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IOT Based Prepaid Electricity Billing System

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Abstract: Any country's growth and development are deeply linked with the efficient way of resources available in their land. The population growth and increase in the needs of people will lead to decrease in the resources available making it depleted for the future generation. Energy sources are one of the widely used resources in present day for electricity consumption, as fuels for transportation or cooking, etc. These energy sources will deplete one day or other so saving them is necessary.
Technology has advanced for leaps and bounds within a century and no one knows how much it will advance coming century. Numerous electrical appliances were introduced along with the dependency on them increasing the electricity consumption of people. The huge amount of usage and requirement of electricity is making it difficult for the utilities in collecting the electricity bill. One does not know how many units of power is being burnt in a month and how much it is affecting in preserving the energy sources. Humans have the tendency to control their expenditure and savings proportionately.
But with the current technology in electricity consumption, it is not possible to increase or decrease according to one's wish. Taking this as the problem statement we have chosen to make this project with different features to make the usage of consumers simple and easy. The major goal of this project is to create a system that aids in the reduction of electricity usage while also increasing openness between the Electricity Board and consumers. The metre should be recharged similarly to a DTH, with payment made via an app that also allows us to track the amount deducted, energy use, frequency, voltage, and power fluctuations.Users can also cut off the power from a remote location when not needed. The energy measurement and billing system in this project is automated without any human's intervention.

I. INTRODUCTION

IOT in different phrases Internet of Things, is a science the place numerous gadgets or matters are interconnected to every other as nodes via the gateways connecting to net through capacity of wireless technologies like Bluetooth, Zigbee, etc. Over 20 billion matters might also be getting related to internet in near future. IOT has evolved from the technologies like Microelectromechanical (MEM's) systems, microservices, wireless technologies by converging them with the internet.
IOT is one of the booming applied sciences in existing times which has a lot of achievable in coming future works. We come throughout a lot of products which now work with internet for better connectivity, safety and utility. We can see numerous home utility tasks with IOT like Air conditioners and ceiling fans, IOT scope is wider and large from smart home to smart city and so on. The statistics taken via the sensors strikes through the IOT gateway into the cloud or a database the place information is analyzed accordingly. The analyzed data will be sent as output performing required action, in others phrase it is if then. If the analyzed facts pass a threshold value, then an alarm rings or a message or an email. This is the basic working of an IOT system.
IOT ecosystem consists internet enabled embedded gadgets such as microcontrollers, processors, sensors and actuators. Sensors play a main function as input in the IOT system, the place they take in the statistics of their surrounding as per their fabrication for example, an ultrasonic sensor calculates the distance as per its echo.

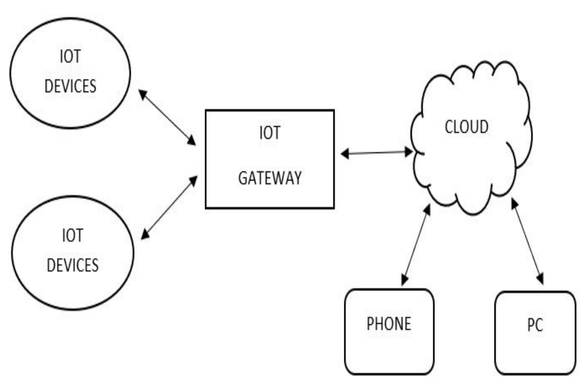

Fig-1: Block Diagram of IOT

In this project, we use a Wi-Fi-enabled Electronic Energy Meter (EEM) to transform it into a smart energy metre. The EEM employed in this project has a number of properties, the most important of which is that it creates pulses based on the amount of electricity consumed. The used energy is translated to digital and presented using an LCD panel based on this information. The utilized energy information is translated and presented in units, and the same is communicated to the concerned mobile through Wi-Fi module, with the added function of being able to terminate the supply from the mobile.
The EEM's analogue pulse output is converted to digital and sent to the microcontroller in this way. Because this meter is intended to generate 1600 pulses per unit, its accuracy is extremely good, allowing it to reliably measure very modest loads. Because the Wi-Fi module also works as a transceiver, it will be able to receive commands from the mobile phone. Our country doesn't use this kind of system presently and so, it has several advantages and uses, which are detailed in subsequent chapters.

II. LITERATURE SURVEY

Municipalities and energy distribution firms spend a significant amount of effort reading metres and billing customers. These tasks also have a significant impact on utility costs, efficiency, productivity, structure, and cash flow. Time-consuming, prone to mistakes, and delays in delivering invoices to customers, solutions based on manually recording measurements and then putting them into a central billing system have a detrimental impact on cash flow. The metre reading process involves a variety of approaches, ranging from old manual procedures to completely automated metre reading systems:

1) *Traditional System:* Traditional metre reading is done by a human operator, which necessitates a larger number of labour operators and a longer working hour in order to complete the entire area data reading and invoicing. As the number of residential and commercial buildings expands, the metre reading duty expands, necessitating a greater number of human operators. Such approaches, in addition to the enormous number of mistakes contained in the reading process, are highly time consuming and do not meet the commercial criteria for the power company. Transparency is impossible to achieve with such systems.
2) *Pic-based Energy Metre:* This technology was developed to increase the billing system's efficiency. This is an electronic energy metre that is meant to replace traditional electromechanical metres and is more precise than traditional energy metres because it is PIC based. The energy utilised by the user is monitored in this system, and charges are imposed accordingly. The major goal of this system was to protect the electrical system against circumstances such as overvoltage, undervoltage, and overload. A step-down transformer and a full wave rectifier are used to detect overvoltage and undervoltage circumstances. A current transformer linked in series with the load was used to identify an overcurrent problem. However, this method is ineffective in the prepaid billing process since it does not minimise the time-consuming chores and is only beneficial for security purposes.
3) *Gsm-Based Automated Metre Reading System:* To get metre readings as needed, so that metre readers are not required to visit each customer for the collection of used energy data and distribution of bill slips. The metre values were monitored and recorded using a microcontroller. If a client defaults, there is no need to send someone to shut off the client's connection. The utility can disconnect and reconnect the client's connection with a single message, and the consumer may monitor the status of power (load) from any location. The usage of GSM is used to send readings from energy meters.

Praveen Vadda and Sreerama Murthy presented a research project to employ Smart metering to measure and analyse the customer's electricity use. For this, they apply the ARIMA model with the XLASTAT tool and the flattening methodology.
Yadav, B.R. et al. (2015) recommended two papers, one for consumer mobile and the other for the electrical department. According to the report, the original idea of a Smart Energy Meter Based, Prepaid Electricity Distribution System was created in order to develop an effective metering system that benefits both the service provider and the user, as well as to preserve critical power. An Energy Meter, an ARM7 microprocessor board, and GSM modules make up the system.The microcontroller is coupled to the energy metre, EEprom, keypad, LCD display, and gsm modulesAccording to Hiware, R.B., et al. (2013), the system comprises of a wireless metre and a server. Wireless metres are installed in homes, businesses, and buildings and communicate data through SMS over the GSM network. The prepaid and post-paid systems were both deployed. The PIC is an 8-bit microcontroller with a Reduced Instruction Set.Because of its great performance and inexpensive cost, it is one of the most popular microcontrollers.
Smart metres allow for two-way communication between the metre and the central system, according to S, Ezhilarsu, et al (2015). In this article, sophisticated technology like as digital metering is discussed as being critical to achieving improved efficiency, reducing theft, reducing AT&C losses, and improving revenue collection. In this way, the metre may be immediately connected to a GSM module, and data may be sent to a specific consumer through SMS.

The P89C5RD2xx has a non-volatile 64KB flash programme memory that can be programmed in both parallel and serial modes in the system and application.A relay cuts off the electrical supply if the available credit is depleted. Human operators are prone to making mistakes when taking readings.The concerns described above are addressed in this project.

M. John and K. Jubi (2013) Meter reading systems have become wireless thanks to the development of GSM infrastructure during the last two decades. The usage of a prepaid energy metre is still debatable. The prepaid card may be refilled for a certain amount and provided as an input to the AT89S52 microcontroller.

According to Rezaul, M., et al. (2015), we used the Atmega32 microcontroller to create the EDU. When the refilled amount is depleted, the Atmega32 is programmed to turn off the power supply through a relay. The system is based on a microcontroller, and the measurements may be logged continually. The balance amount is shown using the Energy Metering IC ADE7755 and an LCD display.

III. METHODOLOGY

A. NodeMCU

NodeMCU is an open-source Lua-based firmware and advancement board planned explicitly for Web of Things (IoT) applications. It includes programming that works on Espressif Frameworks' ESP8266 Wi-Fi SoC and equipment dependent on the ESP-12 module.

On the NodeMCU ESP8266 improvement board, the ESP-12E module has an ESP8266 chip with a Tensilica Xtensa 32-bit LX106 RISC central processor. This microchip upholds RTOS and runs at an adjustable clock recurrence of 80MHz to 160MHz. The NodeMCU has 128 KB of Slam and 4MB of Glimmer memory to store information and projects. As a result of its high preparing power, underlying Wi-Fi/Bluetooth, and Profound Rest Working attributes, it is ideal for IoT applications.

The NodeMCU is energized through a Miniature USB connector and a VIN pin (Outside Supply Pin). It has interfaces for UART, SPI, and I2C.Because it is easy to utilize, the NodeMCU Improvement Board might be promptly customized utilizing the Arduino IDE.It will require close to 5-10 minutes to program NodeMCU utilizing the Arduino IDE. The Arduino IDE, a USB link, and the NodeMCU board are everything you'll require. To set up your Arduino IDE for NodeMCU, see this Beginning Instructional exercise for NodeMCU..

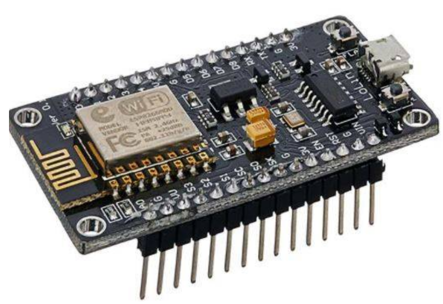

Fig-2: NodeMCU

B. AD7751 Energy Metering IC

The AD7751 is a fault-tolerant, extremely precise energy measuring integrated circuit designed for use in two-wire distribution systems. The AD7751 includes two current channels in addition to a voltage channel, allowing for continuous monitoring of both phase and neutral (return) currents. A defect is signaled if the currents differ by more than 12.5 percent, yet the AD7751 continues to bill appropriately by utilizing the bigger of the two currents.

The AD7755 is a stripped-down, less expensive variant of the AD7751. One current channel and one voltage channel are used in this extremely precise energy measuring integrated circuit with a large dynamic range. Current transformers, Hall Effect sensors, and 200 micro-ohm shunts all work well with the current channel.

These pin-compatible devices have two sets of frequency outputs, each of which consists of fixed-width pulse streams with pin-selectable frequencies. The product of current and voltage is represented by their frequencies. From low-frequency outputs for stepping motors to higher-frequency pulse streams for calibration and test, the outputs cover a wide range. Reading the magnitude-only outputs and monitoring the reverse-power logic output can be used to represent 4-quadrant multiplication. When negative power is detected, the reverse-power indication activates.

The AD7751 and AD7755 include a switched-capacitor architecture that allows a bipolar analogue input to be powered from a single 5-volt supply. The highest nonlinearity for either input is less than 0.05 percent. An integrated power supply monitor is included in these devices to guarantee proper performance during power up and power down. The AD7751 and AD7755 are offered in 24-pin SSOP and DIP packaging and are fabricated using 0.6 CMOS technology for cheap cost and low power usage.

Fig-3: AD7751 Energy Metering IC

C. MAX232

MAX232 is a notable IC that permits Microcontrollers and PCs to convey sequentially (PC). During sequential transmission, this IC is used to change over TTL/CMOS rationale esteems to RS232 rationale levels. A Microcontroller commonly works at TTL (Semiconductor Rationale) voltages of around 0-5V, while a PC runs at RS232 voltages of (- 25 to +25V). Thus, it isn't plausible to associate a PC to a microcontroller straightforwardly, which is the place where a MAX232 IC becomes possibly the most important factor.

MAX232 acts as a bridge between the microcontroller and your computer. This IC's transmitters will convert TTL/CMOS input voltage levels to RS232 voltage levels. The receiver pins may accept voltages ranging from -30V to +30V. Meanwhile, each receiver translates RS232 inputs to a 5V TTL/CMOS logic level that is sent onto a Microcontroller's Rx pin. To summarize, this IC functions as an intermediator by transforming signal voltage levels. With just a single 5V power source, the IC can provide RS232 standard voltage logic levels. This was accomplished using a capacitive voltage generator built into the IC.

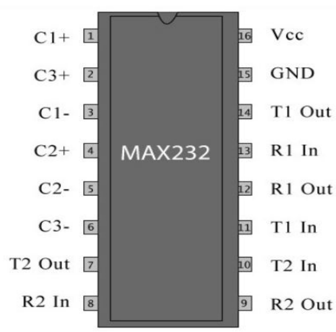

Fig-4: Pin Diagram of MAX232

D. LM7805 Voltage Regulator

In our situation, the 7805 IC is a well-known regulator IC that is used in a wide range of applications. The designation 7805 has two meanings: "78" indicates that it is a positive voltage regulator, and "05" indicates that it outputs 5V. As a result, our 7805 will output a value of +5V. This IC has a maximum output current of 1.5A. However, because the IC loses a lot of heat, a heat sink is advised for applications that use a lot of current. If the input voltage is 12V and you are consuming 1A, then (12-5) * 1 = 7W is the result. These 7 watts will be converted to heat and dispersed.

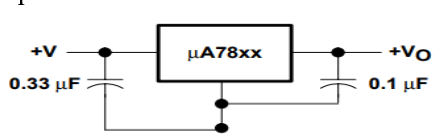

Fig-5: Circuit Diagram of LM7805

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The information capacitor is a 0.33uF ceramic capacitor that takes care of the information inductance issue, and the yield capacitor is a 0.1uF fired capacitor that improves the circuit's soundness. To work appropriately, these capacitors ought to be situated close to the terminals. They ought to likewise be artistic capacitors, as ceramic capacitors are faster than electrolytic capacitors.

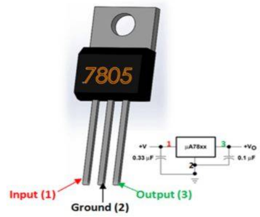

Fig-6: LM7805 Voltage Regulator

E. 555 Timer IC

The 555timer is an integrated circuit with eight pins, each of which is described in the pin description. This timer is utilized in the creation of pulses, oscillators, and other timing circuits. The 555 timer creates time delays in the oscillator as well as in flip flop parts, and it has three modes: astable, bistable, and monostable.

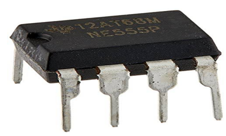

Fig-7: 555 Timer IC

The 555 timer's operating principle may be understood by looking at the 555 timer IC's block diagram. Pin 6 of the first comparator contains a threshold input, while pin 5 provides control inputs. Although the control input is utilized in certain applications, it is not utilized in the majority of them, hence the control voltage is set to +2/3 Vcc. The first comparator's output is sent into the set pin input flip flop. When the threshold voltage exceeds the control voltage, the first comparator flips flops, resulting in an extremely high output. The high output causes flip flop saturation, causing the transistor and capacitor attached to pin 7 to discharge. The complimentary signal is wired to pin 3 and this pin's output is low. Unless the comparator 2 causes the flip flop, these criteria are applied. If the threshold input is less than 2/3 Vcc, the first comparator will be unable to charge the charge flip flop. As a result, the first comparator has a high probability of high flip flop output. The flip-output flop's turns to minimum or low if the voltage at the trigger input is less than 1/3 Vcc. The output is minimized to the flip flips if the second comparator fires. This state is maintained until the trigger input voltage reaches a certain level. With the aid of flip flops, the output of the second comparator is low.

F. Relay

A copper wire is coiled on a metal piece to make an electromagnet. The coil is attached to the relay by joining it's ends with the pins available on relay. This is done to provide DC power. In most cases, two extra connections, referred to as switching points, will be provided to connect a high-ampere load. In order to link the switching points, another contact called a common contact is present.
Usually open (NO), normally closed (NC), and common (COM) contacts are the three types of contacts.AC or DC power can be used to operate the relay. In the case of AC relays, the relay coil becomes demagnetized with each current zero state, increasing the risk of the circuit breaking repeatedly. In order to overcome the problem, AC relays are built with a specific mechanism that ensures continuous magnetism. Electronic circuit layout or shaded coil mechanism are examples of such mechanisms.

Fig-8: Relay

The electromagnetic induction principle governs the operation of a relay. When the current flows through a rotating conductor it induces a magnetic field around the conductor. The relay is shown in action in the image above. To apply DC current to the load, a switch is utilized.
The electromagnet in the relay is made out of a copper coil and an iron core.
When DC current is introduced to the coil, it begins to attract the contact as indicated. This is referred to as relay energizing.
When you remove the supply, it returns to its previous place. This is referred to as relay de-energization. There are other relays whose connections are first closed and then opened when there is power, which is the exact opposite of the relay depicted above.
Solid state relays will feature a sensor element that will sense the input voltage and use opto-coupling to switch the output.

G. LCD

The word LCD refers to the display of liquid crystal. It is a type of electronic display module that is utilized in many applications such as mobile telephones, computers, TV settings, and so on. It is mainly used for multi-segment light emitting diodes and seven segments. Some of the major advantages of this module is cheap, simple programmable, etc. Animations and customizing characters are not restricted.

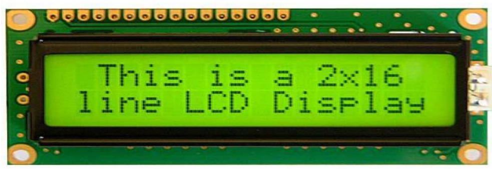

Fig-9: LCD

H. LDR Sensor

It is a photocell that works on the photoconductivity concept. The passive component is a resistor whose resistance lowers as the light intensity falls. This optoelectronic component is commonly found in light-varying sensor circuits and light- and dark-activated switching circuits.

Fig-10: LDR Sensor

When light strikes the sensor, electrons are freed, and the material's conductivity rises. The photons absorbed by the semiconductor provide the energy necessary for band electrons to jump into the conduction band when the light intensity surpasses a particular frequency. As a result, the liberated electrons or holes conduct electricity, substantially lowering the resistance (to 1 Kiloohm).

I. BC547 Transistor

BC547 is a NPN semiconductor, thus when the base pin is kept up at ground, the gatherer and producer are open (turn around one-sided), and when a sign is applied to the base pin, the authority and producer are shut (forward one-sided). The increase worth of the BC547 is 110 to 800, which controls the semiconductor's enhancement capacity.
When fully biased, the transistor enables a maximum of 100mA to pass between the collector and emitter. The voltage permitted across the Collector-Emitter (V-CE) or Base-Emitter (VBE) might be 200 or 900 mV in this stage, this region is known as the Saturation Region. when the base current is eliminated the transistor is in Cut-off Region, and the Base Emitter value may be approximately 660 mV. The saturation and cut-off region of a transistor is similar to On and Off of a Switch.

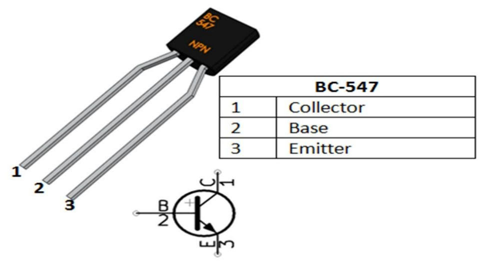

Fig-11: BC547 Transistor

J. Working

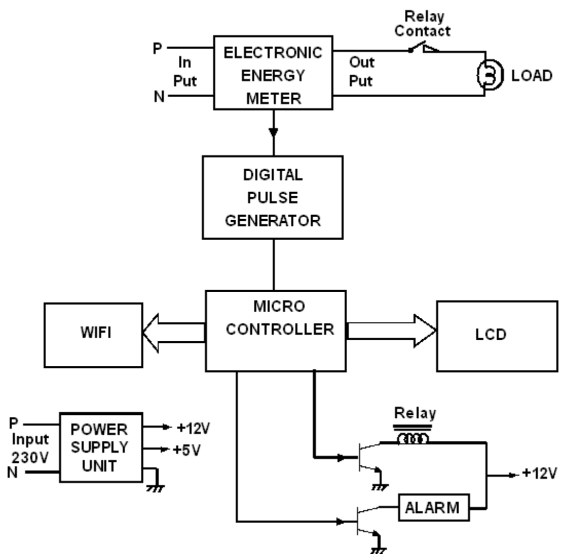

Fig-12: Block diagram

Energy Meter produces 1600 pulses per unit, dividing one measuring unit into 1600 parts. The energy meter produces just 100 pulses per unit, which is split into 1600 pieces to improve accuracy and allow it to properly measure extremely small loads. For calibration purposes, 1600 pulses are turned into 100 pulses, implying that the meter converts 16 pulses into one pulse internally using an encoder.

The energy meter's analogue pulse is transformed into a pure digital pulse with the help of Digital Pulse Generator. The digital pulse generator circuit is made up of an LDR, a tiny bulb, and a 555 timer IC. The IC is set to operate in monostable mode, triggering at 1/3 and 2/3 of the operational voltage levels.

The procedure starts with the energy meter's pulse output. The lamp briefly lights whenever the meter emits a pulse, and the light intensity falls on the LDR (Light Dependent Resistor), causing the voltage level to drop by less than 1/3 Vcc, which activates the IC and creates a perfect square pulse. Instead of a bulb, a high-glow LED can be utilized in this situation.

The microcontroller unit receives the output of the digital pulse generating circuit. This circuit creates square pulses based on the amount of energy consumed, and these pulses are stored in the microcontroller. This controller is referred to as the major unit, and its principal functions are as follows: When the metre is completely filled, the op-amp setup as voltage comparator will output a logic high pulse to the microcontroller, converting the used energy information into digital pulses and feeding it to the controller. To use the LCD to display the amount of energy spent and to use the matching relay to regulate the energy meter's output.

The LCD display part is constructed with a decimal point provision and two digits displayed following the decimal point. The energy meter, as previously said, emits 100 pulses per unit, allowing one unit to be calibrated into 100 equal parts and begin counting in increment mode based on energy usage.

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IV. IMPLEMENTATION

Software Requirements: Arduino IDE, BLYNK.

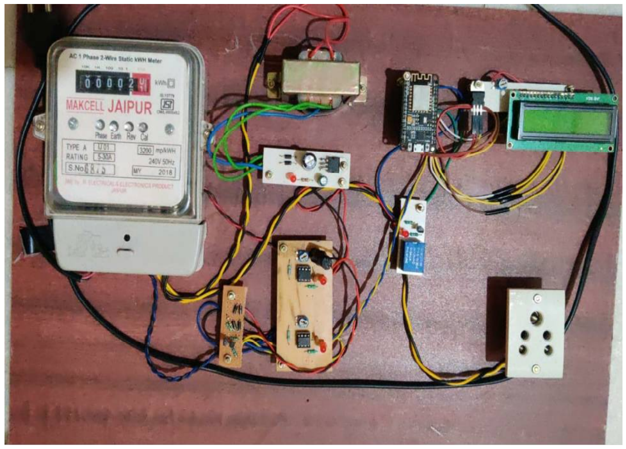

Fig-13:circuit connections.

The Energy Meter IC ADE7751 estimates the corresponding voltage and current throughout a specific timeframe to compute the energy spent, i.e, Energy = V * I * t. These two signs are shipped off the ADE7751 metering IC subsequent to venturing down the voltage under estimation with the help of a resistor-based advance down potential contrast organization and a current transformer (fundamentally this is a stage up transformer). For tallying the beats, the inner clock utilizes a precious stone oscillator. The recurrence signal relative to the energy utilization is gathered from the IC's yield through Pins 23 and 24 (F1 and F2). This beating recurrence has been changed at 1600 heartbeats for every unit of electric energy utilization. This IC has a capacity for showing issue conditions, with two rationale yields named 'Shortcoming' and 'REVP' (Switch Extremity), separately, that might be utilized to flag flaw conditions and converse extremity. In this task, these two signs are utilized, and two LEDs are connected to address the aforementioned flaw conditions.

Two logic outputs named ‘FAULT' and ‘REVP' can be utilized to identify a probable mis-wiring or fault state to identify the fault circumstances. Four LEDs are given for indication in this meter. The first indicator indicates that main power is present, the second indicator glows automatically when a fault occurs, the third indicator glows when the input wires are reversed, and the last indicator is nothing more than a pulse indicator that glows brightly whenever the energy meter detects a pulse.

The beat generator square's essential obligation is to change the simple sign from the energy meter into a computerized beat. The energy meter's heartbeat is just a pinnacle beat, which is then converted into a square heartbeat. A high-shine Drove is situated corresponding to the LDR (Light ward resistor) in this square, which streaks splendidly at whatever point the Energy Meter gets a heartbeat. With the help of a LDR and an IC 555 clock arrangement in monostable multi-vibrator mode, this light energy is changed into discrete electrical heartbeats. With the guide of the microcontroller, these heartbeats are deciphered as clock beats for resulting stages for tallying/show purposes and checking energy use.

A switching transistor is employed to power the high-glow LED source. A bridge rectifier converts the frequency output of the energy metering IC, which is a differential signal, into a proportional DC signal. The driving stage transistor receives this pulsing DC signal, which is then sent on to the LED. Vcc is supplied directly to the anode terminal of the high glow LED from the power supply unit.

The LDR receives this high-intensity LED light. LDR resistance changes depending on the light source that strikes it. As a result, the voltage drop across it varies. The built-in comparators of the IC 555 timer are used to detect the change in voltage. This IC is set up as a monostable stage, which implies that the yield will be either high or low contingent upon whether there is light or no light on the LDR, or whether the edge levels of the upper-level comparator (2/3 Vcc comparator) and low-level comparator (1/3 Vcc comparator) are crossed. The miniature regulator gets the yield of this clock as a clock beat, and the regulator drives the showcase (LCD) to show the beats delivered by the energy meter.

The output of the energy metering circuits (F1 and F2) is sent to a full wave bridge rectifier, which converts the frequency input into proportional dc voltage. Through the transistor, this dc voltage is delivered to the high glow LED source. The metering circuit's input signal determines whether or not this LED will light up. The needed dc voltage for the high glow LED source, namely +5 volts, is obtained straight from the power supply unit and link

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ed to it. This dc voltage is used to power the LEDs, and the ac signal generated by the ADE7751-based metering circuit controls the lamp's ON and OFF.

A transistor is utilized to drive the high glow LED light source because it operates as a switch, which is the most fundamental application of a transistor. The IC 555 timer converts the high light LED source energization/de-energization into clock pulses. Mono-stable Schmitt-trigger is how this timer is set up. This IC's pins No. 2 (Trigger Pin) and No. 6 (Thresh Hold Pin) are set to 1/3 VCC and 2/3 VCC, respectively. As a result, anytime the voltage at Pins 2 / 6 is less than 1/3 VCC or greater than 2/3 VCC, state changes occur. The resistance fluctuations of the light dependent resistor cause this voltage variation (LDR). Because of the light landing on it, this LDR fluctuation occurs. As a result, the timer's output generates clock pulses in response to variations in light/resistance. This, in turn, is proportional to the amount of energy used. As a result, the pulse-shaping block generates the appropriate clock pulses for display based on the energy usage.

The microcontroller executes the software that has been programmed into it. The software is constructed in such a way that the controller output is utilized to power the LCD, relay, and Wi-Fi modem. Through the output port, the LCD panel in this block communicated with the microcontroller. The LCD panel that was utilized in this project has 14 pins. Vcc, Vss, and VEE: Data bus pins 1-8, enable pin 9, Vcc, Vss, and VEE: VEE is used to modulate LCD contrast, whereas Vcc and Vss provide +5V and ground, respectively.

V. RESULTS

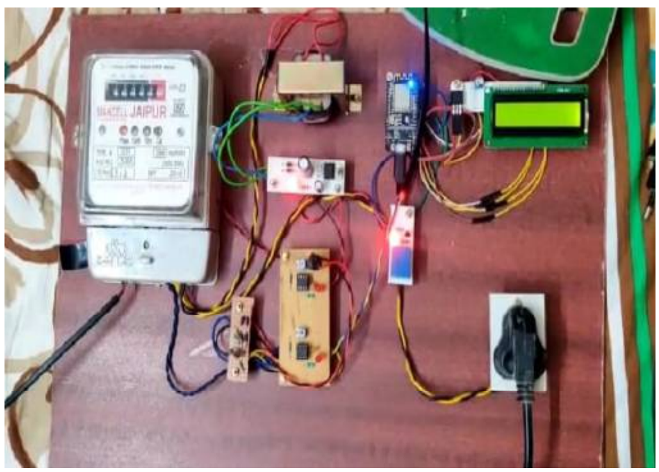

Fig-14: circuit board of IOT based prepaid electric bill system

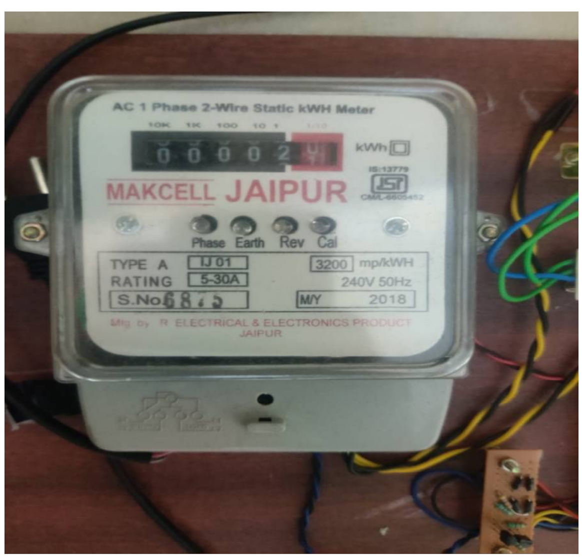

Fig-15: Energy Meter

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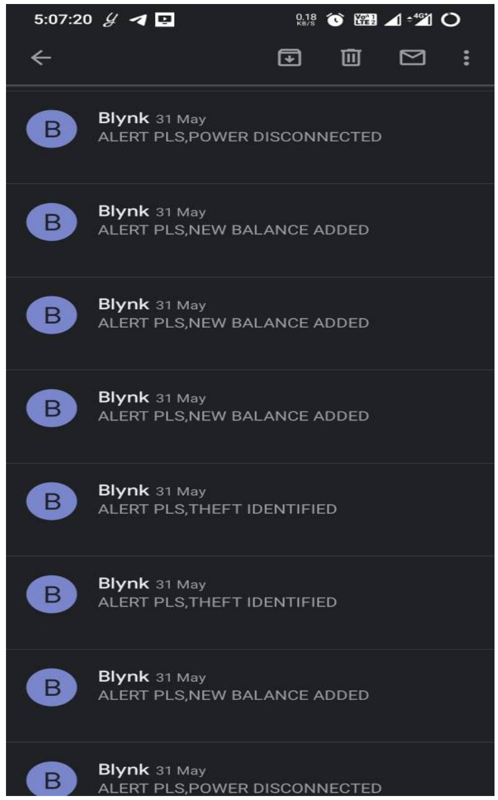

Fig-16: theft identification notifications in E-mail

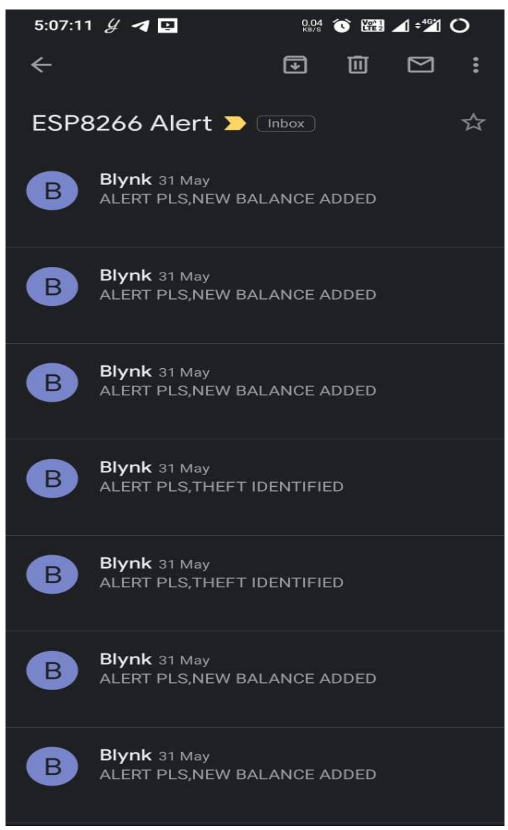

Fig-17: balance added notification in mail

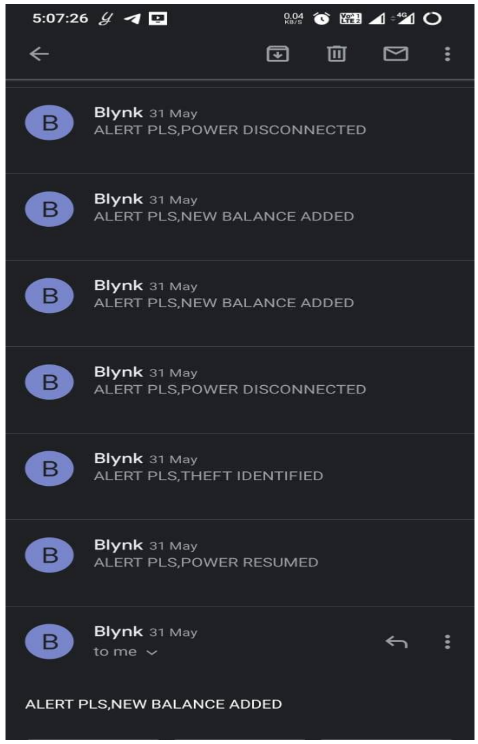

Fig-18: power connection notification in mail

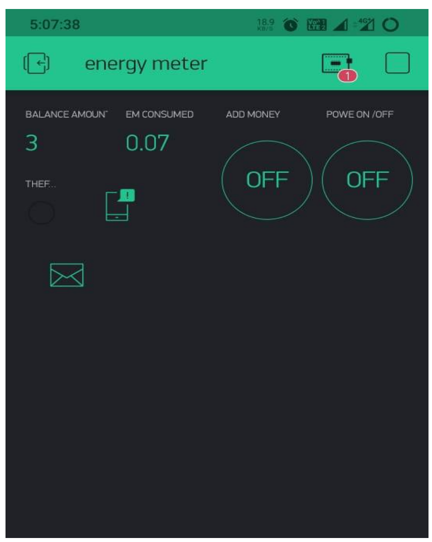

Fig-19: Blynk App

Fig-20: Output on LCD

VI. CONCLUSION

The notion of an IoT-based prepaid power billing system is a new technology trend, but the system built with Wi-Fi technology has several distinctive advantages. As mentioned in the benefits section, the technology used here is highly creative, and the advantages of this system are numerous when compared to other systems.

Many additional functionalities, such as recognizing the tampered energy meter, monitoring the line voltage and load current, and so on, may be monitored remotely thanks to the system's use of Wi-Fi technology. When the client is gone from the property, he can stop the supply to the house using his cell phone. Using Wi-Fi technology, a centralized monitoring station can be constructed from which all energy meters can be monitored continually, allowing for a flawless energy auditing system to be established and energy pilferage to be reduced.

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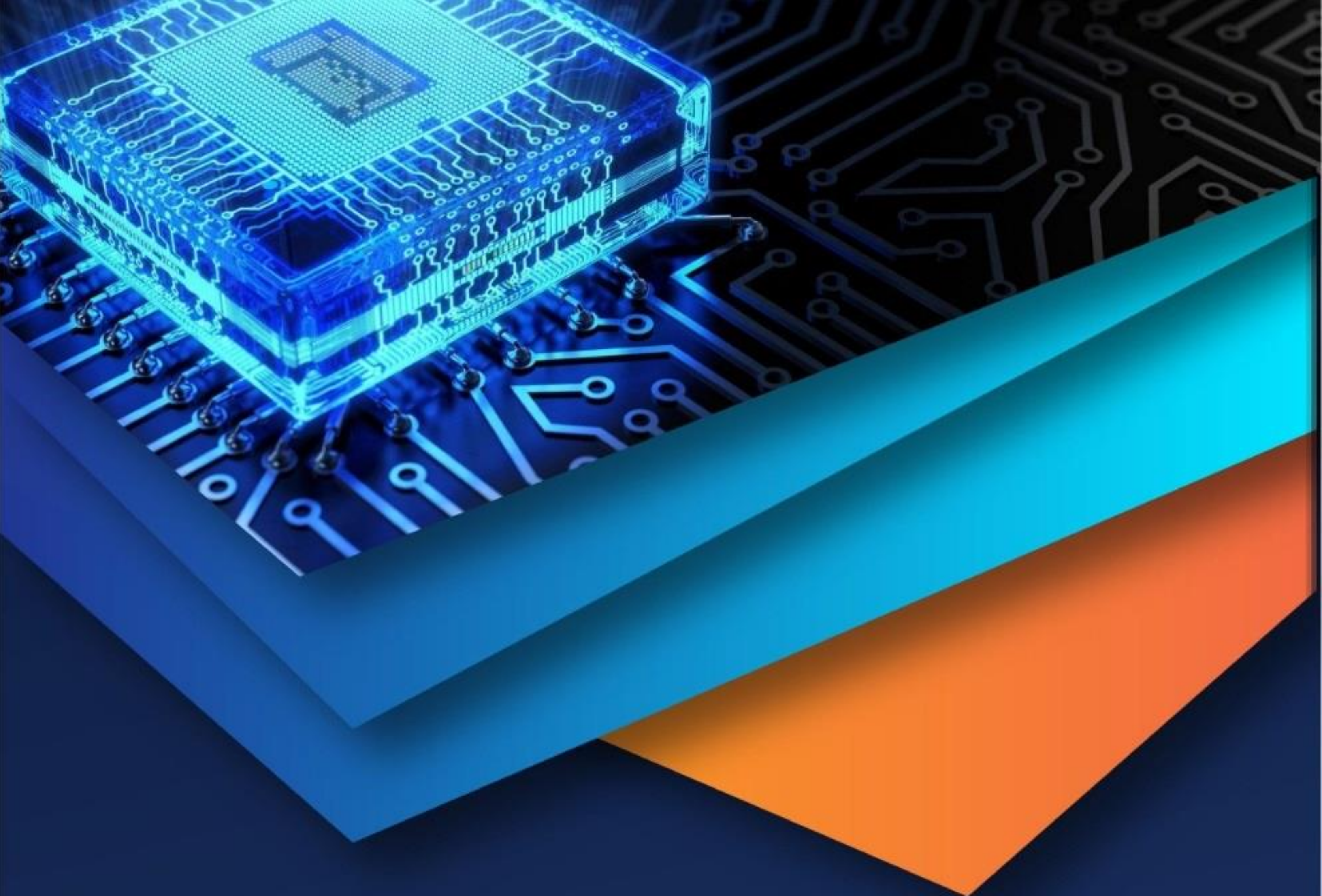

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