Title Of The Project: Intelligent Tri-Energy Management System For Economic Sustainability Among Utility-Solar-Battery

Session: Bsc 2019-2023

Project Supervisor: Engr. Dr. Aamir Nawaz

Submitted By

Sarara Kalsoom

Manahil Javed

Atif Rahman

Electrical Engineering

Gomal University

CERTIFICATION

This is to certify that **Manahil Javed**, roll no **799, Sarara Kalsoom**, roll no **787** and **Atif Rahman**, roll no **794** have successfully completed the final project **"Intelligent Tri-Energy Management System For Economic Sustainability Among Utility-Solar-Battery"** at the **Gomal University**, to fulfill the partial requirement of the degree **Electrical (Telecommunication) Engineering.**

External Examiner	**Project Supervisor**
[Name of Examiner]	Dr Aamir Nawaz
[Designation]	[Designation]

Chairman

Department of Electrical Engineering, Gomal University

ABSTRACT

Solar energy is the most abundant renewable energy resource available and in most regions of the world its theoretical potential is far in excess of the current total primary energy supply in those regions. The energy management is more complex to manage. The work of remote energy monitoring is highly useful, thereby decreasing the manual work.

Old control systems work with 'SUB 'and SBU''. They just control loads without intelligence. Because they can't manage energy consumption. All loads work on battery at a time. Intelligent load controller can smartly control loads. It is capable of taking decision required on basis of information received through communication system installed. Modern system has the ability to manage distribution economically. Moreover, automatic load controller is the key to obtain stability, reliability and device saving.

The control circuit is given below. In this we have 3 sources of power (solar, battery, utility) which can be control by control circuit. Control circuit is intelligently control power by managing load power consumption. We divide the loads into 3 categories soft, medium and high, we also set the priorities in our loads. Our loads work on these priorities if we have solar then all loads work on solar incase solar is not available then our loads shift on battery if battery voltage full then loads work on battery if battery volts less than 75% then our high loads should be off just medium and soft load work on battery if battery volt less then 50% our medium should be off just soft load works if battery volt less then 25% then all loads should be off.

Keywords: Energy, load management, microcontroller, remote metering.

Undertaking

We certify that the project "**Intelligent Tri-Energy Management System For Economic Sustainability Among Utility-Solar-Battery"** is our own work. The work has not, in whole or in part, been presented elsewhere for assessment. where the material has been used from other sources it has been properly acknowledged.

Manahil Javed

Roll no:799

Sarara Kalsoom

Roll no:787

Atif Rahman

Roll no:794

ACKNOWLEDGEMENT

We truly acknowledge the cooperation and help make by [**Name of Acknowledger], Designation** of **[Address of Organization].** He has been a constant source of guidance throughout the course of this project. We would also like to thank [**Name of Acknowledger**] from [**Designation]**, [**Address of Organization]** for his help and guidance throughout this project.

We are also thankful to our friends and families whose silent support led us to complete our project.

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Chapter 1

INTRODUCTION

In this chapter we are elaborating this research. Basic introduction of this research is given in chapter 1. We explain motivation and need of project. Further we discus objectives, benefits toward society that how we offering reliability to user.

1.1 STATEMENT OF THE PROBLEM

It is evident that smart energy system can effectively optimize the performance of electrical utilities, PV and solar. However, installation of IEMS is reliable in balancing demand supply. Current energy crisis has lead to install IEMS. The energy consumption in residential areas has increased with increase of appliances. Intelligently energy saving and renewable energy sources is only method to overcome this consumption.

Several researches proposed energy management system (EMS). Optimization of home power consumption based on power line communication (PLC) has been studied to provide easy-to-access to home energy consumption [1], [2]. At the domestic level, load management plays a vital role as the consumer line gets overloaded due to the various load categories. The fully loaded line consumes more energy units, which increases the electricity bill of the consumer. To circumvent the issue of load unbalancing[3]. Much progress is made in 21st century in ICT technology in intelligent system. Furthermore, smart energy control system is relying on modern ICT and control technologies, smart energy control promote implementation of intelligent energy management system through the ICT devices. To tackle all complex problem of managing energy consumption, intelligent energy management system is the only solution of all these problems. In a country like Pakistan, consumer bills are calculated using a tariff and according to that tariff, there are different slabs for rate per unit. The users have multiple energy meters connected to their houses and can face a surge in their electricity bill due to the increase in tariff on a loaded meter[4]. Based on load scheduling decisions, the change in meter supply can be done. Initially, the change in meter supply was performed manually which results in temporary power loss[5]. Energy consumption and maintenance is complex topic in both academic and industry with many challenges.

For instant, PV is traditional optimizing method for local loads. Nevertheless, after the DR program is introduced, the EMS can negotiate with the DNOs to sell the spare PV generation with a considerable price rather than use it out locally [6]. Through intelligent energy system end user enjoy during off-peak time. Meanwhile this research provide all new features to overcome all challenges faced by user.

Intelligent energy management system help in scheduling the local loads. Moreover real-time control, data prediction and responding mechanism is very important need of user to manage all loads.

This advance research can create new revenue stream, it introduce new controlling techniques. Intelligent energy management system is important in mass coordination, management and control and in many other profiting mechanisms.

The motivations of this thesis are following

The risks of user demand and unbalancing of energy consumption.

All battery energy discharge and user face loss of energy. So automatically energy management system is needed.

1.2 RESEARCH FOCUS, METHOD & CONTRIBUTIONS

We have three sources of supply like grid supply, PV and battery. At the day time when sun rise and sunlight is at peak then our appliance work easily through PV electricity and our batteries fully charge for future use. But when we don't have sunlight due to night or clouds than we can start consuming battery power. Due to this battery starts discharging, we use battery power until battery percentage is 50 or 40%, at this time our system can automatically control loads according to priorities these priorities can set according to user need. This research divide load in three categories soft (fans, lights etc), medium (washing machine, fridge etc) and high (AC etc) When battery reach below this threshold (40%) system switch toward grid supply. Due to this some energy save in battery this saved energy of battery is used when we don't have both supplies (grid, solar). Through this user will not have to survive without electricity.

1.3 OBJECTIVES OF RESEARCH

The main objectives of this research are summarized as follow:

To control overloading. Air conditioner (AC), electrical heater, refrigerator, bulbs and fans are the common home appliances which consume a lot of power. Although a lot of control researches have been done for managing energy, few of them focus on pre-heating periods. But pre-heating is uncontrol-able. Control of overloading can help customer to save energy and electric bills. The control of over loads is feasible and effective methodology.

Design to save energy. The intelligent tri energy management system (ITEMS) is an important for managing all loads consumption to save energy, energy management system (EMS) is very popular method for energy saving.

To automatically control loads. The roof PV is increasing day by day to provide comfort to user but managing of this energy is important task. All energy from PV is used with proper scheduling and managing.

To manage power. The physical platform intelligent tri energy management system (ITEMS) can utilize all energy to validate the feasibility of proposed control.

To provide reliability. To provide service for residential area which give reliable control and billing mechanism. The proposed research is profitably installed.

1.4 MOTIVATION

This research provide following benefits:

It will give reliability to user by automatically controlling their devices.

The main target of this research is to save their energy and devices.

It can also maintain electricity bill

Chapter 2

LITERATURE REVIEW

2 INTRODUCTION

Chapter 2 is totally based on past research which is already done before our research but they all have many flaws. So, this research overcome all flaws. Also this chapter contain information about components like PV system and PV installation capacity.

2.1 HISTORICAL DEVELOPMENT OF SMART HOMES & BUILDINGS

The concept of smart home is very demanding for many years, home automation, homes and building security like automatic door control is done by intelligent system. However before computer invention homes/buildings automation is impossible to establish before 20th century. Along with the widespread of electrical appliance such as TV, HVAC, wash machine, and cloth dryer during 1920s-1960s, the establishment of smart homes/buildings began to have a solid physical basis [7]. In 1975 first communication protocol for homes was established, its aim is that people easily control their devices [8]. With the assistant X10, the home appliances can be monitor and control using 8bit data package [9]. After 1990, smart homes and buildings were able to work due the telecommunication technique, wireless communication technique and Internet technique invention [9]. However, restriction for customer to establish smart home is the prices of microcontroller and communication components [10]. After reduction in prices from 21st century things become affordable for ordinary people [11].

Moreover, Obama the USA president introduce smart grid, the aim of this smart grid is to build self-monitor and cost-effective project [12].

2.2 PHOTOVOLTAIC (PV) SYSTEMS

Shadow casting is one of the biggest issues in urban area. It will affect the accuracy of the solar radiation calculation results as for high stores buildings. The PV can convert solar energy into electricity [13]. The implementation of solar estimation energy project is for the whole Istanbul city. It has an area of about 5,400 square kilometers (approximately 2,063 square miles) including around 1.5 million buildings. It convert DC-AC to feed

energy to appliances [14]. There are two categories of solar energy, depending on how we capture and make use of it - passive and active solar energy. Passive solar acquisition techniques includes selecting material, thermal/light mass, space design of a building as a natural way in circulating the air. PV for residential area need battery bank for energy at night [15]. There are three kinds of PV: Residential roof-top, commercial roof-top and ground-mount utility-scale systems, which are shown in Figure respectively.

Figure 2.2 Residential Roof-Top PV 1

Figure 2.2(a) Commercial Roof-Top PV System 2

Figure 2.2(b) Mega -Watt Of PV System 3

Solar potential analysis can be used to localize the most suited areas on a building in its urban. Several methods of solar analysis were proposed in Good et. al (2014) including the effectiveness of roof-mounted and façade-mounted system, using PV and thermal. The price of PV reduces in 21st century because of reduction in array price of PV [16]. The price reduction of PV from 2001 to 2012, can increase installation capacity correspondingly. PV installation capacity had increased from 4MW to 1.15GW between 1997 and 2008 as shown in figure

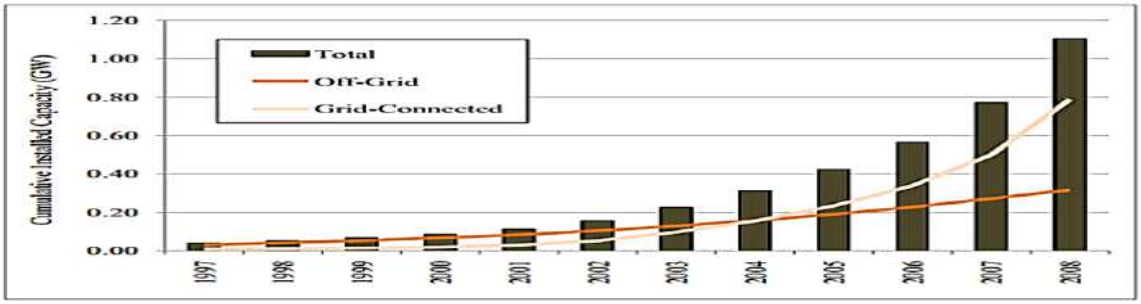

Figure 2.2(c) U.S. PV Installation Capacity 4

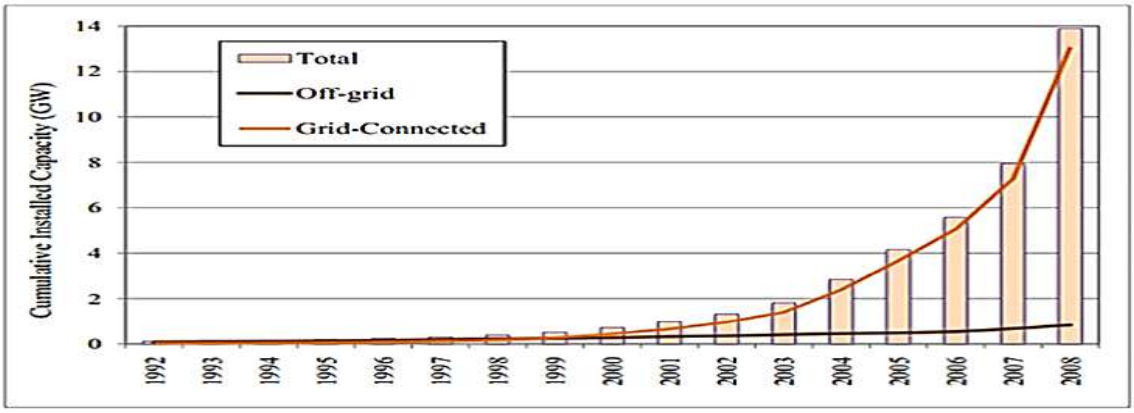

Figure 2.2(d) Global PV Installation 5

For the small/medium scale roof-top PV systems in residential and commercial buildings, there is still great room for growth [17, 18].

Chapter 3

PROBLEM STATEMENT

3. INTRODUCTION

Chapter 3 contain problem statements, it gives information about old system like old control system which have some defects. Also working information of old system is given in this system.

3.1 OLD LOAD CONTROL SYSTEMS

Old control systems work with 'SUB 'and SBU''. They just control loads without intelligence. Because they can't manage energy consumption. In previous system PV control two loads high and low control but in our project PV works on three loads high medium and soft. In three categories we also divide our loads on their voltages. Less voltage loads include on soft, 50% voltage of loads include in medium and high voltages loads include in high loads. SBU will continue using the battery until its low voltage point. SUB – solar provides power to the loads as first priority, if there is insufficient solar to power the loads, utility tops it up. Battery is only used when solar is not sufficient and there is no utility available. SBU: "S" for solar, "B" for battery, "U" for utility. - When solar panels are connected and sun light is sufficient, inverter will convert solar energy via integrated MPPT controller and provide power to load while charging the battery.

3.2 NEED OF INTELLIGENT LOAD CONTROLLER IN HYBRID SYSTEM

Intelligent load controller can smartly control loads. It is capable of taking decision required on basis of information received through communication system installed. Modern system has the ability to manage distribution economically. Moreover, automatic load controller is the key to obtain stability, reliability and device saving.

3.3 MONEY SAVING

In old systems people does not save their money. Home automation actually reduces several of the expenses mentioned by removing the potential for human error. How many times you have left the lights on? Or set the thermostat just a little too high in the winter? Automating these utilities with smart technology can improve your quality of life while cutting down on wasted energy.

3.4 WIRED OR WIRELESS CONNECTIVITY

No wired or wireless connectivity of direct load control. A wired automation system requires cables to install automation devices. Wireless home automation systems are connected via WiFi and Bluetooth technology. There is no need to connect components using cables. Presently, both wired and wireless automation systems are used by people. This technology was not introduced before our research, it provide reliability to user. The performance of wired systems is consistently better than wireless systems, because they are dedicated for this purpose alone. System latency is much lower and seamless controls of multiple circuits can be achieved especially whilst executing profiles/scenes involving multiple circuits or devices.

3.5 MANUALLY SWITCHING

Manual switch over for high loads connection or disconnection. In old control system there is no option for fully automatic controlling of loads according to set conditions. So, our research provide fully control of load consumption and switching of sources without any hazard.

3.6 PRIORITY SETTING

In old PV system there is no priority set on any load all loads work without any priority but in our design system loads work on priorities and shifting the loads according to our priorities. This research operate according to given priority which we introduce by keeping all situation in mind. Our aim is to provide comfort to customer. These priorities will be modify according to user the demand.

Chapter 4

METHODOLOGY

4 INTRODUCTION

In this chapter we explain method of implementation of research. Further components which we use in this research also mentioned in this section. Proposed model is also given and explain in chapter

The methodology of proposed system is explain in this section. The bidirectional converters are used for charging and discharging of battery. In this smart home scenario our aim is to modify the execution of task of controlled appliances, to reduce electricity cost and to provide comfort o customer. When appliances controlled then function of appliances is modified. Every house and building have appliances that produce and consume energy. Solar panel and utility supply energy to run loads. Moreover relays are connected to the utility, solar and battery, if solar power is sufficient to operate loads then the required power is supplied to battery. if the generated power is insufficient the relay switches it to the grid connection so that there is continuous power supply to the appliances. The control circuit can control is used to monitor and control loads.

4.1 PROPOSED NETWORK MODEL

The control circuit of proposed system is given below. In this we have 3 sources of power which can be control by control circuit. Our research is based on this control circuit, this circuit can control the power consumption.

Control circuit is intelligently control power by managing load power consumption. We divide the loads in 3 categories which is shown below

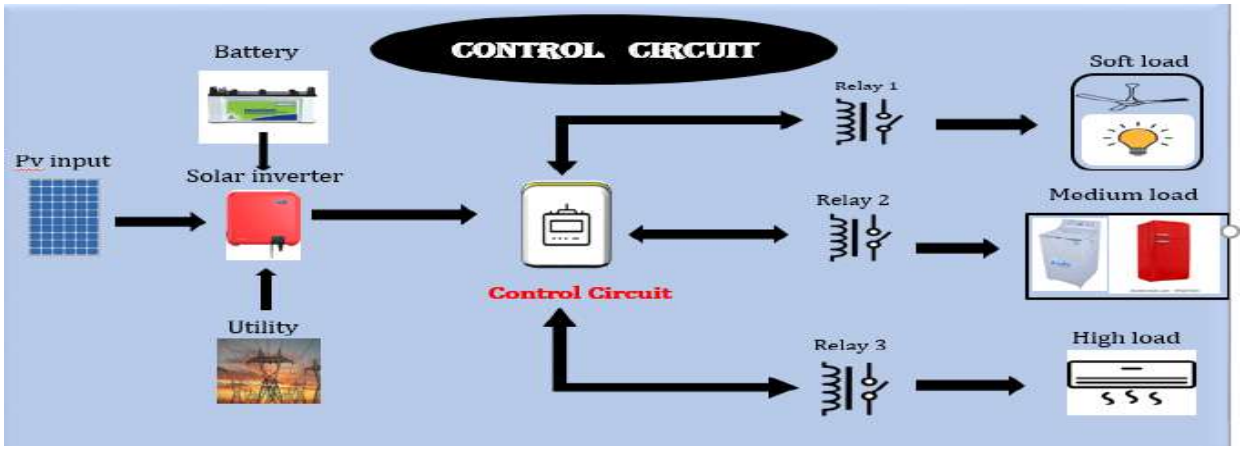

Figure 4.1 (a) control circuit

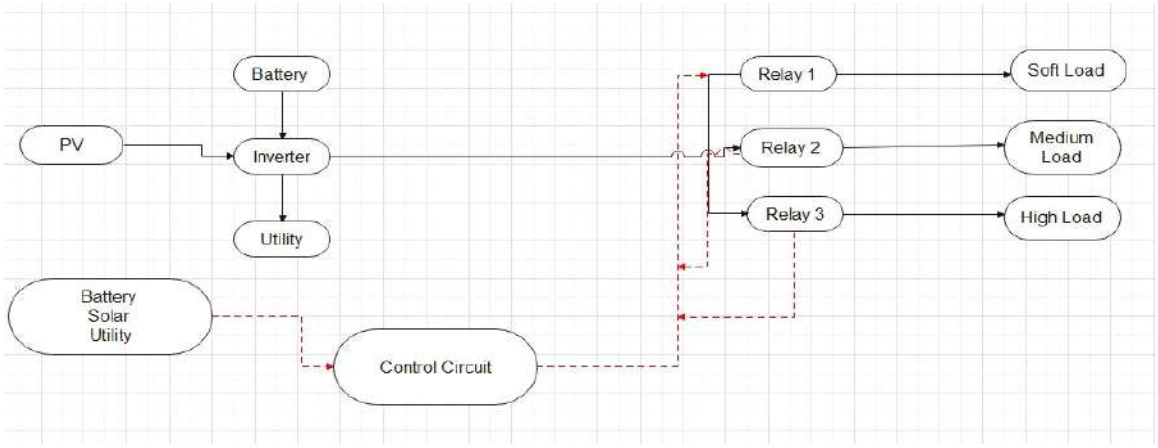

Figure 4.1(b)Block Diagram

This block diagram shows that we have three sources in which inverter invert PV DC volt into AC volt and the inverter connect with the relays and these relays connect with our loads high, medium, soft and battery and utility also connect with the relays and our loads.

Second flow is that our all sources passes through the control circuit and this control circuit connected with the relays and that relays connect with the loads.

4.2 SIMULATION COMPONENTS OF PROPOSED SYSTEM

For smart homes/building photovoltaic and battery act as power sources. The 5 KW is the rating of photovoltaic system. Intelligent tri energy management system is only solution to properly track the maximum power point, the proposed system control has been used to extract maximum power.

4.2.1 ARDUINO

The development of Arduino UNO board is considered as new compared to other Arduino boards. This board comes up with numerous features that helps the user to use this in their project. The Arduino UNO uses the Atmega16U2 microcontroller that helps to increase the transfer rate and contain large memory compared to other boards. No extra devices are needed for the Arduino UNO board like joystick, mouse, keyboard and many more. The Arduino UNO contain SCL and SDA pins and also have two additional pins fit near to RESET pin.

The board contains 14 digital input pins and output pins in which 6 pins are used as PWM, 6 pins as analog inputs, USB connection, reset button and one power jack. The Arduino UNO board can be attached to computer system buy USB port and also get power supply to board from computer system. The Arduino UNO contains flash memory of size 32 KB that is used to the data in it. The other feature of the Arduino UNO is compatibility with other shield and can be combined with other Arduino products.

Arduino is an open-source platform used for building electronics projects.

The Arduino control the loads and sources via relays according to user demand.

If amount of loads current is high than trip signal to the relay to switch off the heavy loads until the desired amount of load is reached, same method for medium load.

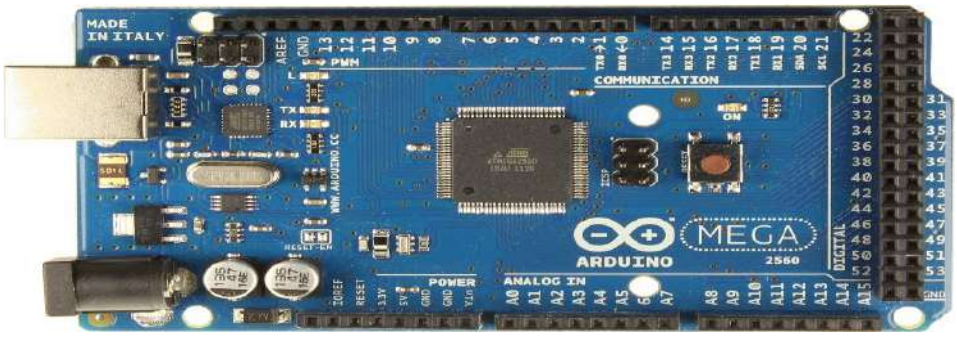

Figure 4.2.1 Arduino

4.2.2 PV PANEL

PV panel is used in this system to make renewable energy resources to track maximum power, PV is utilize when remaining power is unavailable. To manage operating point of array ITEMS technique is used.

solar panel capture the sun's energy and convert it into electricity. The solar panel converts sunlight into DC electricity to charge the battery. A solar panel is actually a collection of solar cells, which can be used to generate electricity through photovoltaic effect. However solar energy is not enough to meet all domestic demands of electricity. So the homes and buildings need additional backup power like utility and battery.

Figure 4.2.2 Solar panel

4.2.3 BATTERY

A battery is a device that stores energy and then discharges it by converting chemical energy into electricity.

The DC electricity converted by a solar inverter into AC power which can be used to run home appliances.

The battery charging and discharging can be classified as,

Charging mode: if charging of battery is beyond charging rate then battery charge from solar or grid. Battery is charge when Ps<Pl if battery is below than 70% then high loads are off and so on, if utility in not available then charge battery from solar.

Discharging mode: when battery charge is sufficient then battery start discharging and supplies energy to loads. If Ps>Pl then battery give power to operate all loads.

Table 4.1

S. no.	Battery parameters	Values
(1)	Nominal voltage	24 V
(2)	Ampere-hour	40 Ah
(3)	State of charge (SOC)	80%
(4)	Fully charged voltage	232.7 V

Figure 4.2.3 Battery

4.2.4 RELAY

Relays are electrically operated switches. They are used to control a circuit by a separate low-power signal or to control several circuits with one signal. Relays were first used in long distance telegraph circuits as amplifiers. They replicated the signal coming in from one circuit and re-transmitted it to another circuit. A simple electromagnetic relay is made up of a solenoid, which is wire coiled around a soft iron core, an iron yoke that provides a low reluctance path for magnetic flux, a movable iron frame, and one or more sets of contacts.

A relay is an electrical component that can control the flow of electricity in a circuit.

It is programmable switch which is control by Arduino. When command is given to relay than it automatically work and close or open the connections.

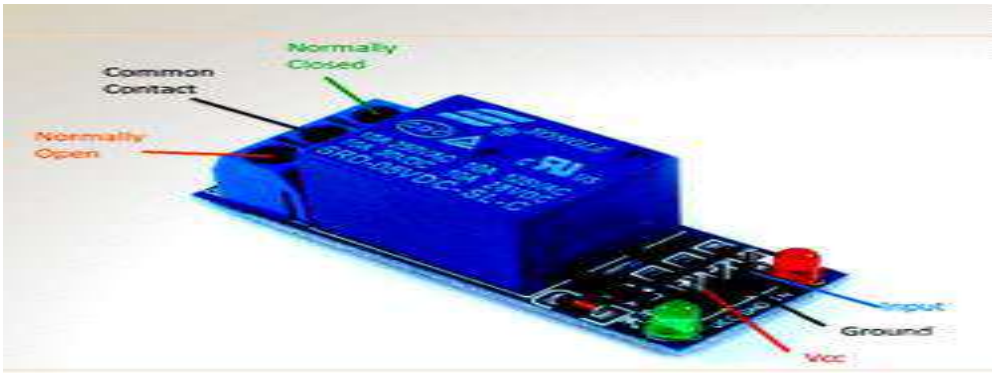

Figure 4.2.4 Relay

4.2.5 LCD SCREEN

LCD display the all parameters like battery percentage, solar power. Through this all work is analyze and decision is taken by control circuit.

Here LCD will display the values of the loads as the output of the controller.

It is used in screens for mobile devices such as laptop, tablets, smart phones.

Figure 4.2.5 LCD

4.2.6 LED

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process. LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction.

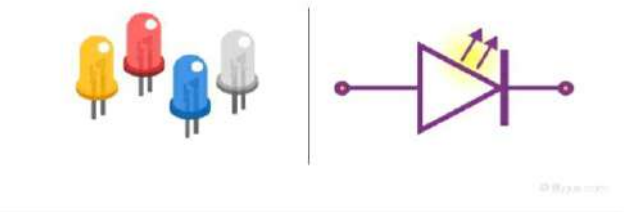

Figure 4.2.6 LED

4.2.7 RESISTOR

The resistor is perhaps the most fundamental of all electrical devices. Its fundamental attribute is the restriction of electrical current flow: The greater the resistance, the greater the restriction of current. Resistance is measured in ohms. The measurement of resistance in unpowered circuits may be performed with a digital multimeter. Like all components, resistors cannot be manufactured to perfection. That is, there will always be some variance of the true value of the component when compared to its nameplate or nominal value. For precision resistors, typically 1% tolerance or better, the nominal value is usually printed directly on the component. Normally, general purpose components, i.e. those worse than 1%, usually use a color code to indicate their value.

Figure 4.2.7 Resistors

4.2.8 DIGITAL VOLTMETER

Digital voltmeters display the value of AC or DC voltage being measured directly as discrete numerical instead of a pointer deflection on a continuous scale as in analog instruments.

Figure 4.2.8 Digital Voltmeter

Chapter 5

DETAILED DESIGN AND ARCHITECTURE

5 INTRODUCTION

Chapter 5 contain detail about designing of research and also conditions for different loads and source is also explained.

5.1 PROPOSED ALGORITHM

All working model concept is given below, research conditions according to all battery thresholds and all loads consumption is explain in this section. According to different conditions different flow of consumption is follow. On the basis of different conditions switching is done.

5.1.1 70% BATTERY CHECK

The 70% battery control is given below. When battery charge is 70% remaining than control circuit work like this.

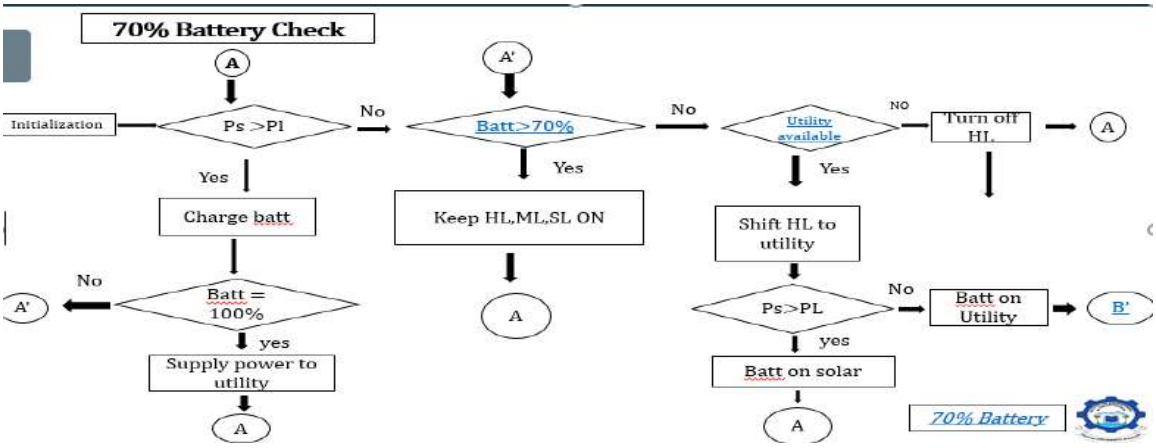

Figure 5.1.1 Check the priorities on 70%

We have three power sources utility solar and battery. These sources manage sharing power to loads, if power of one source is continuously reduce then system or load start consuming power of any other source which is available at this time. Like solar power reduce and it

become below than threshold1 then load shift on battery or wapda depending on which power is available. When solar power is greater than load power means solar threshold1 value is on peak (13) if this condition is right then all loads works on solar high, medium, soft and battery charging is off because their charging is full. When loads shift on battery if solar is not available then battery charging is start on utility and our all loads are ON if our solar is not available for any problem then our loads shift on battery , our battery work on priorities if battery voltage is greater then 70% and their value is 13v our all loads work on battery if their condition is not true battery power is less than 70% and battery voltage is less then 13v then our high load is Off and medium load and soft load is working on battery. If user wants their high load also in working then we shift our high load on utility on user demand, if utility is available.

5.1.2 50% BATTERY CHECK

The 50% battery control is given below. When battery charge is 50% remaining than control circuit work like this

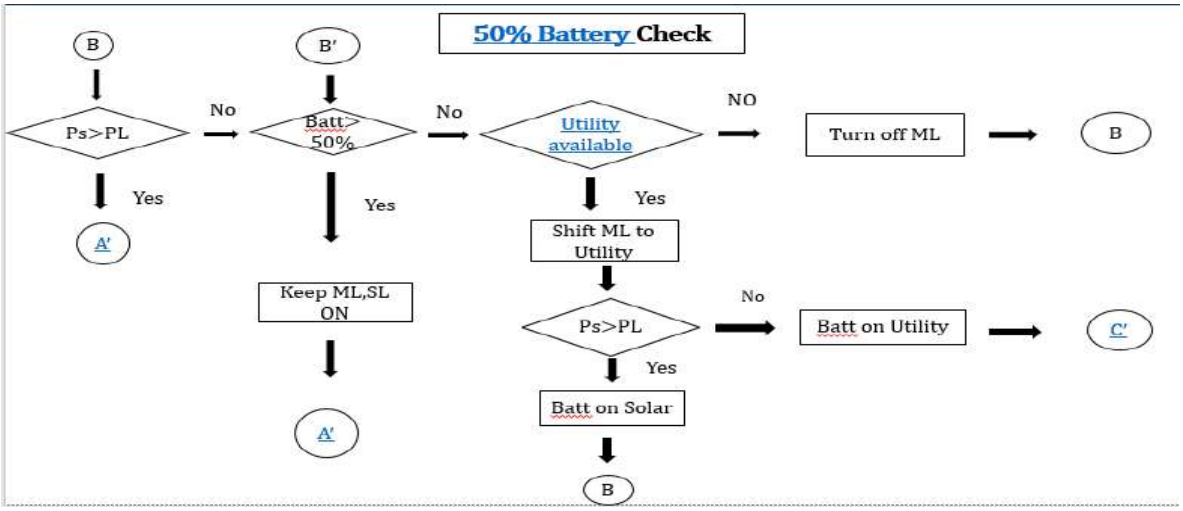

Figure 5.1.2 Check the priorities on 50%

We have three power sources utility solar and battery. These sources manage sharing power to loads, if power of one source is continuously reduce then system or load start consuming power of any other source which is available at this time. Like solar power reduce and it become below than threshold2 then load shift on battery or wapda depending on which power is available. When solar power is greater than load power if this condition is right

then all loads works on solar and battery charging is start and our all loads are ON if our solar is not available for any problem then our loads shift on battery, our battery work on priorities. If battery charging is greater then 50% and less then 70% then our high load is off or working on utility its depend on user demand then medium load and soft load working on battery. If battery charging is less than 50% then our medium load will be off or if user wants their load also in working condition then our medium load also shift on utility and just soft load working on battery.

5.1.3 25% BATTERY CHECK

The 25% battery control is given below. When battery charge is 25% remaining than control circuit work like this

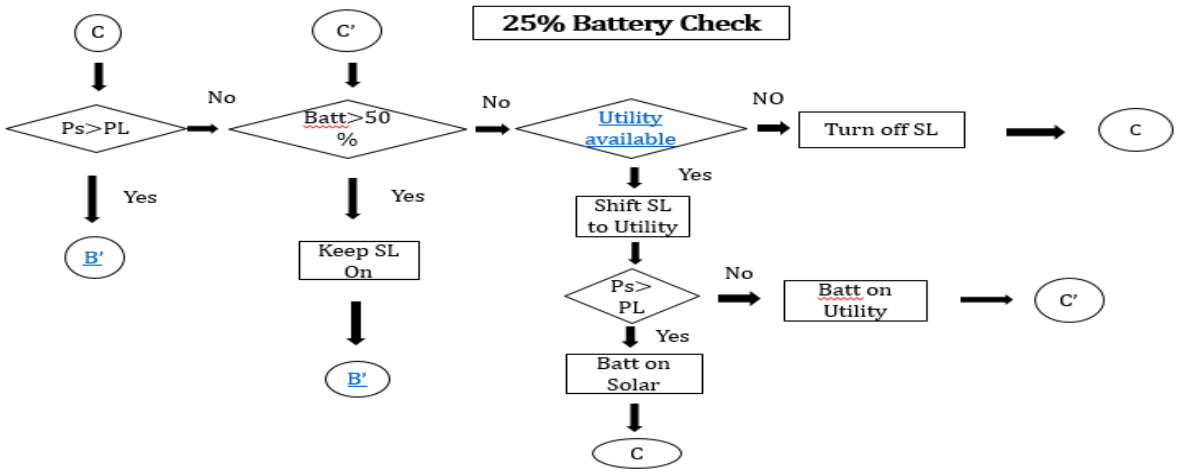

Figure 5.1.3 Check the priorities on 25%

We have three power sources utility solar and battery. These sources manage sharing power to loads, if power of one source is continuously reduce then system or load start consuming power of any other source which is available at this time. Like solar power reduce and it become below than threshold3 then load shift on battery or wapda depending on which power is available. When solar power is greater than load power if this condition is right then all loads works on solar and battery charging is start and our all loads are ON if our solar is not available for any problem then our loads shift on battery, our battery work on priorities. If battery charging is greater then 25% and less then 70% and 50% then our high load and medium load is off or working on utility its depend on user demand then soft load working on battery. If battery charging is less than 25% then our soft load will be off or if user wants their load also in working condition then our soft load also shift on utility if utility are available, and battery charging also shift on utility.

5.1.4 CIRCUIT DIAGRAM

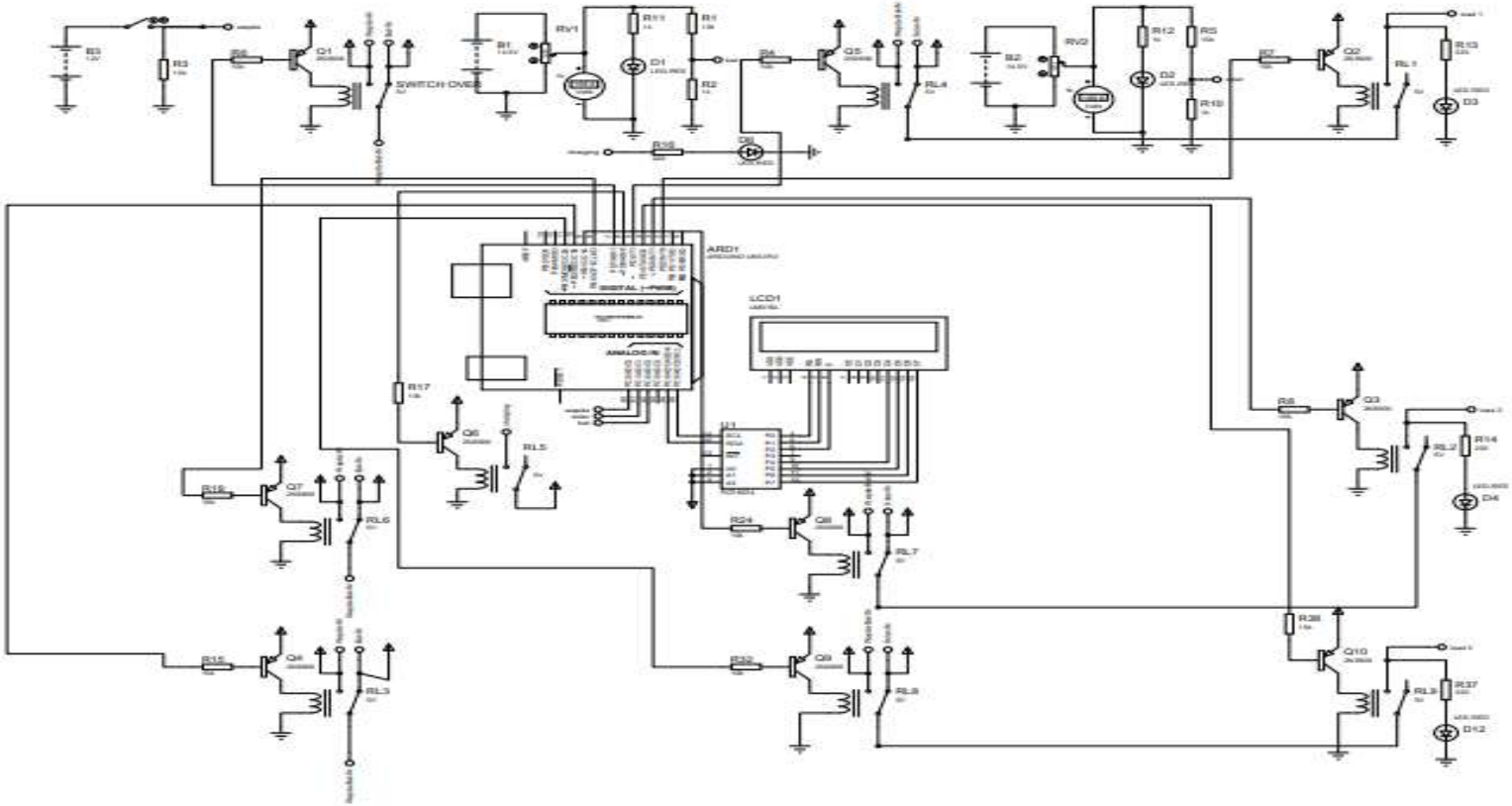

Figure 5.1.4 Software Model

We have three power sources utility solar and battery. These sources manage sharing power to loads, if power of one source is continuously reduce then system or load start consuming power of any other source which is available at this time. Like solar power reduce and it become below than threshold1 then load shift on battery or wapda depending on which power is available. This shifting of loads done continuously depending on situation and also it depend on user demand then this all switching system can be update according to user comfort and demand. All sources are connected to each other to manage consumption. All sources are connected with different relays each relay connected with ardunio input pins we have also three loads, all loads are connected with sources. Main function of these relays is to switch sources and loads power consumption.

5.1.4.1 RELAYS CONNECTION

In this proposed research we use 10 relays. First relay is for wapda-battery shift1 which shift power consumption on wapda or battery. This shift1 relay is used to control load1. Second relay is Solar-battery shift1. This is used to control load1 when solar or battery power increase or decrease then system make decision according to this loads consumption.

In second relay is shown below Arduino. These relays are wapda-battery shift2 and Solar-battery shift2 which is use to control load2.

Same phenomena of relays connection is used for third shift to control load3. These relays are shown below second shift. I also have Solar-battery shift3 and wapda-battery shift3.

Three relays which is given at right of circuit is used for all loads. These relays are use to control switching of loads. At the time when power reduce these loads start OFF and when source power increase they are ON or turn ON but shift or switch source.

Last relay is used for battery charging when battery power goes below threshold then charging of battery start either from solar or wapda.

5.1.4.2 ARDUINO PINS CONNECTION

The relays of loads are also connected with ardunio input pins and charging relays also connected with them. We connect pin2 of Arduino with relay R7 this relay is further connected with load1. Same connection of pin3 of Arduino is used for R8 for load2 and

pin4 connected with for load3. Remaining pins of Arduino from 5 to 11 is used for connection of sources like wapda-battery, solar-battery and battery charging.

Arduino pins A0 to A2 is used for solar, battery and wapda out. A5 an A6 is used for connection of LCD.

When we simulate the circuit, at first we check our all conditions are okay or not. We connect LCD with ardunio output pins for showing the values of battery and solar which we are decreasing or increasing the voltages. If wapda are disconnected and solar are value is on peak all load shift on solar. If solar is not available for any reason like darkness or cloudy whether our loads are shift on battery. Battery works on priorities if battery values less then our priorities all loads turn off one by one or shift on utility if utility are available.

Chapter 6

CONCLUSION AND FUTURE DIRECTIONS

In this smart home scenario our aim is to modify the execution of task of controlled appliances, to reduce electricity cost and to provide comfort of customer. When appliances controlled then function of appliances is modified. It will give reliability to user by automatically controlling their devices. The main target is to save their energy and devices. This system works automatically they will read the priorities and automatically shifting the load from one source to another source. In this system we also set the priorities on sources, solar is on first priority battery on second and utility is on third. At first our loads work on solar incase solar is not available then load shift on battery if battery charging is low then loads shift on utility.

In future we can enhanced our design system now we just work on three loads but in future we work on multiple loads. At that we our on just home appliances but in future we design this system for companies etc. For this design system people feel easy they also save their money their energy their time because our design system works automatically they will also set the priorities according to their needs.

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