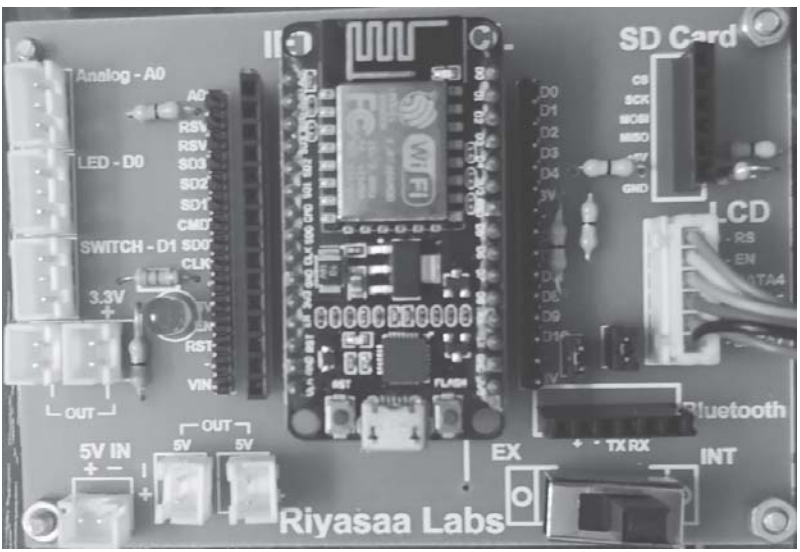
A hand book on IOT



Prepared by

Dr. S. Arumuga Perumal, P. Eng

Advisor, Riyasaa Labs

Ex.Chairman, IETE NAGERCOIL PAC, Trivandrum Center.

Riyasaa Labs

A hand book on Internet of Things

Definition of IoT

The **Internet of things** (**IoT**) is the interconnection of existing physical devices and everyday objects through Internet connectivity. IoT is an integration of embedded technology, Sensor Technology and communication technology to interact with objects in the environment and they can be remotely monitored and controlled through visualization.

Technologies concerned in IoT

- **Real time Analytics**
- **Machine learning**
- **Artificial Intelligence**
- **Embedded systems**
- **Wireless sensor networks**
- **Control systems**
- **Automation in devices**

IoT technology is most synonymous with products pertaining to the concept of the "smart home", covering devices and appliances (such as lighting fixtures, thermostats, home security systems and cameras, and other home appliances) that support one or more common ecosystems, and can be controlled via devices associated with that ecosystem, such as smart phones and smart speakers with privacy and security issues.

There are many technologies that facilitate the IoT such as Addressability, Short range wireless (BLE,ZigBee,NFC,RFID), Medium range wireless(LTE-Advanced), Long Range wireless(LPWAN,VSAT) and Wired (Ethernet and Power Line Communication).

Research Issues in IOT

- **Platform fragmentation**
- **Privacy, autonomy, and control**
- **Data storage**
- **Security and Safety**
- **Environmental sustainability impact**
- **Intentional obsolescence of devices**

- **Lack of interoperability and unclear value propositions**
- **Business planning and models**

IOT Prototype design

IOT prototype is the process of building IoT hardware and devices enhanced with smart sensors and embedded systems using many off-the-shelf components like sensors, circuit boards, and microcontrollers. A lot of these off-the-shelf solutions are readily available to end consumers. Take an NodeMCU/Arduino board, for illustration. You can order it online and have it delivered within 24 hours. Also, a prototype is by no means a market-ready product. It is just a trial version of your connected solution and acts as proof that your innovative idea will work the way you visualize it.

IOT will seep into every facet of our daily lives, managing our homes, tending our gardens, and even monitoring our mailboxes. In future IOT products will be as omnipresent as mobile devices you use in your daily life, so now it is a great time to get involved and practicing in this area to fit you in the present job market. Your IOT prototype is used to understand the pinch points and frame out the necessary parameters of your IOT product deployment. The prototype must be end-to-end, including a thin thread connecting the sensor through the device, network, cloud, end-user interface, and enterprise integration. However, building an Internet of Things (IoT) prototype is rewarding and also a frustratingly challenging engineering process.

To build your own End to End IoT Solution, Be familiar with

- Master IoT Fundamentals
- Design your IoT prototype
- Develop your IoT prototype
- Deploy your IoT prototype & Applications

Application of IOT

- Smart Parking System
- Smart Street Lighting
- Smart Water Management
- Smart Homes & Building
- Smart Waste Management
- Smart Transportation
- Smart Citizen Safety
- Smart Security

- Smart Appliances
- Smart Health Monitoring
- Smart Retail
- Smart Energy Management
- Smart Grids
- Smart Environment
- Smart Manufacturing
- Smart Industries
- Smart Roads & Infrastructure
- Smart Agriculture
- Smart Public Information systems
- Smart Asset Management

IOT Engineer will have expertise in any one of the IOT devices, gateways, IOT Platforms, Cloud services and application development.

Smart Device/Gateway	Communication	Cloud Platform	Application
Arduino UNO + Ethernet Shield	Bluetooth EDR Bluetooth Low Energy	Thingspeak	PHP + MySQL
Arduino YUN	Wi-Fi	Amazon Web Services	Android Application
Arduino UNO + GSM shield	Ethernet	IBM Watson IOT	Arduino IDE
Arduino + Lora Shield	GSM /GPRS	Microsoft Azure	Angular js + Node js
ESP8266 – ESP12E	RF	Google Firebase	MIT App inventor
ESP8266 – ESP32	LoRa, LoRaWAN	Thingworx	Ionic Framework
Raspberry Pi 3	RFID, NFC	API.ai	Android Things
Raspberry Pi Zero	HTTP, HTTPS	Clarify	Python + Flask
Intel Edison	MQTT	--	Python + Django

NodeMCU

The IoT boards can be broken down into two types, microcontroller boards and single computer boards (SBC). A microcontroller board is a system on a chip (SoC) that has data processing and storage Containing processing cores, RAM and EPROM for the storage of custom programs that are executed on the microcontroller, these boards are

PCBs with added circuitry that support the microcontroller. This makes it more convenient when using the board to prototype and program. A single board computer is a step up from microcontroller boards as it allows for the attachment of computer peripheral devices while offering more processing power and memory. Just like microcontroller boards, SBC capabilities can be expanded with the addition of expansion boards or through external modules, such as motor controllers, to mitigate device limitations.

NodeMCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi transceiver module with low cost, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the development kits. The firmware uses the Lua scripting language. NodeMCU was created shortly after the ESP8266 came out. On December 30, 2013, Espressif Systems began production of the ESP8266. The ESP8266 is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications. NodeMCU started on 13 Oct 2014.

The pinout diagram of NodeMCU is shown in the following Figure 1

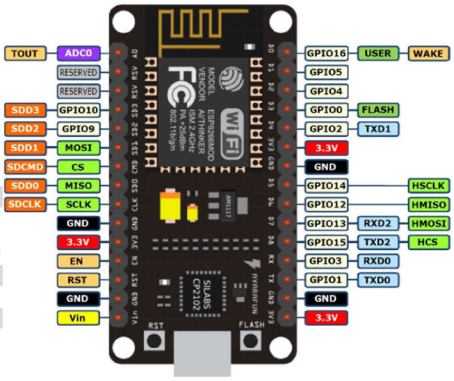


Figure1: Pin out Diagram of NodeMCU

Specification

MCU	32bit TensilicaL106
Frequency	80/160 MHZ
I/O	17XD10
ADC pin	1X110bit(1V)
Operating volt	3-3.6v

Memory 4MB
Wifi IEEE802.11 b/g/n

With features such as Firmware LUA, Micro python Python3, Espruino JavaScript, Arduino IDE, Official Hardware ESP8266

Feature of IETE NGL PAC Node MCU ESP8266

Open source, interactive and programmable, lowcost, simple and smart, wifi enabled, power via USB, Plug and play board

Pros and Cons

Pros : Low energy consumption, integrated support for wifi network, reduced size of the board, power supply via usb, low cost

Cons : Connecting limited number of sensors, Less pin out, New Language and IDE

ESP8266 GPIOs are mapped as detailed below in NodeMCU

NodeMCU	ESP8266
D0	GPIO 16
D1	GPIO 5
D2	GPIO 4
D3	GPIO 0
D4	GPIO 2
D5	GPIO 14
D6	GPIO 12
D7	GPIO 13
D8	GPIO 15
D9	GPIO 3
D10	GPIO 1

For simplicity, IETE NCL PAC designed an IOT KIT with plug and play concepts to motivate the Engineers in the field of Automation with Node MCU as the controlling unit of IETE PAC NCL IoT KIT.

Figure 2 IETE PAC NCL IOT Kit

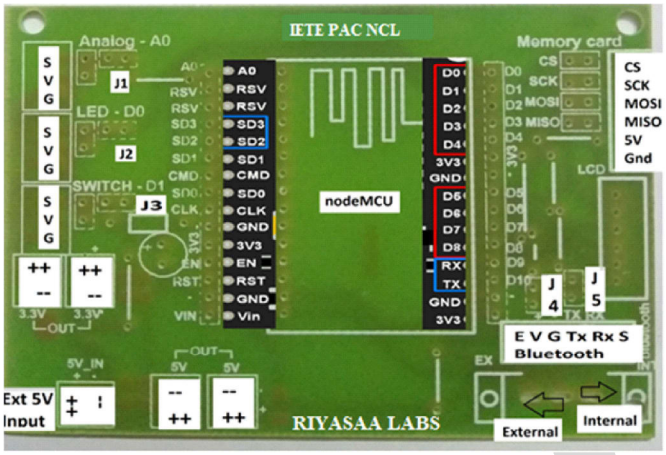


Figure 3Board level pin details of IETE PAC NCL IoT Board

Instructions to install NodeMCU in Arduino:

Keep your PC /laptop connected to the internet while installing NodeMCU.

1. Download Arduino IDE.
2. Open you IDE and click on **"File -> Preferences".**
3. In "Aditional Boards Manager URLs" add this line and click on "OK":
4. **"*http://arduino.esp8266.com/stable package_esp8266com_index.json*"**
5. Go to **"Tools -> Board -> Boards Manager"**, type "ESP8266" and install it.
6. Go again to **"Tools -> Board"** and select "NodeMCU 1.0 (ESP12E module)"
7. Go again to **"Tools->Port"** and select the com port to which NodeMCU is connected.

List of Prototype model developed for practice

I. I/O concept
II. ADC Concept
III. Display Concept
IV. Communication Protocol Concept
V. Web & Cloud Concept

I. I/O Concept

Exercise 1a : LED blinking
Aim : To blink an LED
Requirements : Node Mcu , LED, Connecting Wires
Procedure : Connect Single Color Red LED to port D0
Program :

```
void setup() {
pinMode ( D0, OUTPUT);
}
void loop() {
    digitalWrite(D0, HIGH);
    delay(1000);
    digitalWrite(D0, LOW);
    delay(1000);
    }
```

Output : Red LED connected to port D0 blinks at an interval of 1 second.

Exercise 1b : LED Fading
Aim : LED fading
Requirements : Node MCU , LED, Connecting Wires
Procedure : Connect Single Color Red LED to port D0
Program :

```
int led = D0;        // the pin that the LED is attached to
int brightness = 0;   // how bright the LED is
int fadeAmount = 5;   // how many points to fade the LED by
// the setup routine runs once when you press reset:
void setup() {
pinMode(led, OUTPUT);
}
// the loop routine runs over and over again forever:
void loop() {
 // set the brightness of pin 9:
analogWrite(led, brightness);
```

```
 // change the brightness for next time through the loop:
brightness = brightness + fadeAmount;
// reverse the direction of the fading at the ends of the fade:
if (brightness == 0 || brightness == 255) {
fadeAmount = -fadeAmount ;
}
// wait for 30 milliseconds to see the dimming effect
  delay(30);
}
```

Output : LED brightness increase and decrease continuously

Exercise 1c : **Bi-Color LED**

Aim : To Blink Bi-Color LEDs (Alternate blinking of Red and Green LEDs.)

Requirements: Bicolor LED, nodemcu, connecting wires

Procedure : Bicolor LED has 3 pins one is cathode and Others are anode (Red/Green) Connect two digital pin D0 and D1 corresponding Bicolor LED

Program :

```
void setup() {
pinMode ( D0, OUTPUT);
pinMode (D1, OUTPUT);
}
void loop() {
digitalWrite(D0, HIGH);
digitalWrite(D1, LOW);
delay(1000);
digitalWrite(D0, LOW);
digitalWrite(D1,HIGH);
delay(1000);
}
```

Output: Red LED connected to port D0 is ON, Green LED connected to port D1 will be OFF and Green LED will be ON for 1 second. This process will be repeated till power is applied.

Exercise 1d : **Tri-Color LED**

Aim : TRI Color LED

Requirements: TRI Color LED, Nodemcu , connecting wires

Procedure : LED connect Respective pins D1,D2,D3

Program :

```
int Red =D3, Green = D2, Blue =D 1; //LED pins
void setup() {
pinMode(Red, OUTPUT);//declare pin-5 to be an output
pinMode(Green, OUTPUT);//declare pin-6 to be an output
pinMode(Blue, OUTPUT);//declare pin-7 to be an output
  }
void loop() {
digitalWrite(Red, LOW); digitalWrite(Green, HIGH);
digitalWrite(Blue, LOW); delay(1000);
digitalWrite(Red, HIGH); digitalWrite(Green, LOW);
digitalWrite(Blue, LOW); delay(1000);
digitalWrite(Red, LOW); digitalWrite(Green, LOW);
digitalWrite(Blue, HIGH); delay(1000);
  }
```

Output: You should see your Red LED turn on, Green LED turn off and Blue LED turn off, your Red LED turn off, Green LED turn on and Blue LED turn off, your Red LED turn off, Green LED turn off and Blue LED turn on. If the required output is not seen, make sure you have assembled the circuit correctly, and verified and uploaded the code to your board.

Exercise 1e : **Control LED using Button**

Aim : An LED indicator by pressing a Switch (INPUT and OUTPUT Concept)

Requirements : LED, Button , Nodemcu , connecting wires

Procedure : LED is connected to D0 and Switch is connected to D1

When Switch (Push Button) is pressed, LED will be switched ON and when Switch (Push Button) is released, LED will be switched OFF.

Program:

```
/* Input – Switch  and Output – LED demo */
const int ledPin =  D0;     // the number of the LED pin
const int buttonPin = D1;    // the number of the pushbutton pin
// variables will change:
int buttonState = 0;  // variable for reading the pushbutton status
void setup() {
```

```
 // initialize the LED pin as an output:
 pinMode(ledPin, OUTPUT);
 // initialize the pushbutton pin as an input:
 pinMode(buttonPin, INPUT);
}
void loop() {
// read the state of the pushbutton value:
buttonState = digitalRead(buttonPin);
// check if the pushbutton is pressed. If it is, the buttonState is HIGH:
if (buttonState == HIGH) {
// turn LED on:
digitalWrite(ledPin, HIGH);
} else {
 // turn LED off:
digitalWrite(ledPin, LOW);
}
}
```

Output: When Switch is pressed, LED gets switched ON and the LED will be switched OFF when the switch gets released.

Exercise 1f: Controlling Relay using Button

Aim : To design a Relay by pressing a Switch (INPUT and OUTPUT Concept)

Requirements : Relay Module,Lamp Holder, AC Power supply,LED, Button , Nodemcu , connecting wires

Procedure : Relay is connected to D0 and Switch is connected to D1

When Switch (Push Button) is pressed, Relay will be ON trigger the AC unit and when Switch (Push Button) is released, Relay will be switched OFF.

Program:

```
/* Input – Switch  and Output – Relay demo */
const int relayPin =  D0;    // the number of the LED pin
const int buttonPin = D1;    // the number of the pushbutton pin
// variables will change:
int buttonState = 0;       // variable for reading the pushbutton status
void setup() {
```

```
 // initialize the LED pin as an output:
 pinMode(relayPin, OUTPUT);
 // initialize the pushbutton pin as an input:
 pinMode(buttonPin, INPUT);
}
void loop() {
 // read the state of the pushbutton value:
 buttonState = digitalRead(buttonPin);
 // check if the pushbutton is pressed. If it is, the buttonState is HIGH:
 if (buttonState == HIGH) {
  // turn LED on:
 digitalWrite(relayPin, HIGH);
 } else {
  // turn LED off:
  digitalWrite(relayPin, LOW);
  }
}
```

Output: When Switch is pressed, Relay gets switched ON and the Relay will be switched OFF when the switch gets released.

II. ADC Concept

Exercise 2a : POT Sensor Interface

Aim : To Interface a POT Sensor to ADC Channel and sending equivalent digital data to COM port

Requirements: POT, Nodemcu , connecting wires

Procedure : POT is connected to A0 and Serial port is configured to 9600, N81.

When POT sensor is rotated, analog value applied to Analog Channel A0 will be varied from 0V to 5V and its equivalent digital value (in decimal form) will be displayed in the serial monitor.

Program:

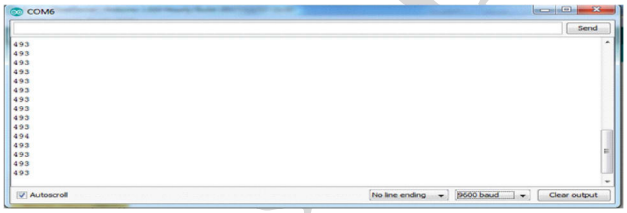
```
// the setup routine runs once when you press reset:
void setup() {
 // initialize serial communication at 9600 bits per second:
 Serial.begin(9600);
}
// the loop routine runs over and over again forever:
```

```
void loop() {
 // read the input on analog pin 0:
 int sensorValue = analogRead(A0);
 // print out the value you read:
 Serial.println(sensorValue);
 delay(100);      // delay in between reads for stability
}
```

The Table shows Analog, Binary and Decimal equivalent reading

S.No	Analog Input in Volts	Binary Output	Decimal Output
1	0.0V	0b 00 0000 0000	0
2	1.25 V	0b 00 1111 11111	255
3	2.5V	0b 01 1111 1111	511
4	3.75 V	0b 10 1111 1111	767
5	5.0V	0b 11 1111 1111	1023

Output: Present value of the serial Monitor



Exercise 2b : LED Control using POT Threshold Value

Aim : To Check for POT threshold Voltage indication through LED

Requirements : POT, LED, Nodemcu , connecting wires

Procedure : POT connected A0 pin,LED connect D0 pin

Program:

```
void setup() {
Serial.begin(9600);
pinMode(D0,OUTPUT);
}
// the loop routine runs over and over again forever:
void loop() {
// read the input on analog pin 0:
int sensorValue = analogRead(A0);
// print out the value you read:
```

```
Serial.println(sensorValue);
delay(1000);      // delay in between reads for stability
if(sensorValue >580)
{
digitalWrite(D0,HIGH);
}
else
{
digitalWrite(D0,LOW);
}}
```

Output:POT can be connected A0 pin.so, NodeMcu reads analog value certain condition met LED on else LED off.

Exercise 2c : Gas Sensor
Aim : Check for Gas Leakage through Gas Sensor
Requirements : Gas sensor(MQ-2),Connecting wires,Nodemcu
Procedure : Gas sensor connected to A0 Pin of Nodemcu.Open serial monitor

Program:

```
void setup() {
Serial.begin(9600);
}
void loop() {
// read the input on analog pin 0:
int sensorValue = analogRead(A0);
//(default state is below 350)
if(sensorValue>350) //read Gas sensor
Serial.println("gas Detected ");
else
Serial.println("No gas Detected ");
delay(1000);// delay in between reads for stability
}
```

Result: You will see Gas Detected on Serial Monitor when the values will exceeds 350 values corresponding to the voltage at pin A0. If those values are below 350 then you will see No Gas Detected on Serial Monitor Frequently of every 1000 milli seconds.

Exercise 2d : Temperature Sensor(LM35)

Aim : To monitor room temperature using Temperature Sensor

Requirements : Temperature Sensor(LM35),Nodemcu,Connecting Wires

Procedure : Temperature sensor Connected to A0 pin of Nodemcu

Program :

```
void setup() {
 Serial.begin(9600);
}
// the loop routine runs over and over again forever:
void loop() {
 // read the input on analog pin 0:
 float sensorValue = analogRead(A0);
 sensorValue=(sensorValue*5000)/10230 ;
 // print out the value you read:
 Serial.println(sensorValue);
 delay(1000);// delay in between reads for stability
}
```

Output: You will see the temperature display on the serial port monitor which is updated every second.

Exercise 2e : Light Sensor using LDR

Aim : To monitor light intensity level using LDR(Light Dependent Resistor)

Requirements : LDR,Nodemcu,connecting wires

Procedure : LDR connected to A0 Pin of Nodemcu.Open Serial monitor

Program:

```
void setup() {
//initialize serial communication
//at 9600 bits per second:
Serial.begin(9600);
}
void loop() {
// read the input on analog pin 0:
int sensorValue = analogRead(A5);
// print out the value you read:
```

```
Serial.println(sensorValue);
delay(1000);//delay in between reads for stability
}
```

Output:

The sensor value is much higher. The numbers you see will vary. This depends on how much light is in the room, and how much gets through to the sensor even when your hand is covering it.

Exercise 2f : DHT sensor

Aim : To measure temperature/Humidity using DHT sensor

Requirements: DHT11, Nodemcu , connecting wires

Procedure : Connect pin 1 (on the left) of the sensor to +5V/3.3V
Connect pin 4 (on the right) of the sensor to GROUND
Connect pin 2 of the sensor to whatever your Digital Pin DHTPIN

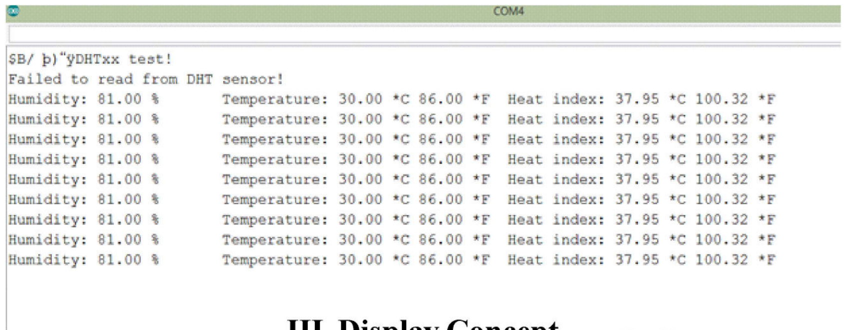
Program:

```
// Example testing sketch for various DHT humidity/temperature sensors
#include "DHT.h"
#define DHTPIN D2    // what digital pin we're connected to
// Uncomment whatever type you're using!
#define DHTTYPE DHT11   // DHT 11
//#define DHTTYPE DHT22  // DHT 22  (AM2302), AM2321
//#define DHTTYPE DHT21  // DHT 21 (AM2301)
// Connect pin 1 (on the left) of the sensor to +5V
// NOTE: If using a board with 3.3V logic like an Arduino Due connect pin 1
// to 3.3V instead of 5V!
// Connect pin 2 of the sensor to whatever your DHTPIN is
// Connect pin 4 (on the right) of the sensor to GROUND
// Connect a 10K resistor from pin 2 (data) to pin 1 (power) of the sensor
// Initialize DHT sensor.
// Note that older versions of this library took an optional third parameter to
// tweak the timings for faster processors.  This parameter is no longer needed
// as the current DHT reading algorithm adjusts itself to work on faster procs.
DHT dht(DHTPIN, DHTTYPE);
void setup() {
Serial.begin(9600);
```

```
Serial.println("DHTxx test!");
dht.begin();
}
void loop() {
// Wait a few seconds between measurements.
delay(2000);
// Reading temperature or humidity takes about 250 milliseconds!
// Sensor readings may also be up to 2 seconds 'old' (its a very slow sensor)
float h = dht.readHumidity();
// Read temperature as Celsius (the default)
float t = dht.readTemperature();
// Read temperature as Fahrenheit (isFahrenheit = true)
float f = dht.readTemperature(true);
// Check if any reads failed and exit early (to try again).
if (isnan(h) || isnan(t) || isnan(f)) {
Serial.println("Failed to read from DHT sensor!");
return;
}
// Compute heat index in Fahrenheit (the default)
float hif = dht.computeHeatIndex(f, h);
// Compute heat index in Celsius (isFahreheit = false)
float hic = dht.computeHeatIndex(t, h, false);
Serial.print("Humidity: ");
Serial.print(h);
Serial.print(" %\t");
Serial.print("Temperature: ");
Serial.print(t);
Serial.print(" *C ");
Serial.print(f);
Serial.print(" *F\t");
Serial.print("Heat index: ");
Serial.print(hic);
Serial.print(" *C ");
Serial.print(hif);
```

```
Serial.println(" *F");
}
```

Output:



```
COM4

$B/ þ)"ÿDHTxx test!
Failed to read from DHT sensor!
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
Humidity: 81.00 %	Temperature: 30.00 *C 86.00 *F	Heat index: 37.95 *C 100.32 *F
```

III. Display Concept

Exercise 3a : LCD interfacing

Aim : To demonstrate the functioning of Liquid crystal Display: 4 bit Mode LCD

Requirements : 16*2 LCD, Nodemcu , connecting wires

Procedure : Display **Hello World to** Demonstrates the use a 16x2 LCD display.

Procedure : The LiquidCrystal library works with all LCD displays that are compatible with the Hitachi HD44780 driver. There are many of them out there, and you can usually tell them by the 16-pin interface. This sketch prints "Hello World!" to the LCD and shows the time.

LCD Pins	NodeMCU Pins
RS	D0
EN	D1
Data 4	D2
Data 5	D5
Data 6	D6
Data 7	D7

IETE NGL PAC circuit board details:

- * LCD RS pin to digital pin 12
- * LCD Enable pin to digital pin 11
- * LCD D4 pin to digital pin 5

```
*    LCD D5 pin to digital pin 4
*    LCD D6 pin to digital pin 3
*    LCD D7 pin to digital pin 2
*    LCD R/W pin to ground
*    LCD VSS pin to ground
*    LCD VCC pin to 5V
*    10K resistor:
 *   ends to +5V and ground
 *   wiper to LCD VO pin (pin 3)  */
```

Program:

```
#include <LiquidCrystal.h>
// initialize the library by associating any needed LCD interface pin
// with the arduino pin number it is connected to
/*const int rs = D0, en = D1, d4 = D2, d5 = D5, d6 = D6, d7 = D7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);*/  //This above line also correct
LiquidCrystal lcd(D0,D1,D2,D5,D6,D7); // here directly mention PIN
name
void setup() {
 // set up the LCD's number of columns and rows:
 lcd.begin(16, 2);
 // Print a message to the LCD.
 lcd.print("hello, world!");
}
void loop() {
 // set the cursor to column 0, line 1
 // (note: line 1 is the second row, since counting begins with 0):
 lcd.setCursor(0, 1);
 // print the number of seconds since reset:
 lcd.print(millis() / 1000);
}
```

Output: The following String will be displayed in the LCD. **Hello World**

Exercise 3b : Sensor value in LCD

Aim : To display sensor/ POT value to LCD interface

Requirements : POT,Nodemcu, connecting wires

Procedure : Potentiometer POT connected to Analog Channel A0 and LCD wiring as like

Program:

```
#include <LiquidCrystal.h>
// initialize the library by associating any needed LCD interface pin
// with the arduino pin number it is connected to
/*const int rs = D0, en = D1, d4 = D2, d5 = D5, d6 = D6, d7 = D7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);*/ //This above line also correct
LiquidCrystal lcd(D0,D1,D2,D5,D6,D7); // here directly mention PIN name
void setup() {
// set up the LCD's number of columns and rows:
lcd.begin(16, 2);
Serial.begin(9600);
// Print a message to the LCD.
lcd.print("hello, world!");
delay(2000);
lcd.clear();
}
void loop() {
int sensorvalue=(analogRead(A0));
lcd.setCursor(0, 0);
lcd.print("sensor value");
// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print(sensorvalue);
delay(1000);
Serial.println(sensorvalue);
 delay(1000);
}
```

Output: The following ADC POT value will be displayed in the LCD.

Exercise 3c : Digital Thermometer

Aim : To design a Digital Thermometer

Requirements: Temperature sensor LM35, Nodemcu, connecting wires,LCD

Procedure : Temperature Sensor LM35 is connected to Analog Channel A0 and LCD wiring as like

Program:

```
#include <LiquidCrystal.h>
// initialize the library by associating any needed LCD interface pin
// with the arduino pin number it is connected to
const int rs = D0, en = D1, d4 = D2, d5 = D5, d6 = D6, d7 = D7;
LiquidCrystal lcd(rs, en, d4, d5, d6, d7);
void setup() {
// set up the LCD's number of columns and rows:
lcd.begin(16, 2);
// Print a message to the LCD.
Serial.begin(9600);
}
void loop() {
// set the cursor to column 0, line 1
// (note: line 1 is the second row, since counting begins with 0):
int Temperature = analogRead(A0);
float TempinC = ( Temperature * 3300)/ 10230.0 ;
lcd.setCursor(0,0);
lcd.print("Digital Thermometer!");
lcd.setCursor(0, 1);
lcd.print("      ");
lcd.setCursor(0, 1);
// print the number of seconds since reset:
lcd.print(TempinC);
Serial.println(TempinC);
delay(1000);
}
```

Output: Temperature sensor display the Digital value of the room temperature

IV. Communication Protocol concept

Exercise 4a : UART Protocol wired
Aim : LED ON/OFF using Serial monitor input condition
Requirements : USB cable ,LED, Nodemcu, connecting wires
Procedure : LED will be connect D0 pin,
Program:

```
const int led1=D0;
```

```
char incomingByte = 0;  // for incoming serial data
void setup() {
Serial.begin(9600); // opens serial port, sets data rate to 9600 bps
pinMode(led1,OUTPUT);
Serial.println(" .");
Serial.println("you have entered 1 LED ON  , 0 LED OFF");
}
void loop() {
// send data only when you receive data:
if (Serial.available()) {
// read the incoming byte:
incomingByte = Serial.read();
Serial.println(incomingByte);
if((incomingByte=='1'))
{
Serial.println("you have entered 1 LED ON ");
digitalWrite(led1,HIGH);
}
if((incomingByte=='0'))
{
Serial.println("you have entered 0 LED OFF ");
digitalWrite(led1,LOW);
}
}
}
```

Output: LED will be ON when 1 enter in serial Monitor, LED will be OFF when 0 enter in serial Monitor

Exercise 4b : UART Protocol wireless

Aim : LED ON/OFF using Bluetooth Module input condition

Requirements : Bluetooth, Bluetooth Terminal app,USB cable, LED, Nodemcu, connecting wires

Procedure : Blue Tooth Module HC-05 is interfaced to NodeMCU

BlueTooth Rx -> Tx of NodeMCU
BlueTooth Tx -> Rx of NodeMCU
Bluetooth vcc ->(3.3v) of NodeMcu
Bluetooth gnd ->(gnd) of NodeMcu

Finally , All set up finish. Open Bluetooth terminal app .Scan and Connect Bluetooth. Send Command in ASIC format

Program:

```
const int led1=D0;
char incomingByte = 0;  // for incoming serial data
void setup() {
Serial.begin(9600); // opens serial port, sets data rate to 9600 bps
pinMode(led1,OUTPUT);
Serial.println(" .");
Serial.println("you have entered 1 LED ON  , 0 LED OFF");
}
void loop() {
// send data only when you receive data:
if (Serial.available()) {
// read the incoming byte:
incomingByte = Serial.read();
Serial.println(incomingByte);
if((incomingByte=='1'))
{
Serial.println("you have entered 1 LED ON ");
digitalWrite(led1,HIGH);
}
if((incomingByte=='0'))
{
Serial.println("you have entered 0 LED OFF ");
digitalWrite(led1,LOW);
}
}
}
```

Output: LED will be ON when 1 enter in Bluetooth app, LED will be OFF when 0 enter in Bluetooth app.

Exercise 4c : Hard serial port

Aim : Display your name using Serial monitor through Hard serial port

Requirements : NodeMCU and Connecting wires

Procedure : Run following Program. Open Serial Monitor

Program :

```
void setup()
{
 Serial.begin(9600);
delay(20);
}
void loop()
{
Serial.println(" RIYASAA LABS ");
delay(2000);
}
```

Output:RIYASAA LABS will be printed in Serial Monitor.

Exercise 4d : Soft serial port

Aim : Display your name using serial monitor through soft serial port

Requirements : NodeMCU and Connecting Wires

Procedure : Connect NodeMCU Digital Pin D7 and D8 to bluetooth as Rx and Tx

Program:

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(D7, D8); // RX, TX
void setup()
{
mySerial.begin(9600);
 delay(20);
}
void loop()
{
mySerial.println(" RIYASAA LABS ");
delay(200);
 }
```

Output:RIYASAA LABS will be printed in Serial Monitor.

Exercise 4e : Bi-directional Communication

Aim : Bidirectional data Communication using BTM (Bluetooth Module)

Requirements : Bluetooth, Bluetooth Termonal app,LED, Nodemcu, connecting wires

Procedure : Blue Tooth Module HC-05 is interfaced to NodeMCU through Soft Serial.

BlueTooth Rx -> D7 of NodeMCU
BlueTooth Tx -> D8 of NodeMCU
POT connected to A0 and LED connected to D0
Analog Value at A0 will be sent to mobile phone through Blue Tooth.
LED connected to Digital Output DO will be controlled (ON/OFF) by sending a Character (A to ON and a to OFF) from Mobile phone through Blue Tooth

Program:

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(D7, D8); // RX, TX
char c;
#define LED D0
void setup() {
// Open serial communications and wait for port to open:
Serial.begin(9600);
while (!Serial) {
 ; // wait for serial port to connect. Needed for native USB port only
}
pinMode(LED,OUTPUT);
Serial.println("Goodnight moon!");
// set the data rate for the SoftwareSerial port
mySerial.begin(9600);
mySerial.println("Hello, world?");
}
void loop() { // run over and over
//Serial.println("HI...");
int a =analogRead(A0);
mySerial.println(a);
delay(200);
if (mySerial.available()) {
     c = mySerial.read();
     if(c == 'A')                    //ASCII mode in app
     digitalWrite(LED,HIGH);
```

```
    if(c == 'a')
    digitalWrite(LED,LOW);
}
}
```

Output: In your Android Mobile phone, install BlueTooth terminal HC-05 available in Google play store.

Select the paired device RiyassaBT1. (BlueTooth module HC-05 is already renamed as RiyassaBT1 and it is paired with our mobile phone – default pairing code is 1234)

Run the BlueTooth terminal HC-05 App and select RiyassaBT1 as the device, you will be able to see the value of Analog POT in The terminal of BT HC-05 App.

By sending character A, LED at port D0 of NodeMCU will be switched ON.

By sending character a, LED at port D0 of NodeMCU will be switched OFF.

Both Transmission and reception through Bluetooth interface of NodeMCU can be understood through this program.

Exercise 4f : SPI Protocol

Aim : To connect ADC channel using MCP3008 Analog IC through SPI protocol

Requirements : Any 1 Sensor, MCP3008 Analog IC, Nodemcu, connecting wires.

Procedure : NodeMCU has one Analog channel. So ,To increase the Analog Channel connect MCP3008 Analog IC to NodeMCU

Download Zip file : https://github.com/adafruit/Adafruit_MCP3008

Add .zip fle in Arduino IDE

Connect following SPI Pins MCP3008 to NodeMCU

MCP3008	NodeMCU
16 vcc	3.3v
14 gnd	gnd
13 clk	D5
12 Dout	D6
11 Din	D7
10 CS	D8

Program:

```
#include <MCP3008.h>
#include <SPI.h>
// put pins inside MCP3008 constructor
//MCP3008 adc(CLOCK_PIN, MOSI_PIN, MISO_PIN, CS_PIN);
MCP3008 adc(D5,D7,D6,D8);
void setup() {
// open serial port
Serial.begin(9600);
}
void loop() {
/*int val = adc.readADC(0); // read Chanel 0 from MCP3008 ADC
Serial.println(val);
*/
Serial.println("value 0 :" + String(adc.readADC(0)));
Serial.println("value 1 :" + String(adc.readADC(1)));
Serial.println("value 2:" + String(adc.readADC(2)));
Serial.println("value 3:" + String(adc.readADC(3)));
Serial.println("value 4:" + String(adc.readADC(4)));
Serial.println("value 5:" + String(adc.readADC(5)));
Serial.println("value :" + String(adc.readADC(6)));
delay(4000);
}
```

Output: Using SPI Protocol read Analog data from MCP3008 IC to NodeMCU

IV. Web and Cloud Connectivity concept

Exercise 5a : WiFi scan

Aim : To Scan the available WiFi Network through NodeMCU

Requirements : Nodemcu, connecting wires, WiFi Network

Procedure : Run following Program. Open Serial Monitor

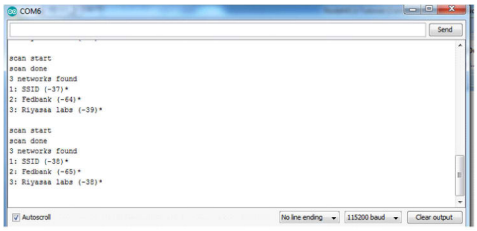
Program:

```
#include "ESP8266WiFi.h"
void setup() {
Serial.begin(115200);
```

```
// Set WiFi to station mode and disconnect from an AP if it was previously
connected
WiFi.mode(WIFI_STA);
WiFi.disconnect();
delay(100);
Serial.println("Setup done");
}
void loop()  {
Serial.println("scan start");
// WiFi.scanNetworks will return the number of networks found
int n = WiFi.scanNetworks();
Serial.println("scan done");
if (n == 0) {   Serial.println("no networks found");                }
else  { Serial.print(n);
Serial.println(" networks found");
for (int i = 0; i < n; ++i)
{
// Print SSID and RSSI for each network found
Serial.print(i + 1);
Serial.print(": ");
Serial.print(WiFi.SSID(i));
Serial.print(" (");
Serial.print(WiFi.RSSI(i));
Serial.print(")");
Serial.println((WiFi.encryptionType(i) == ENC_TYPE_NONE) ? " " : "*");
delay(10);    }   }
Serial.println("");
// Wait a bit before scanning again
delay(5000);                              }
```

(Note that COM Port is configured to work at baud rate of 115200)

Output: Open Serial Monitor,WiFiScan Network display.



Exercise 5b : WiFi scan and Connect
Aim : To Scan and connect the specific WiFi Network
Requirements : Nodemcu, connecting wires,WiFi Network
Procedure : Run following Program. Before that replace SSID and PASSWORD for your Network in Program Open Serial Monitor

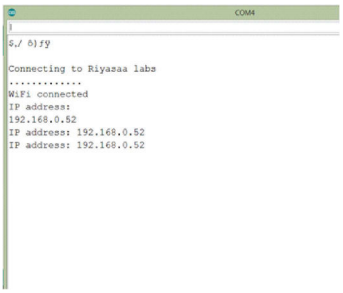
Program:

```
#include<ESP8266WiFi.h>
/************** WiFi Access Point ************************/
#define WLAN_SSID     "Riyasaa labs"
#define WLAN_PASS     "riyasaa54321"
WiFiServer server( 80);
void setup()
{
Serial.begin(9600);
delay(10);
Serial.println();
Serial.println();
Serial.print("Connecting to ");
Serial.println(WLAN_SSID);
delay(500);
WiFi.begin(WLAN_SSID, WLAN_PASS);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
}
Serial.println();
server.begin();
Serial.println("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());
}
void loop()
{
Serial.print("IP address: ");
Serial.println(WiFi.localIP());
delay(5000);
```

}

Output:

//(Note that COM Port is configured to work at baud rate of 9600)



Exercise 5c : Control AC units using Webpage

Aim : To Control AC units through Webpage input

Requirements : LED, Nodemcu, connecting wires,WiFi Network

Procedure : Run following Program.. Before that replace SSID and PASSWORD for your Network in Program. Open Serial MonitorLocal IP address display.Open Browser Type IP address. Webpage Will be appeared.

In that To control Your LED

Program:

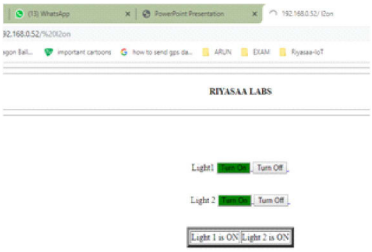
```
#include<ESP8266WiFi.h>
/************************* WiFi Access Point ********************************/
#define WLAN_SSID     "Riyasaa labs"
#define WLAN_PASS     "riyasaa54321"
#define light         "off"
WiFiServer server( 80);
void setup() {
Serial.begin(115200);
delay(10);
pinMode( D2, OUTPUT); // D2 in nodemcu   LIGHT 1
pinMode( D7, OUTPUT); // D7 in nodemcu  LIGHT 2
digitalWrite( D2, LOW);
digitalWrite( D7, LOW);
Serial.println(); Serial.println();
Serial.print("Connecting to ");
```

```
Serial.println(WLAN_SSID);
WiFi.begin(WLAN_SSID, WLAN_PASS);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
}
Serial.println();
server.begin();
Serial.println("WiFi connected");
Serial.println("IP address: "); Serial.println(WiFi.localIP());
}
void loop()
{
WiFiClient client = server.available();
if (! client) { return; }
Serial.println(" new client");
while(! client.available())
{ delay( 1); }
// Read the first line of the request
String request = client.readStringUntil('\r');
Serial.println( request);
client.flush(); // Match the request
if (request.indexOf("l1on") > 0)
{digitalWrite( D2, HIGH);
Serial.println(" Light1 on");
}
if (request.indexOf("l1off") > 0)
{ digitalWrite( D2, LOW);
Serial.println("Light 1 off");
}
if (request.indexOf("l2on") > 0)
{ digitalWrite( D7, HIGH);
Serial.println("LIGHT 2 on");
}
if (request.indexOf("l2off") > 0)
{ digitalWrite( D7, LOW);
Serial.println("Light 2 off");
```

```
}
client.println(“ HTTP/ 1.1 200 OK”);
client.println(“ Content-Type: text/ html”);
client.println(“”); // do not forget this one
client.println(“ <!DOCTYPE HTML>”);
client.println(“ <html>”);
client.println(“ <head>”);
client.println(“ </head>”);
//client.println(“ <body bgcolor = \”#f7e6ec\”>”);
client.println(“ <hr/><hr>”);
client.println(“ <h4><center> RIYASAA LABS  </center></h4>”);
client.println(“ <hr/><hr>”);
client.println(“ <br><br>”);
client.println(“ <br><br>”);
client.println(“ <center>”);
client.println(“ Light1”);
//client.println(“<button onclick=\”funt1()\”> one</button> “);
//client.println(“<script> funtion funt1()”);
if (digitalRead(D2))// read digital pin 5
{
client.println(“ <a href =\”/ l1on\”\”><button style =\”background-
color:green\”> Turn On </button></a>”);
client.println(“ <a href =\”/ l1off\”\”><button> Turn Off </button></
a><br/>”);
}
else
{
client.println(“ <a href =\”/ l1on\”\”><button > Turn On </button></
a>”);
client.println(“ <a href =\”/ l1off\”\”><button style =\”background-
color:red\”> Turn Off </button></a><br/>”);
  }
client.println(“ </center>”);
client.println(“ <br><br>”);
client.println(“ <center>”);
client.println(“ Light 2”);
if (digitalRead(D7))// read digital pin 4
```

```
{
client.println(“ <a href =\”/ l2on\”\”><button style=\”background-
color:green\”> Turn On </button></a>”);
client.println(“ <a href =\”/ l2off\”\”><button> Turn Off </button></
a><br/>”);
}
else
{
client.println(“ <a href =\”/ l2on\”\”><button > Turn On </button></
a>”);
client.println(“ <a href =\”/ l2off\”\”><button style=\”background-
color:red\”> Turn Off </button></a><br/>”);
}
client.println(“ </center>”);
client.println(“ <br><br>”);
client.println(“ <center>”);
client.println(“ <table border =\” 5\”>”);
client.println(“ <tr>”);
if (digitalRead(D2))// read digital pin 5
{client.print(“ <td> Light 1 is ON </td>”); }
else
{ client.print(“ <td> Light 1 is OFF </td>”); }
if (digitalRead(D7))// read digital pin 4
{ client.print(“ <td> Light 2 is ON </td>”); }
else
{ client.print(“ <td> Light 2 is OFF </td>”); }
client.println(“ </tr>”);
client.println(“ </table>”);
client.println(“ </center>”);
client.println(“ </html>”);
delay( 1);
Serial.println(“ Client disonnected”);
Serial.println(“”);
}
```

Output: Webpage Will be displayed in that control your LED through ON/OFF



Exercise 5d : Environmental Data in Webpage
Aim : Displaying Environmental data in Webpage
Requirements : POT ,Nodemcu, connecting wires,WiFi Network
Procedure : Run following Program,. Before that replace SSID and PASSWORD for your Network in Program.
Open Serial Monitor
Local IP address display. Open Browser Type IP address. Webpage Will be appeared.
In that page your sensor data update periodically.

Program:

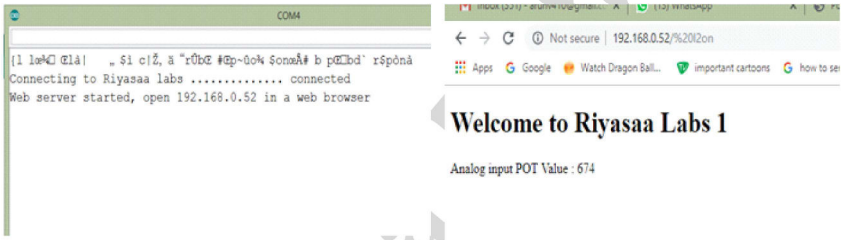
```
#include <ESP8266WiFi.h>
const char* ssid = "Riyasaa labs";
const char* password = "riyasaa54321";
WiFiServer server(80);
void setup()
{
Serial.begin(115200);
Serial.println();
Serial.printf("Connecting to %s ", ssid);
WiFi.begin(ssid, password);
while (WiFi.status() != WL_CONNECTED)
{
delay(500);
Serial.print(".");
}
Serial.println(" connected");
server.begin();
Serial.printf("Web server started, open %s in a web browser\n",
WiFi.localIP().toString().c_str());
```

```
}
// prepare a web page to be send to a client (web browser)
String prepareHtmlPage()
{
String htmlPage =
String("HTTP/1.1 200 OK\r\n") +
"Content-Type: text/html\r\n" +
"Connection: close\r\n" +  // the connection will be closed after completion of the response
"Refresh: 5\r\n" + // refresh the page automatically every 5 sec
"\r\n" +
"<!DOCTYPE HTML>" +
"<html>" +
"<h1>Welcome to Riyasaa Labs 1</h1>"+
"Analog input POT Value :  " + String(analogRead(A0)) +
"</html>" +
"\r\n";
return htmlPage;
}
void loop()
{
WiFiClient client = server.available();
// wait for a client (web browser) to connect
if (client)
{
Serial.println("\n[Client connected]");
 while (client.connected())
{
// read line by line what the client (web browser) is requesting
 if (client.available())
{
String line = client.readStringUntil('\r');
Serial.print(line);
// wait for end of client's request, that is marked with an empty line
if (line.length() == 1 && line[0] == '\n')
{
client.println(prepareHtmlPage());
```

```
break;
}
}
}
delay(1); // give the web browser time to receive the data
// close the connection:
client.stop();
Serial.println("[Client disonnected]");
}
}
```

Output:

Webpage Will be displayed in that control your LED through ON/OFF



Exercise 5e : Thingspeak Cloud

Aim : Uploading Environmental Data to cloud and Visualized through Thingspeak

Requirements : POT ,Nodemcu, connecting wires,WiFi Network, Thingspeak account

Procedure : Login Thingspeak account, Create channel and choose field, copy Write API Key, Paste it in Your program

Run following Program.. Before that replace SSID and PASSWORD for your Network in Program,Open Serial Monitor.

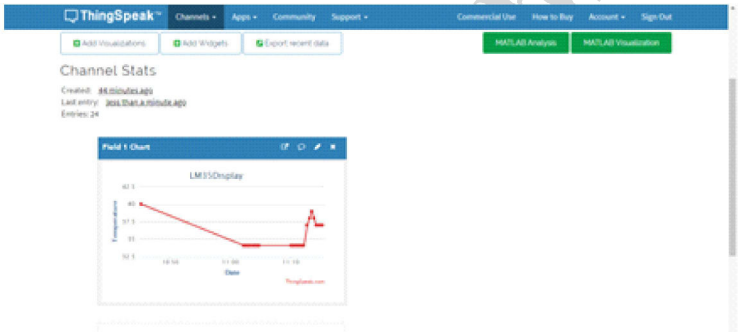
Program:

```
#include <ESP8266WiFi.h>
String apiKey = "W7WZLXU0GVYVPM9K";   // Enter your Write API key from ThingSpeak
const char *ssid =  "Riyasaa labs";   // replace with your wifi ssid and wpa2 key
```

```
const char *pass =  “riyasaa54321”;
const char* server = “api.thingspeak.com”;
WiFiClient client;
void setup()
{
    Serial.begin(115200);
    delay(10);
    Serial.println(“Connecting to “);
    Serial.println(ssid);
    WiFi.begin(ssid, pass);
    while (WiFi.status() != WL_CONNECTED)
    {
    delay(500);
    Serial.print(“.”);
    }
    Serial.println(“”);
    Serial.println(“WiFi connected”);
}
void loop()
{
float t = analogRead(A0);
if (client.connect(server,80))  //  “184.106.153.149” or api.thingspeak.com
{
    String postStr = apiKey;
    postStr +=”&field1=”;
    postStr += String(t);
    //postStr +=”&field2=”;
    // postStr += String(h);
    postStr += “\r\n\r\n”;
    client.print(“POST /update HTTP/1.1\n”);
    client.print(“Host: api.thingspeak.com\n”);
    client.print(“Connection: close\n”);
    client.print(“X-THINGSPEAKAPIKEY: “+apiKey+”\n”);
    client.print(“Content-Type: application/x-www-form-urlencoded\n”);
    client.print(“Content-Length: “);
    client.print(postStr.length());
    client.print(“\n\n”);
```

```
client.print(postStr);
Serial.print("Temperature: ");
Serial.print(t);
//Serial.print(" degrees Celcius, Humidity: ");
 // Serial.print(h);
Serial.println("%. Send to Thingspeak.");
}
client.stop();
Serial.println("Waiting...");
 delay(10000);
}
```

Output:POT /sensor data stored in cloud Platform



Exercise 5f : Home Automation using Voice Control(GA)

Aim : To Develop Smart home automation Control using Google Assistance

Requirements : Relay,LED,Nodemcu, connecting wires,WiFi Network,IFTTT accounthttps://ifttt.com/, Ada fruit Accounthttps://io.adafruit.com/

Procedure : Login IFTTT account, Create trigger and Action,and Login Ada fruit account,create action, copy Write API Key, Paste it in Your program

Run following Program. Before that replace SSID and PASSWORD for your Network in Program, Open Serial Monitor. Then Open google Assistance .Talk to Google Assistance

Program:

```
#include <ESP8266WiFi.h>
#include "Adafruit_MQTT.h"
```

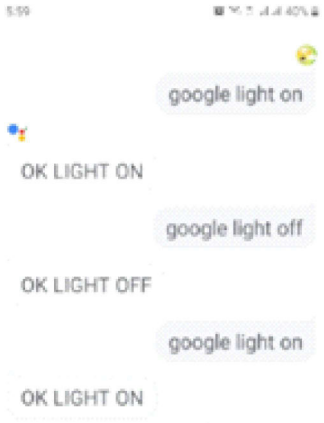
```
#include “Adafruit_MQTT_Client.h”

#define Relay1          D1
#define Relay2          D5
#define Relay3          D2
#define Relay4          D6

#define WLAN_SSID       “Riyasaa labs”          // Your SSID
#define WLAN_PASS       “riyasaa54321”      // Your password
/**************** Adafruit.io Setup *********************/
#define AIO_SERVER      “io.adafruit.com”
#define AIO_SERVERPORT  1883                   // use 8883 for SSL
#define AIO_USERNAME    “ARUNV_25”          // Replace it with
your username
#define AIO_KEY         “8500637f6fe4480397314e1c2acd650a” /
/ Replace with your Project Auth Key
/************ Global State (you don’t need to change this!)
******************/
// Create an ESP8266 WiFiClient class to connect to the MQTT server.
WiFiClient client;
// or... use WiFiFlientSecure for SSL
//WiFiClientSecure client;
// Setup the MQTT client class by passing in the WiFi client and MQTT
server and login details.
Adafruit_MQTT_Client mqtt(&client, AIO_SERVER,
AIO_SERVERPORT, AIO_USERNAME, AIO_KEY);
/************************ Feeds ***********************/
// Setup a feed called ‘onoff” for subscribing to changes.
Adafruit_MQTT_Subscribe Light1 = Adafruit_MQTT_
Subscribe(&mqtt, AIO_USERNAME”/feeds/Relay1"); // FeedName
Adafruit_MQTT_Subscribe Light2 = Adafruit_MQTT_ Subscribe
(&mqtt, AIO_USERNAME “/feeds/Relay2”);
Adafruit_MQTT_Subscribe Light3 = Adafruit_MQTT_ Subscribe
(&mqtt, AIO_USERNAME “/feeds/Relay3”);
Adafruit_MQTT_Subscribe Light4 = Adafruit_MQTT_ Subscribe
(&mqtt, AIO_USERNAME “/feeds/Relay4”);
void MQTT_connect();
void setup() {
```

```
Serial.begin(115200);

pinMode(Relay1, OUTPUT);
pinMode(Relay2, OUTPUT);
pinMode(Relay3, OUTPUT);
pinMode(Relay4, OUTPUT);

// Connect to WiFi access point.
Serial.println(); Serial.println();
Serial.print("Connecting to ");
Serial.println(WLAN_SSID);

WiFi.begin(WLAN_SSID, WLAN_PASS);
while (WiFi.status() != WL_CONNECTED) {
delay(500);
Serial.print(".");
}
Serial.println();

Serial.println("WiFi connected");
Serial.println("IP address: ");
Serial.println(WiFi.localIP());

// Setup MQTT subscription for onoff feed.
 mqtt.subscribe(&Light1);
 mqtt.subscribe(&Light3);
 mqtt.subscribe(&Light2);
 mqtt.subscribe(&Light4);
}

void loop() {
MQTT_connect();
Adafruit_MQTT_Subscribe *subscription;
while ((subscription = mqtt.readSubscription(20000))) {
 if (subscription == &Light1) {

Serial.print(F("Got: "));
Serial.println((char *)Light1.lastread);
int Light1_State = atoi((char *)Light1.lastread);
digitalWrite(Relay1, Light1_State);
}
```

```
if (subscription == &Light2) {
Serial.print(F("Got: "));
Serial.println((char *)Light2.lastread);
int Light2_State = atoi((char *)Light2.lastread);
digitalWrite(Relay2, Light2_State);
}
if (subscription == &Light3) {
Serial.print(F("Got: "));
Serial.println((char *)Light3.lastread);
int Light3_State = atoi((char *)Light3.lastread);
digitalWrite(Relay3, Light3_State);
}
if (subscription == &Light4) {
Serial.print(F("Got: "));
Serial.println((char *)Light4.lastread);
int Light4_State = atoi((char *)Light4.lastread);
digitalWrite(Relay4, Light4_State);
}
}
}
void MQTT_connect() {
int8_t ret;
// Stop if already connected.
if (mqtt.connected()) {
return;
}
Serial.print("Connecting to MQTT... ");
uint8_t retries = 3;
while ((ret = mqtt.connect()) != 0) { // connect will return 0 for connected
Serial.println(mqtt.connectErrorString(ret));
Serial.println("Retrying MQTT connection in 5 seconds...");
mqtt.disconnect();
delay(5000);  // wait 5 seconds
retries--;
if (retries == 0) {
// basically die and wait for WDT to reset me
while (1);
```

}
}
Serial.println("MQTT Connected!");
}

Output:



Appendix 1: IoT gateway and Sensors

Riyasaa Labs

RASPBERRY PI

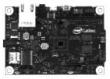
The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science and also for various IoT projects

Riyasaa Labs

INTEL EDISON

Intel Edison is a high-performance, dual-core CPU with a single core micro-controller that can support complex data collection. It has an integrated Wi-Fi certified in 68 countries, Bluetooth® 4.0 support, 1GB DDR and 4GB flash memory.

Riyasaa Labs



INTEL GALILEO

Galileo is a microcontroller board based on the Intel® Quark SoC X1000 Application Processor, a 32-bit Intel Pentium-class system on a chip. It's the first board based on Intel® architecture designed to be hardware and software pin-compatible with Arduino shields

Riyasaa Labs

ARDUINO

***Arduino** is an open source computer hardware and software company, project, and user community that design micro controllers for building interactive objects that can sense and control objects in the physical world.*

Riyasaa Labs

TESSEL

Tessel 2 is a solid development board for serious developers. It comes with a choice of sensors and actuators that can be directly connected to the module ports. The board is powered by a 580MHz MediaTek MT7620n processor for faster execution.

Riyasaa Labs

ONION OMEGA 2

Omega 2 is a Linux computer designed specifically for building connected hardware applications. It combines the tiny form factor and power-efficiency of the Arduino, with the power and flexibilities of the Raspberry Pi.

Riyasaa Labs

BEAGLE BONE BLACK

Beagle Bone Black is a low-cost, open source, reliable, community-supported development platform ARM® Cortex™-A8 processor for developers and hobbyists.

Riyasaa Labs

LATTE PANDA

LattePanda features a quad-core 1.8Ghz processor, 2/4GB RAM, 32/64GB eMMC, Wi-Fi, Bluetooth 4.0, USB 3.0 and an onboard Arduino for rapid IoT prototyping !

Riyasaa Labs

PARTICLE PHOTON

The Particle Photon Series combines a powerful STM32 ARM Cortex M3 microcontroller and a Cypress Wi-Fi chip. It can be used to create commercial sensor networks and smart home projects alike. You can quickly and easily build WIFI connected devices.

Riyasaa Labs

DS1307 RTC

Realtime Clock (RTC) module can saves the current time – even if the power supply is not present – due to the small battery. On computer mainboards such a module is installed, which is why the time of the computer does not have to be re-adjusted every time you restart. Since the Raspberry Pi / Arduino does not carry an RTC module from within, this can be retrofitted

Riyasaa Labs

PIR MOTION SENSOR

The PIR motion sensor has some advantages over other similar products: besides the low price, a signal is sent only if something moves. This allows you to wait for signal flanks using the GPIOs. In addition, a resistance can be varied so that a signal is only sent when the movement is close, or changes that are already far away are perceived.

Riyasaa Labs

DHT11 / DHT22

The DHT11 and DHT22 sensors can measure humidity as well as temperature. Only one GPIO is used. The difference between the two is mainly the measuring range and accuracy.

Riyasaa Labs

MPU-6050 GYROSCOPE

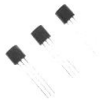
A gyroscope (circular instrument) is used to detect the rotation along the three axes. The MPU 6050 sensor also contains an acceleration sensor. This module can be used e.g. in robot arms to determine the angle of rotation

Riyasaa Labs

HC-SR04 ULTRASONIC SENSOR

The HC-SR04 sensor is not a distance / motion detector, but an ultrasonic sensor. Through a small trick it is nevertheless possible to measure distances. By measuring the time elapsed between transmitting and receiving an ultrasound signal, you can derive the distance as the sound velocity in the air is known.

Riyasaa Labs



DS18B20 TEMPERATURE SENSOR

The DS18B20 and DS18S20 represent a very simple temperature sensor. These Raspberry Pi sensors are addressed via the so-called 1-wire bus. An advantage is that many different 1-wire components can be connected in series and read out by a single GPIO.

Riyasaa Labs

GPS NEO-6M MODULE

The most common and best known GPS receiver is the NEO-6M module. All GPS position data can be determined with the help of the orbiting satellites. In addition, it is compatible with the Raspberry Pi packages minicom and gpsd, which makes reading the coordinates very easy.

Riyasaa Labs

MOISTURE SENSOR

This analogue humidity sensor finds an excellent place in automatic irrigation systems. It is placed in the ground and measures the humidity by current flowing between the strands. The more humid the earth in between, the higher the (analog) signal. In order to read the value with the Raspberry Pi, the ADC Pinout is needed (Arduinos can recognize analog signals directly).

Riyasaa Labs

BMP180 BAROMETER

The determination of the air pressure can be meaningful in weather stations and similar projects. This is best done using the BMP180, which is controlled via I2C on the Raspberry Pi. In addition to the air pressure, the temperature can be read out as well as the altitude.

Riyasaa Labs

7 SEGMENT DISPLAY

7 Segment displays are often used to display numbers and, as the name implies, have seven luminous segments, which can be addressed individually. In order not to occupy too many GPIOs, one usually takes a controller like the MAX7219-LED driver.

Riyasaa Labs

ULN2003

Those 28BYJ-48 stepping motors are often supplied with a driver board. The supplied board usually has a ULN2003 IC, which holds the voltage for the 5V motor, but can be controlled with 3.3V. This is important because the GPIOs are protected and no transistor or relay is needed.

Riyasaa Labs

L293D

An alternative driver IC is the L293D. The advantage of this module, compared to the ULN2003, is that it can also be used with higher voltages than 5V. Furthermore many alternative stepping motors (e.g., fewer steps for faster rotation or higher pulling force) require more than 5V, they must be powered by an external current source. The L293 IC is ideal for controlling these motors. By the way, it is even possible to control two motors simultaneously (individually).

Riyasaa Labs

RSP PI TOUCH SCREEN

In September 2015 the Raspberry Pi Foundation introduced the official touch screen display after a long time. It has 7" at a resolution of 800×480 pixels. The 10 point capacitive touchscreen is connected through the DSI port and doesn't occupy any USB ports or GPIOs.

Riyasaa Labs

POTENTIOMETER

Potentiometers are basically rotatable resistors. You can change the resistor value easily by rotating the control knob. Each module has a maximum resistance (minimum is zero).It can be used in controlling brightness and volume controllers

Riyasaa Labs

28BYJ-48 STEPPER MOTOR

Step motors are motors that can "go" a certain number of steps in one revolution. Two electromagnets are built in, which move the axis through different poles. These motors can be used to build moving robots

Riyasaa Labs

RELAYS

The GPIOs of the Raspberry Pi work with 3.3V, although it also has a 5V pin. However, many devices require a higher voltage. In order not to combine the circuits, one can use relays, which are basically switches. This has the advantage that you can also switch circuits with higher voltages with the Raspberry Pi, without risking something.

Riyasaa Labs

HEARTBEAT / PULSE SENSOR

With a pulse sensor, the heart rate can be read out on the Raspberry Pi. The analogously detected value changes, depending on the pulse beat. This is again converted with an ADC and the pulse is determined on the basis of the last measured values.

Riyasaa Labs

SERVO MOTORS

Unlike ordinary motors, servo motors can be individually controlled. Only the indication of the angle of rotation for moving the motor is necessary. PWM (pulse width modulation) signals are sent to the motor. The Raspberry Pi can use this method of transmission.

Riyasaa Labs

PHOTO RESISTORS

Photo resistors have a light-sensitive surface and have a different resistance value, depending on the light intensity. They can be used, for example, to detect day / night or to build light barriers.

Riyasaa Labs

WATER FLOWMETER

With the aid of water flow meters (Hall effect sensors), the amount of water flowing through the tube per minute / second can be determined at the Raspberry Pi. There are different sensors which have a higher accuracy or a higher flow rate and maximum water pressure.

Riyasaa Labs

ESP8266 NODE MCU

The ESP8266 NodeMCU is a microcontroller that has a built-in Wifi module. Because of this and by its very low price, it is clearly more attractive than an Arduino. The programming takes place via the serial port can be done either via the Arduino IDE or other programs like LUA.

Riyasaa Labs

WS2801B RGB LED

WS2801 LED strips contain many controllable RGB LEDs, which can be addressed individually. Depending on the model, there are variants with 30/60/144 LEDs per meter. With these LED strips Ambilight projects can be implemented very well. In contrast to the cheaper WS2812B models (which have only one data line), the WS2801B RGB LED strips can be addressed directly from the Raspberry Pi, which means that no additional Arduino is required as an intermediate storage.

Riyasaa Labs

LM 386- SOUND SENSOR

The Sound sensor module is a simple microphone. Based on the power amplifier LM386 and the electret microphone, it can be used to detect the sound strength of the environment. The value of output can be adjusted by the potentiometer.

Riyasaa Labs

LUX SENSOR TSL2561

The TSL2561 is an inexpensive, yet sophisticated, light sensor. Unlike simpler sensors, like photoresistors and photodiodes, the TSL2561 incorporates both infrared and visible light sensors to better approximate the response of the human eye. Because the TSL2561 is an integrating sensor (it soaks up light for a predetermined amount of time), it is capable of measuring both very small and very large amounts of light.

Riyasaa Labs

GROVE PI STARTER KIT

GrovePi+ is an easy-to-use and modular system for hardware hacking with the Raspberry Pi, no need for soldering or breadboards: plug in your Grove sensors and start programming directly. Grove is an easy to use collection of more than 100 inexpensive plug-and-play modules that sense and control the physical world. By connecting Grove Sensors to Raspberry Pi, it empowers your Pi in the physical world.

Riyasaa Labs

DIGI XBEE-ZIGBEE

Digi XBee and Digi XBee-PRO Zigbee RF modules provide cost effective wireless connectivity to electronic devices. They are interoperable with other Zigbee PRO feature set devices, including devices from other vendors. Digi Zigbee Development Kits are the perfect way to begin Zigbee application development.*

Riyasaa Labs

BEACON

A Beacon is a device designed to transmit signals using BLE technology to attract attention of public to a specific location in the form of advertising, directions etc.

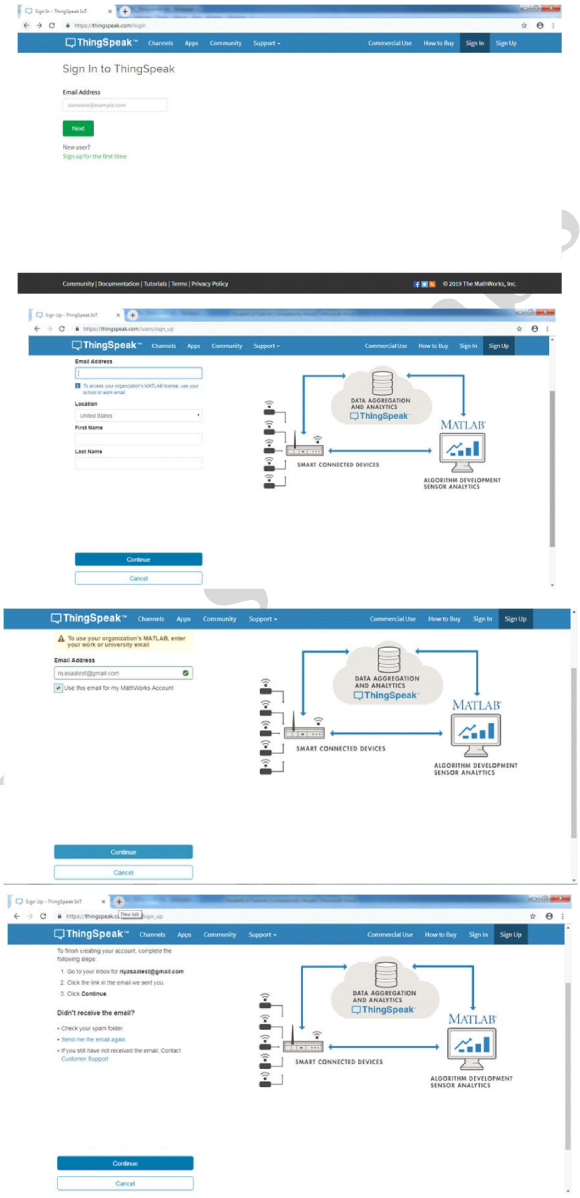
Appendix 2: Procedure to visualize through Thingspeak

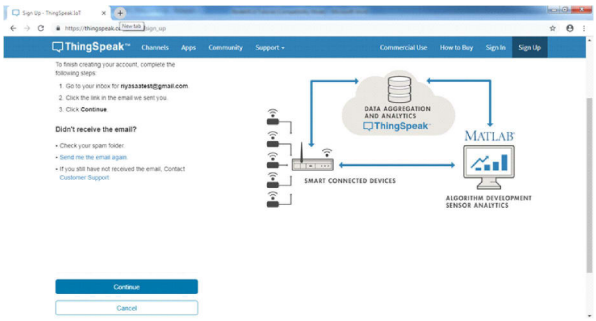
Thingspeak Procedure

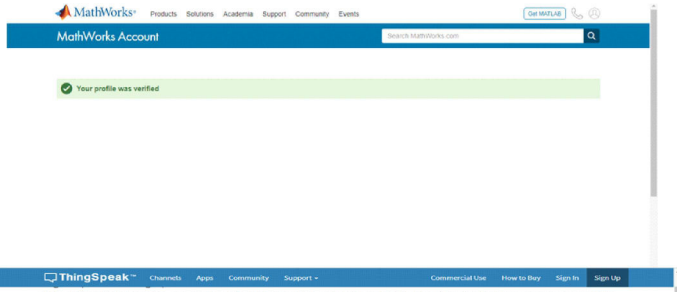
How can create Thingspeak account

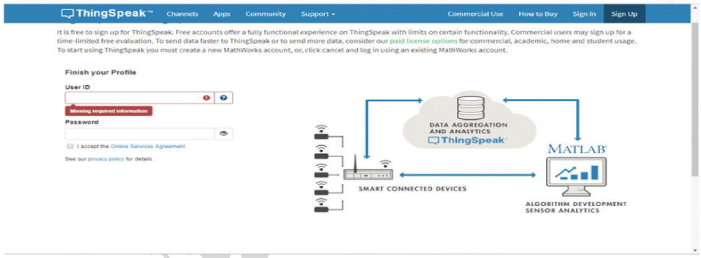
Go to Thingspeak Websitehttps://thingspeak.com/

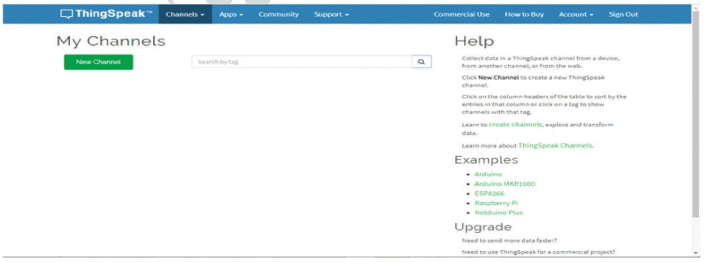
Click sign in and follow the Procedure Below

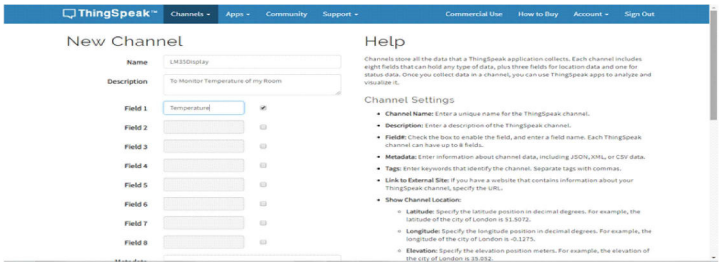


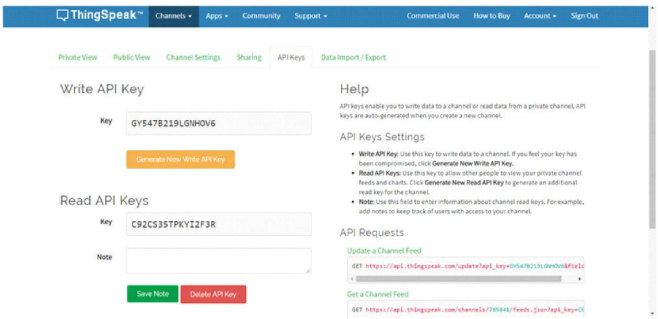

ThingSpeak
Channels
Apps
Community
Support
Commercial Use
How to Buy
Sign In
Sign Up
To finish creating your account, complete the following steps:
1. Go to your inbox for nyzsa1test@gmail.com
2. Click the link in the email we sent you.
3. Click Continue.
Didn't receive the email?
• Check your spam folder.
• Send me the email again
• If you still have not received the email, Contact Customer Support
DATA AGGREGATION AND ANALYTICS
ThingSpeak
MATLAB
SMART CONNECTED DEVICES
ALGORITHM DEVELOPMENT SENSOR ANALYTICS
Continue
Cancel


MathWorks
Products
Solutions
Academia
Support
Community
Events
Get MATLAB
MathWorks Account
Search MathWorks.com
Your profile was verified


ThingSpeak
Channels
Apps
Community
Support
Commercial Use
How to Buy
Sign In
Sign Up
It is free to sign up for ThingSpeak. Free accounts offer a fully functional experience on ThingSpeak with limits on certain functionality. Commercial users may sign up for a time-limited free evaluation. To send data faster to ThingSpeak or to send more data, consider our paid license options for commercial, academic, home and student usage.
To start using ThingSpeak you must create a new MathWorks account, or, click cancel and log in using an existing MathWorks account.
Finish your Profile
User ID
Missing required information
Password
I accept the Online Services Agreement
See our privacy policy for details.
DATA AGGREGATION AND ANALYTICS
ThingSpeak
MATLAB
SMART CONNECTED DEVICES
ALGORITHM DEVELOPMENT SENSOR ANALYTICS


ThingSpeak
Channels
Apps
Community
Support
Commercial Use
How to Buy
Account
Sign Out
My Channels
New Channel
Search by tag
Help
Collect data in a ThingSpeak channel from a device, from another channel, or from the web.
Click New Channel to create a new ThingSpeak channel.
Click on the column headers of the table to sort by the entries in that column or click on a tag to show channels with that tag.
Learn to create channels, explore and transform data.
Learn more about ThingSpeak Channels.
Examples
Arduino
Arduino MKR1000
ESP8266
Raspberry Pi
Netduino Plus
Upgrade
Need to send more data faster?
Need to use ThingSpeak for a commercial project?

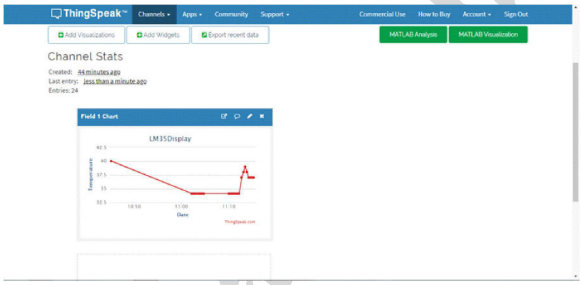

ThingSpeak
Channels
Apps
Community
Support
Commercial Use
How to Buy
Account
Sign Out
New Channel
Name
LM35Display
Description
To Monitor Temperature of my Room
Field 1
Temperature
Field 2
Field 3
Field 4
Field 5
Field 6
Field 7
Field 8
Help
Channels store all the data that a ThingSpeak application collects. Each channel includes eight fields that can hold any type of data, plus three fields for location data and one for status data. Once you collect data in a channel, you can use ThingSpeak apps to analyze and visualize it.
Channel Settings
Channel Name: Enter a unique name for the ThingSpeak channel.
Description: Enter a description of the ThingSpeak channel.
Field#: Check the box to enable the field, and enter a field name. Each ThingSpeak channel can have up to 8 fields.
Metadata: Enter information about channel data, including JSON, XML, or CSV data.
Tags: Enter keywords that identify the channel. Separate tags with commas.
Link to External Site: If you have a website that contains information about your ThingSpeak channel, specify the URL.
Show Channel Location:
Latitude: Specify the latitude position in decimal degrees. For example, the latitude of the city of London is 51.5072.
Longitude: Specify the longitude position in decimal degrees. For example, the longitude of the city of London is -0.1275.
Elevation: Specify the elevation position meters. For example, the elevation of the city of London is 35.052.



Note: Copy your Channel write API Key and Read API Key

Write API Key GY547B219LGNHOV6

Read API Key: C92CS35TPKYI2F3R



Appendix 3: Procedure to control using Voice Assistance

Adafruit Procedure and IFTTT procedure

Voice-controlled home automation using Google Assistance

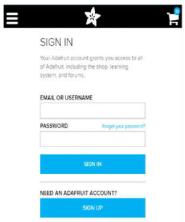
To build home automation application, I used three different platforms

- Google Assistant
- Adafruit
- IFTTT

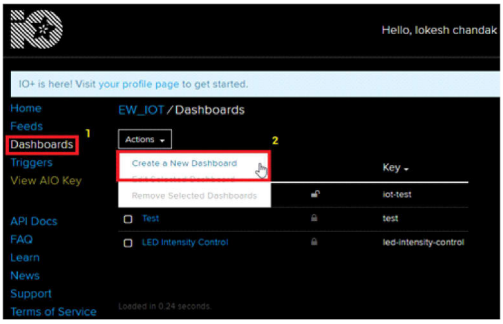
To use above services we need to configure them.

Adafruit Procedure

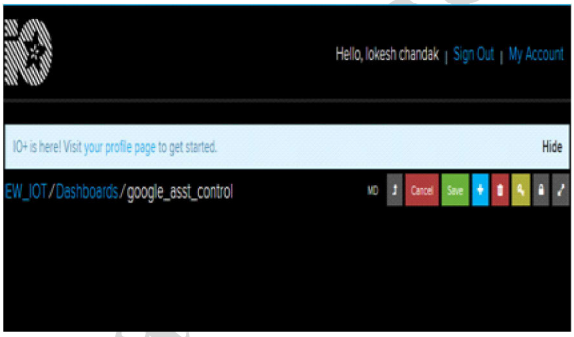
First, created account at www.Adafruit.io



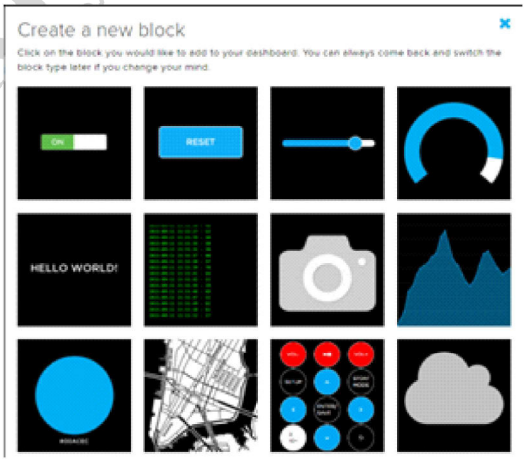
Now, create dashboard at Adafruit. This dashboard is a user interface to control things remotely.



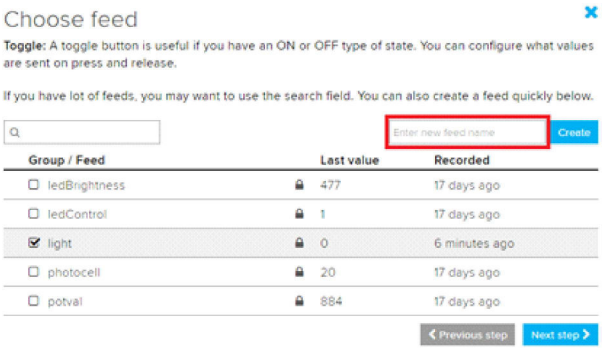
After following above steps, provide name to the dashboard and save it. We can see our dashboard as follows,



Now, create feed (user interface) to control light On-Off. To create it, just click on '+' symbol and select toggle feed shown below,

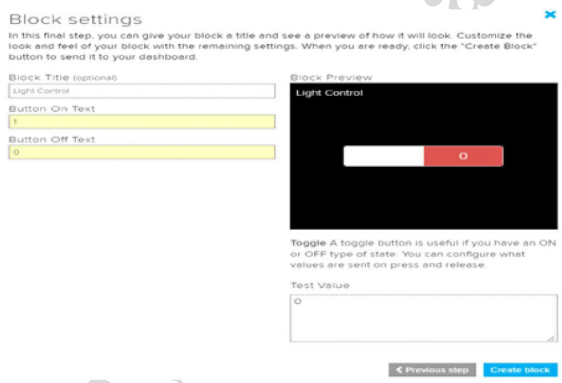


After selecting toggle feed, pop-up window appears as shown below.

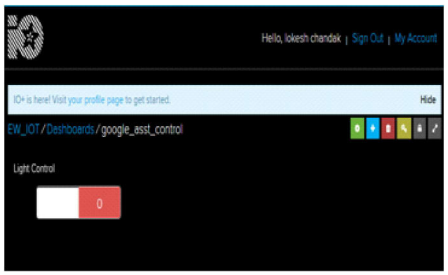


Enter name of our feed (shown in red box) and create it. After creation, select the created feed (here mine is light) and then click on Next step.

In the next step configure the feed which is shown below,



Here, I used 0(OFF) and 1(ON) text for button and then click on create. This will create toggle button on your dashboard which can be used to control things remotely.



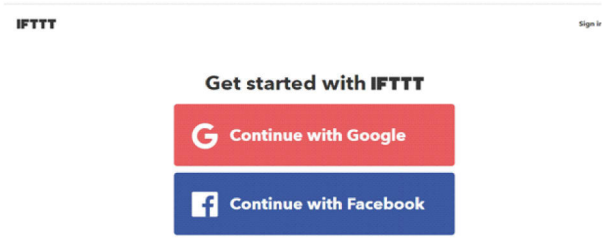
Now, my dashboard is ready for IoT application like home automation.

IFTTT Procedure

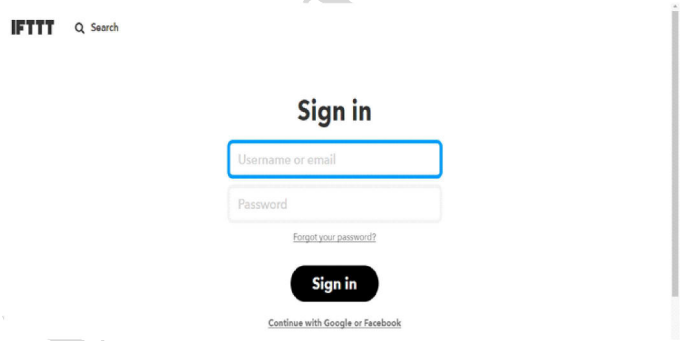
How can create IFTTT account?

Go to website https://ifttt.com/

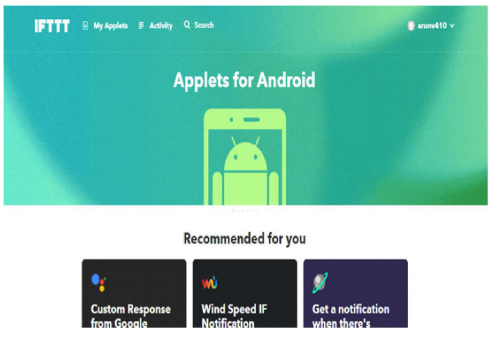
Click signup



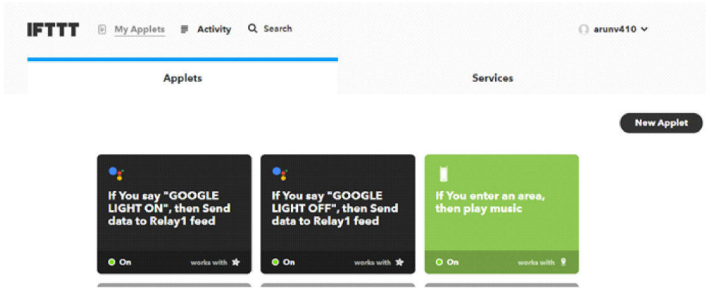
Click continue with google
Select your email account
Verify and come back to IFTTT
Click sign in
Enter your Email Id and Password



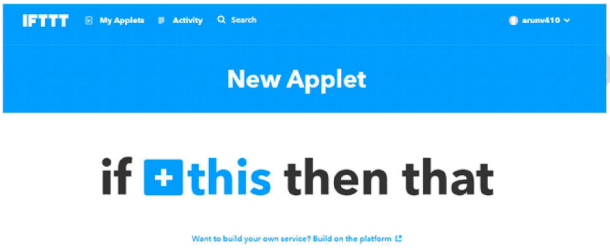
Click My applets



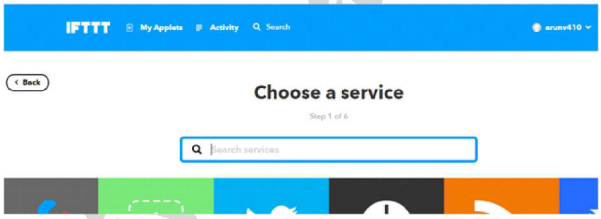
Click your New Applet



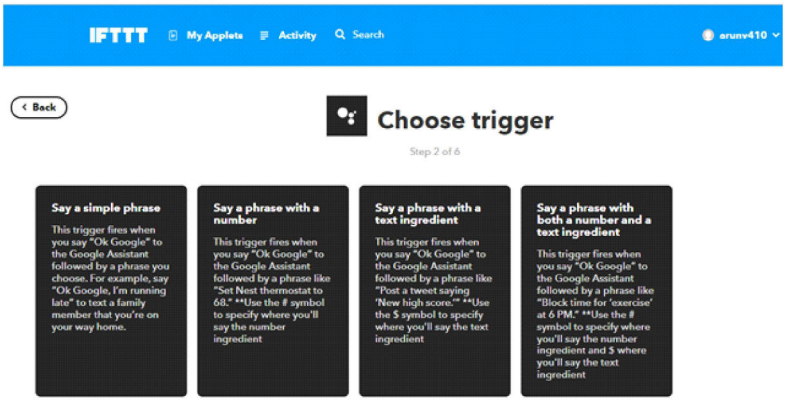
Click *this*

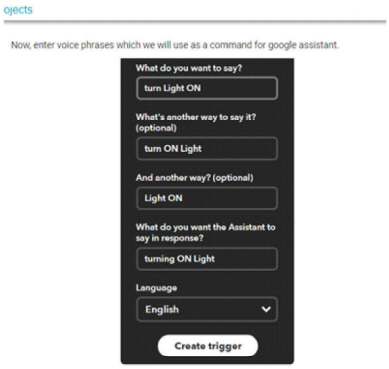


Choose service here select Google assistance



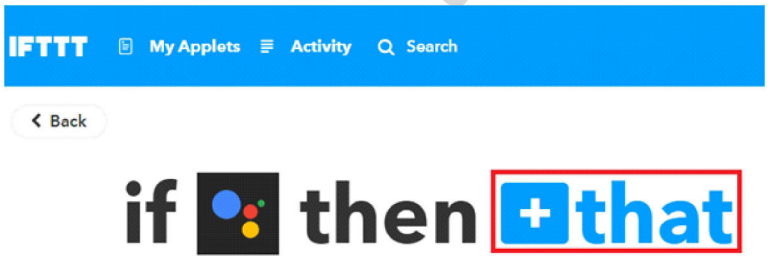
This page appear select *Say a single Phrase*



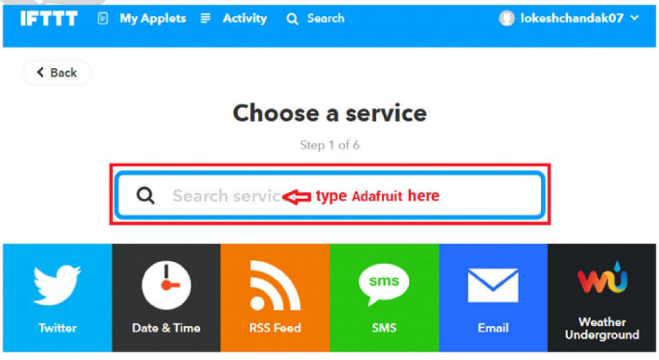


We can enter any phrase as per our application. As you can see, the phrases entered in the above fields is for making **Light ON.** For making **Light OFF**, we have to create another applet with different phrases.

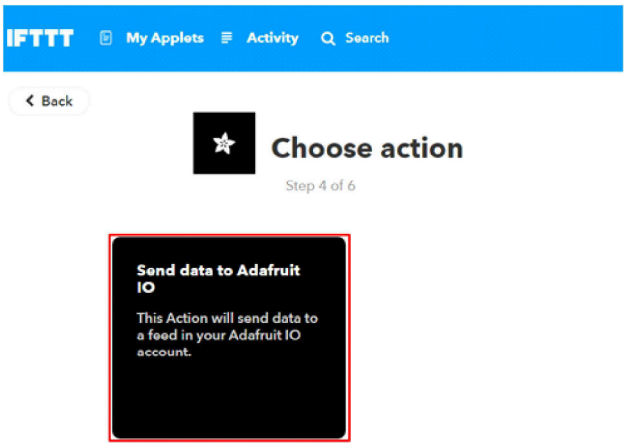
Now, we get another page on which we have to click on **that** option which is used to connect Google Assistant with Adafruit.



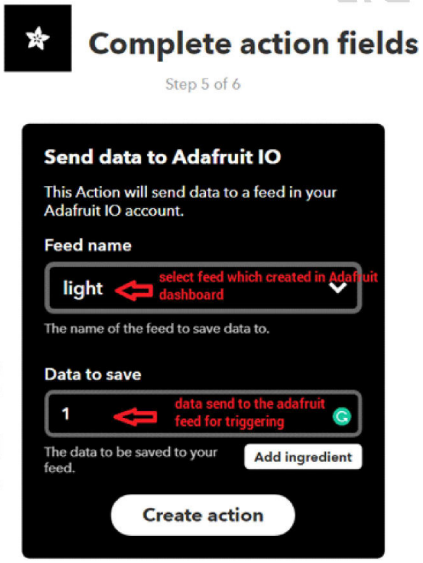
Then search for **Adafruit** and select it.



After selecting Adafruit, choose action as shown below,



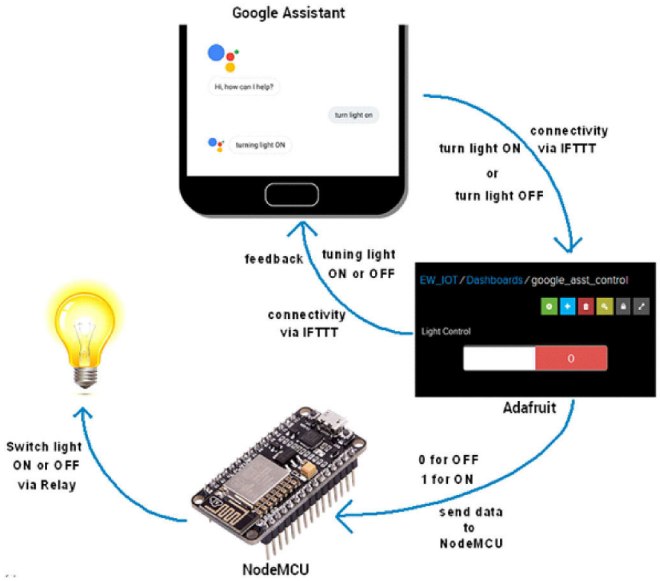
Now enter what data we need to send to which feed of Adafruit dashboard.



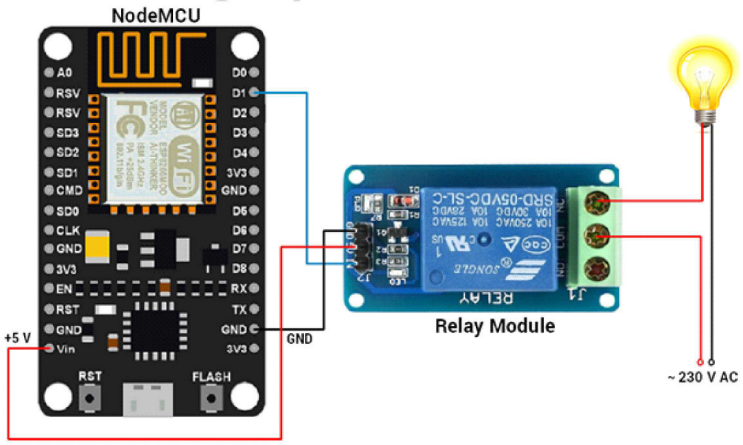
Click on **Create Action.**

So, when I use Google Assistant on my mobile and give voice command as "Ok Google, Turn LED ON", applet created in IFTTT receive this command and will send data '1' to the Adafruit feed. This will trigger the event on Adafruit dashboard which is continuously monitored by the microcontroller (here NodeMCU). This microcontroller will take action as per the data change on the Adafruit dashboard.

Overall view of Voice controlled Home automation using Google Assistance



Interfacing Diagram



https://www.youtube.com/watch?v=1goTMGq26wE

Appendix 4: List of Experiments

IoT BASED PROJECTS

1) IoT based Home Automation
2) IoT based Agriculture System
3) IoT based Patient Monitoring System
4) IoT based Humidity and Temperature Monitoring System
5) IoT based Weather Reporting System
6) IoT based Smart Water Management System
7) IoT based Garbage Monitoring System
8) IoT based Smart Street Light Management System
9) IoT based Industry Automation
10) To control AC units through Webpage
11) To Displaying Environment Data in Webpage
12) Uploading Environment Data to cloud & visualized through Thingspeak
13) Bluetooth Based Home automation
14) Smart Home Automation control using Google Assistance(GA)
15) Smart Home Automation control using Alexa
16) Smart Building Project using PIR

KKLC Nagercoil Nagercoil PAC

STT IoT Objective

The objective of the STT IOT is to introduce short term Training Courses on Emerging Technologies for Student / faculty at campus-based. Short courses are a great way to fill the gaps between academic & industry. Short-term courses help to get more hands-on based learning. Our courses help to enhance the career opportunity of participants and make them fit for the future ready job market.

About IoT Training

We offer 2 / 5 Days Hands-on based training on IoT basic & advanced concepts and methodologies of IoT to design, build and deploy IoT solutions. It also discusses various technologies and protocols used for communication including new generation IoT-friendly applications and physical layer protocols.

- Introduction to IoT Applications, opportunity challenge & market of IoT
- Introduction of IoT development framework like hardware & software
- The training covers popular, service-rich cloud platforms and focuses on how to build and deploy IoT solutions.
- Practical use cases and case studies are included to ensure that the candidate develops an ability to work through practical real-life scenarios.

RIYASAA LABS

JS Plaza, 17,First Floor, Kottar,Nagercoil-629002
Mobile: 04652-243455 / 9444570577
Mail: riyasaa.rabbit@gmail.com, www.riyasaa.com