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Development of Cloud Based Incubator Monitoring System using Raspberry Pi

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Abstract

Accurate and quantifiable measurement of light is essential in creating desired outcomes in practical day to day applications such as in Poultry Industry. Light measurement is essential in ensuring the efficiency of egg hatching process. Artificial incubation has been used in the poultry farm for hatching of the eggs. For better hatching of the eggs, the temperature and humidity has to be maintained properly. The proposed system is equipped with DHT11 sensor which monitors the temperature and humidity of the incubator and continuously updates to the cloud through Wi-Fi. Remote user checks the temperature and humidity values and controls the intensity of the bulb through an Android app in his mobile phone. A servo motor is attached to the egg turner kept inside the incubator and is rotated according to the specified delay in order to prevent the yolk from getting stick to the shell of the eggs and also to provide uniform temperature for the eggs. From the experimental results, it is inferred that better hatching of the eggs could be achieved by controlling the intensity of the bulb remotely.

Index Terms: Incubator, Wi-Fi, egg-hatching, Android app.

1. Introduction

Many of the industries are burdened with limited number of resources and real shortage of experts on their fields; real time remote monitoring presents an effective solution that minimizes their efforts and expenditures to achieve the desired results within time. In real time applications such as poultry industry, traffic lighting system, gardening or farming, at emergency exits, etc light measurement with precision is necessary in creating

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required outcomes[Syed and Sudha, 2016]. There are also other applications in hospitals, laboratories and educational Institutions where sufficient light levels has to be maintained for healthier and safer environment[Sandip and Gaikwad,2016]Artificial incubation has been used in the poultry industry by some farmers for better hatching of the eggs. The devices mainly control the heat, moisture and humidity of the incubator. This project will explore into the development of such a system which will accommodate the egg hatching procedure without the broody process. In addition to that, a monitoring system has also been developed so that the user can have seamless accesses to the incubator. Most importantly, its purpose is to create an environment where the egg incubation process occurs in a more orderly and safe manner. Egg incubator is used for keeping the eggs warm with the appropriate humidity using Raspberry Pi platform to hatch the eggs (Incubator Warehouse, 2012). Egg-Incubator based on Raspberry Pi will allow the foetuses inside the eggs to grow and hatch without the mother (hens) being present. Raspberry Pi is a low-cost ARM-based computer on a small circuit board. It is a capable credit card sized PC which can be used for various purposes as such a desktop PC can provide. This project is developed for the specific reason to assist the small-scale farmers from the technological perspective, so that their productivity can be increased significantly. It also features a monitoring system that allows the owner to control the incubator’s setting remotely from a smart phone; over the internet. The intensity of the bulb is controlled using the Android app by varying the duty cycle of the PWM wave (Alvino et al, 2009). The Section 2 deals with the related works of the egg incubator monitoring system. The section 3 gives the highlights of the proposed system. The Section 4 deals with the pseudo code required for the system. The Section V 5shows the experimental results obtained from the incubator monitoring system. The Section 6 deals with the overall conclusion of the paper. The Section 7 gives the way the proposed system could be enhanced in its future work.

2. Related Works

Radhakrishnan et al, 2014 proposed the design of an ATmega16 microcontroller based egg incubator system which is able to automatically maintain the environment which is optimum for embryo growth. The main drawback is that the bulb has to be turned on and off using relays to control the temperature.

Boopathy S et al, 2014 proposed a system for monitoring different parameters such as temperature, humidity, level of water at egg incubation tray. The disadvantage is that if the temperature exceeds or goes below the prescribed level, it has to be adjusted manually.

VinuSankar et al, 2015 proposed a new incubator system which uses thermo electric heating for egg incubation. The drawback is that the weight loss factor of thermo electric egg incubator takes longer time to analyze which may affect the hatching process.

Fuead Ali and Noor Azhar Amran, 2016 proposed an egg incubator system for precision farming. The disadvantage is that the temperature and humidity values can be monitored remotely in cloud but the values could only be controlled manually.

3. Proposed System

The Fig. 1 shows the block diagram of the egg incubator monitoring system. There are three elements in the system that must be set and controlled, namely temperature, humidity and movements. In this scenario, a 60W light bulb is used to suitably set the correct temperature for the eggs (Isabel and Sandra, 2012). TheDHT11 temperature and humidity sensor interfaced with Raspberry Pi measures the respective values. The percentage of humidity in the incubator needs to be consistent. This is achieved by water running through the incubator. In the same time, it can ensure that the humidity and ventilation of the incubator is in a good condition (Cherry and Barwick, 2010). In order to ensure that the entire part of the eggs receives heat from the bulb and also to prevent the yolk from sticking to the shell, a stepper motor is used that rotates the egg turner and change the position of the eggs. The status of the condition inside the incubator can be viewed remotely via cloud. An Android app is used to control the intensity of the light bulb by varying the duty cycle of PWM (in %) remotely.

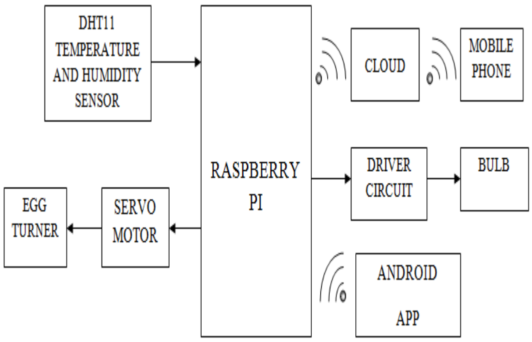

Fig.1. Block Diagram

The schematic of the prototype is shown in Fig. 2. The egg incubator system has been designed with Raspberry Pi Processor, which is connected with DHT11 sensor, servo motor and to the bulb through GPIO pin. The proposed system has a DHT11 sensor whose data pin is connected to pin 7 (GPIO 4), Vcc to pin 2 and Gnd to pin6 of the Raspberry Pi. Servo motor's signal pin is connected to pin 5 (GPIO 3), Vcc to +5V regulated DC output and Gnd to pin 9 of the Raspberry Pi. The external power supply for the servo motor is designed with step down transformer, bridge rectifier and regulator producing 5V regulated DC output.

The bulb leads are connected to pin 2 and 4 of the connector. The power supply voltage for driving the gate is supplied by the voltage across the MOSFET. The MOSFET is used to control D6, R5 and C2 form a rectifier. Due to the bridge rectifier, the MOSFET sees the DC voltage as the drain is always positive with respect to the source. Thus with this combination of the bridge rectifier and MOSFET, by controlling DC switch-the MOSFET, you can control the AC load. R5 limits the current pulses through D6 to about 1.5 A. The voltage across C2 is regulated to a maximum value of 10 V by R3, R4, C1 and D1. An opto-coupler and resistor (R2) are used for driving the gate. From Raspberry Pi, the PWM output is given to pin 1 of the opto-coupler.

R1 is intended as protection for the LED in the opto-coupler. The transistor in the opto-coupler is connected to the positive power supply so that T1 can be brought into conduction as quickly as possible (. Okonkwo and Chukwuezie, 2012). R3 and R4 is a compromise between the lowest possible current consumption and the highest possible duty cycle that is allowed. By controlling the input to the gate terminal of N-Channel MOSFET, the intensity of the bulb could be controlled.

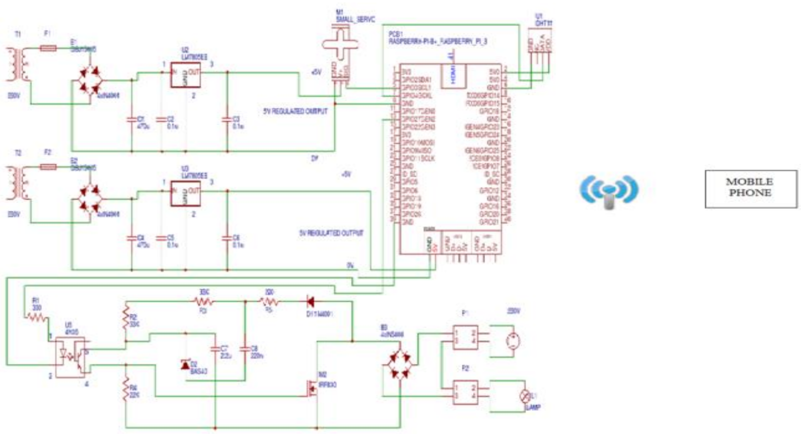

Fig.2. Schematic Diagram

4. Pseudo Code

For developing the egg incubator system, Python, a high level script language is used on the underlying Raspbian OS. Controlling the intensity of the bulb using an Android app also has been implemented. The pseudocode for updating the sensor values on the ThingSpeak cloud and for rotating the servo motor are given below. The code for controlling the intensity of the bulb is also described below.

4.1. Updating DHT11 sensor values to cloud

The Fig. 3 is the pseudo code for updating the temperature and humidity values to the ThingSpeak cloud. Fields have to be specified as temperature and humidity for plotting the values onto the graph accordingly.

For updating the sensor data to the cloud, Write API KEY is used.

API_KEY="TRD3283BIO1E4M1Z"

```
If result is valid, it prints temperature and humidity values on the terminal
        print("Temperature:%dC"%result.temperature)      print("Humidity:%d%%"%result.humidity)
To get the Channel,
        baseURL='https://api.thingspeak.com /update?api_key=%s'%API_KEY
For updating results to the cloud,
    f=urllib2.urlopen(baseURL+"&field =%s&field2=%s"% (result.temperature,
        result.humidity))
```

Fig.3. Pseudo Code for Updating DHT11 Sensor Values to Cloud

4.2. Servo motor

The Fig. 4 is the pseudo code for rotating the servo motor in both clockwise and anticlockwise direction. Pin 5 is set as PWM pin for the servo motor. The PWM frequency is set to 50Hertz. The time period is set to 20ms. Hence, 50 pulses have to be sent every second. At duty cycle 7, motor is at 90^{o} rotation and at duty cycle 2, motor turns to 0^{o} and finally at duty cycle 12, motor turns to 180^{o}.

```
Set the GPIO3  (pin 5) as PWM pin for servo motor
The PWM output is assigned to "servo"
For clockwise rotation of the motor,
    for i in range(0,180):
      DC=1/18.*(i)+2                servo.ChangeDutyCycle(DC)
      time.sleep(.02)
For anticlockwise rotation of the motor,
    for i in range(180,0,-1):
      DC=1/18.*(i)+2                servo.ChangeDutyCycle(DC)
      time.sleep(.02)
```

Fig.4. Pseudo Code for Rotating the Servo Motor

4.3. Intensity

The Fig. 5 is the pseudo code for controlling the intensity of the bulb by changing the duty cycle of PWM for the Raspberry Pi. The UDP_IP and UDP_PORT are initialized to the Raspberry Pi's IP address and port 8080. The two variables pvdata and data are initialized to 5. If both are not equal, then the data is assigned to pvdata.

The data is the variation made by the app. Based on that, the duty cycle is varied.

```
Initialize UDP_IP to Raspberry Pi's IP address
Initialize the UDP_PORT to 8080
Set the GPIO27 (pin 13) as the PWM pin for the bulb
The PWM output is assigned to "bulb"
Initialize pvdata and data to 5
    if data!=pvdata:
      pvdata=data                  bulb.ChangeDutyCycle(int(data))
      print "Changing Intensity"
```

Fig.5. Pseudo Code for Controlling the Intensity of the Bulb

5. Experimental Results

Updating the temperature and humidity values which have been sensed inside the egg incubator onto the ThingSpeak Cloud is shown below. According to the duty cycle variation of the PWM wave, the intensity of the bulb is varied and accordingly the temperature and humidity values get changed which are then automatically updated on the Cloud.

The Fig. 6 shows the egg incubator monitoring system. Inside the incubator, a 60W light bulb is fixed with the bulb holder (Pradeep Kumar and Ravi Kumar Jatoth, 2015). In the lower compartment, an egg turner is placed.

Fig.6. Egg Incubator Monitoring System

A DHT11 sensor is kept inside the incubator which will be sensing the temperature and humidity values (Blatchford et al, 2009). A servo motor is connected to the egg turner for rotating it. The DHT11 sensor is interfaced with Raspberry Pi and it displays the temperature and humidity values over the terminal. The temperature and humidity ranges have to be between 34^{o}C to 39^{o}C & 40% to 70% respectively (Lien et al, 2008).These values are continuously updated onto the ThingSpeak cloud by using the Write API key.

The servo motor connected to the egg turner is programmed in the Raspberry Pi as to rotate according to the specified delay. The Android app is used for changing the intensity of the bulb.

Table 1. Temperature and Humidity Values When the Intensity of the Bulb Is Increased

DUTY CYCLE (in %)	TEMPERATURE (in ^{o}C)	HUMIDITY (in %)	INTENSITY OF THE BULB
52	31	44	Increased
57	34	44	Increased
59	35	46	Increased
61	36	45	Increased

From the Table 1, it is inferred that when the duty cycle of PWM from Raspberry Pi to opto-coupler is varied, the light intensity of the bulb changes which is resulted in the temperature and humidity variation (Kristensen et al, 2007).

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 52%, the intensity of the bulb gets increased and hence the temperature is also increased to 31^{o}C as shown in Fig. 7. (a) and (b).

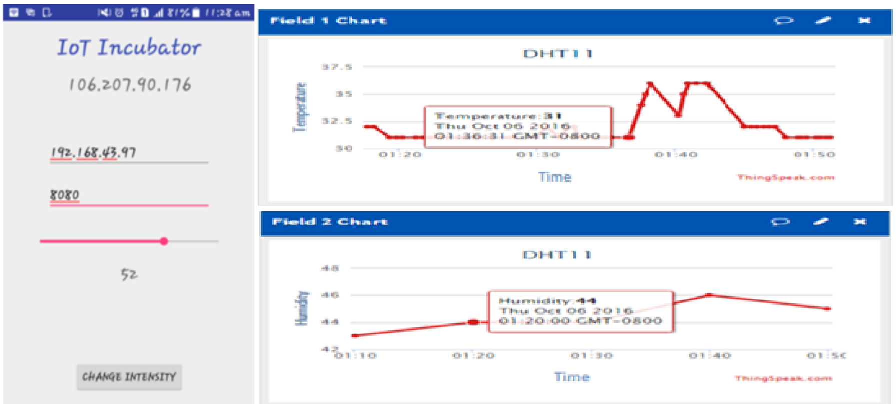

Fig.7. (a) Duty Cycle of PWM wave is at 52% (b) Temperature and Humidity Values When Duty Cycle is 52%

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 57%, the intensity of the bulb gets increased further and the temperature is increased to 34^{o}C as shown in Fig. 8. (a) and (b).

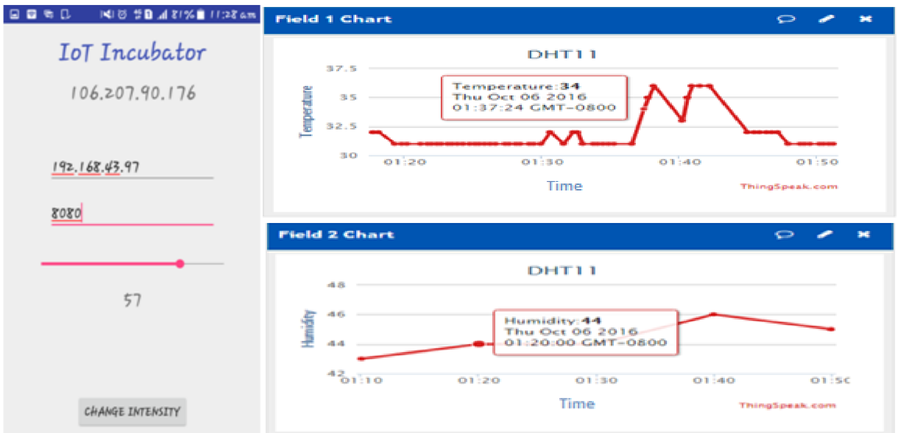

Fig.8. (a) Duty Cycle of PWM wave is at 57% (b) Temperature and Humidity Values When Duty Cycle is 57%

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 59%, the intensity of the bulb gets increased further and the temperature is increased to 35°C as shown in Fig. 9. (a) and (b).

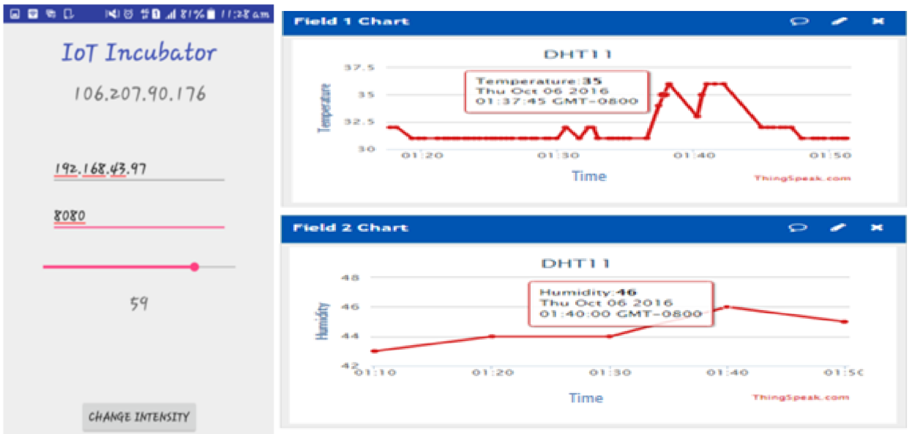

Fig.9. (a) Duty Cycle of PWM wave is at 59% (b) Temperature and Humidity Values When Duty Cycle is 59%

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 61%, the intensity of the bulb gets increased further and the temperature is increased to 36°C as shown in Fig. 10. (a) and (b).

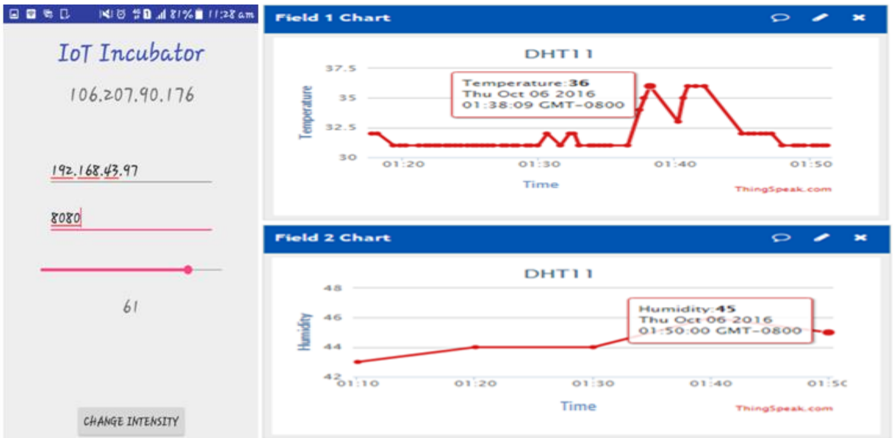

Fig.10. (a) Duty Cycle of PWM wave is at 61% (b) Temperature and Humidity Values When Duty Cycle is 61%

Now when the duty cycle of PWM from Raspberry Pi to opto-coupler is reduced, the intensity variations of the bulb and temperature variations are noted down in Table 2.

Table 2. Temperature and Humidity Values When the Intensity of the Bulb Is Decreased

DUTY CYCLE (in %)	TEMPERATURE (in °C)	HUMIDITY (in %)	INTENSITY OF THE BULB
45	32	45	Decreased
40	31	45	Decreased

From the Table 2, it is inferred that when the duty cycle of PWM is reduced, the intensity of the bulb is decreased and also the temperature and humidity values gets reduced (Olanrewaju, H.A. et al, 2006).

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 45%, the intensity of the bulb gets decreased and hence the temperature is also reduced to 32°C as shown in Fig. 11. (a) and (b).

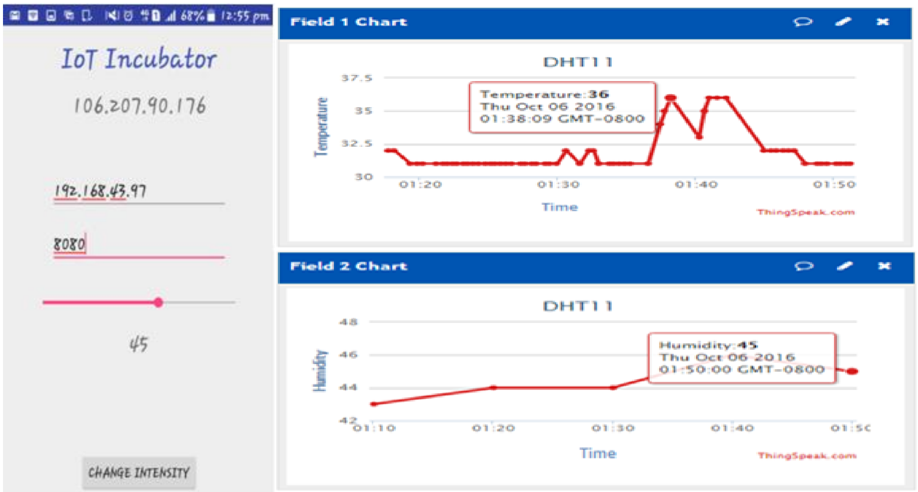

Fig.11. (a) Duty Cycle of PWM wave is at 45% (b) Temperature and Humidity Values When Duty Cycle is 45%

When the duty cycle of PWM from Raspberry Pi to opto-coupler is varied to 40%, the intensity of the bulb gets decreased and hence the temperature is also reduced to 31°C as shown in Fig. 12. (a) and (b).

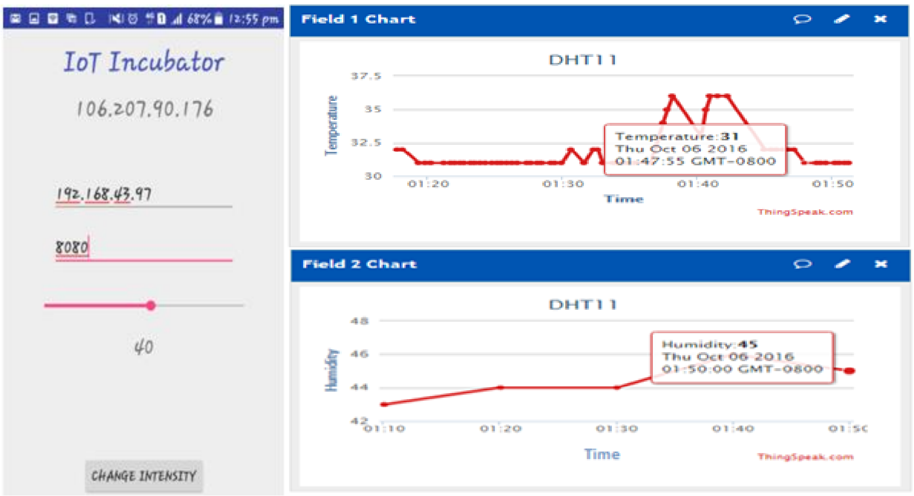

Fig.12. (a) Duty Cycle of PWM wave is at 40% (b) Temperature and Humidity Values When Duty Cycle is 40%

6. Conclusion

This prototype describes an egg incubator monitoring system. This project is developed for the specific reason which is to assist the small-scale poultry farmers from the technological perspective, so that their productivity can be increased significantly. It is not possible to rely upon eyesight to give accurate information about light intensity because eyes adapt to changing light conditions too efficiently. Hence, cloud based egg incubator monitoring system has been developed. The light intensity is being monitored instantaneously and shown in the form of dynamic charts to the user according to the user requirement in a terminal device like Tablet or Smart Phone or any internet enabled device. This helps to remotely control the intensity of the bulb through mobile phone.

7. Future Work

Motion sensor can be used to send emails automatically to admin if there is any motion detected between last three days of hatching. Solar based incubator system could be developed to reduce maintenance and installation cost of electrical incubators and aids in energy conservation. By using buck converter, it steps down the DC voltage for battery charging and by effectively controlling the current flow through this incubator, heating as well as cooling can be done simultaneously.

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Authors’ Profiles

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Dr. S. Jayanthy has received her Bachelor’s Degree in Electronics and Communication Engineering from Government college of Technology, Coimbatore in 1990. She has received her Master’s degree in Applied Electronics at PSG College of Technology in 2001. She has been awarded Ph.D degree in Electrical Engineering from Anna University, Chennai in 2012 in the domain of VLSI Testing.. Presently, she is working as Professor in the Department of Electronics and Communication Engineering at Sri Ramakrishna Engineering College, Coimbatore. She has 20 years of experience in teaching. Her research interests are in VLSI Design & Testing and Embedded systems. She has published 19 research papers in Journals and presented many research papers in National and International Conferences. She has guided many under graduates and post graduates engineering projects. She has received grant from ANNA University, Chennai under the FDTP Program and AICTE under summer winter school scheme. She has organized number of workshops and national conferences in the domain of VLSI, Embedded systems and IOT.

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