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Review on Different Microcontroller Boards Used in IoT

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Abstract: ***Today's technology has been evolved into stand-alone systems which can do all necessary processes by themselves without any additional hardware. Advance microcontrollers have become microcomputers that are also known as single board computers. These systems take their power from powerful microcontrollers. These microcontrollers have many integrated circuits on board so they can achieve many different processes by themselves. They are being used in many applications from powerful industrial devices to simple home appliances. In today's market, there are many different microcontrollers with different structure and capabilities.***
Therefore, understanding the concepts related to the microcontrollers is really important for choosing the best hardware. This paper presents the main concepts of microcontrollers and reveals the basis of their structure. Their components and abilities have been discussed and a comparison of well-known single board computers has been given.
Keywords: Microcontrollers, Integrated Circuits, Arduino UNO, Raspberry PI, BeagleBone Black, ESP8266.

I. INTRODUCTION

Microcontrollers and microcomputers from the early 1970s have developed rapidly from the beginning of today. Although they already have only one calculator function, they are now single-chip microcomputers (SOCs) that can perform all kinds of functions on all electrical systems.
Microcontrollers with 8- and 16-bit lead processors are generally selected at low cost and are easy to use. IoT requires sensors and actuators to create a link between the physical and the digital world. The sensor converts physical activity into an analogue or digital signal, while the actuator converts a digital signal into a specific physical effect. The next step in the development of IoT is a computer program that processes or generates digital signals.
Both microcontrollers and microprocessors can perform these functions. Microcontrollers and microprocessors are not the same, although the boundary between them is somewhat blurred. A microcontroller is an integrated circuit designed to manage certain operations on embedded systems and IoT. A standard standard controller includes a processor, memory and peripheral input / output (I / O) on a single chip.
Sometimes called an embedded controller or microcontroller unit (MCU), small controls are found in cars, robots, office equipment, medical equipment, mobile radio transceivers, commercial equipment and household appliances, among other devices. Simple real-time computers (PCs) are designed to control the features of a large part, without the front-end operating system (OS). In this paper, we discuss the capabilities, features, specifications and differences of the various microcontrollers used in IoT.

1) *Microcontroller:* A microcontroller is a small and low-cost microcomputer, which is designed to perform the specific tasks of embedded systems like displaying microwave's information, receiving remote signals, etc. The general microcontroller consists of the processor, the memory (RAM, ROM, EPROM), Serial ports, peripherals (timers, counters), etc. It is designed for dedicated purpose in various types of machines.
2) *Microprocessor:* Microprocessor is a controlling unit of a micro-computer, fabricated on a small chip capable of performing ALU (Arithmetic Logical Unit) operations and communicating with the other devices connected to it. Microprocessor consists of an ALU, register array, and a control unit. It is designed for general purpose computers.

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II. TYPES OF MICROCONTROLLER BOARDS

A. *Arduino UNO*

1) *Introduction:* Arduino Uno is known as an open-source development board as it allows you to use this board to interact with real-world things by uploading programs on this board. It is a microcontroller board developed by Arduino.cc and is based on Atmega328 Microcontroller. The first Arduino project was started in Interaction Design Institute Ivrea in 2003 by David Cuartielles and Massimo Banzi with the intention of providing a cheap and flexible way for students and professionals to learn embedded programming. Arduino UNO is a very valuable addition in electronics that consists of a USB interface, 14 digital I/O pins(of which 6 Pins are used for PWM), 6 analog pins and an Atmega328 microcontroller. It also supports 3 communication protocols named Serial, I2C and SPI protocol.It can interact with anything that is controlled by electricity in any way. It can also interact with motors, sensors, and electromagnets. In short, we can make devices that react and respond to the world by using this board. In short, we can say that Arduino is the brain of thousands of projects.

2) *Features*

a) Microcontroller: ATmega328
b) Operating Voltage: 5V
c) Input Voltage (recommended): 7-12V
d) Input Voltage (limits): 6-20V
e) Digital I/O Pins: 14 (of which 6 provide PWM output)
f) Analog Input Pins: 6
g) DC Current per I/O Pin: 40 mA
h) DC Current for 3.3V Pin: 50 mA
i) Flash Memory: 32 KB of which 0.5 KB used by bootloader
j) SRAM: 2 KB (ATmega328)
k) EEPROM: 1 KB (ATmega328)
l) Clock Speed: 16 MHz

3) *Arduino UNO Board Description:* Arduino UNO board because it is the most popular board in the Arduino board family. In addition, it is the best board to get started with electronics and coding. Some boards look a bit different from the one given below, but most Arduinos have majority of these components in common.

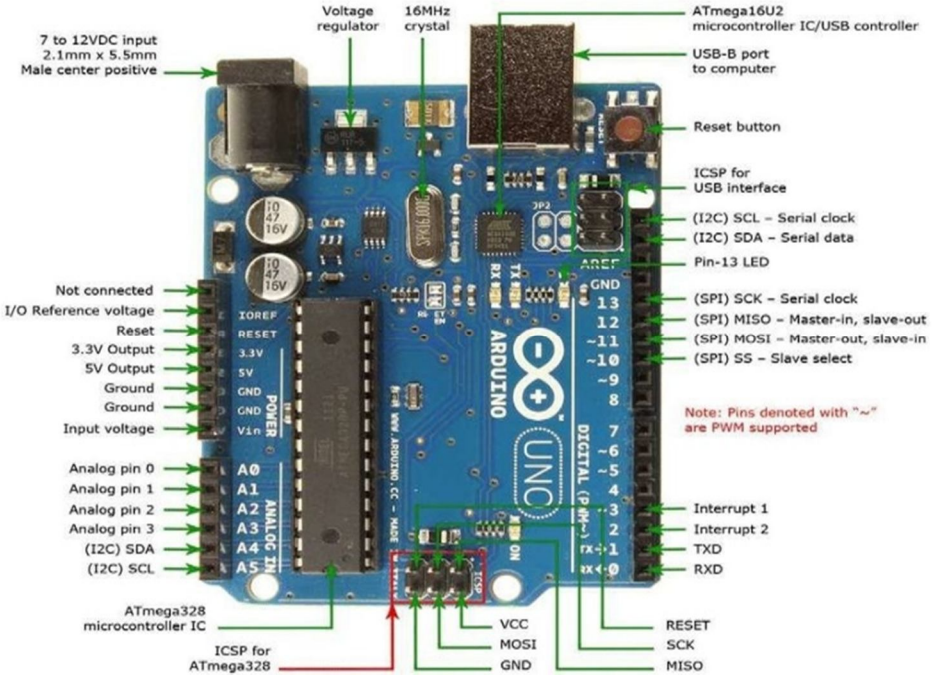

Figure 1: Arduino UNO

a) *Power USB:* Arduino board can be powered by using the USB cable from your computer. All you need to do is connect the USB cable to the USB connection.
b) *Power(Barrel Jack):* Arduino boards can be powered directly from the AC mains power supply by connecting it to the Barrel Jack.
c) *Voltage Regulator:* The function of the voltage regulator is to control the voltage given to the Arduino board and stabilize the DC voltages used by the processor and other elements.
d) *Crystal Oscillator:* The crystal oscillator helps Arduino in dealing with time issues. How does Arduino calculate time? The answer is, by using the crystal oscillator. The number printed on top of the Arduino crystal is 16.000H9H. It tells us that the frequency is 16,000,000 Hertz or 16 MHz.
e) *Aurdino Reset:* You can reset your Arduino board, i.e., start your program from the beginning. You can reset the UNO board in two ways. First, by using the reset button on the board. Second, you can connect an external reset button to the Arduino pin labelled RESET.
f) *Pin (3.3, 5, GND, Vin)*

- 3.3V − Supply 3.3 output volt
- 5V − Supply 5 output volt
- Most of the components used with Arduino board works fine with 3.3 volt and 5volt.
- GND (Ground) − There are several GND pins on the Arduino, any of which can be used to ground your circuit.
- Vin − This pin also can be used to power the Arduino board from an external power source, like AC mains power supply.

g) *Analog Pins:* The Arduino UNO board has six analog input pins A0 through A5. These pins can read the signal from an analog sensor like the humidity sensor or temperature sensor and convert it into a digital value that can be read by the microprocessor.
h) *Microcontroller Pins:* Each Arduino board has its own microcontroller. You can assume it as the brain of your board. The main IC (integrated circuit) on the Arduino is slightly different from board to board. The microcontrollers are usually of the ATMEL Company. You must know what IC your board has before loading up a new program from the Arduino IDE. This information is available on the top of the IC. For more details about the IC construction and functions, you can refer to the data sheet.
i) *ICSP Pin:* Mostly, ICSP is an AVR, a tiny programming header for the Arduino consisting of MOSI, MISO, SCK, RESET, VCC, and GND. It is often referred to as an SPI (Serial Peripheral Interface), which could be considered as an "expansion" of the output. Actually, you are slaving the output device to the master of the SPI bus.
j) *Power LED Indicator:* This LED should light up when you plug your Arduino into a power source to indicate that your board is powered up correctly. If this light does not turn on, then there is something wrong with the connection.
k) *TX and RX LEDs:* On your board, you will find two labels: TX (transmit) and RX (receive). They appear in two places on the Arduino UNO board. First, at the digital pins 0 and 1, to indicate the pins responsible for serial communication. Second, the TX and RX led. The TX led flashes with different speed while sending the serial data. The speed of flashing depends on the baud rate used by the board. RX flashes during the receiving process.
l) *Digital I/O:* The Arduino UNO board has 14 digital I/O pins (of which 6 provide PWM (Pulse Width Modulation) output. These pins can be configured to work as input digital pins to read logic values (0 or 1) or as digital output pins to drive different modules like LEDs, relays, etc. The pins labeled "~" can be used to generate PWM.
m) *AREF:* AREF stands for Analog Reference. It is sometimes, used to set an external reference voltage (between 0 and 5 Volts) as the upper limit for the analog input pins.

4) *Applications:* The Arduino boards can work as a stand-alone project and can be interfaced with other Arduino boards or Raspberry Pi boards. Arduino UNO board is used in the following applications.
a) Weighing Machines
b) Traffic Light Count Down Timer
c) Parking Lot Counter
d) Embedded systems
e) Home Automation
f) Industrial Automation
g) Medical Instrument
h) Emergency Light for Railways

B. Raspberry PI

1) Introduction: Raspberry Pi, developed by Raspberry Pi Foundation in association with Broadcom, is a series of small single-board computers and perhaps the most inspiring computer available today. From the moment you see the shiny green circuit board of Raspberry Pi, it invites you to tinker with it, play with it, start programming, and create your own software with it. Earlier, the Raspberry Pi was used to teach basic computer science in schools but later, because of its low cost and open design, the model became far more popular than anticipated. It is widely used to make gaming devices, fitness gadgets, weather stations, and much more. But apart from that, it is used by thousands of people of all ages who want to take their first step in computer science. The Raspberry Pi is a Broadcom BCM2835 SOC (system on chip board). It comes equipped with a 700 MHz, 512 MB of SDRAM and ARM1176JZF-S core CPU. The USB 2.0 port of the raspberry pi boars uses only external data connectivity options. The Ethernet in the raspberry pi is the main gateway to interconnect with other devices and the internet in model B. This draws its power from a micro USB adapter, with a minimum range of 2.5 watts(500 MA). The graphics, specialized chip is designed to speed up the manipulation of image calculations. This is in built with Broadcom video core IV cable, that is useful if you want to run a game and video through your raspberry pi.

2) Features

a) 512 MB SDRAM memory
b) Broadcom BCM2835 SoC full high definition multimedia processor
c) Dual Core Video Core IV Multimedia coprocessor
d) Single 2.0 USB connector
e) HDMI (rev 1.3 and 1.4) Composite RCA (PAL & NTSC) Video Out
f) 3.5 MM Jack, HDMI Audio Out
g) MMC, SD, SDIO Card slot on board storage
h) Linux Operating system
i) Dimensions are 8.6cm*5.4cm*1.7cm
j) On board 10/100 Ethernet RJ45 jack

3) Raspberry Pi Board Description: When you get your hands on the Raspberry Pi, the first thing you will notice is that it is really small – its measurements are 85.60mm x 56mm x 21mm (3.37 in x 2.21 in x 0.83 in). The device usually comes without a protective case, so you have a good look at all of the components that make up the device. Let's examine each component on the board:

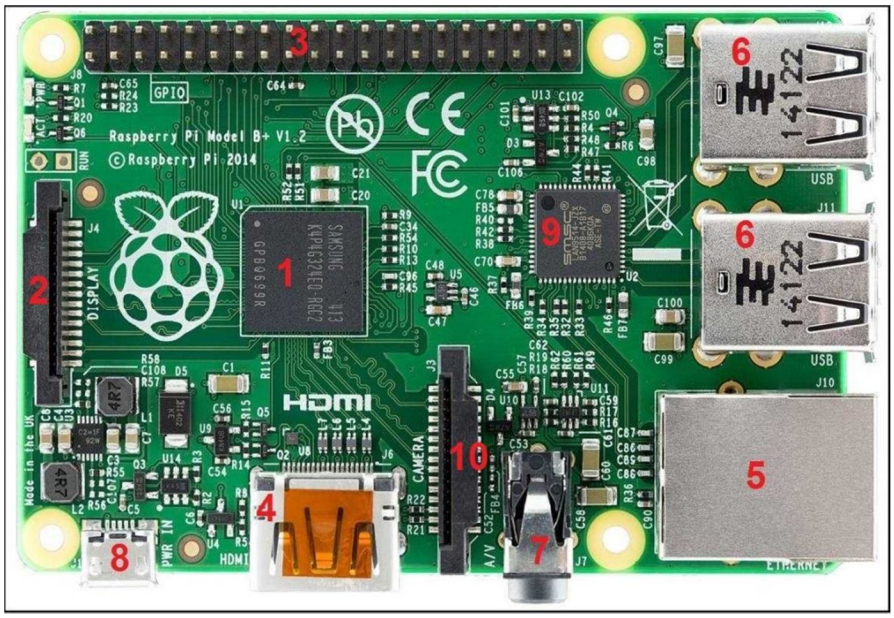

Figure 2: Raspberry Pi

a) A system on a chip (SoC): an integrated circuit that incorporates many computer components on a single chip – the CPU, memory, and RAM. The Raspberry Pi B+ model uses the ARM1176 700 Mhz processor, the powerful GPU (Graphical Processing Unit) capable of playing HD videos, and 512 MB of RAM.
b) DSI display connector: used to attach an LCD panel. On the other side of the board is a microSD card slot that holds the operating system.
c) GPIO (General-Purpose Input/Output) pins: pins used to connect electronics devices. The Raspberry Pi Model B has 26 pins, while B+ has 40.
d) HDMI port: used for connecting to a monitor or TV. HDMI can carry both sound and picture.
e) Ethernet port: a standard 10/100 Mbit/s Ethernet port used to connect your device with the rest of the network.
f) USB ports: standard USB 2.0 ports used to connect peripherals such as a keyboard and mouse. The Raspberry Pi Model B has 2 USB ports, while the B+ Model has 4.
g) Audio port: a 3.5mm jack used to connect speakers.
h) Micro-USB power connector: used to power the Raspberry Pi.
i) USB and Ethernet interface chip
j) Camera connector: enables the capturing of photographs and videos.

4) *Applications:* Like a desktop computer, you can do almost anything with the Raspberry Pi. You can start and manage programs with its graphical windows desktop. It also has the shell for accepting text commands. We can use the Raspberry Pi computer for the following:
a) Playing games
b) Browsing the internet
c) Word processing
d) Spreadsheets
e) Editing photos
f) Paying bills online
g) Managing your accounts.

C. Beagle Bone Black

1) *Introduction:* The BeagleBones are a line of affordable single-board Linux computers (SBCs) created by Texas Instruments. Weighing in at a lower price point and smaller footprint than TI's long-running BeagleBoard family, BeagleBones have been a favorite platform for makers and their projects for a couple of years now. Beagle Bone Black is a low-cost, community-supported development platform for developers. Boot Linux in under 10 seconds and get started on development in less than 5 minutes with just a single USB cable. The Beagle Bone Black Rev C is a powerful microcontroller with 4GB eMMC flash and the Debian Linux OS. The Beagle Bone Black is a small single board computer that makes an excellent brain for advanced robot projects. The Beagle Bone Black Rev C features TI AM335x ARM Cortex A8 processor running at 1Ghz.
2) *Specifications/Features*
a) *Processor:* Sitara AM3358BZCZ100, 1GHz, 2000 MIPS
b) *Graphics Engine:* SGX530 3D, 20M Polygons/S
c) *SDRAM Memory:* 512MB DDR3L 800MHZ
d) *Onboard Flash:* 4GB, 8bit Embedded MMC
e) *Debug Support:* Optional Onboard 20-pin CTI JTAG, Serial Header
f) *Power Board:* mini-USB, DCJack, 5VDC External Via Expansion
g) *Indicators:*1-Power, 2-Ethernet, 4-User Controllable LEDs
h) *Serial Port:* UART0 access via 6 pin 3.3V TTL Header. Header is populated
i) *Ethernet:*10/100, RJ45
j) *SD/MMC Connector:* microSD, 3.3V
k) *User Input:* Reset Button, Boot Button, Power Button
l) *Video Out:* 16b HDMI, 1280x1024 (MAX), 1024x768,1280x720,1440x900 ,1920x1080@24Hz, w/EDIDSupport
m) *Audio:* Via HDMI Interface, Stereo
n) *Weight:* 1.4 oz (39.68 grams)

3) Beagle Bone Black Board Description

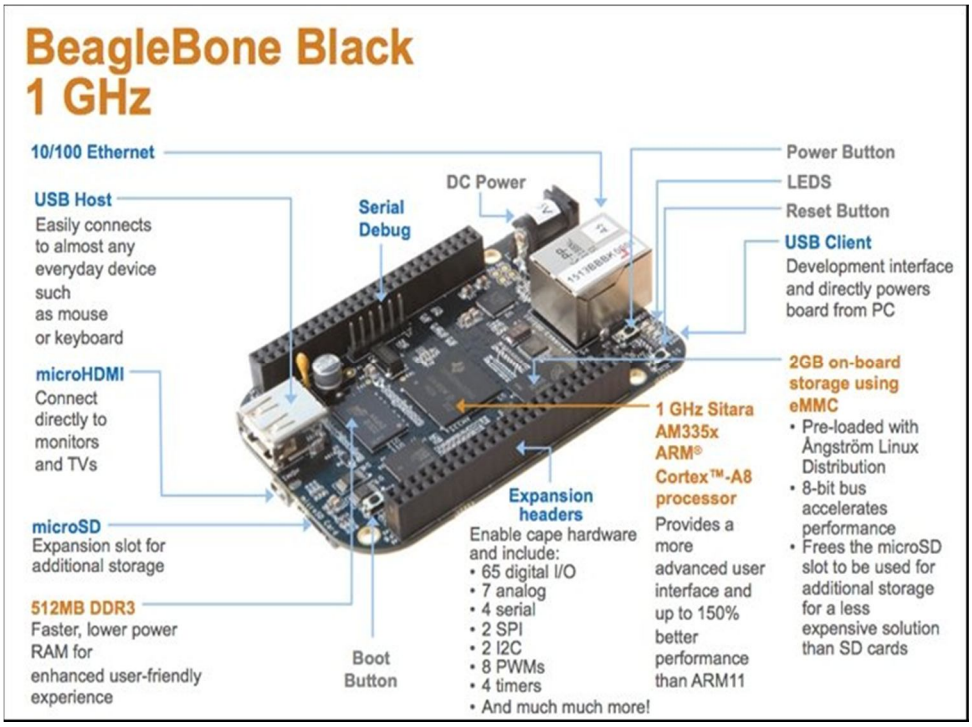

Figure 3: Beagle bone black

a) The micro HDMI port available on the BeagleBone Black gives the board the ability to give output to HDMI monitors and HDMI TVs just like any computer will give.

b) You can power up the BeagleBone Black using the DC Barrel jack available on the left hand side corner of the board using a 5V DC, 2A adapter. There is an option to power the board using USB, although it is not recommended due to the current limit on USB ports. We will see about this in detail in the upcoming chapters when we connect USB Wi-Fi dongle and USB camera to the BeagleBone Black.

c) There are 4 LEDs on board to indicate the status of the board and help us for identifications to boot up the BeagleBone Black from microSD card. The LEDs are linked with the GPIO pins on the BeagleBone Black which can be used whenever needed.

d) You can connect the BeagleBone Black to the LAN or Internet using the Ethernet port available on the board using an Ethernet cable. You can even use a USB Wi-Fi module to give Internet access to your BeagleBone Black.

e) The expansion headers which are in general called the General Purpose Input Output (GPIO) pins include 65 digital pins. These pins can be used as digital input or output pins to which you can connect switches, LEDs and many more digital input output components, 7 analog inputs to which you can connect analog sensors like a potentiometer or an analog temperature sensor, 4 Serial Ports to which you can connect Serial Bluetooth or Xbee Modules for wireless communication or anything else, 2 SPI and 2 I2C Ports to connect different modules such as sensors or any other modules using SPI or I2C communication. It also has 8 PWM output pins that can be used for applications like fading and LED or in robotic applications for varying the speed of a motor which we will be discussing later in the upcoming chapters.

4) Applications

a) It was designed for hobbyists and as an educational tool for the development of open source software. It uses an ARM Cortex-A8 CPU that runs at speeds up to 1 GHz, and can be configured with between 128 MB and 512 MB of RAM. It measures 7.5 mm on each side, and has all the functionality of a basic computer.

b) BeagleBone Black is a low-cost, community-supported development platform for developers and hobbyists. Boot Linux in under 10 seconds and get started on development in less than 5 minutes with just a single USB cable. A true open hardware, community-supported embedded computer for developers and hobbyists.

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D. ESP8266

1) Introduction: ESP8266 is a WIFI SOC (system on a chip) produced by Espressif Systems. It is a highly integrated chip designed to provide full internet connectivity in a small package. ESP8266 can be used as an external Wi-Fi module, using the standard AT Command set Firmware by connecting it to any microcontroller using the serial UART, or directly serve as a Wi-Fi-enabled micro controller, by programming a new firmware using the provided SDK. The GPIO pins allow Analog and Digital IO, plus PWM, SPI, I2C, etc. This board has been around for almost a year now, and has been used mostly in IoT contexts, where we want to add connectivity for example to an Arduino project. A wide adoption has been facilitated by the very modest price, ranging from 2.50 to 10 USD depending on the features offered by the manufacturers.

Some example projects:

a) Temperature logging and Web UI
b) Retro Web Browser
c) Internet Enabled Smoke alarm

The ESP8266 Arduino compatible module is a low-cost Wi-**Fi chip** with full TCP/IP capability, and the amazing thing is that this little board has a MCU (Micro Controller Unit) integrated which gives the possibility to control I/O digital pins via simple and almost pseudo-code like programming language

2) Features

a) 802.11 b / g / n
b) Wi-Fi Direct (P2P), soft-AP
c) Built-in TCP / IP protocol stack
d) Built-in TR switch, balun, LNA, power amplifier and matching network
e) Built-in PLL, voltage regulator and power management components
f) 802.11b mode + 19.5dBm output power
g) Built-in temperature sensor
h) Support antenna diversity
i) off leakage current is less than 10uA
j) Built-in low-power 32-bit CPU: can double as an application processor
k) A-MPDU, A-MSDU aggregation and the 0.4 Within wake
l) 2ms, connect and transfer data packets
m) standby power consumption of less than 1.0mW (DTIM3)
n) Type: 32-bit microcontroller
o) CPU: Ten silica Diamond Standard 106Micro (aka. L106) @ 80 MHz (default) or 160 MHz
p) Memory: 32 KiB instruction, 80 KiB user data

3) ESP8266 Board Discription

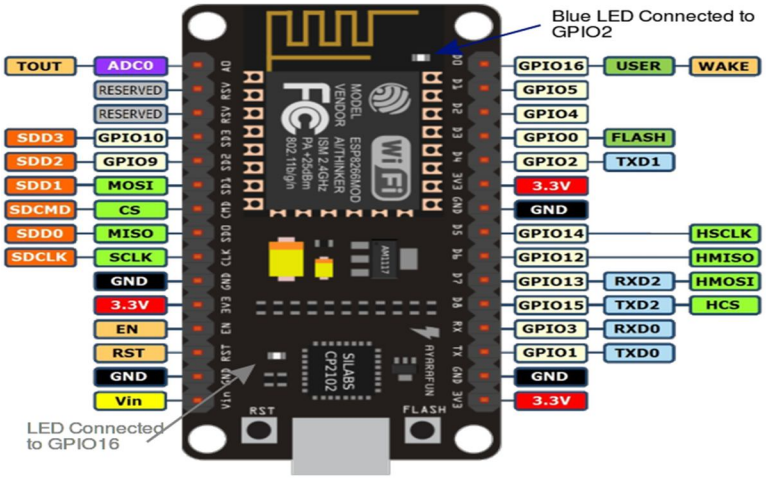


Figure 4: ESP8266

The pinout is as follows for the common ESP-01 module:

a) GND, Ground (0 V)
b) GPIO 2, General-purpose input/output No. 2
c) GPIO 0, General-purpose input/output No. 0
d) RX, Receive data in, also GPIO3
e) VCC, Voltage (+3.3 V; can handle up to 3.6 V)
f) RST, Reset
g) CH_PD, Chip power-down
h) TX, Transmit data out, also GPIO1

4) Applications

a) Home appliances
b) Home automation
c) Smart plugs and lights
d) Industrial wireless control
e) Baby monitors
f) IP cameras
g) Sensor networks
h) Wearable electronics
i) Wi-Fi location-aware devices
j) Security ID tags
k) Wi-Fi position system beacons

III. STUDY OF COMPARISION

Table 1.Study of Comparison Between Microcontrollers and Microprocessors

Microcontroller	Microprocessor
Microcontrollers are used to execute a single task within an application.	Microprocessors are used for big applications.
Its designing and hardware cost is low.	Its designing and hardware cost is high.
Easy to replace.	Not so easy to replace.
It is built with CMOS technology, which requires less power to operate.	Its power consumption is high because it has to control the entire system.
It consists of CPU, RAM, ROM, I/O ports.	It doesn't consist of RAM, ROM, I/O ports. It uses its pins to interface to peripheral devices.

Table 2.Study of Comparison Between Various Types of Microcontroller Boards

Parameter	Arduino	Raspberry Pi	ESP8266 Node MCU	Beagle Bone Black
Developer	Arduino	Raspberry Pi Foundation	ESP8266 open source community	Texas Instruments
Type	Single board microcontroller	Mini computer	Single board microcontroller	Mini computer

Operating System	None	Linux	XTOS	Linux, Debian, Android, and Ubuntu.
CPU	Atmel, ARM, Intel	ARM Cortex	LXT106	super-scalar ARM Cortex A8
Clock Speed	16 MHz	1.2GHz	26 MHz – 52 MHz	1 GHz
Memory	32KB	1-4GB	Upto 128MB	512 MB
Storage	1KB	MicroSDHC Slot	4MB	4GB 8-bit eMMC on-board flash storage
Power	USB, Battery, Power Supply	USB, Power Supply	USB	USB and mini-USB, DCJack
Operating Voltage	5V	5V	3.3V	5V
Pins	14	40	17	2x46
Microcontroller	ATmega328	RP2040	-	TI AM3359

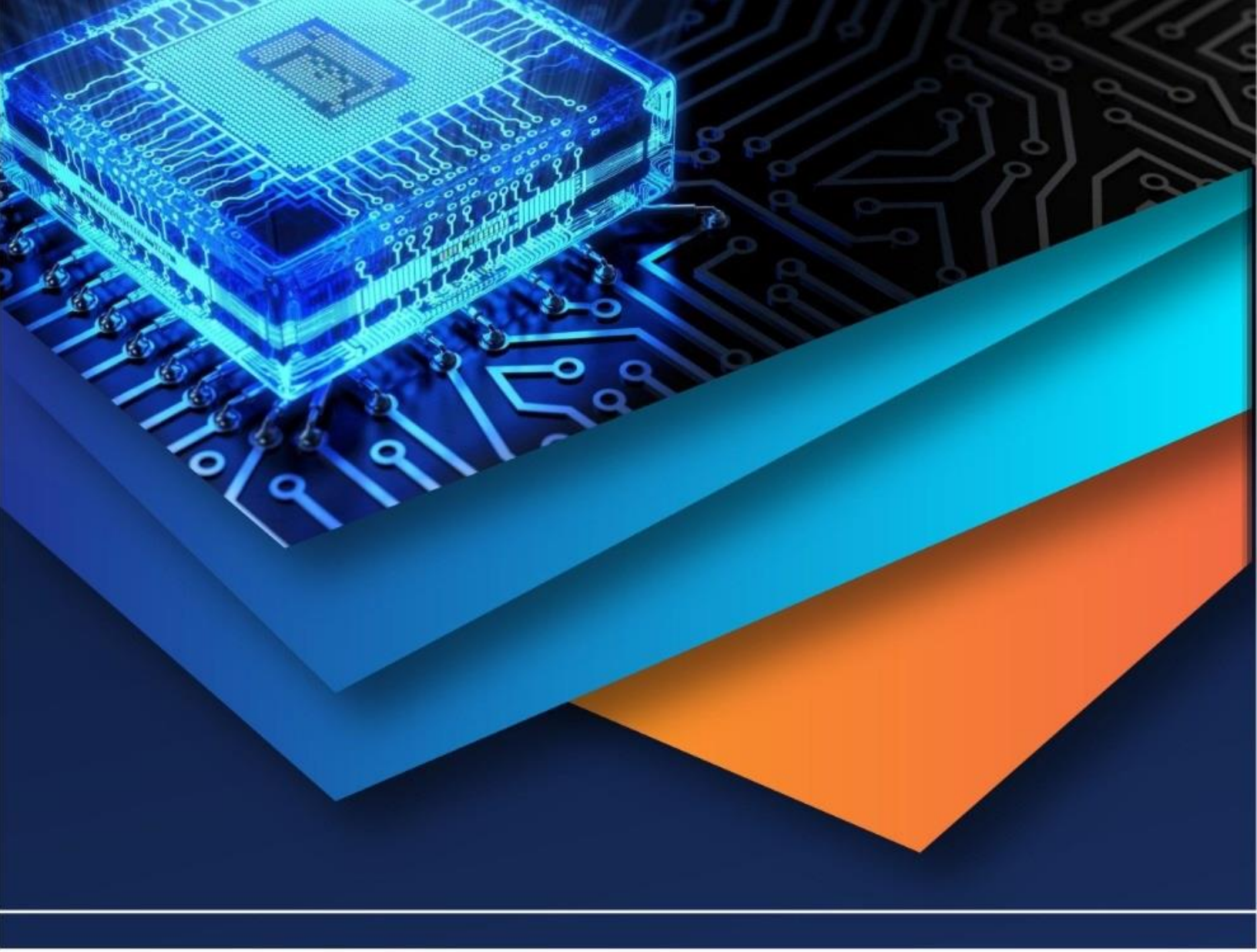
IV. CONCLUSION

In this paper we have learned about the different types of Microcontroller Boards used in IoT and studied the Comparison Between Microcontrollers and Microprocessors also the Comparison Between Various Types of Microcontroller Boards. According to our research, we conclude that each microcontroller board has its own capabilities and features and according to need in project we have to choose a specific and convenient microcontroller. We conclude that from any other microcontroller the arduino boards can work as a stand-alone project and can be interfaced with other arduino boards or raspberry pi boards, Like a desktop computer, you can do almost anything with the Raspberry Pi, Beagle bone black was designed for hobbyists and as an educational tool for the development of open source software and ESP8266 is a highly integrated chip designed to provide full internet connectivity in a small package.

In recent years, the number of applications developed using microcontrollers has increased rapidly. A variety of microcontroller development cards are used in most of the courses in the universities. These systems, which are also preferred in student projects, are increasing in importance due to the large number of hardware and the large software support. However, when there are many different types of microcontroller and application development cards on the market, it is observed that students have difficulty in where to start. In addition, they are unfamiliar with the basic concepts of microprocessors and microcontrollers, so they are inadequate in selecting the necessary hardware for reading and implementing technical documents. Rapidly evolving microcontroller technologies now become embedded systems that can do all the work at the same time with single card computer systems. Many of these systems, which are open source, are becoming more and more popular. Linux, Android and Windows, as well as its own operating systems, automation and control systems, as well as image and signal processing can perform many functions. It is aimed that this work will be a guide for newcomers to microcontrollers and embedded systems.

REFERENCES

[1] John Crisp, Introduction of Microprocessor and Microcontroller, 2nd ed.S. Furber,
[2] “Microprocessors: the engines of the digital age,” Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences, vol. 473, no. 2199, p. 20160893, 2017.
[3] Alheraish, “Design and Implementation of Home Automation System” IEEE Transactions on Consumer Electronics, Vol. 50, No. 4, pp. 1087-1092, November 2004.
[4] Ali ZiyaAlkar and UmitBuhur, “An Internet Based Wireless Home Automation System for Multifunctional Devices”, IEEE Transactions on Consumer Electronics, Vol. 51, No. 4, pp. 1169-1174, November 2005.
[5] M. A. Mazidi, R. D. Mckinlay, D. Causey, “PIC Microcontroller and Embedded System,” Pearson Education, INC., Pearson Prentice Hall.
[6] D. Paul and S. Som, “Microcontroller Based Intelligent Digital Volume Controller with Timer”, International Journal of Computer Applications, 38(1):19-26, January 2012.
[7] Beningo, J. 10 Step to Selecting a Microcontroller. ARM Embedded Communities. 12 Jan 2014.https://community.arm.com/iot/embedded/b/embedded-blog/posts/10-steps-to-selecting-a-microcontroller, 11 February 2017
[8] https://www.arduino.cc/
[9] https://en.wikipedia.org/wiki/Raspberry_Pi
[10] https://beagleboard.org/black



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