

Internet of Things (IoT) Application Development

Technology Training Program for Kerala Start Up Mission (KSUM)



by

ICT Academy of Kerala



Building the Nation's Future

Overview

- **Basics of Internet of Things (IoT)**
- **IoT Project Life Cycle**
- **Introduction to IoT System Components**
- **Hands-On with IoT Development Platforms**
 - Hardware - NodeMCU
 - Software - Arduino Integrated Development Environment (IDE)
 - Do It Yourself (DIY) Experiments
- **Familiarizing Cloud Platforms**
 - ThingSpeak - www.thingspeak.com
 - Ubidots - www.ubidots.com
- **IoT Projects**

Puzzle - 1



?

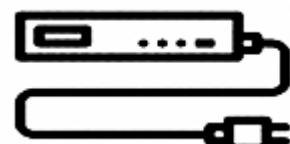


Image Source: <https://www.rs-online.com/designspark/rel-assets/dsauto/temp/uploaded/Embedded-System-and-Its-Real-Time-Applications-Image-31.jpg>

Puzzle - 1



I am a
Technology

?

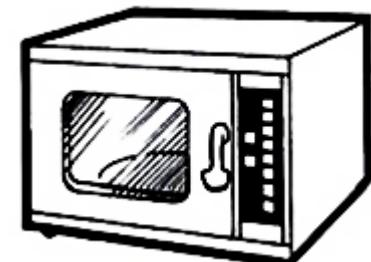
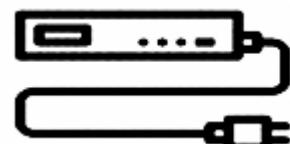


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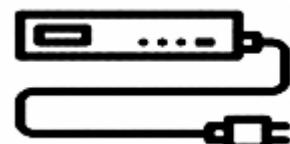
Puzzle - 1



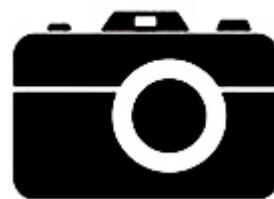
I am a
Technology

?

You all have one
or two devices
utilizing me



Puzzle - 1



I am a
Technology



I have two words,
and the meaning
of one among
those is "Include"

?

You all have one
or two devices
utilizing me





Embedded Systems

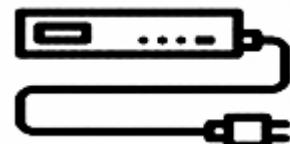


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Embedded Systems

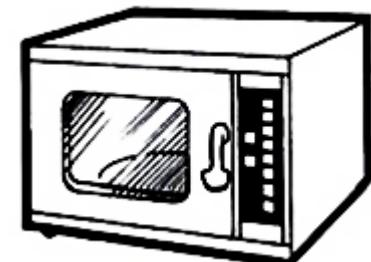
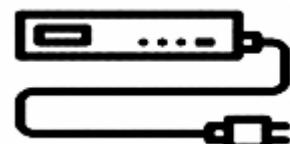


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Puzzle - 2



Image Source: <https://www.lanner-america.com/wp-content/uploads/2016/10/IoTsensoretech.png>

Puzzle - 2

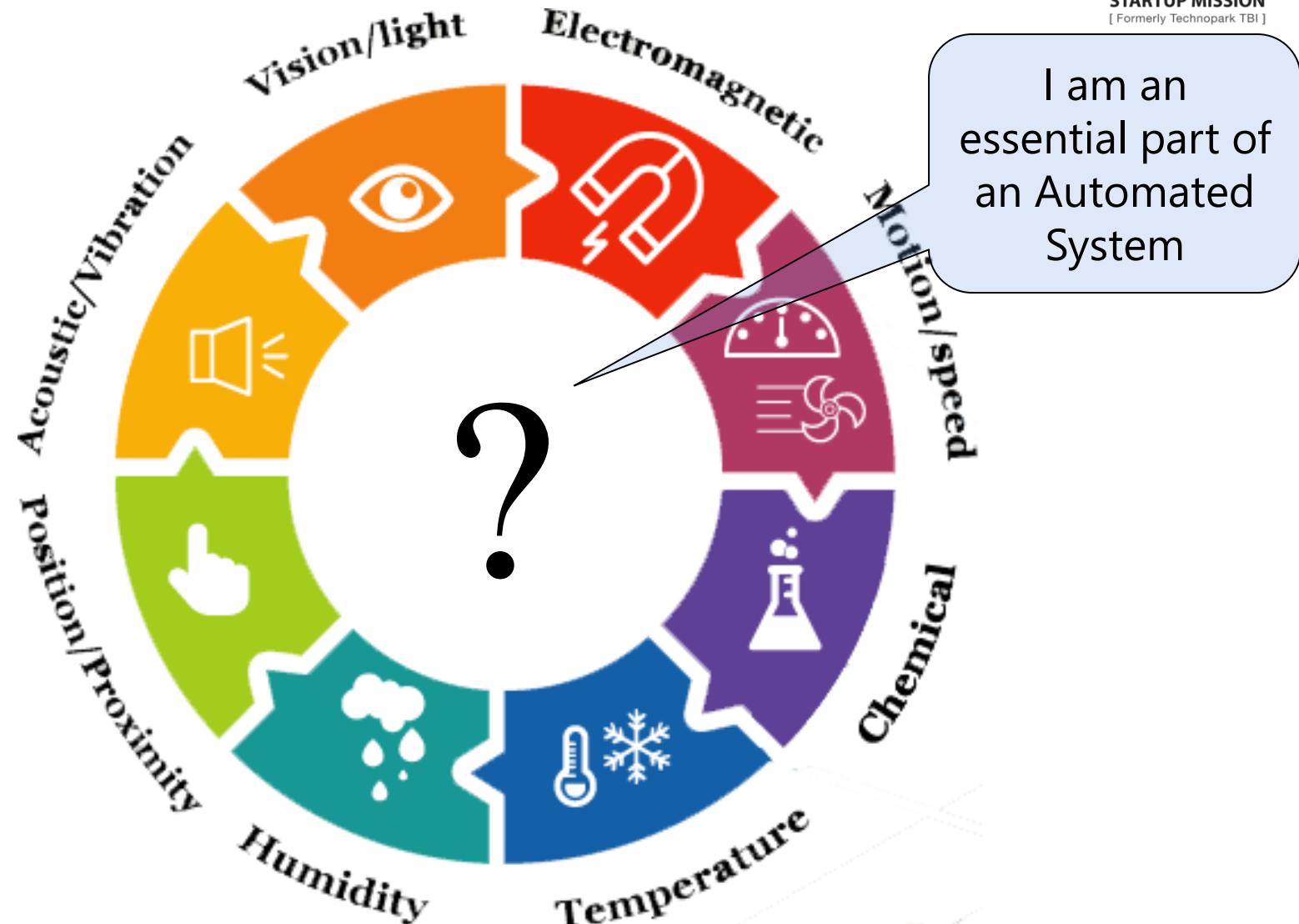


Image Source: <https://www.lanner-america.com/wp-content/uploads/2016/10/IoTsensoretech.png>

Puzzle - 2

Without me devices cannot collect any information from the nature

I am an essential part of an Automated System

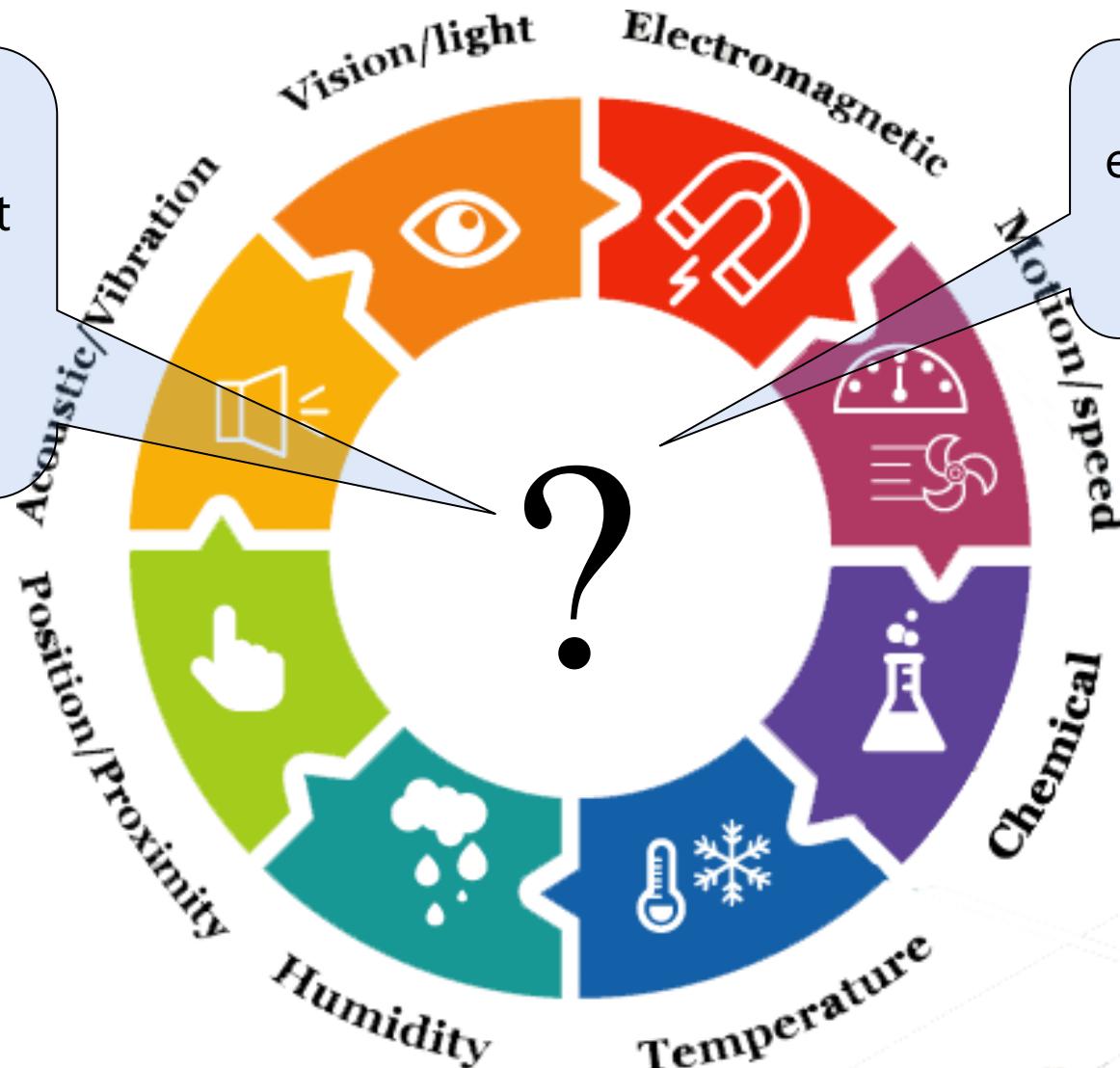
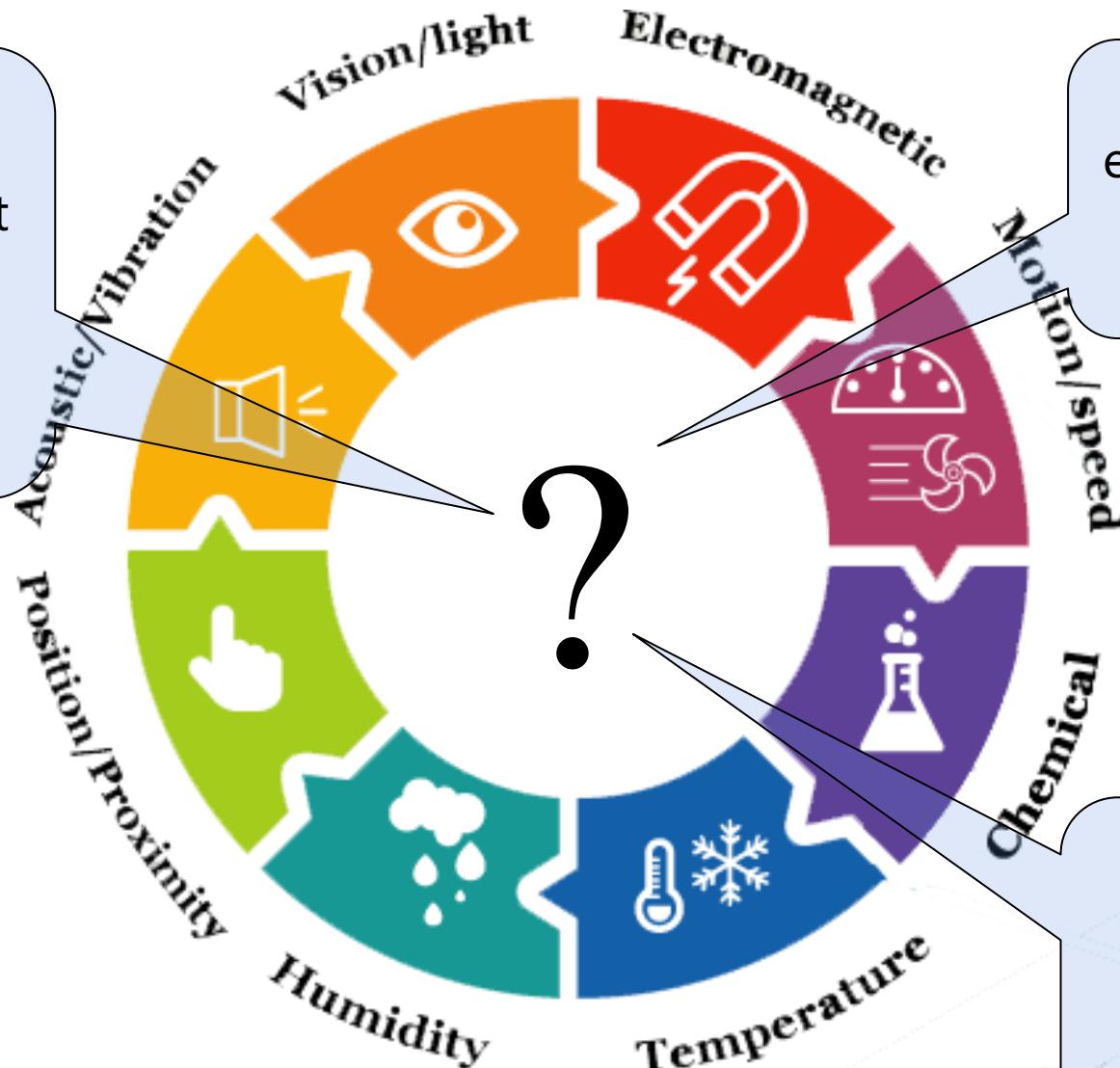


Image Source: <https://www.lanner-america.com/wp-content/uploads/2016/10/IoTsensoretech.png>

Puzzle - 2

Without me devices cannot collect any information from the nature



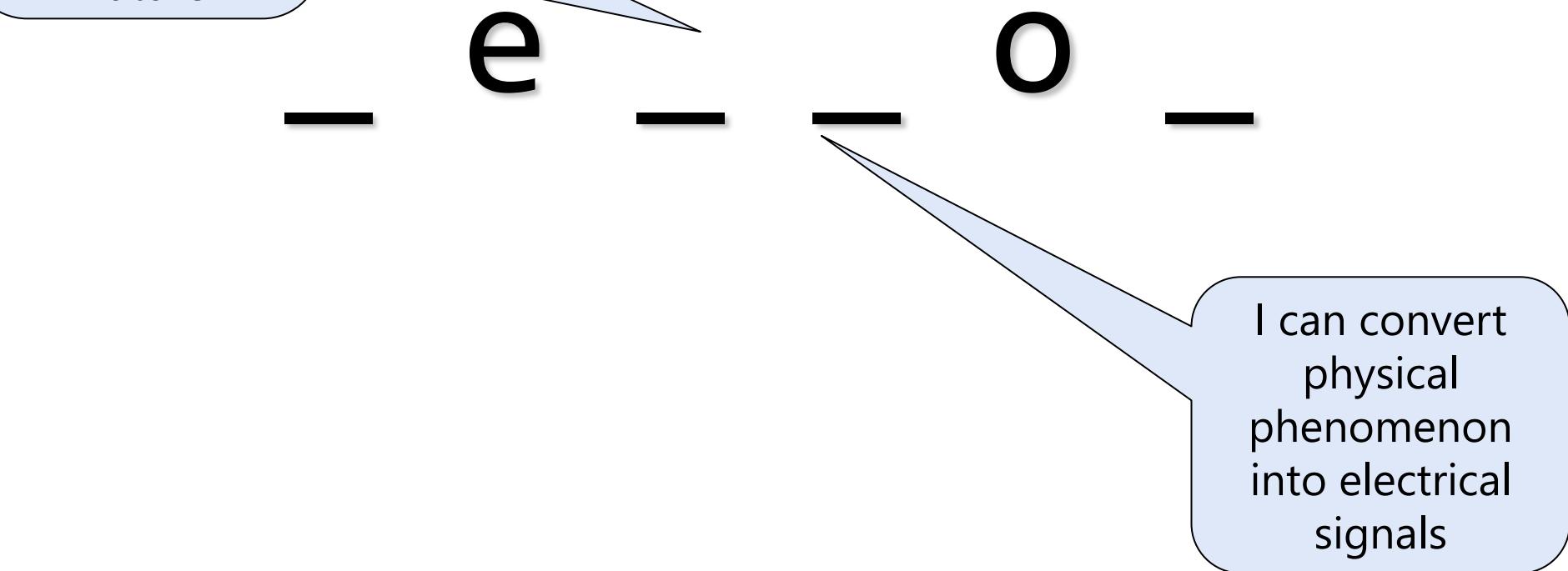
I am an essential part of an Automated System

I can convert physical phenomenon into electrical signals

Image Source: <https://www.lanner-america.com/wp-content/uploads/2016/10/IoTsensoretech.png>

Puzzle - 2

Without me devices cannot collect any information from the nature



I am an essential part of an Automated System

I can convert physical phenomenon into electrical signals



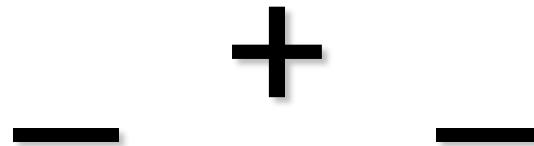
Puzzle - 2



s e n s o r

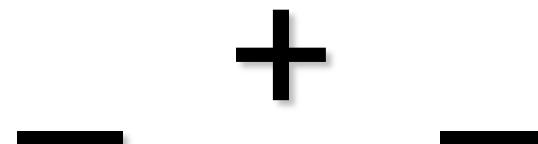
S e n s o r

Puzzle - 3



Puzzle - 3

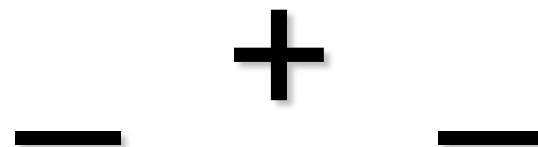
I am a
Programming
Language



Puzzle - 3

I am a
Programming
Language

My elder one
follows
procedural
programming



Puzzle - 3

I am a
Programming
Language

My elder one
follows
procedural
programming

+

-

-

People say
OOPS! While
hearing about
me

Puzzle - 3

I am a
Programming
Language

My elder one
follows
procedural
programming

C + +

People say
OOPS! While
hearing about
me

C + +



Puzzle - 4



?

Puzzle - 4

My name
resembles a
natural
phenomenon

?

Puzzle - 4

My name
resembles a
natural
phenomenon

I am closely
related to the
Internet

?

Puzzle - 4

My name
resembles a
natural
phenomenon

I am closely
related to the
Internet

I can store
huge amount
of Data

?

Puzzle - 4

My name
resembles a
natural
phenomenon

1

d

I can store
huge amount
of Data

Puzzle - 4

My name
resembles a
natural
phenomenon

c l o u d

I am closely
related to the
Internet

I can store
huge amount
of Data

c l o u d

Puzzle - 5

A — u — o —

Puzzle - 5

I am the
Companion of
the Sensor

A — — u — — o —

Puzzle - 5

I am the
Companion of
the Sensor

I can convert an
Electrical Signal
into Physical
form

A

— —

U

— — —

O

—

Puzzle - 5

I am the
Companion of
the Sensor

I can convert an
Electrical Signal
into Physical
form

A

— —

U

— — —

O

I am the end
part of an
Automated
System

A c t u a t o r

Puzzle - 6

?

Puzzle - 6



I am a world
conquering
technology

?

Puzzle - 6

I am a world
conquering
technology

?

People use me for
making their lives
easy

Puzzle - 6

I am a world conquering technology

?

People use me for making their lives easy

Surely you will search for me if you want to control a remote device

Puzzle - 6



I am a world
conquering
technology



People use me for
making their lives
easy



Surely you will
search for me if
you want to
control a remote
device



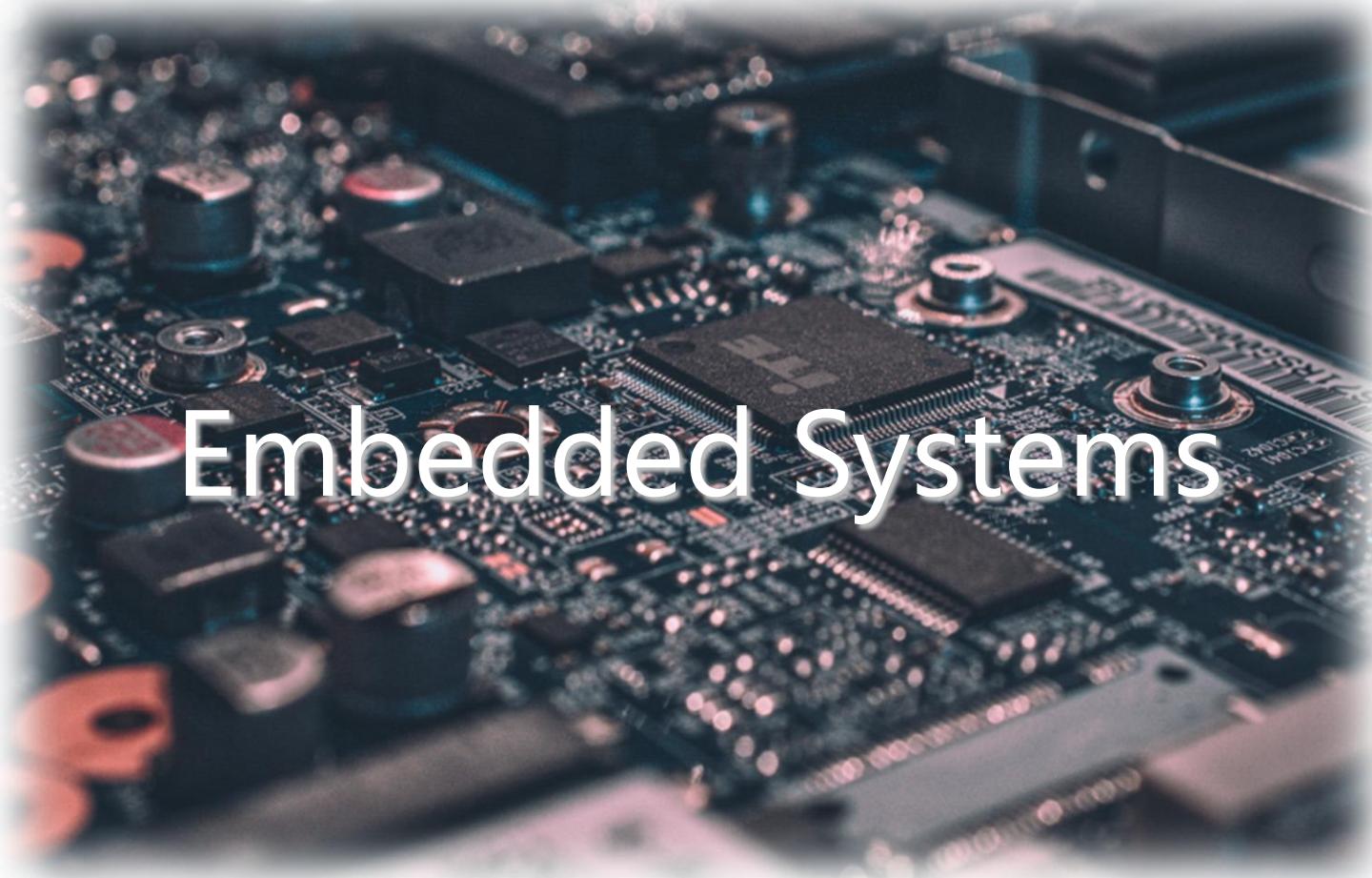
Internet of Things (IoT)



I am a world conquering technology

People use me for making their lives easy

Surely you will search for me if you want to control a remote device



Embedded Systems

Image Source: Google®

Embedded Systems ...



Image Source: https://images-na.ssl-images-amazon.com/images/I/81pTG2IEL7L._SL1500_.jpg

Embedded Systems ...



Image Source: <https://ae01.alicdn.com>

Embedded System

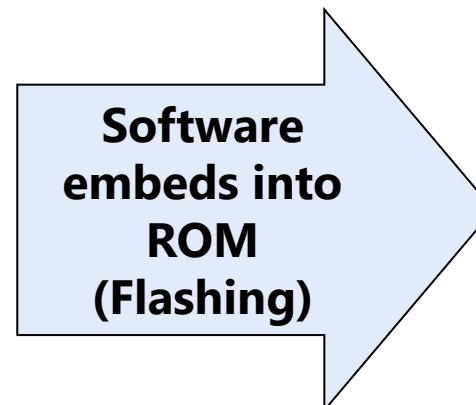
An Embedded System is one that has Computer Hardware with Software embedded inside.

Software Program

```
#include "NodeMCU.h"
#define ledPin D0

void setup()
{
    pinMode(ledPin, OUTPUT);
}

void loop()
{
    digitalWrite(ledPin, HIGH);
    delay (1000);
    digitalWrite(ledPin, LOW);
    delay (1000);
}
```



Roles of Embedded System In Modern World



Demonstration

Obstacle Range Finder

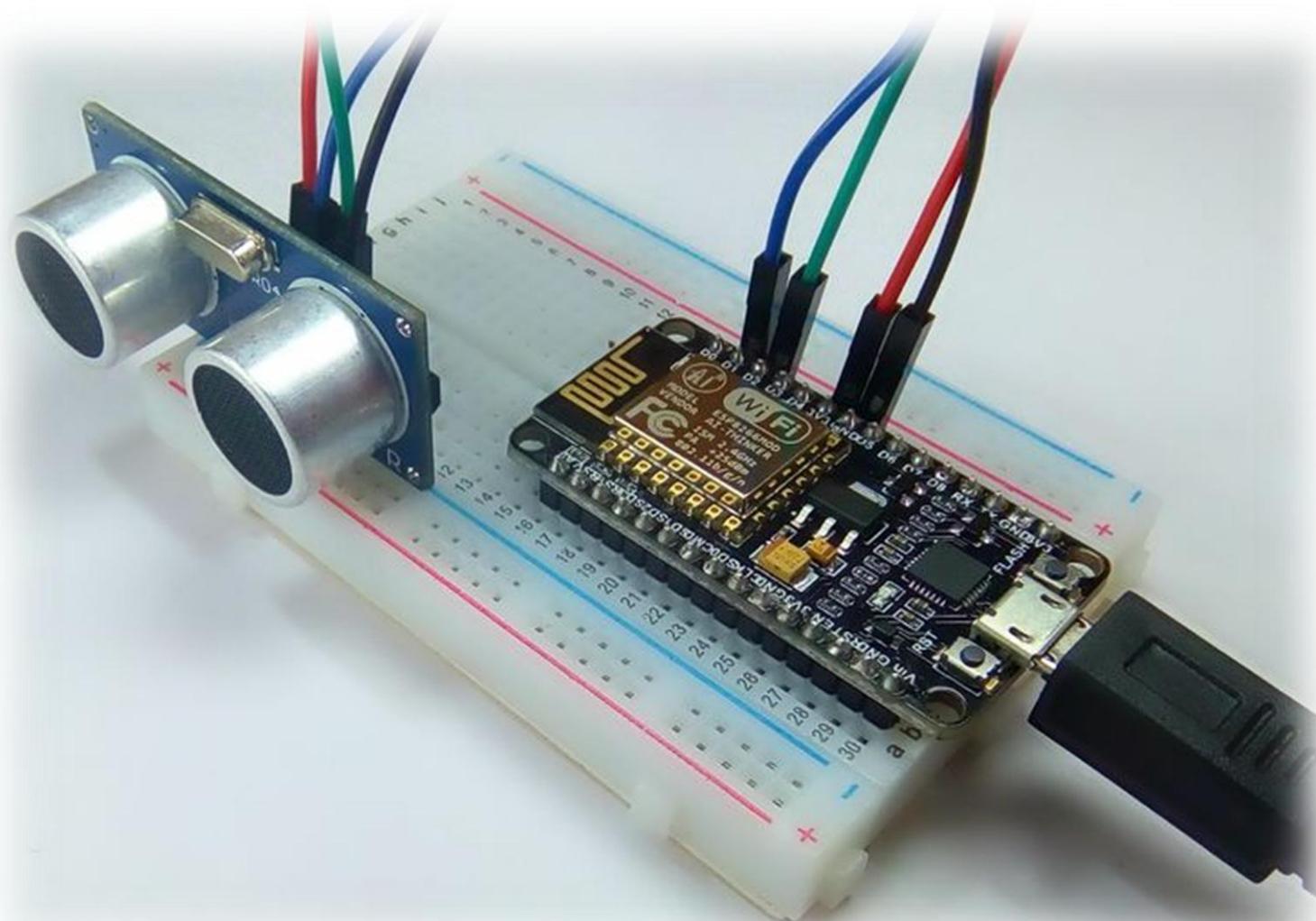
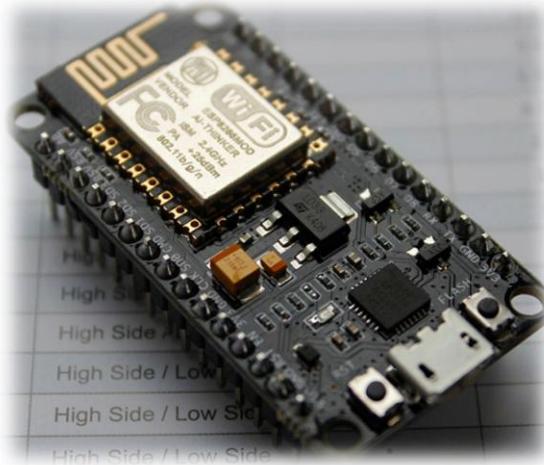


Image Source: <https://cdn.instructables.com/F9F/7UFQ/J48Q4APW/F9F7UFQJ48Q4APW.LARGE.jpg>

Demonstration

Obstacle Range Finder - Components

Hardware



NodeMCU

ESP8266 WiFi SoC based Open Source
Hardware Development Platform

Ultrasonic Sensor

HC-SR04
5V-12V, 0.2 – 0.45m range
with 0.03m precision

Software



ARDUINO 1.8.9

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.

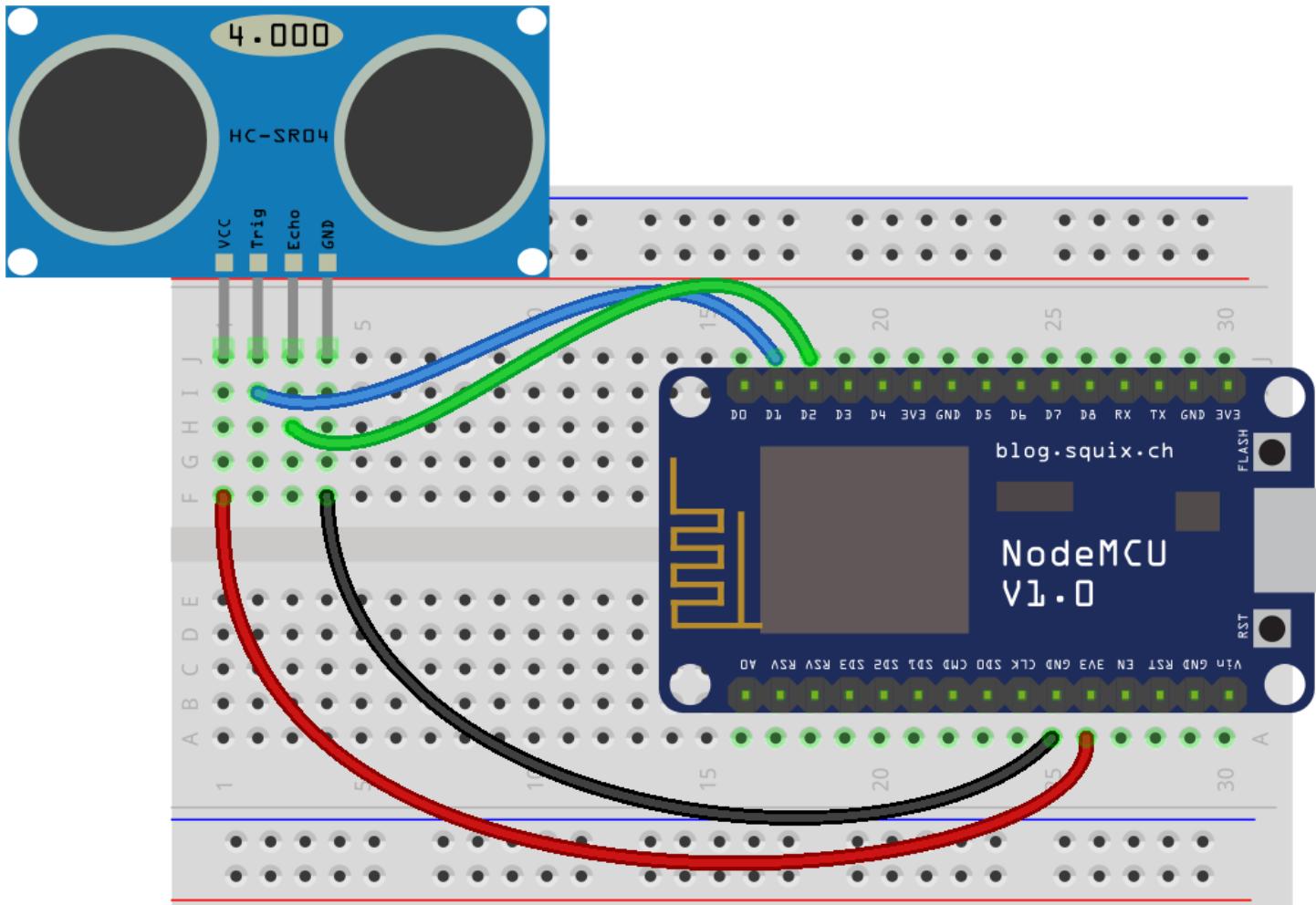
This software can be used with any Arduino board. Refer to the [Getting Started](#) page for installation instructions.

Arduino IDE

C++ based Embedded Software
Integrated Development Platform

Demonstration

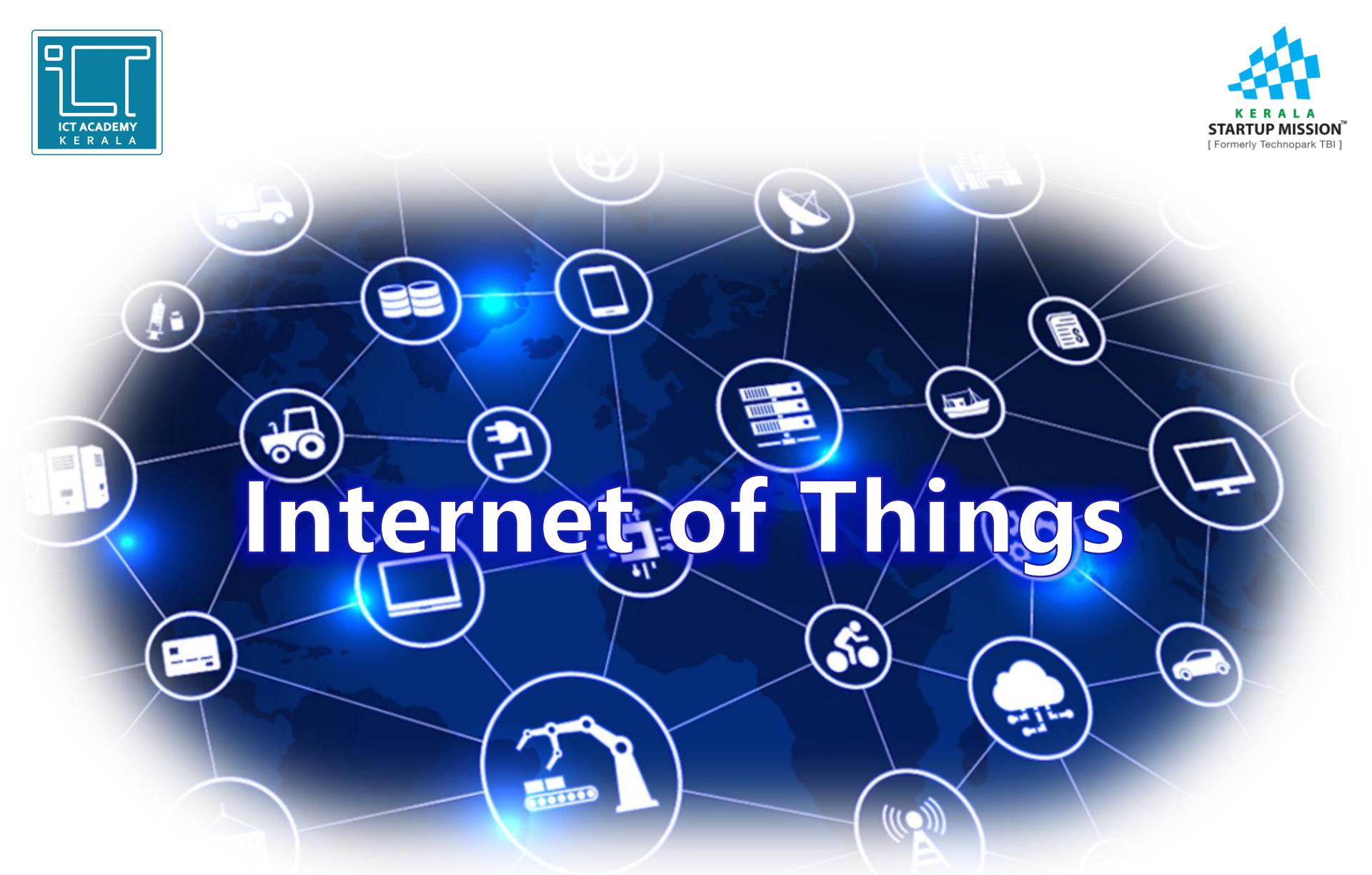
Obstacle Range Finder - Wiring



Layout designed using Fritzing® - <http://fritzing.org>

NodeMCU part Source: <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

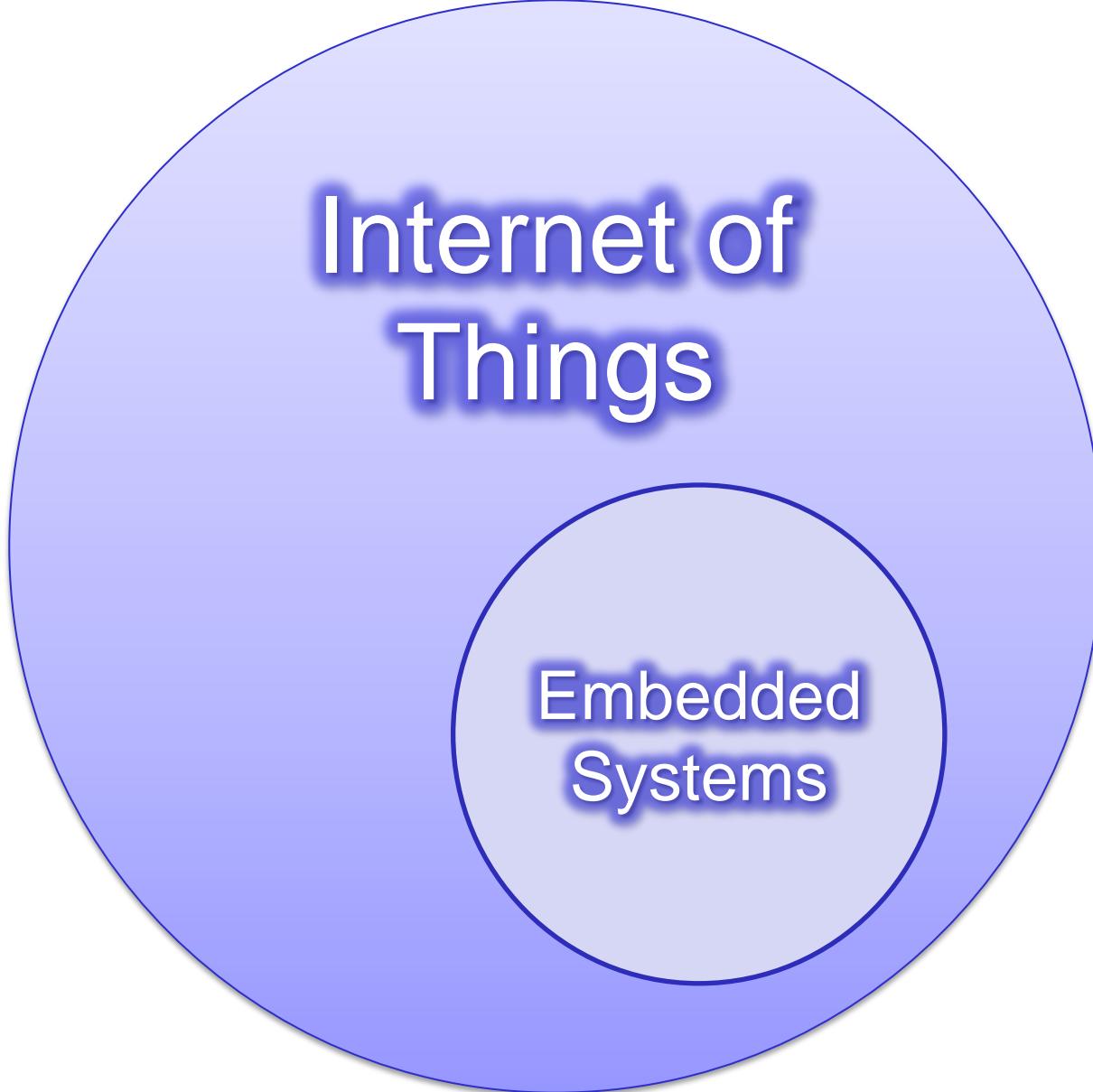
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Internet of Things

Image Source: https://martechtoday.com/wp-content/uploads/2018/08/Internet-of-Things_hvrxab.png

Internet of Things



Embedded
Systems

What is IoT ?

Internet of things (IoT) refers to the concept of connecting **any thing** to the Internet. It is the Idea that people can communicate with the objects and physical things

Things can be Humans, Animals, Buildings, Energy Stations, Smartphones, Tablets, Bicycle, Sensors, Cameras, Vehicles, Health monitoring devices and so on...



Image Source: <https://des.gbtcnd.com/uploads/pdm-desc-pic/Electronic/image/2017/03/21/1490059347782768.jpg>

Smart Wrist Band

Heart Rate Monitor



Sedentary Monitor

Pedometer



Calorie Monitor

Sports Monitor



Call Alert

Alarm Clock



Sleep Monitor



Image Source: <https://des.gbtcnd.com/uploads/pdm-desc-pic/Electronic/image/2017/03/21/1490059347782768.jpg>



Image Source: <https://fortunedotcom.files.wordpress.com/2014/05/google-gadgets-car.jpg>

Driverless Cars



Image Source: <https://fortunedotcom.files.wordpress.com/2014/05/google-gadgets-car.jpg>

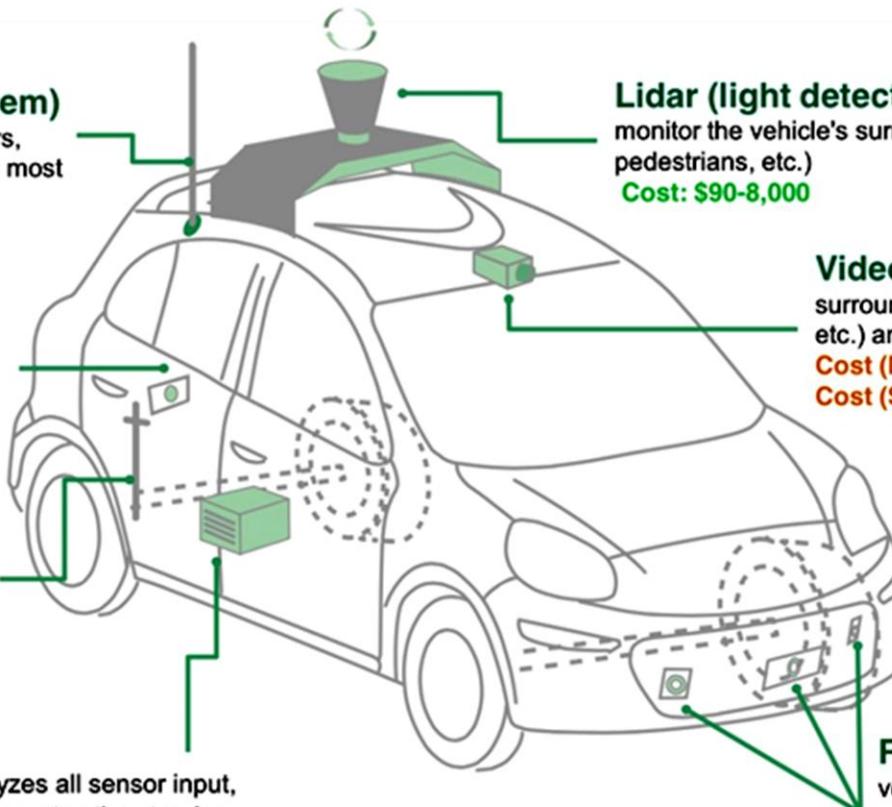
Driverless Cars

GPS (global positioning system)
combined with readings from tachometers, altimeters and gyroscopes to provide the most accurate positioning
Cost: \$80-\$6,000

Ultrasonic sensors to measure the position of objects very close to the vehicle
Cost: \$15-\$20

Odometry sensors to complement and improve GPS information
Cost: \$80-\$120

Central computer analyzes all sensor input, applies rules of the road and operates the steering, accelerator and brakes
Cost: ~50-200% of sensor costs



Lidar (light detection and ranging)
monitor the vehicle's surroundings (road, vehicles, pedestrians, etc.)
Cost: \$90-\$8,000

Video cameras monitor the vehicle's surroundings (road, vehicles, pedestrians, etc.) and read traffic lights
Cost (Mono): \$125-\$150
Cost (Stereo): \$150-\$200

Radar sensors monitor the vehicle's surroundings (road, vehicles, pedestrians, etc.)
Cost (Long Range): \$125-\$150
Cost (Short Range): \$50-\$100



Image Source: <https://informedmag.com/wp-content/uploads/2016/10/Best-Smart-Wifi-Outlets-1.jpg>

Smart Power Outlets



Wireless Control • Energy Monitoring & Conservation • Smart Device Integration

Image Source: <https://informedmag.com/wp-content/uploads/2016/10/Best-Smart-Wifi-Outlets-1.jpg>

Smart Key Chains & ID Cards



Image Source: Google®

Things !!!



Image Source: Google®

How Things Communicate ?

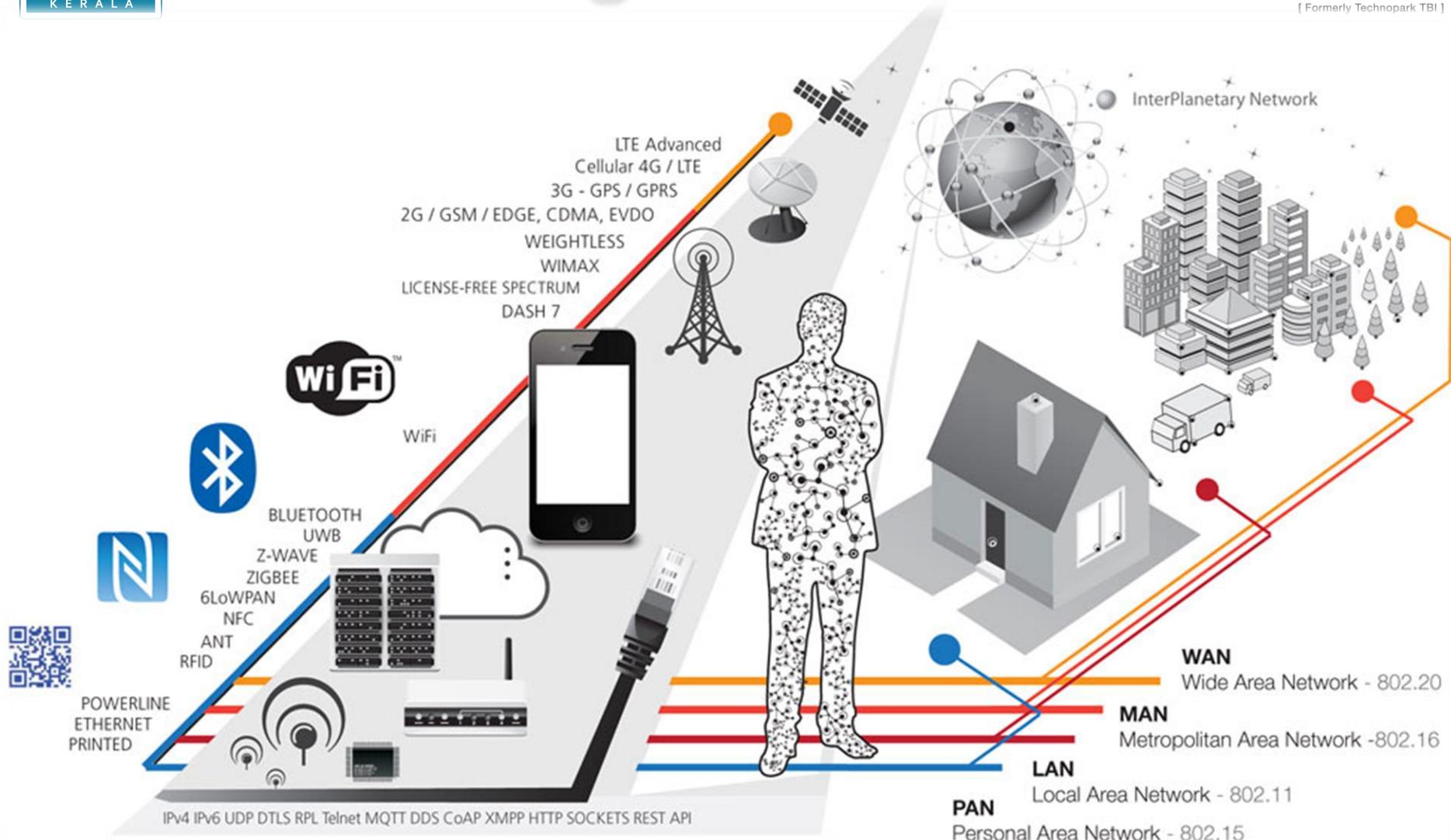


Image Source: <https://www.postscapes.com/wp-content/uploads/2018/03/connectivity-diagram.jpg>

Data Analysis & Action



Image Source: <https://www.postscapes.com/wp-content/uploads/2018/03/connectivity-diagram.jpg>

IoT Life Cycle

Collect

Communicate

Organize, Store & Process

Analyse & Act



Image Source: <https://www.postscapes.com/wp-content/uploads/2018/03/connectivity-diagram.jpg>

Choosing the right Hardware Platform

Major Factors

- Processor
- Chipset
- Memory
- On-Board Peripherals
 - I²C, SPI, CAN, USB, HDMI, Parallel ports etc.
- System Clock options
- OS support
- Cost

NodeMCU Development Board



Image Source: <https://dziadalnfpolx.cloudfront.net/blog/wp-content/uploads/2015/09/official-nodemcu-development-board.jpg>

NodeMCU Development Board

Specification & Pin Out

- Tensilica L106, 32-bit RISC Processor, 160 MHz
- 9 Digital I/O Pins (digital input/output pins)
- 1 Analog pin (10 Bit ADC)
- 4MB Flash (Program) memory
- 128KB Data Memory
- Inbuilt WiFi 802.11 b/g/n
- UART(2), SPI(2), I²C (1)
- USB Powered
- Operating Voltage 3.3V
- 3.3V & 5V Outputs available for external use

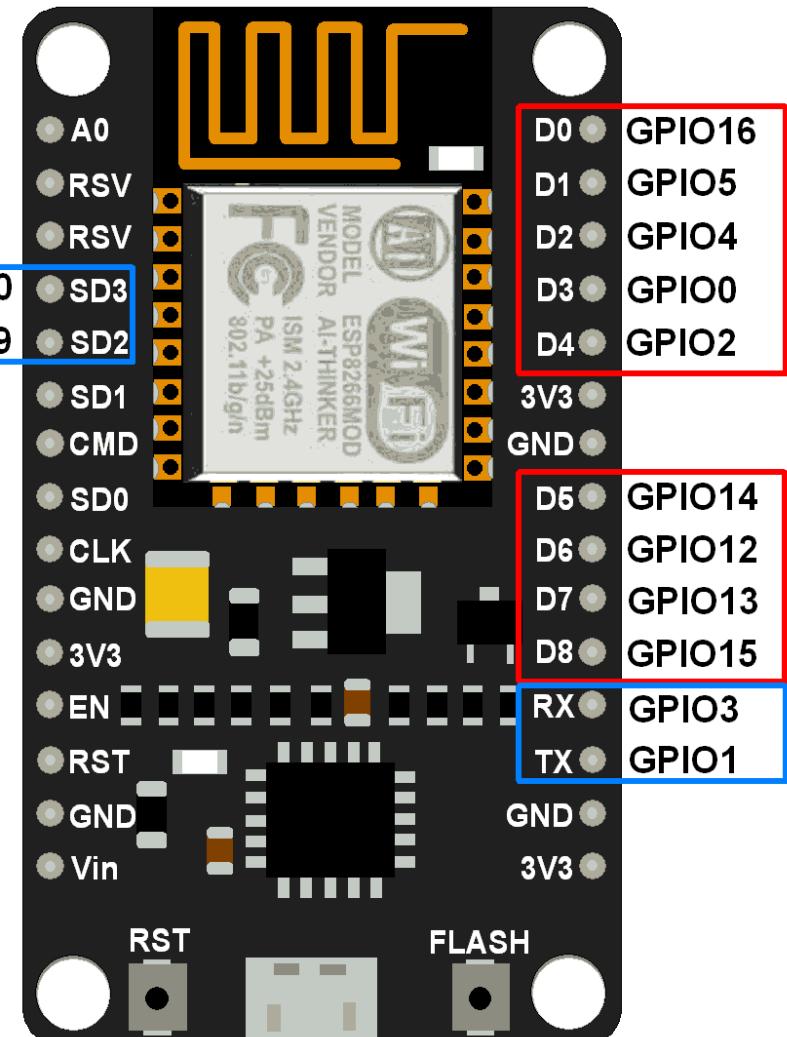
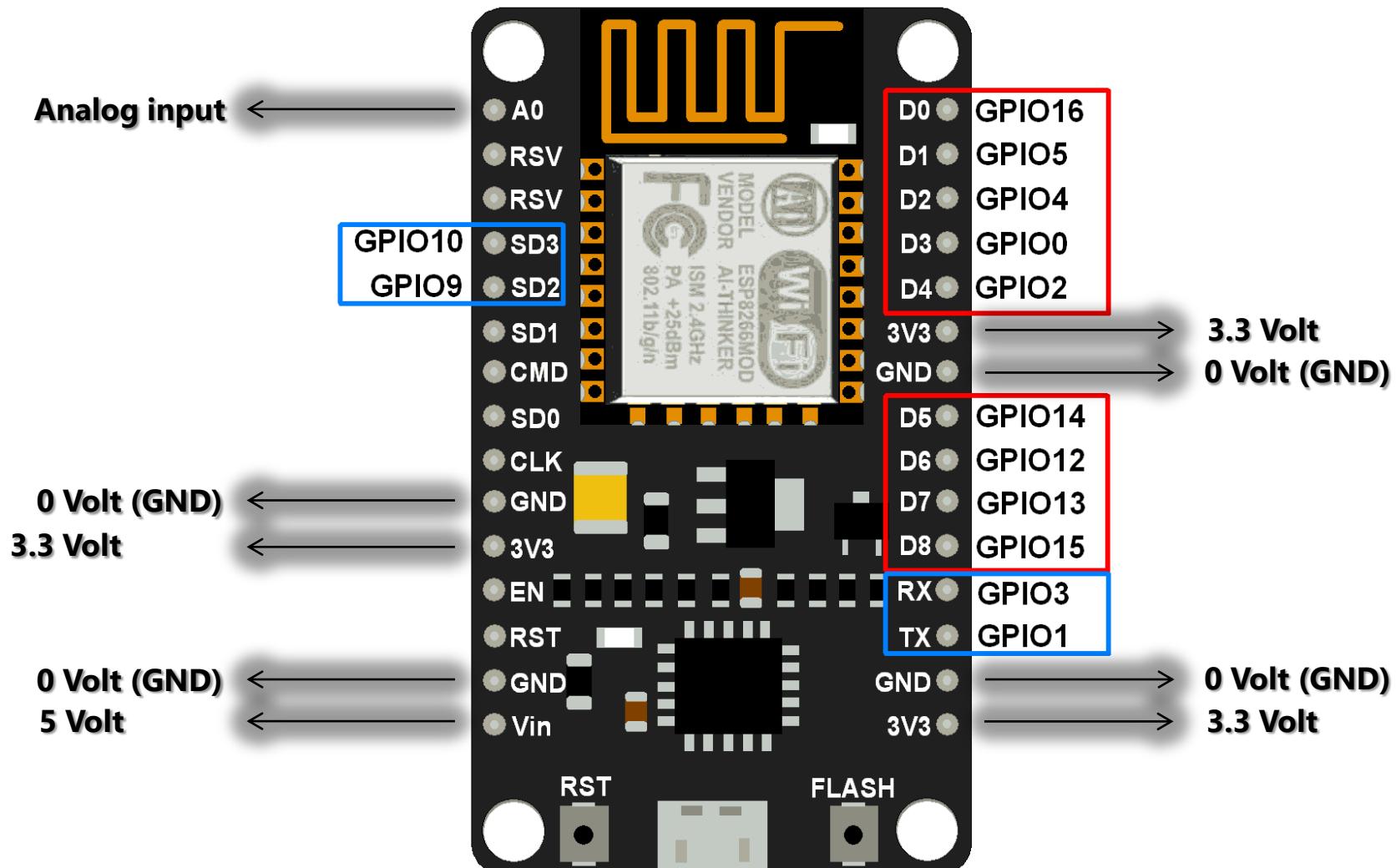


Image Source: <https://www.electronicwings.com>

NodeMCU Development Board

Pin Out



Software Development Platform

Arduino® Integrated Development Environment (IDE)



ARDUINO

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X, and Linux. The environment is written in Java and based on Processing and other open-source software.

This software can be used with any Arduino board. Refer to the [Getting Started](#) page for installation instructions.

<https://www.arduino.cc>

Windows Installer, for Windows XP and up

Windows ZIP file for non admin install

Windows app Requires Win 8.1 or 10



Mac OS X 10.8 Mountain Lion or newer

Linux 32 bits

Linux 64 bits

Linux ARM 32 bits

Linux ARM 64 bits

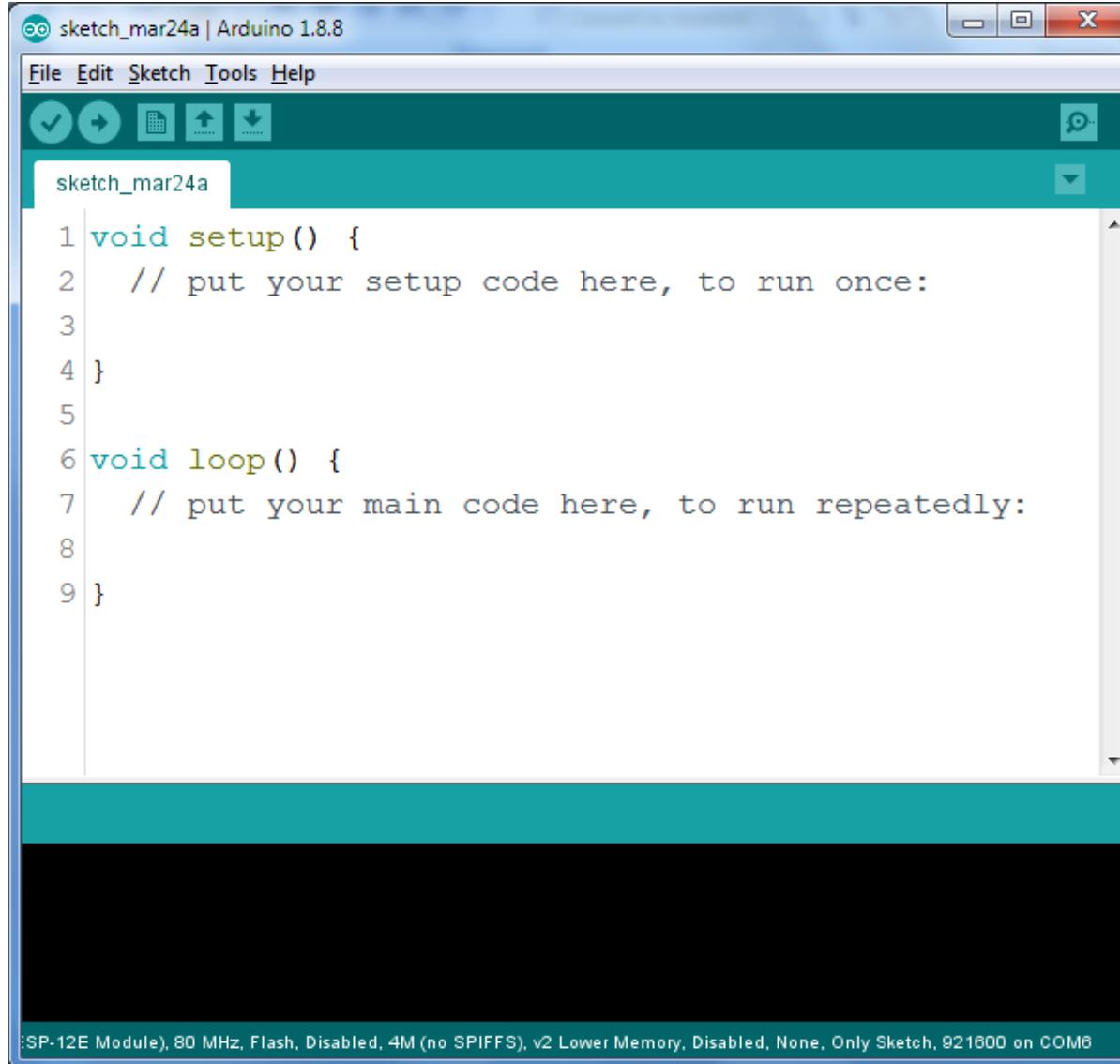
[Release Notes](#)

[Source Code](#)

[Checksums \(sha512\)](#)

Software Development Platform

Arduino® Integrated Development Environment (IDE)

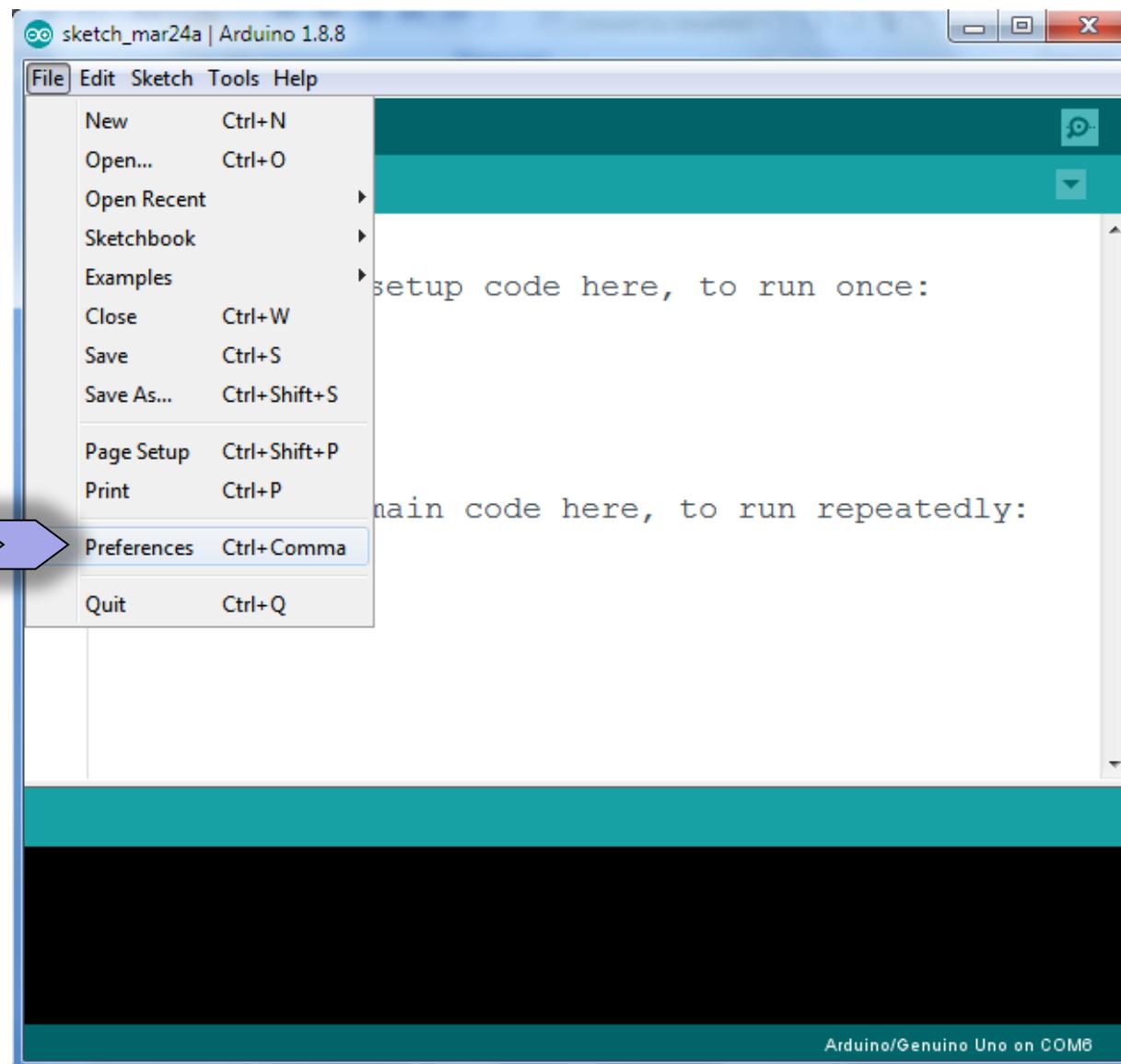


The screenshot shows the Arduino IDE interface with the following details:

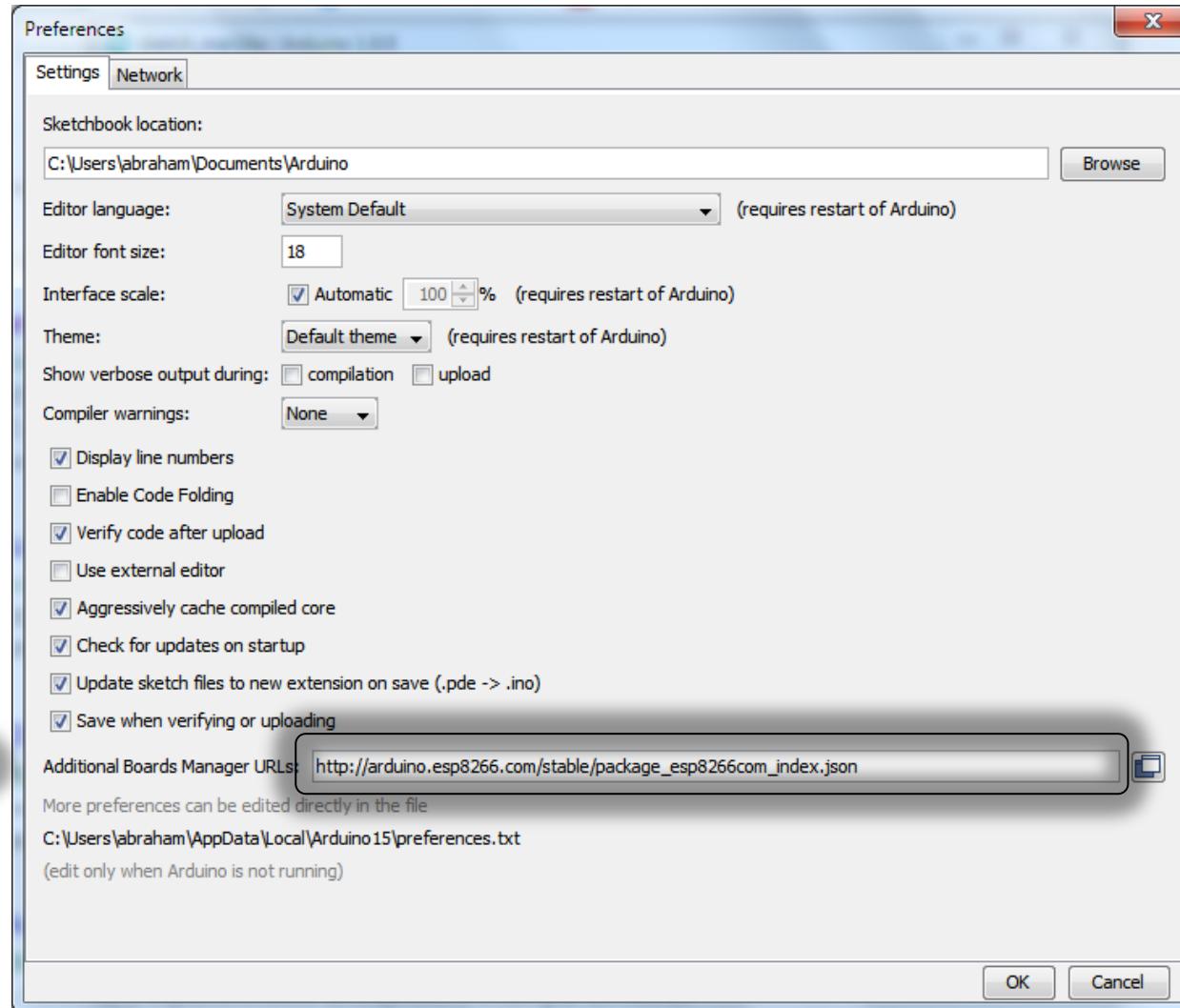
- Title Bar:** sketch_mar24a | Arduino 1.8.8
- Menu Bar:** File Edit Sketch Tools Help
- Toolbar:** Includes icons for Save, Undo, Redo, Open, Upload, and Download.
- Sketch Editor:** Displays the following C++ code:

```
1 void setup() {  
2     // put your setup code here, to run once:  
3  
4 }  
5  
6 void loop() {  
7     // put your main code here, to run repeatedly:  
8  
9 }
```
- Bottom Status Bar:** (SP-12E Module), 80 MHz, Flash, Disabled, 4M (no SPIFFS), v2 Lower Memory, Disabled, None, Only Sketch, 921600 on COM6

Setting up Arduino IDE for NodeMCU Board

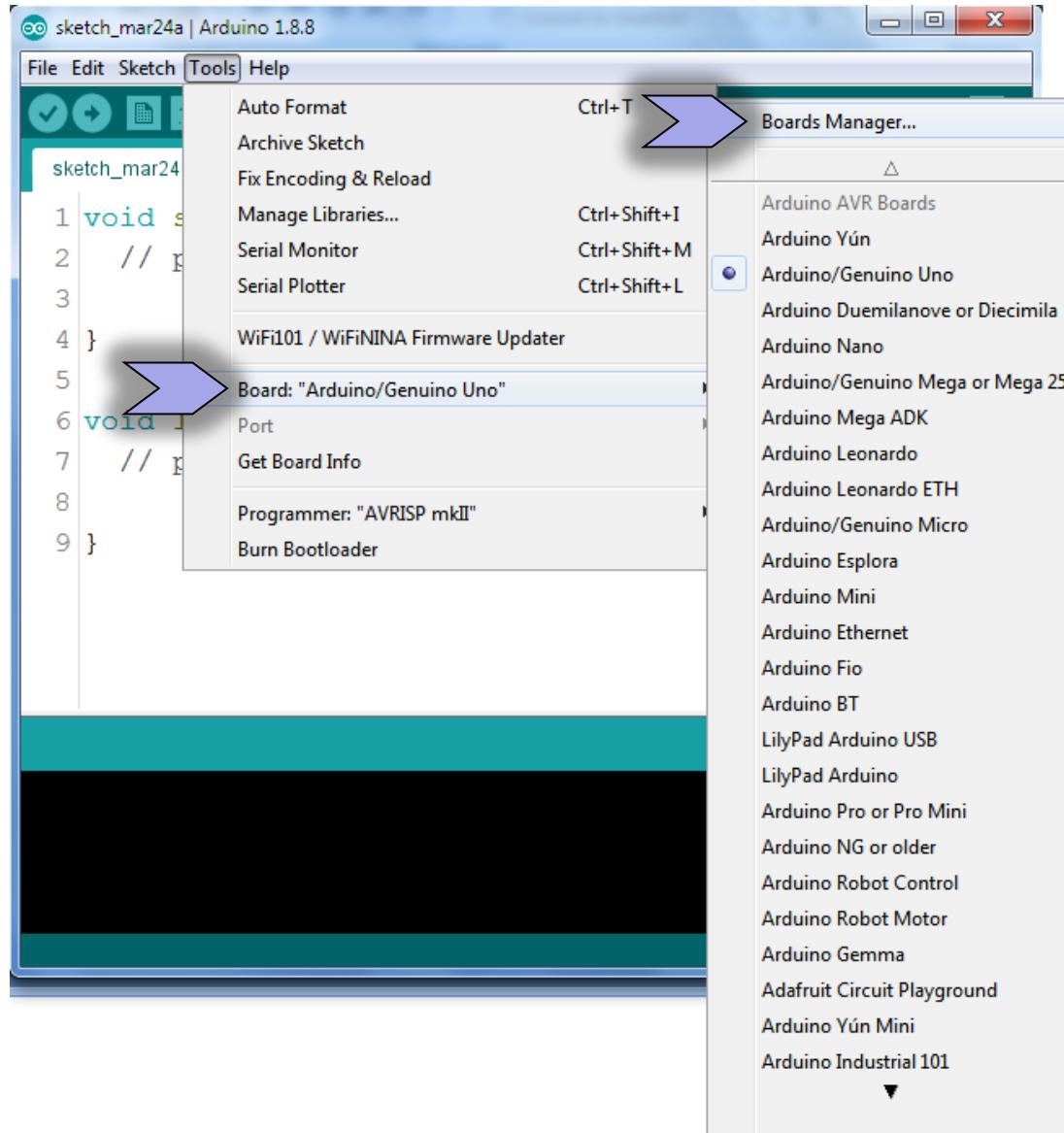


Setting up Arduino IDE for NodeMCU Board

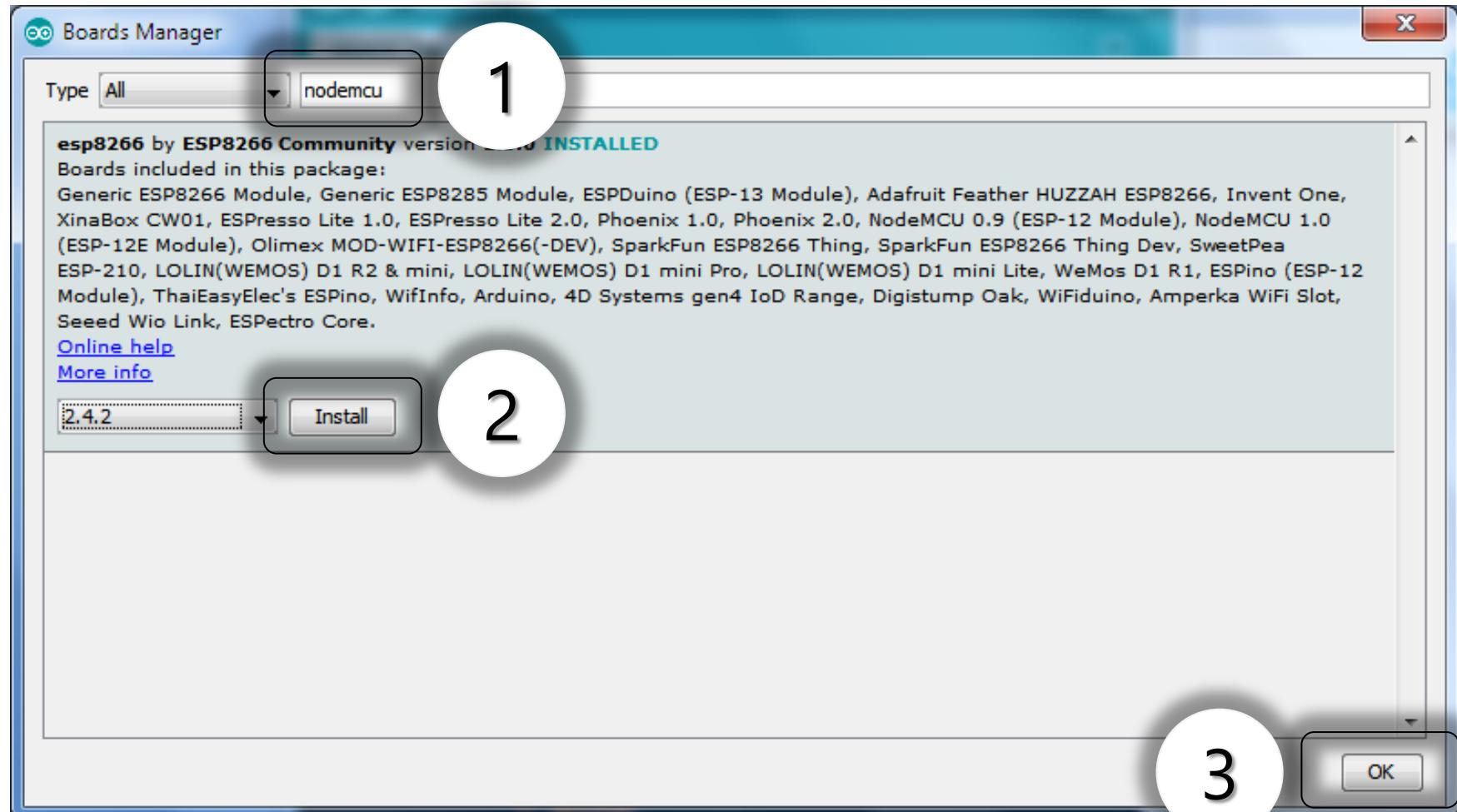


Google Search keyword: "Arduino additional Board manager URL for NodeMCU"

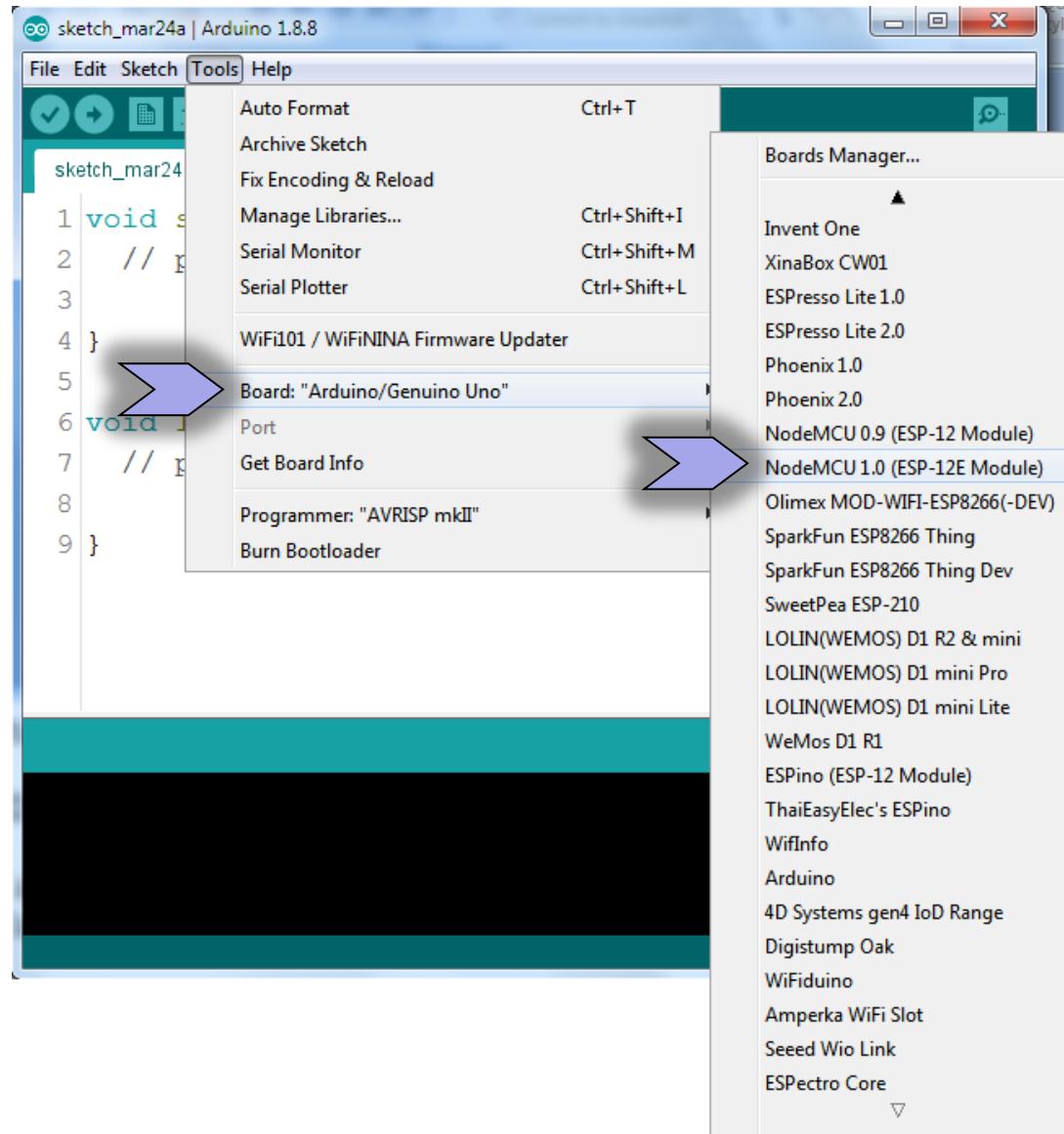
Setting up Arduino IDE for NodeMCU Board



Setting up Arduino IDE for NodeMCU Board



Setting up Arduino IDE for NodeMCU Board



Programming NodeMCU

Commonly used Arduino Functions

Function	Purpose	Example Syntax
pinMode()	Used to configure pins as input/output	pinMode(D0, INPUT);
digitalRead()	Used to read digital signals from a pin	digitalRead(D0);
digitalWrite()	Used to write digital signals on to a pin: HIGH for 5V & LOW for 0V	digitalWrite(D0, HIGH);
analogRead()	Used to read analog signals from a pin using internal A to D Conversion	analogRead(A0);
analogWrite()	Used to generate width varying digital pulses using Pulse Width Modulation (PWM) which can be used to produce low frequency Analog signals with the help of additional filters.	analogWrite(D6, 400);

Programming NodeMCU

Commonly used Arduino Functions ...

Function	Purpose	Example Syntax
Serial.print()	Used to transmit data through serial interface for debugging / monitoring / communication purposes	Serial.print("Hello World");
Serial.begin()	Sets the data rate in bits per second (bps or baud) for serial data transmission.	Serial.begin(115200);
delay()	To delay the next command for a certain duration in milliseconds.	delay(1000);

Let's Do It Yourself Hands-On!!!

Let's connect them together

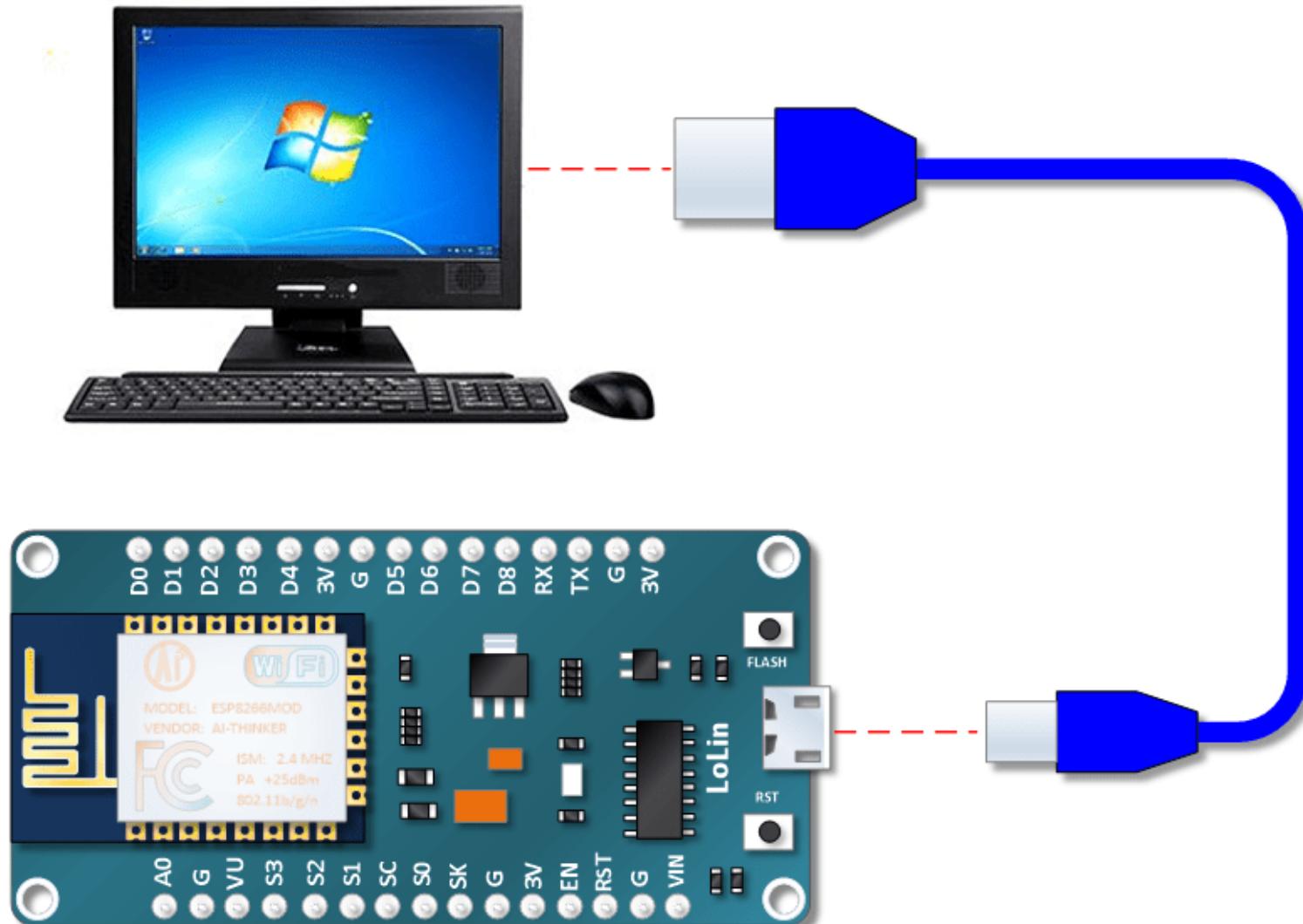
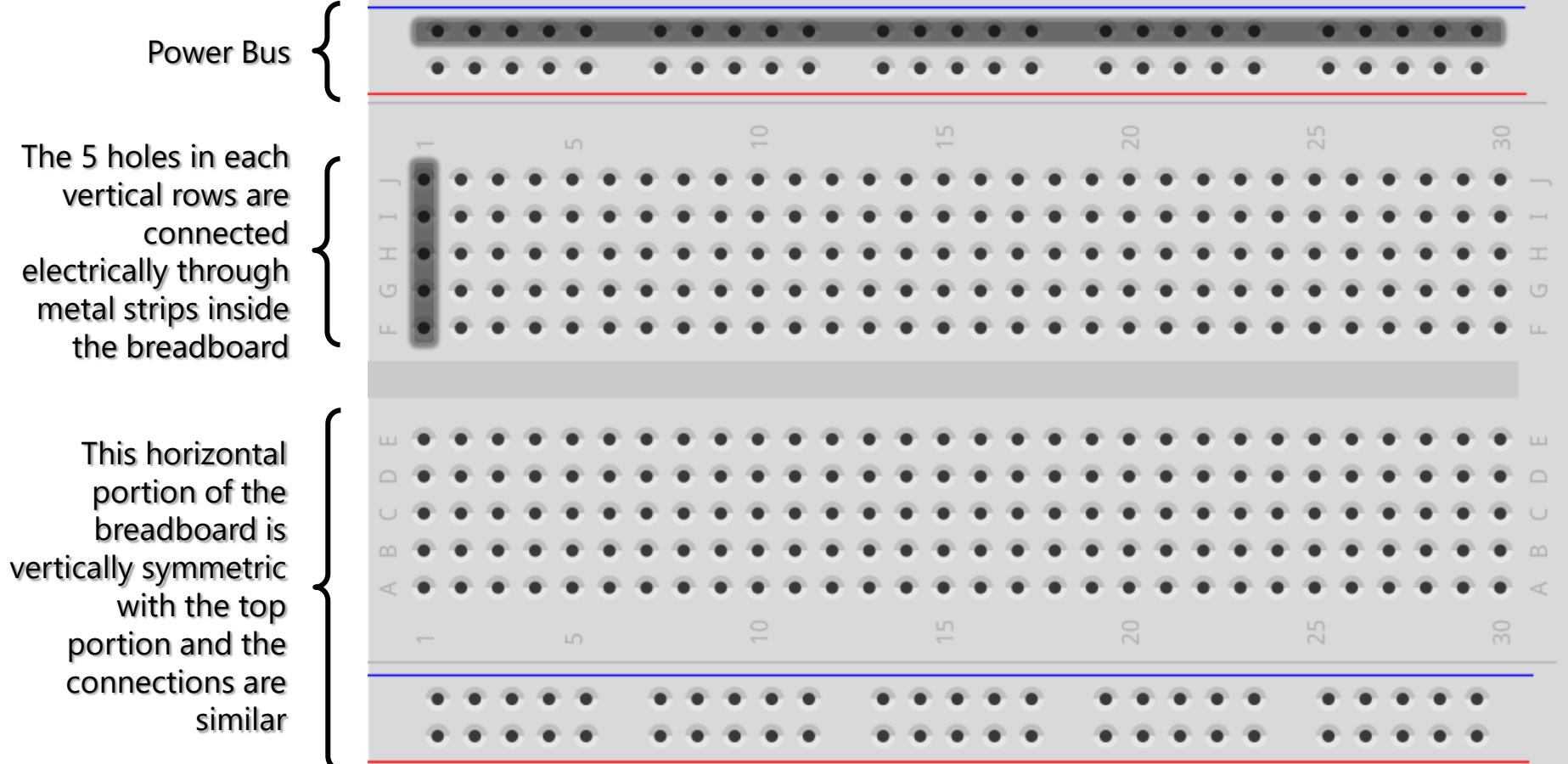


Image Source: <https://i0.wp.com/henrysbench.capnfatz.com/wp-content/uploads/2016/09/Connect-to-Computer.png>

Breadboard Connection

The horizontal strips that run the length of the breadboard are electrically connected inside. The strips are usually used for power and ground connections

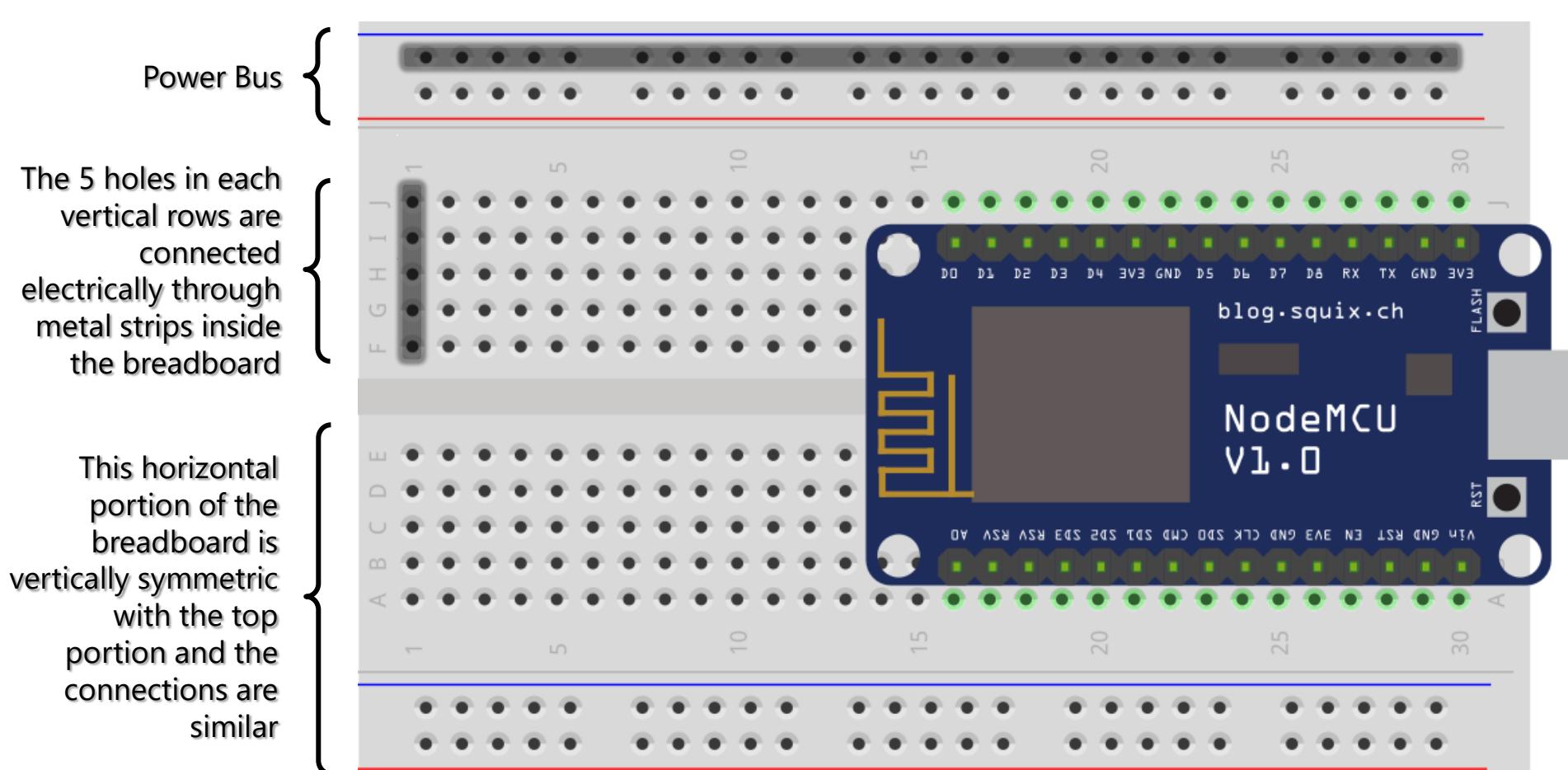


Reference: <https://diygeeks.org/wp-content/uploads/2018/01/BreadBoard-Labelling-1012x1024.jpg>

fritzing

Breadboard Connection

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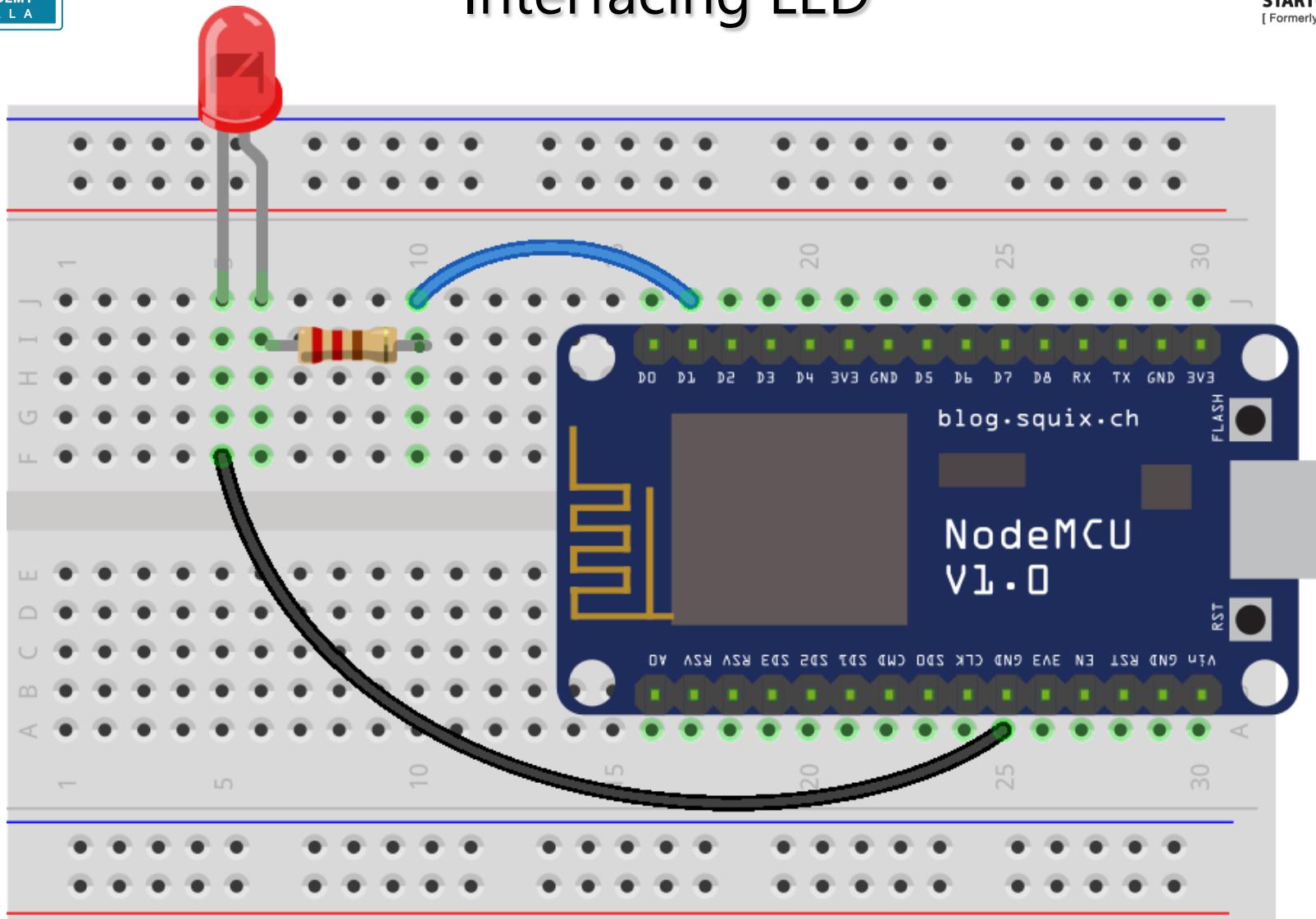


Reference: <https://diygeeks.org/wp-content/uploads/2018/01/BreadBoard-Labelling-1012x1024.jpg>
 Layout designed using Fritzing® - <http://fritzing.org>. NodeMCU part Source(s):<https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

fritzing

DIY Experiments with NodeMCU

Interfacing LED



Layout designed using Fritzing® - <http://fritzing.org>

NodeMCU part Source(s): <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

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Momentary Tactile Push Button / Switch

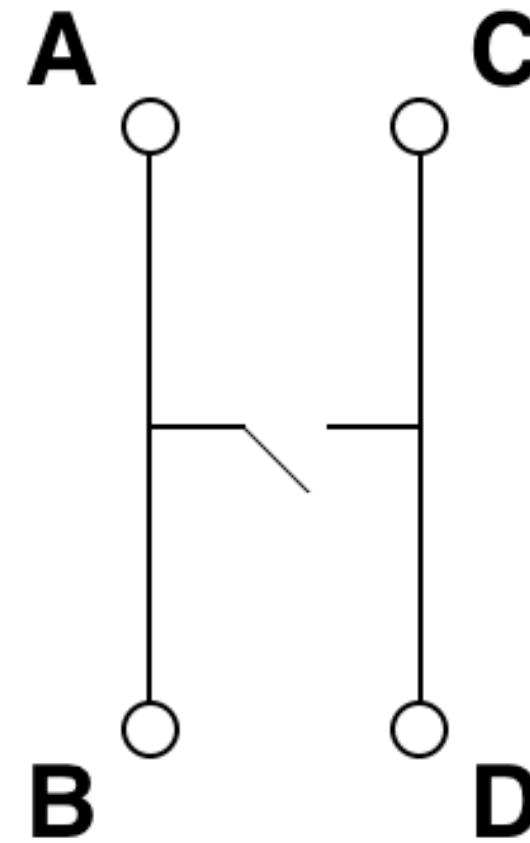
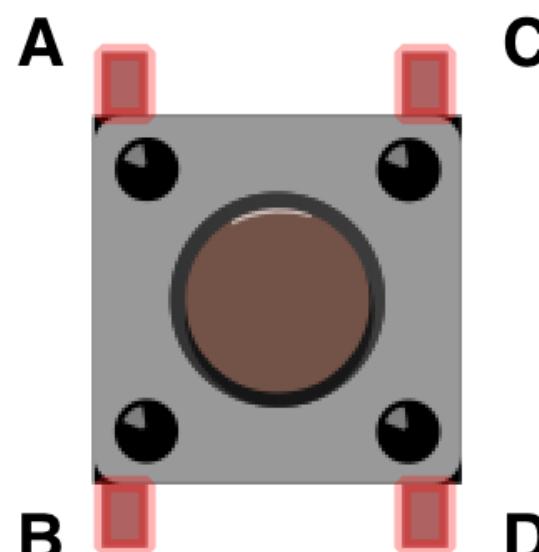


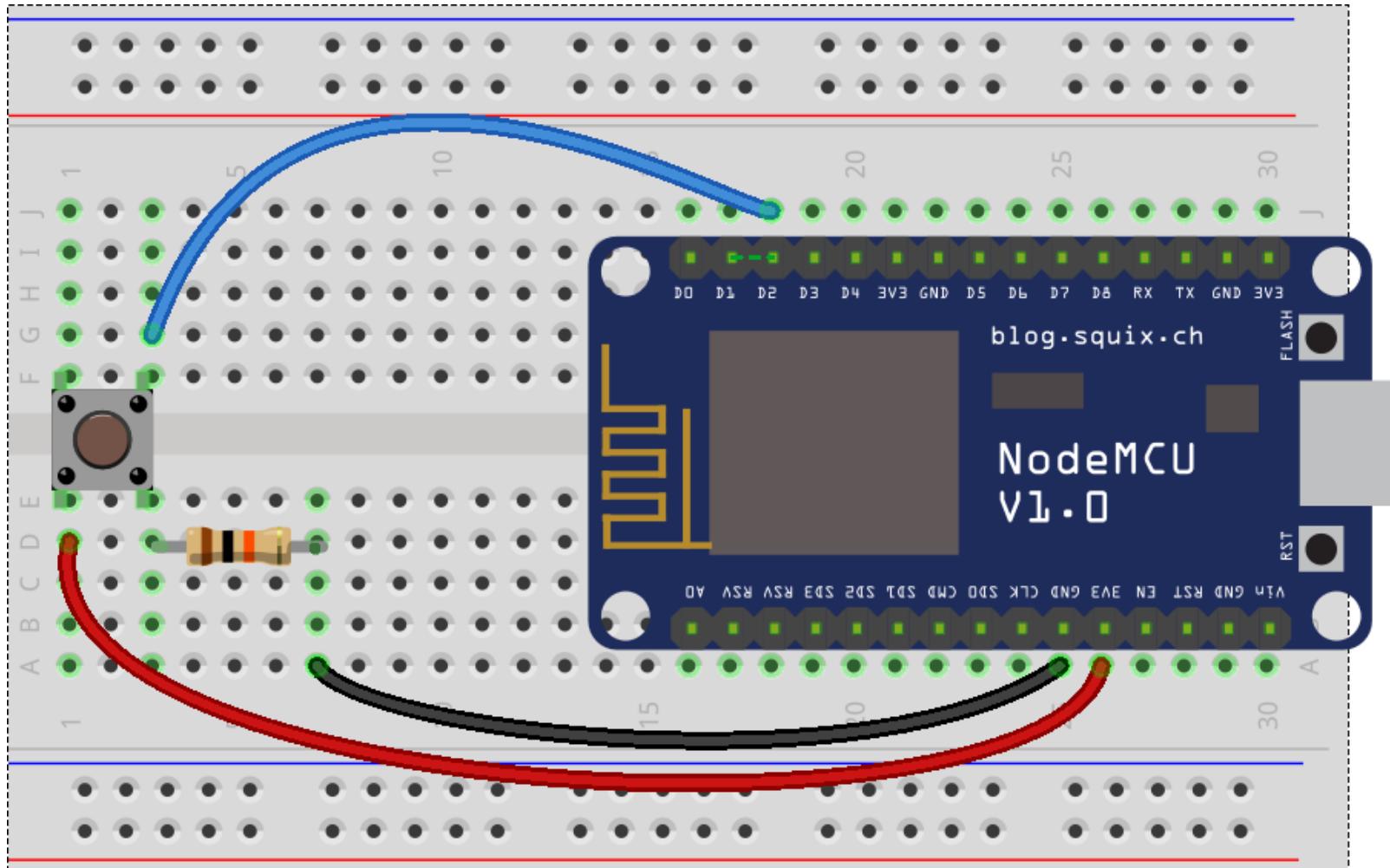
Image Source(s):

http://razzpisampler.oreilly.com/images/rpck_1102.png,

https://docs.labs.mediatek.com/resource/linkit7697-arduino/files/en/12880064/12880062/1/1498095674923/button_sch.png

DIY Experiments with NodeMCU

Interfacing Push Button Switch

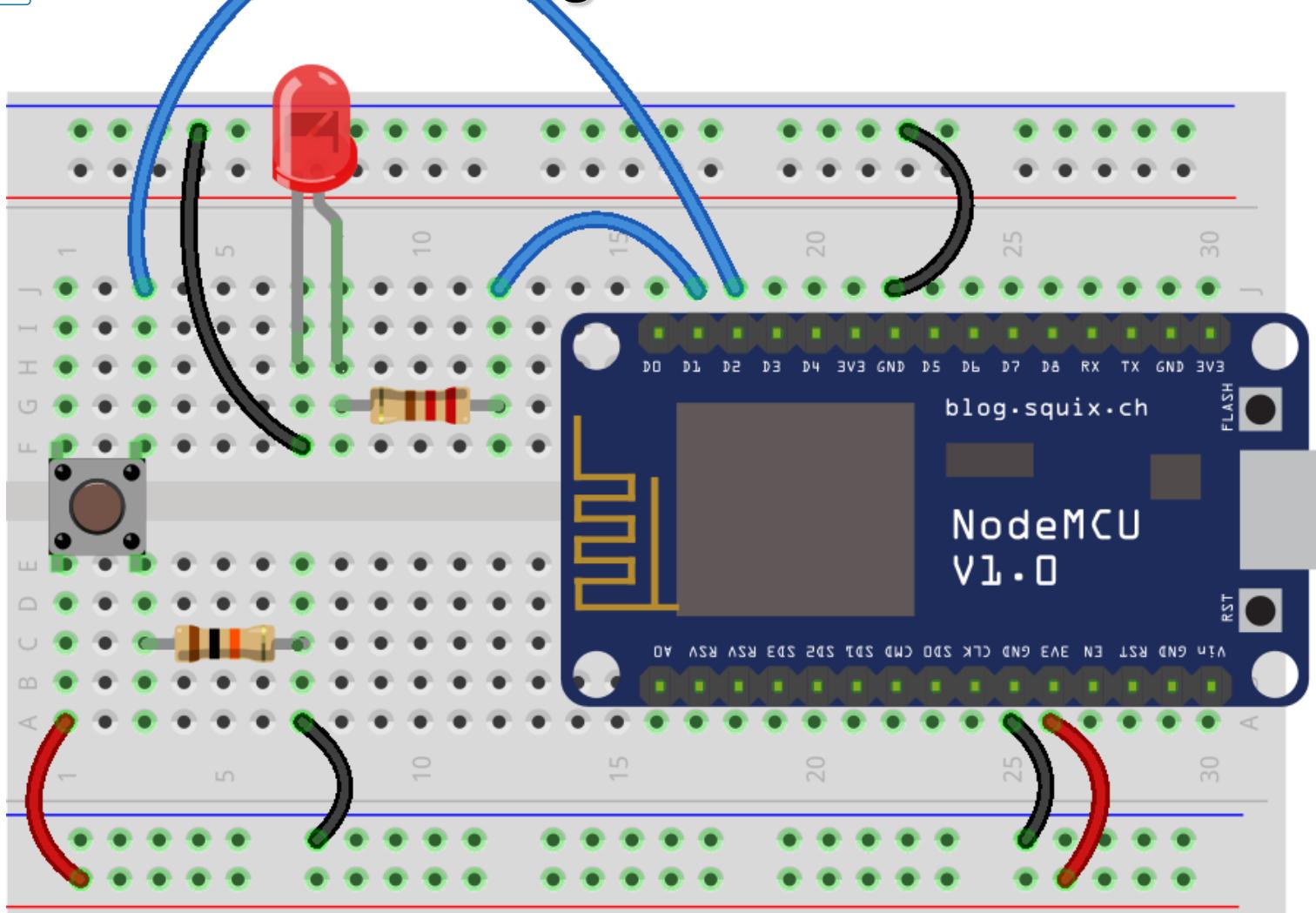


Layout designed using Fritzing® - <http://fritzing.org>

NodeMCU part Source: <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

DIY Experiments with NodeMCU

Interfacing Switch and LED



Layout designed using Fritzing® - <http://fritzing.org>

NodeMCU part Source: <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

fritzing

Light Dependent Resistor (LDR)

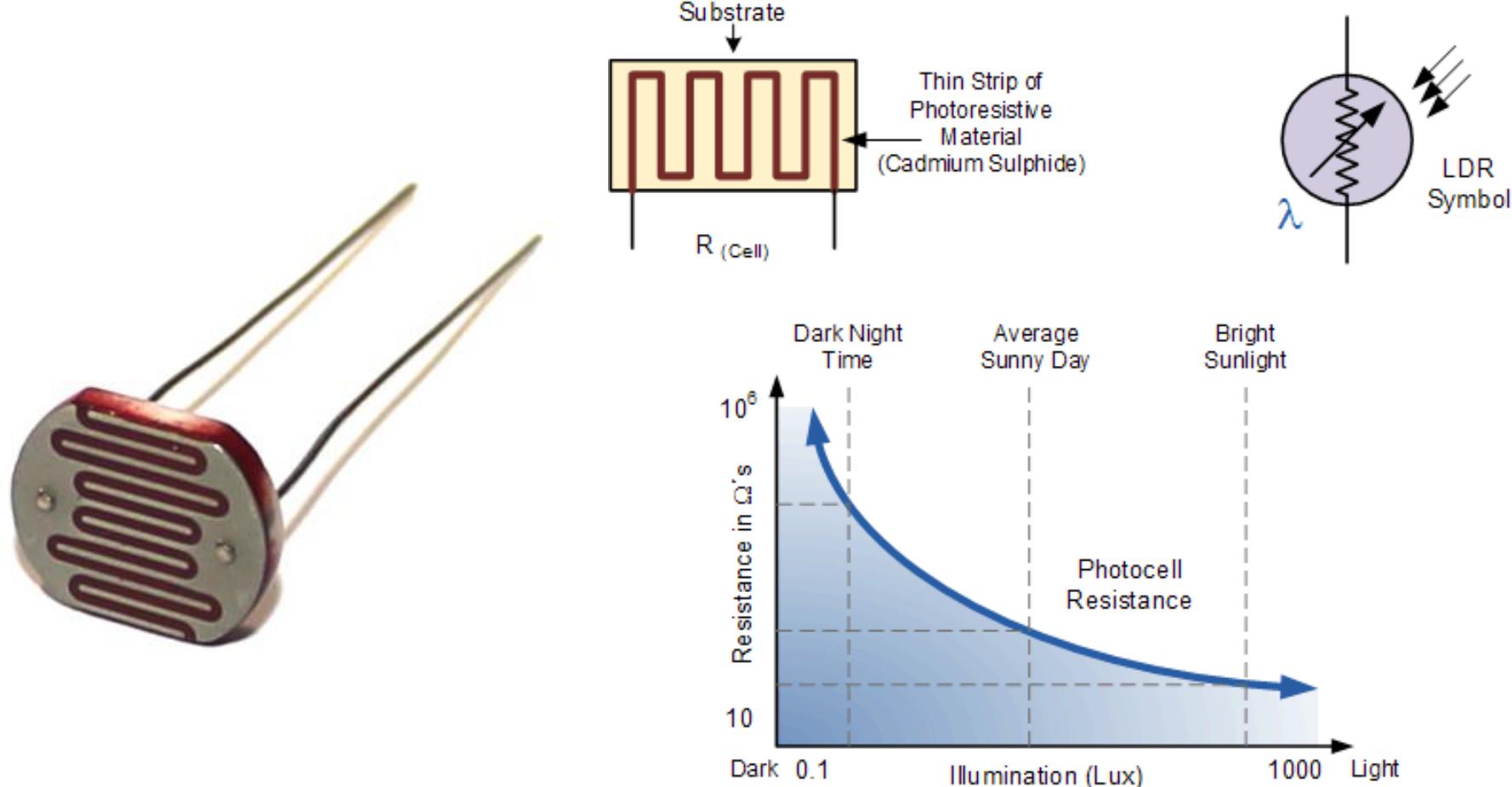


Image Source(s):

<http://www.electriclelibrary.com/wp-content/uploads/2017/08/LDR-destaque.jpg>
<https://www.electronics-tutorials.ws/io/io19.gif>

LDR application circuit diagram

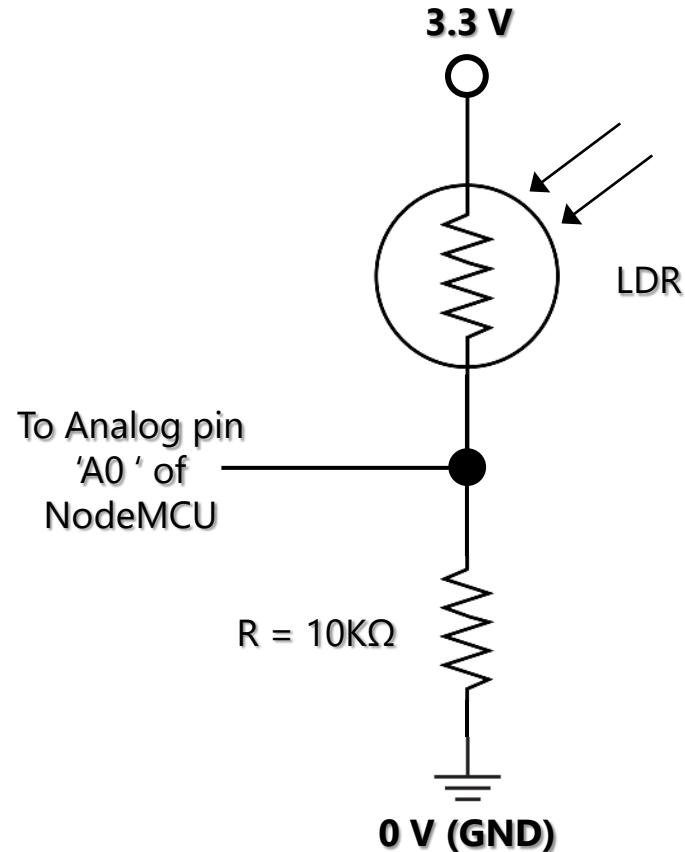
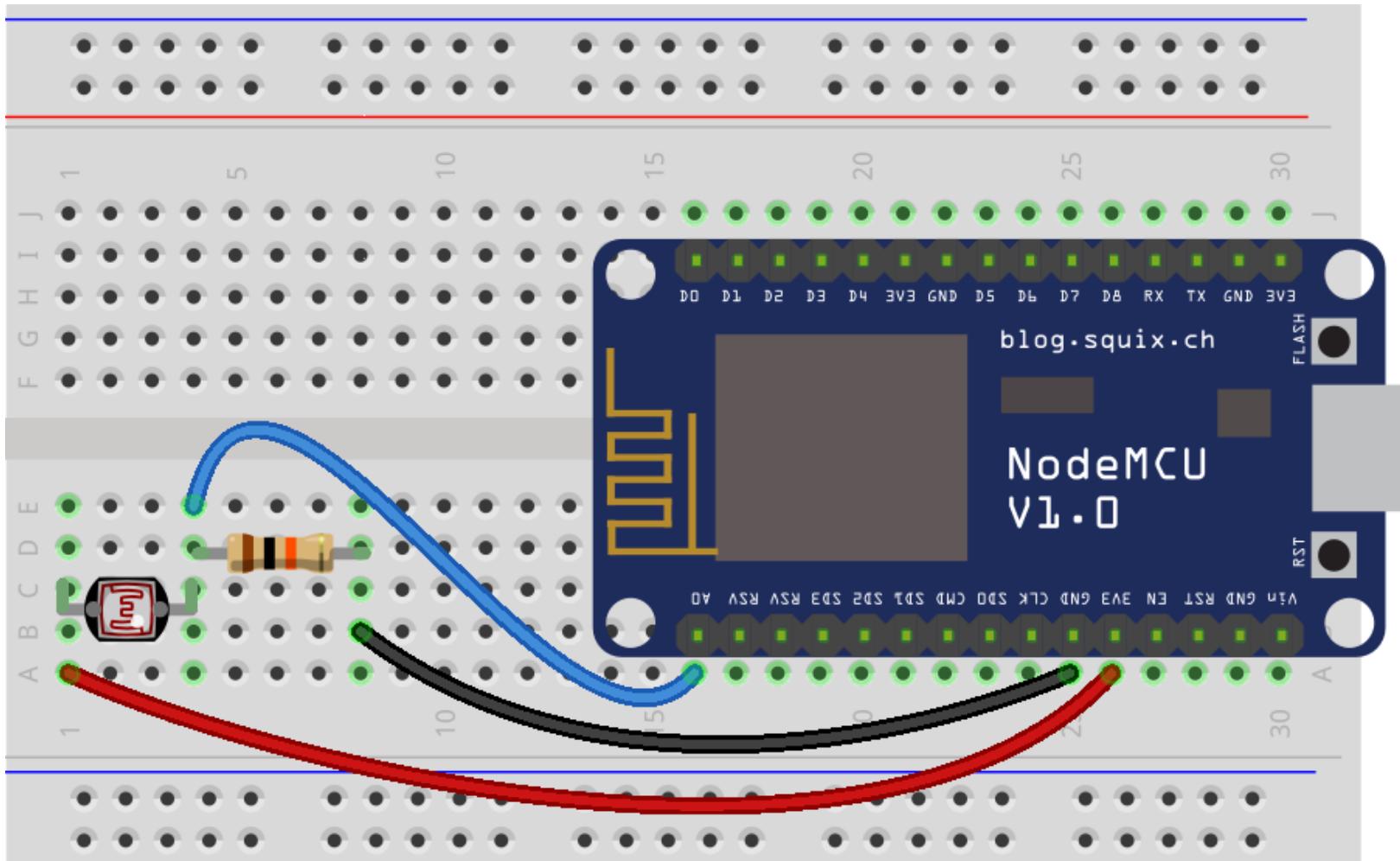


Image Source: <https://www.electronics-notes.com/images/light-dependent-resistor-photoresistor-circuit-symbol.svg>

DIY Experiments with NodeMCU

Interfacing LDR



Layout designed using Fritzing® - <http://fritzing.org>

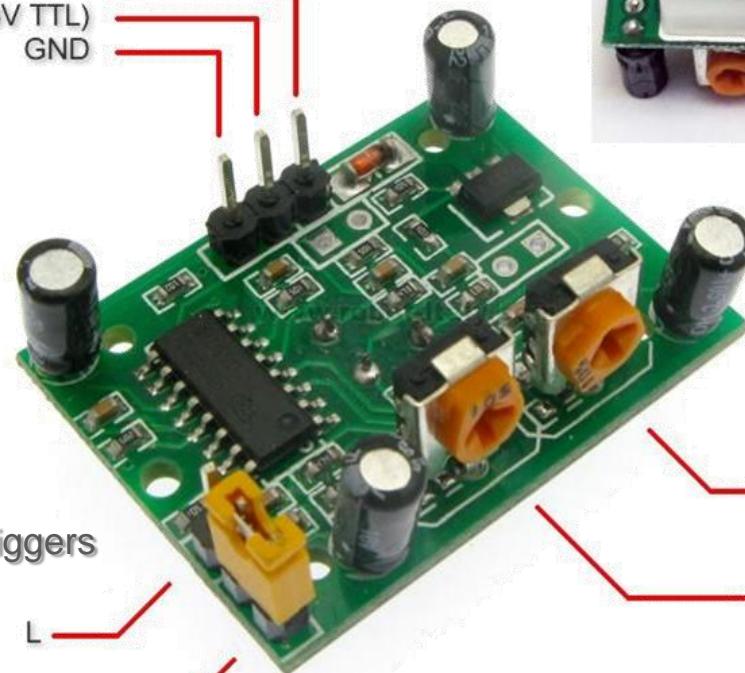
NodeMCU part Source: <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

fritzing

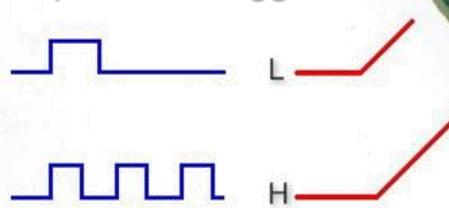
PIR Motion Sensor – HCR501



VCC 5-12VDC
OUT (3.3V TTL)
GND



Setting for Single or Repeatable Triggers



Delay Time Adjust
Distance Adjust

Image Source: https://c.76.my/Malaysia/hc-sr501-motion-sensor-arduino-ir-bodypassive-infrared-sensor-module-redbean77-1711-20-F625876_1.jpg

PIR Motion Sensing

Fresnel Lens Focusing

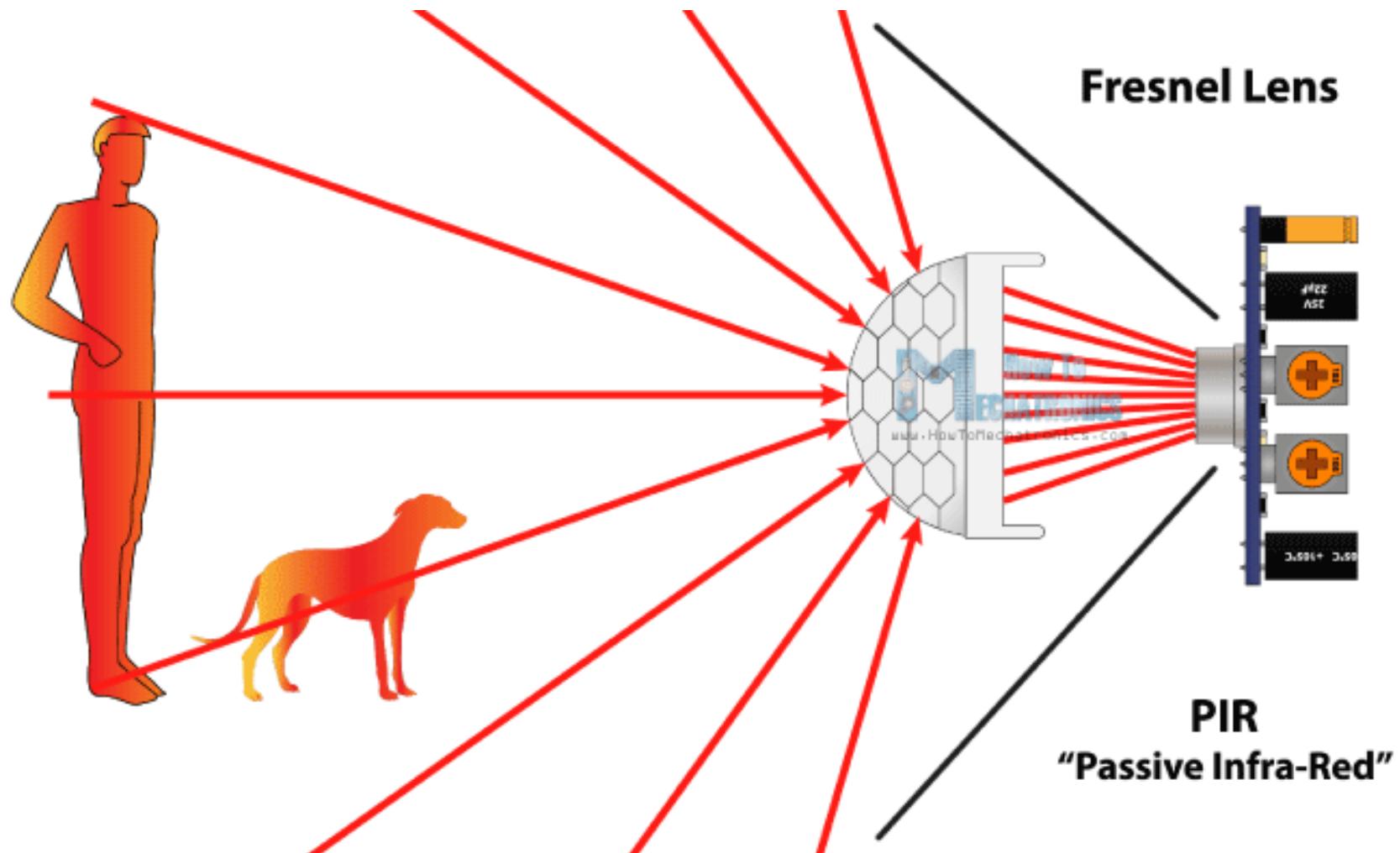


Image Source: <https://howtomechatronics.com/wp-content/uploads/2015/09/PIR-Motion-Sensor-How-It-Works.png>

PIR Motion Sensing

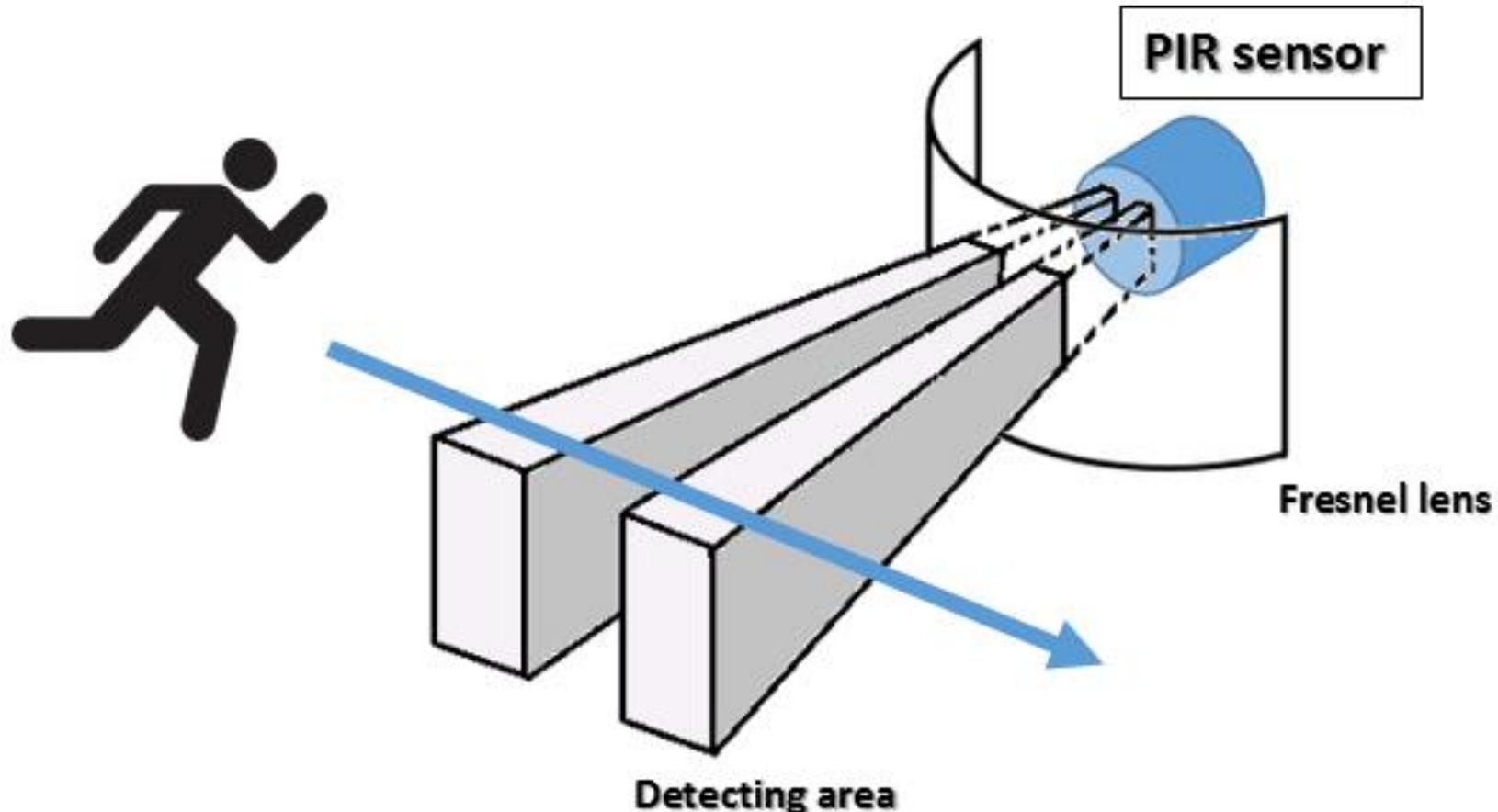


Image Source: <https://static1.squarespace.com/static/557f31e6e4b0971f7f8bcac6/t/5b04a73e352f53cc9e14f413/1527031679239/Meccanismo-Complesso-PIR-sensor-how-to.png>

DIY Experiments with NodeMCU

Interfacing PIR Motion Sensor – HCR501

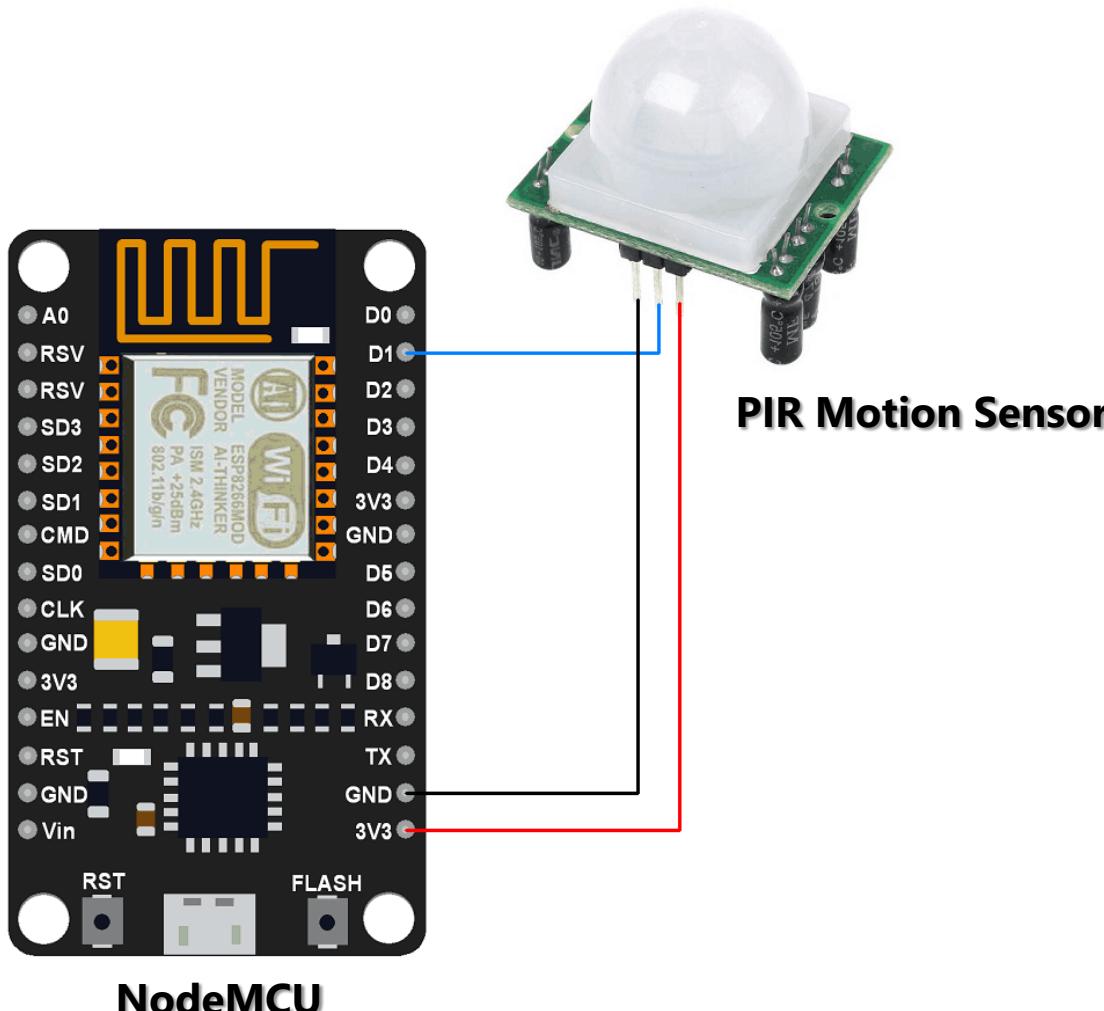
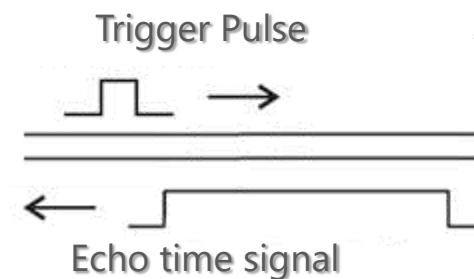


Image Source: <http://www.electronicwings.com>

Ultrasonic Sensor – HC-SR04



HC-SR04



Working of HC-SR04

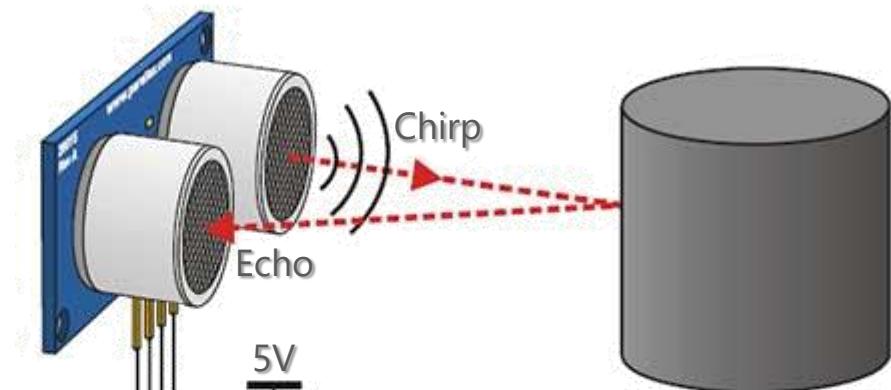


Image Source:: <https://cdn2.bjultrasonic.com/wp-content/uploads/2017/04/Ultrasonic-Sensors.jpg>

Ultrasonic Sensor HC-SR04

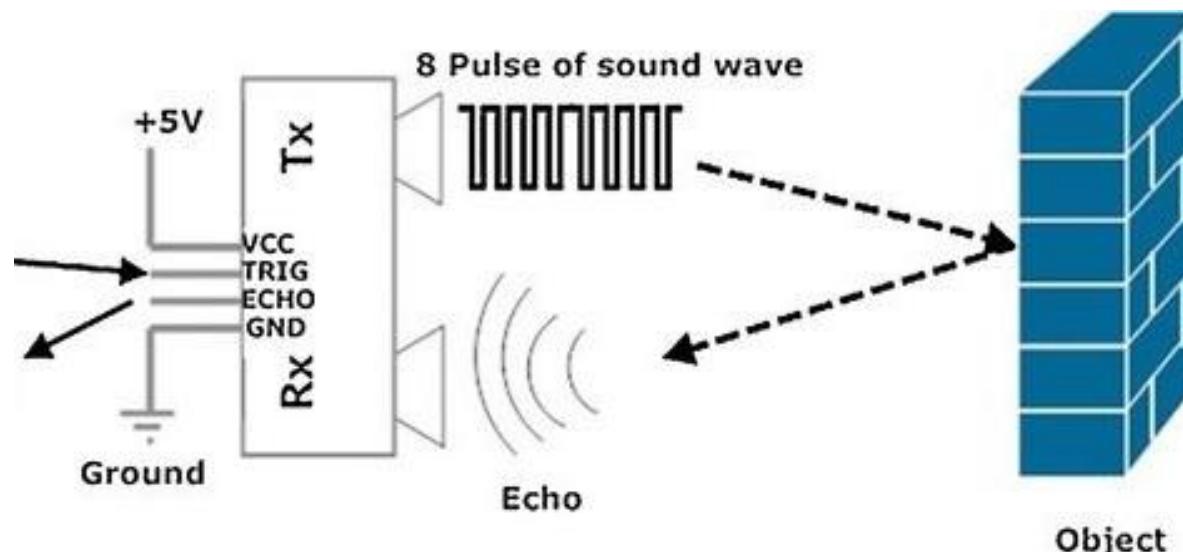
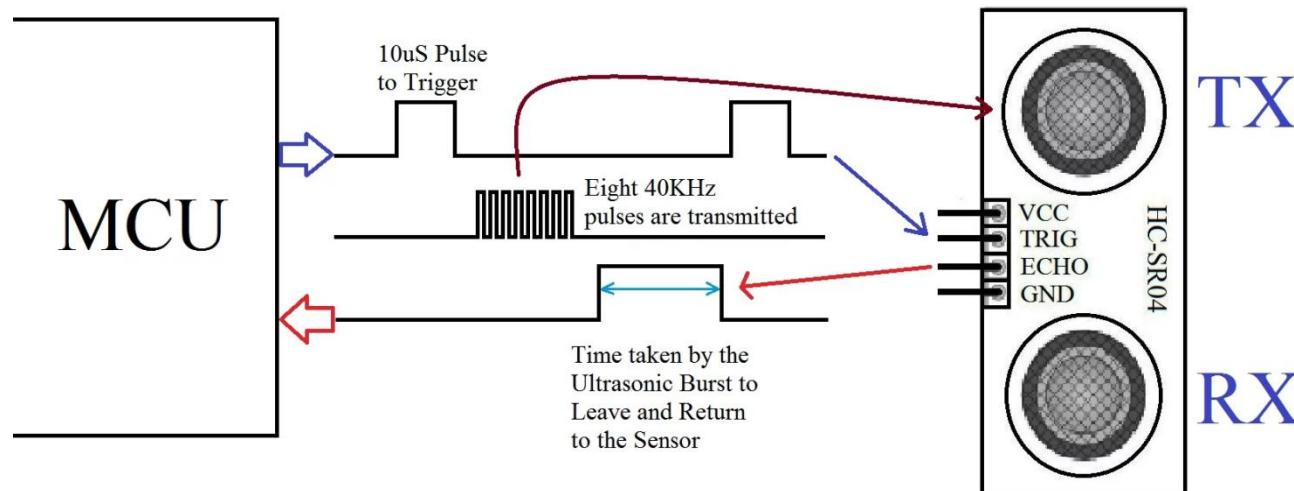


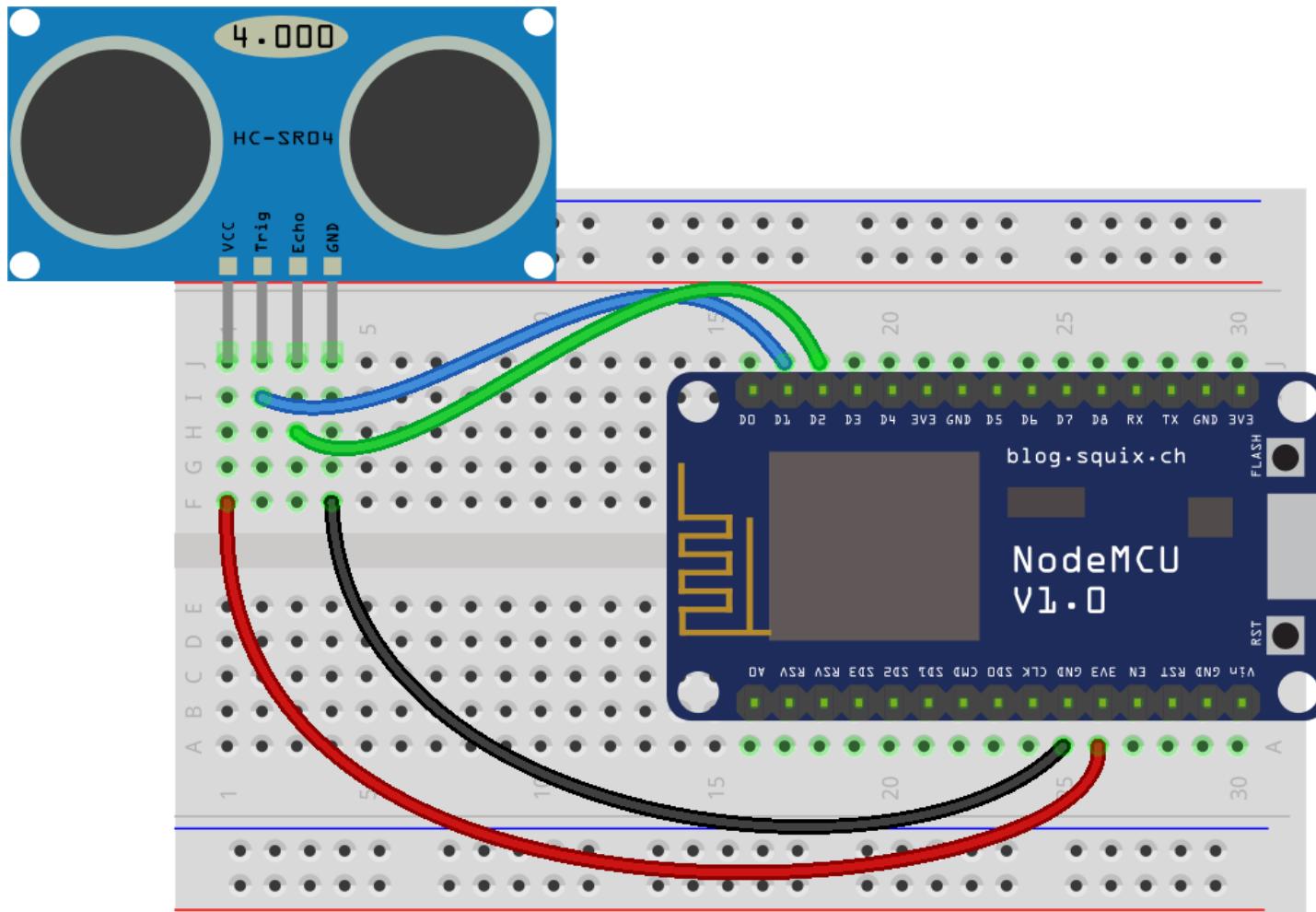
Image Source:

<https://electrosome.com/wp-content/uploads/2014/08/Working-of-HC-SR04-Ultrasonic-Sensor.jpg>

https://www.researchgate.net/figure/Working-principle-of-an-ultrasonic-sensor_fig1_304822025

DIY Experiments with NodeMCU

Interfacing Ultrasonic Sensor



Layout designed using Fritzing® - <http://fritzing.org>
NodeMCU part Source: <https://github.com/squix78/esp8266-fritzing-parts/tree/master/nodemcu-v1.0>

fritzing

Cloud Platforms

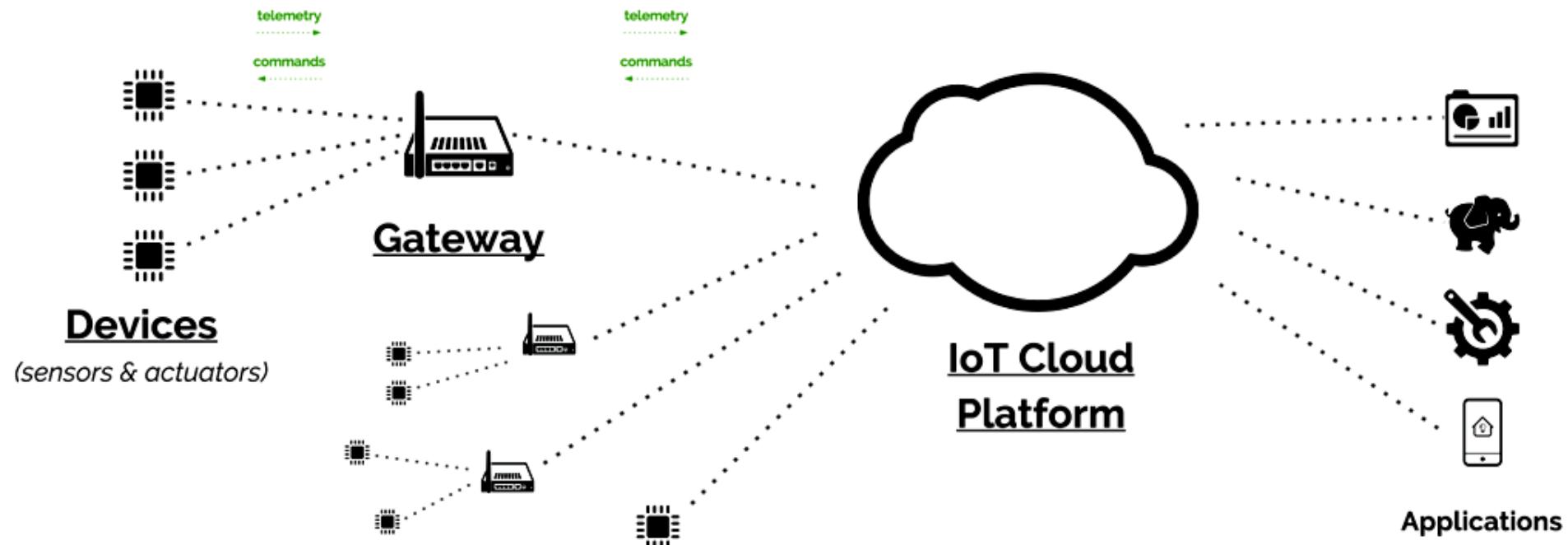
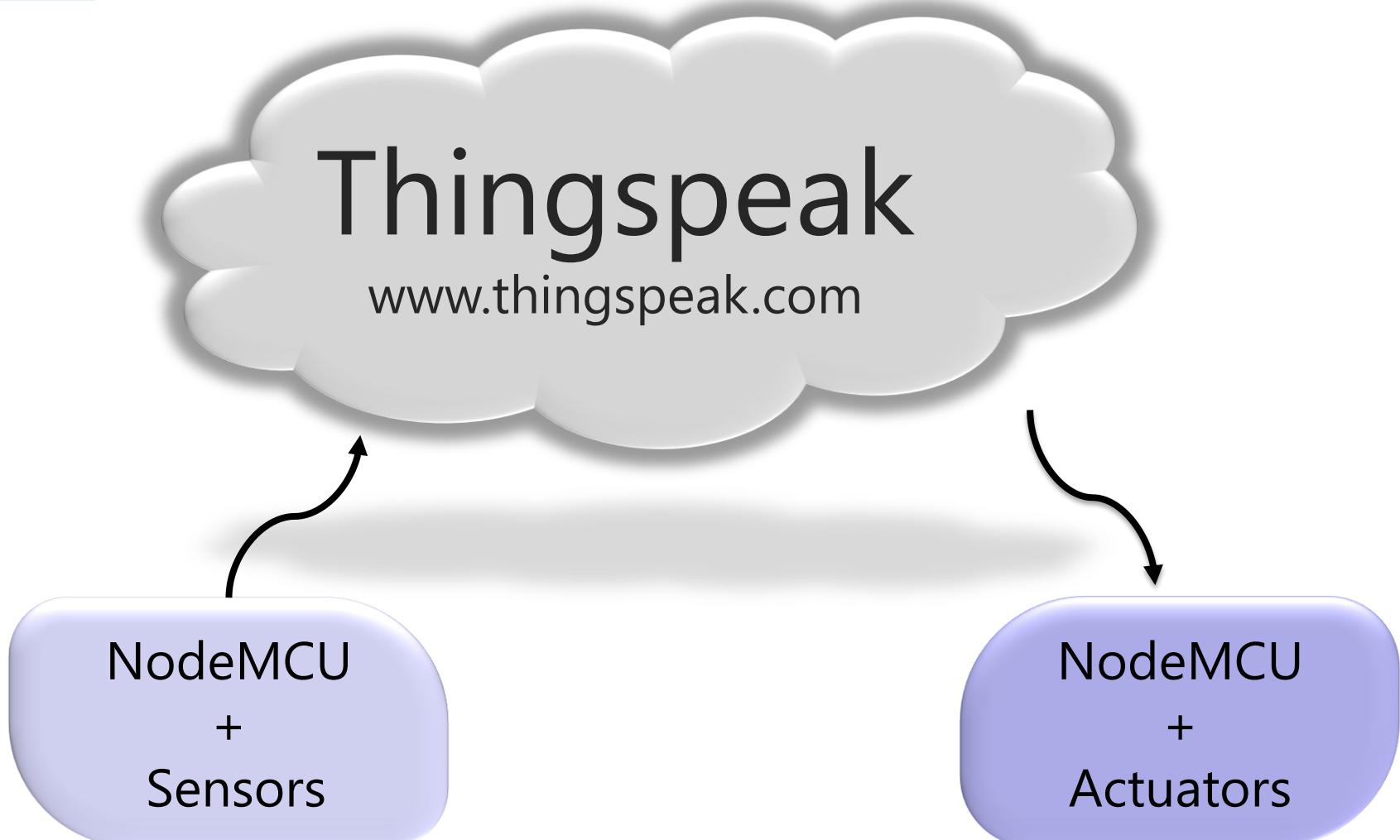


Image Source: <https://iot.eclipse.org/resources/white-papers/iot-architectures/image/IoT-arch.png>

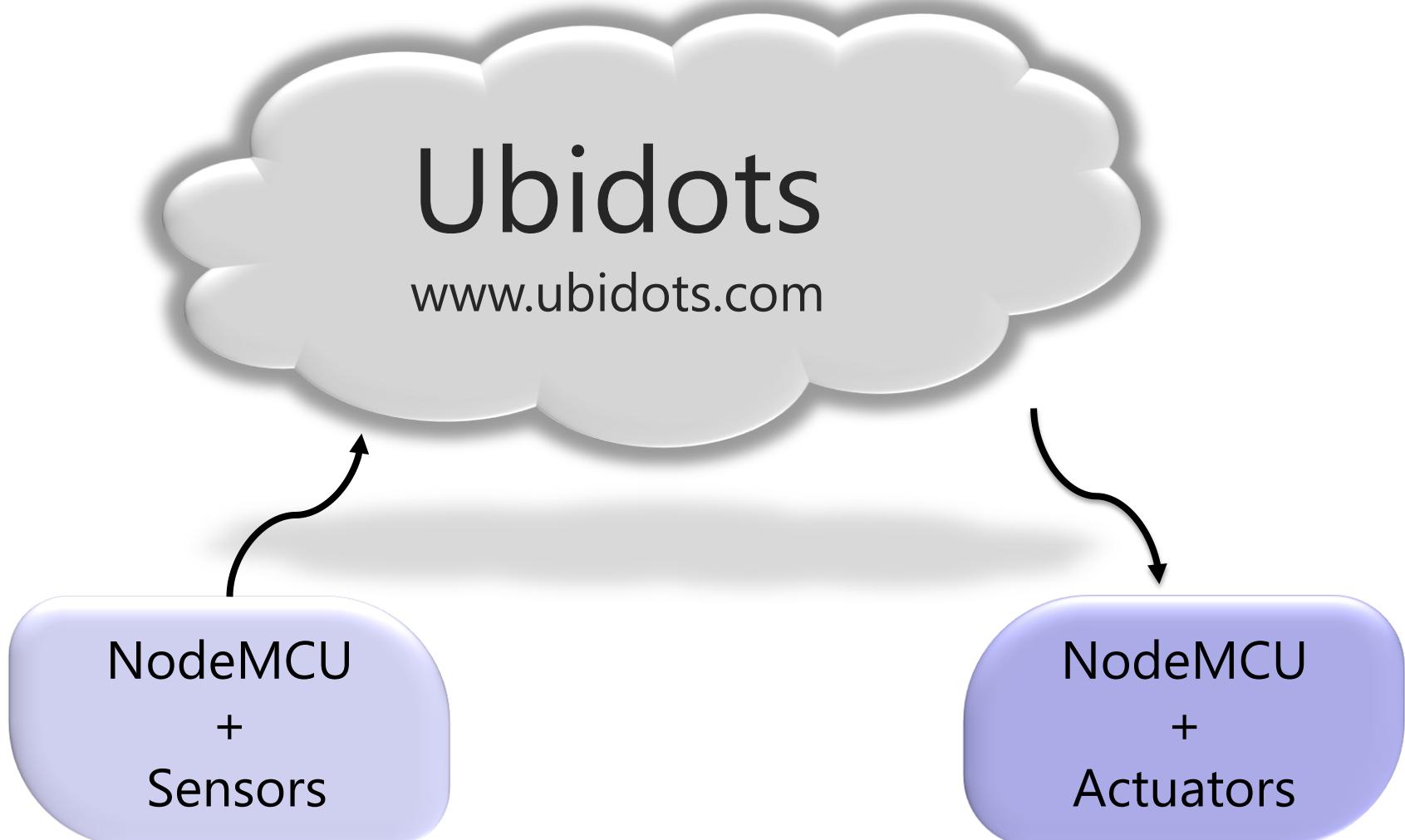
Cloud Platforms



IoT Projects

Application of IoT in Smart Cities Use Case: Urban Waste Management

Cloud Platforms



DIY Experiments with NodeMCU

Interfacing Temperature & Humidity Sensor

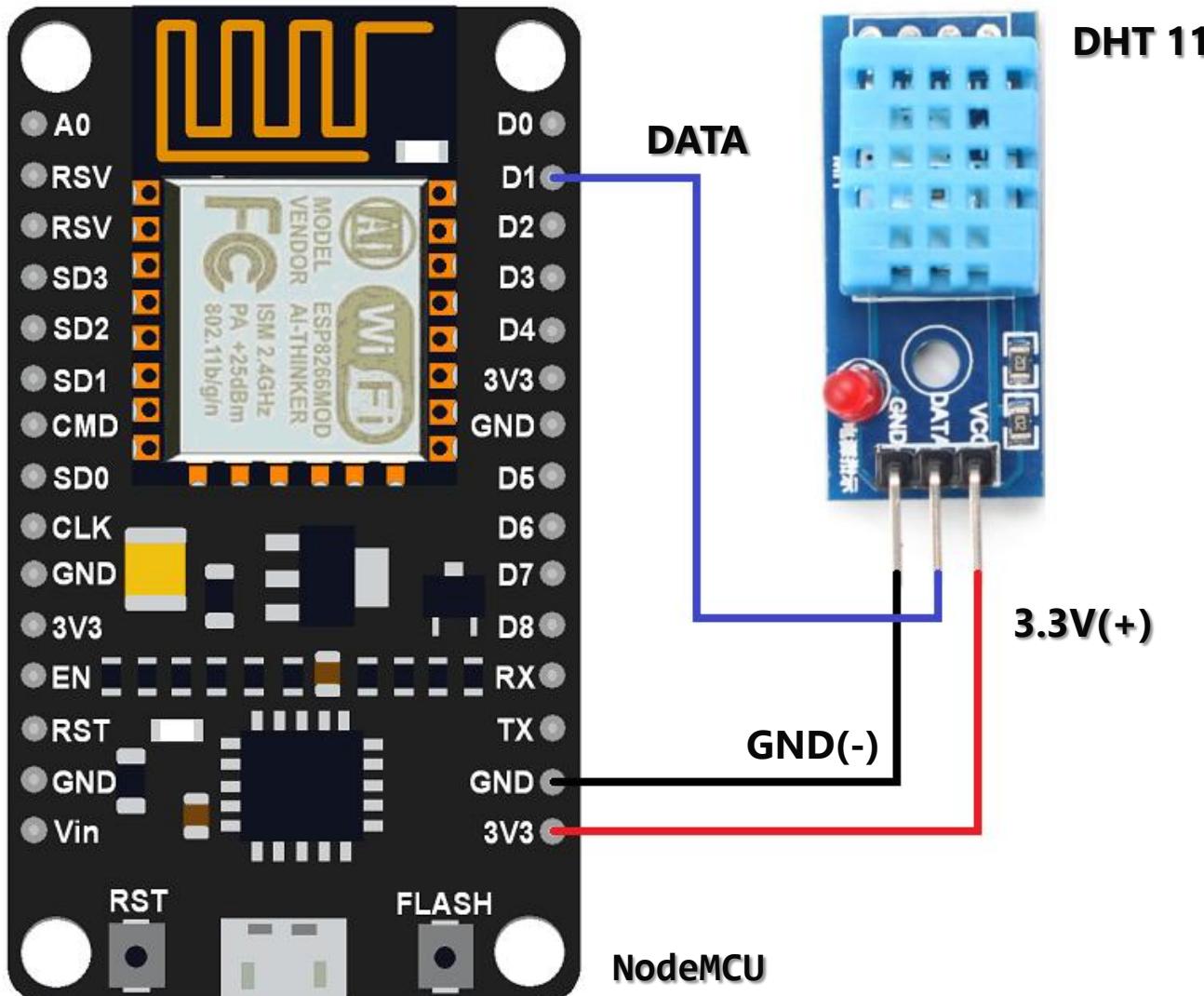


Image Source: <https://www.makerfabs.com>

Application of IoT in Home Automation

Use Case: Remote Switching of Air Conditioner

Thank You 😊