Internet
of
Things
Master Class
Day 3

M.K.Jeevarajan
www.pantechsolutions.net

What you will learn Today

- ✓ What is Node MCU ,ESP32,ESP32CAM
- ✓ Features of Node MCU , ESP32,ESP32CAM
- ✓ PINOUT of Node MCU , ESP32,ESP32CAM
- ✓ UART,SPI, IIC —How it works
- ✓ IoT Applications

About Pantech Prolabs India Pvt Ltd

- ✓ Started in the Year 2004
- ✓ Lab equipments and Sensor Interface
- ✓ Manufacturer of Brainsense EEG Headset
- ✓ Reconfigurable Algorithms on AI
- ✓ Manufacture of AI development Boards
- ✓ Power electronics, Fuel cell and Renewable Energy trainers
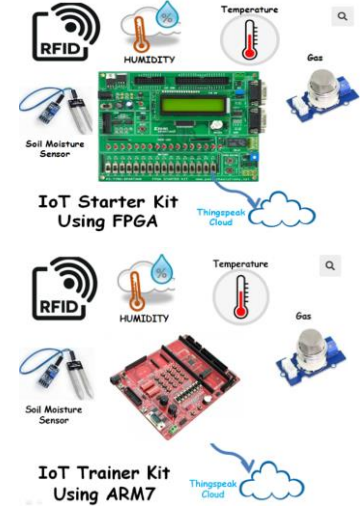
Vision

To help 10 Million students around the globe to learn technology in a easy way

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IoT Starter Kit Using FPGA

IoT Trainer Kit Using ARM7

About me

Education

College of Engineering, Guindy
Masters of Engineering, Applied Electronics
2002 – 2004

Govt College of Engg,Bargur
Bachelor of Engineering (B.E.), Electrical, Electronics and Communications Engineering, A
1998 – 2002

My Primary Expertise
Microcontroller Architecture: 8051,PIC,AVR,ARM,MSP430,PSOC3
DSP Architecture: Blackfin,C2000,C6000,21065L Sharc
FPGA: Spartan,Virtex,Cyclone
Image Processing Algorithms: Image/Scene Recognition, Machine Learning, Computer Vision, Deep Learning,
Pattern Recognition, Object Classification ,Image Retrieval, Image enhancement and denoising.
Neural Networks : SVM,RBF,BPN
Cryptography :RSA,DES,3DES,Ellipti curve,Blowfish,Diffe Hellman
Compilers: Keil,Visual DSP++,CCS, Xilinx Platform studio,ISE, Matlab, Open CV

https://www.linkedin.com/in/jeevarajan/   www.pantechsolutions.net

Announcement

- Attendance Link at 9 pm
- Minimum attendance required for an E-Certificate is 27 Days. Attendance link will be valid for 1 hrs. after the event.
- For Internship Candidates no attendance required ,it will be accessed from the LMS Portal. (learn.pantechsolutions.net)
- **Recorded Video Streaming for LAB classes** to improve Learning Experience
- PPT in facebook group
- Source code and projects available download only for Internship canditates

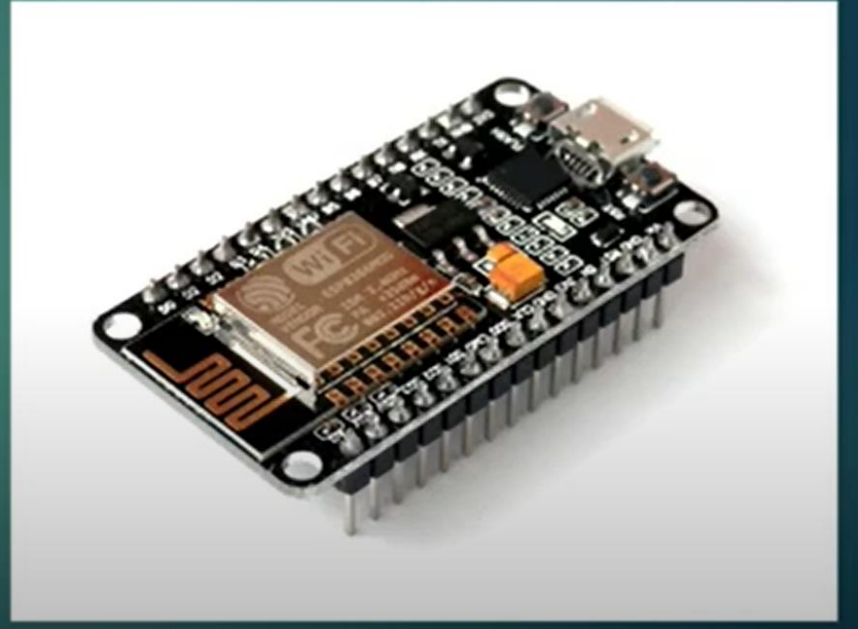# Mindset Lesson for the Day

Formal Education will make you Living
Self Education will bring you Fortune.
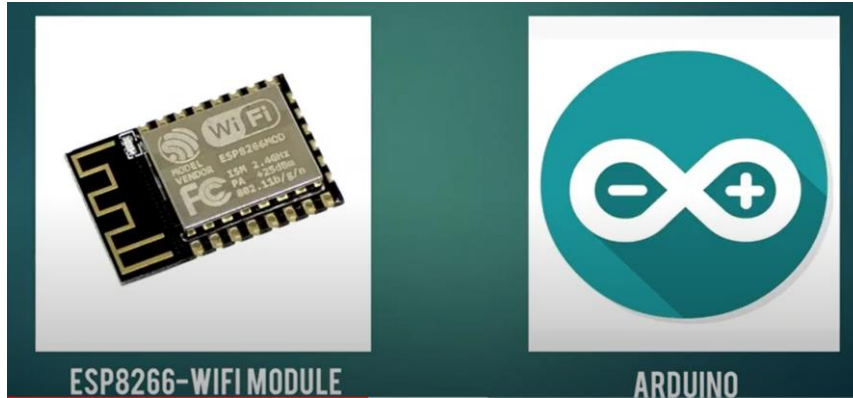   -Jim Rohn

List down the learning and investment needed to achieve Your Goal.

What is NodeMCU

▶ Low cost open source Iot platform

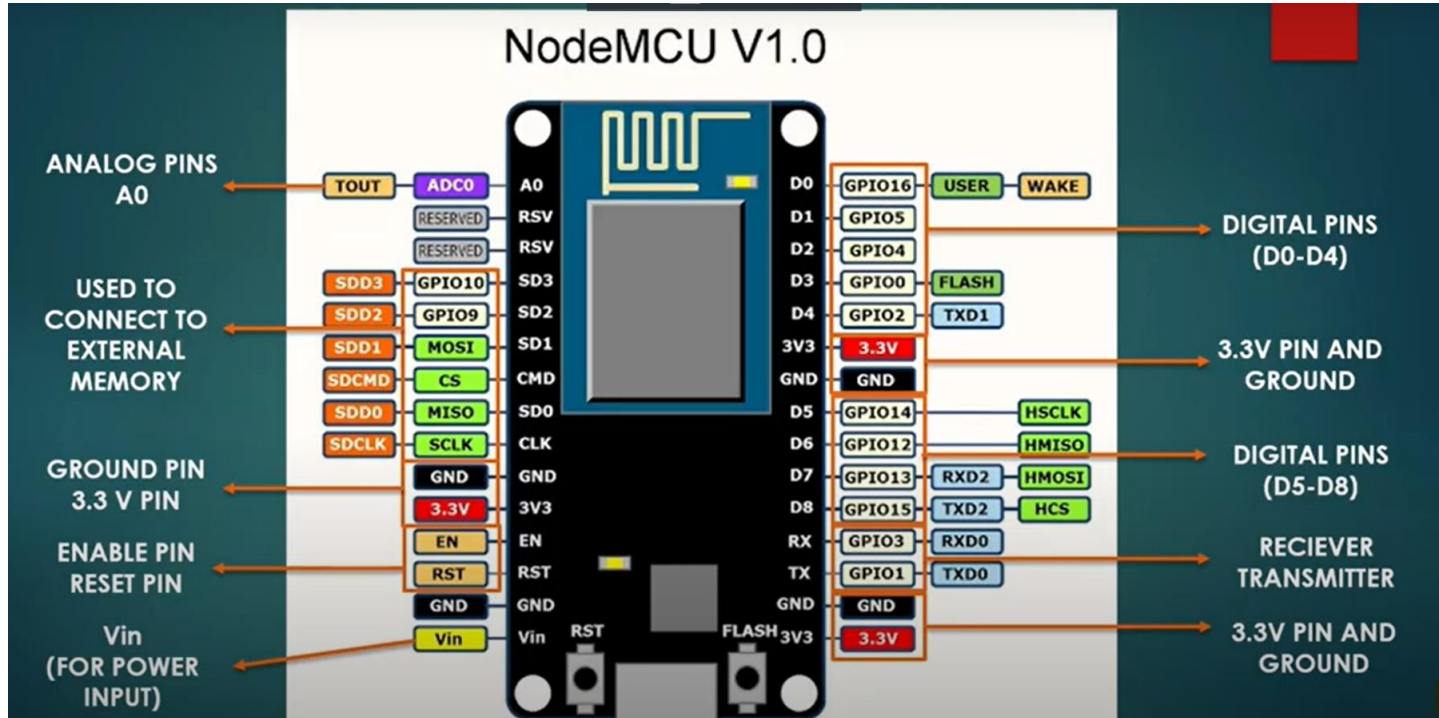▶ MCU-MicroController Unit

▶ Firmware + hardware based on ESP8266

Why is so Popular

✓**Cheap**
✓**Powerful**
✓**Low Power consumption**

Node MCU V 1.0

ESP8266

- 32-bit RISC CPU: Tensilica Xtensa LX106 running at 80 MHz
- 64 KiB of instruction RAM, 96 KiB of data RAM
- External QSPI flash - 512 KiB to 4 MiB
- IEEE 802.11 b/g/n Wi-Fi
    - WEP or WPA/WPA2 authentication, or open networks
- 16 GPIO pins
    - SPI, I²C,
    - I²S interfaces with DMA (sharing pins with GPIO)
    - UART on dedicated pins, plus a transmit-only UART can be enabled on GPIO2
    - 1x10-bit ADC
    - 3xPWM

What is ESP32

- ESP32 is an evaluation board designed by Espressif Systems. ESP series of microcontrollers are very powerful controllers with very high clock speeds, wireless connectivity, camera interfaces.

- It also has common peripherals and supports protocols like I2C, ADC, SPI, UART. As a whole, it is one step below the computer. It also supports different bootloaders. You can also install **"Circuit Python"** which is a python version especially used to programme microcontrollers.

- This evaluation board might look similar to NodeMCU, but it is entirely different when coming to specifications.

- This board has a 5V to 3.3V voltage regulator, CP2102 USB to UART converter which is used to programme the ESP32.
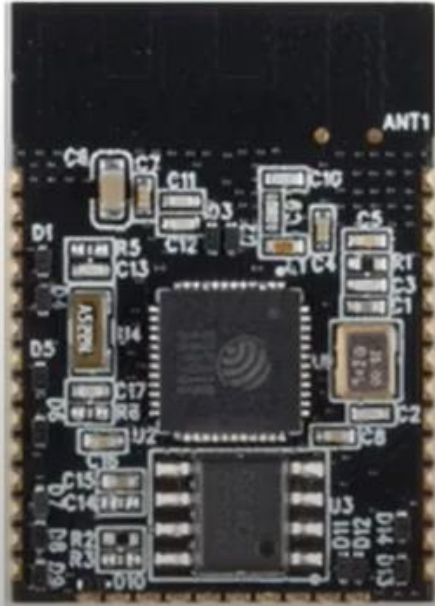
What is ESP32

- The special features of ESP32 are the architecture of microcontroller and the number of wireless connectivities

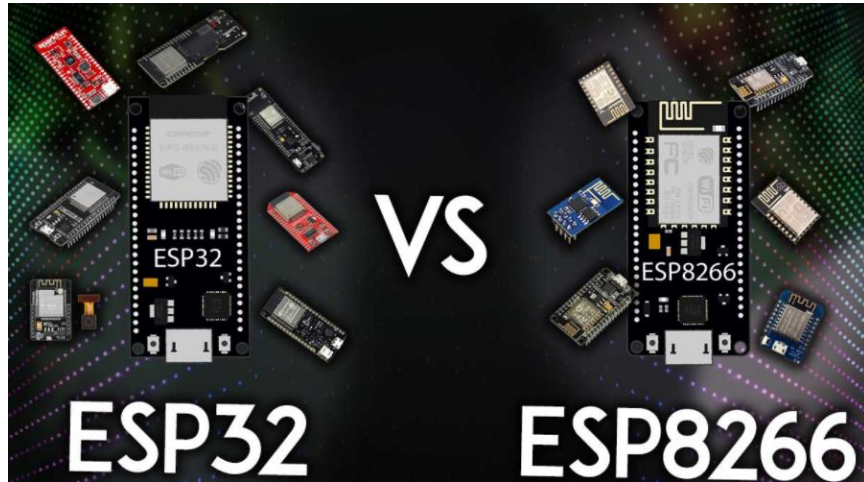- ESP32 has Wi-F Low Energy (BLE) connectivity features in it. All of these can happen thr oard.

- ESP32 comes w NA) filtering and impedance matching circuits making it extremely easy ign applications.

- It has 2 cores, performed at the same time making it extremely powerful. For i one core and simultaneously control a motor on the other core with

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ESP32 vs ESP8266

	ESP8266	ESP32
MCU	Xtensa Single-core 32-bit L106	Xtensa Dual-Core 32-bit LX6 with 600 DMIPS
802.11 b/g/n Wi-Fi	HT20	HT40
Bluetooth	X	Bluetooth 4.2 and BLE
Typical Frequency	80 MHz	160 MHz
SRAM	X	✓
Flash	X	✓
GPIO	17	34
Hardware /Software PWM	None / 8 channels	None / 16 channels
SPI/I2C/I2S/UART	2/1/2/2	4/2/2/2
ADC	10-bit	12-bit
CAN	X	✓
Ethernet MAC Interface	X	✓
Touch Sensor	X	✓
Temperature Sensor	X	✓(old versions)
Hall effect sensor	X	✓
Working Temperature	-40ºC to 125ºC	-40ºC to 125ºC

Softwares supported for Node MCU

- **Official NodeMCU firmware – LUA**
- Micropython – Python 3
- Espruino - Javascript
- Arduino
- Official ESP 8266 SDK
- Adafruit etc.

What is ESP32 CAM
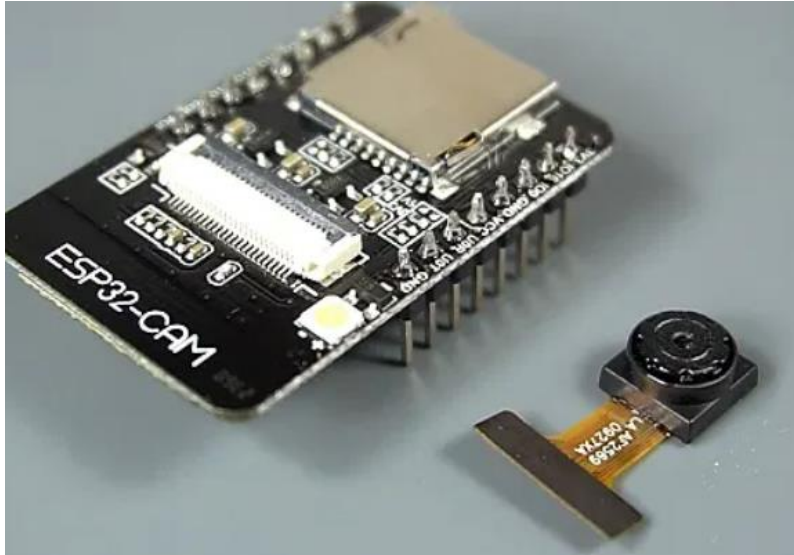
The **ESP32-CAM** is a very small camera module with the ESP32-S chip that costs approximately $10. Besides the OV2640 camera, and several GPIOs to connect peripherals, it also features a microSD card slot that can be useful to store images taken with the camera or to store files to serve to clients.

Block diagram

ESP32-S

IPEX block output

Tantalum capacitor

Reset

Voltage regulator chip

PSRAM

TF Card holder

Voltage regulator chip

FPC connector

Flash lamp

ESP32-CAM

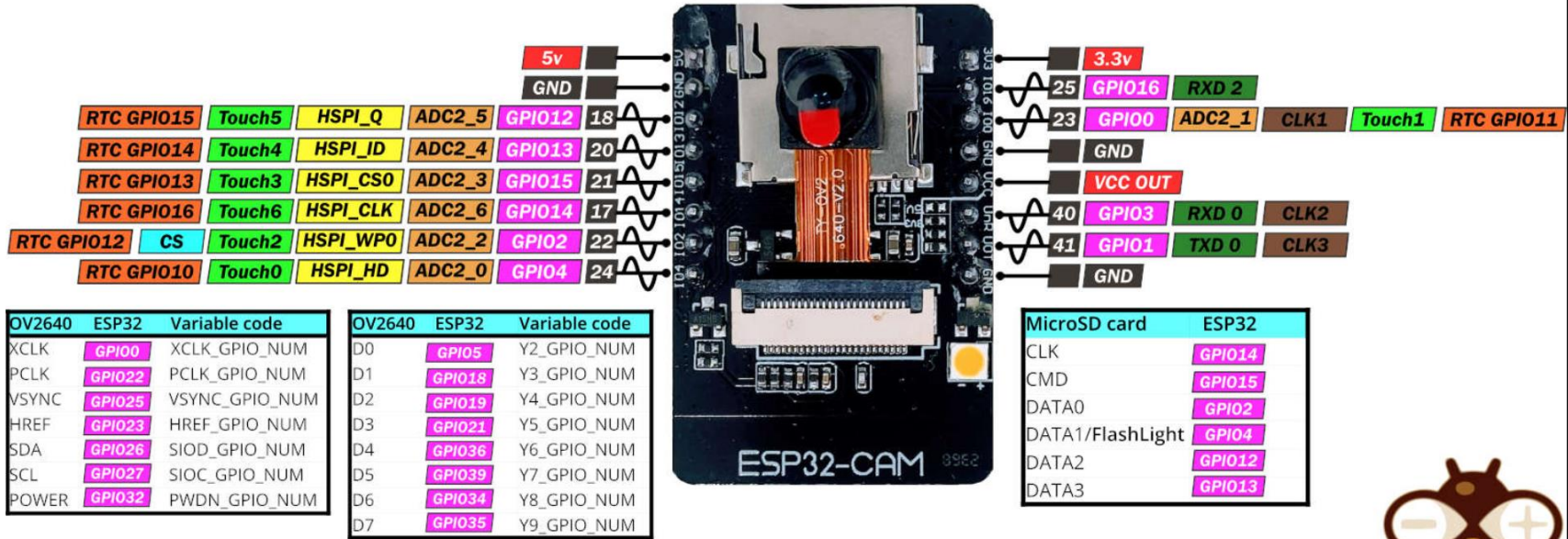# PIN OUT FOR ESP32CAM

5v					
GND					
RTC GPIO15	Touch5	HSPI_Q	ADC2_5	GPIO12	18
RTC GPIO14	Touch4	HSPI_ID	ADC2_4	GPIO13	20
RTC GPIO13	Touch3	HSPI_CS0	ADC2_3	GPIO15	21
RTC GPIO16	Touch6	HSPI_CLK	ADC2_6	GPIO14	17
RTC GPIO12	CS	Touch2	HSPI_WP0	ADC2_2	GPIO2	22
RTC GPIO10	Touch0	HSPI_HD	ADC2_0	GPIO4	24

3.3v				
25	GPIO16	RXD 2		
23	GPIO0	ADC2_1	CLK1	Touch1	RTC GPIO11
GND				
VCC OUT				
40	GPIO3	RXD 0	CLK2	
41	GPIO1	TXD 0	CLK3	
GND				

OV2640	ESP32	Variable code
XCLK	GPIO0	XCLK_GPIO_NUM
PCLK	GPIO22	PCLK_GPIO_NUM
VSYNC	GPIO25	VSYNC_GPIO_NUM
HREF	GPIO23	HREF_GPIO_NUM
SDA	GPIO26	SIOD_GPIO_NUM
SCL	GPIO27	SIOC_GPIO_NUM
POWER	GPIO32	PWDN_GPIO_NUM

OV2640	ESP32	Variable code
D0	GPIO5	Y2_GPIO_NUM
D1	GPIO18	Y3_GPIO_NUM
D2	GPIO19	Y4_GPIO_NUM
D3	GPIO21	Y5_GPIO_NUM
D4	GPIO36	Y6_GPIO_NUM
D5	GPIO39	Y7_GPIO_NUM
D6	GPIO34	Y8_GPIO_NUM
D7	GPIO35	Y9_GPIO_NUM

MicroSD card	ESP32
CLK	GPIO14
CMD	GPIO15
DATA0	GPIO2
DATA1/FlashLight	GPIO4
DATA2	GPIO12
DATA3	GPIO13

ESP32-CAM

Programming of ESP32 CAM
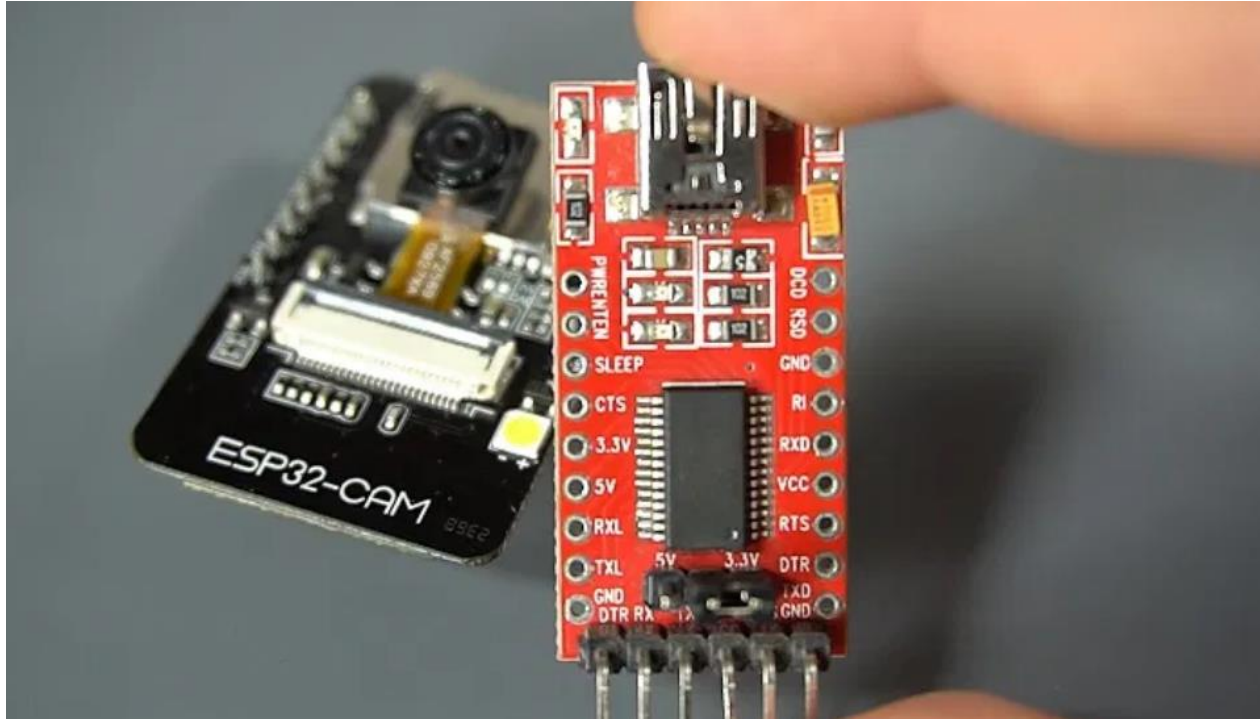
Features of ESP32CAM

- The smallest 802.11b/g/n Wi-Fi BT SoC module
- Low power 32-bit CPU,can also serve the application processor
- Up to 160MHz clock speed, summary computing power up to 600 DMIPS
- Built-in 520 KB SRAM, external 4MPSRAM
- Supports UART/SPI/I2C/PWM/ADC/DAC
- Support OV2640 and OV7670 cameras, built-in flash lamp
- Support image WiFi upload
- Support TF card
- Supports multiple sleep modes
- Embedded Lwip and FreeRTOS
- Supports STA/AP/STA+AP operation mode
- Support for serial port local and remote firmware upgrades (FOTA)

WHAT IS UART

- Universal asynchronous receiver and Transmitter
- Serial port, COM port, RS232, RS485
- VERY COMMON AND SIMPLE
- Useful for communication to

    - Microcontroller

    - Computer

    - Other FPGA

# Asynchronous Vs Synchronous

Asynchronous *v.s.* Synchronous

— Asynchronous transfer does not require clock signal. However, it transfers extra bits
  (start bits and stop bits) during data communication
— Synchronous transfer does not transfer extra bits. However, it requires clock signal
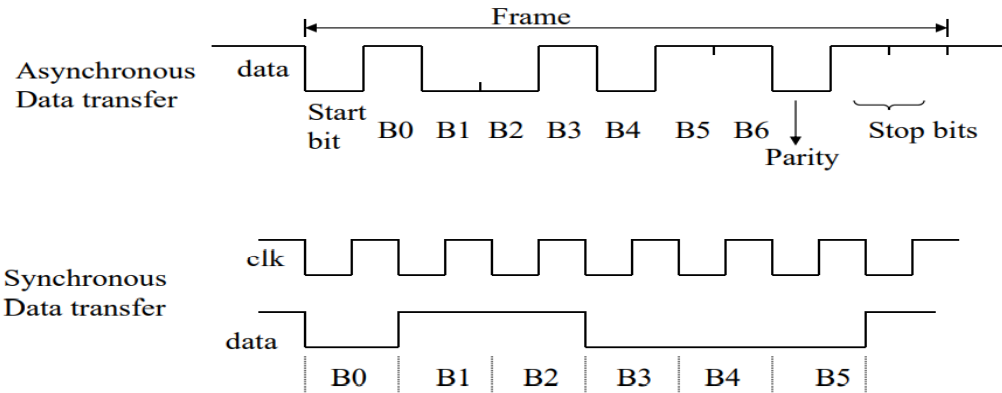
Two methods of serial communication are

- Synchronous Communication: Transfer of bulk data in the framed structure at a time
- Asynchronous Communication: Transfer of a byte data in the framed structure at a time
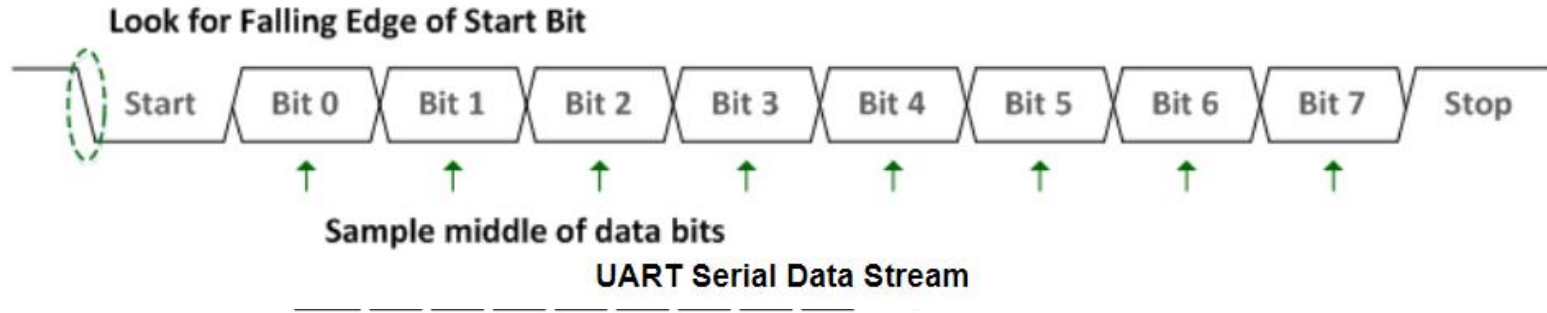
UART
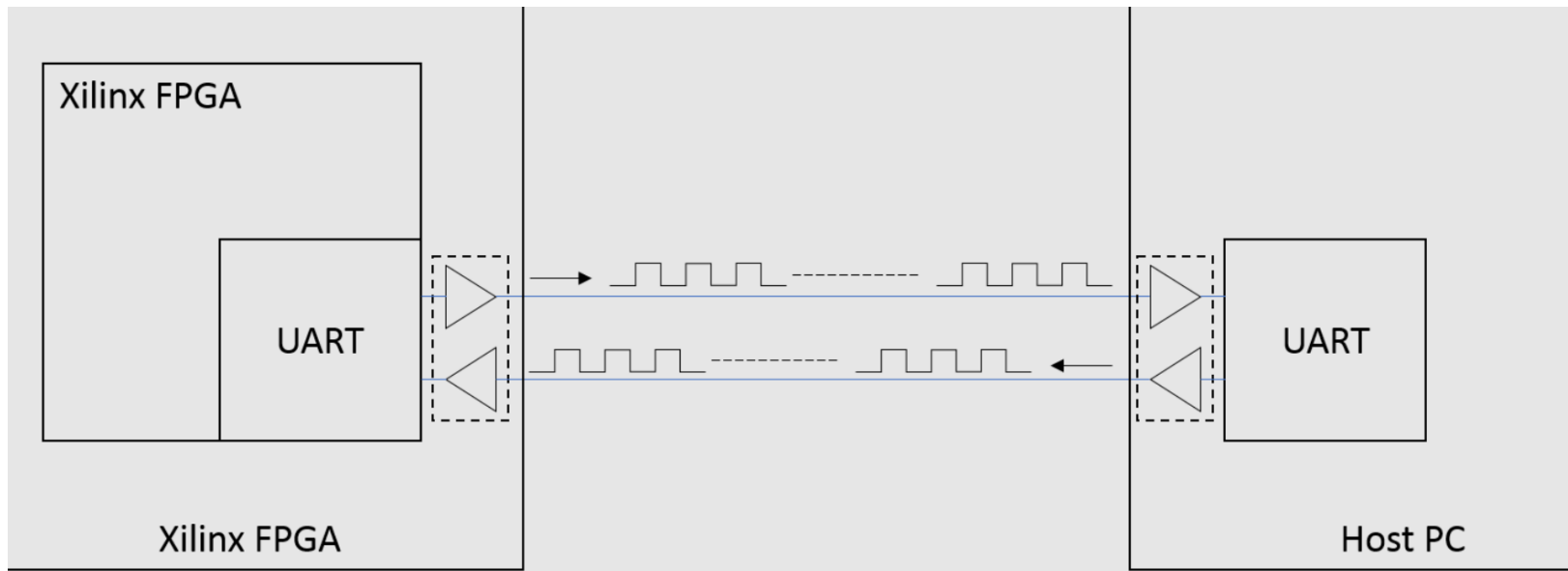
UART PARAMETERS

- Baud Rate   (9600, 19200, 115200, others)
- Number of Data Bits (7, 8)
- Parity Bit   (On, Off)
- Stop Bits   (0, 1, 2)
- Flow Control   (None, On, Hardware)

UART DATA STREAM EXAMPLE

Look for Falling Edge of Start Bit

| Start | Bit 0 | Bit 1 | Bit 2 | Bit 3 | Bit 4 | Bit 5 | Bit 6 | Bit 7 | Stop |

Sample middle of data bits

UART Serial Data Stream

❑ Signal is 1 (high voltage) when the system is idle

❑ Start bit is placed before the data and, optionally, stop bits are placed at the end of data
   Start bit is 0 and stop bits are 1

❑ LSB is first transmitted or received

❑ **Baud rate**: number of bits per second; frequently used baud rate: 9600, 19,200

❑ **Number of Data bits**

❑ **Stop bits**

❑ Whether parity check is enabled?

❑ Multiplication factor for clock, e.g. x8 clk (means baud rate x 8 = system clock freq.)

Introduction to SPI

✓ **Serial Peripheral Interface**

✓ Full-Duplex, Serial Communication Protocol.

✓ Synchronous Communication Protocol.

✓ Four Wire Communication Protocol.

✓ Single-master Multi-slave.

✓ Widely used for short-distance communication, primarily in Embedded System.

Master and Slave Mode
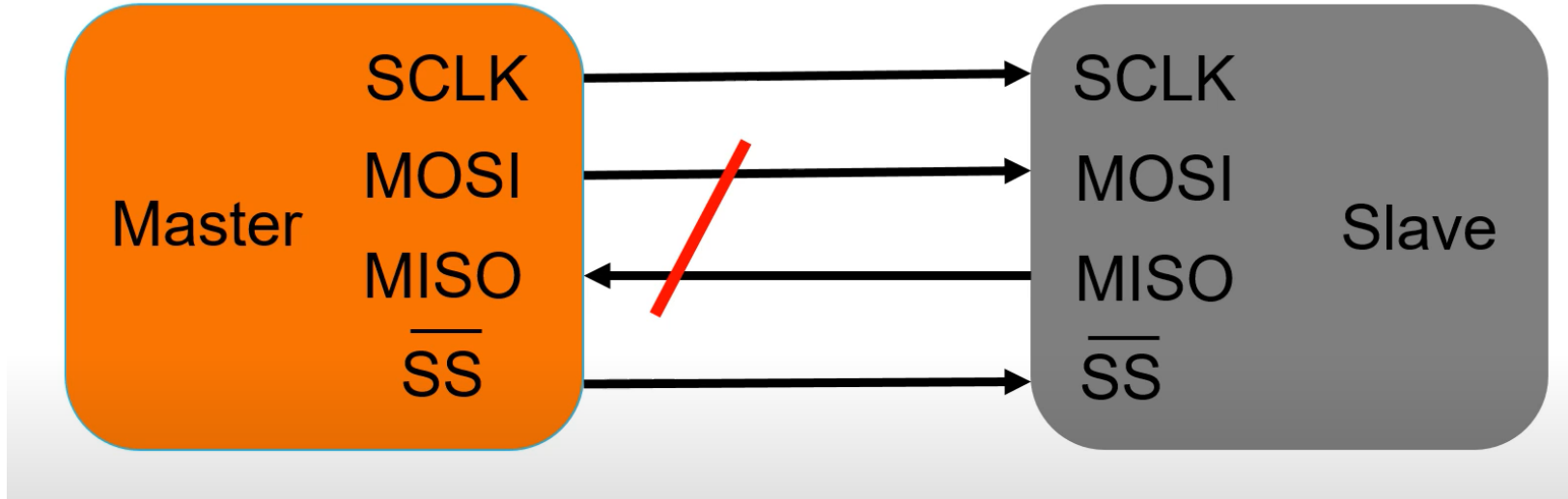
Master and Slave Mode –Multiple Slave
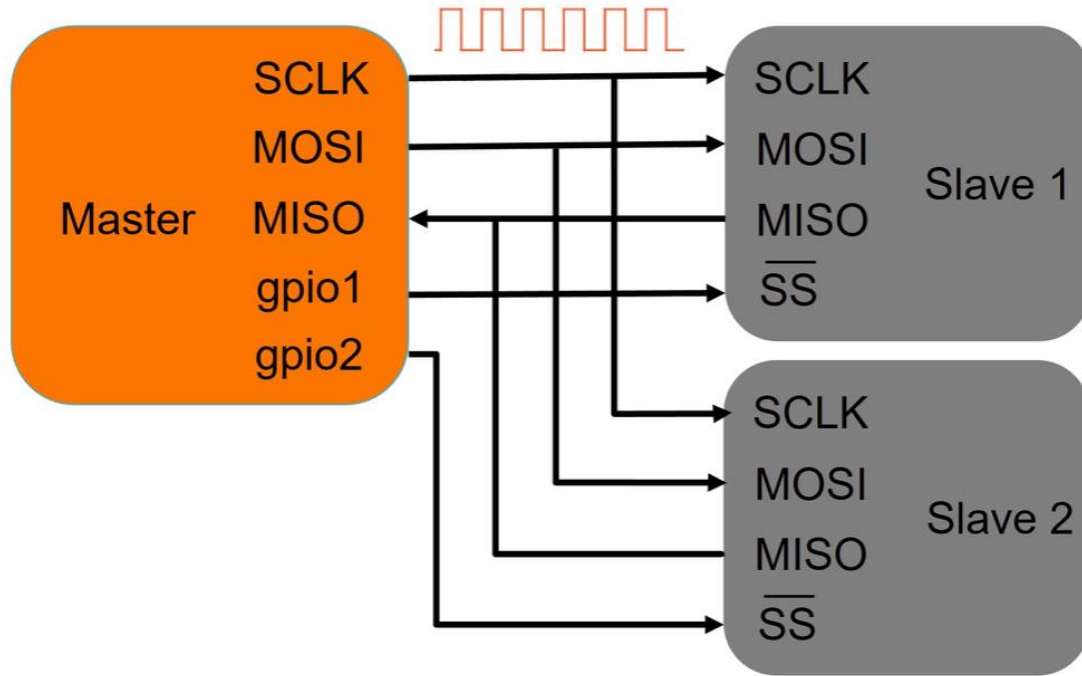
What is IIC

I^{2}C requires a mere two wires, like asynchronous serial, but those two wires can support up to 1008 peripheral devices. Also, unlike SPI, I^{2}C can support a multi-controller system, allowing more than one controller to communicate with all peripheral devices on the bus (although the controller devices can't talk to each other over the bus and must take turns using the bus lines).
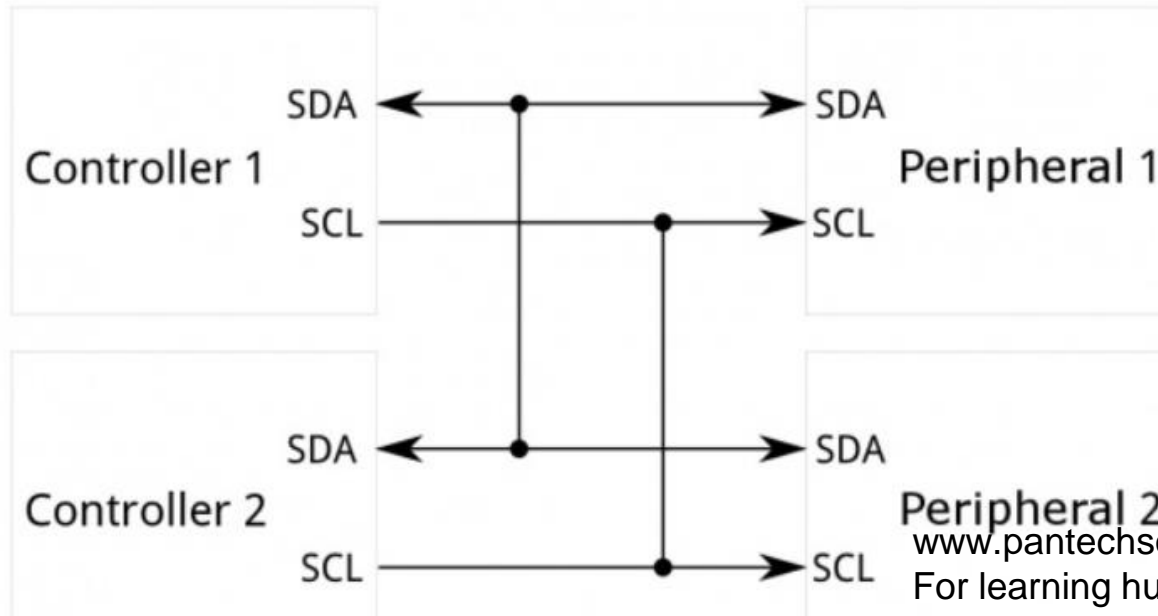
# Why Use I2C?

Disadvantage of Serial Port(UART)

- serial ports are asynchronous (no clock data is transmitted), devices using them must agree ahead of time on a data rate. The two devices must also have clocks that are close to the same rate

- Another core fault in asynchronous serial ports is that they are inherently suited to communications between two, and only two, devices. While it is possible to connect multiple devices to a single serial port, bus contention (where two devices attempt to drive the same line at the same time)

Disadvantage of SPI

- The most obvious drawback of SPI is the number of pins required. Connecting a single controller [1] to a single peripheral [1] with an SPI bus requires four lines; each additional peripheral device requires one additional chip select I/O pin on the controller.
- SPI only allows one controller on the bus,

I2C is Open Drain

- UART or SPI connections, the I2C bus drivers are "open drain", meaning that they can pull the corresponding signal line low, but cannot drive it high. Thus, there can be no bus contention where one device is trying to drive the line high while another tries to pull it low, eliminating the potential for damage to the drivers or excessive line has a pull-up en no device is
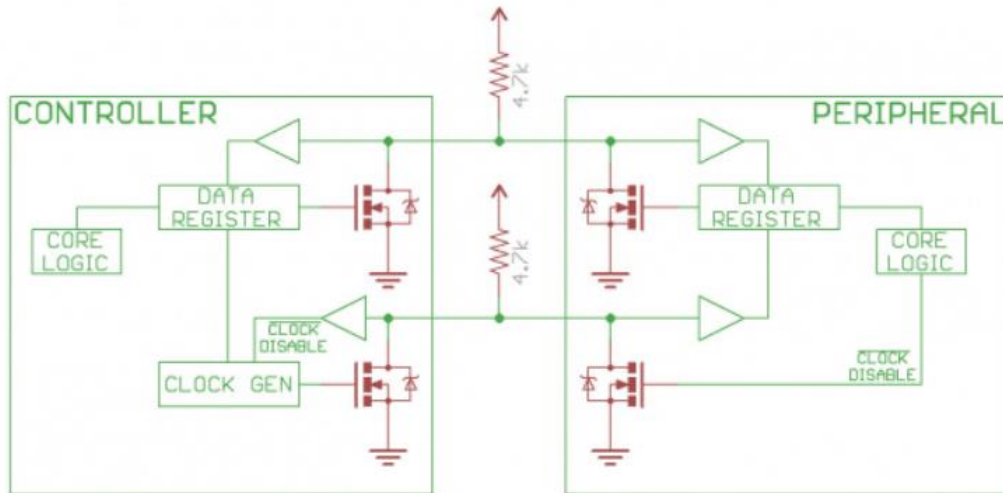
Features of I2C

- Half-duplex Communication Protocol
  Bi-directional communication is possible but not simultaneously.
- Synchronous Communication — The data is transferred in the form of frames or blocks.
  Can be configured in a multi-master configuration.
- **Arbitration** —
  I2C protocol supports multi-master bus system but more than one bus can not be used simultaneously. The SDA and SCL are monitored by the masters. If the SDA is found high when it was supposed to be low it will be inferred that another master is active and hence it stops the transfer of data.
- **Serial transmission**
  I2C uses serial transmission for transmission of data.
  Used for low-speed communication.

- **Clock Stretching**
  The clock is stretched when the slave device is not ready to accept more data by holding the SCL line low, hence disabling the master to raise the clock line. Master will not be able to raise the clock line because the wires are AND wired and wait until the slave releases the SCL line to show it is ready to transfer next bit.
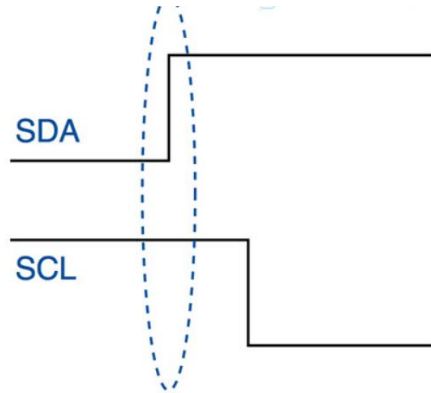
Start

- **Start Condition:** The SDA line switches from a high voltage level to a low voltage level *before* the SCL line switches from high to low.
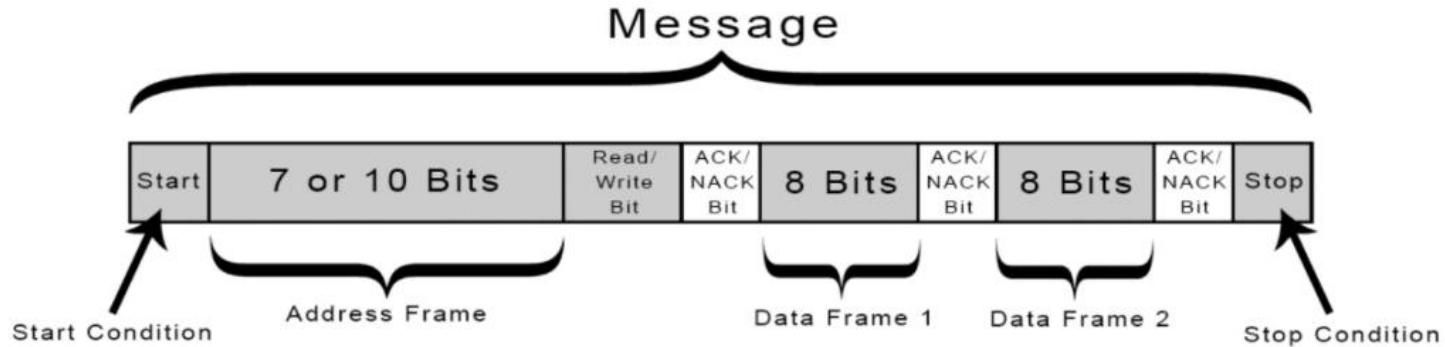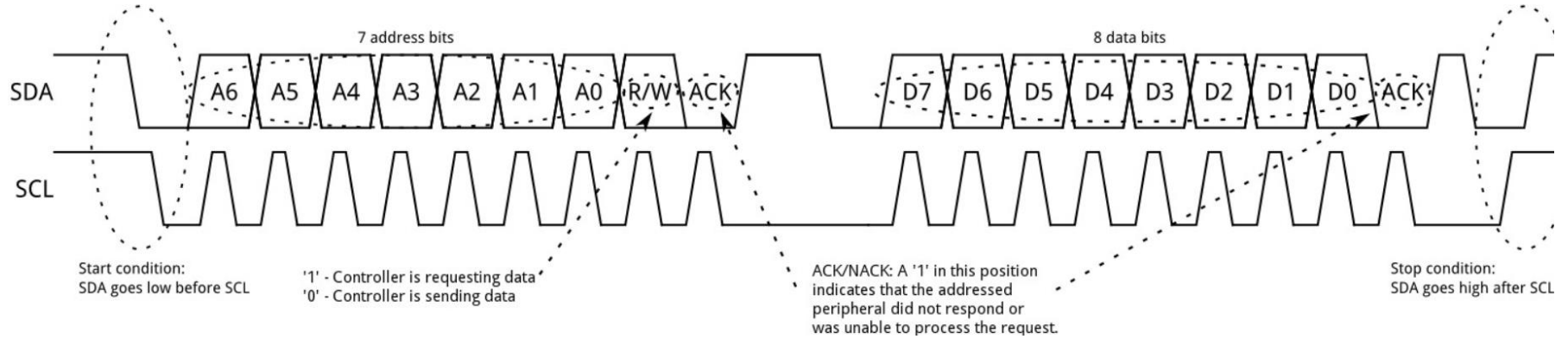

Start Condition
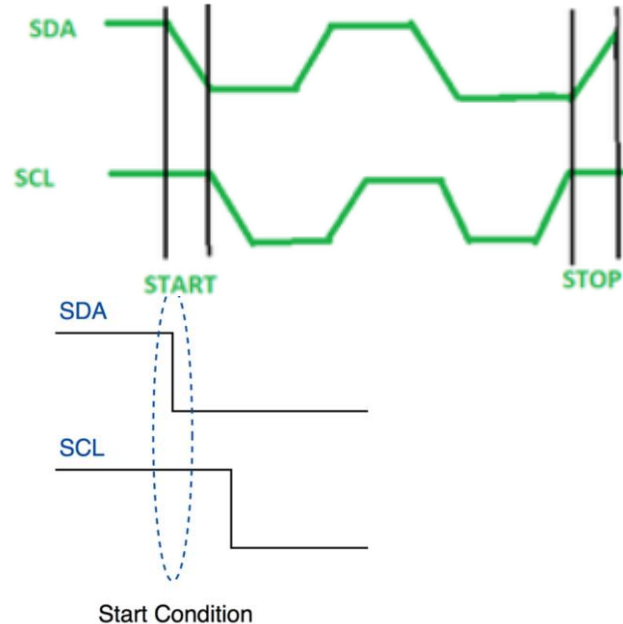
Stop

After required data blocks are transferred through the SDA line, the master device switches the SDA line from low voltage level to high voltage level before the SCL line switches from high to low.

SDA

SCL

Stop Condition

I2C – How it works

7 address bits

SDA | A6 | A5 | A4 | A3 | A2 | A1 | A0 | R/W | ACK | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | ACK

SCL

8 data bits

Start condition:
SDA goes low before SCL

'1' - Controller is requesting data
'0' - Controller is sending data

ACK/NACK: A '1' in this position
indicates that the addressed
peripheral did not respond or
was unable to process the request.

Stop condition:
SDA goes high after SCL

Message

| Start | 7 or 10 Bits | Read/Write Bit | ACK/NACK Bit | 8 Bits | ACK/NACK Bit | 8 Bits | ACK/NACK Bit | Stop |

Start Condition
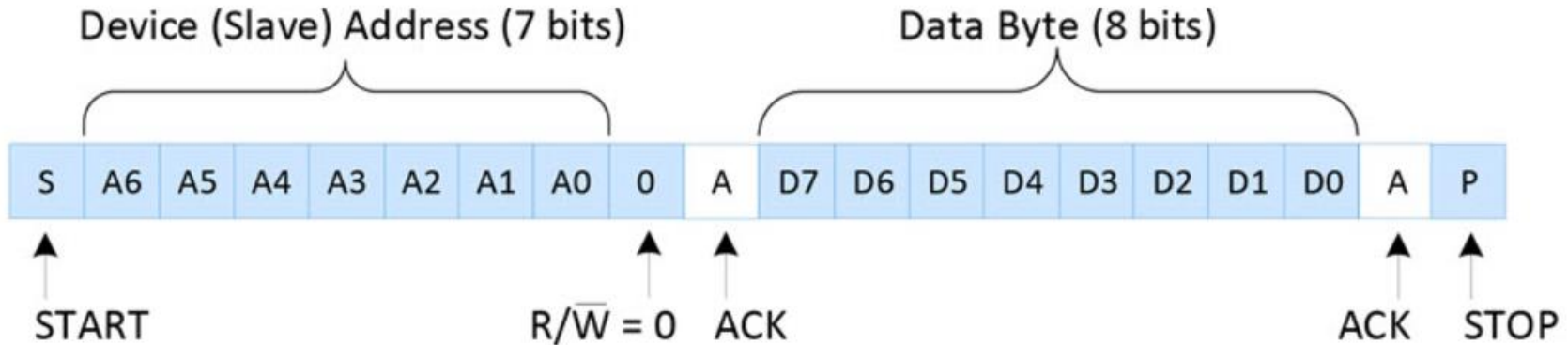
Address Frame

Data Frame 1

Data Frame 2

Stop Condition

Sending Data to a Slave Device

Master Controls SDA Line

Slave Controls SDA Line

Device (Slave) Address (7 bits)

Data Byte (8 bits)

| S | A6 | A5 | A4 | A3 | A2 | A1 | A0 | 0 | A | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 | A | P |

START

R/W̄ = 0   ACK

ACK   STOP

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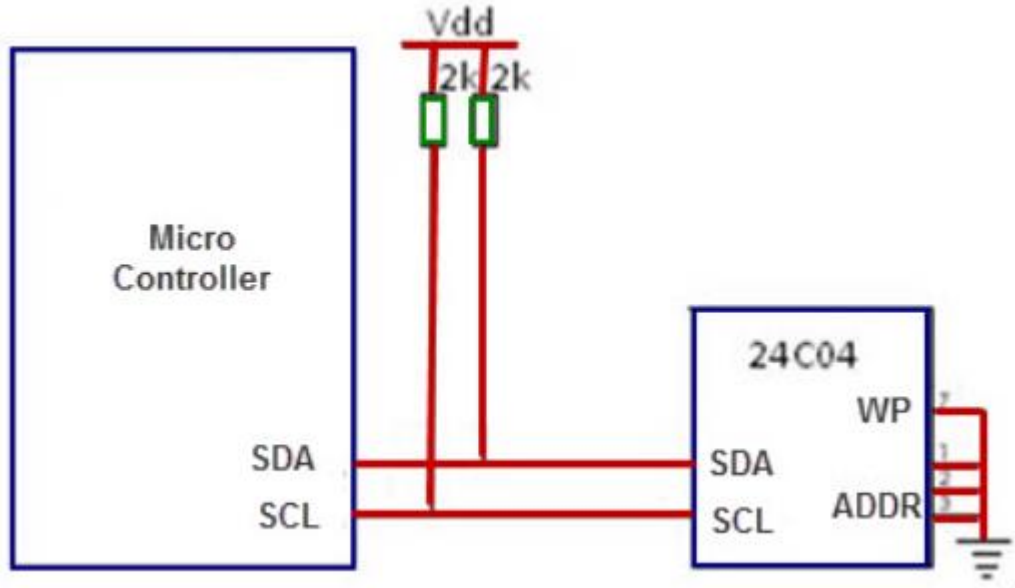For learning hub visit learn.pantechsolutions.net

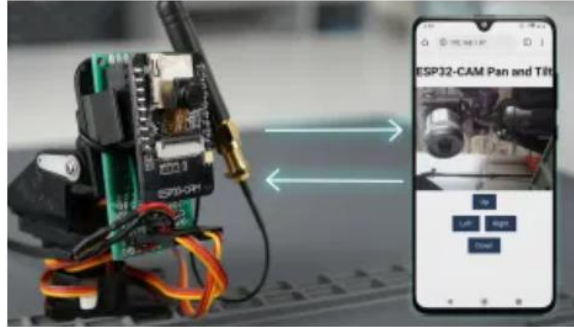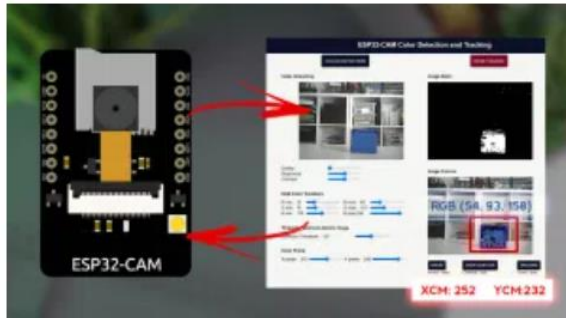# Reading Data from a Slave Device

Circuit Diagram

IoT applications with ESP32 CAM
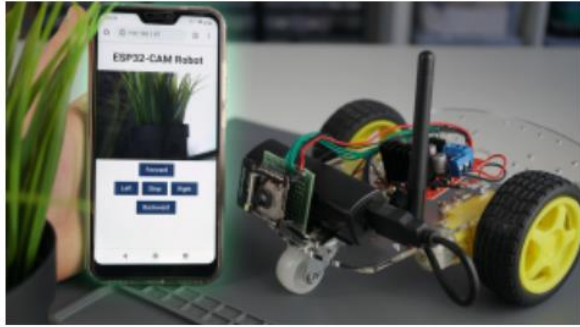
ESP32-CAM Remote Controlled Car Robot Web Server

ESP32-CAM Pan and Tilt Video Streaming Web Server (2 Axis)

ESP32-CAM Web Server with OpenCV.js: Color Detection and Tracking

ESP32-CAM with Telegram: Take Photos, Control Outputs, Request Sensor Readings and Motion Notifications
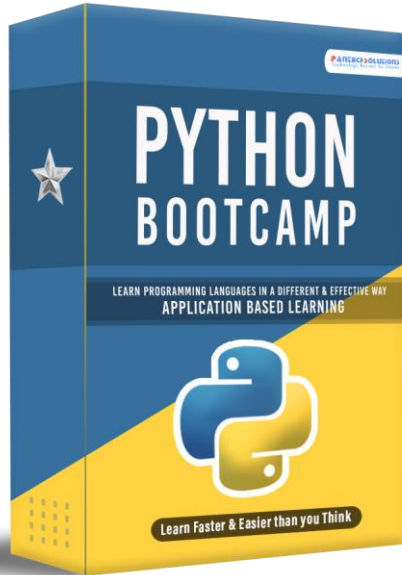
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Big Announcement for Diwali offer

ESD & IoT JOB ASSISTANCE PROGRAM
Warriors Way
Job Assistance Bundle

LIMITED TIME OFFER

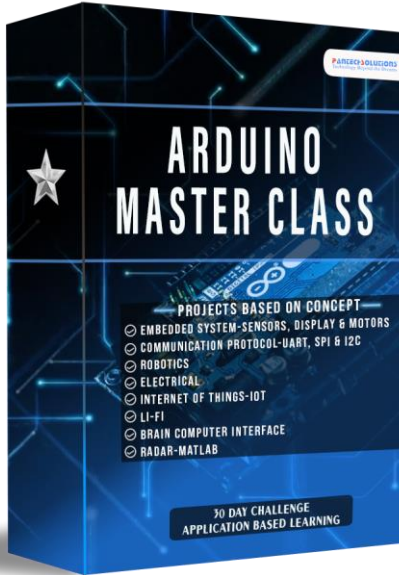# Launching Warrior Way Community

Python Boot camp(10 Days)

- Application Based Learning
- Notebooks: Anaconda Navigator, Google Colab, Pycharm, Jupyter, Spyder
- Python Object & Data Structure
- Python Statements
- Methods & Functions
- Object Oriented Programming
- Modules and Packages
- Decorators & Generators
- Working with Images
- Working with Files
- Emails with Python

# Embedded System Design & IOT Master Class(30 Days)

- **8051 Architecture (5 Days)**
- **PIC Architecture(5 Days)**
- **ARM7-LPC2148(5 Days)**
- **LPC4088 CortexM4(5 Days)**
- **NodeMCU(5 Days)**

EMBEDDED SYSTEM DESIGN
&
IOT MASTER CLASS

— YOU WILL LEARN —

BOARDS
8051 | ARM7 | CORTEX-M4 | PIC
NODEMCU/ESP8266

PROGRAMMING
EMBEDDED C

30 DAY CHALLENGE
APPLICATION BASED LEARNING

Arduino Master Class(30 Days)

- **Basics of Arduino**
- **Building ESD using Arduino**
- **Communication Protocol**
- **Sensors**
- **Display**
- **Motor**
- **Robotics System**
- **Electrical System**
- **Matlab & IoT**

# Raspberry PI Master Class(30 Days)
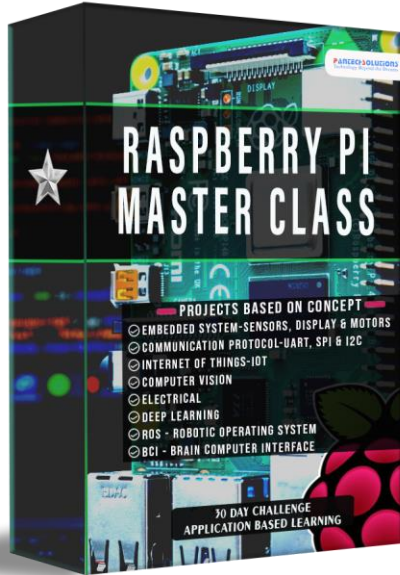
- **Basics of Raspberry PI**
- **Building ESD using RPI**
- **Communication Protocol**
- **Sensors**
- **Display**
- **Motor**
- **Robotics System**

PCB Design Master Class(12 Days)

- ✓ Introduction to Schematic Capture

- ✓ Introduction to Allegro and Footprint Creation

- ✓ Importing Schematics in allegro ,Placement and route

- ✓ Gerber Creation, BOM, PDF

- ✓ How to Design a 8051 Microcontroller Board
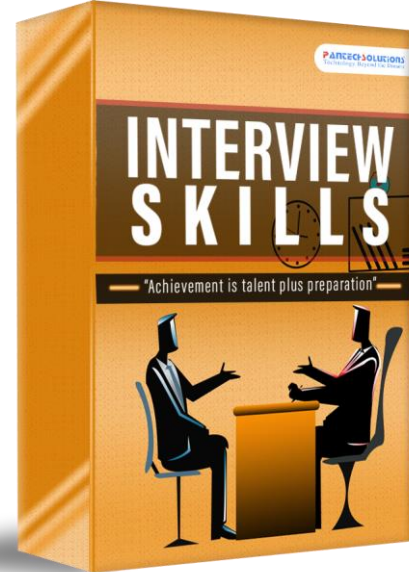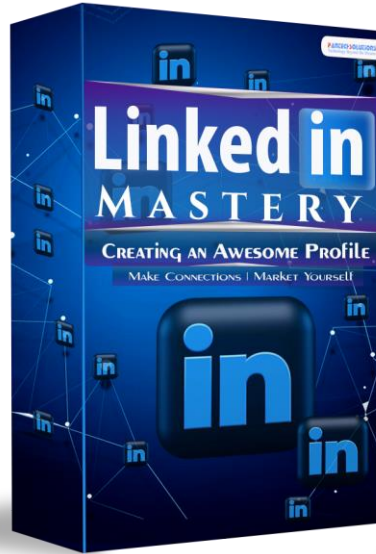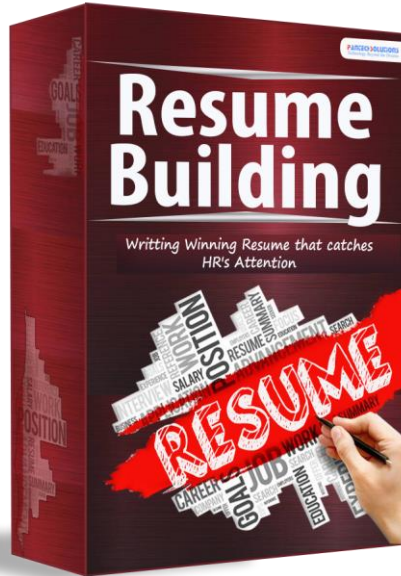
Soft Skills

Here's What
EVERYTHING You'll Get
When You Accept The 'ESD & IoT Job Assistance Program' Today!

✅ **Internship on Embedded Design & IoT** (value ₹2999)

✅ **Internship on Arduino** (value ₹2,999)

✅ **Internship on Raspberry Pi** (value ₹2,999)

✅ **Internship on IoT** (value ₹2,999)

✅ **Internship on PCB Design** (value ₹999)

✅ **Internship on Python** (value ₹999)

✅ **Resume Building** (value ₹499)

✅ **LinkedIn Mastery** (value ₹499)

✅ **Interview Skills** (value ₹499)

Here's What
EVERYTHING You'll Get
When You Accept The 'ESD & IoT Job Assistance Program' Today!

Bonus #1: Resume Review (value ₹1000)

Bonus #2: Group Career Coaching (value ₹5000)

Bonus #3: Weekly Master Mind (value ₹3000)

Bonus #4: Private Community (value ₹1000)

Bonus #5: Monthly Hackathon (value ₹1000)

Validity for One year

Click here to enroll

Total Value: ~~₹ 24,491~~

Today Just ₹ 2,999

Validity for One year

Click here to enroll

PROGRAM STARTS FROM NOV 10

How it works

- ✓ First Batch of Job Assistance Coaching program starts on November 10.
- ✓ It is a Coaching Program.
- ✓ You have to do self study ,Have to participate in Master mind get feedback to Improve.
- ✓ Get the Resume reviewed before applying (5 Resume review included)
- ✓ Group career coaching

INTERNSHIP BENEFITS:

✅ **Internship Certificate**
You Will Receive An Internship Certificate For 30 Days.

✅ **Recorded videos**
Access To All 30 Day's Of Recorded Videos

✅ **Learning Portal**
Separate Learning Portal Where You Can Login And Access All The Courses That You Have Enrolled .

✅ **180 Day's Course Access**
You Can Access All The 30 Day's Of Recorded Videos For 180 Days(6 Months).

✅ **Download Source code**
You Can Download 15+ Source Codes At Your Convenient.

✅ **Learn & Practice 10+ Projects**
You Can Learn And Practice The 10+ Projects.

✅ **Download Materials**
You Can Download 30 Day's Of PPT At Your Convenient.

✅ **Telegram Discussion & Support**
Being A Practical Based Workshop, You May Need Our Support Every Especially When You Implement What You Will Be Learning.

WEBINAR ATTENDEES:

✅ **Webinar Participation Certificate**
You Will Receive A Webinar Participation Certificate For 30 Days. Minimum 27 Days Of Attendance Is Mandatory.

✅ **30 Hours of Learning**
You Can Attend The Youtube Live Class For 30 Days.

❌ No Recorded videos

❌ No Learning Portal

❌ No Source code Downloads

❌ No Material Downloads

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