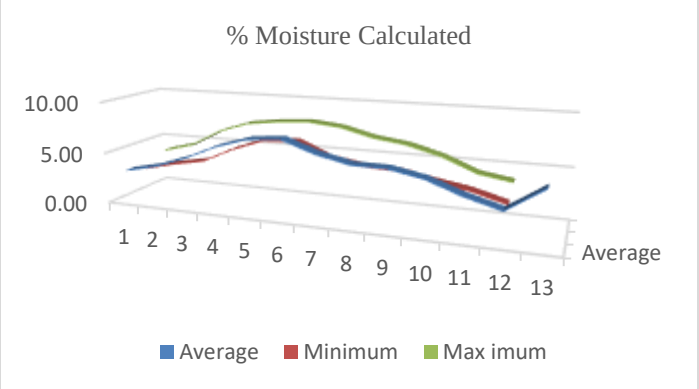

Figure 9. Moisture Computed

This project is very useful in daily life because at present Pakistan's 44% GDP depends on agriculture [14]. The load shedding is a big problem, so renewable energy sources are very compulsory for future irrigation loads to overcome electricity, which is not available all the time in Pakistan.

IV. CALCULATIONS

Solar Power:

The total load is 12-Watt watches, comprising the wattage of all the components connected to the solar-based automatic irrigation system. It includes the Arduino, soil moisture sensor, touch buttons, GSM module, relays, water pump, rain sensor, water level sensor, humidity sensor, battery, and solar panels.

Battery Sizing:

$$12\ (No.of\ Batteries)\ (Effeicincy)(\frac{Amp}{Load})\ \ldots\ldots(i)$$

$$Backup\ Formula = \frac{(12)(1)(0.8)(50)}{190} = 2.5\ hours\ \ldots\ldots(ii)$$

Soil dampness:

Soil moisture on a weight basis (%) can be changed to soil moisture on a volume basis (%) thru the following formula given by:

$$\%\ Moisture\ by\ Volume = \%\ Moisture\ by\ Weight - Bulk\ Density\ of\ Soil\ \ldots\ldots\ (iii)$$

Let's aim at a depth of 1 foot, this assessment specifies water in inches per foot deepness. On an acre or hectare basis, this value is written as an acre or hectare inches per acre or hectare foot of soil. [15]-[18]

$$\%\ Moisture = \left(\frac{Loss\ in\ weight}{Oven\ -Dry\ Weight}\right)(100)\ \ldots\ldots(iv)$$

V. CONCLUSION

The final project has been designed and the project is working along with its components according to expectations. The final design of this solar-based automatic irrigation system would be able to solve a major problem of this era. This concept will change the trend toward agricultural irrigation and gives new direction and speed, plus gives easy control.

Pakistan is an agricultural country. At present, ranchers physically water land at normal interim. This procedure now and again disburses more water for a while when the water arrives late, resulting in the vintages getting dried. The late arrival of water affects the generation of harvests and agriculturalists endure a major disaster in its revenue. In these ways, due to moisture sensors programmed to control water pumping, the venture is to exhibit the hypothesis that is important to investigate and plan of controlling the framework with accentuation and essential ideas and thoughts. It utilizes the GSM and dampness sensor with sensitive programming. It is accessible for calculation and recreation, so much tedious data can be left to the programmed water system.

REFERENCES

[1] N. Husain, S. M. U. Ali, "On integration of wind power into existing grids via Modular Multilevel Converter based HVDC systems", *IJRER*, Vol 10, No 3, 2020, pp. 1060-1070.

[2] P. S. kulkarni and J. R. Rana, "Solar Based Smart Irrigation system Using IoT:A Review," 2020 International Conference on Smart Innovations in Design, Environment, Management, Planning and Computing (ICSIDEMPC), 2020, pp. 315-317, doi: 10.1109/ICSIDEMPC49020.2020.9299592.

[3] H. N. Saha et al., "Smart Irrigation System Using Arduino and GSM Module," 2018 IEEE 9th Annual Information Technology, Electronics and Mobile Communication Conference (IEMCON), 2018, pp. 532-538, doi: 10.1109/IEMCON.2018.8614839.

[4] J. Uddin, S. M. T. Reza, Q. Newaz, J. Uddin, T. Islam and J. -M. Kim, "Automated irrigation system using solar power," 2012 7th International Conference on Electrical and Computer Engineering, 2012, pp. 228-231, doi: 10.1109/ICECE.2012.6471527.

[5] G. M. Ud Din, N. Husain, A. Yahya and Z. A. Arfeen, "Mathematical Analysis of Advanced High Voltage Direct Current Transmission Systems," *2021 International Conference on Applied and Engineering Mathematics (ICAEM)*, 2021, pp. 61-66, doi: 10.1109/ICAEM53552.2021.9547195.

[6] G. M. Ud Din, N. Husain, Z. A. Arfeen, A. Yahya, N. Iqbal and F. Shaukat, "Emergence of Advanced Multi-Terminal HVDC Transmission Systems and DC Grids," *2021 6th International Multi-Topic ICT Conference (IMTIC)*, 2021, pp. 1-6, doi: 10.1109/IMTIC53841.2021.9719688.

[7] A. Yahya, N. Husain, and S. M. U. Ali, "Multilevel inverter – a survey for MV and HV applications," *IJSER*, vol. 6, no. 1, pp. 1453–1460, 2015.

[8] Z. A. Arfeen *et al.*, "Exposure of Electrically Driven Vehicles and Smart Vehicle-to-Grid Technology," *International Journal of Progressive Sciences and Technologies (IJPSAT)*, Vol. 30, No. 1, pp. 220-228, ISSN: 2509-0119, 2021.

[9] M. A. Sadiq *et al.*, "Prominence of Filtering Techniques for Harmonics Mitigation in Advanced Power Electronics Systems," *IJIST*, Vol. 4, No. 2, pp. 512-525, ISSN: 2618-1630, 2022.

[10] Y. A. Badamasi, "The working principle of an Arduino," *2014 11th International Conference on Electronics, Computer and Computation (ICECCO)*, 2014, pp. 1-4, doi: 10.1109/ICECCO.2014.6997578.

[11] Tjandi, Yunus & Kasim, Syarifuddin. (2019). Electric Control Equipment Based on Arduino Relay. Journal of Physics: Conference Series. 1244. 012028. 10.1088/1742-6596/1244/1/012028.

[12] Kanagaraj, Indirajith. (2017), solar battery charger and protection. 10.13140/RG.2.2.27040.28166.

[13] Geoffrey J. May, Alistair Davidson, Boris Monahov, Lead batteries for utility energy storage: A review, Journal of Energy Storage,Volume 15, 2018, Pages 145-157.

[14] M. W. Chughtai, M. W. Malik, R. Aftab, Impact of Major Economic Variables on Economic Growth of Pakistan Acta Universitatis Danubius. Œconomica, Vol 11, No 2 (2015).

[15] Munoth, Priyamitra & Goyal, Rohit & Garg, Anchit. (2016). ESTIMATION OF SOIL MOISTURE AND ITS APPLICATION TO IRRIGATION WATER ALLOCATION: A REVIEW.

[16] Jadhav, H.T., Patil, T. & Jamadar, N.M. Evaluation and Cost Analysis of Methods of Power Supply for Irrigation Pumps. *J. Inst. Eng. India Ser. B* (2022). https://doi.org/10.1007/s40031-022-00718-6

[17] Oyeyiola G.P., Agbaje A.B., Physicochemical Analysis of a Soil near Microbiology Laboratory at The University of Ilorin, Main Campus, Vol.3, No.6, 2013.

[18] G. Alex and M. Janakiranimathi, "Solar based plant irrigation system," 2016 2nd International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB), 2016, pp. 425-428, doi: 10.1109/AEEICB.2016.7538323.

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