MEASURE THE PARAMETERS OF ELECTRIC MOTOR USING WIRELESS SMART METER

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Preface

This Smart Meter is used to measure various parameters of an electric motor on a single platform. The Phase Voltage applied to the motor and the Current drawn by the motor forms the two input quantities to Arduino. The Voltage is measured with the help of a Voltage Sensor, whereas the current is measured by a Clamp on Current Transformer.

The Arduino further uses these two input quantities to extract the remaining parameters of motor, such as Power Factor, Active Power (P), Reactive Power (Q), and Apparent Power (S). Once calculated, these parameters are displayed on a LCD Display. These measured values will also be available on the cloud server for two purposes:

1. Remote Monitoring 2. Data Logging.

Data will be sent in a form of packet having intervals of 15 seconds in between two consecutive packets. Thus the measure data can monitored from anywhere in the world by using the IOT Tool. ESP8266 Wi-Fi Module is used to send the data from Arduino to Thing Peak server. Along with the Remote Monitoring, Data logging is also made available so as to retrieve the measured values any time in future. This will help to calculate the Monthly or Annual usage.Thus our SMART METER is capable to find and suggest appropriate measures for maintenance.

I would like to acknowledge the contribution of Hrithik Shire, Aboli Dobale,Atul Bhalerao,Payal Parate ,Dhiraj Soni, and many more who are directly or directly involved in this work .I personally thank our Head of Department Dr. M.S. Narlawar and Dr..R.M.Mohril,who had given full support for completing this work

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Chapter 1

Introduction

1.1 OVERVIEW

Electric motors is an imminent and an indispensable power source due to the robustness and energy consumption, and already gained popularity by their utilization in diverse industries, such as automotive, medical, aerospace, military, consumer, industrial, road vehicles, diverse equipment, etc. They have the advantages of low costs, good efficiency, lower maintenance, high power and wide speed range. Although induction motors are reliable, they are subjected to some undesirable stresses, causing faults resulting in failure.[1] Monitoring of an induction motor is a fast-up-and-coming technology for the detection of initial faults. It avoids unpredicted failure of an industrial process. This project aims at developing a Smart Meter that will be able to measure the various parameters of an electric motor in running condition. The measured values will be displayed on LCD display. Once the values stands measured, they will send on an online server for Remote Monitoring purpose. Thus the measure parameters of a motor will be monitored from a remote place anywhere in the world.

Once the data is sent remotely, it will also be saved automatically for future analysis of load consumption and other billing purposes. This SMART METER uses Arduino which will be continuously measure, display and send the data remotely. The data will be sent using a Wi-Fi module i.e. ESP8266.

1.2 PROBLEM STATEMENT

For measuring various parameters of an electric motor, number of meters required is large. Also the difficult wiring makes the job of measurement much more tedious. So there is a requirement for a meter the will be able to display various parameters of electric motor on a common platform.Also the traditional meters are not able to send the data wirelessly, which stands important for the purpose of Remote Monitoring. Also the entire data sent to the server should be logged continuously; so as to retrieve the data can be used in future for various purposes

1.3THESIS OBJECTIVES

Thus our METER will be SMART enough to Measure the various parameters of motor such as Voltage (V), Current (I), Power Factor, Active Power (P), Reactive Power(Q) and Apparent Power (S) on a common platform. It will also be able to send the measured values using IoT technique on a real time basis for remote monitoring purpose. Also Data Logging will be possible.

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Thus the SMART METER will prove to be a real friend of Motor Operator.

This project will achieve following objectives: -

- To overcome the difficulties that may occur in Wired System during measurement.
- To gather the data on a common platform for the analysis.
- Remote Monitoring of motor as well as Conditioning of Motors during running condition.
- To check the performance of motor on a regular basis.
- To estimate the bill for the energy consumed.

Chapter 2

Literature Review

2.1 OVERVIEW

This chapter reviews the literature on the need of technological advancements in monitoring the electric motors so as to develop a system which is faster, accurate and consists of advanced technology using IoT (Internet of Things). Chapter 2 also discusses the work done by other researchers in the field of Smart Meter for Electric Motor.

2.2LITERATURE SURVEY

In the year 2017, the authors Jonas Queiroz, José Barbosa, José Dias, Paulo Leitão&Eugénio Oliveira presented a paper titled "Development of a Smart Electric Motor Test bed for Internet of Things and Big Data Technologies". In this paper they described the digitization of an electric motor, through the incorporation of sensing and an analytical computational environment, towards the development of a test bed for IoT and Big Data technologies. The [2] [3] smart electric motor provides real-time data streams, enabling a continuous monitoring of its operation along all the device life-cycle through advanced data analytics.

In the year 2004, the author U. S. Doe presented a paper titled "Industrial wireless technology for the 21st century". [4][5] In this paper the focus was on the issues of portability, reliability, flexibility, and robustness, while using wireless connectivity in industrial applications such as instrumentation and predictive maintenance, and to design a workable solution.

In the year 2018, the author Swapnil Dol and RaunakBhinge presented a paper titled "SMART Motor for Industry 4.0". In this paper they described SMART Electric Motors are the electric motors of the future. A SMART Motor can monitor its own status [11] 24 hours a day, seven days a week, and forecast problems months ahead of time, allowing corrective actions can be done to avert premature equipment and process failures in the industry.

Chapter 3

Work Done

3.1 COMPONENTS

3.1.1 ARDUINO UNO

Arduino Uno is a microcontroller board that uses the ATmega328P microcontroller. There are 14 digital input/output pins (six of which can be used as PWM outputs), six analogue inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button on the board. It comes with everything you'll need to get started with the microcontroller; simply plug it into a computer via USB, or power it with an AC-to-DC adapter."UNO" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases [6].

The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform.

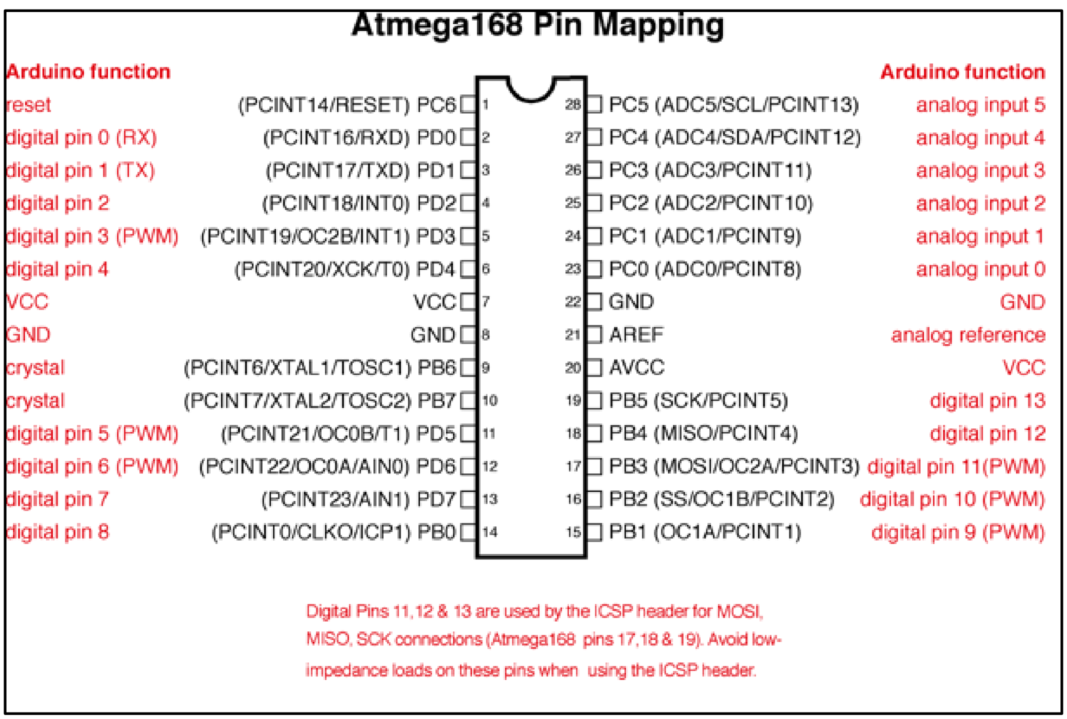

Fig. 3.1 Atmega168 Pin Diagram

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POWER SOURCE

The Arduino Uno board can be powered either by USB or by an external power source. The power source is automatically selected. An AC-to-DC adapteror a battery can provide external (non-USB) power. A 2.1mm center-positive plug can be plugged into the board's power jack to connect the adapter. Leads from a battery can be plugged into the POWER connector's GND and Vin pin headers.The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volt.[7][8] and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

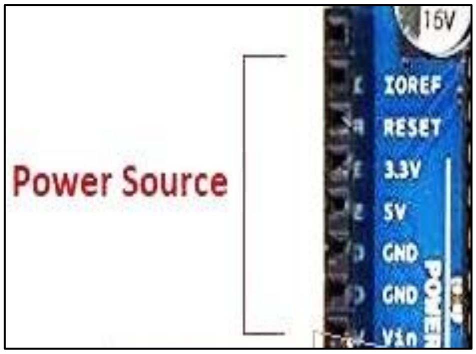

Fig. 3.2 Atmega168 Power Pins

- **Vin-** The input voltage to the Arduino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- **5V-**This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board.
- **3.3V-** A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- **GND-** Ground pins.
- **IOREF-**The voltage reference with which the microcontroller runs is provided by this pin on the Arduino board. The IOREF pin voltage can be read by a correctly constructed shield, which can then select the right power supply or enable voltage translators on the outputs to function with 5V or 3.3V.

MEMORY

The ATmega328 has 32 KB (with 0.5 KB occupied by the boot loader. It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).

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INPUT AND OUTPUT

In addition, some pins have specialized functions:

- **Serial:** 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- **External Interrupts:**2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- **PWM:** 3, 5, 6, 9, 10, and 11. Provide 8-bit PWM output with the analogWrite() function.
- **SPI:** 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- **LED:** 13. There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.[9][10]

Fig. 3.3 I/O Pins

TECHNICAL SPECIFICATION

Table 3.1 Specification of Arduino UNO

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V

Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by boot loader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

3.1.2 VOLTAGE SENSOR

ZMPT101B voltage sensor module is a voltage sensor made from the ZMPT101B voltage transformer. It has high accuracy, good consistency for voltage and power measurement and it can measure up to 250V AC. It is simple to use and comes with a multi turn trim potentiometer for adjusting the ADC i.e.

Analog to Digital Convertor output. The ADC output is adjusted using the trim pot to an appropriate value.[12]

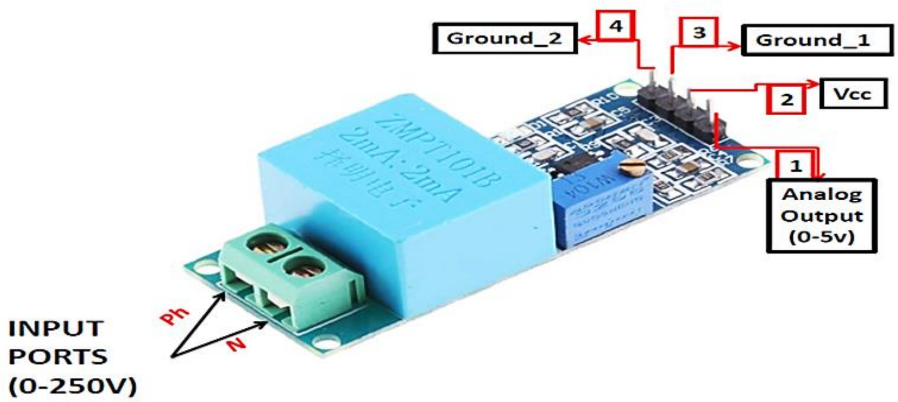

Fig. 3.4 ZMPT101B Voltage Sensor

ELECTRICAL SPECIFICATION

Table 3.2 Specification of ZMPT101B

Primary Current	2mA
Secondary Current	2mA
Turns Ratio	1000:1000
Current Range	0 to 3mA
Linearity	0.1%
Accuracy Class	0.2
Rated Burden	<200 Ω
Frequency Range	50 to 60 Hz
Dielectric level	3000 VAC/min
DC Resistance at 20°C	110 Ω

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INPUT AND OUTPUT WAVEFORMS

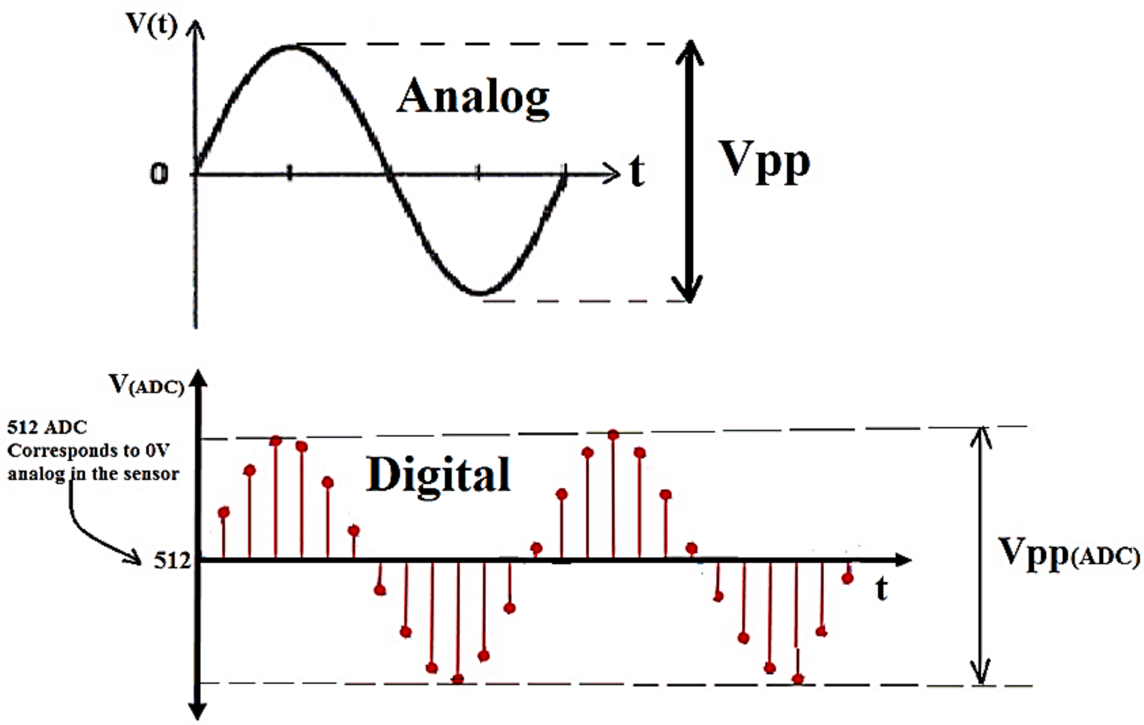
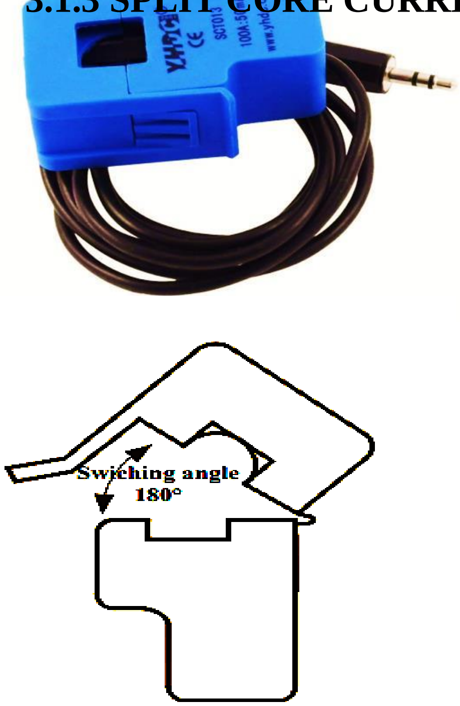


Fig. 3.5 Input-Output waveforms of ZMPT101B Voltage Sensor

3.1.3 SPLIT CORE CURRENT TRANSFORMER



SCT-013-000 is a Non-Invasive, Split Core Current Transformer which is used to measure AC current up to 100 amperes.SCT-013-000 is clipped straight on to either the live or neutral wire of load under measurement without having to do any high voltage electrical work.

Like any other transformer, a current transformer has a primary winding, a magnetic core, and a secondary winding. In the case, the primary is either the live or the neutral wire (not both) that goes through the hole in the CT. The secondary

Fig. 3.6 Current Transformer

winding comprises many turns of fine wire housed within the casing of the transformer.

CHARACTERISTICS

Table 3.3 Specification of Current Transformer

Input Current	0 to 100A
Output Current	0 to 50mA
CT Ratio	2000:1
Opening Size	13mm*13mm
Non-Linearity	±3%
Core Material	Ferrite
Mechanical Strength	Number of Switching > 1000 times
Dielectric Strength (between Shell and Output)	1000VAC/min
Work Temperature	25℃ to +70℃
Resistance Grade	Grade B

3.1.4 ESP8266 Wi-Fi Module

The ESP8266 Wi-Fi Module is a self-contained System on Chip with integrated TCP/IP protocol stack that can give any microcontroller access to your Wi-Fi network.

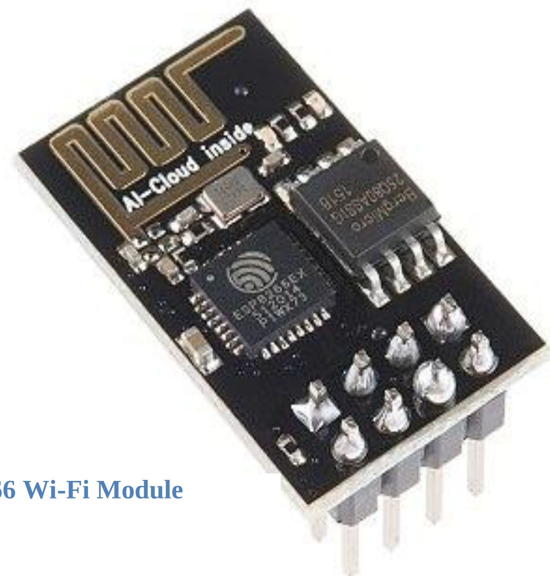


Fig. 3.7 ESP8266 Wi-Fi Module

The ESP8266 is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor.

The ESP8266 - 01 Wi-Fi module is used to get connected to a Wi-Fi network for internet access. The chip first came to the attention of western makers in August 2014 with the ESP8266 module, made by a third-party manufacturer Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands.

It is used as a Wi-Fi adapter to give wireless internet access to the microcontroller. This module comes loaded with firmware that can accept AT commands over the serial interface to do various functions.

This module is powerful in terms of on-board processing and storage capability that allows it to be integrated with the sensors and other application specific devices through its GPIOs with minimal development up-front and minimal loading during runtime.

POWER

Table 3.4 ESP8266 Power Requirements

POWER	CONSUMPTION
Vcc	3.0-3.6 V
Standby	0.9 µA
Running	60-215 mA
Average	80 mA

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WI-FIFEATURES

Table 3.5 ESP8266 Wi-Fi features

FEATURE	SPECIFICATION
Protocols	802.11 b/g/n/e/i
Frequency Range	2.4 GHz to 2.5 GHz
Security	WPA/WPA2

BASIC CONNECTION

Table 3.6 Basic Connections of ESP8266 with ARDUINO UNO

PIN	CONNECTION
V_{CC}	3.3 V
GND	GND
TX	RX on Arduino
RX	TX on Arduino
Chip Enable	3.3 V

LEDs

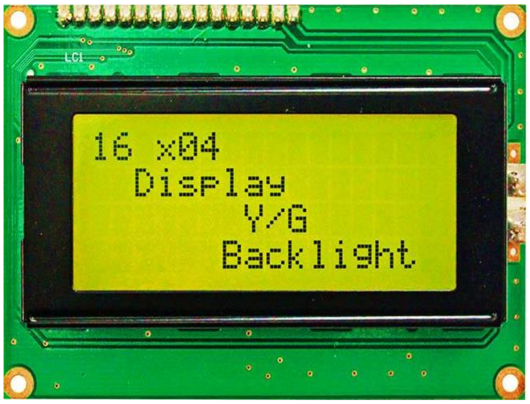
Table 3.7 LED Representation of ESP8266

LED COLOR	REPRESENTATION
RED	POWER

BLUE	TX

3.1.5 LCD DISPLAY (16*4)

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16*4 LCD display is very basic module and is commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs.



The reasons being: LCDs are cost-effective, easy to programme, and can show a wide range of unique and even custom characters. A 16*4 LCD can display 16 characters per line on each of its four lines. Each character is presented in a 5x7 pixel matrix on this LCD. Command and Data are the two registers on this LCD. The LCD command instructions are stored in the command register. An instruction is what a command is.

Fig. 3.8 16*4 LCD Display

Table 3.8 Pin Description of LCD 16*4

PIN NUMBER	SYMBOL	DISCRIPTION
1	VSS	Ground
2	VDD	Power Supply (+5v)
3	VO	Contrast Adjustment
4	RS	Data/Instruction Select Signal
5	R/W	Read/Write Select Signal
6	E	Enable Signal
7 to 14	DB0 to DB7	Data Bus Line
15	A	Power Supply for Backlight (+ve)
16	K	Power Supply for Backlight (–ve)

3.1.6 ADAPTER (9V, 1A)

Fig. 3.9 ADAPTER

An Adapter is used to as a power supply to Arduino Board and other components connected to Arduino board. The adapter is required to ensure continuous supply to Arduino.

The use of battery as power supply to Arduino is unreliable as compared to adapter and it needs to be replaced once discharged. Also the amperage rating of battery is insufficient for the Arduino to work when different components are fed from it.

The adapter has a 2.1mm power plug on the Arduino end. The plug must be ‘center positive’ i.e., the middle pin of the plug has to be the +ve connection.

Table 3.9 Adapter Specification

AC Input Voltage	100 to 240 V
AC Input Frequency	47 to 63 Hz
Inrush Current	30 A (Max)
DC Output Voltage	9V
DC Output Current	1.0 A
Insulation Resistance	50M Ω
MTBF (Mean Time Between Failure)	50000 Hours

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3.1.7 RESISTOR (33 Ω, 10k Ω)

A resistor is a passive, two-terminal, electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage.

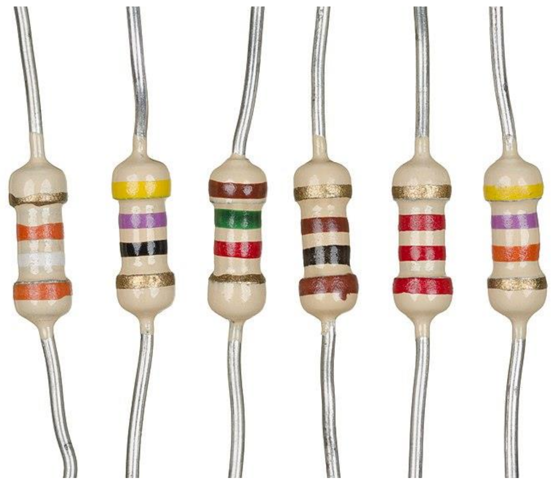

Fig. 3.10 Resistors

COLOUR CODES FOR IDENTIFYING RESISTOR RATING

Table 3.10 Resistor Color Code

COLOR	VALUE	MULTIPLIER	TOLERANCE
Black	0	$x10^0$	20%
Brown	1	$x10^1$	1%
Red	2	$x10^2$	2%
Orange	3	$x10^3$	3%
Yellow	4	$x10^4$	-0, +100
Green	5	$x10^5$	0.50%
Blue	6	$x10^6$	0.25%
Violet	7	$x10^7$	0.10%
Grey	8	$x10^8$	0.05
White	9	$x10^9$	10%

Gold	---	x10^{-1}	5%
Silver	---	x10^{-2}	10%

3.1.8 VARIABLE POT RESISTOR (10k Ω, 0.3W)

Potentiometers, or POTs, are essentially variable resistors. By just adjusting the knob on top of its head, they may supply different resistance. There are two primary parameters that can be used to classify it. The first is their resistance (R-ohms) and the second is their power (P-Watts) rating. The resistance value determines how much resistance it gives to current flow. The current will flow more slowly as the resistance value increases. 500, 1K, 2K, 5K, 10K, 22K, 47K, 50K, 100K, 220K, 470K, 500K, 1 M are some common potentiometer values. Resistors are also rated by the amount of current they can handle; this is known as the Power (wattage) rating.

Resistors are also classified based on how much current it can allow; this is called Power (wattage) rating. The higher the power rating the bigger the resistor gets and it can also more current. For potentiometers the power rating is 0.3W and hence can be used only for low current circuits. Pot resistors is used to adjust LCD backlight

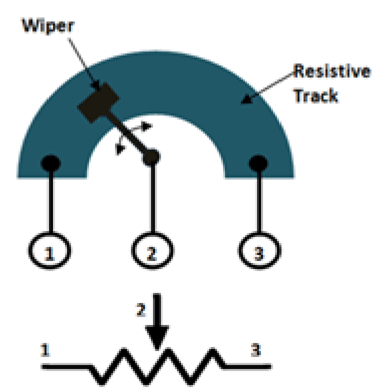

Fig. 3.11 Three Terminal Pot Resistor Fig. 3.12 Pot Resistor Pin Diagram

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Table 3.11 Pin Description

PIN NO.	PIN NAME	DESCRIPTION
1	Fixed End	This end is connected to one end of the resistive track
2	Variable End	This end is connected to the wiper, to provide variable voltage
3	Fixed End	This end is connected to another end of the resistive track

3.1.9 FILTER CAPACITOR (10 µF)

All electrolytic capacitors are polarized capacitors whose anode (+ve) is made of a particular metal on which an insulating oxide layer formed by anodization, acting as the dielectric of the electrolytic capacitor. A non-solid or solid electrolyte which covers the surface of the oxide layer in principle serves as the second electrode i.e. cathode (-ve) of the capacitor.

They are widely used for decoupling or noise filtering in power supplies and DC link circuits for variable-frequency drives, for coupling signals between amplifier stages, and storing energy as in a flash lamp.

Fig. 3.13 Capacitor

Standard electrolytic capacitors are polarized components due to their asymmetrical construction, and may only be operated with a higher voltage (ie, more positive) on the anode than on the cathode at all times. Voltages with reverse polarity, or voltage or ripple current higher than specified (as little as 1 or 1.5 volts may suffice), can destroy the dielectric and thus the capacitor. The destruction of electrolytic capacitors can have catastrophic consequences (explosion, fire).

3.1.10 SWITCH

In electrical engineering, a **switch** is an electrical component that can "make" or "break" an electrical circuit, interrupting the current or diverting it from one conductor to another. The mechanism of a switch

Fig. 3.14 Switch

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removes or restores the conducting path in a circuit when it is operated. It may be operated manually.

3.2 WORK DONE

3.2.1 BLOCK DIAGRAM

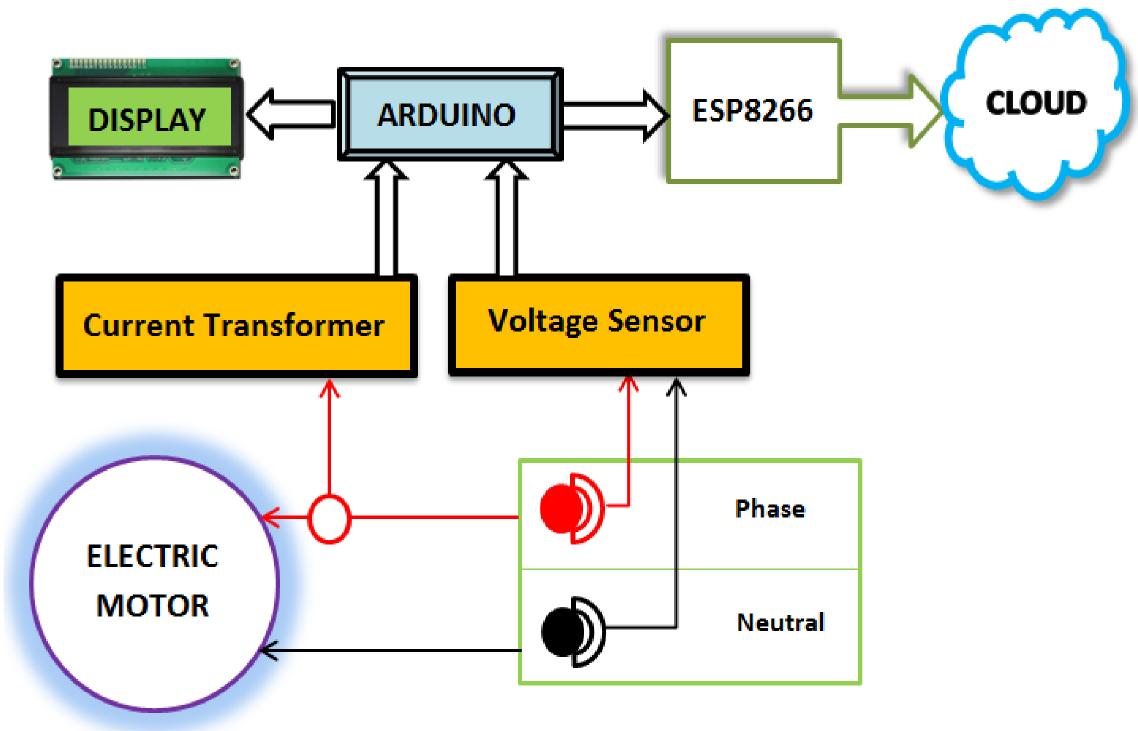

Fig. 3.15 Functional Block Diagram

The Current Transformer measures the load current and gives stepped down output to Arduino. The Voltage sensor measures the phase voltage and gives stepped down output to Arduino. The Arduino then calculates remaining parameters i.e. Power Factor, Active Power, Reactive Power and Apparent power. The measured values are then gets displayed on the Display and also the values are sent to cloud server using ESP8266 Wi-Fi module.

3.2.2 CIRCUITRY FOR CURRENT TRANSFORMER

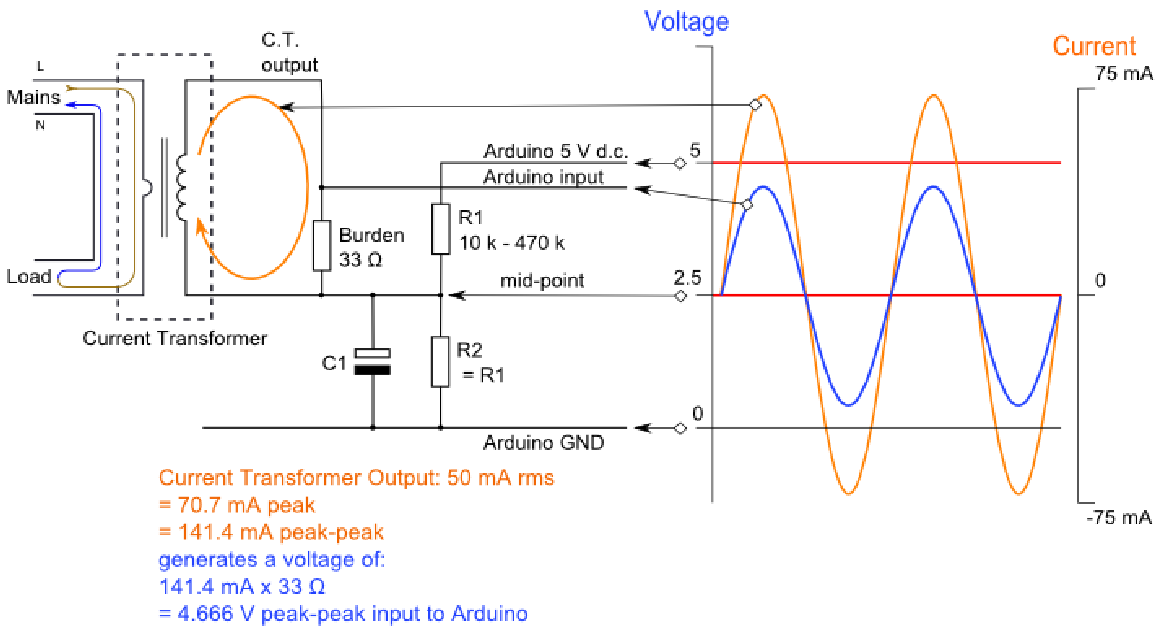

Fig. 3.16 Circuit Diagram for Current Transformer

As we know that only voltage signals can applied to Arduino, we need to change the current output of current transformer into voltage output before applying it to Arduino analog pin. For this a burden resistor of 33 Ω is connected at the secondary side of Current Transformer. The value of burden resister is calculated as follows,

$$Burden\ Resistor = \frac{(System\ Voltage)/2}{(Irms \times 1.414/CT\ Turns)}$$

For,

$$System\ Voltage = 5V$$

$$I_{rms} = 100A$$

Since this converted voltage signals will have negative pulses which are not sensed by the Arduino, their level needs to be shifted. The circuitry for this consists of a voltage divider circuit having 5V DC as an input voltage and 2.5V at its mid-point.

For the level shifting of the converted voltage signal on the secondary side of current transformer, the neutral wire is connected to mid-point of potential divider circuit at 2.5V DC. Such connection shifts the reference of analog waveform of voltage from 0V to 2.5V and thus makes the complete waveform to be in positive side.

In this way the output of current transformer is made suitable for Arduino for measurement purpose.

3.2.3 WORKING MODEL

Fig. 3.17 Hardware Model of SMART METER

The Phase Voltage applied to the motor is measured by using ZMPT101B voltage sensor. The connection of phase and neutral to the voltage sensor is made by using crocodile pins. The voltage sensor steps down this voltage to a value suitable for Arduino. The Current drawn by the motor is sensed with the help of Current Transformer which is clamped to either phase or neutral wire (not both). The current output of current transformer is then converted into voltage. Also the converted voltage level is modified to eliminate the negative pulses.

Thus the values Voltage (V) and Current (I)measured by voltage sensor and current transformer, forms the two inputs to Arduino.The Arduino further uses these two input quantities to extract the remaining parameters of motor, such as Power Factor, Active Power (P), Reactive Power (Q), and Apparent Power (S). Where,

$$P = V \times I \times Cos\emptyset$$

$$Q = V \times I \times Sin\emptyset$$

$$S = V \times I$$

Once calculated, these parameters are displayed on a 16*4 LCD Display.

All the measured data is also sent to Things peak Server for remote monitoring purpose using ESP8266 Wi-Fi Module. Data is sent in a form of packet having intervals of 15 seconds in between two consecutive packets. Thus the measured data can monitored from anywhere in the world by using the IOT Tool.Along with the Remote Monitoring, the data sent on the things peak server is logged continuously after every 15 seconds of time interval. This data can be extracted in the form of .csv format for various applications such as comparing energy usage between any particular periods, calculation of bill, analyze the performance of motor, etc.

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Chapter 4

Results and Discussions

4.1 HAIR DRYER AS LOAD: COOL air at LOW Speed (*Load 1*)

The SMART METER was tested for a hair dryer of 1000W, as an electrical load. The dryer was used with cool air setting at low speed.

1. The first output is on LCD, which is mounted on the SMART METER itself.
2. For Remote Monitoring, the second output will be on Things Peak Website as well as on the Things Peak Application.
3. The third output will be in the form of Logged Data, which can be extracted at any time in the form of Microsoft Excel Sheet

4.1.1 Output on LCD

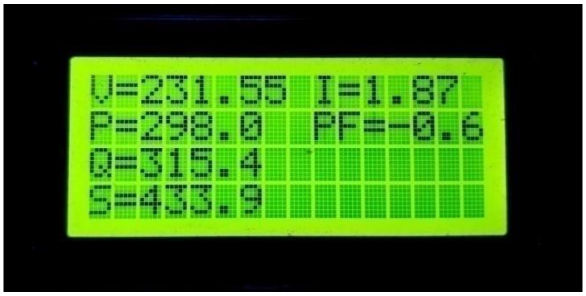

Fig. 4.1 LCD Output for Load 1

The LCD shows the measured input parameters of hair dryer with cool air setting at low speed.

4.1.2 Output on THINGSPEAK Application

The measured values are sent on Things peak server. The screenshots of Things Peak Application showing all parameters of hair dryer with cool air setting at low speed are given below.

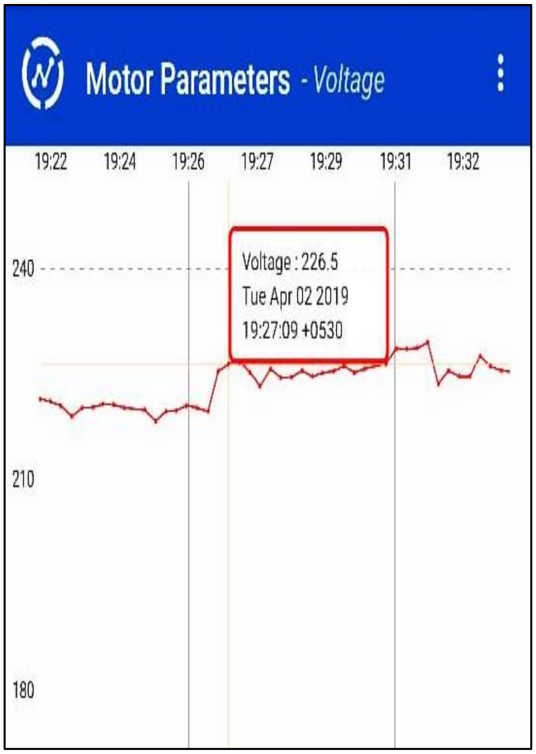

Fig. 4.2 Voltage Readings for Load 1

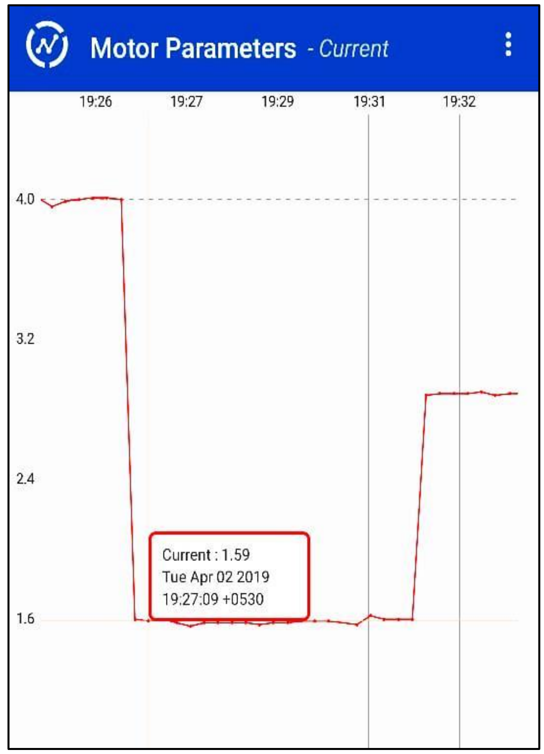

Fig. 4.3 Current Readings for Load 1

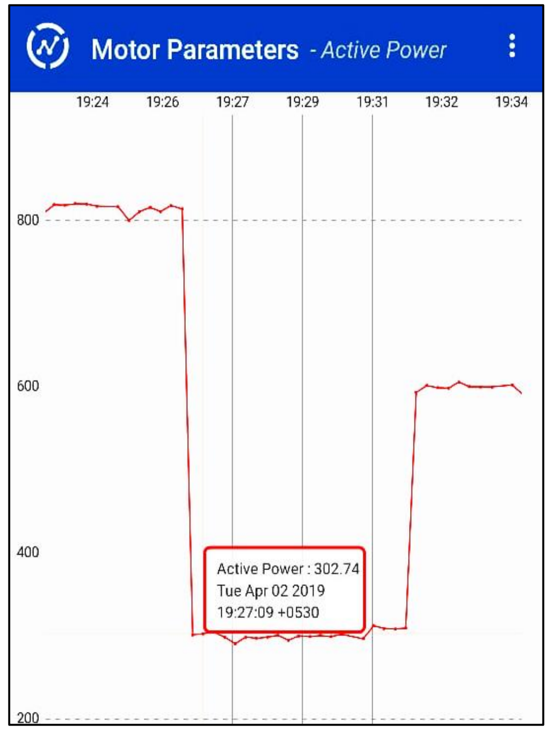

Fig. 4.4 Power Factor Reading for Load 1

Fig. 4.5 Active power Reading for Load 1

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Fig. 4.6 Reactive Power Reading for Load 1

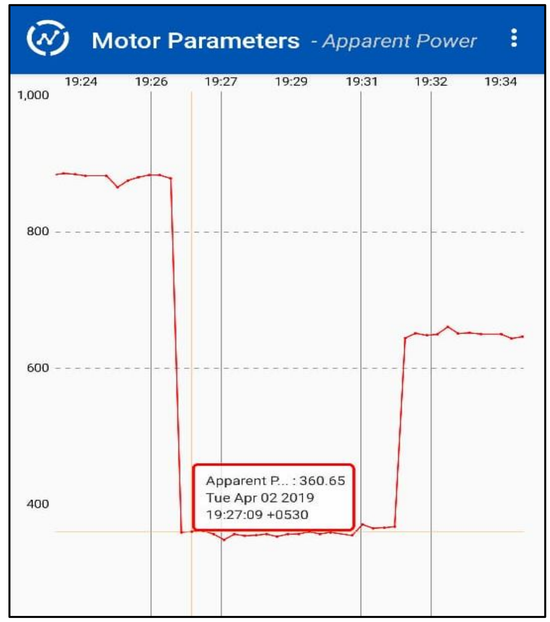

Fig. 4.7 Apparent Power Reading for Load 1

4.1.3 Logged output.

The data sent on things peak gets logged continuously. The logged data showing all parameters of hair dryer with cool air setting at low speed are given below.

Table 4.1 Logged Output of Load 1

DATE & TIME	Voltage	Current	Power Factor	Active Power	Reactive Power	Apparent Power
02/04/19 07:26:54 PM	225.44	1.6	-0.84	301.29	196.38	359.64
02/04/19 07:27:09 PM	226.5	1.59	-0.84	302.74	196	360.65
02/04/19 07:27:25 PM	226.8	1.6	-0.84	304.06	196.46	362.01
02/04/19 07:27:40 PM	225.36	1.58	-0.84	298.49	195.83	356.99
02/04/19 07:27:55 PM	223.31	1.56	-0.83	290.58	192.8	348.72
02/04/19 07:28:10 PM	225.79	1.58	-0.84	298.73	195.03	356.75
02/04/19 07:28:25 PM	224.54	1.58	-0.84	297.04	193.22	354.35
02/04/19 07:28:41 PM	224.62	1.58	-0.84	298.39	193.07	355.4

02/04/19 07:28:56 PM	225.56	1.58	-0.84	300.81	192.04	356.89
02/04/19 07:29:11 PM	224.68	1.57	-0.83	294.79	194.62	353.24

4.2HAIR DRYER AS LOAD: HOT air at HIGH Speed (*Load 2*)

The SMART METER was tested for a hair dryer of 1000W, as an electrical load. The dryer was used with hot air setting at high speed.

1. The first output is on LCD, which is mounted on the SMART METER itself.
2. For Remote Monitoring, the second output will be on Things Peak Website as well as on the Things Peak Application.
3. The third output will be in the form of Logged Data, which can be extracted at any time in the form of Microsoft Excel Sheet

4.2.1 Output on LCD

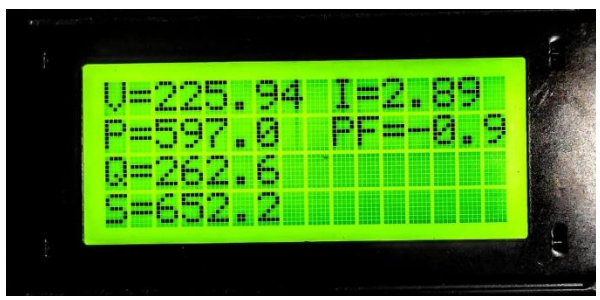

Fig. 4.8 LCD Output for Reading for Load 2

The LCD shows the measured input parameters of hair dryer with hot air setting at high speed.

4.2.2 Output on THINGSPEAK Application

The measured values are sent on Things peak server. The screenshots of Things Peak Application showing all parameters of hair dryer with hot air setting at high speed are given below.

Fig. 4.9 Voltage Reading for Load 2

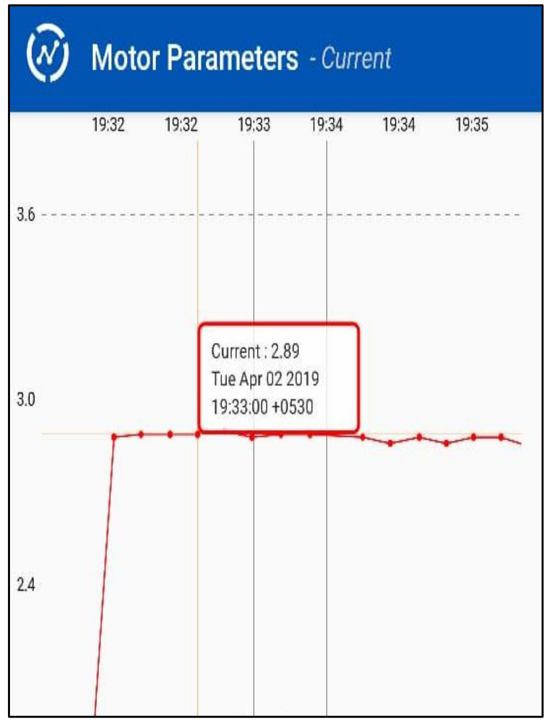

Fig. 4.10 Current Reading for Load 2

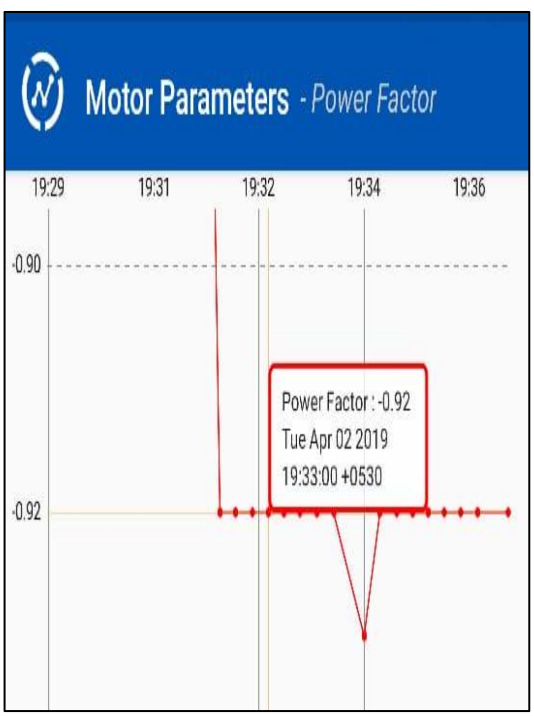

Fig. 4.11 Power Factor Reading for Load 2

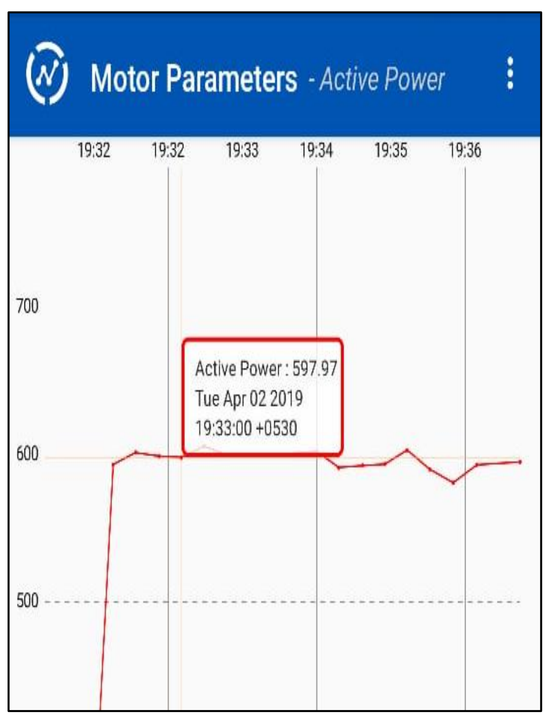

Fig. 4.12 Active Power Reading for Load 2

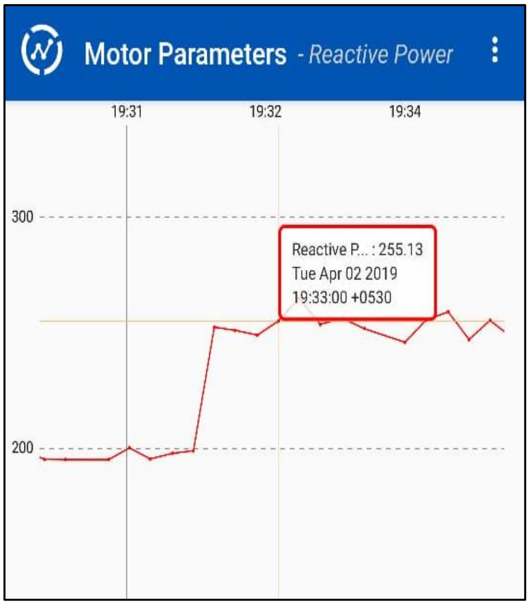

Fig. 4.13 Reactive Power Reading for Load 2

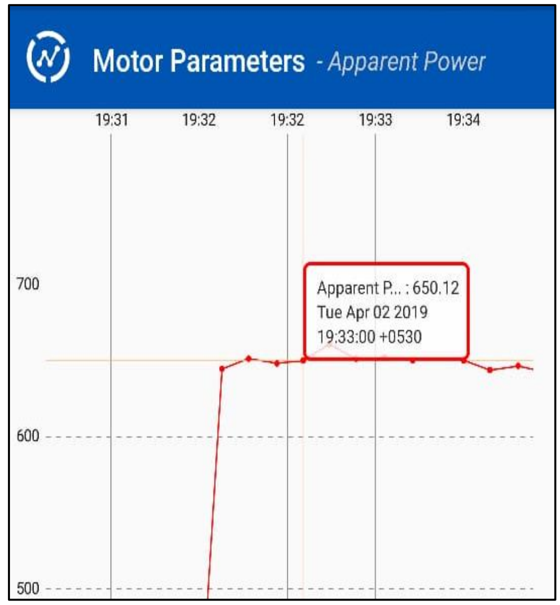

Fig. 4.14 Apparent Power Reading for Load 2

4.2.3 Logged output.

The data sent on things peak gets logged continuously. The logged data showing all parameters of hair dryer with hot air setting at high speed are given below.

Table 4.2 Logged Output of Load 2

DATE & TIME	Voltage	Current	Power Factor	Active Power	Reactive Power	Apparent Power
02/04/19 7:32:14 PM	223.65	2.88	-0.92	593.13	252.5	644.64
02/04/19 7:32:29 PM	225.58	2.89	-0.92	601.19	251.11	651.53
02/04/19 7:32:45 PM	224.68	2.89	-0.92	598.74	249.06	648.48
02/04/19 7:33:00 PM	224.68	2.89	-0.92	597.97	255.13	650.12
02/04/19 7:33:15 PM	227.64	2.9	-0.92	605.53	265.06	661
02/04/19 7:33:30 PM	226.15	2.88	-0.92	599.84	253.66	651.27
02/04/19 7:33:46 PM	225.54	2.89	-0.92	599.73	256.33	652.21

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02/04/19 7:34:02 PM	225.35	2.89	-0.92	599.65	251.77	650.36
02/04/19 7:34:31 PM	225.95	2.88	-0.93	602.04	245.94	650.34
02/04/19 7:34:46 PM	225.41	2.86	-0.92	591.07	255.46	643.91

4.3ELECTRIC WATER HEATER AS A LOAD (*Load 3*)

The SMART METER was tested on an electric water heater of 1200W, as an electric load.

1. The first output is on LCD, which is mounted on the SMART METER itself.
2. For Remote Monitoring, the second output will be on Things Peak Website as well as on the Things Peak Application.
3. The third output will be in the form of Logged Data, which can be extracted at any time in the form of Microsoft Excel Sheet

4.3.1 Output on LCD

Fig. 4.15 LCD Output Reading for Load 3

The LCD shows the measured input parameters of electric water heater.

4.3.2 Output on THINGSPEAK Application

The measured values are sent on Things peak server. The screenshots of Things Peak Application showing all parameters of electric water heater are given below

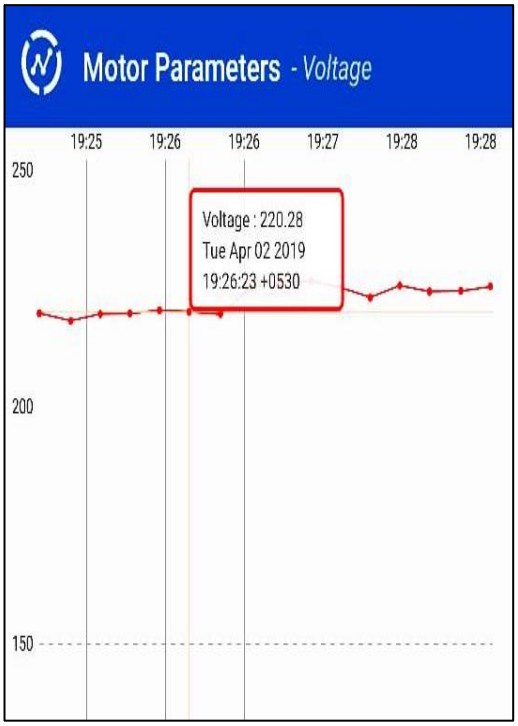

Fig. 4.16 Voltage Reading for Load 3

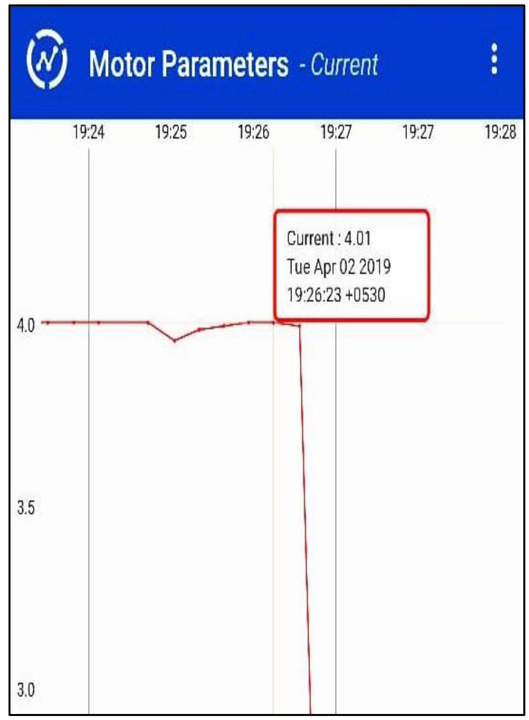

Fig. 4.17 Current Reading for Load 3

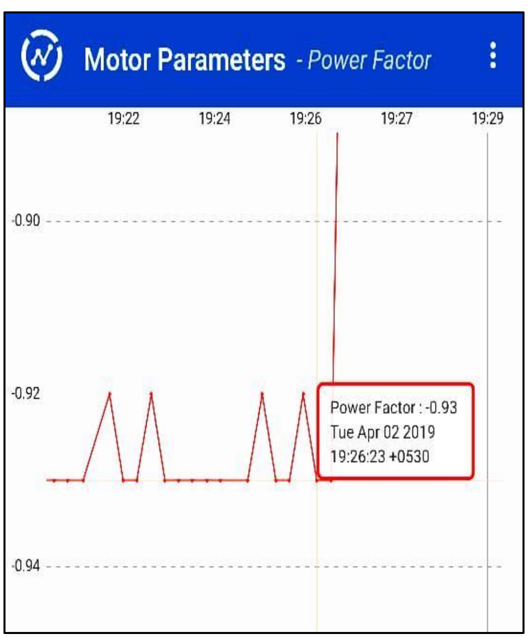

Fig. 4.18 Power Factor Reading for Load 3

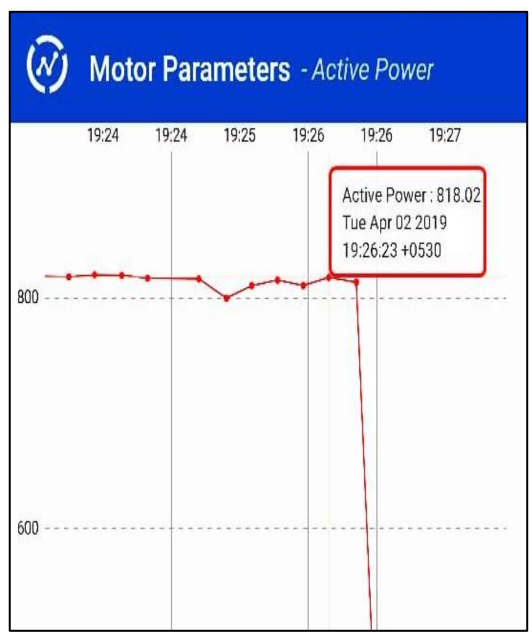

Fig. 4.19 Active Power Reading for Load 3

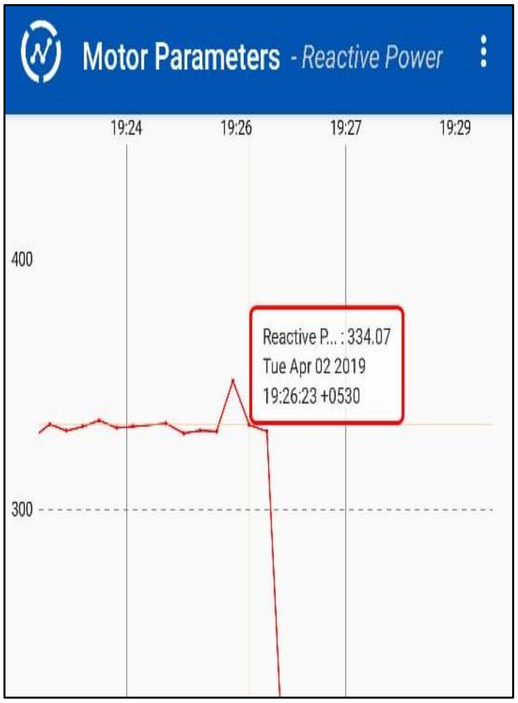

Fig. 4.20 Reactive Power Reading for Load 3

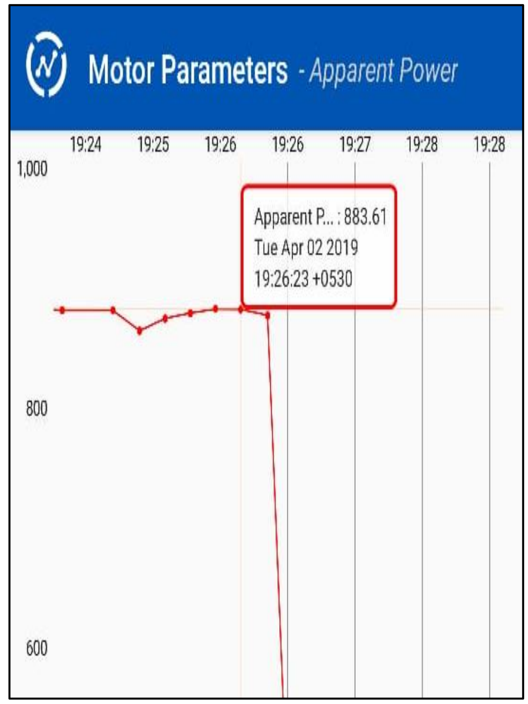

Fig. 4.21 Apparent Power Reading for Load 3

4.2.3Logged output

Table 4.3 Logged Output of Load 3

DATE & TIME	Voltage	Current	Power Factor	Active Power	Reactive Power	Apparent Power
02/04/19 7:18:16 PM	222.1	4.04	-0.92	828.96	344.13	897.55
02/04/19 7:18:31 PM	222.14	4.04	-0.93	830.32	338.66	896.72
02/04/19 7:18:46 PM	221.51	4.04	-0.93	827.02	339.61	894.03
02/04/19 7:19:01 PM	222.49	4.04	-0.93	832.44	340.54	899.41
02/04/19 7:19:17 PM	221.92	4.04	-0.92	827.96	342.78	896.11
02/04/19 7:19:47 PM	221.84	4.04	-0.93	832.13	332.41	896.07

02/04/19 7:20:02 PM	222.37	4.04	-0.93	833.76	335.39	898.68
02/04/19 7:20:18 PM	225.75	4.05	-0.92	839.1	364.77	914.96
02/04/19 7:20:33 PM	224.1	4.05	-0.92	836.07	350.29	906.49
02/04/19 7:20:48 PM	220.33	4.02	-0.93	820.2	336.04	886.37

The data sent on things peak gets logged continuously. The logged data showing all parameters of electric water heater is given below.

4.3 BILL CALCULATION

The SMART METER was also connected with different household appliances for a total duration of 15hrs. The connected load was consisted of small room cooler, water Heater cord, hair dryer etc. The estimated bill for this duration is thus calculated using the logged data. In this way the logged data can be used to estimate the Bill for any desired period.

Table 4.4Bill Calculation

SLOT	TOTAL READING	Samples	WATTS CONSUMED	Duration	(Watt*hr.) Consumed
6-7 pm	3127	33	96.093	1 hr.	96.093
7-8 pm	7459	174	42.8705	1 hr.	42.8705
8-9 pm	7815	182	42.944	1 hr.	42.944
9-10 pm	7084	170	41.6738	1 hr.	41.6738
10-11 pm	7276	175	41.5773	1 hr.	41.5773
11-12 midnight	7502	181	41.4485	1 hr.	41.4485
12-1 am	7813	183	42.6977	1 hr.	42.6977
1-2 am	7881	171	46.0903	1 hr.	46.0903
2-3 am	8212	177	46.3987	1 hr.	46.3987
3-4 am	2970	179	16.5948	20 min.	5.5316
4-5 am	0		0		0
5-6 am	0		0		0
6-7 am	0		**0**		0
7-8 am	0		0		0
8-9 am	84388	184	458.6313	28 min.	214.0279
9-10 am	3366	27	124.7025	8 min.	16.627
				TOTAL (Watt*hr.)	**677.9803**
				Units Consumed	**0.6778**
				BILL	**Rs 2.03**

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Chapter 5

Conclusion and Future Scope

5.1 CONCLUSION

Thus the smart meter is capable to provide various parameters of an electric motor on a single platform. This will eliminate the number of meters that would have been required for the same purpose. Since the platform on which values are being displayed is digital, this will eliminate the errors in manual meter reading.

The real time data monitoring facility using IoT technique will help to monitor the motors so as to utilize the motor more efficiently. Also the data will be logged continuously which will help to keep the track of motor behavior so as to determine the requirement of preventive maintenance. This logged data will also be useful to estimate the Bill for any desired period.

5.2 FUTURE SCOPE

The future scope for this project would be on a software side. The time delay of 15 seconds will be tried to remove as the rapid changes may not get logged that may be useful for the protection as well as to analyze the motor.

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