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MONITOING OF INDUSTRIAL ELECTRICAL EQUIPMENT USING RASBERRY PI PICO W

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ABSTRACT

Power lines, transformers, and motors are examples of electrical equipment that is essential to both economic growth and social stability. The benefits of early warning systems for electrical equipment safety and the Internet of Things (IoT) have been merged to create a new approach to monitoring and early warning systems. Sensors, network connectivity, and cloud computing are examples of IoT technologies that provide data sharing and connection between electrical equipment and the Internet of Things (IoT). This allows for real-time operation status monitoring to avert equipment failure and other problems. This project leverages the Internet of Things (IoT) and a Raspberry Pi Pico W to monitor industrial electrical equipment through sensors, all while avoiding human intervention.

Keywords- Internet of Things, Raspberry Pi Pico W, Network communication, Cloud computing.

1. INTRODUCTION

The pandemic has led to a shift towards smarter living, with people adapting to online platforms and other technologies. Current consumption is a significant issue globally, especially as people live more at home. There are currently three different kinds of energy meter on the market: smart energy meters, electronic energy meters, and electromechanical induction type energy meters. These meters give immediate power as well as instantaneous voltage and current measurements and product calculations. Depending on the supply being used, they can be either single phase or three phase meters. The kilowatt hour, which measures the energy consumed by a load of one kilowatt hour over an hour, is the most widely used unit of measurement for electricity. Researchers have been implementing these meters before the pandemic, considering their importance in daily life. This project aims to create a system for monitoring industrial electrical equipment parameters using the Raspberry Pi Pico W microcontroller board. The system collects real-time data on voltage, current, temperature, humidity, and light intensity to improve operational efficiency, safety, and maintenance practices in industrial settings. The main target is to develop an energy meter, monitor voltage and current using the internet of things, and monitor motor speed, LED intensity, and temperature. The IoT-based device is efficient, affordable, and easy to use, addressing common daily life problems. The project uses sensors like temperature, motion, and flame sensors to monitor energy consumption and detect anomalies. The collected data is transmitted to a central server via Wi-Fi or cellular networks, where it is analyzed using machine learning algorithms. The algorithms provide insights into industrial process efficiency, enabling better decision-making and improved safety. This IoT-based device has the potential to thrive in the modern market.

2. PARAMETERS MONITORING

2.1 Voltage

The difference in electric potential between two places in a system is called voltage, sometimes referred to as electric tension, electric pressure, or electric potential difference. It is equivalent to the amount of work required to transfer a positive test charge from one location to another per unit of charge. The volt (V) is the derived unit for voltage in the International System of Units (SI). In addition to the build-up of electric charge or electromotive force, electrochemical reactions, pressure-induced piezoelectric effect, and thermoelectric effect can also produce voltage on a macroscopic level. When measuring voltage between two points in a system, a voltmeter is typically used in conjunction with a common reference potential, such as the ground.

$$V = IR \qquad (1)$$

V - Voltage

I - Current

R - Resistance

When one ampere of current dissipates one watt of electricity, the electric potential between two points of a conducting wire is one volt, given in SI base units.

$$V = \frac{\text{power}}{\text{electric current}} = \frac{W}{A} = \frac{kg \cdot m^2 \cdot s^{-3}}{A} = kg \cdot m^2 \cdot s^{-3} \cdot A^{-1}.$$

2.2 Current

Electric current refers to the movement of charged particles across space or an electrical conductor like ions or electrons. Its meaning is the net rate at which electric charges flow across a surface. Charge carriers are the moving particles in electric circuits that can be electrons, holes, ions, or both. The International System of Units (SI) uses amperes to measure electric current, which is equivalent to one coulomb per second. It is measured with an ammeter and goes by the name amperage as well. Magnetic forces are produced by electric currents and are employed in transformers, inductors, generators, and motors. Additionally, they heat conventional conductors to the point of Joule heating, which illuminates incandescent light bulbs. Electromagnetic waves, which are utilized to broadcast information in telecommunications, are produced by time-varying currents.

$$I = V / R \quad (2)$$

V - Voltage

I - Current

R - Resistance

Ohm's law states that the current flowing through a conductor is exactly proportional to the potential difference between two points. The mathematical equation for this relationship is I = V/R, where I is the current in amperes, V is the potential difference in volts, and R is the resistance in ohms. The constant R is unaffected by the current.

2.3 AC Motor Speed

Because of the pulsing field's quicker spin, squirrel cage motors operate at tens of RPM slower than synchronous speed. The rotor slips past the surface as a result, which accounts for the discrepancy between synchronous and real speed. Internal mechanical losses prevent the slip from reaching zero even in the absence of load, even when the motor slows down and loads. This is because the rotor's flux remains constant and no current is produced in the squirrel cage. The two primary elements influencing the speed of an AC motor are the frequency of the AC supply and the number of poles in the stator winding.

$$Ns = 120F / p \quad (4)$$

Ns - Synchronous speed, in revolutions per minute

F - AC power frequency, in cycles per second

p - Number of poles per phase winding

2.4 Light Intensity

The basic unit of light intensity, the candela, is the amount of light emitted by one candle. With a radiant intensity of 1/683 watt per steradian, it emits monochromatic radiation. A light source, such as an incandescent bulb, is the centre of a sphere of radiated light that produces light in all directions. We refer to the entire energy of light as the "luminous flux." A lumen is one candela per steradian, and lux is the amount of lumens falling on a surfaceLumens per square metre, or lux, is a unit of measurement used to relate brightness to distance from source. Light intensity is commonly measured in foot-candles in the United States, which is one lumen per square foot. When light strikes a sensor, its energy is transformed into an electrical charge. More charge accumulates the more light that strikes the surface. In measuring electronics, a calibration transforms voltage or current into a lux value. The human eye is more sensitive to green wavelengths than to other light wavelengths. Lux meters are set up to anticipate light with the spectral distribution of residential tungsten-filament lighting, or CIE standard illuminant A, in order to address this. This adjustment, which is advised for all applications involving incandescent lighting, aids in the correlation between the raw intensity measurement and the impression of brightness by humans.

2.5 Temperature

Temperature is a physical number that may be measured with a thermometer to indicate how hot or cold something is. It shows the average kinetic energy of colliding and vibrating atoms in a substance. The scales in which thermometers are calibrated are the Celsius scale (°C), the Fahrenheit scale (°F), and the Kelvin scale (K), which is mostly used for scientific purposes. The Kelvin is one of the seven fundamental units in the International System of Units (SI). Absolute zero, or −273.15 °C, is the lowest point on the thermodynamic temperature scale and is unreachable in experiments. Temperature is a major factor in many natural scientific fields, such as physics, chemistry, Earth science, astronomy, medicine, biology, ecology, material science, metallurgy, mechanical engineering, geography, and daily living.

3. INTERNET OF THINGS (IoT)

The Internet of Things (IoT) is a network of interconnected devices that can share data and interact over the internet. By offering automated control over complicated systems and real-time insights, the IoT is revolutionizing a number of sectors.. This article discusses the various components, architecture, applications, security risks, challenges, and the future of the project, focusing on its potential to revolutionize various aspects of our lives. The IoT architecture comprises layers such as sensors, connectivity, data processing, applications, and end-users. Sensors collect environmental data, which is processed in the connectivity layer, then sent to the cloud or data centers for further analysis. The data processing layer uses cloud computing and big data analytics to transform raw data into valuable insights. The applications layer includes software platforms for end-user interaction, while the end-users layer comprises humans.

IoT, despite its numerous benefits, presents both challenges and opportunities. The technical complexity of IoT systems, along with social and ethical issues like privacy concerns and job impact, necessitates significant infrastructure investments. However, IoT offers opportunities like increased efficiency, automation, and real-time insights into complex systems. It can also lead to cost savings, improved safety and security, and new business opportunities. Overall, IoT presents both challenges and opportunities in the digital age.

The "Monitoring Industrial electrical equipments using Rasbperry Pi Pico W" project has the potential to significantly impact the social impact of the industrial sector. It can contribute to worker health and safety by monitoring flame and gas activity, reducing the risk of injuries and fatalities. The system can also detect potential dangers in workers' work areas, allowing for timely intervention. Remote control of machines can improve working conditions by eliminating the need for manual operation, reducing the risk of repetitive motion injuries. The system's energy consumption monitoring can lead to more efficient resource use, reducing costs and improving working conditions. Finally, the project can contribute to the sustainable development of the industrial sector by optimizing energy consumption and reducing costs, leading to more efficient and sustainable operations, creating a more stable and sustainable economy.

4. COMPONENTS

4.1 Raspberry Pi Pico W

The Raspberry Pi Pico is a microcontroller board designed by the Raspberry Pi Foundation, featuring the RP2040 microcontroller chip based on the ARM Cortex-M0+ architecture. Its low cost, small size, and versatility make it suitable for various projects, from simple electronics to complex embedded systems and IoT applications. The board has GPIO pins, supports programming languages like Micro Python and C/C++, and can be programmed via a USB interface. Its core component is the RP2040 microcontroller chip, and it also includes voltage regulators, USB connectors, and GPIO headers.

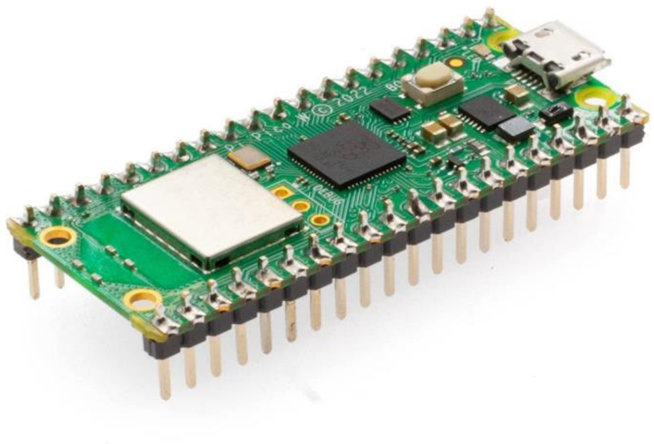

Fig.1 Raspberry Pi Pico W

The Raspberry Pi Foundation created the RP2040 microcontroller chip, which is the heart of the Raspberry Pi Pico. It features dual ARM Cortex-M0+ cores running at 133MHz, providing ample processing power for various applications. It also has 264KB of shared SRAM, which can be dynamically allocated.

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Intensity Sensor

Intensity (Amplitude) sensors measure the intensity of light in an environment, modulating the light carried by an optical fiber. They can be defined using a normalized modulation index (m). Illuminance, which is measured by light sensors, is more comprehensive than light source brightness. The BH1750 is an ambient light sensor that detects light levels in a broad variety of lighting conditions, from complete darkness to brilliant sunshine. Because it has a digital output, interacting with microcontrollers and other digital devices is simple. Intensity sensors are commonly used in applications like automatic brightness adjustment for displays, smart lighting systems, and environmental monitoring.

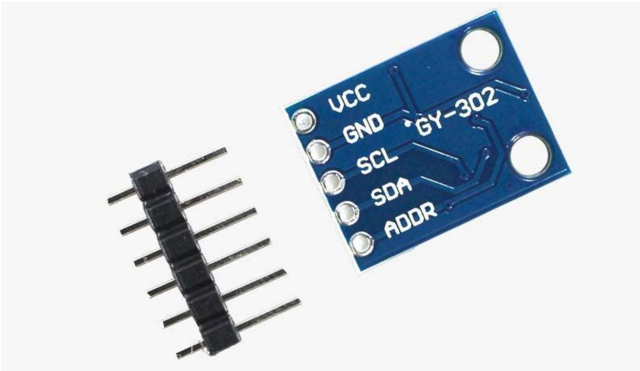

Fig.2 Intensity Sensor

Voltage and Current sensors

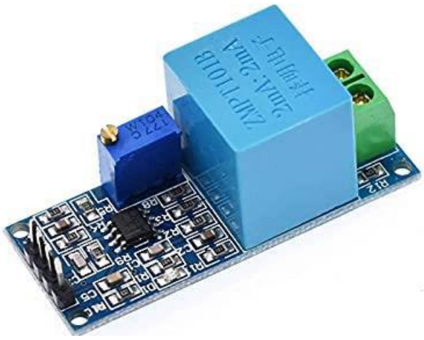

Fig.3 Voltage sensor

It is a plug-and-play sensor that can measure AC voltages without the need for additional electronics. A resistor divider yields an analogue signal with an output voltage of 0 to 5V, which is the most straightforward method for measuring an AC signal. The transformer, input/output resistors for current limitation, the opamp circuit for signal amplification, and other components were included in this sensor module. The ACS712 current module which detects alternating and ACS712 detects the maximum current of 30A.The other versions of this module that can detect the current of 20A and 5A.

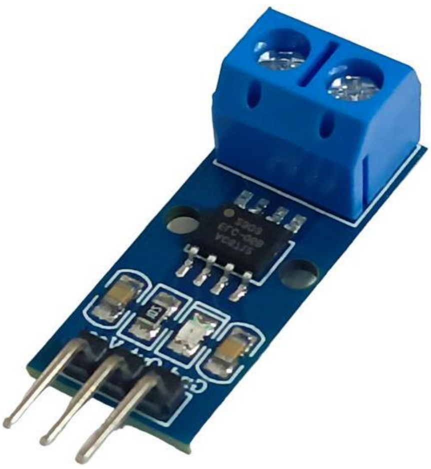

Fig.4 Current sensor

On the other side of the module, there are three pins. The VCC to power the module requires 5V, the ground. And the analog pin to read.

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LCD Display module

The term LCD stands for liquid crystal display. It is one kind of electronic display module used in many range of applications. These displays are mainly preferred for seven segments.

Fig.5 LCD display

The main benefits of using this module are inexpensive; simply programmable.

Temperature Sensor

The DS18B20 digital thermometer is a thermocouple or Resistance temperature detector having nonvolatile user-programmable trigger points, an alert feature, and temperature readings in Celsius from 9 to 12 bits. It uses the proprietary "One-Wire" communication protocol to communicate and has a useable temperature range of -55 to 125°C. The DS18B20 can operate in parasite power mode, which uses only ground and data lines and power supplied through the data line, reducing the need for three wires for operation.

Fig. 6. Temperature Sensor

5. WORKING METHODOLGY

The Monitoring of Industrial Electrical Equipments project utilizes a system design consisting of hardware and software components, focusing on the communication protocol between them, to achieve the desired outcomes, utilizing multiple components for effective system operation.

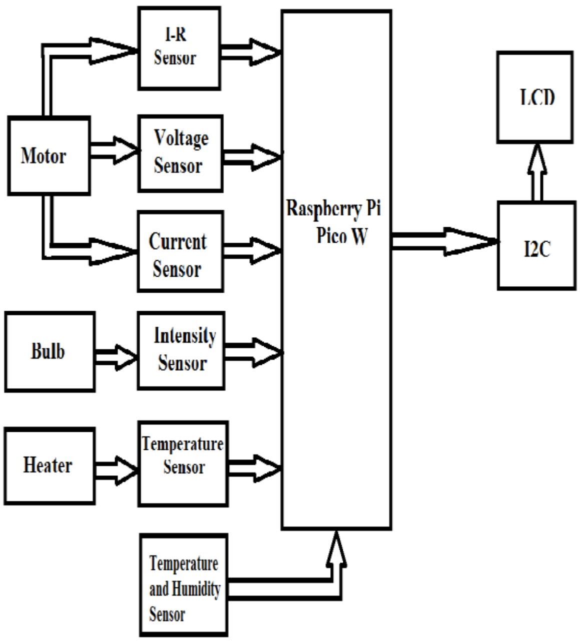

Fig.7. Block Diagram

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The project uses a Raspberry Pi Pico W to connect all sensors and modules in the system, with five sensors used for the experiment. The motion sensor detects loads' motion activity, which can be turned on or off. Data from these sensors is sent to the Firebase database, which is then used by apps to send changes. Users can control loads using apps, and loads activity is displayed on the apps. The project operates on the internet, and failure to connect will result in no data being loaded to apps or changes being applied to the system and database. Over voltage stresses in power systems are typically transient, characterized by sudden sizing of voltage to a high peak in very short duration. These surges are primarily caused by lightning impulses and switching impulses, but can also result from insulation failure, arcing ground, and resonance. They exist for very short durations. Motor overload can occur when the load is too heavy or the power source is insufficient. To avoid mechanical overload, consider if your process has recently changed, as seen in a food manufacturing company's recent dough recipe change. An IR sensor is a widely used device that detects an object's presence through infrared radiation. It is widely used in remote control, proximity sensors, line following robots, and security systems. The sensor consists of an IR transmitter and receive.

The project's circuit diagram, presented in Figure 8, outlines the components of a monitoring system using Raspberry Pi Pico W. The central controller receives data from sensors and sends it to the cloud for analysis. It also receives commands from the cloud to control the load. Sensors detect current, voltage, flame, motion, and gas in the surrounding area. The relay module switches the load on or off based on cloud commands. The circuit diagram provides a clear understanding of how the system components are connected together to form a functional monitoring system.

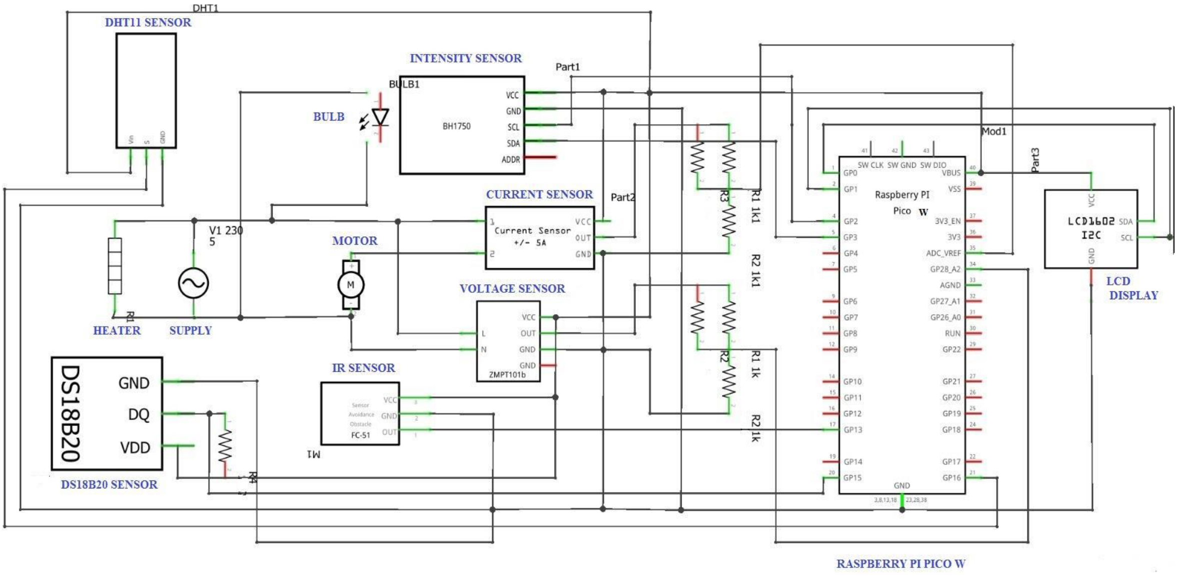

Fig.8. Circuit Diagram

6. MICRO PYTHON CODE

```
# importing the required libraries
From machine import ADC
From machine import Pin,I2C
From time import sleep
From pico_i2c_lcd import I2cLcd
From lcd_api import LcdApi
From dht import DHT11
From BH1750 import BH1750
Import machine, onewire, ds18x20, time
Import network
Import BlynkLib
Import utime
Wlan = network.WLAN(network.STA_IF)
Wlan.active(True)
Wlan.connect("V2027","12345678")
```

```
BLYNK_AUTH = “FWFO6Sl5hturMyrl-oBaj2sahn9hN9lH”
# connect the network
Wait = 10
While wait > 0:
If wlan.status() < 0 or wlan.status() >= 3:
Break
Wait -= 1
Print(‘waiting for connection…’)
Utime.sleep(1)
# Handle connection error
If wlan.status() != 3:
Raise RuntimeError(‘network connection failed’)
Else:
Print(‘connected’)
Ip=wlan.ifconfig()[0]
Print(‘IP: ‘, ip)
“Connection to Blynk”
# Initialize Blynk
Blynk = BlynkLib.Blynk(BLYNK_AUTH)
Counter = 0
# constants
SAMPLING_TIME = 1 # ( in seconds )
# You may also ask the user to input sample time
# pin declaration
tachometerPin = Pin(14, Pin.IN, Pin.PULL_DOWN)
dhtPin = Pin(2, Pin.IN , Pin.PULL_DOWN)
dhtSensor = DHT11(dhtPin)
ds_pin = machine.Pin(3)
ds_sensor = ds18x20.DS18X20(onewire.OneWire(ds_pin))
roms = ds_sensor.scan()
# interrupt handler function
Def tachometer(pin):# pin is default positional argument
Global counter
Counter += 1
# attach the interrupt to the tachometer Pin
tachometerPin.irq(trigger = Pin.IRQ_RISING,
handler = tachometer)
pot = ADC(Pin(28))
pot1 = ADC(Pin(26))
# which is pin id
I2c = I2C(0, sda=Pin(16), scl=Pin(17), freq=400000)
Lcd = I2cLcd(i2c, 0x27, 2, 16)
Light = BH1750(i2c)
# main logic of the program
While True:
Voltages = [] # Initialize an empty list to store voltages
For _ in range(600): # Loop 10 times
```

```
# Read value from the potentiometer
Pot_value = pot.read_u16() # Raw value, 0-65535
Voltage = (pot_value – 34100) * 0.045
#print(voltage)
Voltages.append(voltage) # Append the voltage to the list
#time.sleep(1) # Optional: Wait for 1 second between readings
Max_voltage = max(voltages) # Find the maximum voltage
#print("The largest voltage is:", max_voltage)
Vrms= max_voltage/1.414
Print("Vrms =" ,Vrms)
#lcd.clear()
Lcd.putstr(str("Vrms= "))
Lcd.putstr(str(Vrms))
Lcd.putstr(str("V"))
Lcd.putstr("\n")
Print("\n")
Blynk.virtual_write_msg(0, Vrms)
Utime.sleep(1)
# Initialize an empty list to store voltages
Currents = []
For _ in range(800): # Loop 10 times
# Read value from the potentiometer
Pot1_value = pot1.read_u16() # Raw value, 0-65535
#print(pot_value)
Current = (pot1_value – 33700) * 0.0009
#print(current)
Currents.append(current) # Append the voltage to the list
#time.sleep(1) # Optional: Wait for 1 second between readings
Max_current = max(currents) # Find the maximum voltage
#print("The largest voltage is:", max_current)
Irms= max_current/1.414
Print("Irms =" ,Irms)
Lcd.putstr(str("Irms= "))
Lcd.putstr(str(Irms))
Lcd.putstr(str("I"))
Lcd.putstr("\n")
Print("\n")
Blynk.virtual_write_msg(1, Irms)
Utime.sleep(1)
Lcd.clear()
Revolutions_per_sampling_time = counter / 2 # two white strips on the rotor
Revolutions_per_sec = revolutions_per_sampling_time / SAMPLING_TIME
Revolutions_per_minute = revolutions_per_sec * 60
Print("RPM : ", revolutions_per_minute )
Lcd.putstr(str("RPM= "))
Lcd.putstr(str(revolutions_per_minute))
Lcd.putstr("\n")
```

```
Blynk.virtual_write_msg(2, revolutions_per_minute)
# reset the counter to zero
Counter = 0
Utime.sleep(1)
Lux=light.luminance(BH1750.ONCE_HIRES_1)
Print("LUX: ", lux )
Lcd.putstr(str("LUX= "))
Lcd.putstr(str(lux))
Lcd.putstr("\n")
Blynk.virtual_write_msg(3, lux)
Utime.sleep(1)
Try:
dhtSensor.measure()
temp_value = dhtSensor.temperature
hum_value = dhtSensor.humidity
print("Temperature : ", temp_value, "Degree Celcius")
lcd.clear()
lcd.putstr(str("Temp= "))
lcd.putstr(str(temp_value))
lcd.putstr("\n")
utime.sleep(2)
print("Relative Humidity : ", hum_value, " %", "\n")
lcd.putstr(str("Humanity= "))
lcd.putstr(str(hum_value))
lcd.putstr("\n")
utime.sleep(2)
lcd.clear()
except Exception as e:
print("Error:", e)
# Delay before taking the next reading
Utime.sleep(1) # Adjust delay as needed
Ds_sensor.convert_temp()
Time.sleep_ms(750)
For rom in roms:
Print("Temp")
tempC= round(ds_sensor.read_temp(rom),2)
tempF= tempC*(9/5)+32
print(tempC,'C')
lcd.putstr(str("TempC= "))
lcd.putstr(str(tempC))
lcd.putstr(str(" C"))
blynk.virtual_write_msg(4, tempC)
lcd.putstr("\n")
utime.sleep(1)
print(tempF,'F')
lcd.putstr(str("TempF= "))
lcd.putstr(str(tempF))
```

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```
lcd.putstr(str(“ F”))
lcd.putstr(“\n”)
utime.sleep(2)
lcd.clear()
```

7. RESULT

Fig. 9 Output 1(Vrms&Irms).

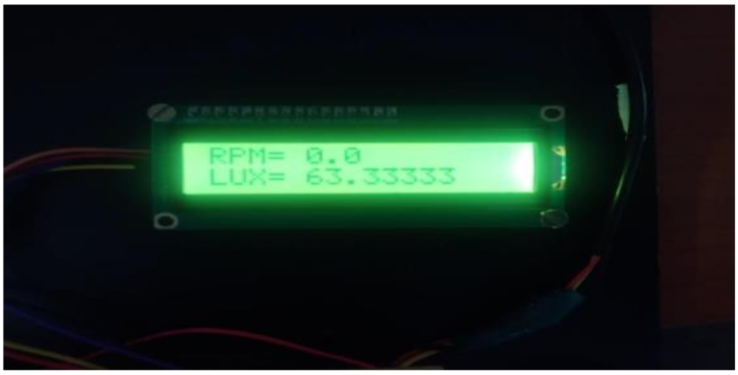

Fig.10 Output 2(Speed &Lux)

Fig.11 Output 3(Temperture)

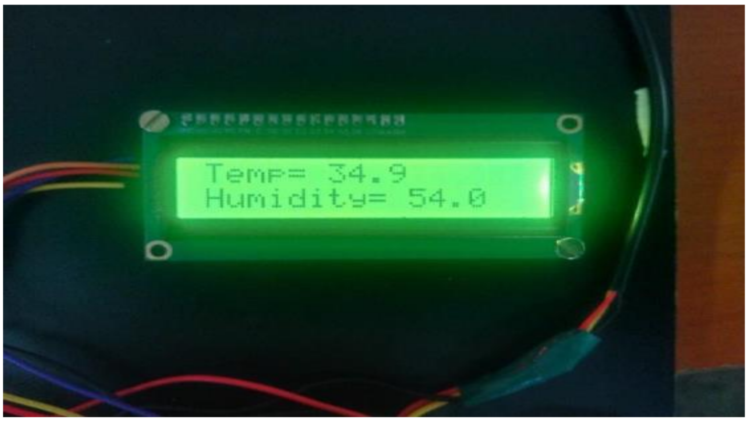

Fig.12 Output 4 (Temp &Hum)

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The Raspberry Pi Pico W has been successfully developed for monitoring industrial electrical equipment. The system, which works with sensors measuring temperature, humidity, current, voltage, and motion, is highly effective in controlling industrial loads and detecting fire and motion alarms. The data collected is sent to a cloud server via Wi-Fi, where it is analyzed and processed. The system can be remotely monitored and controlled using a mobile app

This project aimed to develop an IoT-based industrial load monitoring system that provided real-time data on machine performance, motion activity, and flame activity. The system was designed to be reliable, accurate, and user-friendly, accessible from mobile devices. The project successfully achieved its objectives, with the hardware and software components being designed and implemented successfully. The system accurately monitored and controlled industrial loads, detected motion and flame activity, and improved workplace safety. One of the key advantages of this system is its ability to provide real-time data on machine performance. The project’s success highlights the importance of IoT in industrial monitoring.

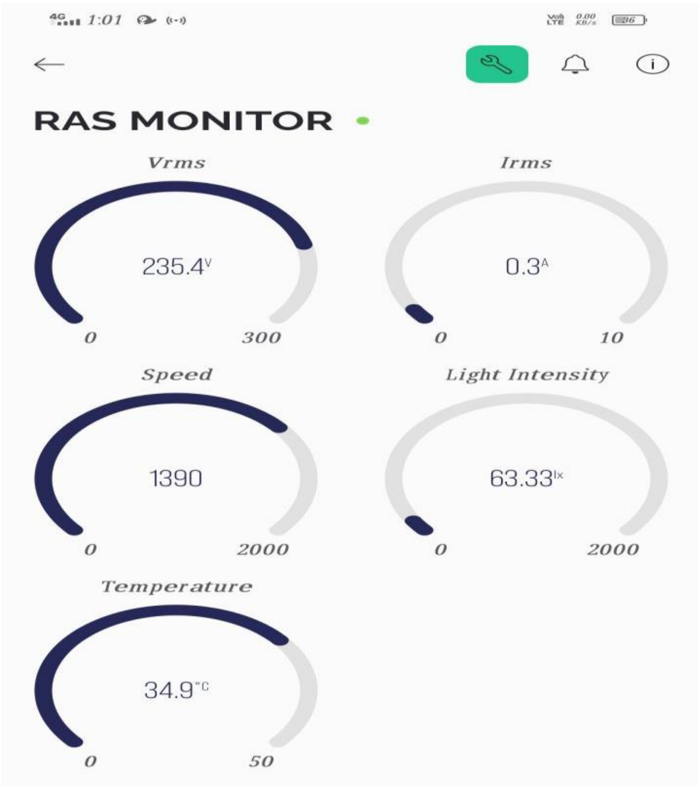

Fig.13 Blynk Output

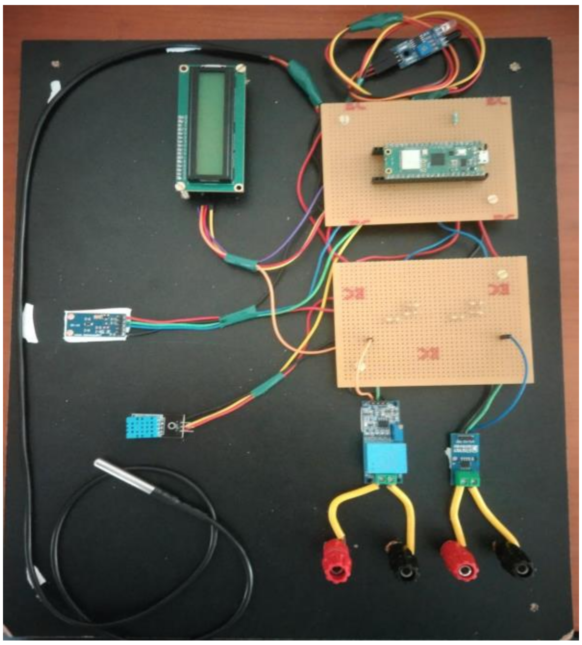

Fig.14 Hardware Kit

8. CONCLUSION

The project focuses on the development of a Monitoring of Industrial Electrical Equipments using Raspberry Pi Pico W, which is designed to monitor and control various parameters such as load current, temperature, voltage, and light intensity. The system is designed to provide real-time updates to users via a mobile app, enhancing accessibility and ease of use. The hardware implementation and testing have shown the system to operate reliably and accurately, delivering precise measurements and quick response times. The project has significant industrial and social impacts, potentially improving workplace safety and efficiency while reducing downtime and energy consumption. It is particularly relevant in Bangladesh, where industrial accidents and power outages are common. The project builds on existing research on IoT technology and its applications in industrial settings, addressing challenges such as scalability, security, and interoperability. With further development, the system has the potential to significantly impact workplace safety, efficiency, and productivity.

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