PRIORITY BASED LOAD MANAGEMENT SYSTEM

A Project Report Submitted to

Government College of Engineering, Aurangabad

In Partial Fulfillment of the Requirements for the Award of

Bachelor of Technology in Electrical Engineering

Submitted by

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Place of Project Work

Electrical, Electronics & Power Engineering Department

Government College of Engineering Aurangabad

(2021-22)

GOVERNMENT COLLEGE OF ENGINEERING AURANGABAD

(An Autonomous Institute of Government of Maharashtra)

CERTIFICATE

This is to certify that, Mayur Ghadge (BE19S03F004), Hemant Chavan (BE19S03F003), Pranav Barhanpure (BE18F03F005), Achal Dhatbale (BE18F03F012), Shreyas Sarpotdar (BE18F03F044) & Snehal Sirsat (BE18F03F048), students of final year Electrical Engineering Department have submitted their project report on "**PRIORITY BASED ENERGY MONITORING & AUTO LOAD SHEDDING**" during academic session **2021-2022** as a part of project work prescribed by Government College of Engineering, Aurangabad for partial fulfillment for the award of Degree in Electrical Engineering.

The project work is the record of students of their own work under my guidance and to my satisfaction.

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ACKNOWLEDGEMENT

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without the mentioning of the people whose constant guidance and encouragement made it possible. We take pleasure in presenting before you, our project, which is result of studied blend of both research and knowledge.

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Finally, we express our gratitude to all other members who are involved either directly or indirectly for the completion of this project.

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ABSTRACT

Energy crises nowadays are a big issue in the entire world and countries like India are affected more and severe short fall occurs in energy sector which affects economic growth and industrial development. In India fossil fuels like (furnace oil, natural gas, coal), hydro are the main sources of energy generation along with very limited renewable energy resources. Government has been planning various strategies to resolve the issue of energy crises and most of them are long term planning. In this project, a cost effective method of smart metering has been applied to narrow down the gap between supply and demand where electricity units can be calculated in peak and off peak hours separately and switch off unnecessary loads in peak hours, so by managing the different loads in peak and off peak hours we can overcome the energy crises and also a great impact will be seen in utility bills.

Index Terms: Smart Meter, Energy Management System, Demand Side Management, Load Control, Energy Management Controller, Smart Pricing, Consumer Participation.

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1. INTRODUCTION

Electrical energy is very important for every organization Industries, educational institutions, information technology, agriculture, and commercial markets. Any country that wants to improve living standards and grow its economy must secure a bulk energy supply. The uses of energy increases every month and year due to increase of new industries, homes, markets and new projects. As more countries rise out of poverty and develop their economies, energy demand rises correspondingly. India’s energy sector mostly depends on thermal, hydro, oil and gas resources to meet and fulfill energy requirements. The resources of coal, gas and oil are not enough to quench energy thirst of a growing economy. In India around 60% of electricity is generated from fossil fuels. Out of that coal-based thermal power plants have a share of almost 52%. The obvious result is tremendous increase in pollution that leads to several diseases and death. Consequently, the Government of India has set to achieve 450 GW of renewable energy installed capacity by 2030.

The power industry has always been a key driver for industrial development, infrastructure growth and social welfare. The journey of electricity in India began with the transfer of electricity-based technologies from England to India during the colonial period, from the first flickering of the light bulb in Calcutta in 1879 to the first commercial hydroelectric power station in 1897. The motivation behind this was to leverage the resources and not to transfer the knowledge. The electricity was generated and distributed primarily by private companies in the urban areas before independence.

In 1964 our nation was split into five electricity regions to make the planning process smoother. These regional grids were implemented to meet common demands and efficient grid operations, namely Southern, Northern, North-Eastern, Western and Eastern. SEBs were unable to meet the people’s demands in their respective states, to cope up with this situation in 1976 a central organization was formed for generation and transmissions like National Thermal Power Corporation (NTPC), National Hydro-electric Power Corporation (NHPC) and National Power Corporation (NPC). In the next few years, the condition of the SEBs became grim as the debt rose to 41,000 crores. This issue had predominantly risen because of high transmission losses and political interference over SEBs in granting of subsidies to the farmers. The privatization wasn’t even considered to be good at that time, somehow the government decided in 1991 to open up the paths for private companies in the power sector. These were permitted to generate and supply electricity in confined areas. With the involvement of private companies in the sector, the responsibility of SEBs was increased, thereby requiring a regulatory body for proper governance. The Electricity Regulatory Commission Act 1998 (ERC Act 1998) was formed to monitor and keep the government away from tariff determination. The Central Electricity Regulatory Commission (CERC) at the national level and the State Electricity Regulatory Commission (SERC) at the state level were set up to rationalize the electric tariff. The consequence of these laws can be seen from the growth of electricity generation, which boosted from about 5.1 billion units to 420 billion (82-fold increase) and the per capita consumption of electricity also increased from 15 units in 1950 to about 338 units in 1997-98, which was about 23 times higher. There were also many maladies in the Indian power sector; Electricity Act 2003 was introduced to eradicate these maladies. This was the most essential act in Indian history that properly integrated all previously established acts.

The various objectives of this act are enumerated below:

- To promote competition in the market.
- Strengthening the laws relating to power generation, transmission and distribution.
- Guaranteeing transparency in the subsidy programs.
- Strict rules for the minimization of theft and misuse.
- Mandatory metering in all houses.
- Ensuring that electricity reaches all areas.
- To protect the rights of the consumer.
- Fostering efficient and environmentally sustainable policies.
- To take action for the development of the power industry.

This act was amended several times in between 2004 to 2014. The 2005 reforms centered specifically on energy protection, with the offenses relating to power stealing, energy poles and meter manipulation as recognized offenses. The distribution sector did not remain untouched by the restructuring of the power sector.

Central Government launched various schemes for the electrification of every household; one of them is Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) on 4th April 2005 for attaining the National Common Minimum Programme (NCMP) goal of providing access to electricity to all households in the country in five years. In this step, the rapid growth of solar energy is only made possible with the Jawaharlal Nehru National Solar Mission (JNNSM), which was launched to encourage environment-friendly development while tackling India’s energy security issue. It will also mark India’s main contribution to the global initiative to confront the problems of climate change. The Mission’s immediate goal was to focus on creating an encouraging environment for the country’s penetration of solar energy at both centralized and decentralized level. With the motive of transparency and competition in trading of power in 2008, the Indian Energy Exchange (IEX) and Power Exchange India Limited (PXIL) have been established. PXIL and IEX facilitate transparent trading of electricity, a larger market spectrum, and allow the participation of other players in the market. IEX’s services include Term Ahead Market (TAM), Day-Ahead Market (DAM), and much more. Availability-based tariff is one of the main mechanisms to estimate the DAM successfully. Fig. 1 shows the transformation of the Indian power sector.

The next and foremost important revolution in the Indian Power Sector was the implementation of “Availability Based Tariff (ABT)” in the tariff structure. The frequency of the grid increases when generation is more than demand and if the generation is less than demand the frequency falls. The past problems associated with the grid are low frequency at peak load periods, high frequency during off-peak hours, and frequent tripping of generators. ABT has proved to be the best equipment for handling all these problems. To maintain the grid frequency at its nominal value of 50 Hz, the ABT introduced the concept of Unscheduled Interchange (UI) charges. In this tariff framework, the generating station is entitled to obtain the incentive payment for the additional amount of generation according to the frequency guided rate whenever the actual energy supplied is greater than the pre-committed scheduled amount and will pay fine in a vice-versa situation. The ABT was implemented in all the five regions of India by 1 November 2003 and also its enactment had displayed a notable improvement in grid discipline. The permissible frequency band is reduced from the introductory range of 49 – 50.5 Hz in 2002-03 to 49.7 – 50.2 Hz in 2012. After ABT was introduced, the frequency profile of all regions was improved greatly and Fig 2 shows the frequency comparison of all regions within one year of pre-ABT and post ABT period.

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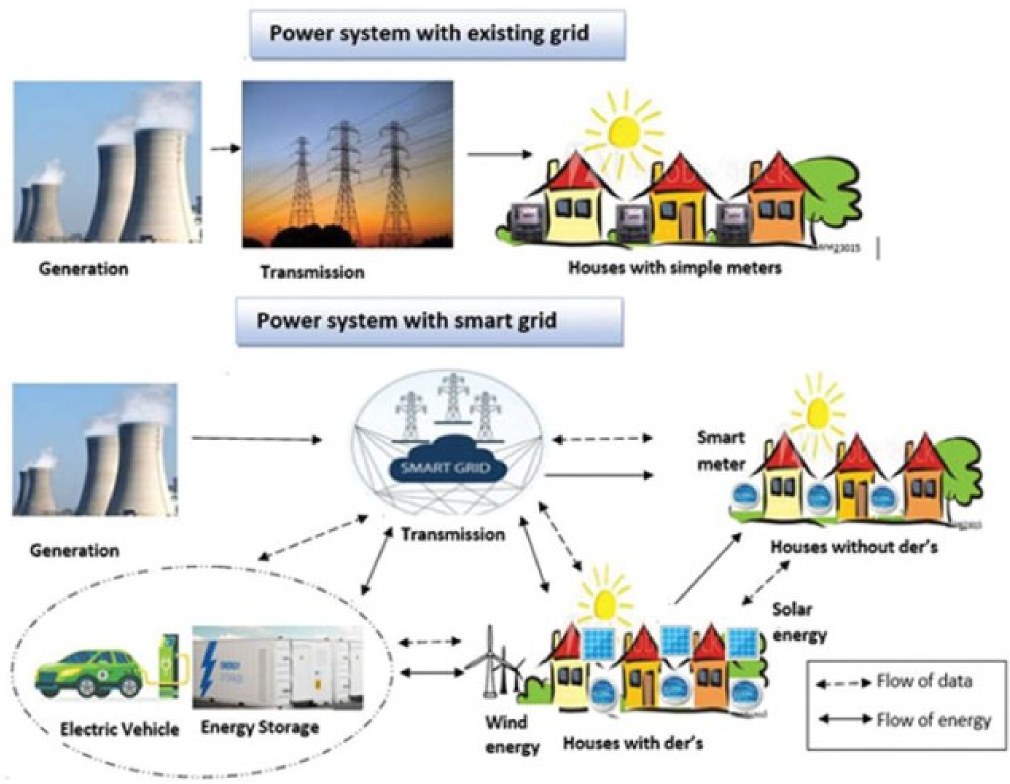

Figure 1.1.Power System with Existing & Smart Grid

The aforementioned reforms undoubtedly opened up all the avenues for the growth of the power industry. Yet the situation was different, the gap between demanded and supplied energy rose from 8.1% in 1997-98 to 11.1% in 2008-09. The two key factors that hampered the development were power generation capacity and failure to reduce distribution losses. In order to address this problem, the generation capacity was increased from 723.8 BU in 2008-09 to 1376.09 BU in 2018-19 within a decade. It brings the deficit to 0.6% in 2018-19. In certain regions, the electricity was in surplus condition therefore, the other states were provided with unused electricity.

ALL INDIA INSTALLED CAPACITY (IN MW) OF POWER STATIONS
(As on 31.10.2021)

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(As on 31.10.2021)

Region	Ownership/ Sector	Mode wise breakup: Thermal: Coal	Lignite	Gas	Diesel	Total	Nuclear	Hydro	RES * NRE)	Grand Total
Northern Region	State	17319.00	250.00	2879.20	0.00	20448.20	0.00	5888.25	725.51	27061.96
	Private	22425.83	1080.00	558.00	0.00	24063.83	0.00	3061.00	21819.76	48944.59
	Central	15662.48	250.00	2344.06	0.00	18256.54	1620.00	11484.52	379.00	31740.06
	Sub Total	55407.31	1580.00	5781.26	0.00	62768.57	1620.00	20433.77	22924.27	107746.61
Western Region	State	21290.00	900.00	2849.82	0.00	25039.82	0.00	5446.50	569.28	31055.60
	Private	31947.17	500.00	4676.00	0.00	37123.17	0.00	481.00	30897.67	68501.84
	Central	20479.10	0.00	3280.67	0.00	23759.77	1840.00	1635.00	666.30	27901.07
	Sub Total	73716.27	1400.00	10806.49	0.00	85922.76	1840.00	7562.50	32133.25	127458.51
Southern Region	State	20322.50	0.00	791.98	159.96	21274.44	0.00	11819.83	594.88	33689.15
	Private	12747.00	250.00	5340.24	273.70	18610.95	0.00	0.00	44686.53	63297.48
	Central	11835.02	3390.00	359.58	0.00	15584.60	3320.00	0.00	541.90	19446.50
	Sub Total	44904.52	3640.00	6491.80	433.66	55469.99	3320.00	11819.83	45823.31	116433.13
Eastern Region	State	7450.00	0.00	100.00	0.00	7550.00	0.00	3537.92	275.11	11363.03
	Private	5553.00	0.00	0.00	0.00	5553.00	0.00	209.00	1427.35	7189.35
	Central	14613.38	0.00	0.00	0.00	14613.38	0.00	1005.20	10.00	15628.58
	Sub Total	27616.38	0.00	100.00	0.00	27716.38	0.00	4752.12	1712.46	34180.96
North Eastern Region	State	0.00	0.00	466.36	36.00	502.36	0.00	422.00	233.25	1157.60
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	160.70	160.70
	Central	770.02	0.00	1253.60	0.00	2023.62	0.00	1522.00	30.00	3575.62
	Sub Total	770.02	0.00	1719.96	36.00	2525.98	0.00	1944.00	423.95	4893.92
Islands	State	0.00	0.00	0.00	40.05	40.05	0.00	0.00	5.25	45.30
	Private	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.66	27.66
	Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	5.10
	Sub Total	0.00	0.00	0.00	40.05	40.05	0.00	0.00	38.01	78.06
ALL INDIA	State	66381.50	1150.00	7087.36	236.01	74854.86	0.00	27114.50	2403.27	104372.64
	Private	72673.00	1830.00	10574.24	273.70	85350.95	0.00	3751.00	99019.67	188121.62
	Central	63360.00	3640.00	7237.91	0.00	74237.91	6780.00	15646.72	1632.30	98296.93
	Total	202414.50	6620.00	24899.51	509.71	234443.72	6780.00	46512.22	103055.25	390791.18

Figures at decimal may not tally due to rounding off

Table 1.1 All India Installed Capacity (In Mw) Of Power Stations

According to the CEA report, installed capacity was raised to 369,428MW till 29.02.2020, from which thermal energy had its contribution of 62.8%, renewable energy had 23.5%, hydro energy had 12.4% and remaining was from nuclear energy. The growth in the renewable sector is appreciable from 2015 onwards; the rise last year was 24%. The Indian market was flooded with china's cheap solar module and the government subsidy help boost renewable energy generation which marks the 23.5% share of total generation.

Due to power shortage in India the utilities departments (MSEDCL, UPPCL, etc) managed the load demand by load shedding. The load shedding of power is actually switching off the load feeder for some time; the feeder can be switched on again after some time. In 132 kV to 11 kV substations, three phase supply is incoming in 132 kV lines which can be step down through power transformers into medium voltage 11 kV, this 11 kV supply is provided to outgoing feeders through a control panel or medium voltage (MV) panel.

In the control panel, circuit breaker, protection relay, ampere meter, energy meter and a control circuit for on off are installed. There are two push buttons in the control panel; these are on push button and off push button, which are used for switching on/off the 11 kV panel or feeder. Oil or vacuum circuit breakers are used in 11 kV feeders. Over current, short circuit and phase sequence failure relays are commonly used in these control panels. These control panels are operated manually by a substation operator. The energy meters in the control panels are connected to potential transformer (PT) for voltage measuring and current transformer (CT) for current measuring. From these signals of voltage and current the energy meter measures kilo watt hours (kWh), kilo watt (kW) and kilo volt ampere reactive hours (KVArh). The 11 kV feeders are then transmitting power to the consumers through distribution transformers 11 kV/ 440V. The power utility company/suppliers have installed energy meters before the consumer loads, which record the consumed energy units (kWh). The energy consumers pay bills according to energy consumed on monthly basis. In Pakistan the energy demand is increases in morning and evening in summer season. The government has introduced peak and off peak hours to meet the energy demand and to aware the consumers to minimize the load in peak hours. The energy tariffs are higher for peak hour load than off peak hour load. But this function is not available in the traditional electromagnetic and rotating disc type energy meters. The modern digital microprocessor based energy meter records the energy consumed in peak hour and off peak hour separately. Thus the consumers will avoid using maximum load during peak hours, but still some consumers don’t avoid using maximum load in peak hours. The designed project “**PRIORITY BASED ENERGY MONITORING AND AUTO LOAD SHEDDING**” will switch off low priority load in peak hours to minimize the load.

2. CURRENT SCENARIO OF SMART ENERGY METERS

There are different types of smart energy meters recently presented for residential energy consumers. Some of them are wired and some are wireless based (GSM, Wi-Fi etc.) energy meters, which calculate the consumed energy and prices. The consumed energy units can be sent daily and monthly through GSM to mobile phone of the consumer or data monitoring system/ database system of the utility. The smart meter also sent an alert message to the consumer to avoid extra load, or take other action to minimize load and energy units from over billing. In Wi-Fi based smart meters, power system parameters energy units are calculated in microcontroller and sends these data over Wi-Fi through the home's Wi-Fi wireless router to the database or monitoring station. A Base station is based on an application which extracts the data from TCP/IP protocol, sent by the smart meters. The entire TCP/IP communication system protocol is a standard implemented by almost all the communication systems. It provides a communication link between smart meter and base station based on IP addresses. Some systems were designed to combine capabilities for web-based control and monitoring control. The purpose of the internet based control and monitoring system is to allow users to check and control the energy data via a home URL with a GUI (Graphical User Interface).

ON/OFF: Depends On Load Limit, HP Load Will Remain In ON Condition If the Loads under Limit, HP Load Will Switch OFF If the Load Exceeds the Limit.

Type of Electric Loads	Priority Level	Status in Peak Hours
Lighting-a	Important	ON
Electric Fans-a	Important	ON
Computers-a	Important	ON
Lighting-b	High Priority	ON/OFF
Electric fans-b	High Priority	ON/OFF
Computers-b	High Priority	ON/OFF
Microwave Oven	High Priority	ON/OFF
Water Pump	Low Priority	OFF
Motors	Low Priority	OFF
Laptops	Low Priority	OFF
Air Conditioners	Low Priority	OFF
Others	Low Priority	OFF

Table 2.1: Different Types of Loads

3. PROPOSED METHODOLOGY

- The aim of our proposed project is to reduce or eliminate planned and unplanned load shedding via switching off the unnecessary equipment's in peak hours.
- There are many smart meters developed recently, many smart meters have function of energy calculation, billing and sending data to monitory station through wired and wireless communication. But these smart energy meters are not helpful to reduced load shedding and meet the energy demand.
- The load connected to supply load are divided into three sections, i.e. high priority (H.P), low priority (L.P) and important/necessary load through TRIACS (switch).
- The RELAY MODULES are used to switch on and off high priority (H.P) and low priority (L.P) load sections during peak hour.
- The peak hour can be adjusted via Bluetooth device connected to the smart meter. The switching on/off L.P and H.P load function can be enabled and disabled commands, these commands can be sent to energy meter through mobile phone with Android software (BLUETOOTH TERMINAL)
- Current Transformer (CT) in series of line of load and Potential Transformer (PT) are connected in parallel of the load and supply source.
- From PT and CT signals microcontroller measures voltage, current and power. Alternating current and voltage signals are shifted into DC offset signal. These signals are now analogue not alternating current signal, the magnitude of voltage current signals varies but do not change the direction.
- In Arduino UNO ATMEGA 328 controller there are built in analogue to digital converter which converts these analogue voltage and current signals into digital and then provided to micro controller.
- Using C++ programming in Arduino IDE software, the voltage current, power and energy have been calculated.
- These values are also shown on LCD 16 X 2 character display.
- According to programming in microcontroller, the H.P and L.P load will switch on and off through RELAY MODULE.
- A 5VDC source is provided to controller for operation. To connect a CT sensor to an Arduino, the output signal from the CT sensor needs to be conditioned so it meets the input requirements of the Arduino analog inputs, i.e. a positive voltage between 0V and the ADC reference voltage (05 VDC).
- The transformer in the adapter provides isolation from the high voltage mains. As in the case of current measurement with a CT sensor, the main objective for the signal conditioning electronics detailed below is to condition the output of the AC power adapter so it meets the requirements of the Arduino analog inputs: a positive voltage between 0V and the ADC reference voltage.
- The AC voltage waveform can be shifted into DC offset voltage using a voltage divider connected across the potential transformer terminals, and the offset can be added using a voltage source created by another voltage divider connected across the Arduino's power supply (+5 VDC).
- Resistors R1 and R2 form a voltage divider that scales down the power adapter AC voltage. Resistors R3 and R4 provide the voltage bias. Capacitor C1 provides a low impedance path to ground for the AC signal. The value is not critical; the value between 1 µF and 10 µF will be satisfactory. R1 and R2 need to be chosen to give a peak-voltage-output of ~1V. For an AC-AC adapter with a 9V RMS output, a resistor combination of 10k for R1 and 100k for R2 would be suitable:

$$V_{OUT} = \{R1/ (R1+R2)\} * V_{IN}$$

- Peak voltage output = 10k / (10k+100k) x 8.4V = 0.76 V.
- The voltage bias provided by R3 and R4 should be half of the Arduino supply voltage. As such, R3 and R4 need to be of equal resistance. If the Arduino is running at 5V the resultant waveform has a positive peak of 2.5V + 0.76V = 3.26V and negative peak of 1.35V satisfying the Arduino analog input voltage requirements. This also leaves some "headroom" to minimize the risk of over or under voltage.

4. HARDWARE DESCRIPTION

- Arduino Uno is a microcontroller board based on the ATMEGA 328 P. It has fourteen digital input/output pins, six analog inputs, a 16 MHz quartz crystal for clock speed, a USB connection for communication and program uploading, a 5 VDC power supply pin and a reset button.
- It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or connect it to +5 VDC to get started.
- A liquid-crystal display (LCD) is a flat panel display, or video display, electronic visual display that uses the light modulating properties of liquid crystals.16 x 2 means that 16 characters can be displayed in each of the 2 rows of the 16 x 2 LCD, thus a total of 32 characters can be displayed at any instance of time.
- Display is used to show the power system parameters voltage, current, power, energy and time.
- The relay module can be used for switching and controlling current. The relay module is an ideal device to use for AC switching applications because it can control the current flow over both positive and negative half cycles of an alternating cycle.
- In this project, HC-05 Bluetooth device is used for communication between consumer and energy meter.
- The consumer can send the commands to the controller for adjusting energy meter parameter i.e. load limit, peak hour timing and enable/disable function. The consumers receive data from energy meter via this Bluetooth device.
- This module can be set as a transmitter or receiver, transmitter can pair with receiver, receiver can pair with computers and cell phone's Bluetooth, receiver and receiver or transmitter and transmitter can't communication between each other.
- The data is showing on LCD of the smart meter and also is showing on computer or consumer mobile phone via Bluetooth.
- Power system parameters voltage, current, power, energy and time are shown on LCD 16 X 2 character display. The consumer can check the consumed energy unit any time.
- The consumer can send the commands to the controller for adjusting energy meter parameter i.e. load limit, peak hour timing and enable/disable function via HC-05 Bluetooth device used for communication.
- When the peak hour starts (11:00 -14:00 here in this project), the low priority load disconnect to reduce load in peak hours. But the high priority load will disconnect only when it exceeds load limit peak hours. The consumer can adjust this limit via Bluetooth.
- When high priority load disconnected then will connect again after some time about 5 minutes. After 5 minutes duration, the high priority load will connect again if the load limit not exceed then will remain on otherwise will trip. The consumer can check the status of energy meter and load parameters via wireless communication system i.e. Mobile phone or computer etc.

- **CIRCUIT DIAGRAM**

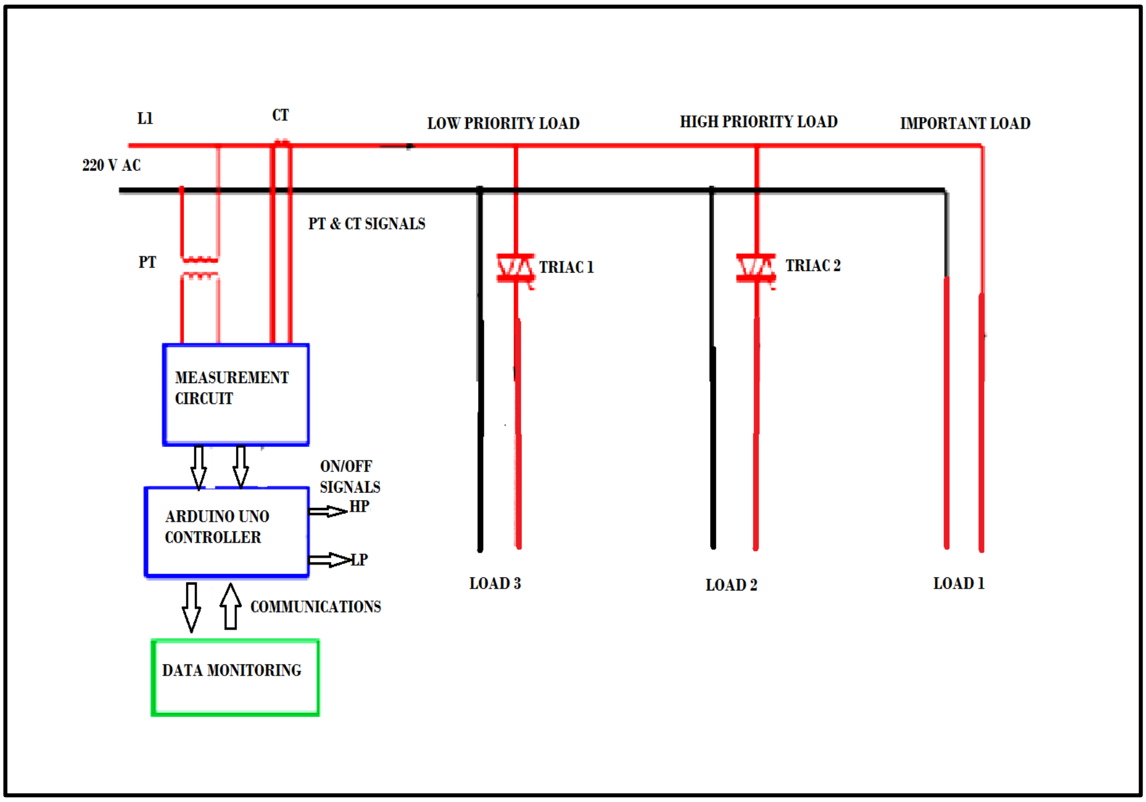

Figure 4.1: Circuit diagram of the proposed system

- **WIRING DIAGRAM**

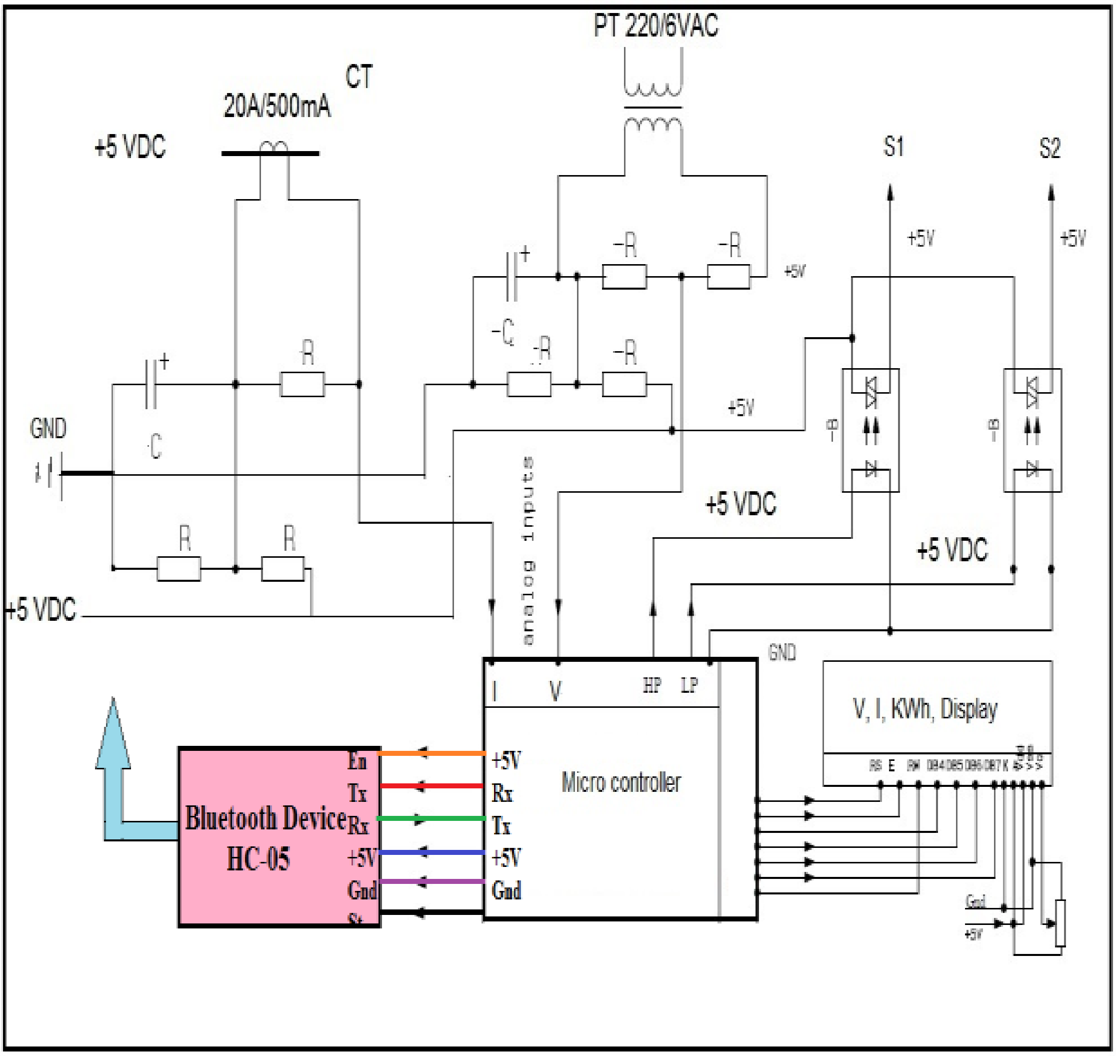

Figure 4.2: Wiring Diagram of Energy Monitoring and Priority Based Load Shedding Project

- **FLOW CHART OF CURRENT SYSTEM APPROACH**

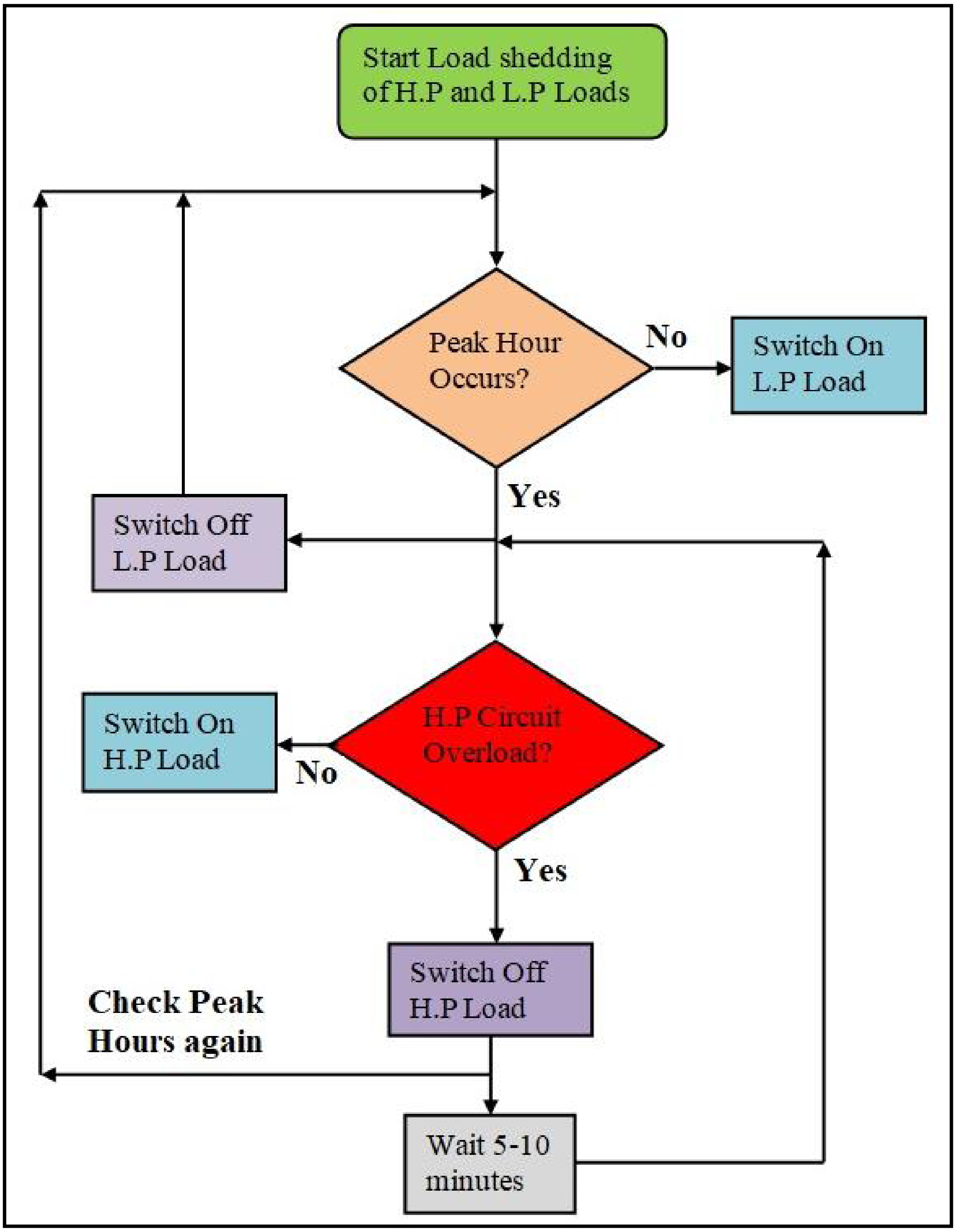

Figure 4.3 : Flow chart of current system approach

5. RESULTS

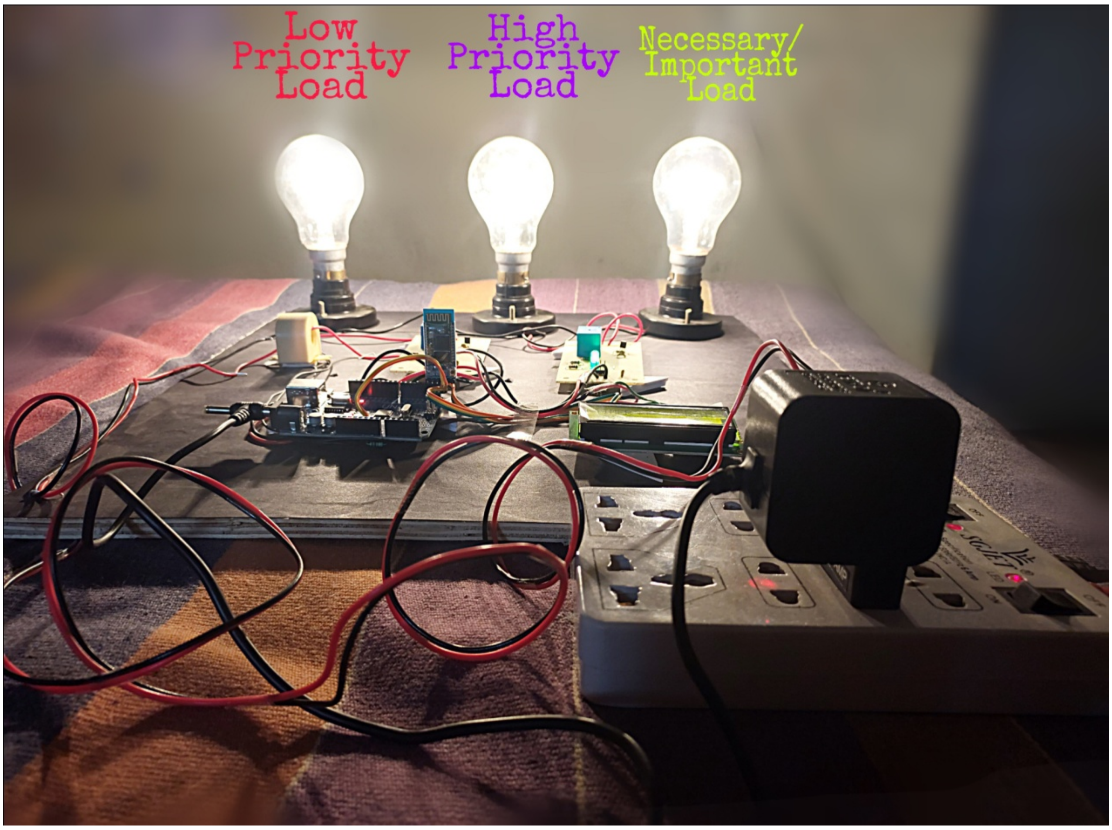

Figure 5.1: Project hardware of Smart Energy Meter

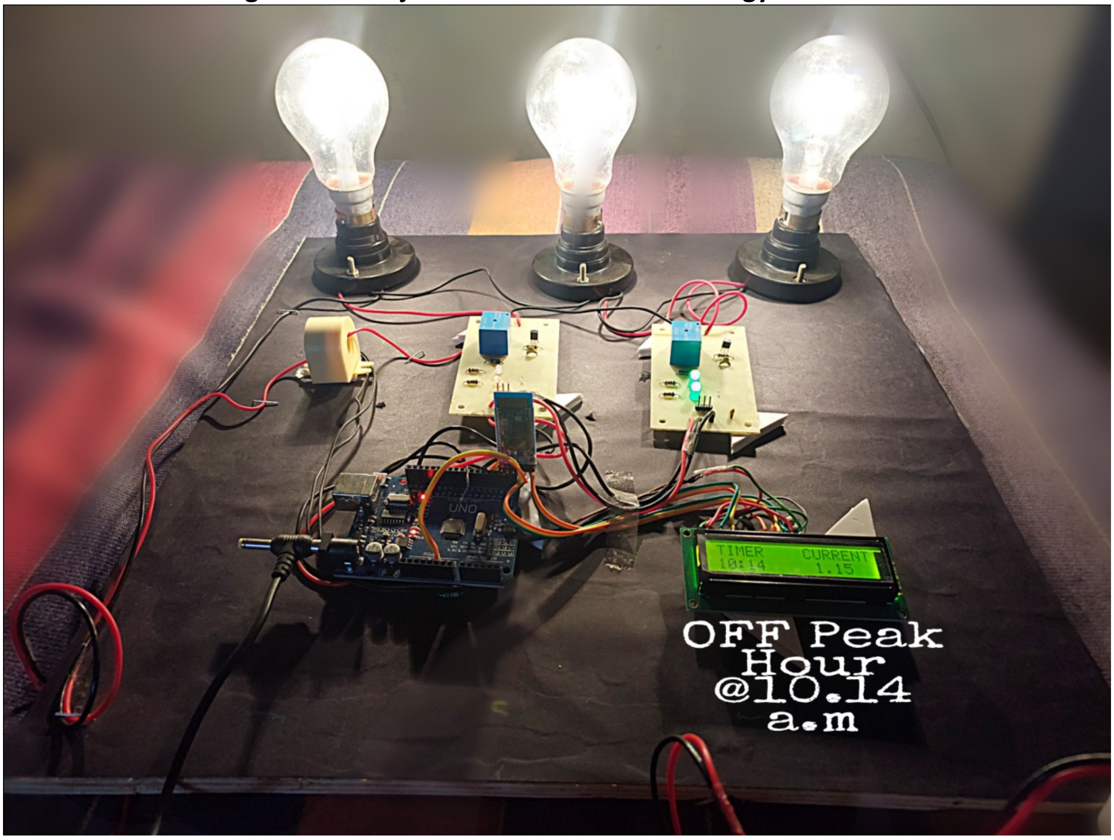

Figure 5.2: Project Hardware Working during OFF Peak Hour

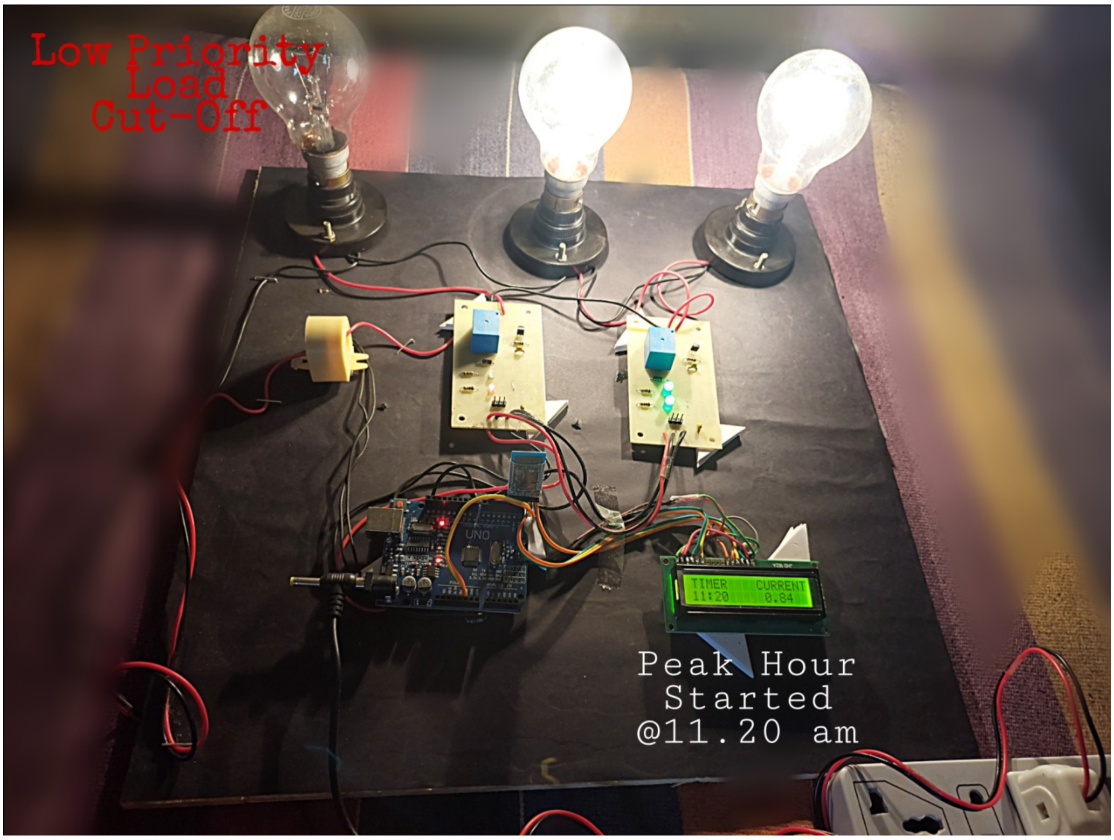

Figure 5.3: Project Hardware Working As Peak Hour Starts L.P. Load Gets Cut-off

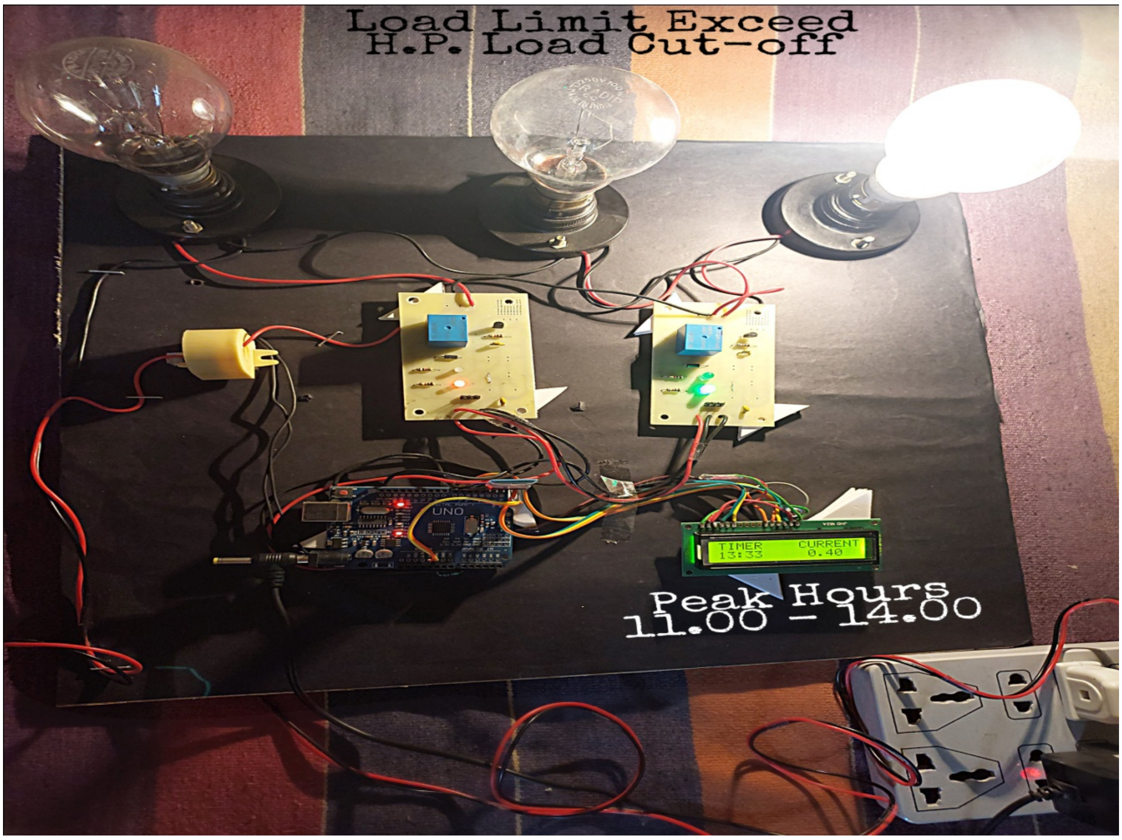

Figure 5.4: Project Hardware Working During Peak Hour as Load Limit Exceed

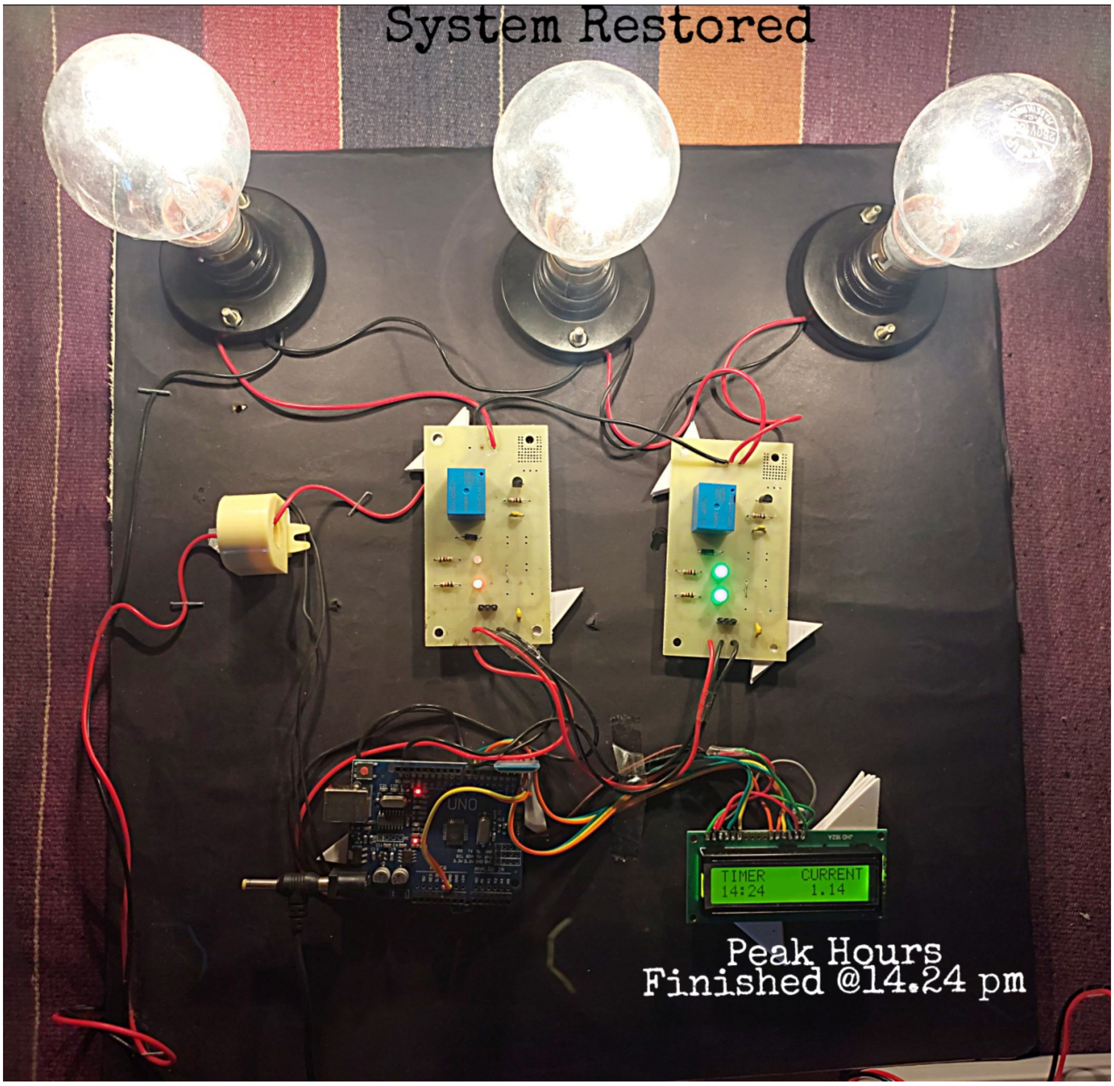

Figure 5.5: Project Hardware Working After Completion of Peak Hours

- **LCD DISPLAY SHOWS THE VALUE OF V, I, P, AND LOAD PEAKS**

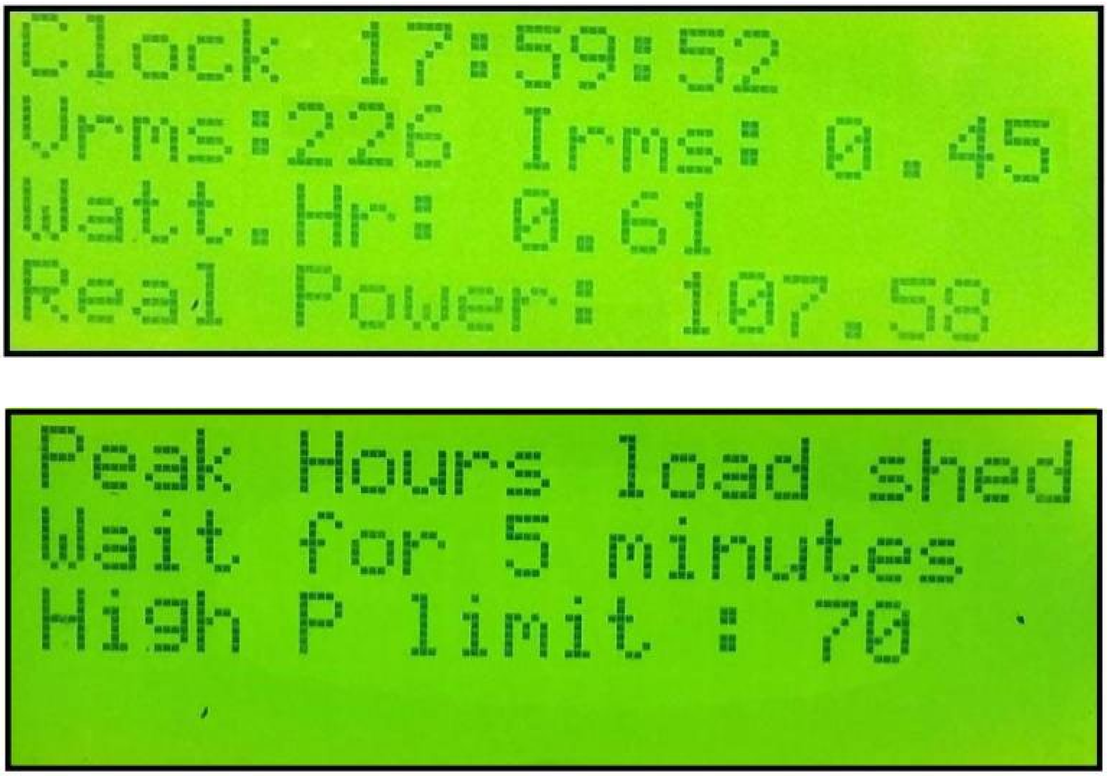

Figure 5.6: LCD Display shows the value of V, I, P, and load peaks

- **ENERGY METER DATA AND STATUS**

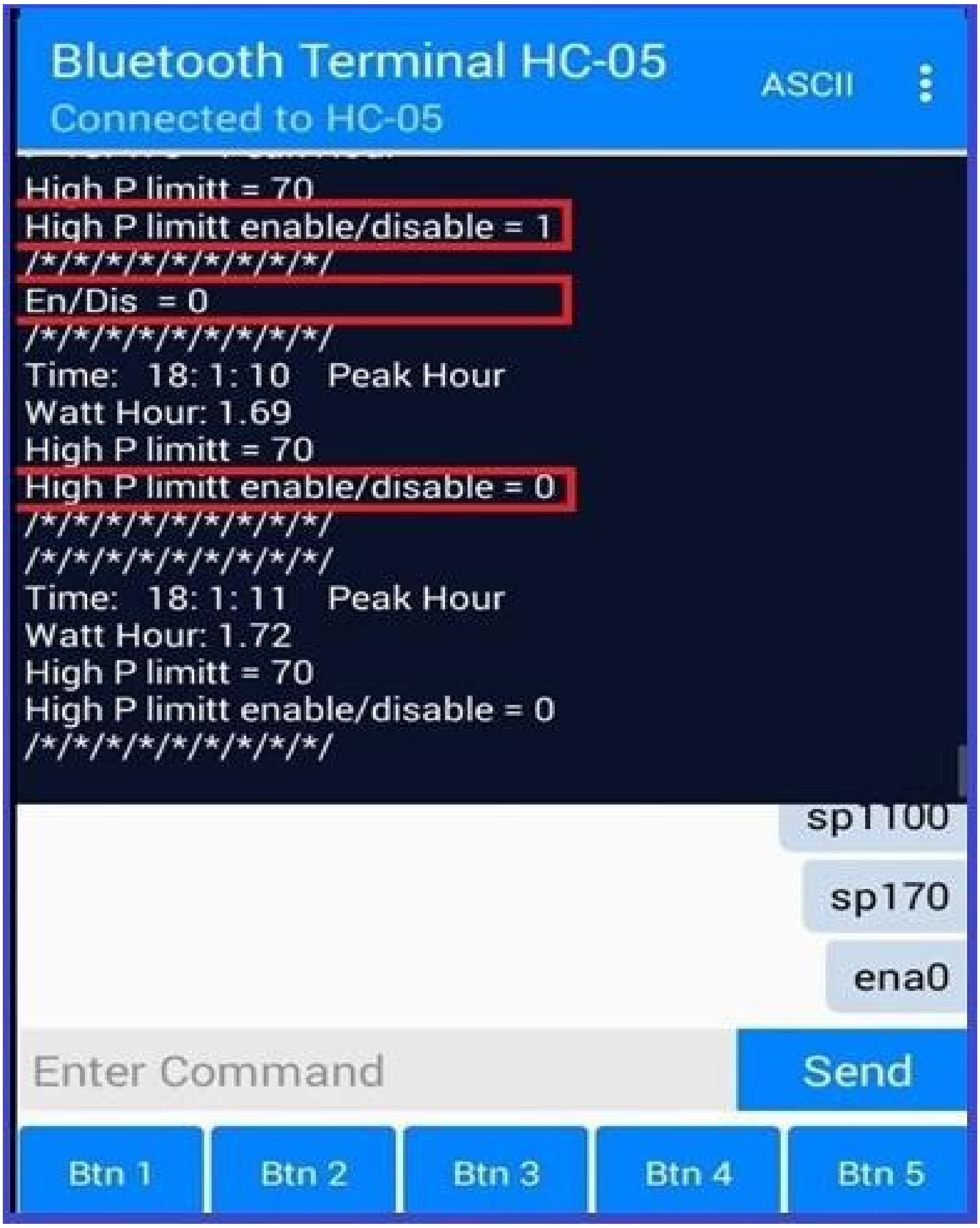

Figure 5.7: Energy Meter Data and Status

- **HP LOAD SHED IN PEAK HOUR AS LIMIT EXCEEDED**

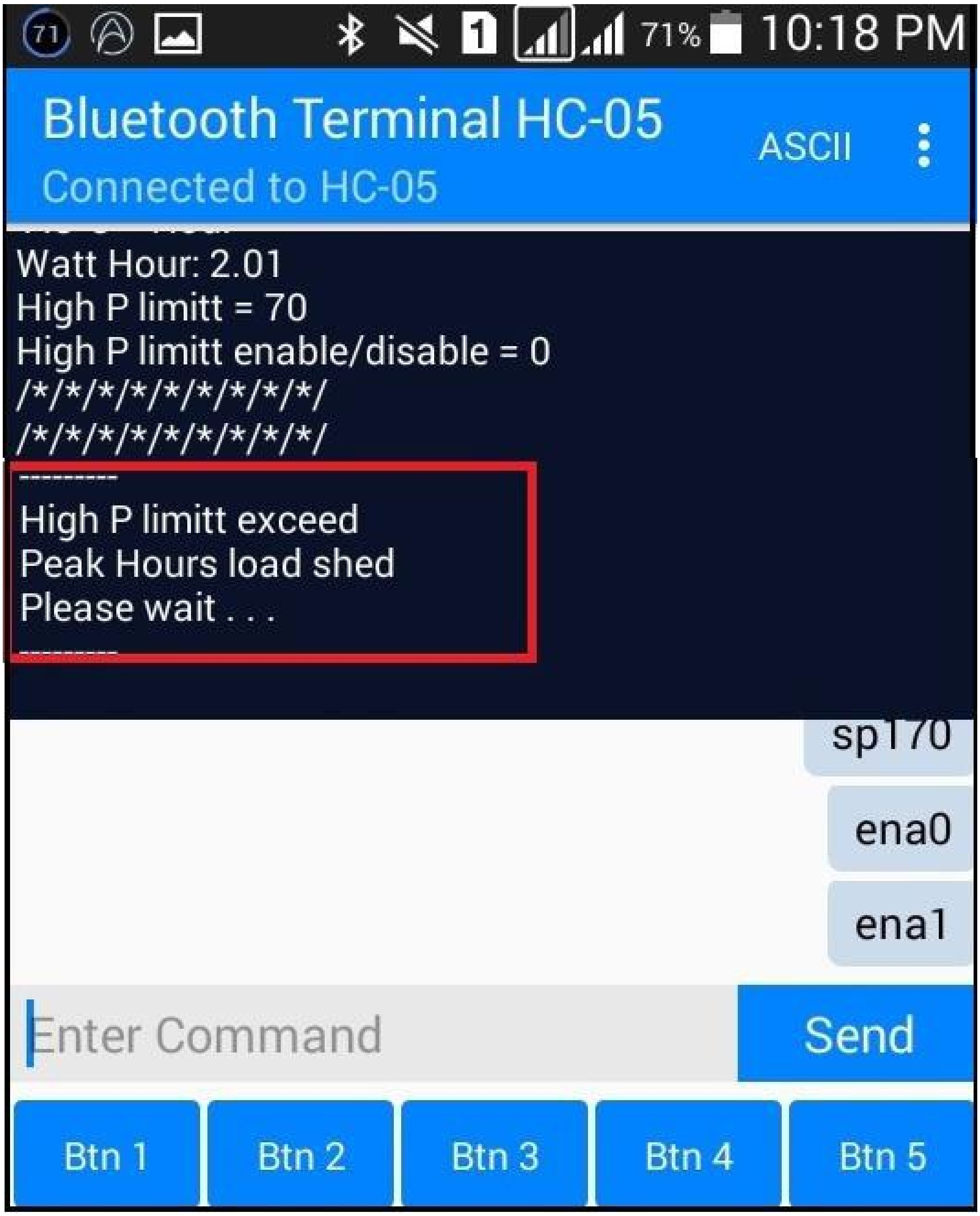

Figure 5.8: HP load shed in peak hour as limit exceeded

6. CONCLUSION

The aim of our designed project is to minimize load on customer side during peak hours and off peak hours. Due to these energy meter the energy demand will be reduced in peak summer season & the planned and unplanned load shedding will also reduce.

The usage of uninterruptable power supply (UPS) will also reduce which is also a cause of power losses because the efficiency of UPS is not greater than 70 %. It means 5 KVA UPS will use power of about 5 kW when connected into power supply but will provide only 3- 3.5 kW during load shedding period. The efficiency of UPS will degrade as battery charging degrade, a faulty battery will consumed more power than it capacity and provide minimum or small amount of energy. The design energy meter has functions of calculating energy units consumed in peak hours and off peak hours separately. It can control the usage of energy in peak hours.

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