International Journal of Scientific Research in Science, Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)
doi : https://doi.org/10.32628/IJSRSET229243

Smart Irrigation System Deploying PSoC and Wireless Sensor Network

Komal Pilani[1], Ms. N. Gupta[2], Dr. Prashant Mane-Deshmukh[3]
[1]Department of Electronics Engineering J.C. Bose University of Science and Technology, YMCA, Faridabad, India
[2]Department of Electronics Engineering J.C. Bose University of Science and Technology, YMCA, Faridabad, India
[3]Head, Department of Electronics Jayawantrao Sawant College of Commerce and Science, Hadapsar, Pune, Maharashtra, India

Article Info
Volume 9, Issue 3

Page Number : 78-84

Publication Issue :
May-June-2022

Article History
Accepted : 01 May 2022
Published: 13 May 2022

ABSTRACT

Traditional agricultural systems require huge amount of power for field watering. This paper deals with designing of a smart irrigation system, that helps farmers water their agricultural fields using innovative technology. There is no need to frequently apply water across entire fields. Instead, they can use the minimum quantities required and target very specific areas. To increase the productivity, the newer technology is more helpful. The important factors of agricultural sectors are temperature, water and fertilizer management. On survey it is found that water management is an important issue, hence the research work is focused on the water and moisture management of soil.

In last decades advancements in technology is tremendous. Programmable System-on-chip (PSoC) integrate configurable analog and digital blocks which makes it different from traditional microcontrollers and is a miniaturized device. It combines the architectures of FPGA and ASIC. Deploying the advanced features of PSoC it is proposed to design and develop the smart irrigation system based on PSoC and Wireless Communication Technology. To achieve the desired goal, the data from the soil moisture sensor is processed and the data is calibrated in real units. After that it is displayed on LCD and using wireless technology same is transmitted towards the base station. The smart NRF24L01 transceiver operates on IEEE 802.15.4 Industrial Scientific and Medical (ISM) Band. Moreover, the base station of Wireless Sensor Network is designed to demonstrate collected information in user friendly format.

Keywords : PSoC4, NRF24L01, Wireless Sensor Network, Soil Moisture Sensor, Agriculture Field

I. INTRODUCTION

Climate change may adversely impact soil health. Moreover, irrigation can affect soil health. Extreme downpour can lead to run off and erosion. This strips the soil of key nutrients needed to sustain agriculture. Consequently, this will compromise the availability of freshwater used for primary production in agriculture. Conversely, reduced precipitation coupled with increasing heat will cause desertification and the loss of farm production in some areas. Frequent droughts and enhanced evaporation kill off the vital living soil ecosystems necessary to grow healthy crops whilst leaving less water to dilute pollutants. There is no need to frequently apply water, fertilizers, and pesticides uniformly across entire fields. Instead, they can use the minimum quantities required and target very specific areas, or even treat individual plants differently [1]. For farming technology, important factors related to the healthy growth of the crop are: temperature management and water management, this study is focused on the water and moisture management issues [2].

Advanced technologies can bring benefits to the majority of people. In recent years, the VLSI technology has become standard in the field of electronic research and design, resulting in a highly promising field of design of programmable system on chip for dedicated applications. These devices include configurable blocks and programmable interconnects and flash memories which resemble FPGA and ASIC. It is found that, for electronic system design, in addition to digital design the analog part is also equally important. Therefore, nowadays a new technology has emerged wherein both analog as well as digital design is considered. Such technology is referred to as Analog and Mixed Signal Based Programmable System on Chip (AMS-PSoC) design. In April 2013, Cypress released the fourth generation, PSoC 4 [3]. The PSoC 4 features a 32-bit ARM Cortex-M0 CPU, with programmable analog blocks, programmable digital blocks, programmable routing and flexible GPIO, a serial communication block, a timer/counter/PWM block and more. Using configurable analog and digital blocks, designers can create and change mixed-signal embedded applications [4].

Wireless Sensor Networks (WSNs) are used to monitor physical or environmental conditions, such as temperature, sound, pressure, motion, moisture and to cooperatively pass their data through the network to a main location or sink where the data can be observed and analyzed. A sink or base station acts like an interface between users and the network [5] [6]. Typically, a wireless sensor network contains hundreds of thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. A wireless sensor node is equipped with sensing and computing devices, radio transceivers and power. For wireless communication the "NRF24L01" is used for RF communication. The NRF24L01 is also the best example of development of a system on chip for dedicated application. This is operating according to the standards laid down by the IEEE 802.15.4 at 2.4 GHz in ISM band. The technology of Analog and Mixed Signal Based Programmable System on Chip (AMS-PSoC) has recently emerged. Therefore, it is proposed to undertake the project work on deployment of AMS-PSoC technology for sensor nodes. Deploying PSoC 4 the sensor node is designed for typical environmental parameters and base station is used as receiver, wherein NRF24L01 technology is realized for wireless communication. The developed embedded system is truly SoC and results of the implementation are interpreted in this paper.

II. HARDWARE DESIGN

The designing of hardware consists of two parts as; one is designing of the sensor node and other is designing of the base station. First we discuss the designing of sensor node and then base station.

2.1 SENSOR NODE

Sensor node is a sink device which senses the desired environmental parameter and transmits the data towards the base station which is at a remote location [7]. The figure 1 depicts the block diagram of the sensor node [8]. The sensor node consists of the sensor array, signal conditioning and wireless technology. The present research work realizes the soil moisture monitoring system to facilitate smart irrigation. The outline of the work is depicted through following point.

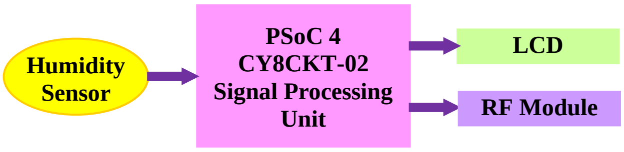

Figure 1: Block Diagram of Sensor Node

2.1.1 Humidity Sensor

To monitor the Soil Moisture of Soil at the area under investigation, the soil moisture sensor (FC-28) is used [9]. The figure 2 shows the soil moisture sensor. Soil moisture sensor measures the water content of the soil by measuring the resistance. The sensor is connected to the on chip Analog to Digital Convertor (ADC) of PSoC [10] [11].

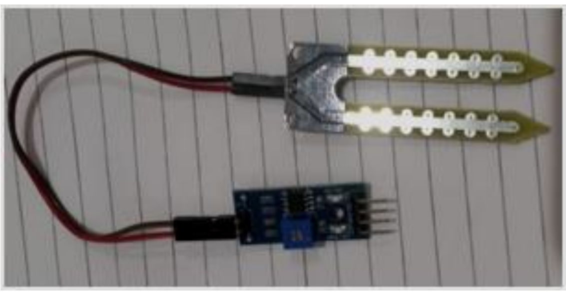

Figure 2: Soil Moisture Sensor

2.1.2 Programmable System on Chip (PSoC)

The processor plays a prime role in any embedded system. The process of development of an embedded system using PSoC is divided into three parts; Design of the hardware, Configuration of the each analog and digital blocks and Developing firmware. For present research work PSoC 4 (CY8CKIT-042) of PSoC family devices kit from Cypress Semiconductors is deployed [12]. The wireless sensor node with desired target module (CY8C425AXI-483) of PSoC is designed. While designing hardware the on chip resources are configured to cater the need of electronic systems. For this purpose the on chip resources like ADC, SPI are configured through the software, PSoC Creator IDE 4.2 of Cypress Semiconductors. To configure the PSoC with the PSoC creator, a schematic diagram is designed with components for ADC, NRF24L01 library, etc. Moreover, by making a custom component, analog pin, UART, SPI and some digital pins such as SS, CE, LED pin configuration designed as figure 4. After the schematic diagram is designed the pin configuration is carried out as shown in figure 5. After successfully on chip wiring of the PSoC system the sensor node hardware is ready for firmware. The RF module is externally interfaced to the SPI port.

Figure 3: Programmable System on Chip (PSoC) 4

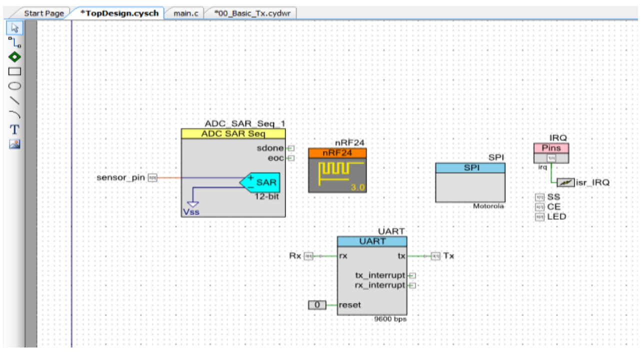

Figure 4: Top Schematic Design

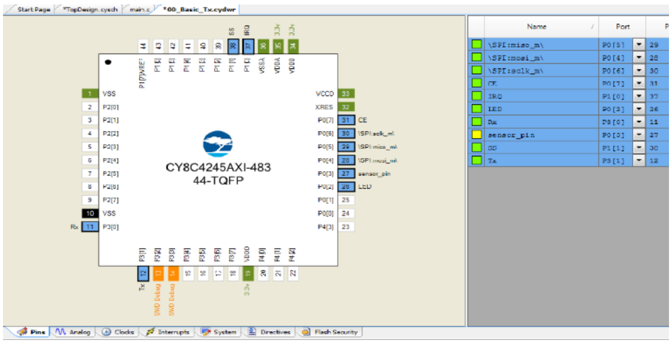

Figure 5: Design wide resources (Pin Configuration)

2.1.2 RF Module

The wireless sensor network is a distributed collaboration of various sensing devices called Sensor Nodes. The sensor nodes are equipped with wireless technology. On literature Survey it is found that there are many RF modules available like Zigbee, Bluetooth, WiFi, etc [13]. However, for present research work the RF Module NRF24L01 depicted in figure 6. The NRF24L01RF works with 2.4 GHz Industrial Scientific and Medical (ISM) [14]. It consumes very low power hence the life of the sensor node increases. One can configure the NRF24L01 as Coordinator, Router or Sink Node. The NRF24L01 is easily connected to the master devices through the SPI. For present design two NRF24L01 modules are used out of which one is configured as Coordinator and one is as a receiver. The Base station is explained through the following points.

Figure 6: RF module NRF24L01

2.2 BASE STATION

The wireless sensor network is a distributed collaboration of various sensor nodes and a coordinator called Base Station. In Wireless Sensor Network, the Base Station is important and plays a main role in the network. The base station consists of coordinator RF module, processor and display device as shown in figure 7. The coordinator helps to initialize the network with and allow joining the sensor node. The signal transmitted by the sensor nodes is collected by the coordinator node and processed using the processor. For present research work the Arduino UNO is deployed at the base station to process the data. Here it only synchronizes the working of the coordinator and display device. The Arduino IDE is used to program the Arduino [15] [16]. The libraries are included for the RF module and the code is done in embedded C. The received data is demonstrated on the smart LCD display. Whenever there is any change in the sensor reading, it displays the same. Measures it in units of volumetric water content percentage and the moisture percentage is displayed on LCD [17].

Figure 7: Block Diagram of Base Station

3. SOFTWARE

The development of an embedded system involves two major components such as hardware and software. The

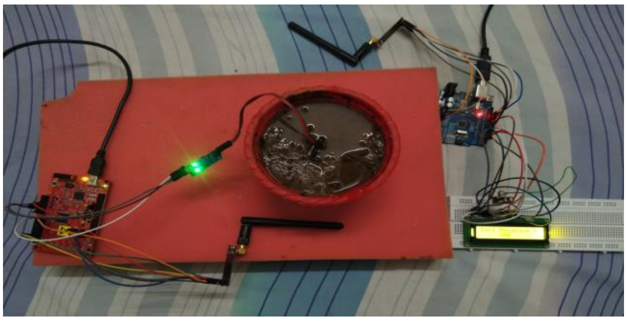

Figure 8: Prototype of Wireless Sensor Network to monitor Soil Moisture

software is co-developed in "embedded C" language using PSoC Creator 4.2 development tool. A firmware is developed to measure soil moisture. Debug and build the design at the sensor node and compile the design to base station. Program the design and transfer the same through USB cable connected to CY8CKIT-042 and update the base station through USB port. The system design is routed onto the chip and configured according to the requirements. The firmware is designed such a way that, when the water content of soil changes, the water content in soil dependent emf generated by sensor module is acquired by a processor which is wired around the PSoC board. After processing the signal is transmitted to the base station through an RF module connected at the SPI port of PSoC. At the other end the receiver receives data from the RF module and after proceeding data is displayed on a smart LCD. After successfully designing the system, it is calibrated by using a two point calibration system. After that the system is ready for implementation in the area under investigation. The implementation of the system is discussed through subsequent points.

III. IMPLEMENTATION

An agricultural country, like India, has been following traditional means of agriculture. However, recently, the scenario is changing and the agriculturists are attracting towards precision agriculture wherein the crops are cultivated in controlled environment. Indeed, the agriculturists are demanding sophisticated electronics for controlling environmental as well as soil parameters. An embedded System is designed to measure soil moisture. The soil moisture sensor consists of two probes that are used to measure the volumetric content of water. The two probes allow the current to pass through the soil, which gives the resistance value to measure the moisture value. For measurement of moisture content of the soil the experimental arrangement shown in figure 8 a test bed used for this measurement is designed by taking dry soil of about 100gm in a backer of 250ml capacity. Water is slowly added by means of the burette and the emf is measured. The time allowed for each measurement is 1 minute. This period is taken for spreading of water uniformly in the soil. When there is water, the soil will conduct more electricity, which means that there will be less resistance. Dry soil conducts electricity poorly, so when there is less water, then the soil will conduct less electricity, which means that there will be more resistance. To connect the sensor in the analog mode, the analog output of the soil moisture sensor is processed using an ADC of 12-bit resolution. When taking the analog output from the soil moisture sensor, the sensor gives us a value from 0 to 4096. The moisture is measured in percentages, so we will map these values from 0 to 100, and then show the reading on the LCD. Figure 8 presents the experimental arrangement for calibration of the FC-28 soil moisture sensor with PSoC 4 (CY8C4245AXI-483 44-TQFP) and RF module at sensor node and Arduino UNO with RF module and LCD module. The complete setup is shown below and is implemented in a pot. The ADCs values taken from are used for calculating analog output and then in moisture percentage and this calibration equation is implemented in software. Thus the observed readings are displayed on LCD in moisture percentage as well as the same are transmitted towards the base station. The results obtained are discussed.

IV. RESULT AND DISCUSSION

It is found that the percentage of moisture content in the soil is calibrated, the data is highly important particularly in case of the poly houses where the crops are grown, in a controlled environment. It is found that the agriculturists are demanding highly sophisticated and reliable systems for soil moisture measurement. As discussed earlier, the system is designed and calibrated for moisture percentage and is transmitted wirelessly from sensor node to the base station. After successfully deploying the sensor node, the readings are taken for a given amount of water. On the observation of recorded data by sensor node, the soil moisture varies with respect to location to location as well as time. The water is continuously supplied and the moisture percentage starts increasing. For approximately 10ml of water added to the soil the moisture percentage is increased by 8. The low energy consumption is also achieved.

V. CONCLUSION

A mixed signal PSoC based system is designed for measurement of soil moisture of the environment. Using Cypress PSoC microcontroller the system is developed by reconfiguring the Analog as well as Digital blocks of the PSoC. Deploying the IDE provided by the Cypress, the necessary firmware is developed and integrated to ensure the embedded system on chip design. The soil moisture observations shown by the system are highly reliable and precise. On inspection of the result of implementation, it can be concluded that the present system works successfully and gives the data regarding moisture present in the soil in the environment very precisely

VI. REFERENCES

[1]. S. C. Pathan, S. S. Shaikh, S. K. Tilekar, P. V. Mane-Deshmukh, P. S. Wagh and B. P. Ladgaonkar, “Design and Development of Mixed Signal Based SoC using SmartFusion Device for Wireless Sensor Network for Precision Agricultural (PA) Application” International Research Journal of Engineering and Technology (IRJET) 8, 8 (2021) pp. 235-243

[2]. C. P. Kumar, “Water Resources Issues and Management in India”, Journal of Scientific and Engineering Research, 5, 9 (2018) pp. 137-147

[3]. https://docs.rs-online.com/3cf8/0900766b8170a280.pdf

[4]. Sayani Singha ,Santashraya Prasad , " PSOC Based Implementation of Bluetooth Low Energy Mesh Network " , International Journal of Advance Computational Engineering and Networking (IJACEN) , 7, 3 (2019) pp. 55-58.

[5]. K. Gulati, R. S. K. Boddu, D. Kapila , S. L. Bangare, N. Chandnani, G. Saravanan , “A review paper on wireless sensor network techniques in Internet of Things (IoT)”, Materials Today: Proceedings, (2021) pp. 1-5

[6]. Y. Li, L. Qin and Q. Liang, "Research on Wireless Sensor Network Security," International Conference on Computational Intelligence and Security, (2010), pp. 493-496,

[7]. P. Singh, Dr. O. Gupta and S. Saini, “A Brief Research Study of Wireless Sensor Network”, Advances in Computational Sciences and Technology, 10, 5 (2017) pp. 733-739

[8]. P. V. Mane-Deshmukh, B. P. Ladgaonkar, S. C. Pathan, S. S. Shaikh, “Microcontroller PIC 18f4550 Based Wireless Sensor Node to Monitor Industrial Environmental Parameters”, International Journal of Advanced Research in Computer Science and Software Engineering, 3 10 (2013) 943-950.

[9]. L. Yu, W. Gao, R. R. Shamshiri, S. Tao, Y. Ren, Y. Zhang, Guilian Su, “Review of research progress on soil moisture sensor technology”, International Journal of Agricultural and Biological Engineering 14, 4(2021) pp. 32–42.

[10].https://www.infineon.com/dgdl/Infineon-Component_Datsheet_PSoC_4_Scanning SAR ADC_(Scan_ADC)_3.10-Software

[11].S. K. Tilekar*, S. C. Pathan, P. V. Mane-Deshmukh, S. N. Patil, S. V. Chavan and B. P. Ladgaonkar, “Synthesis of AMS Based System-on-Chip for Measurement of Physicochemical Parameters of Water”, International Journal of Engineering and Advanced Technology, 6 (2017) 147-152.

[12].P. Adi, A. Kitagawa, V. Sihombing, G. J. Silaen, N. E. Mustamu, “A Study of Programmable System on Chip (PSoC) Technology for Engineering

Education", Journal of Physics: Conference Series; 1899, 1, (2021) PP 1742-6596

[13].P. V. Mane-Deshmukh, (2018) Designing of Wireless Sensor Network to Protect Agricultural farm from wild Animals, i-manager's Journal on Information Technology, 7(4), 30-36.

[14].A. Martínez, E. Cañibano and J. Romo, "Analysis of Low Cost Communication Technologies for V2I Applications", Applied Science, 1249, 10 (2020) pp.1-18

[15].M. Prasad, P. Kumar, Rohit Kumar Singh, Smruti Ranjan Pradhan, "Home Automation Using Microcontroller (Arduino Uno)", International Journal of Engineering Research & Technology (IJERT), 6, 3 (2017) PP. 383-385

[16].https://www.farnell.com/datasheets/1682209.pdf

[17].https://www.sindadisplay.com/cob-character-lcd-display/character-16x2-lcd-module.html

Bibliography

Komal Pilani is M.Tech student at J.C. Bose University of Science and Technology in Faridabad, India. Her interests in working in the field of electronics and VLSI and working for branch based projects. She completed under graduation degree in Electronics and Communication at UIET, Kurukshetra University, Kurukshetra.

Neetu Gupta, Assistant Professor, Electronics Engineering Department, J.C. Bose University of Science and Technology, YMCA, Faridabad, has an experience of more than 15 years in teaching. She is currently pursuing her Ph.D. degree from the same University. Her doctoral research investigates the use of Bayes Filters for anomaly detection in videos. She takes a multidisciplinary approach that encompasses the fields of artificial intelligence, machine learning and computer vision and pattern recognition. During her course of teaching and research work she has authored and coauthored over 20 research papers in different academic journals and national and international conferences. She holds a master's degree in Communication Systems and a bachelor's degree in Electronics and Communication Engineering from Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal, Madhya Pradesh.

Dr. Prashant V. Mane-Deshmukh is currently working as the Head at the Department of Electronics at Jayawantrao Sawant College of Commerce and Science, Pune, India. He has completed Ph. D degree from Solapur University, Solapur, India. He was awarded with best paper presentation award, five times at the Research Festivals organized by Solapur University, Solapur, India and two awards as best paper presentation award at National level Conferences. He published 4 Books at international level. Moreover he published 35 papers in International Journals. He presented number of research papers in National Conferences. His areas of research are Embedded Technology, VLSI Technology, Signal Processing, Wireless Sensor Network, IoT and Instrumentation Designing for High Tech Process Industries, Medical, Precision Agricultural, and Environmental Parameters Monitoring Applications.

Cite this article as :

Komal Pilani, Ms. N. Gupta, Dr. Prashant Mane-Deshmukh, "Smart Irrigation System Deploying PSoC and Wireless Sensor Network", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 9 Issue 3, pp. 78-84, May-June 2022. Available at doi : https://doi.org/10.32628/IJSRSET229243

Journal URL : https://ijsrset.com/IJSRSET229243