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Electrical & Mechanical Engineering

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NUST COLLEGE OF
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POWER EXCHANGE AMONG PV SYSTEMS THROUGH BIDIRECTIONAL CONVERTER

A PROJECT REPORT

DE-40 (DEE)

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“BACHELORS

IN

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CERTIFICATE OF APPROVAL

It is to certify that the project, "**Power Exchange Among PV Panels Through Bidirectional Converter**"

was done by GC CH M Usama Sipra, GC Syed Hussain Kamil, and GC Abdullah Riaz, under the

supervision of Assistant Professor Dr. Sarmad Majeed Malik.

"This project is submitted to Department of Electrical Engineering, College of Electrical & Mechanical Engineering, Peshawar Road, Rawalpindi, National University of Science and Technology, Pakistan in partial fulfillment of requirements for the degree of Bachelor of Engineering in Electrical Engineering."

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DECLARATION

“We want to make it clear that no part of the work mentioned in this Project Thesis has been submitted for another degree or qualification of this kind at any other university or other learning institution. If any form of plagiarism is found, we are fully responsible for any disciplinary action taken against us, up to and including having our degree taken away.

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ACKNOWLEDGMENTS:

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Personally, I, Ch M Usama Sipra, would like to express my gratitude to my parents, Mr. & Mrs. Azmat Javaid Chaudhry, the noor of my eyes, my brothers Hamza, Hadi and my beloved sisters, my pillars of strength, and also my beloved friends, Danish, Ahab, Hussain, Abdullah, Haris, Zubair, Usman, Ateeq, and Ahmad, who are the constants of my support and happiness.

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We are overwhelmed in all humbleness and gratefulness to acknowledge our depth to all those who have helped us to put these ideas, well above the level of simplicity and into something concrete."

ABSTRACT:

PV systems have gained importance in past few years all over the world. Especially in the countries like Pakistan where energy crises is the serious issue. By focusing on the advancement of use of these systems we have strong concern with management and exchange of power among different systems through bidirectional DC-DC converter. Actually, this system is working on 4 modes of power sharing where condition decides which mode to operate at a time. We have designed two PV systems representing houses which are having main power source of solar panels and they are interlinked through the bidirectional converter for power exchange. If we talk about the specifications and characteristics of Solar panels which we are using then they shall give us 8V-18V voltages and about 25W-30W of power. These panels are good enough for our system to work smoothly. For battery charging, we are using SEPIC converter which behaves as a charge controller and the reason behind this is to make backup system for the project. This will assist us to give continuous power flow. After that we used

bi-directional FLYBACK converter for the sharing of power among the systems. FLYBACK with the use of relays and Arduino also responsible for the power sharing as well as operating modes of our system. To display information we are used 16X2 LCD.

There are four modes on which this project is working. In the first mode, power is being transferred from the system having more power to the system which needs more power to fulfil its requirements. In the second mode, same procedure is getting repeat but in opposite or reverse direction like first mode. In third and fourth mode, when both systems fulfilling their demands by their own then there will be cut off mode on and no power is being shared among systems. Simply, we can say that when there is unbalanced situation occurring only then systems help each other to manage power. On balanced condition bidirectional converter behaves as an open circuit.

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CHAPTER 1: INTRODUCTION

PV systems have gained importance in past few years all over the world. Especially in the countries like Pakistan where energy crisis is the serious issue. By focusing on the advancement of use of these systems we have strong concern with management and exchange of power among different systems through bidirectional DC-DC converter. Actually, this system is working on 4 modes of power sharing where condition decides which mode to operate at a time. We have designed two PV systems representing houses which are having power source of solar panels and they are interlinked through the bidirectional converter for power exchange.

A bidirectional DC-to-DC converter is usually the main device in a renewable energy system that connects the storage devices between the power source and the load. It is also used to make sure that there is a steady flow of power, since the output of a renewable energy system changes as the weather changes. In EVs, too, a bidirectional converter is used between the energy or power source and the motor to get power from the battery. In our case, however, we use this converter to exchange power and make sure it flows smoothly and continuously between PV systems that work in different ways depending on the loads we have. In this way, both academic research and industrial applications are paying more and more attention to bidirectional DC-DC converters.

Bidirectional DC-to-DC converters usually work in both buck and boost modes. They can control the flow of power in both directions between two DC sources and a load by using a specific switching scheme and phase-shifted control. Any extra energy can be stored in batteries or a supercapacitor. So, this document shows the basics, classification, and different types of Dc-Dc bidirectional converters based on galvanic isolation, a comparison of their ratio of voltage conversion to ripple of output current, and different topologies that have been researched over the past few years. So, soft switching schemes with zero current and zero voltage, as well as methods and techniques for controlling with phase shift, are also shown.”

1.1 Aims and Objectives

The fundamental target of this work is to utilize PV systems having batteries for backup for power sharing with the help of bidirectional Dc-Dc converter for domestic purposes initially. Further objects are given as: 1. Use of Bidirectional converter for the charging of batteries and exchange of power in the renewable energy resources like PV panels.

2. Upgrading the use of photovoltaic systems by power sharing among them through the use of bidirectional converter.

3. Continuous availability of power to the loads in efficient manner through Arduino controlling and batteries.

4. Awareness and encouragement to the people for the use of interlinked PV systems and their role in controlling energy crises.

5. Making this project to operate on main four modes which have been discussed above.

1.2 Ambiguities

As is well-known, Pakistan's socioeconomic progress has been hampered by a severe lack of power due to the country's reliance on imported fuels. “As a result of this sort of circumstance, local fuel prices go up, and new industrial sectors are limited. Pakistan's current imbalance between demand and supply is between 5000

and 8000 MW, with an annual rise of 6 to 8 percent. As a result, more continuous and renewable sources of energy are needed to address the current challenges. It is possible to generate renewable energy in Pakistan by using wind, sun, hydropower, and biomass. It is possible that these resources will play an important role in the future energy grid, efforts to reduce climate change, and the ongoing growth of the country.

An evaluation of Pakistan's alternative energy resources and the possibility for full-scale development of continuous energy systems are included in these reports. It also addresses several methods for expanding the use of locally sourced or indigenous energy sources.

People are not well aware of the use of the renewable energy resources like photovoltaic panels. In urban areas, some people are using these systems on domestic level and time by time industries and companies start using these renewable energy systems which helps to overcome the energy crises. The main problem of the fuel based energy sources there is a large amount of air pollution which causes severe health problems.

So the encouragement of clean energy sources helps to avoid pollution, health problems and climate change which is also responsible for the global warming. The lack of knowledge to all these problems country or under developed countries have burden which leads to the energy crises for the country. But the project we are working on is the next level to this as it can manage and share power among different interlinked systems working with solar panels or other renewable energy resources. We can see proper working and topologies of these systems in the article [5].

1.3 Current state

Today, world is changing and fueled energy is getting old day by day and it is also harmful, expensive for the living things and against clean environment. PV systems with having facility of storing energy through batteries and sharing of energy among different systems in the time of need is better than conventional sources to produce energy.

Bidirectional converters can be used to store energy in the batteries for the backup of the systems and they are also responsible for the continual and smooth power flow because in the systems of PV’s there might some fluctuations due to any reason like weather conditions or etc.

Renewable energy systems have received a lot of government support in the last few years since they allow for the contribution of clean and safe electricity while decreasing the use of fossil fuels and the spread and emission of greenhouse gases that are particularly destructive for society. A substantial number of photovoltaic (PV) systems have been erected throughout the US in the last decade [1]. Continuous PV power production is an issue that has to be overcome before the technology can gain mainstream adoption

[2]. It is possible to put energy storage devices to store significant amounts of energy and deliver it when needed in order to alleviate the discontinuous issue [3] and increase micro grid stability [4].

An energy storage system, such as a two-battery bank, requires a bidirectional power converter to interact with a DC link linked to an inverter in order to operate effectively. Battery-based power converters must have high efficiency and seamless charging and discharging to prolong the battery bank's life. An energy management system is required in addition to this power converter in order to transfer of PV and battery bank energy to be managed in accordance with grid conditions and cost of energy.

Renewable energy systems cannot function without energy storage technologies [3] and [4]. As more solar photovoltaic (PV) and wind turbines are placed around the country and the world, more energy and power storage devices will be required to ensure system stability and account for fluctuations in power output.

Since the storage system and PV system must be connected to the grid, a high-quality power converter is required. The stability of the system, the dependability of the system, and the coordination between various components of the system must also be improved by a smart energy system. With regard to the photovoltaic system, the primary goal of this thesis is to design and simulate a bidirectional DC-to-DC converter to connect a battery bank and develop a smart-energy management system to manage and coordinate the operation of a storage device like a battery with the photovoltaic system. These systems handling and managing power in different fields of power sector specially in EV systems.

World is going to say good bye to all conventional energy methods and adopting all new methods of use of energy related to systems working with batteries and renewable energy resources. Electrical cars, ships and yachts and more start getting help by this technologies. Use of Bi-directional converters can take the world to the next level in technology because they have the ability to replace all other huge devices working in power sectors.

CHAPTER 2: LITERATURE REVIEW

2.1 History

History of development of semi-conductors is very interesting as it played a vital role in the power sector.

Before this, conversion of lower voltage to higher one used to do by conversion to AC with vibrator, then by trans-former and in the last rectifier. Motor generator was also a device for higher power. So, the thing is that the introduction of power-semi-conductor as well as integrated circuits made it eco-friendly by use of some techniques. For example, firstly it converts Dc to higher-frequency Ac which gets rectified back to Dc.

If we talk about the transistor-radio-receivers used in the cars in 1976 did not need high voltages. Some amateur radio operators was still using vibrators supplies and dynamotors for mobile transceivers which require high voltages. While, there was a possibilities of deriving a lower voltage from a higher one. These type of methods dissipated the excess in the form of heat where conversion became possible only with solid-state-switch-mode circuits.

2.2 Research

There are a lot of bi-directional converters in the market and they are being used various applications for power field. Basically, these converters used for the purpose of flow of power in both directions. Converters commonly used in those applications where we need some power sharing mode and circuits are connected between two level of direct current DC voltage where energy transferred from one level to another one.

Some types of these converters are given below.

□

Boost bi-directional DC/DC converters

□

Buck bi-directional DC/DC converters

□

Buck-boost non-inverting bi-directional DC/DC converters

□

Buck-boost inverting bi-directional DC/DC converters

□

SEPIC bi-directional DC/DC converters

□

CUK bi-directional DC/DC converters

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There are multiple isolated DC/Dc converters which are commonly used in cases where there is a need of galvanic isolation.

□

Bi-directional FLYBACK

□

Isolated SEPIC/ZETA AND CUK

□

Push-Pull

□

Forward

- Dual-active bridge (DAB)
- Half-full bridge
- Dual-half bridge
- Multiport DAB

We have choose FLYBACK and SEPIC converters for our project because they seemed and proved to be more convenient to us in the regard of efficiency and performance of our project practically. In the next chapters we will briefly discuss about these converters along with all components which we have used for complete hardware.

2.3 Applications

Following are some examples or applications given working on the same mechanism which we have used in project. The only difference in our project is that we are using power sharing technique along with the use of renewable energy resources like solar panels.

2.3.1 Battery Management System for Electrical Yacht:

This section will provide further explanation regarding the concepts involved in this project. It will present the tools, techniques and technologies utilized and different topologies of the bidirectional converter.

Today, the transportation industry of fueled running vehicles are replacing with electric vehicles (EV) but the evolution of electrical yacht and boats are much slower. In order to change this thing a project about updating boats from having engine running on fossil fueled petrol to BLDC which is powered by PV panels.

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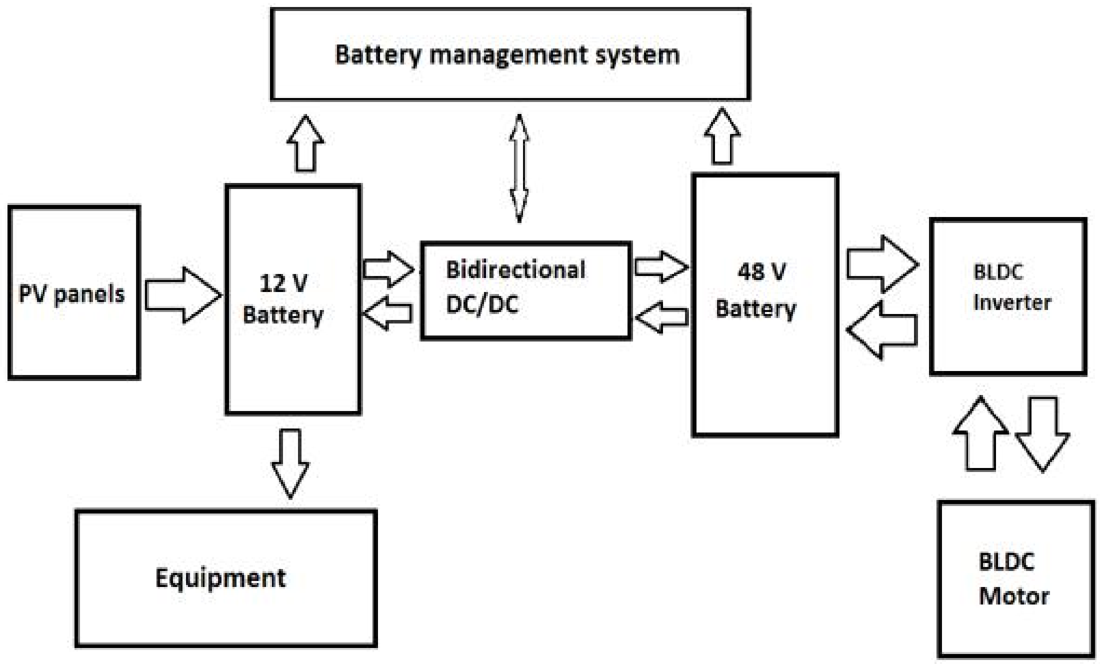

By designing of bidirectional converter for the dual battery system, the target is to allow power batteries lower the need of charging of battery.

The block diagram of this system is:

Figure 1: Flow diagram of Battery management System

2.3.2 Hybrid Energy Storage System of New Energy Vehicle:

“Hybrid Energy Storage System (HESS) is commonly used to fulfil the requirements of power and energy density of NEV. The basic structures of HESS for NEV is given. Fuel cell (FC) gives average power and the super capacitor (SC) gives the instantaneous power when the operating conditions get change. The unidirectional DC-DC converter estimates power decoupling and voltage matching between FC and DC bus.

The bidirectional DC-DC converter realizes voltage matching between DC and SC bus, and bidirectional flow of instantaneous energy. Power battery provides average power, and SC provide instantaneous power when the operating conditions change instantaneously. The bidirectional DC-DC converter on the power battery side realizes the voltage matching between DC bus and the battery, and the inflow of the feedback energy.

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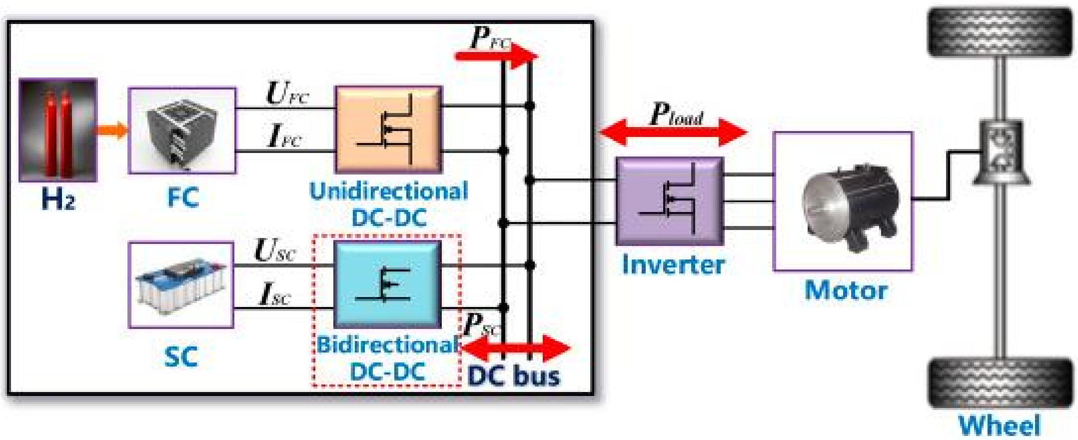


The SC side bidirectional DC-to-DC converter realizes voltage matching and instantaneous energy bidirectional flow. The FC is used as the auxiliary energy source and the power battery is used as the main energy source. When the power demand frequent changes, the SC provides instantaneous power; when the power battery energy is insufficient, FC starts to work. ; When the power demand of vehicle powertrain is low, only the power battery provides energy. The SC stores feedback energy and provides the required instantaneous power for the powertrain."

Figure 2: Bi-directional system in EV's

As already referenced, vehicles do not just have mechanical parts. Regardless of there is a collection of electronic parts. There is a segment indispensable that is key for any vehicle, the engine. Engines are, most of the time, a collection of pieces that cooperate to blend air and fuel (gas, diesel or liquor). From this blend is combustion is incited that creates a series of produced forces, converted into work (motion) by another collection of components.

CHAPTER 3: SYSTEMATICS AND METHODOLOGY:

3.1 Research Analysis

As we know there are a lots of methods and techniques available to perform some tasks. Same is the case here, as our main concern is to charge the batteries through converters from solar panels and also to perform power sharing among two or more than two systems. Different charging techniques are applicable on different scenarios based on some specific parameters like voltage levels, charging speed, number of components, rated power and number of stages. In addition, converter compensation, effective modulation and charging infrastructure schemes can be encouraged to study and work on. So, SEPIC converter seemed more useful to us for charging purpose.

Moreover, if we talk about the power sharing methods then a lot of topologies are available but we selected bidirectional dc-dc converter with the help of relays to share and to perform four basic modes of our task.

Now we will discuss sequence and strategy for our project to get it done.

3.2 Proposed methodology

A few stages have been set up to accomplish the destinations this work:

1. Design and simulations of the suitable bidirectional Dc-Dc converter with the help of Proteus and Matlab.

2. Designing of 2 solar panel systems which are interlinked to each other and working on power sharing through converter which is controlled by the Arduino Nano.

3. Arduino learning for burning of coding in the Arduino and setting of pulse width modulation (PWM) to control the directions of current or to decide working of buck-boost modes.

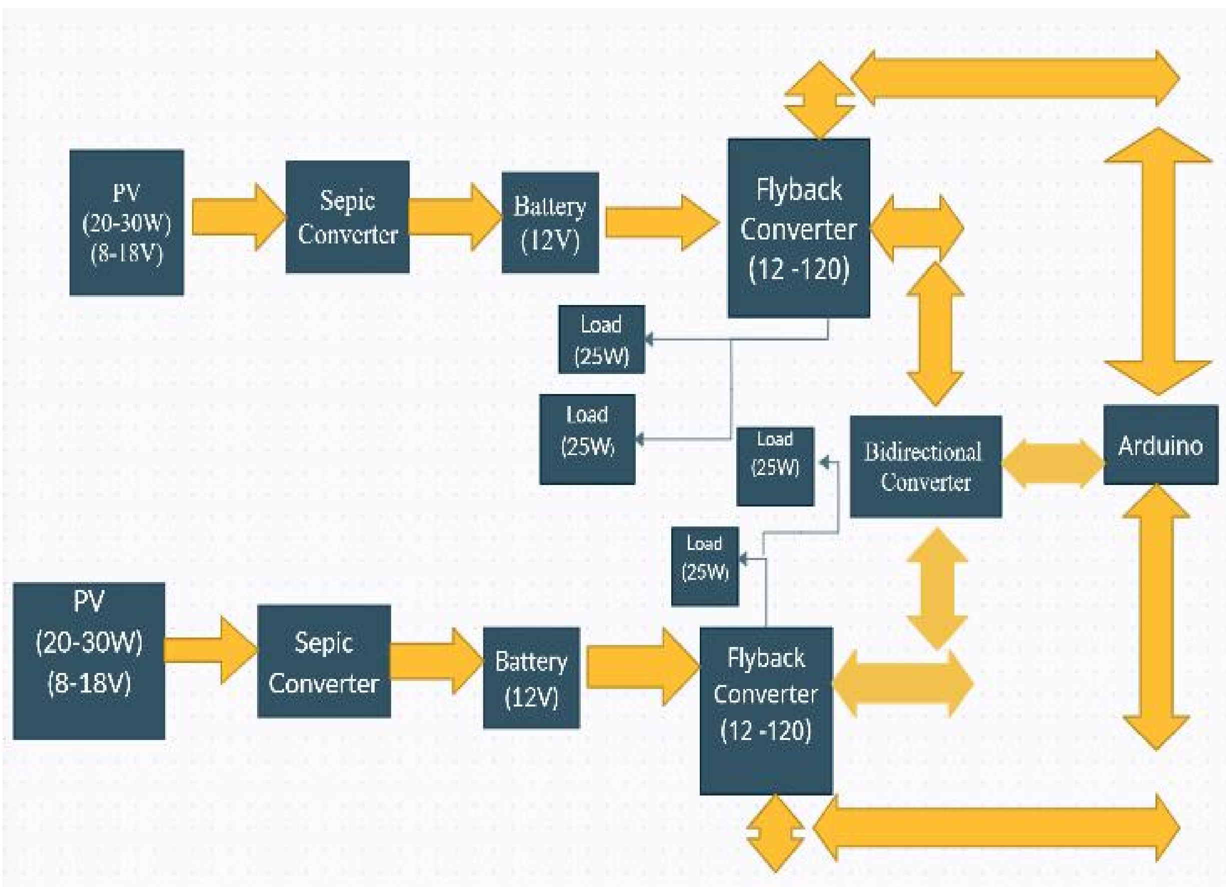
4. Printing out of PCB design through Proteus for the fabrication on hardware.

5. Implementation of software on hardware through fabrication.

6. Testing of hardware to check its working according to the requirement.

7. Analyze, subjectively the outcomes acquired.

In the first stage, we have designed and our main circuit which is bidirectional Dc-Dc converter through which we have to do battery charging/discharging process and exchange of power. After that we have 19



designed two solar panel systems which are working on Dc and loads are also Dc. For the use of Ac load we have to use inverter but our main concern is with the dealing of DC system. We have done Arduino coding to handle current direction for power sharing. After software work, we have done with the implementation on hardware.

For battery charging, we are using SEPIC converter which behaves as a charge controller and the reason behind this is to make backup system for the project. This will assist us to give continuous power flow. After that we used bi-directional FLYBACK converter for the sharing of power among the systems. FLYBACK

with the use of relays and Arduino also responsible for the power sharing as well as operating modes of our system. To display information we are used 16X2 LCD. Then in the last, testing and observation told us our requirements which we demand from the project.

3.3 Block diagram

Figure 3: Block diagram of power exchange systems by bidirectional converter

This is the complete diagram that defines the working of our project. The proposed methodology used by our project is that the power coming from solar panel is of around 25-30(watts).In which the value of voltage is around (8-18) volts and the value of current is 1.46 ampere which is given to SEPIC converter for the charging of Battery of 12 volts the battery charging cycle percentage is shown to us by using Arduino Nano then the regulated voltage of around 12 volts is given at the output of the SEPIC then that voltage is utilized by battery as battery is being charged then that 12 volts from battery is transferred to the FLYBACK

converter.

Then FLYBACK converter uses that 12 volts to perform the function of boosting voltage upto 120 volts that voltage is boosted by using the circuit of FLYBACK that is first converted to ac by using transformer then that transformed voltage is converted to DC by using bridge rectifier and smoothing capacitor to get the value of output in the form of DC of 120volts.

Then afterwards we give that 120volts dc to the relay and MOSFET connected circuit to achieve that power sharing among two systems of dc loads of around 50watts each that is being controlled by using current sensor based Arduino that when current will exceed in one house depending on the load then at that time the current will start coming from the second house to run the appliances or in other words to meet the need of the power in other house thus we are able to run the appliances at around 120 volts.

CHAPTER 4: SOFTWARE

4.1 Software(s) used

Following are the software which we have used to implement our project.

1. Proteus 8.0.1

2. Arduino IDE

These are software which we have used for the schematics, PCB layout for implementation or fabrication and programming to control specific things.

4.1.1 Proteus 8.0.1

Proteus is a software mainly used for modelling and designing of circuits as well as their working on the software before the practical implementation of circuits or hardware. We can run and monitor voltages, currents and many more through this software to avoid any problem in hardware performance.

On Proteus we can also get PCB layout and get it print for the hardware fabrication. Same is case for our project, we have done with the schematics and designing of hardware in the software as shown in the figures below.

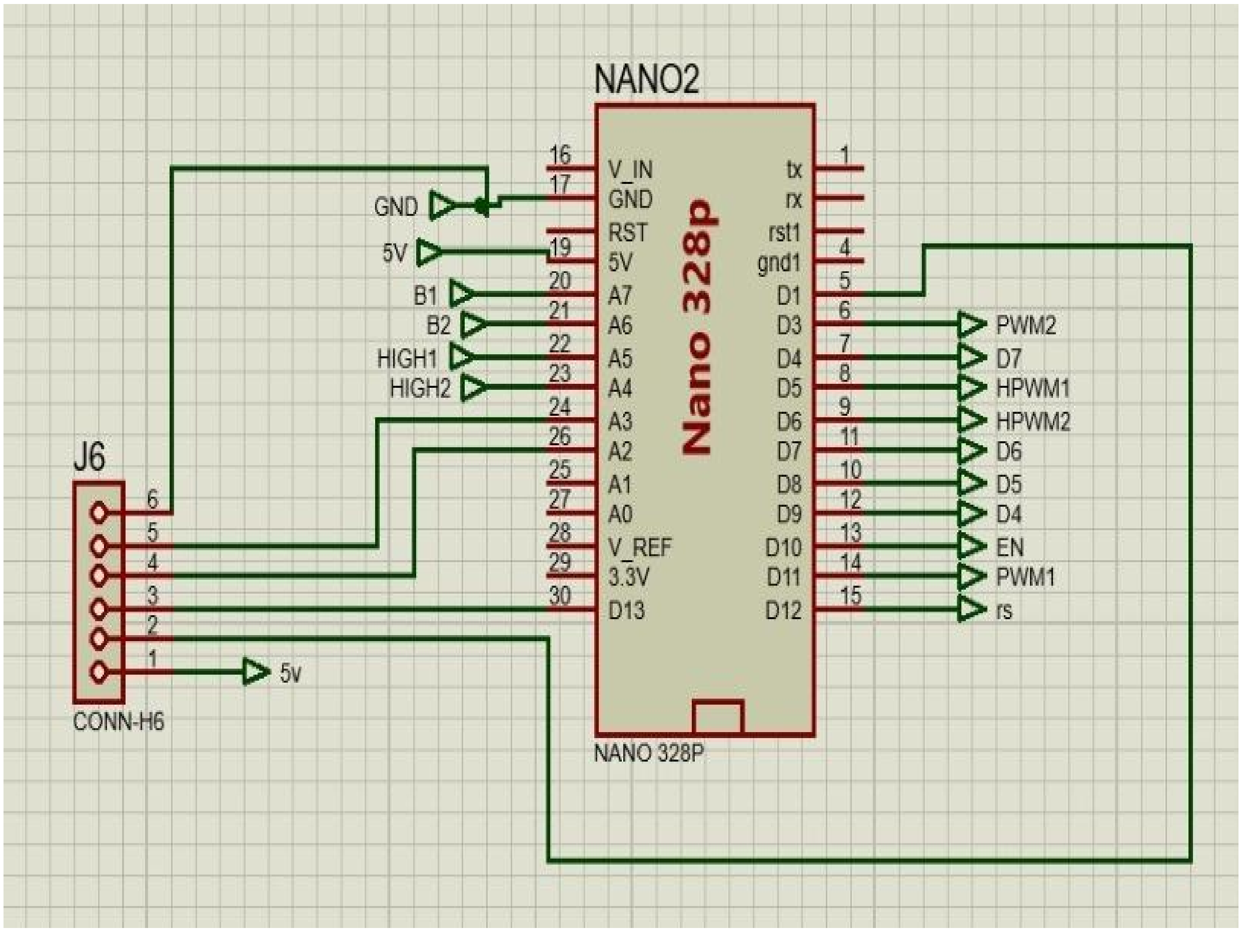
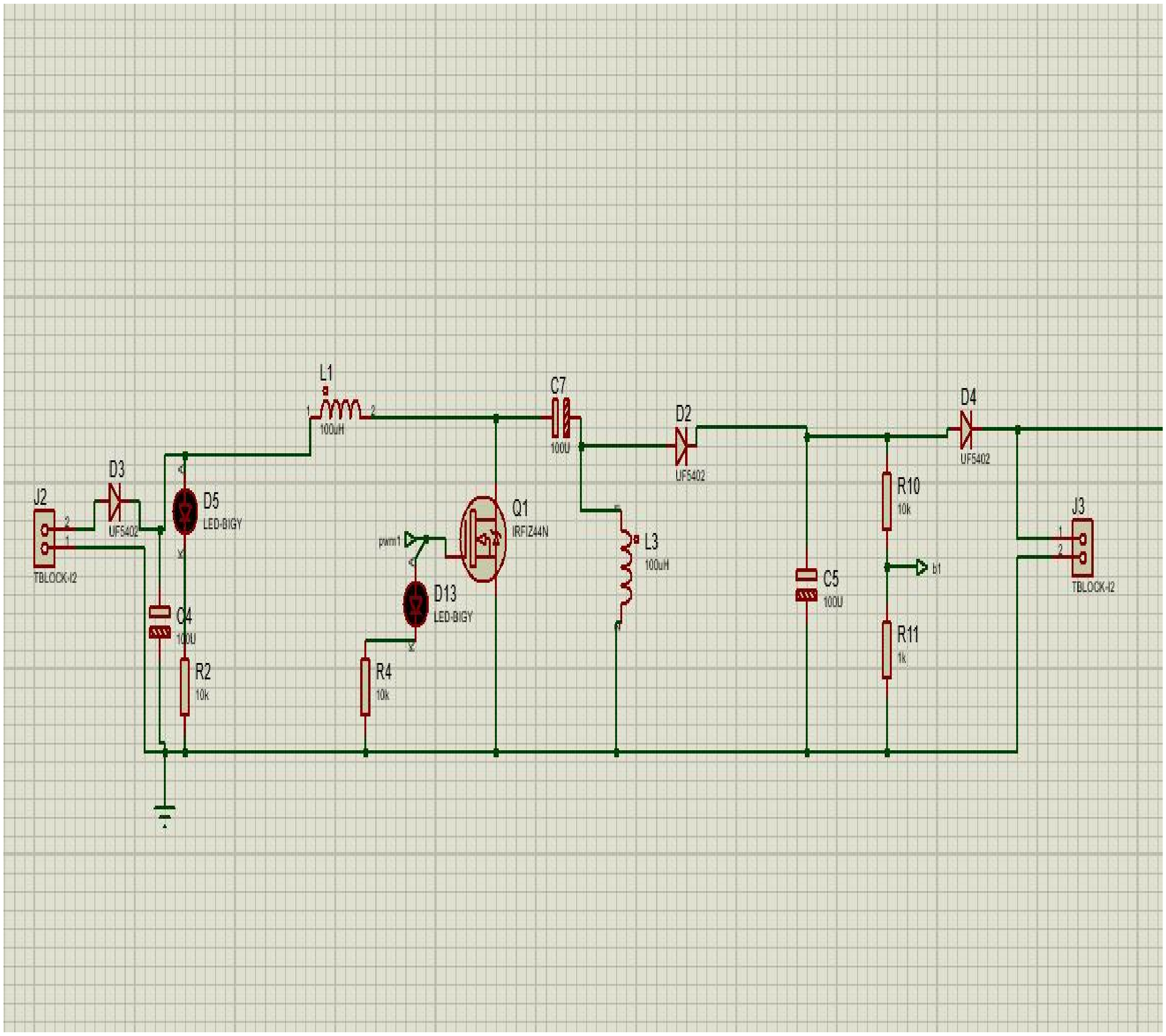


Figure 4 Proteus model of Arduino Nano

Above is the design of Arduino Nano in the Proteus which controls some function of the project through programing which can be burn in to this chip.

Now there are some schematics of our project as:



J2
TBLOCK-I2
D3
UF5402
D5
LED-BIGY
C4
100U
R2
10k
L1
100uH
C7
100U
Q1
IRFIZ44N
pwm1
D13
LED-BIGY
R4
10k
L3
100uH
D2
UF5402
C5
100U
R10
10k
R11
1k
b1
D4
UF5402
J3
TBLOCK-I2

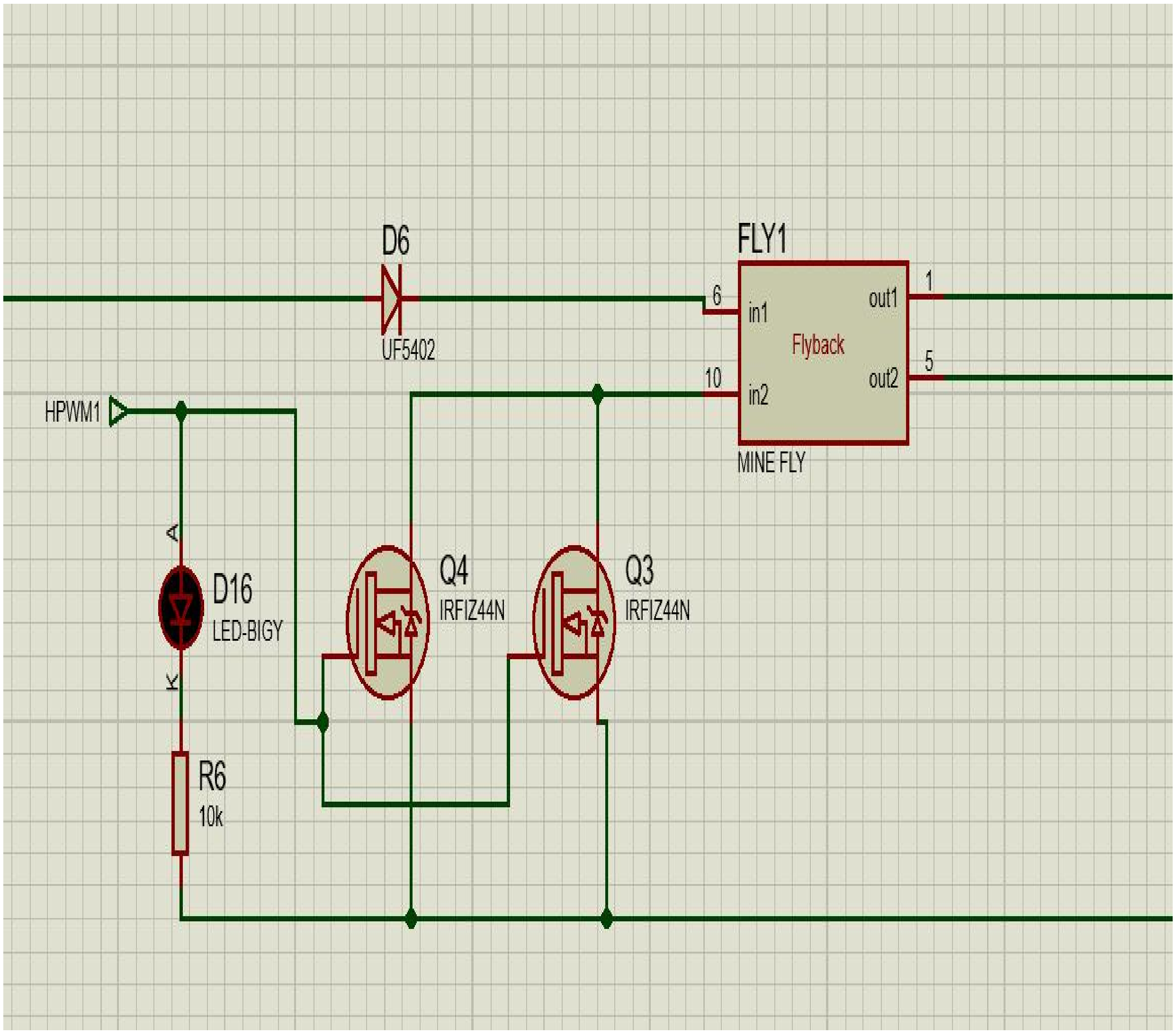
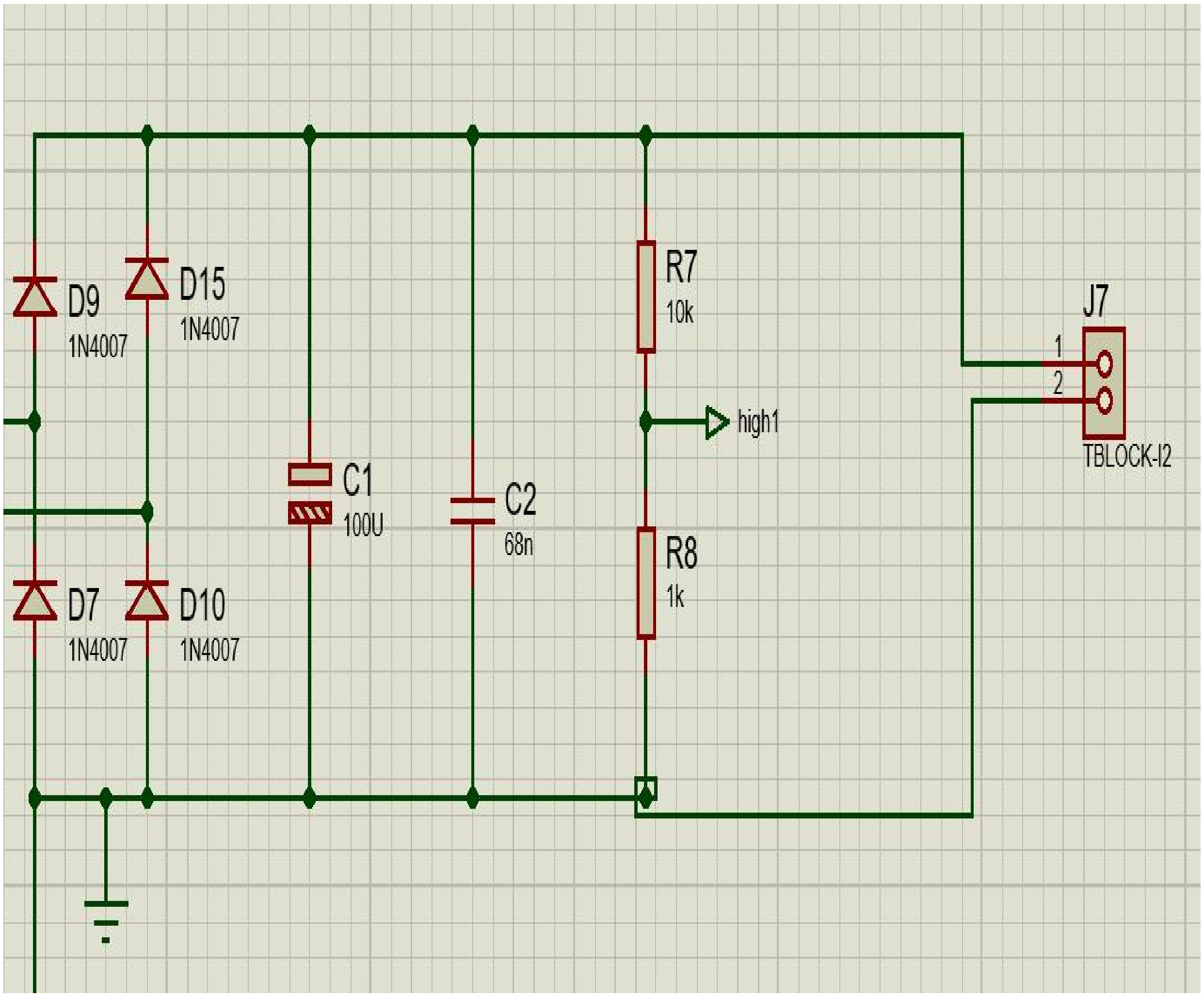


Figure 5: SEPIC converter model in Proteus

Figure 6: Design of FLYBACK converter



D9
1N4007
D15
1N4007
D7
1N4007
D10
1N4007
C1
100U
C2
68n
R7
10k
high1
R8
1k
J7
1
2
TBLOCK-I2

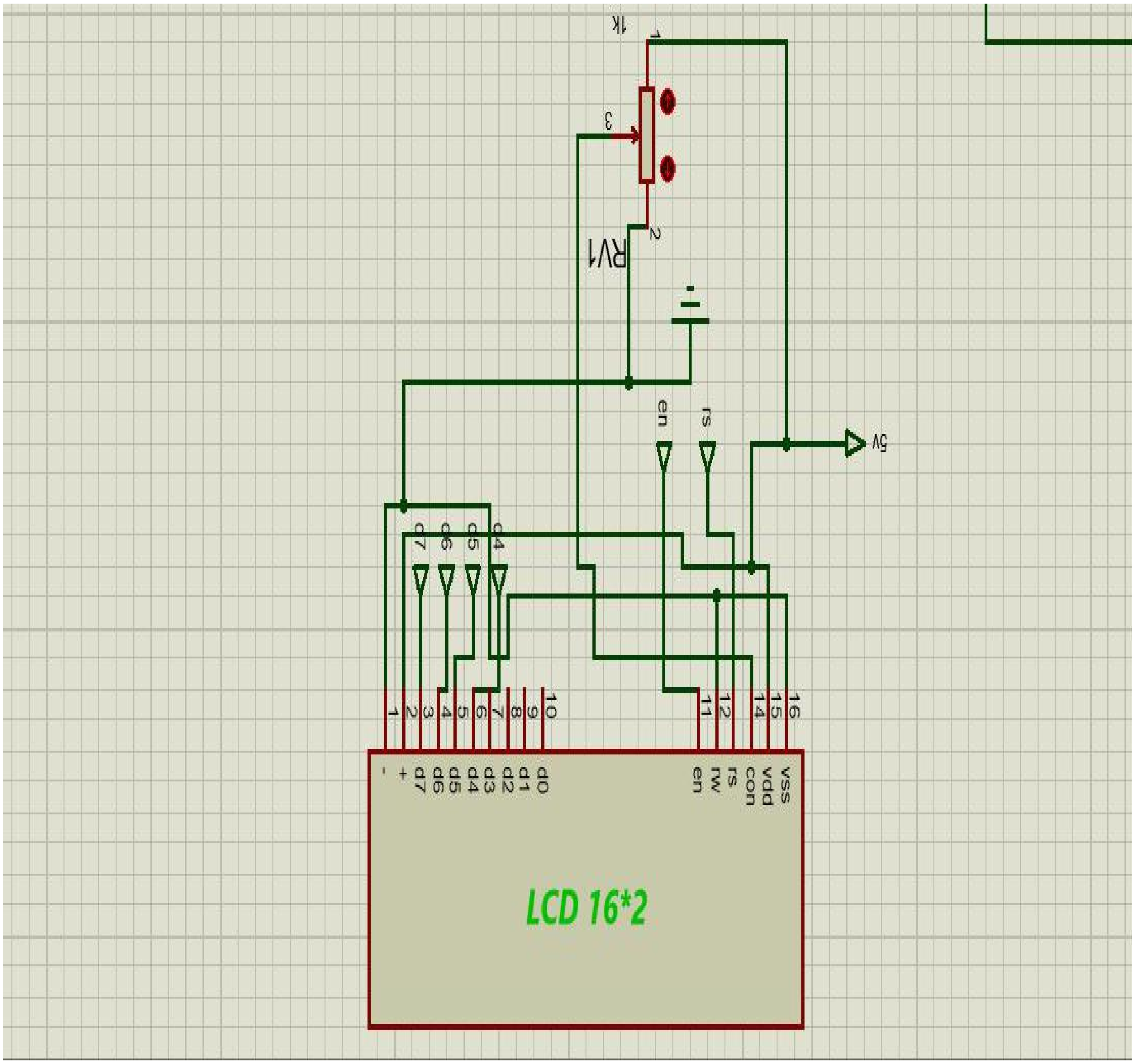
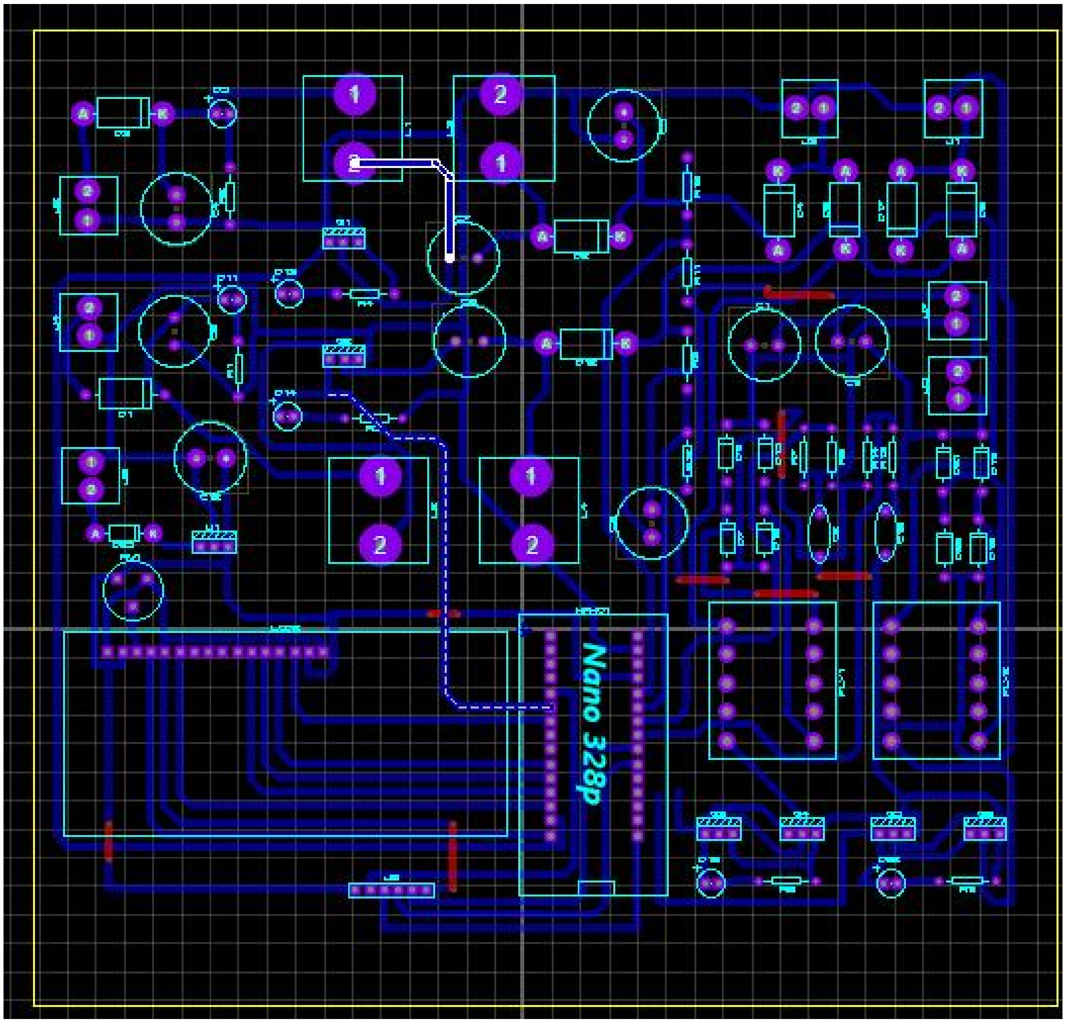


Figure 7: Proteus design of rectifier

Figure 8: LCD Display of 16x2



PCB Layout:

There is also a PCB layout of the project as:

Figure 9: PCB Layout

4.1.2 Arduino IDE

The brain of our project is Arduino which is controlling everything through the coding programming in our project. This is software which is commonly used to code the boards.

When and how power flow from one system to other one. Some are the modes which are being executed after burning code in the chip are:

- Power coming from system B to system A
- Power transferring from system A to system B
- No power flow occurred or there will be a cutoff mode

4.1.2.1 Coding

```
float v1=0;

float v2=0;

float i1=0;

float i2=0;

#define r1 2

#define r2 A0

#include <LiquidCrystal.h>

const int rs = 12, en = 11, d4 = 9, d5 = 8, d6 = 7, d7 = 4;

LiquidCrystal lcd(12, 10, d4, d5, d6, d7);

int d1=100;

int d2=100;

int l1=00;
```



```
int l2=00;”

float b1=00;
```

```
float b2=00;

void setup() {

TCCR0B = TCCR0B & B11111000 | B00000001; // for PWM frequency of
62500.00 Hz

lcd.begin(16, 2);

lcd.print("hello, world!");

Serial.begin(9600);

pinMode(r1,OUTPUT);

pinMode(A0,OUTPUT);

digitalWrite(r1,0);digitalWrite(A0,0);

}

void loop() {

v1=0;

v2=0;

i1=0;

i2=0;

b1=0;

b2=0;

for(int a=0;a<1000;a++)
```



```
{
```

```
v1+=analogRead(A5);
v2+=analogRead(A4);
}
v1=v1/1900.7;
v2=v2/1900.7;
for(int a=0;a<5000;a++)
{
i1+=analogRead(A2);
i2+=analogRead(A3);
}
i1=i1/1000.0;
i2=i2/1000.0;
b1=analogRead(A7)/17.8;
b2=analogRead(A6)/17.8;
b1=(22.05*b1)-203;
b2=(22.05*b2)-203;
Serial.print(" V1: ");Serial.print(v1);
Serial.print(" duty: ");Serial.print(d1);
Serial.print(" I: ");Serial.print(i1);
```

```
Serial.print(" B: ");Serial.print(b1);

Serial.print(" W: ");Serial.println(l1);

Serial.print(" V2: ");Serial.print(v2);

Serial.print(" duty: ");Serial.print(d2);

Serial.print(" I: ");Serial.print(i2);

Serial.print(" B: ");Serial.print(b2);

Serial.print(" W: ");Serial.println(l2);

Serial.println(" ---------------------------------------------------------------------
-"); if(v1!=100)

{

if(v1<100){d1++;}

if(v1>100){d1--;}

if(d1>120){d1=120;}

if(d1<50){d1=50;}

}

else{d1=d1;}

if(v2!=100)

{

if(v2<100){d2++;}

if(v2>100){d2--;}
```

```
if(d2>120){d2=120;}

if(d2<50){d2=50;}

}

else{d2=d2;}

if(i2<3){l2=0;}

if(i2>200 &i2<400){l2=25;}

if(i2>50 &i2<200){l2=50;}

if(i1<3){l1=0;}

if(i1>200 &i1<400){l1=25;}

if(i1>50 &i1<200){l1=50;}

analogWrite(5,100);

analogWrite(6,100);

if(b1<2){b1=2;}

if(b2<2){b2=2;}

if(v1>100){v1*.95;}

if(v2>100){v2*.95;}

lcd.setCursor(0,

0);lcd.print("L:");lcd.print(l1);lcd.print("W

B:");lcd.print(b1,0);lcd.print("%

V:");lcd.print(v1,0);lcd.print(" ");
```

```
lcd.setCursor(0,
1);lcd.print("L:");lcd.print(l2);lcd.print("W
B:");lcd.print(b2,0);lcd.print("%
V:");lcd.print(v2,0);lcd.print(" ");
31
if(l1>30){
//if(l2<25){ digitalWrite(r1,1);}
// else {digitalWrite(r1,0);}
digitalWrite(r1,1);
}
else{digitalWrite(r1,0);}
if(l2>30){
// if(l1<25){ digitalWrite(r2,1);}
// else {digitalWrite(r2,0);}
digitalWrite(r2,1a);
}
else{digitalWrite(r2,0);}
}
32
```

CHAPTER 5: HARDWARE

5.1 Hardware components

- Solar Panel (30-40 W) of Monocrystalline
- SEPIC Converter
- FLYBACK Converter
- MOSFET
- ASC 712 Current sensor
- 16 x 2 LCD Display
- 12V Li-Ion Battery
- 120V Bulb as a Load
- Inductors
- Capacitors
- Diodes
- Power diodes
- Button
- Connectors
- Connecting wires

5.2 Solar Panel (30-40 W) of Monocrystal ine

It is assumed that solar panels are commonly used to produce electric power from solar light energy in both rural and urban areas. The output voltage of a solar panel decreases as the amount of light diminishes. Due to the fact that the charging voltage is lower than the battery's rated voltage, it will not charge. This occurs the majority of the time throughout the day due to cloud cover, the monsoon season, and the shading effect.

By boosting/bucking the voltage produced at the solar panel's lower end using a controller-based SEPIC

converter, the rated charging voltage for the battery may be reached. Based on a charger for electric vehicles, this project sought to build and improve a SEPIC dc/dc converter. As a result, this converter only has one output.

5.2.1 DESCRIPTION

When you're not connected to the power grid, a 30-watt monocrystalline solar panel is great for charging small electronics. This panel is tiny and light, making it simple to store and reposition as needed. Although small, this panel can handle strong wind and snow loads thanks to its junction box, which makes connecting it to the charge controller or additional panels as simple as 1-2-3. This solar panel may be used to power your electronics everywhere there is sunlight.

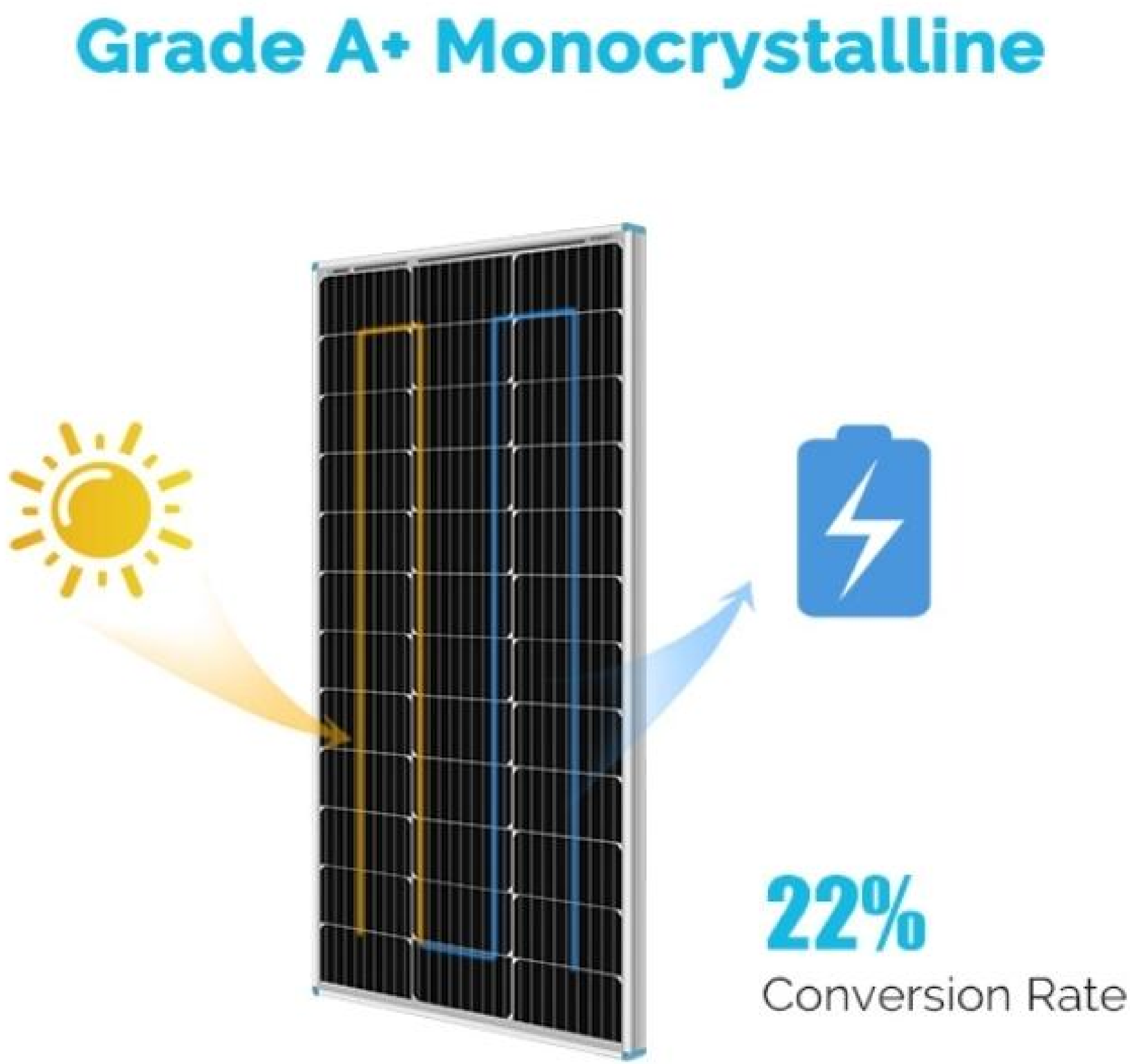
5.2.2 KEY FEATURES

Product Efficiency

High conversion efficiency of modules. 120Wh per day is the ideal output (depending on the availability of sunlight). The bypass diode reduces power loss due to shadow and provides good performance in low-light conditions.

Portable

With dimensions of 22.4x13.4x1.0 inches, you can conveniently transport these 30W solar panels.



Easy Installation

The back of the panel has pre-drilled holes for quick mounting and fastening.

Reliability

Solar modules that have been EL tested; no hotspot heating is guaranteed.

Higher Efficiency

The Panel’s top is made of anti-reflective, low-iron tempered glass with a clarity of up to 91.5 percent. It permits more direct sunlight to be turned to electrical power than traditional solar panels.

Figure 10: A+ grade Solar panel

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Usability in our project (30 Watt):

Figure 11: 30W solar panel

5.3 SEPIC Converter

Future DC-based charging for electric cars and household distribution is attractive because of renewable energy and energy storage. The low power rating of the system necessitates limiting the number of converter stages and maximizing the usage of the produced energy. The idea here is to use an electric vehicle charger-based SEPIC converter with PI controller to effectively decimate produced energy to charge a battery, rather than several specialized converters from various unidirectional renewable sources. Commercial value will arise when some of the extra sources aren't large enough to necessitate the use of a separate converter. Input and output power sources' optimal working conditions are defined by the converter's characteristics, and the duty cycle of the converter is adjusted accordingly. As part of this investigation, a range of modes for the proposed converter will be examined.

For circuits, it is desirable to have constant and specific inputs. Controlling input to particular sub circuits to satisfy design requirements is essential. While converting AC to DC is simple, the reverse is not always the case. It is possible to reduce the voltage by a certain amount using diodes and voltage bridges, but they are inefficient. Using voltage regulators, you can get a reference voltage. Batteries lose their voltage as they degrade, which may create several problems without proper voltage control. For voltage adjustments in a circuit, dc-dc converters are the best option. It's possible to choose from a variety of dc-dc converter models.

There is nothing wrong with using buck converters. Voltage may be increased or decreased by Buck-boost, CUK, and SEPIC converters, but only by boost converters.

In certain cases, a simple voltage buck or boost is all that is required for a converter application. However, it is possible that the desired output voltage will fall inside the input voltage range on rare occasion. When this is the case, a voltage converter is typically the best solution. Buck-boost converters are less costly since just a single inductor and a capacitor are needed. In contrast, the input current ripple in these converters is rather large. Harmonics may be produced by this ripple, necessitating the use of an LC filter or a big capacitor.

Buck-boost is often out of stock or expensive. Ineffectual. Another problem that might make the operation of buck-boost converters more challenging is the fact that they invert voltage. Both of these drawbacks are mitigated in CUK converters by the inclusion of an extra capacitor and inductor. The components of a CUK

or buck-boost converter are subjected to a great deal of electrical stress, which increases the risk of device failure or overheating. SEPIC converters address both of these concerns.

5.3.1 SEPIC use in our Project:

The variable voltage from solar panel around the range of 12-18V is then fed into SEPIC converter the converter is use to regulate the voltage down or up to some sequential manner like up to 12Volts.

5.3.2 Practical use:

Figure 12: SEPIC in hardware

5.3.3 Functionality of SEPIC Converter

A step-down/step-up or Buck-Boost single inductor converter (Bu-BoSIC) produces an output voltage that can be higher or lower than the input voltage, as well as a negative-polarity output with regard to the input current's common terminal. The key benefit of the BuBoSIC converter is the small number of devices required for conversion.

Its significant drawbacks include the following:

- The switch and the diode are subjected to significant input voltage ripple and electrical stressors, and the output power is negative polarity in comparison to the input power.

- The key storage device is the inductor L, which transmits energy from input to output. This converter works on the principle of inductive energy transfer (L).

The SEPIC signal-controlling done in this way that the boost converter is triggered at lower input voltage from the solar panel and the buck converter is activated at greater input voltage from the solar panel, charging the battery at very low and very high speeds while also protecting the battery from damage.

The Buck Boost converter has two modes of operation.

a) Continuous conduction mode, in which the current through the inductor is never zero, and the inductor partially discharges before the switching cycle begins.

b) Discontinuous conduction mode, in which the current through the inductor is zero at the end of the switching cycle, i.e. the inductor is entirely discharged.

Due to the depletion of fossil fuels and the environmental difficulties created by conventional power generation, the focus has switched to renewable energy generation, the most prevalent of which are solar power plants. Solar panels are used in a variety of applications, including battery charging, water pumping, home power supply, swimming pool heating system, satellite powering system, and so on. Because solar power plants have lower operating costs than other renewable sources, the overall system cost can be reduced by using a high efficiency power converter. They have the advantage of being both pollution-free and cost-free. Despite the many benefits of wind energy, it is still in its early stages of development. Light energy is converted to electrical energy by the solar panel."

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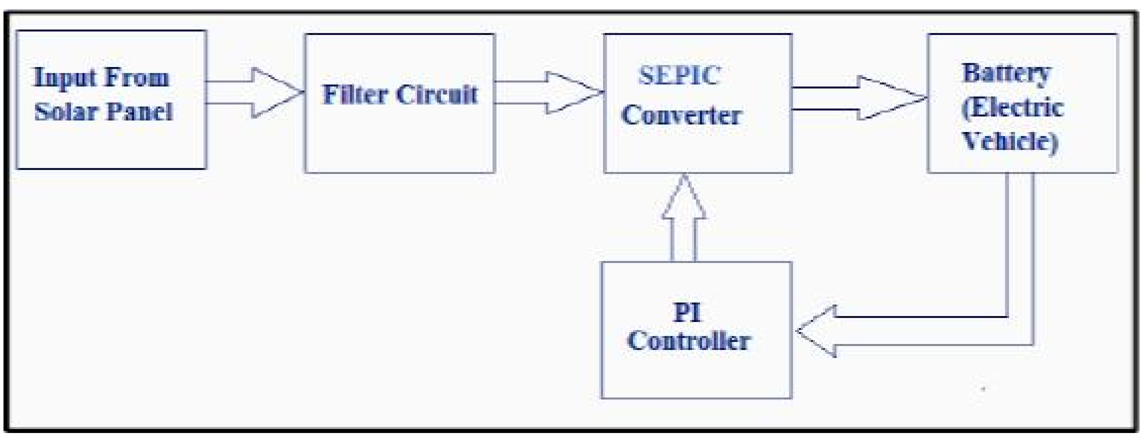

Figure 13: Block diagram of system working with SEPIC

"Although there is a surplus of energy, researchers are always looking for the most efficient ways to harness it. A battery-powered solar panel is the focus of this investigation. The sun's radiation is the single source of solar power, and that radiation fluctuates since the sun's radiation is not constant. When a battery is being recharged, the voltage must stay constant. As shown in fig, a buck-boost converter in an existing system receives power from the solar panels and charges a battery thereafter. It doesn't matter how much electricity is supplied; the battery still won't charge up. You may raise additional issues with this system at the introductory meeting.

To maintain a steady voltage and avoid system damage when solar energy is low, the converter raises the output voltage. When solar energy is high, the converter operates in buck mode and lowers the voltage.

For example, a single-ended primary-inductor (SEPIC) is a DC/DC converter that permits the output voltage to be higher or lower than the input voltage. The SEPIC's output is controlled by the duty cycle of the control switch, like a power semiconductor switch.

If you're looking for an inverted buck-boost converter, you'll need a SEPIC. Using a series capacitor to connect the energy from the input to the output, the output voltage is the same as that of the input. When the switch is turned off all the way, the output voltage decreases to 0 volts, allowing for a complete shutdown."

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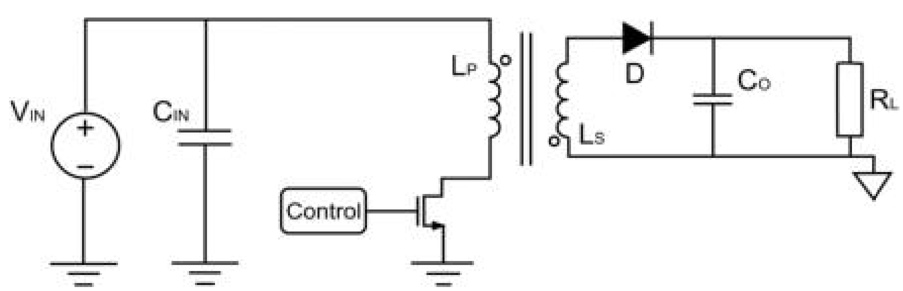

5.4 FLYBACK Converter

There are many multiple kinds of regulators on the market that are dependent on the power supply. However, in the DC-to-DC conversion process, there are mainly two types of regulators: linear and switching. The output of a linear regulator is regulated by a resistive voltage drop. This can result in a decrease in efficiency and a loss of power in the form of heat**.** For energy transfer from source to destination, switching regulators use an inductor, diode, and power switches. A FLYBACK converter, on the other hand, is a switching regulator that is preferred by many designers**.** Because it reduced switch/passive element count. Furthermore, a FLYBACK converter has a larger voltage gain.

Using galvanic isolation between the source and the load, a FLYBACK converter is used for both AC to DC

and DC to DC conversions. The inductor is divided into the transformer in this buck-boost converter, and as a result, the voltage proportions are increased with the added benefit of isolation. When several outputs are required to provide a single output supply, the FLYBACK converter topology is used. Furthermore, the topology allows designers to alter the output polarity, providing for the fabrication of +4V, +8V, and -7V

levels of output from a simple converter module. In both situations, higher efficiency rates are possible.

Electrical isolation for both the input and output is another property of the FLYBACK converter. Isolation is necessary to lower noise levels and to do some safety-related tasks.

Figure 14: SEPIC circuit

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5.4.1 Operation of fly back converter

The FLYBACK transformer, rectifier, filter, and switch are all parts of the device. It also has a controlling process that simulates the switch and controls it. This is the smaller section count switching type of converter, which is also the easiest to build. A FLYBACK converter is also a type of isolated switching converter that can be step-up or step-down.

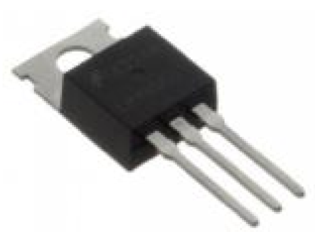
5.4.2 Use of Transformer

A transformer, in general, has the capacity to transmit energy from the main winding to the secondary winding properly and in real time. A FLYBACK transformer, on the other hand, gathers energy in its primary magnetic field before transferring it to the secondary winding after a set period of time."

Figure 15: Transformer

5.4.3 Use of Switch

The switch's main function is to switch between ON and OFF states that correspond to the primary circuit's ability to magnetize or demagnetize the FLYBACK transformer. The PWM signal received from the controller is used to control this switch. These switches are MOSFET



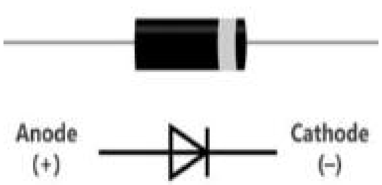


Figure 16: Switch

5.4.4 Process of Rectification

The rectifier on the secondary winding of the transformer rectifies the voltage, producing in a pulsing type of DC. The diode or rectifier's second job is to cut down and then connect the load section to the secondary winding. This rectified voltage is then filtered through the capacitor, which raises the DC level and allows it to be used for the desired purposes. In many cases, a FLYBACK converter requires the use of a snubber circuit, which aims to remove voltages created across diodes or switches.

Figure 17: Diode

5.4.5 Working Principle

The operation of the FLYBACK converter can be divided into two main types:

- Switch ON

- Switch OFF

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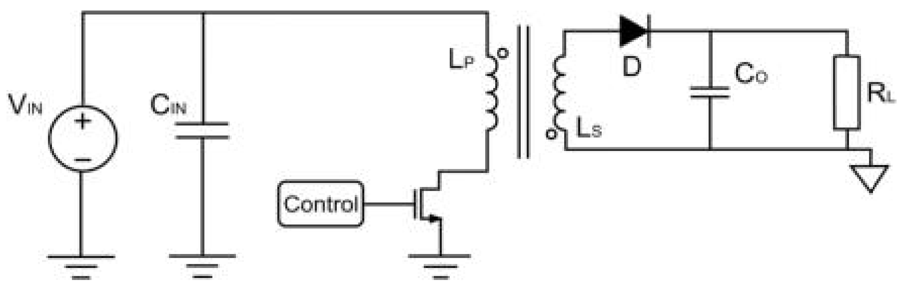

Switch ON State

Design of FLYBACK converter when switch is ON.

Figure 18: FLYBACK on state

Switch ON Condition

The FLYBACK converter's operation is mostly based on switch operation. When the switch is turned on, current will flow downwards from Vin to the primary and then to the ground. This allows energy to be accumulated in the primary winding. Because the diode is reverse biased, there will be no current flowing in the secondary winding at this time. The load requirement will be supplied by the output capacitance, which is Cout, in this case. . The following is the derivation.

$$V_{in} - V_L - V_s = 0$$

At this circumstance, the voltage drop is '0' in the ideal scenario

$$V_{in} - V_L = 0$$

so we have,

$$V_{in} = V_L$$

$$V_L = L_p (di/dt)$$

$$di = (V_L/L_p)\, dt$$

As $V_{in} = V_L$

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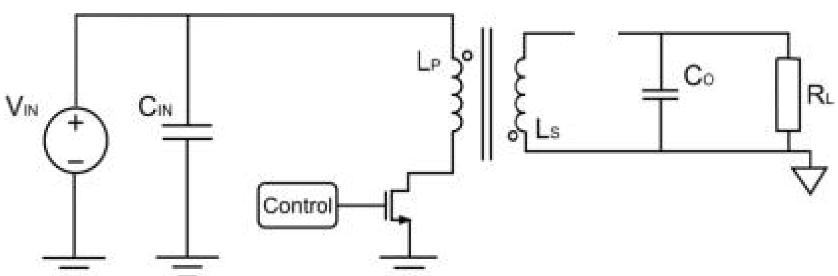

We get,

$$di = (V_{in}/L_p)\, dt"$$

$$I_{pri} = \int_0^{T_{ON}} (V_{in}/L_p)\, dt$$

$$I_{pri} = (V_{in}/L_p)\, T_{ON}$$

When the equation is written as accumulated energy, the result is

$$E_{pri} = (1/2) i_{pri}^2 L_p$$

$$E_{pri} = (1/2)\,](V_{in}/L_p).T_{ON}]^2 L_p$$

The input voltage of the primary winding is represented by **Vin.**

The primary inductance of the transformer is denoted by **Lp.**

The time taken into account when the switch is turned on is referred to as the **TON.**

Switch OFF State

Design of FLYBACK converter when switch is OFF.

Figure 19: FLYBACK off state

The primary winding of the transformer withstands a sudden shift in current when the initial switch is in a cut-off state, and the polarity of the winding is reversed. This causes the output diode to be biased forward.

Through the diode, the stored energy in the primary winding is transferred to the secondary winding and finally to the load section. The output capacitor tends to gain charge in this situation. The following is the derivation.

VLsecondary – Vs – Vout = 0

The voltage drop at the secondary diode should be '0' in an ideal situation.

VLsecondary – Vout = 0

So, we have

VLsecondary = Vout

VL = Ls (di/dt)

di = (VLsecondary /Ls) dt

As,

VLsecondary = Vout

We get

$$di = (V_{Lsecondary} / L_s)\, dt = (V_{out} / L_s)\, dt$$

We get the following result when we apply the integration formula to the preceding formula.

$$I_{sec} = \int_{TON}^{T} (V_{sec}/L_s)\, dt$$

$$I_{sec} = (V_{sec}/L_s)\,(T - T_{ON})$$

When the equation is written as transferred energy, the result is

$$E_{sec} = (1/2)][(V_{sec}/L_s).(T - T_{ON})]^2 L_s$$

46

Ls is the secondary inductance of the transformer.

The time taken into account when the switch is turned on is referred to as the TON.

5.4.6 Final Hardware Design of FLYBACK Converter

The final hardware design of FLYBACK converter after implementation of all the component is shown in the following figure.

Figure 20: FYBACK on hardware

5.4.7 Limitations of FLYBACK

When used in continuous and discontinuous modes, the FLYBACK converter has a few limitations, which are as follows:

- Small bandwidth is required for voltage feedback because of the converter's sensitivity to the right-side half plane zero.

- When the duty cycle is more than 50%, slope adjustment is necessary. "

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- In order to reduce waste heat in the switching component, the speed at which power switches turn on is crucial.

- In the inductor, there will be a peak level of currents, RMS, and flux fluctuations.

5.4.8 Application of FLYBACK

The following are examples of FLYBACK converter applications:

- Used mostly in SMPS circuits, which include mobile chargers, computer standby supply, and a variety of other applications.

- Used in low-cost output power supply, such as personal computers with less than 250 watts of power.

- Used to power oscilloscopes in monitors and televisions with a wide voltage range.

- Lasers, photo-state machines, xenon type flash lamps, and other applications that require a high amount of voltage are examples.

- Gate operators who have been isolated
- Micro-inverters of the solar kind
- Telecom departments use it

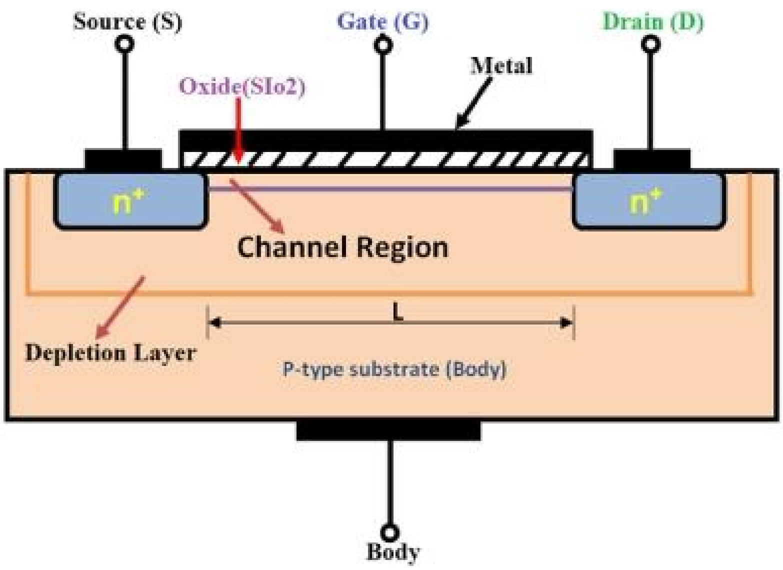
5.5 MOSFET (IRF 4940) for switching

The MOSFET is a symmetrical device having a source and drain that can be swapped out (if the body is not short-circuited to the drain or source). Even though the MOSFET is bidirectional, current can only flow via the source-drain if the source voltage is larger than the drain voltage.

Because the "source" and "drain" terminals may be interchanged, the MOSFET is a bidirectional device.

When the gate-source voltage is over a threshold voltage and the drain voltage is greater than the source voltage, an n-channel MOSFET (taken as an example) conducts to enable electron passage through the induced channel.

Electrons flow from the source to the drain when a positive potential is applied from the source to the drain after the channel has been created by applying an acceptable positive potential between the source and gate terminals.



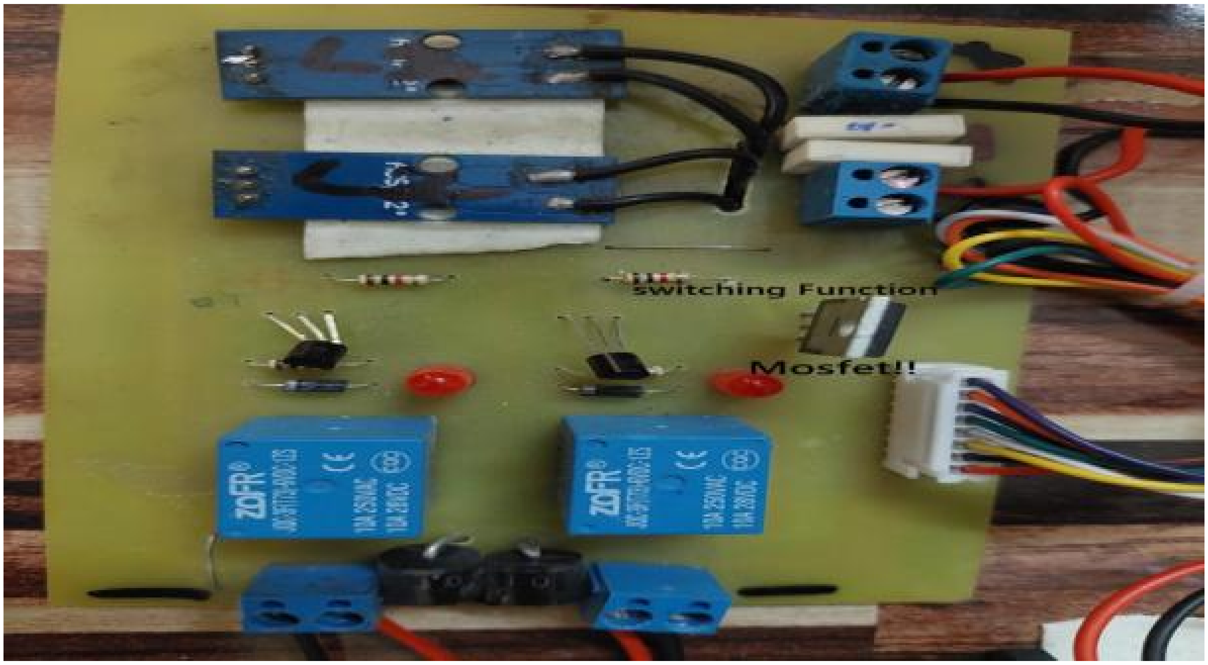
Let's imagine we want to use an n-channel MOSFET to conduct electrons from the source to the drain. The gate connector is fixed for obvious reasons. The SOURCE can be one of the other two, and the gate voltage for that terminal must be higher than the device's threshold voltage.

Due to the substrate diode between the source and drain, it can only block in one way. When two MOSFETs are coupled in series with their respective sources, they block current in both directions when off and conduct current in both directions when on.

Figure 21: MOSFET

5.5.1 Working of MOSFET in our Circuit

The role of Bidirectional in our project is achieved by using a MOSFET and the relays according to our demand the function will run in the way that when it has to perform the function of flow of power between two systems we use MOSFET in a way that the gate terminal is off of MOSFET and the flow of current is through the source to drain by means of a diode which is in the structure of MOSFET. Then we ON the ground terminal of MOSFET by means of the feedback and then it supply the current or voltage to the system with low potential then the threshold we are giving to it by means of MOSFET the flow is possible in the same way we are controlling the relays which control the 3rd and 4th Mode of our project.



- For this when the second system has voltage drop across it and in this way the ground terminal gets on and the bidirectional function will be carried out

- For the modes in which the power is remain between the two houses then for it the relay function gets activated.

Figure 22: MOSFET, relays and current sensors

5.5.2 Description:

- “International Rectifier's Fifth Generation HEXFETs use innovative processing techniques to provide ultra-low on-resistance per silicon area. This benefit, when paired with the quick switching speed and ruggedized device architecture that HEXFET Power MOSFETs are known for, gives the designer an exceptionally efficient and dependable device that can be used in a wide range of applications.

- At power dissipation values of around 50 watts, the TO-220 package is universally recommended for all commercial-industrial applications. The TO220's low heat resistance and inexpensive package cost contribute to its widespread appeal in the industry.

- Advanced Process Technology
- Ultra-Low On-Resistance

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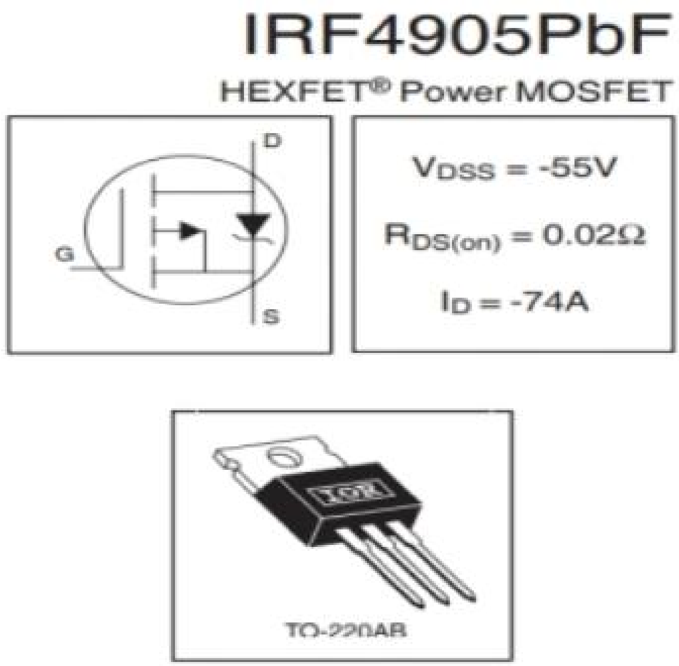

- Dynamic dv/dt Rating
- 175°C Operating Temperature
- Fast Switching P-Channel
- Lead Free”

Figure 23: Power MOSFET

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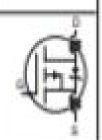
Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	-55	—	—	V	V_{GS} = 0V, I_D = -250μA
$\Delta V_{(BR)DSS}/\Delta T_J$	Breakdown Voltage Temp. Coefficient	—	-0.05	—	V/°C	Reference to 25°C, I_D = -1mA
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.02	Ω	V_{GS} = -10V, I_D = -38A ④
$V_{GS(th)}$	Gate Threshold Voltage	-2.0	—	-4.0	V	V_{DS} = V_{GS}, I_D = -250μA
g_{fs}	Forward Transconductance	21	—	—	S	V_{DS} = -25V, I_D = -38A
I_{DSS}	Drain-to-Source Leakage Current	—	—	-25	μA	V_{DS} = -55V, V_{GS} = 0V
		—	—	-250		V_{DS} = -44V, V_{GS} = 0V, T_J = 150°C
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS} = 20V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS} = -20V
Q_g	Total Gate Charge	—	—	180	nC	I_D = -38A
Q_{gs}	Gate-to-Source Charge	—	—	32		V_{DS} = -44V
Q_{gd}	Gate-to-Drain ("Miller") Charge	—	—	86		V_{GS} = -10V, See Fig. 6 and 13 ④
$t_{d(on)}$	Turn-On Delay Time	—	18	—	ns	V_{DD} = -28V
t_r	Rise Time	—	99	—		I_D = -38A
$t_{d(off)}$	Turn-Off Delay Time	—	61	—		R_G = 2.5Ω
t_f	Fall Time	—	96	—		R_D = 0.72Ω, See Fig. 10 ④
L_D	Internal Drain Inductance	—	4.5	—	nH	Between lead, 6mm (0.25in.) 
L_S	Internal Source Inductance	—	7.5	—		from package and center of die contact
C_{iss}	Input Capacitance	—	3400	—	pF	V_{GS} = 0V
C_{oss}	Output Capacitance	—	1400	—		V_{DS} = -25V
C_{rss}	Reverse Transfer Capacitance	—	640	—		f = 1.0MHz, See Fig. 5

Source-Drain Ratings and Characteristics

	Parameter	Min.	Typ.	Max.	Units	Conditions
I_S	Continuous Source Current (Body Diode)	—	—	-74	A	MOSFET symbol showing the 
I_{SM}	Pulsed Source Current (Body Diode) ①	—	—	-260		integral reverse p-n junction diode.
V_{SD}	Diode Forward Voltage	—	—	-1.6	V	T_J = 25°C, I_S = -38A, V_{GS} = 0V ④
t_{rr}	Reverse Recovery Time	—	89	130	ns	T_J = 25°C, I_F = -38A
Q_{rr}	Reverse Recovery Charge	—	230	350	nC	di/dt = -100A/μs ④
t_{on}	Forward Turn-On Time	Intrinsic turn-on time is negligible (turn-on is dominated by L_S+L_D)				

Notes:

① Repetitive rating; pulse width limited by max. junction temperature. (See fig. 11)

② Starting T_J = 25°C, L = 1.3mH R_G = 25Ω, I_{AS} = -38A. (See Figure 12)

③ $I_{SD} \le$ -38A, di/dt $\le$ -270A/μs, $V_{DD} \le V_{(BR)DSS}$, $T_J \le$ 175°C

④ Pulse width $\le$ 300μs; duty cycle $\le$ 2%.

Table 1: Ratings and characteristics of MOSFET

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Absolute Maximum Ratings

	Parameter	Max.	Units
I_D @ T_C = 25°C	Continuous Drain Current, V_{GS} @ -10V	-74	A
I_D @ T_C = 100°C	Continuous Drain Current, V_{GS} @ -10V	-52	
I_{DM}	Pulsed Drain Current ①	-260	
P_D @T_C = 25°C	Power Dissipation	200	W
	Linear Derating Factor	1.3	W/°C
V_{GS}	Gate-to-Source Voltage	± 20	V
E_{AS}	Single Pulse Avalanche Energy②	930	mJ
I_{AR}	Avalanche Current①	-38	A
E_{AR}	Repetitive Avalanche Energy①	20	mJ
dv/dt	Peak Diode Recovery dv/dt ③	-5.0	V/ns
T_J T_{STG}	Operating Junction and Storage Temperature Range	-55 to + 175	°C
	Soldering Temperature, for 10 seconds	300 (1.6mm from case)	
	Mounting torque, 6-32 or M3 screw	10 lbf•in (1.1N•m)	

Thermal Resistance

	Parameter	Typ.	Max.	Units
$R_{\theta JC}$	Junction-to-Case	—	0.75	°C/W
$R_{\theta CS}$	Case-to-Sink, Flat, Greased Surface	0.50	—	
$R_{\theta JA}$	Junction-to-Ambient	—	62	

Table 2: Absolute maximum ratings

5.6 ASC 712 Current sensor

Have you ever wondered how much electricity each of your appliances uses? Learning everything takes time, but that's where the utility of a current sensor comes into play. Because different devices require different amounts of electricity, feeding them the incorrect amount can result in disastrous consequences (overloading, etc.). As a result, keeping track of the required current for applications is critical, which is where a current sensor like the ACS712 AC/DC Current sensor may help.

5.6.1 Sensor for current:

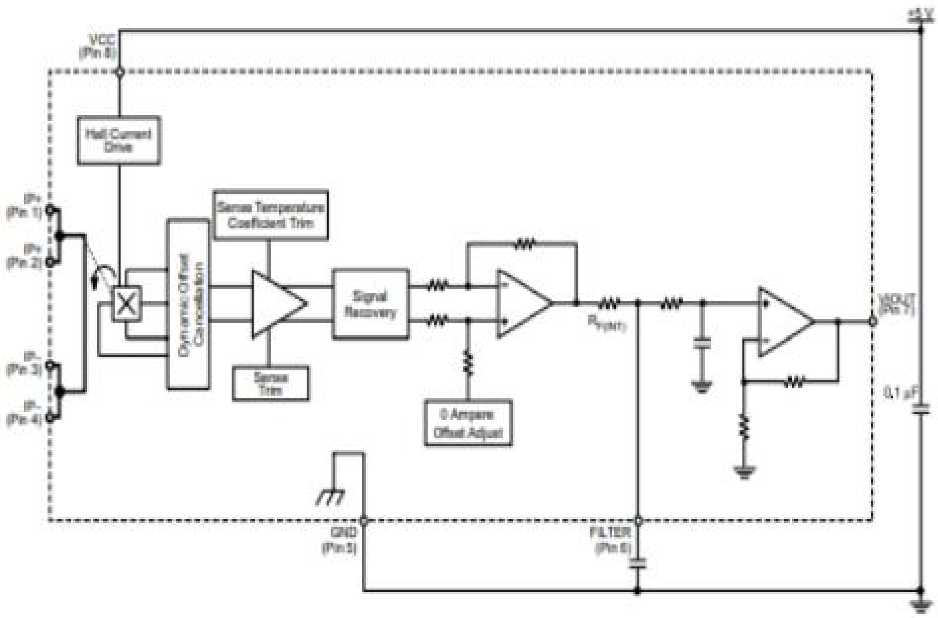
The ACS712 is a fully integrated hall effect-based linear current sensor with 2.1kVRMS voltage isolation and an integrated low-resistance current conductor. It's simply stated as a current sensor that calculates and measures the amount of current applied through its conductor, minus the technical jargon.

The following are the characteristics of 9.1.1-ACS712:

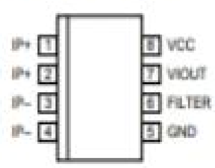
- Analogue signal path with low noise
- 66 to 185 mV/A output sensitivity
- 1.2 m internal conductor resistance
- 80 kHz bandwidth
- 1.5 percent total output error at TA = 25°C
- Stable output offset voltage”
- Magnetic hysteresis is near zero
- Device bandwidth can be changed through the new FILTER pin

ACS712 Fully Integrated, Hall-Effect-Based Linear Current Sensor IC with 2.1 kV_{RMS} Isolation and a Low-Resistance Current Conductor

FUNCTIONAL BLOCK DIAGRAM



Pinout Diagram



Terminal List

Number	Name	Description
1 and 2	IP+	Terminals for current being sampled; fused internally
3 and 4	IP–	Terminals for current being sampled; fused internally
5	GND	Signal ground terminal
6	FILTER	Terminal for external capacitor that sets bandwidth
7	VIOUT	Analog output signal
8	VCC	Device power supply terminal

Table 3: current sensor internal design and specifications

COMMON OPERATING CHARACTERISTICS [1]: Over full range of T_A, C_F = 1 nF, and V_{CC} = 5 V, unless otherwise specified

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
ELECTRICAL CHARACTERISTICS						
Supply Voltage	V_{CC}		4.5	5.0	5.5	V
Supply Current	I_{CC}	V_{CC} = 5.0 V, output open	–	10	13	mA
Output Capacitance Load	C_{LOAD}	VIOUT to GND	–	–	10	nF
Output Resistive Load	R_{LOAD}	VIOUT to GND	4.7	–	–	kΩ
Primary Conductor Resistance	$R_{PRIMARY}$	T_A = 25°C	–	1.2	–	mΩ
Rise Time	t_r	I_P = I_P(max), T_A = 25°C, C_{OUT} = open	–	3.5	–	μs
Frequency Bandwidth	f	–3 dB, T_A = 25°C; I_P is 10 A peak-to-peak	–	80	–	kHz
Nonlinearity	E_{LIN}	Over full range of I_P	–	1.5	–	%
Symmetry	E_{SYM}	Over full range of I_P	98	100	102	%
Zero Current Output Voltage	$V_{IOUT(Q)}$	Bidirectional; I_P = 0 A, T_A = 25°C	–	V_{CC} × 0.5	–	V
Power-On Time	t_{PO}	Output reaches 90% of steady-state level, T_J = 25°C, 20 A present on leadframe	–	35	–	μs
Magnetic Coupling [2]			–	12	–	G/A
Internal Filter Resistance [3]	$R_{F(INT)}$			1.7		kΩ

[1] Device may be operated at higher primary current levels, I_P, and ambient, T_A, and internal leadframe temperatures, T_A, provided that the Maximum Junction Temperature, T_J(max), is not exceeded.

[2] 1G = 0.1 mT.

[3] $R_{F(INT)}$ forms an RC circuit via the FILTER pin.

COMMON THERMAL CHARACTERISTICS [1]

Characteristic	Symbol	Test Conditions	Min.	Typ.	Max.	Units
Operating Internal Leadframe Temperature	T_A	E range	–40	–	85	°C
Characteristic	**Symbol**	**Test Conditions**			**Value**	**Units**
Junction-to-Lead Thermal Resistance [2]	$R_{θJL}$	Mounted on the Allegro ASEK 712 evaluation board			5	°C/W
Junction-to-Ambient Thermal Resistance	$R_{θJA}$	Mounted on the Allegro 85-0322 evaluation board, includes the power consumed by the board			23	°C/W

Table 4: Table 3: current sensor internal design and specifications

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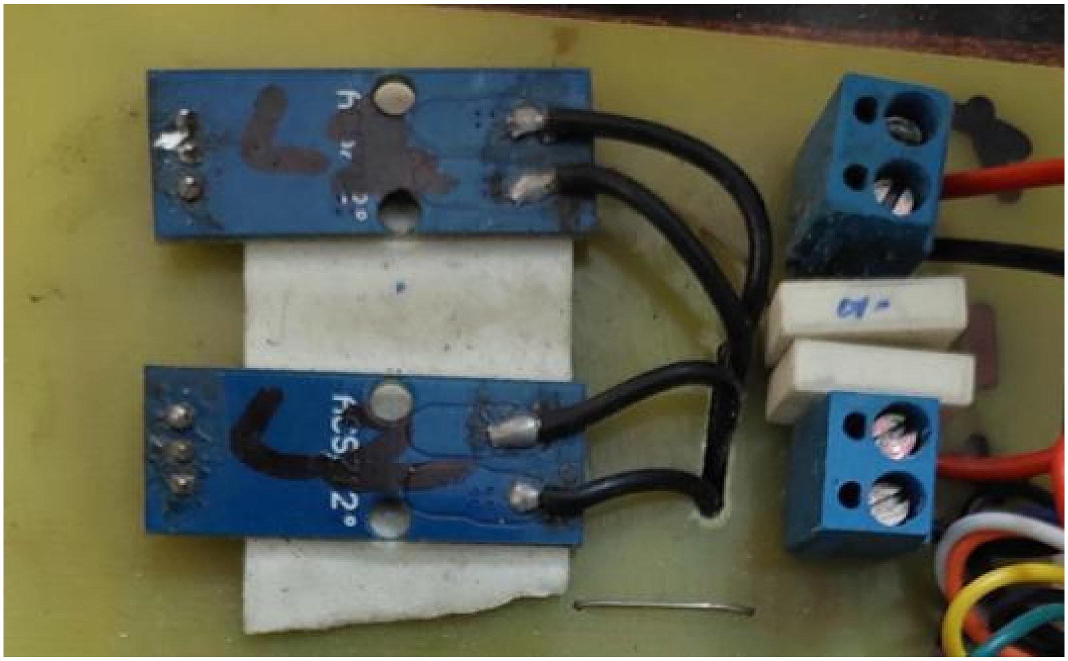

5.6.2 Circuit Usability:

Figure 24: current sensor on hardware

5.6.3 Purpose of the ACS712 Current Sensor

Now that we've gotten a taste of what the ACS712 can do, we'll look at how it works. When it comes to how a current sensor operates, there are two options: directly or indirectly. The ACS712 uses indirect sensing to its advantage.

• When a flowing current is recognized by direct-sensing current sensors, ohm's law is utilized to calculate the voltage drop.

A simplified explanation of how the ACS712 work is as follows:

• Current flows through the inbuilt hall sensor circuit in its IC, which monitors incoming current by generating a magnetic field.

When a magnetic field is detected, the Hall Effect sensor generates a voltage proportional to the field, which is then used to determine the current.”

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5.6.4 Current Sensor Applications

We've already gained a wide understanding of the applications for present sensors. There are a variety of uses for the ACS712, which can detect both AC and DC current, in addition to electrical equipment.

Compatible with Arduino, other microcontrollers, and a wide range of other commercial and industrial projects, as well as communication systems.

A list of common applications is provided below:

• Detection and management of electrical loads • Controlling the speed of a motor in a motor control circuit

• Power supplies with a switchable mode (SMPS)

• Over-current protection

5.7 Relay

In our project, we employ two JQC-3F (T73)-6VDc-1ZS relays that operate in the third and fourth modes. In our project, these two relays serve as cut-off switches. They operate in such a way that when both power transmission modes are turned off, the function of the two relays is activated.

5.7.1 Function of Relays

A power relay module is activated by an electromagnet, which is a switch. A microcontroller-generated low-power signal is utilized to activate the magnets. To open or shut a circuit, the magnetic exerts force when it is activated.

The major reason behind employing relays in our project is to implement switching. With the help of current sensor and Arduino, we obtain our power flow condition between two houses by feeding 120Volts from the FLYBACK converter into relays and then using MOSFET to achieve our power flow condition between two houses

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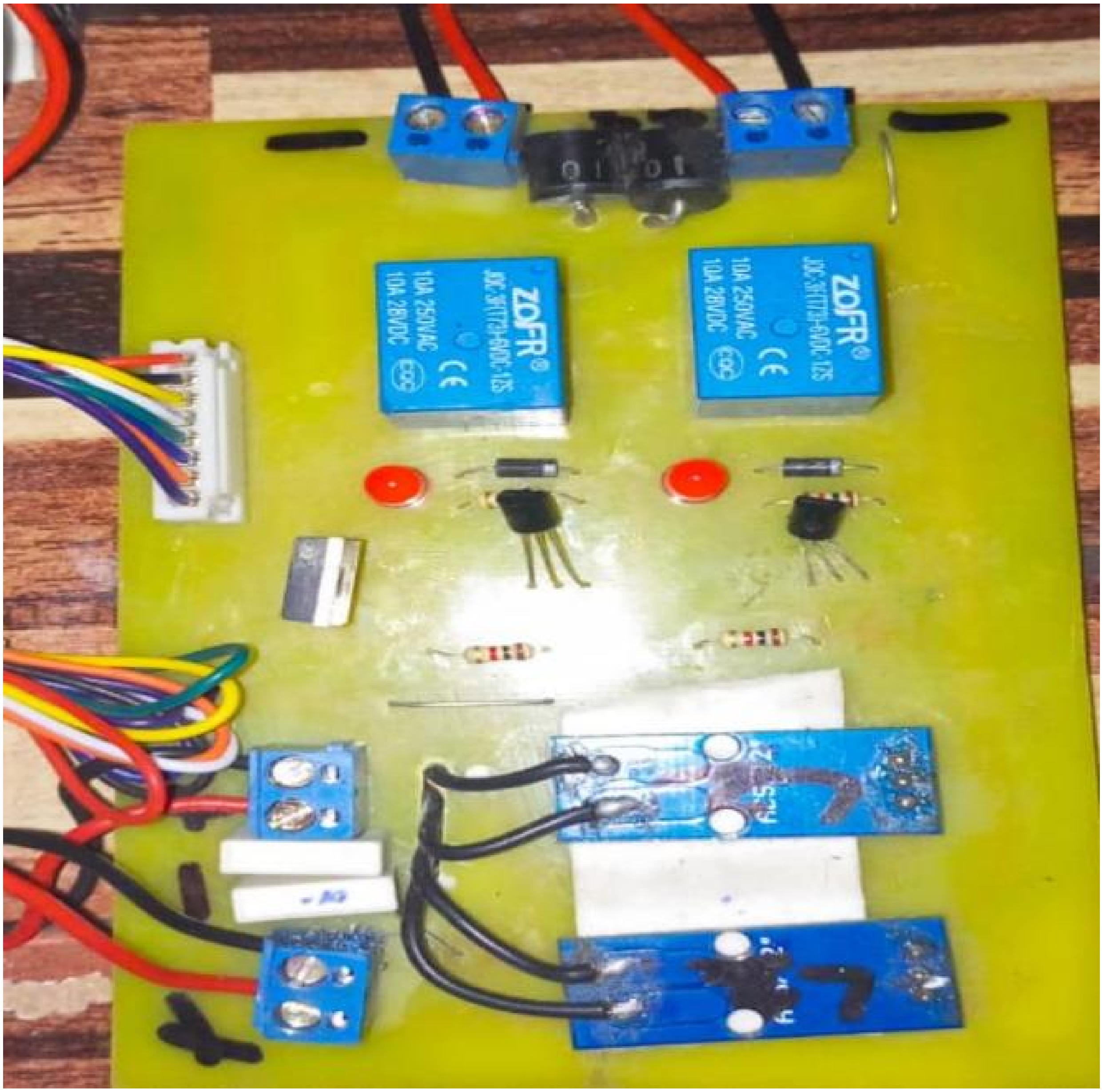

Figure 25: RELAYS

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PCB Relay—JQC-3F(T73)

Order Model

JQC-3F 1C DC12V

- Coil Voltage:3,5,6,9,12,24VDC
- Contanct Form:1A 1C
- Relay Type

Contact Data

Contact Form	1A,1C
Contact Material	AgCdO
Contact Resistance	≤100MΩ(1A 6VDC)
Max Switching Current	10A
Rated Load	10A 250VAC/30VDC

Coil Specificaton

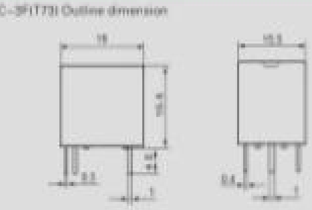
Coil Voltage	3~24VDC
Coil Power	0.36W,0.45W

Technical Specification

Insulation Resistance	≥100MΩ(500VDC)
Dielectric Strength (Between coil and Contact)	≥1000VAC
Operate Time	≤10ms
Release Time	≤5ms
Mechanical Life	1×10^7
Electrical Life	1×10^5
Install Mode	PCB
Weight	10g

Dimension / Mounting holes / Wiring dragram

JQC-3F(T73) Outline dimension



JQC-3F(T73) Mounting holes (Bottom view)

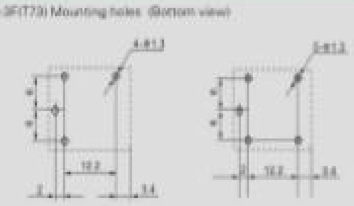


Table 5: Relay specification

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Pin No.	Function	Name
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	Vcc
3	Adjusting the contrast is best done with a variable resistor, such as a potentiometer. This pin is connected to the potentiometer's output. To adjust the LCD contrast, move the potentiometer knob forward and backward.	Vo / VEE
4	When the command register is low, it selects the data register, and when the command register is high, it selects the data register.	RS (Register Select)
5	To write to the register at a low level; To read from the register at a high level	Read/write
6	When a high to low pulse is given, data is sent to data pins; The EN (enable) signal is utilized to provide the extra voltage push required to execute the instruction. Normally, we set En=0, then raise it to En=1 for a few milliseconds when we wish to execute the instruction. After that, we make it ground again, using En=0.	Enable

5.8 LCD Display 16x2

Liquid Crystal Display (LCD) screens may be seen all over the place. The time is displayed on computers, calculators, television sets, mobile phones, and digital watches using some type of display.

Table 6: LCD 16X2 specification

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7	8-bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	LED Backlight VCC (5V)	Led+
16	LED Backlight Ground (0V)	Led-

An LCD screen is an electrical display module that generates a visible image using liquid crystal. The 162

LCD display is a fairly basic module that can be found in many DIY projects and circuits. The 162

corresponds to a two-line display with 16 characters per line. Each character is presented in a 5x7 pixel matrix on this LCD.

5.8.1 Displaying Custom Characters on 16X2 LCD

Creating custom characters on an LCD panel isn't that tough. A knowledge of LCD custom generated random access memory (CG-RAM) and LCD chip controller is required to do this procedure. It is a common controller for LCDs, the Hitachi HD4478.

CG-RAM is an integral part of developing custom characters. After putting them in the code, the characters are saved for future use. As the CG-RAM has a memory capacity of 64 bytes, eight characters may be generated simultaneously. Each character has a byte count of eight.

Addresses for CG-RAM begin at 0x40 in hexadecimal (64 in decimal). We're able to produce custom characters for you at these IP addresses, too. Once we've produced our characters at these locations, we can simply send instructions to the LCD to print them. The character addresses and printing instructions may be found below.


L:0W B:70% V:121
L:0W B:63% V:112

CHAPTER 6: RESULTS AND DISCUSSIONS

6.1 Results

The results of the hardware and the voltage appear at the outputs of Solar, SEPIC, FLYBACK and at load are shown below respectively

6.1.1 Basic values

Figure 26: Readings on LCD display

This will happen when there are not any load connected to the output terminal so the value of the power is zero at both side of the system. Then the value of voltage at each side is shown by alphabet (V).

6.1.2 Output voltage of panel

Figure 27: Panel Voltage on display

When Solar panel is placed in Sun light then that will show us this output voltage.

6.1.3 Output voltage of SEPIC converter

Figure 28: Output voltage of SEPIC

When voltage from Solar panel of around (8-18) volts enters to SEPIC then from SEPIC

voltage of 12 volts comes out.

6.1.4 Output voltage of FLYBACK converter

Figure 29: Output voltage of FLYBACK

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Conclusion:

In the end we have concluded that with the use of converters we can design the systems which can be operated with the green energy or renewable energy resources like solar panels and

interlinked to each other for the sake of power sharing. This could be responsible for smooth and continuous power flow among systems. We also have learnt that how could we achieve a high

level voltage from low level.

The purpose of this project was to make a system which could transfer power from house A to house B depending on the load conditions. For this purpose, we installed two PV system of

power 20-30W of each in two different houses in which batteries of 12V of each house were

charged by using SEPIC converter which works as a charge controller. Similarly for increasing voltage from 12V to 120V FLYBACK converter had used. At the end, relays and MOSFET were

used for bidirectional switching which mainly transfer power from house A to house B and vice versa. In short, by the use of converters we can design the systems which can be operated with the green energy or renewable energy resources like solar panels and interlinked to each other for the sake of power sharing. This could be responsible for smooth and continuous power flow

among systems. We also have learnt that how could we achieve a high-level voltage from low

level. This type of projects can play a vital role in the society for managing and all-time availability of power with the backup of batteries. This type of projects can play a vital role in the society for managing and all time availability of power with the backup of batteries.

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