[1] **Binu Mol T. V.**

A Study on Raspberry PI, Arduino and IoT with Its Application in E-Controlling UPS

Abstract: - A feasibility study on automating the computer lab by managing the operation of an IoT-based UPS has been conducted. In many laboratories, there are no technical assistants to check whether all the systems are switched off or on or to look after any day-to-day maintenances. Raspberry Pi devices have low power consumption, making them ideal for battery-operated or energy-saving IoT solutions. With the advances of IoT technology the status of Uninterrupted Power Supply (UPS) can be monitored and manage the organization. Arduino, a microcontroller device, can be utilized in a variety of systems, including those that involve sensors, actuators, and real-time control. A comparative study of Arduino with RPi is done. Various IoT standards are used in the category of IoT implementations. IoT systems can be created using various platforms, incorporating Raspberry Pi, Arduino, or a mix of both, according to the specific demands of the project.

Keywords: IoT, Raspberry Pi, Arduino, UPS, Raspbian

INTRODUCTION

The Internet of Things (IoT) refers to a network of interconnected computing devices, mechanical and digital machines, objects, animals, or people, each equipped with unique identifiers (UIDs) and capable of exchanging data over a network without the need for human-to-human or human-to-computer interaction [1]. Different devices and systems can be connected together and establish decisions based on real time data.

The word "Internet of Things" (IoT) was introduced by Kevin Ashton in 1999 in his presentation at Procter & Gamble (P&G). When Ashton was working at Auto-ID Center at MIT, aimed to draw attention to the benefits of RFID (Radio Frequency Identification) technology in managing supply chain [2]. Currently, IoT spans a broad spectrum of technologies, such as sensors, wireless networking, cloud computing, and artificial intelligence. These technologies collaborate to empower intelligent devices and systems capable of data communication, analysis, and decision-making with minimal human involvement.

The Internet of Things (IoT) can be classified by various sectors and use cases. Key categories include Consumer IoT, Commercial IoT, Industrial IoT (IIoT), Infrastructure IoT, and Agricultural IoT. Consumer IoT includes devices created for individual use, frequently found in homes or worn as wearable technology, such as voice-controlled assistants (e.g., Amazon Alexa, Google Home), smartwatches, and fitness tracking devices. Commercial IoT focuses on IoT applications in businesses, retail like IoT-enabled inventory management and smart shelves, healthcare like remote patient monitoring, and other service industries like automated lighting, and security systems in buildings. Industrial IoT (IIoT) involves the use of IoT technologies in the manufacturing sectors like Smart factories with automated machinery and real-time monitoring of production lines, logistics like asset tracking, fleet management, energy like smart grids and remote monitoring of oil and gas pipelines, and other industrial sectors. The goal is to boost operational efficiency, decrease downtime, and support predictive maintenance using data analytics. Infrastructure IoT leverages IoT technologies in public infrastructure, enhancing urban planning through smart cities, public services like Intelligent Transportation Systems (ITS) for real-time traffic control and smart parking, and city-wide management systems such as water and energy management to optimize resource utilization and minimize waste [3].

[1] Assistant Professor, Department of Computer Science, KKTM Govt.College, Pullut,Thrissur,Kerala, India

Email: binumoltv@gmail.com

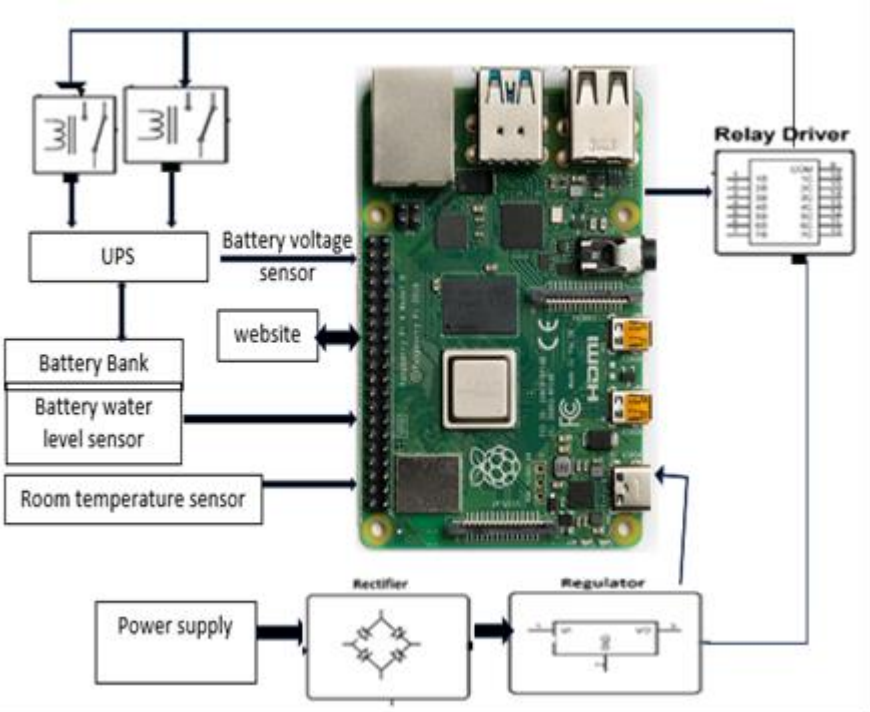
II. METHODOLOGY

Literature Review

In a two-way communications and control, unauthorized individuals gain remote access to the UPS power systems, hence I prefer an uninterruptible power supply system that can be switched on and off remotely in a unidirectional way. The system is designed with Raspberry Pi that automate easily through internet for low cost. The UPS and a WiFi module is connected to the Raspberry Pi and either an IoT Gecko free web interface or a particle cloud can be used for control by sending switching commands over IoT to the circuit. After receiving commands through an internet connection via the WiFi module, the Raspberry Pi processor executes these commands. Then it operates ups for switching on/off according to the user command.

The schematic block diagram, hardware and software specifications can be as follows:

Block Diagram:



Hardware requirements might consist of a rectifier, regulator, relay driver, relays, power supply, UPS, battery water level sensor, room temperature sensor, battery voltage sensor a WiFi modem, while the software requirements may involve a Raspberry Pi with Raspbian installed and the Python programming language. Power is supplied to the Raspberry Pi. The probes of the inverter battery water level sensor are inserted into battery electrolyte to detect the water level and set the system for giving alerts for low water level. This to be done to all cells connected in the battery bank. The same is connected to the Raspberry Pi GPIO pins. For sealed batteries it is hard to follow the method. The room temperature sensor is connected to GPIO pins. The ground wire of the to RPis ground, the positive pin to the Raspberry Pi power pin. The python code will extract data from sensor through digital pin according to the requirement. The alerts are checked for various parameters and if it does not satisfy the parameter value then message or alarm will work . The IoT Gecko free web interface will work in bidirectional to give command to the UPS through Raspberry Pi and display necessary alerts for the battery water level and room temperature through the relays connected via relay driver.

Raspberry Pi

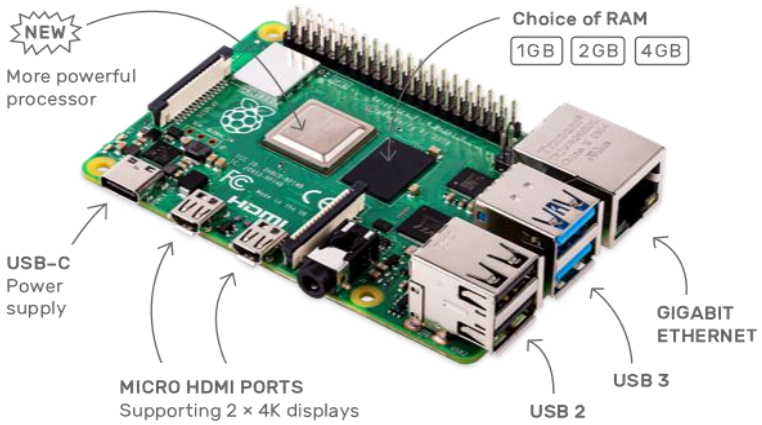
Raspberry Pi boards are quite economical and operate on Linux-based systems such as Raspberry Pi OS (formerly known as Raspbian). This enables them to support a variety of software applications, including programming languages like Python, Java, and C++, along with IoT frameworks and cloud services. The GPIO (General Purpose Input/Output) pins on the board allow connections to electronic devices such as sensors,

motors, LEDs, and other peripherals [5]. The Raspberry Pi can operate multiple other open-source operating systems, including Ubuntu and Arch Linux. The GPIO libraries used to control hardware, like RPi. GPIO in Python, are open source [6]. Raspberry Pi's key advantages is its fanless, energy-efficient design, which allows it to operate quietly and consume significantly less power than traditional desktop or laptop computers which makes it ideal for projects that need to run continuously [7].

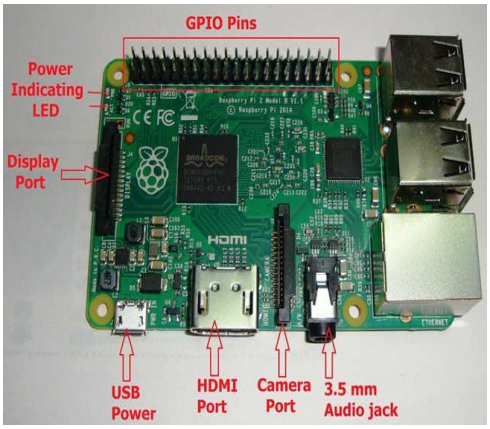
Raspberry Pi 4 Model B components

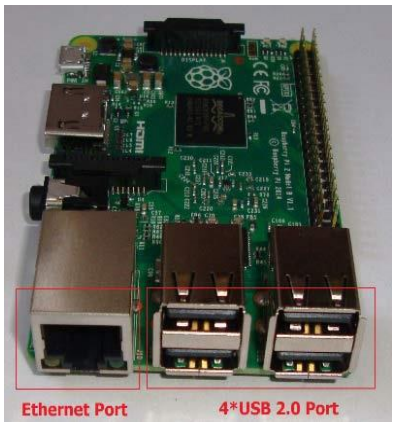
Equipped with a 1.5GHz quad-core 64-bit ARM Cortex-A72 processor (~3× performance improvement), it offers configurations with 1GB, 2GB, or 4GB of LPDDR4 SDRAM. It features full-speed Gigabit Ethernet for enhanced network performance, dual-band 802.11ac Wi-Fi for faster and more reliable wireless connections, and Bluetooth 5.0. The board includes two USB 3.0 ports and two USB 2.0 ports, supports dual monitors with resolutions up to 4K, has VideoCore VI graphics with OpenGL ES 3.x compatibility, and supports 4Kp60 hardware decoding of HEVC video.

Schematic diagram of Raspberry Pi 4 Model B [7]



The cost of a Raspberry Pi 4 module along with a 15.6" monitor and keyboard-mouse set might be approximately Rs 15,000.





The Raspberry Pi is built on the ARM architecture, specifically using ARM Cortex processors. The ARM architecture is known for its efficiency in power consumption and is widely used in mobile and embedded devices. The Raspberry Pi is capable of managing several tasks at once, just like a regular PC, including web browsing, media streaming, programming, and handling background operations, making it a pocket-sized computer. The Raspberry Pi is compatible with various ARM-based GNU/Linux distributions, including Raspberry Pi OS, Ubuntu, and more as it possesses an ARMv7 processor. Certain Raspberry Pi models are also

capable of running Windows 10 IoT Core, a streamlined version of Windows specifically designed for embedded systems and IoT applications [8].

Hardware Requirements of Raspberry Pi:

To begin using the Raspberry Pi, a RPi board, a power supply, a microSD card with the operating system, and basic input/output devices like a monitor, USB keyboard, and mouse are necessary. The board can be powered with a 5V, 3A USB-C power adapter. Ensuring a stable power supply is essential to prevent potential issues like SD card corruption or under-voltage warnings. The Raspberry Pi boots from a microSD card, which acts as its primary storage and the card should have minimum 8GB size. As the Raspberry Pi 4 uses micro-HDMI ports, a LCD/LED monitor or display that supports HDMI is required. It can also be used without monitor and can be controlled over network. To connect the Raspberry Pi to a laptop, tools like Putty or VNC Viewer can be utilized. HATs (Hardware Attached on Top) are expansion boards that provide additional functionalities to the Raspberry Pi, such as incorporating sensors.

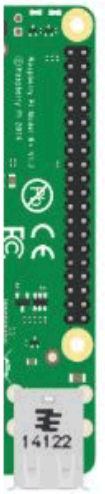
Software Requirements:

The operating system (OS) for the Raspberry Pi can be downloaded from the Downloads section of the official Raspberry Pi website: https://www.raspberrypi.org/downloads/. This section lists all the supported operating systems for the Raspberry Pi 2. Choose and install any OS available there. Choose RASPBIAN to download the complete desktop version of Raspbian Jessie. After downloading, use a file extraction tool like WinRAR or WinZip to unzip the Raspbian image.. Python comes pre-installed on Raspberry Pi OS and serves as a major programming language used for development on the platform. Notable libraries include RPi.GPIO, a widely used Python library for handling GPIO pins, and pigpio, a more sophisticated library for controlling the GPIO pins. In higher versions of Raspberry Pi built in wifi modules are included. The required library for the sensors is also included. The webpage required for the required functionalities must be designed to control the system remotely.

General-Purpose Input/Output

The GPIO (General-Purpose Input/Output) pins on the Raspberry Pi, as shown below, are utilized for a range of analog and digital connections.

GPIO pin datasheet [9]



Peripherals	GPIO	Particle	Pin #			Pin #	Particle	GPIO	Peripherals
3.3V			1	X	X	2	5V		
I2C	GPIO2	SDA	3	X	X	4	5V		
	GPIO3	SCL	5	X	X	6	GND		
Digital I/O	GPIO4	D0	7	X	X	8	TX	GPIO14	UART
GND			9	X	X	10	RX	GPIO15	Serial 1
Digital I/O	GPIO17	D1	11	X	X	12	D9/A0	GPIO18	PWM 1
Digital I/O	GPIO27	D2	13	X	X	14		GND	
Digital I/O	GPIO22	D3	15	X	X	16	D10/A1	GPIO23	Digital I/O
3.3V			17	X	X	18	D11/A2	GPIO24	Digital I/O
SPI	GPIO10	MOSI	19	X	X	20		GND	
	GPIO9	MISO	21	X	X	22	D12/A3	GPIO25	Digital I/O
	GPIO11	SCK	23	X	X	24	CE0	GPIO8	SPI (chip enable)
GND			25	X	X	26	CE1	GPIO7	
DO NOT USE	ID_SD	DO NOT USE	27	X	X	28	DO NOT USE	ID_SC	DO NOT USE
Digital I/O	GPIO5	D4	29	X	X	30		GND	
Digital I/O	GPIO6	D5	31	X	X	32	D13/A4	GPIO12	Digital I/O
PWM 2	GPIO13	D6	33	X	X	34		GND	
PWM 2	GPIO19	D7	35	X	X	36	D14/A5	GPIO16	PWM 1
Digital I/O	GPIO26	D8	37	X	X	38	D15/A6	GPIO20	Digital I/O
GND			39	X	X	40	D16/A7	GPIO21	Digital I/O

Raspberry Pi 4 Case

Raspberry Pi 4 Case shown above is a low cost high-quality protection case is designed by Raspberry Pi. It boasts durable two-piece ABS construction with openings for the dual micro-HDMI, Audio/Video, USB, and Ethernet ports, along with the USB-C power connector and access to the microSD card. An optional snap-on lid can be detached to allow access to the Raspberry Pi's GPIO pins or to attach a HAT [10].

Arduino Uno microcontroller

The Arduino UNO is a microcontroller board built around the ATmega328P. It features 14 digital input/output pins, 6 of which can serve as PWM outputs, 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It can be connected to a computer using a USB Type-B cable or powered by an AC-to-DC adapter or battery to get started. It is programmed based on Integrated Development Environment (IDE) which is based on C/C++. The figure below shows Arduino UNO [11].

Comparing the Raspberry Pi and the Arduino Uno

The Arduino is a microcontroller development board that lacks a full operating system and executes compact programs for managing sensors. Raspberry pie have full OS and functions like a mini computer. The Raspberry Pi has 40 GPIO pins in new models and 26 pins on older models that can be used for digital and analog inputs and outputs. The Arduino on the other hand have only 14 GPIO pins. RPi can be utilized for more advanced projects that demand computing power, multitasking, and networking capabilities. Arduino may be used for simple, real-time applications, and control tasks [11]. Raspberry Pie can be used for projects requiring significant computing power, multitasking, and networking. Arduino is used in real-time applications where a control over electronics is needed. Shields can be added to Arduino to increase its functionality as per applications. HAT or additional RPi can be used to increase functionality. [18]. The two IoT boards can be combined together for more functionalities using the processing and network capability of Rpi and real time control of Arduino.

IoT standards- Some IoT standards include 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks), an adaptation layer standard that allows any low-power radio to connect to the internet, including 802.15.4, Bluetooth Low Energy, and Z-Wave (used for home automation) [11], ZigBee, another low-power wireless communication protocol, is commonly employed in home automation, smart lighting, and industrial IoT [11], CoAP (Constrained Application Protocol) is designed for devices with limited resources, where the Raspberry Pi can act as a CoAP server or client, and Arduino can interface with CoAP services using lightweight libraries [11], HTTP/HTTPS, commonly used for communication in IoT applications, especially for web-based APIs. Raspberry Pi Can host a web server and interact with IoT devices using RESTful APIs. Arduino Can send data to cloud services or web APIs using Ethernet or Wi-Fi modules [11]. LiteOS, OneM2M, a machine-to-machine service layer, DDS (Data Distribution Service) and AMQP (Advanced Message Queuing Protocol) are also key standards in IoT [12].

IoT frameworks- IoT frameworks facilitate the connection of IoT devices to a network using protocols such as MQTT, CoAP, HTTP, or WebSocket. AWS IoT, provided by Amazon Web Services (AWS) allows connected devices to communicate with cloud applications and other devices. Similarly, Microsoft's Azure IoT Suite, Google's Brillo/Weave, provide platforms for developing IoT applications [12].

IoT Data and Semantic Standards [13]:

JSON (JavaScript Object Notation) and XML (eXtensible Markup Language) are widely used formats for organizing and transmitting IoT data.

RDF (Resource Description Framework) is a framework for describing and linking IoT data in a machine-readable way.

OWL (Web Ontology Language) is used for building ontologies in IoT to enable data interoperability [13].

Conclusions:

IoT applications can be used in the field of agriculture, healthcare, organizations etc . Various IoT are available where these protocols can be selected according to the applications. The UPS automation in laboratories can be done by working on the strategy of Raspberry Pi which is a low cost IoT implementation.

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