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Power Consumption Dashboard Using Iot

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Abstract:
“Power Consumption Dash Board Using IoT" was developed using a web application. The planned system includes a home energy monitoring system and cloud service notifications. An Internet of Things (IoT) platform was implemented to monitor energy consumption data at home and send the energy consumption data to the IoT cloud. The system uses the WiFi connected to the RaspberryPiPico to measure the energy consumption of the house. Energy consumption data is collected and stored in IoT cloud services. Consumers can monitor the energy consumption of their home on a daily basis and thus control how much energy is used on a daily basis. The data collection experiment aims to determine household energy consumption. Also, the website shows data on energy consumption before and after the load is connected to the system. IoT dashboard available online that allows users to check their daily energy consumption using IoT dashboard. IoT Cloud performs event analysis based on collected energy consumption data and alerts the owner with an alert, an email recommendation and a telegram notifying the customer when the energy consumption limit is exceeded, helping to reduce excessive energy consumption.
Keywords:Internet of Things, RaspberryPiPico, Cloud Services, web application.

I.**Introduction**

Internet of Things (IoT) Analytics is a data analysis tool that evaluates a variety of data collected from IoT devices. IoT analyzes evaluate huge amounts of data and generate actionable insights from it. IoT analytics are usually discussed alongside Industrial IoT (IoT). Data is collected from a variety of sensors found in manufacturing infrastructure, weather stations, smart meters, vans, and all types of machinery. IoT analytics can be applied to data center management, retail, and healthcare applications. IoT data is similar to big data in many ways. The main difference between them lies not only in the amount of data but also in the range of sources from which it is extracted. All of this data needs to be processed into an understandable data stream. When you consider multiple types of information sources, data integration becomes quite difficult and this is where IoT analytics makes a difference, even though it can be difficult to develop and implement.

Smart homes have security systems that you can access and control when you're away from home, as well as devices that you can turn on and off with digital assistance. There is a wide variety of devices that can be installed in your home and a variety of data that can be collected to assess usage patterns, system efficiency and more. With a huge choice of devices, there is an endless stream of data in huge amounts. IoT Analytics helps you analyze this data across all connected devices without hardware or infrastructure. As the needs of your business change, the computing power and data storage grow or shrink accordingly, providing the necessary IoT analytics capability.Regular restocking: Monitor stock levels in real-time. A food retailer with connected vending machines can request replenishment depending on the stock. This can be triggered when the machine's inventory reaches a certain level.

The IoT power monitoring system consists of three layers. The lowest level of architecture is the hardware part, which includes device sensors and smart meters. Flexible connectivity allows these devices to be connected over wireless or wired networks. Smart energy meters have a number of advanced features such as B. Intelligent monitoring and analysis of energy consumption based on parameters such as power factor, energy consumption, peak voltage and energy consumption. The versatility of the meter allows it to be used for a variety of monitoring purposes.The middle layer handles the transmission of the collected data to the gateway and then to the local computer or the Internet (cloud) using standard connection protocols, such as e.g. B. ZigBee radio technology. The sensors can be placed very flexibly at nearby or remote locations.

Data from the device/cloud is sent to software or other business systems such as Manufacturing Execution Systems, Building Management Systems (BMS), Advanced Production Scheduling Systems (APS) and comprehensive analysis of the data is performed and actionable. action insights are derived. . IoT energy management solutions help reduce energy costs in residential/commercial environments and also reduce operating and labor costs. You can predict energy consumption patterns and make decisions based on budgets and plans. Data collected by sensors can be used to control air conditioning and lighting levels in real time. Using IoT for energy monitoring and management in the form of intelligent sensors and detectors will reduce overall energy consumption.

Ii.Related Works

"Development of Internet of Things (IoT) Based Energy Consumption Monitoring and Device Control System" – by Stephen Bassi Josepha, Emmanuel Gbenga Dadab and Muhammed Sadiq Abdullahia.The Internet of Things is an extension of an existing Internet framework to enable communication, connection and work on the Internet between multiple devices and physical objects, also called "things". The urbanization explosion of recent years has required the implementation of sustainable, efficient and intelligent solutions to monitor and control energy consumption. Traditional home energy monitoring systems are unable to automatically monitor, bill, and manage energy consumption in IoT homes. Therefore, to fill this gap, the article introduces an IoT-based power monitoring and control device that uses the Atmega328 microcontroller.The proposed system is able to monitor, bill, control and monitor the energy consumption of all devices. In addition, the system is able to calculate and bill the total energy consumption, which is automatically sent to consumers. The proposed system has an average overall operational accuracy of about 95%. This shows that the proposed system shows promise in monitoring and controlling energy consumption.

"Smart Energy Meter Using Android Application And GSM Network"– by Diya Elizabeth Paul , Prof . Alpha Vijayan.The aim is to create a fully automated electricity billing system. The aim is to measure and monitor the electricity consumption of consumers in a specific location, send the consumed energy to the station and issue an automatic bill for the consumed energy.

"Design and Implementation of IoT Based Smart Power Monitoring And Management System Using WSNS" – by Iman Mohammed Nayyef and Assit.Prof. Anas Ali Husein.It will design a system based on WSN and IoT technologies to manage building power supply in real time. The system includes: a wireless sensor network (discovery nodes and base station) and a smart home gateway. The Sensing Node uses wireless sensors to measure voltage and current; for calculating the power consumption of connected devices, transmitted wirelessly to the base station via a Zigbee node. The base station is designed to receive all data transmitted by the sensor node and display it through a graphical interface available on a personal computer, with the ability to control the switching on and off of devices according to the needs of the consumer; All these readings are stored in the database for analysis. In addition, the smart home gateway will connect the system to the internet, allowing consumers to continuously monitor and control their devices remotely via a smartphone app.The advantage of this system is that the device control mechanism can be performed in different ways (manual, automatic and remote). Various household

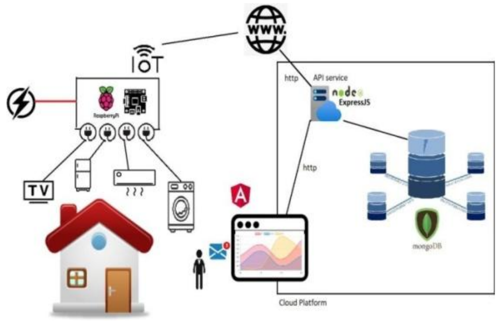


Fig.1. Proposed system Architecture

appliances were tested to verify the correctness of the electrical parameters measured in the system and to compare them with practical "Smart Energy Meter" – by Jithin Jose K, Leneesh Mohan, Nijeesh U K , Tony C Benny.Even the latest to design a tamper-proof energy meter that supports an automatic metering and billing system while helping to locate faults in transmission lines.

III.**Proposed Architecture**

The proposed system is a digital based power consumption monitoring system which can alert the power consumers based on their usage which can also give us the detailed usage report with info graphics and insights. Thus reduces manual intervention and errors.

measurements. The average error rate was found to be between them (0.3%) for voltage, (1.5%) for current and (1.8%) for power.

enemeteris not untouchable. As a result, taking all these factors into account, it is possible

The Proposed System Architecture is shown in the Fig1.

A. REGISTERING IOT DEVICE IN THE PORTAL

In the IoT registration portal, fill out the "Create a device" form with your IoT device's MAC address and a unique device name to help identify the device. A copy of your IoT credentials will be sent to you via email, SMS, or both. If you choose SMS or Both, you will need to enter your mobile phone number and select your wireless service provider.

B. COLLECTING DATA USIG IOT

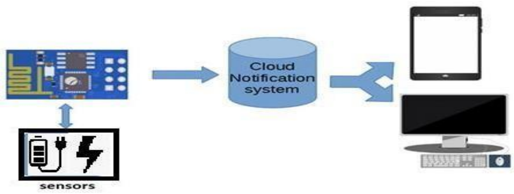


Fig.2. Processing in Cloud

IoT data collection uses sensors to monitor the performance of devices connected to the Internet of Things. The sensors track the health of the IoT network by collecting and transmitting real-time data that can be stored and retrieved at any time.

C. SENDING DATA TO CLOUD

IoT devices are often sensors that collect and forward data for processing. In the IoT space, physical sensors are virtualized before the data is uploaded to the cloud. While IoT devices can generate a lot of data, cloud computing allows for the transmission of that data.

D. PROCESSING DATA IN THE CLOUD

In the processing stage, a computer transforms the raw data into information. The transformation is carried out by using different data manipulation techniques, such as:

- Classification: Data is classified into different groups.
- Sorting: Data is arranged in some kind of an order (e.g. alphabetical).

- Calculation: Arithmetic and logical operations are performed on numericdata.

E. ALERTING USER

The IoT alert system provides a convenient way to distribute instant messages to specific people so appropriate action can be taken. Their implementations are numerous and cover different domains. At the heart of an IoT alarm system are sensors, which can be wired or wireless. Various physical phenomena such as energy and consumption as well as the five human senses: sight, hearing, touch, taste and smell are recorded and measured with the help of sensors.

If the sensor is to be the heart of an alarm system, notifications are like the arteries through which messages are sent.We may provide users with all kinds of information through notifications. This article details how to use IoT alarm systems to address pressing issues in various areas of life.

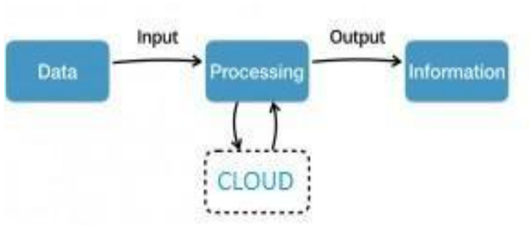


Fig 3.Cloud Notification System

E. DASHBOARD VISUALIZATION

Import dashboard data from a data warehouse, via web services like Google Analytics, or by uploading old-fashioned Excel or CSV files. When you use a modern data visualization tool, you take advantage of its integrations, which allow you to pull data from hundreds of other cloud platforms your business may be using.

Once you've collected data in your favorite analytics tool, we recommend that you download this dataset, apply it, and start creating visualizations that answer your questions.

IV. **System Overview:**

The proposed system consists of three parts: a web application, a base station and a sensor node. Starting at the bottom, the sensor node uses a Hall-effect AC current sensor and a transformer-based AC voltage sensor with a Raspberry Pi Pico microcontroller to calculate real-time power consumption of connected electrical devices.

A. VOLTAGE MEASUREMENT

The voltage sensor used in our work is a single-phase AC voltage sensor consisting of a voltage transformer ZMPT101B. Figure 1 shows the picture of the ZMPT101B chip. It has high accuracy, good consistency in measuring voltage and power, and can reach 250VAC.Added to this are the low price, small size and easy mounting on printed circuit boards (PCB). The output signal is sent to the analog input channel of the microcontroller.

B. CURRENT MEASUREMENT

To measure the current, we used the ACS712 current sensor. Figure 2 shows the ACS712. The main features of this sensor measure AC/DC current up to 20A.Its operating voltage is 5 V. The output signal is sent to the analog input channel of the microcontroller. This sensor works on the basis of the Hall effect principle. When current flows through a conductor placed in a magnetic field, a voltage perpendicular to the direction of the current and magnetic field is created at its edges.

C. POWER MEASUREMENT

For calculating power of a single-phase AC circuit, the output of volts and amperes must be multiplied by the power factor. Power Factor is the cosine of the phase angle of voltage and current waveforms as shown in the Figure 3. It is one,if voltage and current are in same phase. The current sensor output signal depends entirely on the nature of the connected appliance, whether the connected load is pure resistive, capacitive or is inductive.

The power is calculated at the microcontroller after receiving voltage outputs from corresponding current and voltage sensors as in (1).

$P=Vrms\times Irms\times P.F$…………………(1)

WhereP= CalculatedPower.
Vrms = Supplied voltage.
Irms= Drawn current
P.F=powerfactor.
Then, accumulated power consumption is calculated with run time of appliances, in order to calculated KWh as in (2).
$Energy(KWh)$ =($Power(W)$×$Time(t)$)/1000…(2)
Once the calculation is complete, the measured readings are displayed on the liquid crystal display (LCD). In addition, a relay for permission to control devices is activated when the demands of the consumer and envoy are met without commands from the microcontroller base station or in the event of a lockout of authorized processing limits. Diet. The ZigBee module is responsible for the wireless transmission of all readings measured in this part to the base station. The base station is designed to receive all readings transmitted from the metering node to continue real-time monitoring through a graphical user interface available on the computer system and website. With the energy monitoring function, the user can reduce the energy consumption and thus save money.These measured values are stored in a database for further analysis. These measured readings are then sent over the internet to the top layer of the application, which has different uses at different layers and for different purposes.
A microcontroller was used to record and process the information in the base station. Node MCU is a single-chip microcontroller (MCU) that supports Wi-Fi. Known as a Wi-Fi module, it can perform Wi-Fi-related tasks such as IoT applications and home automation. It is used as an alternative to the Node MCU's Wi-Fi Shield for connecting to a Wi-Fi network as it is considered a low cost alternative, comes with standard firmware and has the same functionality as the Wi-Fi Shield has . It's also out-of-the-box compatible with breadboards. It includes a built-in TCP/IP stack and many Internet conventions to facilitate Internet access.
D.NODE MCU

E.PIN CONFIGURATION OF NODE MCU DEVELOPMENT BOARD
This module provides access to the GPIO subsystem. All access is based on the I/O index number of the node's MCU assemblies, not

PIN NAME ON NODE MCU DEVELOPMENT KIT	ESP8266 INTERNAL GPIO PIN NUMBER	PIN NAME ON NODE MCU DEVELOPMENT KIT	ESP8266 INTERNAL GPIO PIN NUMBER
0 [*]	GPIO16	**7**	GPIO13
1	GPIO5	**8**	GPIO15
2	GPIO4	**9**	GPIO3
3	GPIO0	**10**	GPIO1
4	GPIO2	**11**	GPIO9
5	GPIO14	**12**	GPIO10
6	GPIO12		

Node MCU (Node Microcontroller Unit) is an open-source and low-cost IOT platform. It initially included firmware running on Espressif Systems' ESP8266 Wi-Fi SoC and hardware based on the

Fig 4 Node MCU index ↔ GPIO mapping.

ESP-12 module.Later, support for the ESP32 32-bit MCU was added.
NodeMCU is an open source firmware for which open source prototyping board designs are available. The name ―NodeMCU combines ―node and―MCU (micro-controller unit). The name "NodeMCU" combines "node" and "MCU" (microcontroller unit). The term "NodeMCU" refers solely to the firmware and not to the associated development kits. The firmware and breadboard projects are open source.
The firmware uses the Lua scripting language. The firmware is based on the eLua project and is based on the Espressif Non-OS SDK for ESP8266. It uses many open source projects like luacjson and SPIFFS. Due to limited resources, users should select appropriate modules for their project and create firmware suitable for their needs. Support for 32-bit ESP32 has also been implemented.
Typically, the prototyping hardware used is a printed circuit board that acts as a dual in-line package (DIP), integrating a USB controller with a smaller surface mount board containing the MCU and antenna. The choice of DIP format allows easy prototyping on models. The project was originally based on the ESP8266 system's ESP-12 module, a Wi-Fi SoC integrated into the Tensilica Xtensa LX106 core, which is widely used in IOT applications.
internal GPIO pins. For example, pin D0 of the development kit is mapped to GPIO pin 16. The MCU node provides access to the GPIO pins and the pin mapping table below is part of the API documentation.

[*]D0 (GPIO16) can only be used to read/write GPIOs. Does not support Open Drain/Interrupt/PWM/I²C or 1-Wire. The ESP8266 node MCU has a total of 30 pins connecting it to the outside world. The pins are grouped according to their functionality as follows:

Power Pins: There are four power pins viz. a VIN pin and a; three 3s.Pin 3V. The VIN pin can be used to directly power the ESP8266 and its peripherals if you have a regulated 5V voltage source. The 3.3V pins are the output of the integrated voltage regulator. External components can be supplied with power via these contacts.

GND: This is the ground pin of the ESP8266 node MCU development board. IC 12 Pin: Used to connect all kinds of sensors and I2C devices in your project. Both I2C master and I2C slave are supported. The functionality of the I2C interface can be implemented via software; the clock frequency is a maximum of 100 kHz. Note that the I2C clock speed must be higher than the slowest clock speed of the slave.

GPIO Pins: The ESP8266 node MCU has 17 GPIO pins, which can be programmatically assigned to various functions such as I2C, I2S, UART, PWM, IR remote control, LED light and button. Each digitally enabled GPIO can be configured for internal pull-up, pull-down, or set to high impedance. Once configured as an input, it can also be set to edge or level trigger to generate processor interrupts.

ADC Channel: The MCU node is integrated with a 10-bit precision SAR ADC. Both functions can be implemented using ADC viz.Test the supply voltage of the VDD3P3 pin and test the input voltage of ALL pins. However, they cannot be implemented at the same time.

UART Pins: The ESP8266 node MCU has 2 UART interfaces, namely UART0 and UART1, which enable asynchronous communication (RS232 and RS485) and can communicate at a speed of up to 4.5 Mbps. UART0 can be used for communication (pins TXD0, RXD0, RST0 and CTS0). Supports fluid control. However, UART1 (TXD1 pin) only supports data transmission signal, so it is generally used for protocol printing.

SPI: ESP8266 has two SPI ports (SPI and HSPI) in slave and master mode.These SPI interfaces also support the following general SPI functions: 4 SPI transmission timing modes, shared clocks up to

SDIO: The ESP8266 features a secure digital input/output interface (SDIO) used to directly connect SD cards. Both 25 MHz 4-bit SDIO v1.1 and 50 MHz 4-bit SDIO v2.0 are supported.

PWM: The board has 4 PWM (pulse width modulation) channels. The PWM output can be implemented in software and used to control digital motors and LEDs. The PWM frequency range can be adjusted from 1000 µs to 10000 µs or 100 Hz to 1 kHz.

Control pin : Used to control the ESP8266. These pins include the chip enable pin (EN), the reset pin (RST) and the WAKE pin.

EN pin – The ESP8266 chip is enabled when EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.

RST pin – RST pin is used to reset the ESP8266 chip.

WAKE pin – Wake pin is used to wake the chip from deep-sleep.

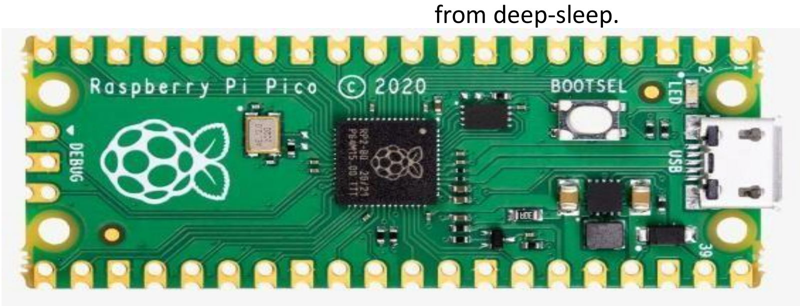


Fig 5 Node MCU pinout

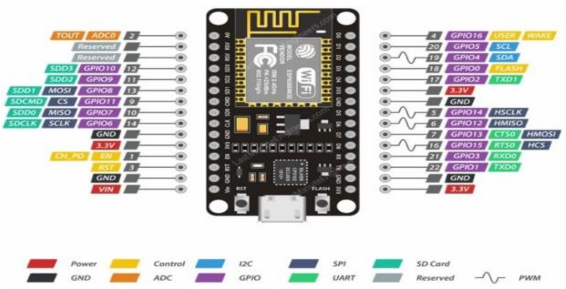
F.INSTALLATION OF NODE MCU

Nowadays, devices usually download and install drivers automatically. Windows doesn't know how to communicate with the USB driver on the MCU node, so it can't determine that the card is an MCU node and proceed normally. Node MCU Amica is a development board based on the ESP8266 WiFi module. It has a micro USB port that can be connected directly to a computer or other USB host device. The Ti comes with 15X2 pin headers and a Micro USB socket, the headers can be mounted on breadboards and the Micro USB socket is used to connect to a USB host device.It has a CP2120 USB to serial converter. To install CP2120 (USB to Serial Converter), the user needs to download the corresponding driver. After the user downloads the drivers according to the corresponding operating system, the system connects to the MCU node. The user needs to change the COM location assigned to the newly connected USB device (MCU node) by the System Device Manager. This COM port number is required when using the Amica MCU node.After installing the CP2120 driver, the MCU node can be programmed using the Raspberry Pi Pico software coded in C. This requires installing the ESP8266 card in the Raspberry Pi Pico via the Board Manager and assigning a communication port.

G.RASPBERRY PI PICO

Raspberry Pi Pico is a microcontroller board based on the Raspberry Pi RP2040 microcontroller chip.

Fig 6. Raspberry pi pico



Raspberry pi pico has been designed to be a low cost yet flexible development platform for RP2040, with the following key features:

- RP2040microcontrollerwith2MBFlash
- Micro-USBBportforpoweranddata(andforreprogramming theFlash)
- 40pin21×51'DIP'style1mmthickPCBwith0.1"throug h-holepinsalsowith edge castellations
- Exposes26multi-function3.3VGeneralPurposeI/O(GPIO)
- 23 GPIOaredigital-onlyand3 areADC capable
- Canbesurfacemountedasamodule
- 3-pinARMSerialWireDebug(SWD)port
- Simpleyethighlyflexiblepowersupplyarchitecture
- Variousoptionsforeasilypoweringtheunitfrommicro -USB,externalsuppliesorbatteries
- Highquality,lowcost,highavailability
- ComprehensiveSDK,softwareexamplesanddocume ntation
- 2×ProgrammableIO(PIO)blocks,8state machinestotal
- ForfulldetailsoftheRP2040microcontrollerpleasese etheRP2040Datasheet,howeverthe headlinefeaturesare:
- Dual-corecortexM0+atupto133MHz
- On-chipPLLallowsvariablecorefrequency
- 264kBmulti-bankhighperformanceSRAM
- ExternalQuad-SPIFlashwitheXecuteInPlace(XIP)and16kBon-chipcache
- Highperformancefull-crossbarbusfabric
- On-boardUSB1.1(deviceorhost)
- 30multi-functionGeneralPurposeIO(4canbeusedforADC)
- 1.8-3.3VIOVoltage(NOTEPico IOvoltageis fixed at3.3V)
- 12-bit500kspsAnaloguetoDigitalConverter(ADC)
- Variousdigitalperipherals
- 2×UART,2 ×I2C,2 ×SPI,16 ×PWMchannels
- 1×Timerwith4 alarms,1 ×Real Time Counter
- Flexible,user-programmablehigh-speedIOCan emulate interfaces such as SD Card and VGA

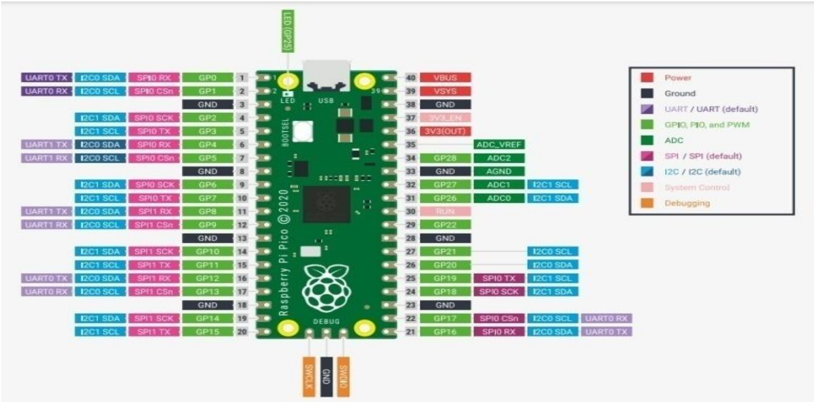


Fig 7 . Raspberry Pi Pico pinout

Pico provides minimal (but flexible) external circuitry to support the RP2040: flash memory (Winbond W25Q16JV), crystal, power supplies and decoupling, and a USB port. Most of the pins of the RP2040 microcontroller are connected to the user IO pins on the left and right edges of the board. Four RP2040-IO modules are used to perform internal functions: LED control, integrated switching power supply (SMPS) power control, and system voltage sensing.
The Model Pico is designed to use 0.1" solder wire or pin connectors (it is a 0.1" connector).Not 1 inch wider than a standard 40-pin DIP package) or can be used as a surface mount “module” as the user I/O pins are also die-cast. There are SMT pads under the USB port and BOOTSEL button that allow access to these signals when used as a reflow soldered SMT module. The Pico uses an on-chip buck-boost SMPS module capable of supplying the required 3.3V voltage (to power the RP2040 and external circuitry) from a wide range of input voltages (~1 .8-5.8V).5V). This allows for significant flexibility in powering the device from different sources, such as a single lithium-ion cell or three AA cells connected in series.
Chargers can also be easily integrated into the Pico drive chain. Pico Flash reprogramming can be done via USB (simply drag and drop the file onto Pico, which will appear as a mass storage device) or via the standard Serial Wire Debug (SWD) port. You can restore the system and upload and run the code without buttonspresses. The SWD port can also be used to interactively debug code running on the RP2040.

V.**Implementation:**

By monitoring the power consumption of devices, data is collected from the base station and stored in a computer system database for processing and analysis, and in a cloud database for remote access. The parameters stored are voltage, current, power factor, real and apparent power, as well as the state of each relay, kWh and the total system operating time. The data for these settings is displayed via the GUI.

Fig 8. Power consumption dashboard using IoT

The implementation includes software and hardware implementation. To implement the website we used Angular, Express, NodeJS, MongoDB, HTML, EMBEDDED C, JavaScript and PHP. For hardware implementation, we use a voltage sensor, a current sensor, an LCD display, a Raspberry Pi Pico, a WiFi module, an internet portal, a computer or a laptop. However, current measurement presents far more difficult problems due to the high harmonic content of the current waveform. The current transformer sensor not only requires the much larger dynamic range of the measurement, but also must handle a much larger frequency range.Voltage Sensing is usually obtained by using either the voltage division method or a step down voltage transformer. Decision making about which method should be used, is related to the work necessities. Wi-Fi enabled devices can connect to the Internet via Wi-Fi. A web portal is usually a specially designed website that collects information from various sources in a consistent manner.

VI.**Conclusion**

In today's world, energy consumption is calculated manually, which is time-consuming, cost-effective and carries the risk of incorrect values and human error. There is no real-time visibility or usage model. This makes it impossible to predict future energy consumption and expectations. This report explains the structure of the system and its impact on the energy consumption panel. The use of IoT gives us the ability to consciously manage our electricity consumption and also gives us the ability to make absolute predictions about energy consumption trends that can be used by the government to make policy decisions. A real-time energy alert system helps consumers and government officials detect electricity fraud and theft.

Future improvements in conducting analysis and data we have in a distributed data warehouse and applying machine learning techniques to understand the electricity consumer market.

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