

Bi-directional Energy Meter with Automatic Power Factor Correction

**A
Project Report**

Submitted by

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in partial fulfillment

for

the award of the degree

of

BACHELOR OF TECHNOLOGY

In

ELECTRICAL AND ELECTRONICS ENGINEERING



**DEPARTMENT OF ELECTRICAL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY, UTTARAKHAND
APRIL 2019**

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APRIL 2019



**DEPARTMENT OF ELECTRICAL ENGINEERING
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Candidate's Declaration

This is to certify that the work which is being presented in this project report entitled **“BI-DIRECTIONAL ENERGY METER WITH AUTOMATIC POWER FACTOR CORRECTION”** in fulfillment of the requirement for the award of the degree of **BACHELOR OF TECHNOLOGY** in **Electrical and Electronics Engineering** and submitted in the Department of Electrical Engineering of National Institute of Technology Uttarakhand is an authentic record of my own work under the supervision of **Mr. Himesh Kumar**, Trainee Teacher, Electrical Engineering Department.

The matter presented in this thesis has not been submitted by me for the award of any degree of this or any University/Institute. I have followed the guidelines provided by the Institute in preparing the project report. Whenever I have used the material (data, theoretical analysis, figures and text) from other sources, I have given due credits by citing in the text of thesis with details in the references.

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Abstract

The Report in its present form gives the idea of Bi-directional metering and control of power factor automatically using capacitor bank. There undoubtedly exists energy meters for calculate the consumption of energy- but such meter are neither efficient nor economical when viewed from the large scale perspective. The sole idea behind this project is to present a model or idea that can demonstrate an efficient way of metering the energy consumption with an objective to minimize the reactive power consumption as much as possible. Surely the cost factor may seem to be higher when working on the small models , but then the tremendous decrease in the reactive power consumption and the electricity cost using the same model justifies the idea used. Here, instead of using the fixed rate for billing purpose, we have implemented the idea of Wi-fi module technique, to fetch the instant electricity rate from vidyut pravah site. To provide an interface between our hardware and Wi-fi module, we are using Arduino Mega as the development board. Finally the 16*2 LCD display facilitates the user to look on to the energy consumption and electricity bill.

Nomenclature

A	-	Amper
V	-	Volt
R	-	RealPower
Q	-	ReactivePower
S	-	Apparent Power
PCB	-	Printed Circuit Board
PIC	-	Peripheral Interface Controller
IEEE	-	Institution of Electrical and Electronics Engineering
IC	-	Integrated Circuit
SPI	-	Serial Peripheral Interface
R	-	Resistor orresistance
L	-	Inductor
C	-	Capacitor
X	-	Reactance
Z	-	Impedance
kW	-	kilo-Watt
kVa	-	kilo-volt-ampere
kVar	-	kilo-volt-ampere-reactive
P.F	-	PowerFactor
I	-	Current

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Chapter 1

Introduction

1.1 Introduction to Bi-directional metering with smart features

In the present innovative unrest, control is exceptionally valuable and the power framework is ending up increasingly more intricate with each passing day. An energy meter is a gadget which screens our power usage or at the end of the day vitality utilization. It shows the units in types of digits that assistance the eyewitness to compute the power bill as far as cash. all things considered, it winds up important to transmit every unit of intensity created over expanding separations with least loss of intensity on the grounds that the consumer needs to pay for every one of the factor. Not withstanding with expanding the number of inductive burdens vast variety in burden and so forth the misfortunes have additionally expanded complex. Consequently, it has turned out to be judicious to discover the reasons for power misfortune and improve the influence framework. Because of expanding utilization of inductive burdens the control factor diminishes extensively which builds the misfortunes in the framework and consequently influence framework misfortunes its efficiency. Also, there is soo much issue in executes charging methodology as pursues: an approved individual comes to take readings. At that point, he gathers every one of the information and submits it to the workplace. Presently there are so many factors that could cause the mistake, for example, human blunder while taking the readings. So the fact is that the framework is less viable or less proficient and loaded up with bunches of influencing factors. So we structure such a meter that makes it simple for the consumer to trust that 'he is paying for what he will utilize' and furthermore with the assistance of APFC reduces the utilization of reactive power utilization.

A bidirectional meter with automatic power factor amendment gadget peruses active and reactive power and furthermore the power factor from line voltage and line current sense by voltage and current sensor. It decides the stage edge slack between the voltage and current flags and after that decides the comparing power factor at that point the microcontroller figures the pay necessity and likewise switches on the required number of capacitors from the capacitor bank until the power factor is standardized to about solidarity and charging with the assistance of information brought utilizing wi-fi module from the power board site.

The automatic power factor redress strategies that we use in this meter can be connected to modern units control frameworks and furthermore families to make them stable. Therefore the framework ends up stable and proficiency of the framework just as of the mechanical assembly increments. This corrector results in diminished generally speaking expenses for both the customers and the providers of electrical vitality.

Power factor revision utilizing capacitor banks diminishes receptive power utilization which will prompt minimization of misfortunes and in the meantime builds the electrical

framework's proficiency. Power sparing issues and responsive power the executives has prompted the advancement of single stage capacitor banks for household and mechanical applications. The improvement of this task is to make wise framework power compose in mastermind to supply profitability with a viable supply of intensity inexpensiveness and security.

Chapter 2

Review of Literature

2.1 Bidirectional Meter:

The bidirectional meter will gauge the stream of power in two ways. It gauges what quantity vitality originates from your electrical organization kWh sent. It likewise measures the distinction between the generators creation. The meters nowadays doesn't quantify the generators in power generation.

2.2 Requirements for Bi-Directional Metering:

1. An application for age interconnection must be submitted to your electric organization preceding age association.
2. Age must meet the details of the net energy meter rider which indicates generator limit what's more sustainable generator source.
3. Generation hardware must meet utility item security and network interconnection details. for a model, an outside separate is required inside 10 feet of the meter area.
4. An electrical review is required before empowering an age interconnection.
5. After the electrical review another bi-directional meter will be introduced by your electric organization.

2.3 Power Factor:

Power factor is a vitality idea that is identified with power stream in electrical frameworks. To comprehend the control factor, it is useful to comprehend three distinct sorts of intensity in electrical frameworks.

Genuine Power is the power that is really changed over into valuable work for making warmth, light, and movement. Genuine power is estimated in kilowatts (kW) and is totalized by the electric charging meter in kilowatt-hours (kWh). A case of genuine power is the helpful work that straightforwardly turns the pole of an engine Reactive Power is the power used to continue the electromagnetic field in inductive and capacitive gear. It is the non-working force part. Responsive power is estimated in kilovolt-amperes receptive (kVAR). Responsive power does not show up on the client charging explanation.

Complete Power or Apparent power is the mix of genuine power and receptive power. All out power is estimated in kilovolt-amperes (kVA) and is totalized by the electric charging meter in kilovolt-ampere-hours (kVAh). Power factor (PF) is characterized as the proportion of genuine capacity to add up to power and is communicated as a rate (%).

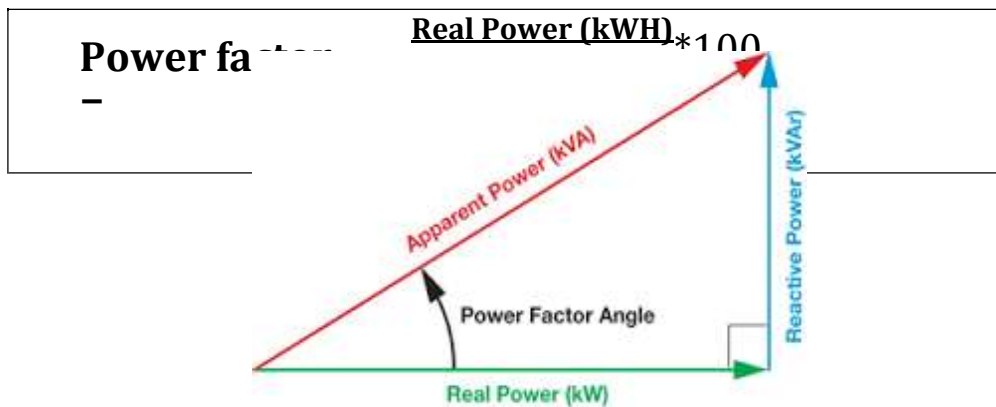


Fig. 1: Power Triangle

2.4 Power Factor Correction:

Power issue rectification is the method toward adjusting for the lagging current by creating a main current by associating capacitors to the availability. Associate adequate capacitance is related to the goal that the ability issue is acclimated to be as close to commonality as can be expected underneath the circumstances. Power issue adjustment PFC is a rendezvous of equalization the nettlesome impacts of electrical masses that build an influence factor that's in need of what one 1 power issue rectification could be connected either by associate electric power transmission utility to enhance the stability and proficiency of the gear or modification could be introduced by individual electrical shoppers to minimize the prices charged to them by their power specialist organization. an electrical burden that works on workflow needs evident power that contains real power and responsive power. the distance of receptive power makes the real power be not precisely the evident power that the electrical burden incorporates a power issue of in need of what one. the responsive power expands this streaming between the ability supply and also the heap that builds the ability misfortunes through transmission and conveyance lines. this outcome in operational and cash connected misfortunes for influence organizations. on these lines, management organizations need their shoppers significantly those with expansive burdens to stay up their capacity factors over a predefined add significantly around partner zero.90 or higher or be liable to additional charges. electrical architects needed with the transmission dissemination .utilization of electric power have an enthusiasm for the ability issue of burdens since power factors influence efficiencies and expenses for each the electrical power trade and also the customers. even so the swollen operating prices receptive power will need the use of wiring switches circuit breakers transformers and transmission lines with higher current limits.

2.5 Disadvantages of a Low PowerFactor:

1. The limit of intensity plant transmission and circulation hardware must be more than that which would be fundamental if the heap was requested at solidarity control factor.
2. For a similar dynamic power .Operation of a current power framework at a low power factor implies over-burdening the hardware now and again of full burden.
3. Low power factor implies a more noteworthy current and henceforth higher vitality misfortunes.
4. The voltage guideline to be poor.

2.6 Advantages of Power Factor Correction:

There are a few favourable circumstances in using power factor remedy capacitors. these include

- 1.Reduction in circuit current
2. Increased in voltage level at the burden
- 3.Reduction in copper misfortunes in the framework because of the decrease in current
- 4.Reduction in interest in the framework offices per kW
- 5.Reduction in the kVA stacking of the circuits.
- 6.Reduction in kVA request charges for vast purchasers

.

2.7 Electrical Loads:

In general, electrical systems are created of three components: resistors, inductors, and capacitors. Inductive instrumentality needs associate magnetic attraction field to work. Due to this, the inductive load needs each real and reactive power to work. The ability issue of inductive loads is mentioned as insulation, or but a thousandth, primarily based upon our power issue quantitative relation.

In most business and industrial facilities, a majority of the electrical instrumentality acts as resistance or associate electrical device. Resistive loads embrace incandescent lights, molding heaters, and cookery ovens. Inductive hundreds embrace fluorescent lights, AC induction motors, arc welders and transformers. Typical average power issue values for a few inductive loads:

Load	PF %
Induction Motor	70-90
Small Adjustable Speed Drive	90-98

Fluorescent Lights	
Magnetic Ballast & Electronic Ballast	70-80 & 90-95 resp.
Arc Welders	35-80

2.7.1. Inductive:

An inductor with AC supply is appeared in the figure beneath alongside its Phasor graph, which demonstrates the stage edge among current and voltage. In the event of an inductor, voltage drives current by 90° . The voltage over an inductor drives the current in light of the fact that the Lenz' law conduct stands up to the development of the current and it requires a limited investment for a forced voltage to compel the development of current to its most extreme.

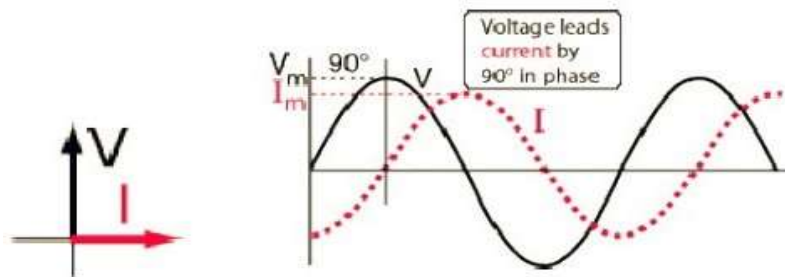


Fig. 2: Waveform and Phasor Diagram of V and I across the Inductor

2.7.2 Capacitive:

A capacitor with AC supply is appeared in the figure beneath alongside the waveform and Phasor graph, which demonstrates that the stage point among current and voltage. If there should arise an occurrence of a capacitor, voltage falls behind the current by 90° . The voltage over a capacitor slacks the current in light of the fact that the current must stream to develop charge and the voltage is corresponding to that energize which is based on the capacitor plates.

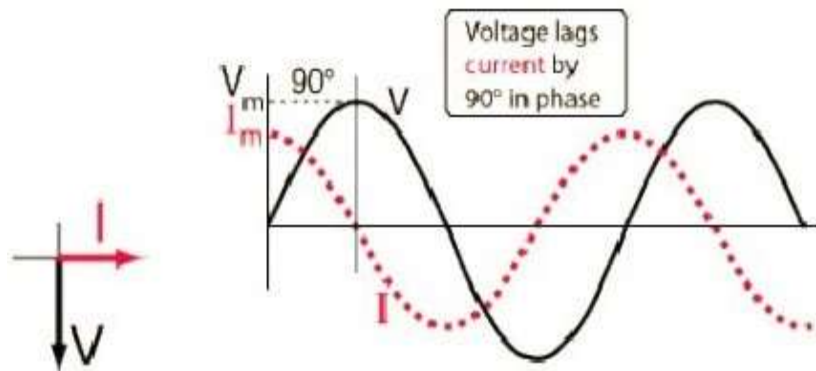


Fig. 3: Waveform and Phasor diagram

2.7.3 Resistive

A capacitor with AC supply is appeared in the figure beneath alongside the waveform and Phasor outline, which demonstrates that the stage point among current and voltage. If there should be an occurrence of a capacitor, the stage point among current and voltage is 0° . For customary flows and frequencies, the conduct of a resistor is that of a dissipative component which changes over electrical vitality into warmth. It is free of the course of current stream and the recurrence. So we state that the AC impedance of a resistor is equivalent to its DC obstruction.

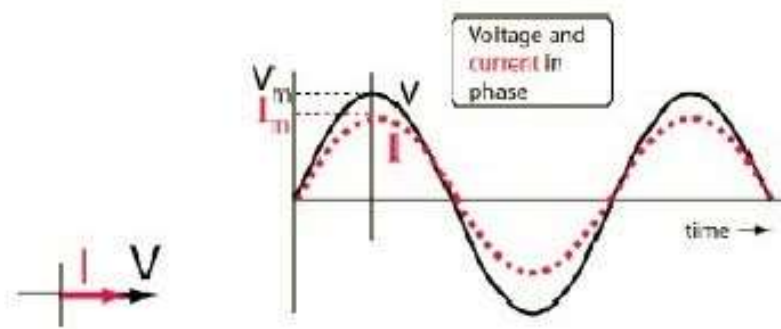


Fig. 4: Waveform and Phasor diagram

2.8 Power Pricing

Wi-Fi module is associated with the web through a versatile hotspot or can be associated with any close by accessible Wi-Fi. It interfaces with the API of the site ""for fetching the live value information and update itself after at regular intervals. The value esteem is passed to Arduino Mega through Serial Communication between Arduino Mega and Wi-Fi module. Energy cost is determined by utilizing the vitality devoured by burden and value information brought by Wi-Fi Module.





Fig. 5: Electricity Rate from Vidyut Pravah

Chapter 3

Design and Development

3.1 Principle:

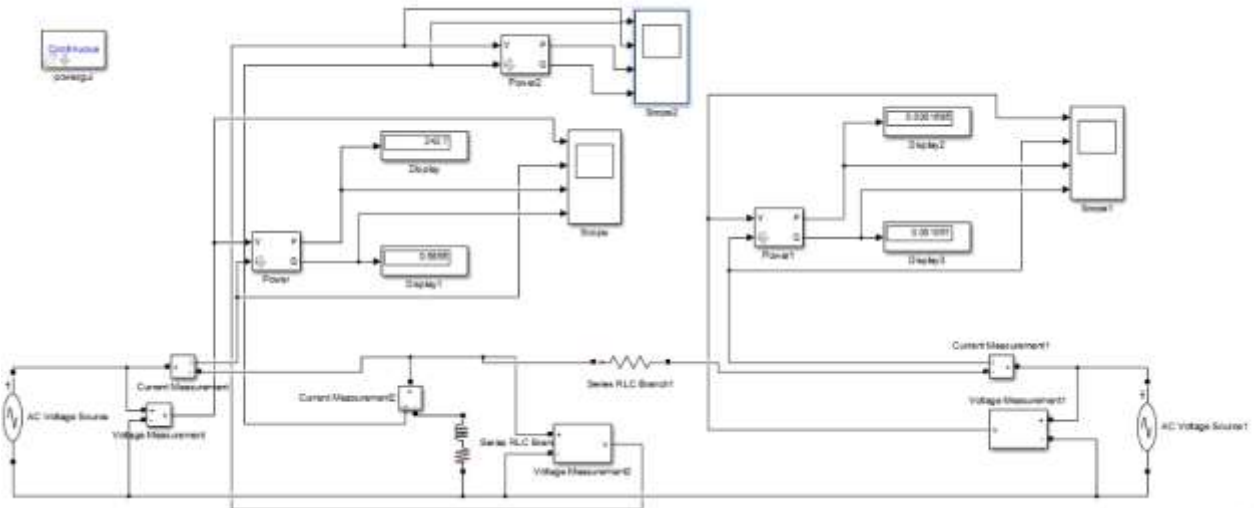


Fig 6. Block Diagram Bi-directional meter

The given circuit for Bi-directional energy meter with automatic power issue discovery and change works on the chief of continually checking the power and billing on the basis of consumption including all factors. Also it monitor the ability factor of the framework and to start out the specified adjustment on the off probability that the power factor isn't precisely the set estimation of intensity factor

3.2 Circuit Diagram:

The voltage signal obtained is converted into the digital by comparator circuit since the small controller accepts the digitized format solely. This can be given to the microcontroller joined input. Similarly, for the current signal, from the present electrical device is converted into a voltage signal by rectification. As antecedently digitized the voltage signal, this current signal within the sort of voltage is additionally digitized by the comparator circuit.

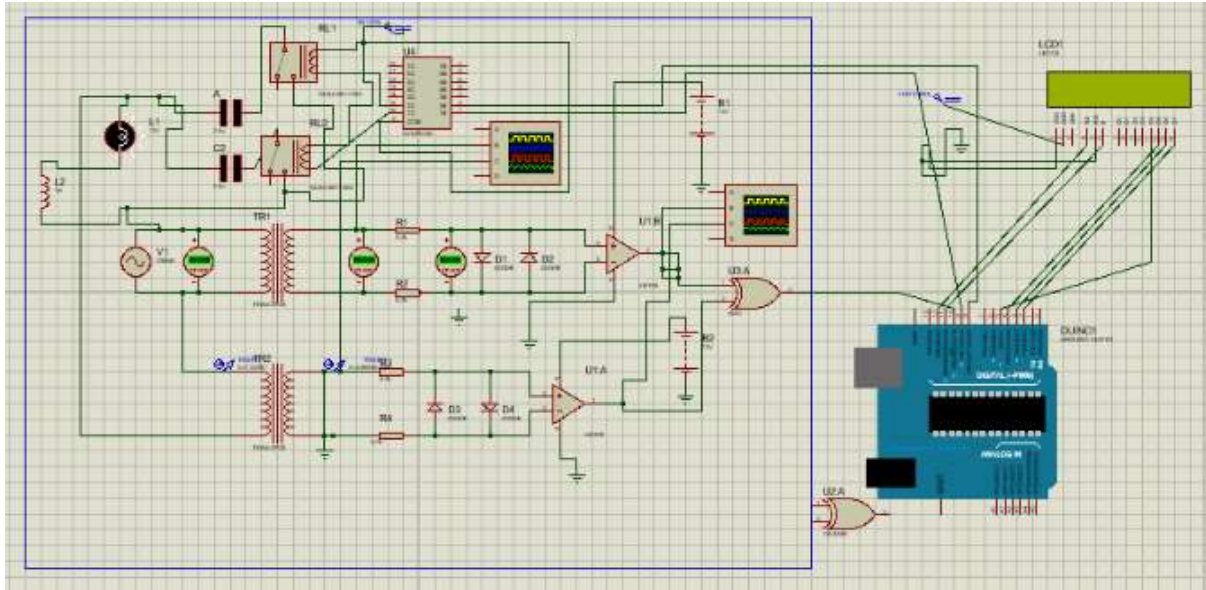


Fig 7.ZCD

These 2 digitized signals i.e. voltage and currents are sent to the microcontroller because of the inputs. In keeping with the program written microcontroller calculates the time distinction between the zero crossings of those 2 signals. This point distinction is indirectly proportional to the system power factor. The knowledge concerning this power factor and therefore the power loss is displayed on the alphanumeric display. And in keeping with the range calculated by the microcontroller program; this drives the relays that switch the shunt capacitors across the load. While increasing of the inductive load by connecting the opposite loads like motors to the current circuit leads to reduced power factor. This may build the microcontroller to drive the additional variety of relays leading to more shunt capacitors to be connected. In this project, the easy technique of capacitance demand calculation used supported the time delay between the voltage and current to bring the power factor as regards to unity. However, in real-time applications, it'll not be therefore. It needs the calculations like load current magnitude and KVAR demand etc. Variety of capacitors needs depends on the load on the actual system. These parameters should be thought of whereas handling the industrial power factor improvement or compensating products.

3.3 Zero crossingdetector:

A zero intersection is wherever the indication of a scientific capability changes (for example from positive to negative), spoken to by the intersection of the hub (zero esteem) within the chart of the capability. it's an ordinarily utilized term in gadgets, arithmetic, sound, and picture making ready. In exchanging current, the zero-intersection is that the immediate time once there's no voltage present. In a wave, this condition normally happens double during a cycle. A zero intersection finder may be a vital utilization of operation amp comparator circuit. It will likewise be alluded to as a sin to square wave converter. Anybody of the displeasing or the non-modifying comparators are often utilized as a zero intersection symbol. The reference voltage

for this case is about to zero. The yield voltage waveform demonstrates once and in 7 what heading a data flag crosses zero volts. Whenever input voltage may be a low repeat flag, at that time yield voltage can rush to alter beginning with one immersionpoint then onto the subsequent. What's additional, if there's commotion within the middle of the 2 data hubs, the yield might amendment among positive and negative immersion voltage $= V_{sat}$ '. Here IC LM358 is employed as a zero intersection finder.

Chapter 4

Modules

4.1 Components and their Description

4.1.1 Potential Transformer

A potential transformer, a voltage transformer or a covered center transformer is the most well-known sort of transformer broadly utilized in electrical power transmission and apparatuses to change over mains voltage to low voltage so as to control low power electronic gadgets. They are accessible in power evaluations going from mW to MW. The Insulated overlays limit swirl current misfortunes in the iron center.



Fig8: Potential transformer used as an Instrument Transformer

A potential transformer is commonly portrayed by its voltage proportion from essential to optional. A 600:120 potential transformer would give a yield voltage of 120V when a voltage of 600V is awed over the essential winding. The potential transformer here has a voltage proportion of 230:24 i.e., when the information voltage is the single stage voltage 230V, the yield is 24V.

The potential transformer here is being utilized for voltage detecting in the line. They are intended to display an insignificant burden to the supply being estimated and have an exact voltage proportion and stage relationship to empower precise optional associated metering. The potential transformer is utilized to supply a voltage of about 12V to the Zero Crossing Detectors for zero intersection location. The yields of the potential the transformer is taken from one of the fringe terminals and the focal terminal as just a voltage of about 12V is adequate for the task of Zero intersection locator circuit.

4.1.2. Current Transformer:

The current transformer is an instrument transformer used to venture down the current in the circuit to quantifiable qualities and is consequently utilized for estimating exchanging flows. At the point when the current in a circuit is too high to even think about applying legitimately to an estimating instrument, a present transformer delivers a diminished current precisely relative to the current in the circuit which can thus be helpfully associated with estimating and recording instruments. A current transformer confines the estimating instrument from what might be an extremely high voltage in the checker circuit. Current transformers are ordinarily utilized in metering and defensive transfers.

Like some other transformer, a current transformer has a solitary turn wire of an exceptionally extensive cross-area as its essential winding and the auxiliary winding has a substantial number of turns along these lines diminishing the current in the optional to a small amount of that in the essential. Consequently, it has an essential winding an attractive center and an optional winding. The substituting current in the essential creates a rotating attractive field in the attractive center which at that point incites an exchanging current in the auxiliary winding circuit.



Fig 9. Current Transformer

4.1.3 Current Sensor:

This present sensor board depends on the Allegro ACS712ELCTR-30A bi-directional Hall effect current sensor chip that identifies positive and negative streaming ebbs and flows in the scope of less 30 Amps to positive 30 Amps. The board works at 5V DC and the present move through the sensor is changed over to a yield voltage beginning at 1/2Vcc (or 2.5V) for no present stream and climbs 66mV per amp for positive

present or down - 66mV per amp for negative current. For instance: The yield voltage at +2 amps would be $(2.5V + (0.066 * 2)) = 2.632 V$ The yield voltage at - 5 amps would be $(2.5V - (0.066 * 5)) = 2.170 V$



Fig10: Current Sensor

4.1.4 Capacitor Bank:

A capacitor bank is a gathering of a few indistinguishable or non-indistinguishable capacitors interconnected in parallel or an arrangement with each other. These gatherings of capacitors are normally used to address or balance bothersome qualities, for example, control factor slack or stage shifts inalienable in substituting flow electrical power supplies. Capacitor banks may likewise be utilized in direct current power supplies to increment put away vitality and improve the swell current limit of the power supply. The capacitor bank comprises of a gathering of eight (8) a.c. capacitors, all evaluated at 230V, 50 Hz i.e., the supply voltage and recurrence. The estimation of capacitors is extraordinary and it comprises of four capacitors of 2.5µfarad, two capacitors of 4.5 farads and two residual capacitors are appraised at 10µfarads each. Every one of the capacitors is associated in parallel to each other and the heap. The capacitor bank is constrained by the hand-off module and is associated over the line. The activity of a hand-off interfaces the related capacitor over the line in parallel with the heap and another capacitor.

4.1.5 Summer/Adder (X-OR) gate:

They give the framework planner methods for usage of the exclusive OR capacity rationale entryways use silicon door cmos innovation to accomplish working rates like LSTTL entryways with the low power utilization of standard cmos coordinated circuits. All gadgets can drive STTL loads. The HCT rationale family is practically stick perfect with the standard LS rationale family.

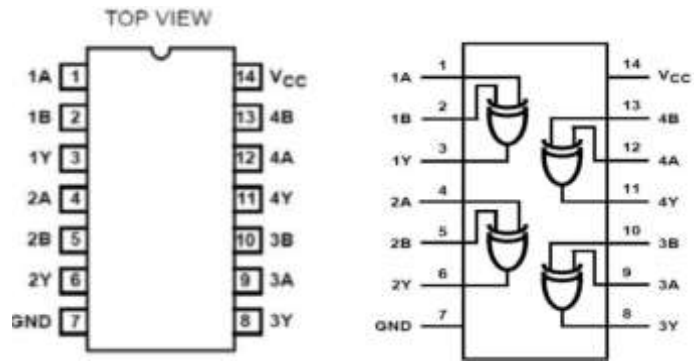


Fig11: X-OR gate

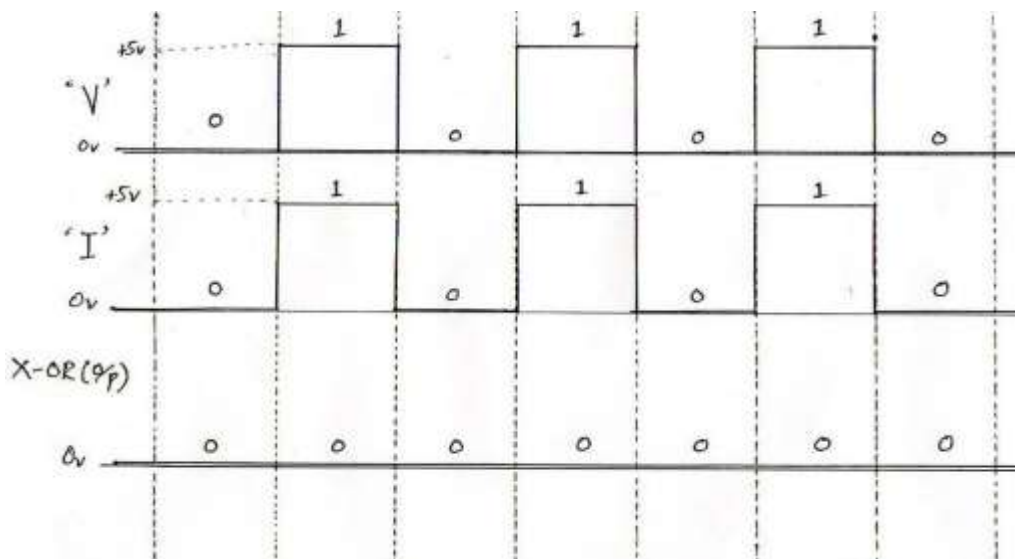


Fig12: Current and Voltage inputs to the X-OR gate and the output on purely Resistive load

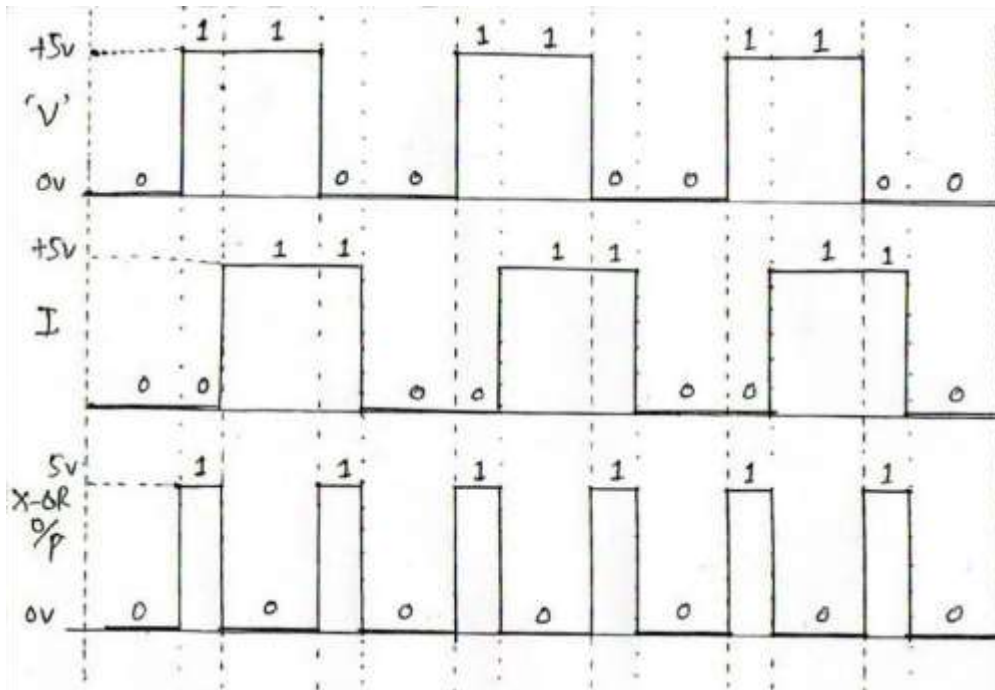


Fig13: Current and Voltage inputs to the X-OR gate and the output on Resistive and Inductive Load.

4.1.6 Relay:

The relays utilized in the control circuit are top notch Single Pole-Double Throw (SPDT), fixed 6V Sugar Cube Relays. These relays work by uprightness of an electromagnetic field produced in a solenoid as current is made to stream in its winding. The control circuit of the hand-off is normally low power (here, a 6V supply is utilized) and the controlled circuit is a power circuit with a voltage around 230V air conditioning.

The relays are separately determined by the hand-off driver through a 6V control supply. At first, the transfer contacts are in the Normally Open 'state. At the point when a relay works, the electromagnetic field powers the solenoid to climb and hence the contacts of the outside power circuit are made. As the contact is made, the related capacitor is associated in parallel with the heap and over the line. The hand-off curl is evaluated up to 8V, with a base exchanging voltage of 5V. The contacts of the hand-off are evaluated up to 7A @ 270C AC and 7A @ 24V DC.

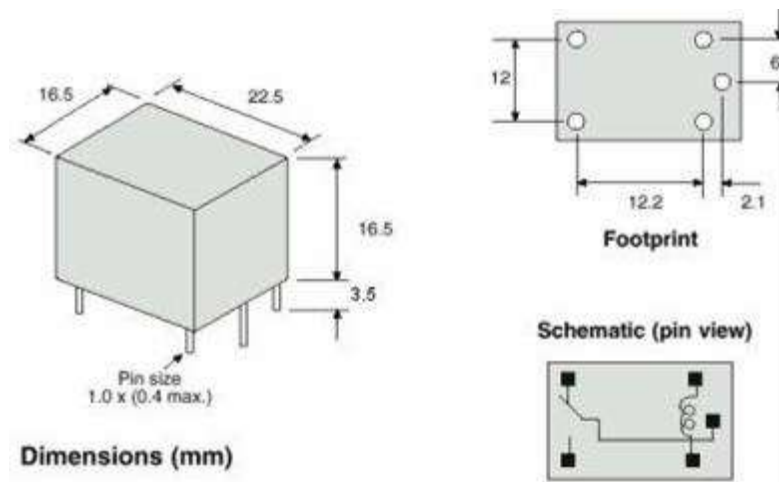


Fig.14: Relay

4.1.7 Wi-fi Module:

As ESP8266 needed 3.3 potential unit to control that's why you'll need a separate transformer for the Wi-Fi module. There are 2 push buttons present here. These push buttons are helpful in longterm application. If you don't wish to attach these buttons then it's your alternative. RST electrical switch is for hardware Reset of ESP8266. On the opposite hand, FLASH electrical switch is to update the package of the Wi-fi module.



Fig.15:Wi-Fi Module

The fastest and most straightforward approach to begin with an ESP8266 is to get to it by means of the AT direction interface. Wi-Fi module ESP8266 has a worked in UART (Serial) association. This implies it can both send and get information utilizing the UART convention.

Imagine a scenario in which we had an application that kept running on the ESP8266 which took "directions" got over the sequential connection, executed them and after that restored a reaction. This would then enable us to utilize the ESP8266 while never knowing the programming dialects that are local to the gadget.

This is actually what a program that has so far been observed to be re-introduced on the ESP8266. The program is known as the "AT direction processor" named after the configuration of the directions sent through the sequential connection. These directions are altogether prefixed with "AT".

These AT Commands will control every one of the information that ought to be sent or got through the Wi-Fi module.

How to use ThingSpeak with Energy Meter:

We have utilized an officially accessible IOT stage called "ThingSpeak" to store the readings.

The total technique is partitioned into two areas:

Agreeing to accept ThingSpeak and interfacing esp8266 Wi-Fi module with Wi-Fi

2 . Sending meter readings to ThingSpeak.

Creating account on ThingSpeak and connecting esp8266 Wi-Fi module with Wi-Fi:

Step 1

The first step is to create an account on ThingSpeak. Visit [ThingSpeak](#) and create your account.

After signing up, create a channel as shown in figure below: Arduino will send the data.

After clicking on Green New Channel button, they will ask about the requirements. Fill the fields as you want.

After that open API Keys tab and save your write keys to use later in the Arduino Code. Arduino will send measured readings to the ThingSpeak using this API write key.

Step 2

Now the second step is to connect ESP8266 with Wi-Fi router. ESP8266, in its default configuration, boots up into the serial modem mode. In this mode you can communicate with it using a set of AT commands. These AT commands are then used

to transfer data to the ThingSpeak channel. Below are the Arduino commands used to connect esp8266 with Wi-Fi.

In second step we will also include a Softwareserial library in Arduino code. This library is to use Arduino pins as RX and TX other than the default RX, TX pins (pin 0 and 1).

Step 3

Next step is to declare your Wi-Fi router related information like ssid, password and ThingSpeak's ip address

```
#define SSID "your Wi-Fi ssid" #define PASS "your Wi-Fi password" #define IP "184.106.153.149"
```

Step 4

In the next step create a serial port for communicating with esp8266. Here 9600 is the baud rate choose for esp8266 module.

Step 5

In next step, use AT commands to connect esp8266 module with Wi-Fi.

After establishing a connection as client, ESP8266 module is ready to send data to ThingSpeak.

4.1.8 LCD (Liquid CrystalDisplay):

LCD panel consist two patterned glass panels in which crystal is filled under vacuum. The thickness of glass varies according to end use. Most of the LCD modules have glass thickness in the range of 0.70 to 1.1mm. Normally these liquid crystal molecules are placed between glass plates to form a spiral staircase twist the light. This LCD cannot display any information directly. These act as an interface between electronics and electronics circuit to give a visual output. The values are displayed in the 2x16 LCD modules after converting suitably. The liquid crystal display (LCD), as the name suggests is a technology based on the use of liquid crystal. It is a transparent material but after applying voltage it becomes opaque. This property is the fundamental operating principle of LCD



Fig.16: Liquid Crystal Display

4.1.9 Arduino Mega:

Arduino mega 2560 is a microcontroller board dependent on atmega2560. It accompanies more memory space and I/O pins when contrasted with different sheets accessible in the market. There are 54 advanced I/O pins and 16 simple pins joined on the board that make this gadget interesting and emerge from others. Out of 54 computerized i/o 15 is utilized for PWM beat width adjustment a precious stone oscillator of 16mhz recurrence is included the board. This board accompanies USB link port that is utilized to associate and exchange code from pc to the board. DC control jack is combined with the board that is utilized to control the board. Some variant of Arduino board comes up short on this component like Arduino pro mini doesn't accompany dc control jack. ICSP header is a remarkable expansion to Arduino mega which is utilized for programming the Arduino and transferring the code from the pc.



Fig.17: Arduino Mega Board

This board accompanies two voltage controller as an example 5V and 3V which provides the ability to regulate the voltage in step with wants once contrasted with Arduino professional mini that accompanies simply one voltage controller. There is no a lot of distinction between Arduino Uno and Arduino Mega except for later accompanies a lot of memory house, larger size and a lot of I/O pins. Arduino programming known as Arduino IDE is employed to program the board that could be typical programming utilized for all sheets had an area with Arduino family. Accessibility of Atmega16 on the board makes it distinctive in reference to Arduino professional mini that utilizes USB to the consecutive converter to program the board. There are a reset catch and four instrumentation consecutive port known as USART that delivers most extreme speed for fitting correspondence.

Arduino Mega Specification:

Microcontroller	Atmega 2560
Operating Voltage	5V
Input Voltage	7V-12V
USB Port	Yes
DC Power Jack	Yes
Current rating Per I/O Pin	20mA
Current Drawn from Chip	50mA
Digital I/O Pins	54
PWM	15
Analog Pins(Can be used as digital pins)	16(out of digital I/O pins)
Flash Memory	256KB
SRAM	8KB
EEPROM	4KB
Crystal Oscillator	16 MHz
LED	Yes/Attached with digital pin 13
Wi-Fi	No
Shield Compatibility	Yes

Chapter 5

Software Development

5.1 Programming Development Environment:

The Arduino is a solitary board microcontroller, proposed to make the use of intuitive articles or situations progressively available. The equipment comprises of an open-source equipment board planned around an 8-bit Atmel AVR microcontroller or a 32-

bit Atmel ARM. Current models highlight a USB interface, 6 simple information pins, just as 14 advanced I/O pins which enable the client to connect different expansion sheets.

Presented in 2005, at the Interaction Design Institute Ivrea, in Ivrea, Italy, it was intended to give understudies a cheap and simple approach to program intelligent items. It accompanies a straightforward Integrated Development Environment (IDE) that keeps running on standard PCs and permits composing programs for Arduino utilizing a mix of basic Java and C or C++.

The Arduino Integrated Development Environment (IDE) is a cross stage application written in Java and is gotten from the IDE for the handling programming language and the wiring ventures. It is intended to acquaint programming with craftsmen and different newcomers new to programming advancement. It incorporates a coding supervisor with highlights, for example, Syntax featuring, Brace coordinating and Automatic Indentation, and is likewise fit for gathering and transferring projects to the board with a solitary snap. A program or code composed for the Arduino is known as a —Sketchll. The Arduino IDE additionally accompanies a product library called —Wiringll from the first Wiring Project, which makes numerous basic info/yield tasks a lot simpler. Clients need just characterize two capacities to make a run able cyclic official program:

- `setup()`: a capacity run once toward the beginning of a program that can introduce settings.
- `loop()`: a capacity called over and again until the board controls off.

The past code won't be seen by a standard C++ compiler as a legitimate program, so when the client taps the "Transfer to I/O Board" catch in the IDE, a duplicate of the code is kept in touch with an impermanent record with an additional incorporate header at the top and an exceptionally basic „main()" work at the base to make it a substantial C++ program.

The Arduino IDE utilizes the GNU tool chain and AVR Libc to incorporate projects and uses AVR dude to transfer projects to the board As the Arduino stage utilizes Atmel microcontrollers, Atmel's improvement condition AVR Studio or the more up to date Atmel Studio, may likewise be utilized to create programming for the Arduino.

5.2 pulseIn():

•Description:

The work peruses a heartbeat (either HIGH or LOW) on a stick. For instance, if esteem is HIGH, pulseIn() trusts that the stick will go HIGH, begins timing, at that point trusts that the stick will go LOW and quits planning. Returns the length of the beat in microseconds. Surrenders and returns 0 if no heartbeat begins inside a predetermined time out.

The planning of this capacity has been resolved experimentally and will most likely show mistakes in longer heartbeats. Takes a shot at heartbeats from 10 microseconds to 3 minutes long.

•Syntax:

`pulseIn(pin, esteem) pulseIn(pin, esteem, timeout)`

•Parameters:

stick: the quantity of the stick on which you need to peruse the beat. (int) esteem: kind of heartbeat to peruse: either HIGH or LOW. (int)

timeout (discretionary): the number of microseconds to trust that the beat will begin; default is one moment (unsigned long), restores the length of the beat (in microseconds) or 0 if no heartbeat began before the timeout (unsigned long)

5.3 Program:

Arduino Code-

```
#include <LiquidCrystal.h>
```

```
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
```

```
int pin = 13;
```

```
int re1=6;
```

```
int re2=7;
```

```
int re3=8;
```

```
int re4=9;
```

```
float time;
```

```
float rads = 57.29577951; // 1 radian = approx 57 deg.
```

```

float degree = 360;
float frequency = 50;
float nano = 1 * pow (10,-6); // Multiplication factor to convert nano seconds into
seconds
// Define floats to contain calculations
float pf;
float angle;
float pf_max = 0;
float angle_max = 0;
int ctr;
const int sensorIn=A0;
int mVperAmp=66;
double Voltage=0;
double VRMS=0;
double AmpsRMS=0;
void setup()
{
  pinMode(pin, INPUT);
  pinMode(6,OUTPUT);
  pinMode(7,OUTPUT);
  pinMode(8,OUTPUT);
  pinMode(9,OUTPUT);
  Serial.begin(9600);
  Serial2.begin(4800);
  lcd.begin(16, 2);
  lcd.print("ANUJ KUMAR");
  lcd.setCursor(0, 1);
  lcd.print("BT16EEE004");

```

```
delay(2000);
lcd.clear();
lcd.print("JUNAID ALAM");
lcd.setCursor(0, 1);
lcd.print("BT16EEE005");
delay(2000);
lcd.clear();
lcd.print("BHUMIKA MEENA");
lcd.setCursor(0, 1);
lcd.print("BT16EEE003");
delay(2000);
lcd.clear();
lcd.print("RITIK SINGH");
lcd.setCursor(0, 1);
lcd.print("BT16EEE001");
delay(2000);
lcd.clear();
lcd.print("GUIDED BY");
lcd.setCursor(0, 1);
lcd.print("MR HIMESH KUMAR");
delay(2000);
lcd.clear();
}
void loop()
{
float price=wifi();
Serial.print("price=");
Serial.println(price);
```

```

lcd.print("CURNT PRC=");
lcd.setCursor(11, 0);
lcd.print(price);
lcd.setCursor(0, 1);
lcd.print("VidyutPravah.in");
delay(3000);
lcd.clear();
Voltage=getVPP();
VRMS=(Voltage/2.0)*0.707;
AmpsRMS=(VRMS*1000)/mVperAmp;
Serial.print("current=");
Serial.println(AmpsRMS);
lcd.setCursor(0,0);
lcd.print("CURRENT");
lcd.setCursor(9,0);
lcd.print(AmpsRMS);
lcd.setCursor(0,1);
Serial.println("VOLTAGE=230.00");
lcd.print("VOLTAGE 230.00");
delay(3000);
lcd.clear();
for (ctr = 0; ctr <= 4; ctr++) // Perform 4 measurements then reset
{
// 1st line calculates the phase angle in degrees from differentiated time pulse
// Function COS uses radians not Degree's hence conversion made by dividing
angle / 57.2958
angle = (((pulseIn(pin, HIGH)) * nano) * degree) * frequency);
// pf = cos(angle / rads);

```

```

if (angle > angle_max) // Test if the angle is maximum angle
{
angle_max = angle; // If maximum record in variable "angle_max"
pf_max = cos(angle_max / rads); // Calc PF from "angle_max"
}
}

if (angle_max > 360) // If the calculation is higher than 360 do following...
{
angle_max = 0; // assign the 0 to "angle_max"
pf_max = 1; // Assign the Unity PF to "pf_max"
}

if (angle_max == 0) // If the calculation is higher than 360 do following...
{
angle_max = 0; // assign the 0 to "angle_max"
pf_max = 1; // Assign the Unity PF to "pf_max"
}

//Serial.print(angle_max, 2); // Print the result
//Serial.print(",");
// Serial.println(pf_max, 2);
float m=fabsf(pf_max);
Serial.print("powerfactor=");
Serial.println(m);
lcd.setCursor(0,0);
lcd.print("PF=");
lcd.setCursor(4,0);
lcd.print(m);
lcd.print(" ");
lcd.setCursor(0,1);

```

```

lcd.print("Ph-Shift=");
lcd.setCursor(10,1);
lcd.print(angle_max);
lcd.print(" ");
delay(3000);
lcd.clear();
float z=m*m;
float p=1-z;
float q=AmpsRMS*230*sqrt(p);
lcd.setCursor(0,0);
lcd.print("ACT PWR");
lcd.setCursor(9,0);
float power=AmpsRMS*230*m;
int powerint=power;
Serial2.write(powerint);
lcd.print(power);
Serial.print("Act power=");
Serial.println(power);
lcd.setCursor(0,1);
lcd.print("RACT PWR");
lcd.setCursor(9,1);
    lcd.print(q);
    //Serial.println(AmpsRMS*230*sqrt(p));
    Serial.print("React pwr=");
    Serial.println(q);
    delay(3000);
    lcd.clear();

```

```
time = millis();
float wh=time/3600000;
float kwhPower=power/1000;
float energy=kwhPower*wh;
lcd.setCursor(0, 0);
lcd.print("ENERGY");
lcd.setCursor(8, 0);
lcd.print(energy);
Serial.print("energy=");
Serial.println(energy);
//Serial.print("time ");
//Serial.println(wh);
//lcd.setCursor(12, 0);
//lcd.print("kwh");

lcd.setCursor(0, 1);
lcd.print("COST=");
lcd.setCursor(6, 1);
float cost=energy*price;
lcd.print(cost);
Serial.print("cost=");
Serial.println(cost);
//lcd.setCursor(10, 1);
//lcd.print("rps");
delay(3000);
lcd.clear();
```

```
angle = 0; // Reset variables for next test
```

```

angle_max = 0;
//relay

if (m < 0.98)
{
digitalWrite(re1,HIGH);
if (m < 0.98)
{
digitalWrite(re2,HIGH);
if (m < 0.98)
{
digitalWrite(re3,HIGH);
if (m < 0.98)
{
digitalWrite(re4,HIGH);
}
}
}
}
else if(m >= 0.98)
{
Serial.print("\tThe circuit has a resistive load, hence the normal power factor is:\t\t");
Serial.println(m);
}
Serial.println("-----XXXXXXXXXXXXXXXXXXXXXXXXXXXXX-----");
}
float getVPP()
{

```



```

float result;
int readValue;
int maxValue=0;
int minValue=1024;
uint32_t start_time=millis();
while((millis()-start_time)<1000)
{
readValue=analogRead(sensorIn);
if(readValue>maxValue)
{
maxValue=readValue;
}
if(readValue<minValue)
{
minValue=readValue;
}
}
result=((maxValue-minValue)*5.0)/1024.0;
return result;
}

float wifi(){
while(Serial2.available(>0){
String payload = Serial2.readString();
Serial.print("payload ");
Serial.println(payload);
float val=payload.toFloat();
return val;
}
}

```

```
delay(1000);  
}
```

Wi-Fi Code-

```
#include <SoftwareSerial.h>  
#include <WiFiClientSecure.h>  
SoftwareSerial NODEMCU(D2,D3);  
int data;  
#include "ThingSpeak.h"  
#include <ESP8266WiFi.h>  
const char* host = "api.thingspeak.com";  
const int httpsPort = 443;  
const char fingerprint[] PROGMEM = "F9 C2 65 6C F9 EF 7F 66 8B F7 35 FE 15 EA  
82 9F 5F 55 54 3E";  
//----- Fill in your credentials -----  
char ssid[] = "anuj";      // your network SSID (name)  
char pass[] = "anujanuj";  // your network password  
unsigned long myChannelNumber = 749923; // Replace the 0 with your channel  
number  
const char * myWriteAPIKey = "8CR1CVEK34KO0QEC"; // Paste your ThingSpeak  
Write API Key between the quotes  
//-----  
WiFiClient client;  
void setup() {  
  NODEMCU.begin(4800);  
  Serial.begin(9600);  
  WiFi.mode(WIFI_STA);  
  ThingSpeak.begin(client);  
  if(WiFi.status() != WL_CONNECTED){
```

```

while(WiFi.status() != WL_CONNECTED){
  WiFi.begin(ssid, pass);
  delay(5000);
}

}

WiFiClientSecure client;
client.setFingerprint(fingerprint);
if (!client.connect(host, httpsPort)) {
  NODENMCU.println("connection failed");
  return;
}
String url = "/apps/thinghttp/send_request?api_key=PGDLA4VOV1ZTHURL";
client.print(String("GET ") + url + " HTTP/1.1\r\n" +
"Host: " + host + "\r\n" +
"User-Agent: BuildFailureDetectorESP8266\r\n" +
"Connection: close\r\n\r\n");
while (client.connected()) {
  String line = client.readStringUntil('\n');
  if (line == "\r") {
    break;
  }
}
String line = client.readStringUntil('\n');
NODENMCU.print(line);
}
void loop() {

```

```
if (NODEMCU.available()>0)
{
data=NODEMCU.read();
}
// Connect or reconnect to WiFi
// Write to ThingSpeak. There are up to 8 fields in a channel, allowing you to store up
to 8 different
// pieces of information in a channel. Here, we write to field 1.
int x = ThingSpeak.writeField(myChannelNumber, 1, data, myWriteAPIKey);
// Check the return code
if(x == 200){
Serial.println("Channel update successful.");
}
else{
Serial.println("Problem updating channel. HTTP error code " + String(x));
}
Serial.println(data);
delay(20000); // Wait 20 seconds before sending a new value
}
```

Chapter 6

Results and Conclusion

6.1 Results

Following fig. shows the assembled circuit of energy meter

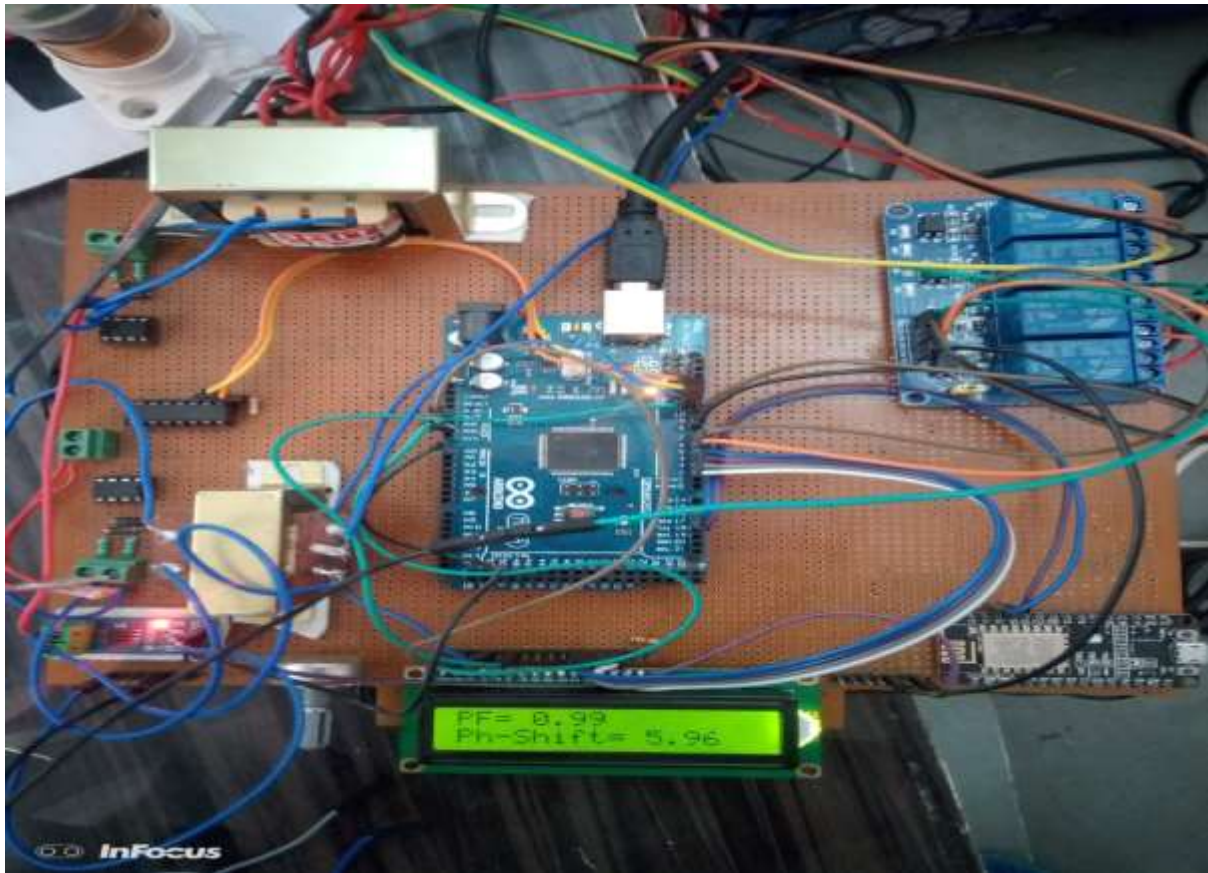


Fig 18 Energy meter showing power factor after correction

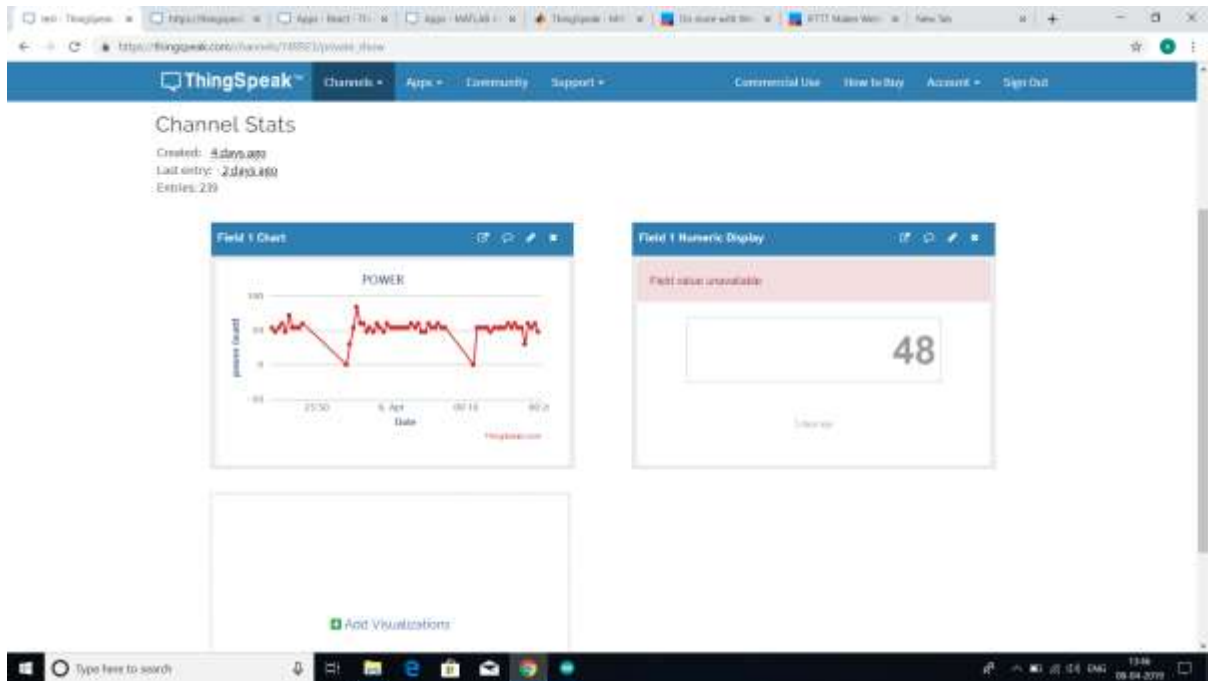


Fig.19 Wi-fi Module fetch active power data from vidyut pravah site



Fig. 20 SMS to consumer for controlling reactive power

Conclusion:

The Bi-directional meter with Automatic Power Factor Detection and Correction gives a precise estimation of power use without the requirement for an evaluated month to month bills or visits from meter per users likewise improve the power factor of a power framework by an efficient way. It Eliminate the manual meter reading, Monitoring the electric framework all the more quickly, Making it conceivable to utilize control assets all the more efficiently, Providing ongoing information valuable for adjusting electric burdens ,Enabling powerful estimating (raising or bringing down the expense of power dependent on interest) ,Offering increasingly itemized input on vitality use to client which causes them to alter their propensities to bring down electric bills

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