DE-40(DEE)

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NUST COLLEGE OF

ELECTRICAL AND MECHANICAL ENGINEERING

SWITCH MODE CHARGER

A PROJECT REPORT

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Submitted by

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ABSTRACT

A power supply is an essential part of almost every electronic device and the current trend is towards the miniaturization of these devices. It is thus desirable to also attempt to reduce the size of the power supply and it is possible to achieve this objective by increasing the power density which is attainable by decreasing the size of the passive/energy storage components such as the inductors, capacitors and the transformer. The size of these components can also be decreased by increasing the switching frequencies. Linear power supplies use bulky line frequency transformers and heat sinks and are thus not capable of providing a significant opportunity to reduce their size and weight. Switch Mode Power Supplies (SMPS) use higher switching frequencies, which replaces the bulky line frequency magnetics by smaller high frequency magnetics which are then able to offer significant size and weight reductions. The efficiency and size of the SMPS depends on a suitable switching frequency. Previously, the SMPS were implemented using bipolar power devices and their switching frequency range was limited to a range of a few kHz. With the availability of modern and efficient power MOSFETs, it is possible to switch the SMPS from several kHz to a MHz range. In addition, core based transformers were previously used in SMPS. These transformers have hysteresis and eddy current losses. Their switching frequency was limited to several hundreds of kHz. Recent research has produced energy efficient multilayered PCB transformers which can be implemented in SMPS for power and signal transfer applications, in the MHz frequency range. Thus, with the emerging power devices in GaN and SiC technology and the development of high frequency multilayered PCB power transformers, it is now possible to design high frequency and power efficient isolated converters. The focus of the research is to design, implement and evaluate energy efficient AC-DC and DC-DC isolated converter topologies. These converters are designed by using the latest power electronic devices and PCB transformers. They are switched in the MHz frequency range. In this thesis, two DC-DC converters, half bridge and full bridge, are designed, implemented and evaluated. These converters are switched in the MHz frequency range. The energy efficiency of the converter is measured and analyzed by varying different circuit parameters. Feedback analysis is made in the case of the Half Bridge converter. The opto-coupler and auxiliary feedback techniques are implemented, measured and analyzed in a high frequency half bridge converter using a PCB power transformer. The feasibility of the feedback signal, using the auxiliary winding of a PCB power transformer, is discussed. The multilayered PCB transformers used in the converter circuits have provided a major contribution with regards to both the energy efficiency and size compactness. This research work is a initial step in the design, implementation and analysis of SMPS operating in the MHz frequency region, using PCB transformers.

ABBREVIATIONSANDACRONYMS

AC ....AlternatingCurrent

ADC ....AnaloguetoDigitalConverter

CTR ....CurrentTransferRatio

FR4.................................FlameRetardent4

DC ....DirectCurrent

EMC ....ElectroMagneticCompatibility

EMI ....ElectroMagneticInterference

HEMT ....HighElectronMobilityTransistors

IR....................................Infra-Red

GaN ....GalliumNitride

LED ....LightEmittingDiode

MOSFET ....MetalOxideSemiconductorFieldEffectTransistor

PCB ....PrintedCircuitBoard

PWM ....PulseWidthModulation

SiC..................................SiliconCarbide

SMPS..............................SwitchModePowerSupplies

ZVS ....ZeroVoltageSwitching

CHAPTER 1:INTRODUCTION

Switch-mode charger, how to use it, and what to expect. A switch mode charger rectifies AC voltage before converting it to a lower DC voltage via a DC/DC converter. A charger of this type has extra charge control circuitry to modify current flow into the battery. The charge control governs how the power switch turns on and off and can be performed using a circuit, a specific integrated chip, or some sort of software control.

A typical buck switch-mode charger will have four FETs to control charging and power path. When an input is detected, the first FET turns on and acts as a resistor.The FETs connected between [INAUDIBLE] and ground operate as a switch-mode buck converter, producing a switching waveform at SW node. This voltage passes through a low-pass LC filter, producing a DC output at sys, used to power the system.The last FET acts as an LDO or a FET, depending on battery and sys voltage,and controls the current delivered into the battery.

In summary, a buck switch-mode charger offers a flexible design with the capabilityof future growth for current. It can maintain a high efficiency, around 90%,even at high conversion ratios and charge currents, resulting in a reduced temperature rise for the charging device.

Given the versatility of buck chargers, it should be no surprise that theycan be found in a wide range of applications, such as gaming controllers, cell phones, and even portable power banks. Buck switch-mode charger can be powered by a dedicated AC/DC adapter, a standard 5-volt USB source, a USB-PD source, or even a wireless input power source.

It can be used with different battery configurations, such as 1S or 2S, provided that the input is above the target charge voltage.Typically, these solutions work for charging handheld products at up to 2 and 1/2 amps, due to thermal limitations. But this is highly dependent on system design.And this circuit could offer higher charge currents for different applications.

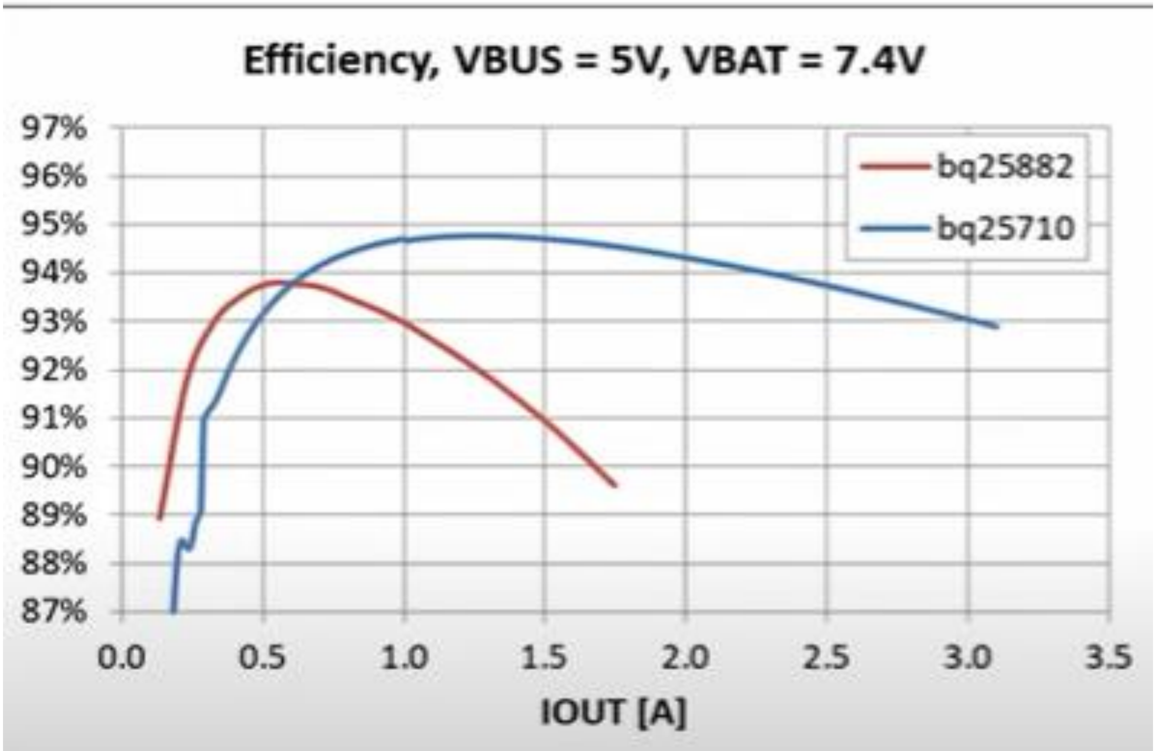
The solution can be implemented in around 70 millimeterssquared and achieves efficiencies above 90%, which can be scaled to different charge currents. A buck charger offersgood thermal performance and the design flexibility to grow in future generations without changing the architecture.

It is planned to use a switch-mode Li-ion battery charger. In the current generation of gadgets, it is suited for the input power supply of a wall adapter or USB port. When powered via a USB port, its input current is automatically restricted to a predetermined value. A power-path management system is used to enable charging and power delivery at the same time based on load priority. In switch mode controller, it also achieves a seamless transition from constant current charging to constant voltage charging.

to create a universal charging solution, the buck-boost charger. The buck-boost battery charge controller utilizes four switching FETs, along with a battery FET, in order to charge a battery that is either below or above the input voltage. This is accomplished by effortlessly transitioning between buck and boost modes of operation based on input and output voltage levels. In buck mode, high drive 1 and low drive 1are switching signals, while high drive 2 is on all the time. In boost mode, high drive 1 is on all the time. And high drive 2 and low drive 2 are the switching signals. This is a truly universal charging solution since it can charge a battery stack anywhere from 1S to 4S from an input voltage anywhere from 5 volts to 20 volts.

Since this is a charge controller, external FETs are required. And their choice means that efficiency is easily scalable for different powers.Now, because external components are required, this creates a larger PCB footprint, around 600 millimeters squared, and increases the complexity for the system design. Because of its versatility, this charger may be utilized in a variety of applications, including robotic vacuum cleaners, drones, and even laptop computers.

The graph below compares the efficiency of the boost and buck-boost chargers. It is clear that the buck-boost can achieve higher efficiency and higher charge currents for the same conversion ratio.But the trade-off here is circuit size and complexity. The boost converter incorporates all switching and sensing FETs to provide a simple compact charger capable of charging a two-cell battery stack from a conventional 5-volt, 3-amp input.



The buck-boost charger can charge one-cell up to four-cell battery stacks, with up to 100 watts from a dedicated adapter or a standard USB PD source, which can provide from 5 volts to 20 volts [INAUDIBLE] up to 5 amps. The complete charger solution requires 600 millimeters squared PCB footprint and can achieve around 94% efficiency. This device offers a universal charging solution for wide-range input and output voltage levels.

Charger summary

Topology	Source	VBAT	ICHG	Results	Special value
Linear	Adapter, USB 5V	1S	<1A	$12mm^2$ I_{BAT} = 0.4µA	Smallest PCB size and I_Q, no switching noise
Buck switch-mode	Adapter, USB 5V, USB-PD, wireless	1S, 2S	<1A to 2.5A	~$70mm^2$ η ~ 91%, scalable	Good thermal, design for power growth
Three-Level buck switch-mode	Adapter, USB5V, USB-PD, wireless	1S	2.5A to 4A	~$56mm^2$ η ~ 95%, scalable	Excellent thermal, high charge current
Direct charger	USB-PD PPS: 20mV / 50mA steps	1S	3.5A to 8A	~65 – $75mm^2$ η ~ 97%+	Best thermal, highest charge current
Dual Charger	Adapter, USB5V, USB-PD, PPS	1S	≥2.5A to 8A	~126 – $145mm^2$ η ~ 95%, scalable	Combine different topologies for flexibility
Boost switch-mode	Adapter, USB-5V	2S	<2A	$133mm^2$ η ~ 93%	Higher power loads with simple & integrated boost
Buck-Boost Switch-Mode	USB PD: 5V – 20V, 100W max	1S – 4S	<3A (2S)	$600mm^2$ η ~ 94% (5Vin, 2S)	Universal charging for wide-range input / output

1.1 Literature Review:

A switch mode charger (also known as a high frequency charger) may interact with a battery management system to regulate and monitor the charging process. The charging process is handled by the battery management system rather than the charger, which increases system security. This method of communication, which is typically utilised for lithium batteries, is not available in all chargers.]

1.1.1 Battery Chargers and Charging Methods:

There is three key functions of chargers:

- Recharge the battery (Charging)
- Improving the charging rate (Stabilizing)
- Recognizing when to stop (Terminating)

1.1.2 Charge Termination

The charging current must be dissipated in some way when the battery is fully charged. The consequence is heat and gas obstetrics, both of which are harmful for batteries. The capacity to determine when the reconstitution of the active chemicals is complete and to terminate the charging process before any harm is done, while keeping the cell temperature below safe limits, is at the heart of successful charging. It is vital to detect this cut off point and terminate the charging in order to preserve battery life.

1.1.3 Safe Charging

If there is a possibility of overcharging the battery, either due to errors in establishing the cutoff point, this is usually related to a rise in temperature. High temperatures hasten the death of batteries, therefore monitoring cell temperature is an effective method of identifying indicators of concern for a variety of reasons. To avoid damaging the battery, the temperature signal or a resettable fuse can be utilized to cut off or disconnect the charger when problem symptoms occur.

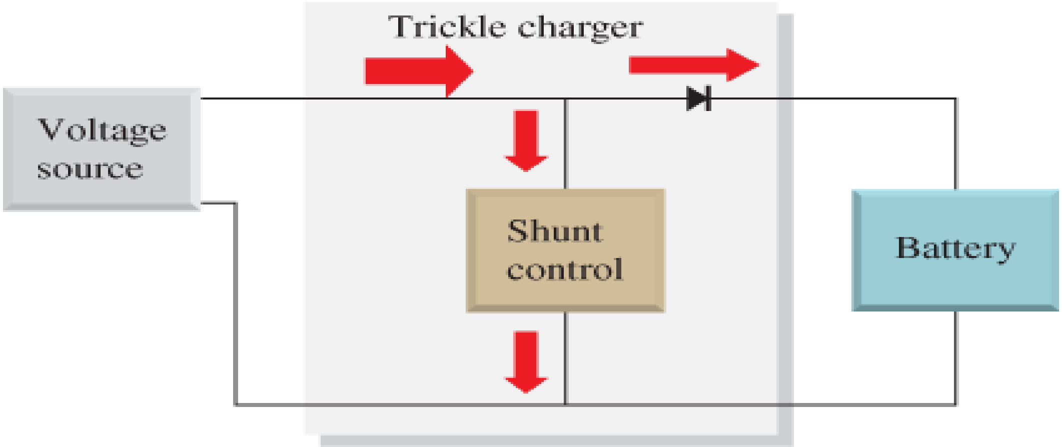
1.1.4 Charge Efficiency:

This relates to the battery's qualities and is independent of the charger. It is the ratio of the energy withdrawn from a battery during discharge to the energy necessary to restore the original capacity during charging.

1.1.5 Basic Charging Methods:

1.1.5.1 Trickle charge:

Trickle charging is intended to compensate for battery self-discharge. Charge indefinitely. Long-term constant current charging for use in suspension. The charge rate varies depending on the frequency of discharge. When the battery is fully charged, certain chargers are programmed to switch to trickle charging.

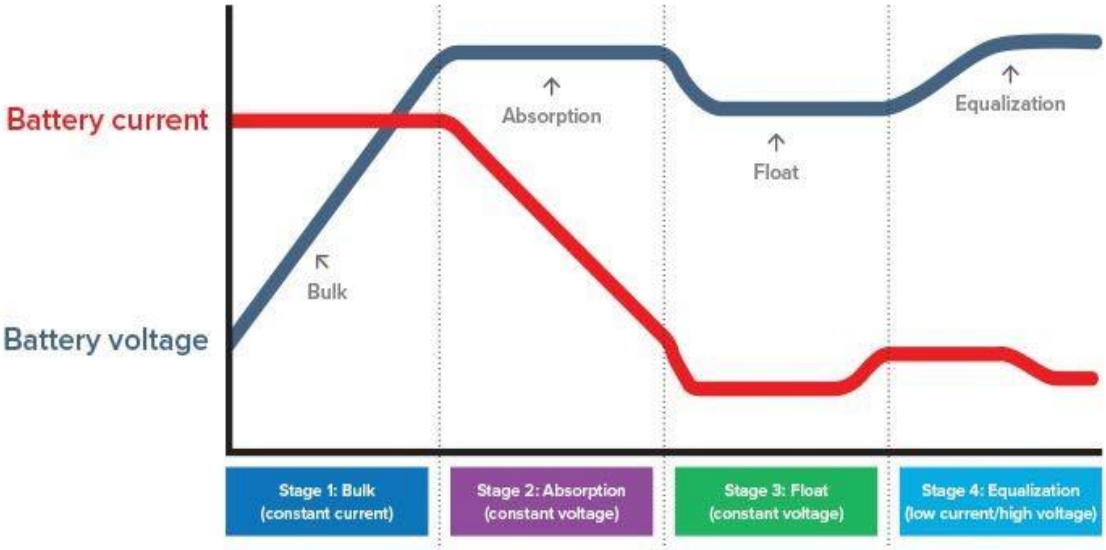


1.1.5.2 Float charge:

The battery and load are always linked in parallel across the DC charging source and kept at a constant voltage lower than the battery's top voltage limit. Used to assist emergency power systems. Most commonly used with lead acid batteries.

1.1.5.3 Random charging:

All of the above uses require a regulated charge of the battery, however there are several applications in which the energy to charge the battery is only accessible in an uncontrolled and random manner. This is true for automotive applications where energy is dependent on engine speed, which is continually changing. The issue is exacerbated in EV and HEV systems that employ regenerative braking, as this causes high power spikes during braking that the battery must endure. Solar panel systems, which can only be charged when the sun shines, are a more benign application. All of these necessitate the use of specialized procedures to limit the charging current or voltage to limits that the battery can tolerate.



1.2 Previous Research:

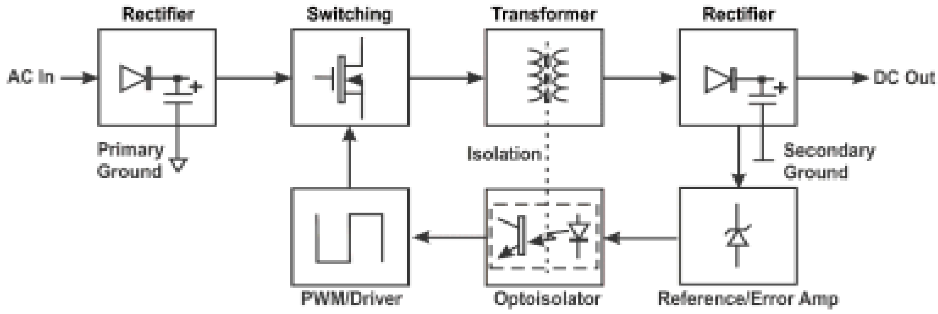
1.2.1 Switch Mode Power Supplies in MHz Frequency Region

Previously, SMPS were implemented using bipolar power devices, and their switching frequency range was restricted to hundreds of kHz. It is now feasible to switch the SMPS from several kHz to an MHz range using contemporary and efficient power MOSFETs. In addition, core-based transformers were employed in SMPS. Addy current and hysteresis losses were seen in these transformers. In recent experiments, multilayer transformers utilised in SMPS yielded efficient results despite their switching frequencies being restricted to hundreds of kHz. The primary goal of this research is to develop, implement, and test energy-efficient DC-DC and AC-DC isolated converter topologies. These converters are built with the most recent power electrical components and PCB transformers. Now the frequency range is switched to MHz from kHz.

Two DC-DC converters, half bridge and full bridge, are developed, implemented, and used in this study. MHz frequencies are employed in these converters. Different components are also employed, as well as feedback loop analysis. Aside from optocoupler and feedback loop control,

A transformer with a high frequency An isolated type is used to insulate the output from the input, monitor the size of the output voltage with turn ratio, and generate numerous DC outputs. Large step down or step up ratios may be produced in converters with the use of a transformer. Voltage/current strains on transistors and diodes can be reduced by selecting the suitable transformer turn ratio.

1.2.2BLOCK DIAGRAM



Block diagram of switch mode power supply

1.2.3 Automatic Switch-Off Battery Charger

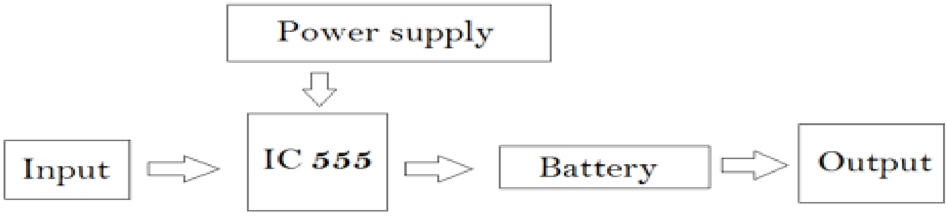
The goal of this project was to create an automated battery charger. A Ni-Cd battery charger is seen here. An auto turn off battery charger will continue charging the battery automatically until it is completely charged, at which point it will shut off on its own. Rechargeable batteries store electricity for later use and can be readily replenished when the energy is depleted. The goal of this project is to design and build an electronic gadget that will provide electrical charges (energy) to a battery. During the resting stage of charging, the developed gadget contains a circuit that performs charging and displays the battery charge level via LED.

This project attempted to include technology to reduce the continual loss of electricity that occurs without human intervention. The term 'auto' refers to a battery charger that is automatically regulated. Overcharging batteries not only shortens their life but also poses a major risk to humans. The proposal is nearly entirely based on the automation of battery charging. Everyone is responsible for preserving energy resources. Electricity is a created energy source. The expansion of human-populated communities has resulted in the loss of authority in modern times.

1.2.4 SYSTEM OVERVIEW

The auto turn off battery charger can automatically control the flow of electricity to the electronic gadget during charging. The auto turn-off battery charger for Ni-Cd batteries that may be recharged spontaneously disconnects to cease charging when the battery is fully charged. It can even charge partly discharged batteries.

1.2.5 Block diagram of charging



1.3Related Projects:

There are many related projects for the charging purpose and charging types such as:

1.3.1 Cell Phone Charger:

In today's market, mobile phone chargers come with a variety of power supplies. One of the projects in mobile phone chargers is the creation of a circuit that will be used to obtain a 5V regulated DC supply from a 220V AC source. The same circuit may be used to power the other devices, such as microcontrollers and ICs.

Basically, there are three steps that is involved in making a cell phone charger:

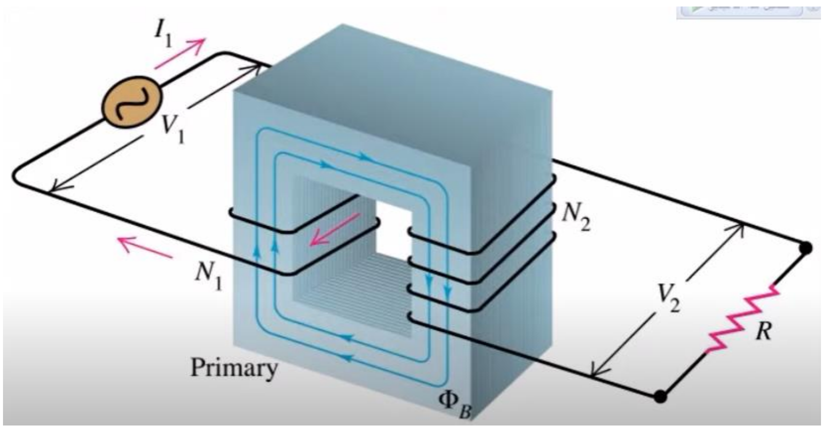
- The first stage is to reduce the 220V AC supply to a low voltage.
- The second step is to convert the AC to DC using a full wave bridge rectifier.
- Because the DC voltage obtained in the second stage contains AC ripple, it is eliminated using the filtration process. The next stage is voltage regulation, which is accomplished by using an IC 7805 to create a 5 volt controlled DC supply.

1.3.2 Laptop Charger

A laptop charger is an AC DC power adapter intended to receive a certain AC input and convert it to a specific DC output; the key is to match the adapter's DC output to the laptop's DC input. DC adapters are used with electrical devices that need electricity but do not have internal components. They require voltage and power from the mains.

An AC-DC charger now consists of three parts: a power cable, an AC power adapter, and an adapter plug. The AC power adapter consists of a core unit that receives power from an outlet and a second cord that connects into the computer. What we're interested in is the physics behind the central unit inside, which contains a transformer, four diodes in a bridge rectifier, and an electrolyte capacitor to smooth the waveform. The transformer's purpose is to convert one alternating current voltage to another alternating current voltage.

If the secondary path has the same number of turns as the primary, the voltage in the secondary will be half that of the primary. It is well known that the primary in this specific transformer utilizes extremely small wire while the secondary uses considerably thicker wire to drop down to 19.5 volts. The main must have six times the number of turns as the secondary.



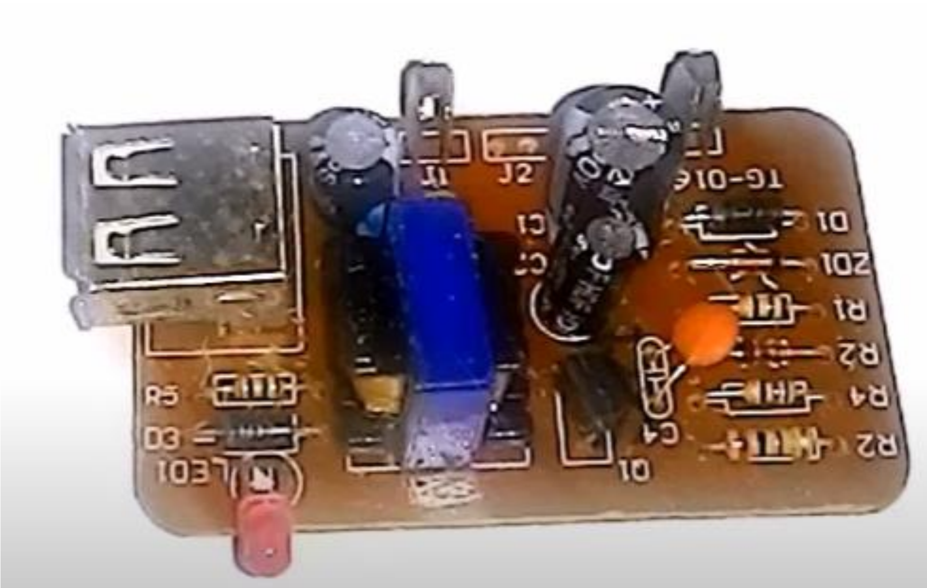
1.3.3 Secondary

On the other side of the transformer, there are two diodes covered in rubber insulation. The diodes operate as a rectifier, converting the alternating current to direct current, resulting in the same polarity of output for either polarity of input.

Now the topic of why they are heated when in use arises. This is because when they convert energy, part of it is squandered and generates heat. On the other hand, when we discuss power in our electronics, we must first define voltage and current. Voltage is measured in volts, current is measured in amps, and resistance is measured in ohms.

The power adapter displays voltage in amps but not resistance. Because of the power rating and the kind of plug on the end, an AC adapter is not universal and can only be used with devices that have the same requirements and connector. Tweaking any of these three variables increases or decreases the amount of electrical power sent to the laptop.

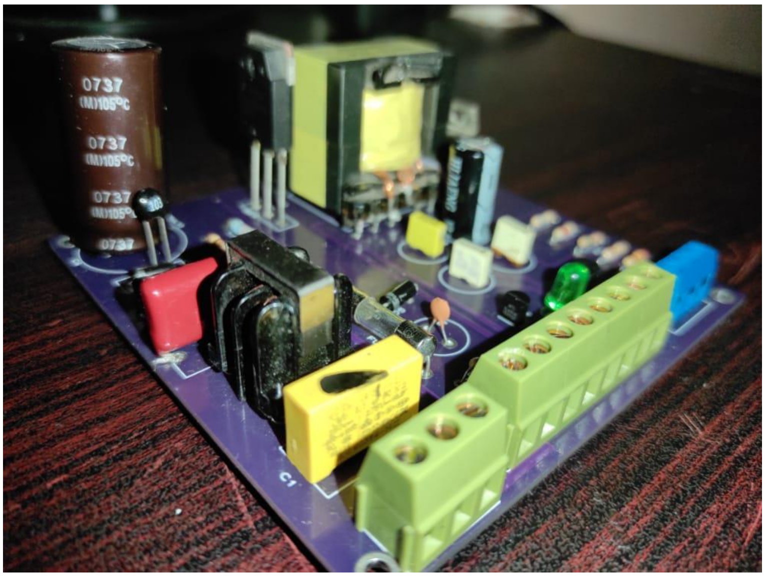
It is significant because insufficient power means the laptop will not charge or run properly, whereas insufficient power causes excessive heat, which is the devil of delicate electronics. We can find power by multiplying the voltage by the current, but the number of watts alone will not tell you if the adapter is right for the device, but it will tell you how much power your lab needs to work. So voltage has nineteen point five volts times current as 2.31 amps gives a good estimate as measured with the kilowatt having forty eight point seven watts.



Chapter 2:Design and Modeling

This chapter includes components detail, and PCB design of Switch Mode Charger.

2.1 Hardware:



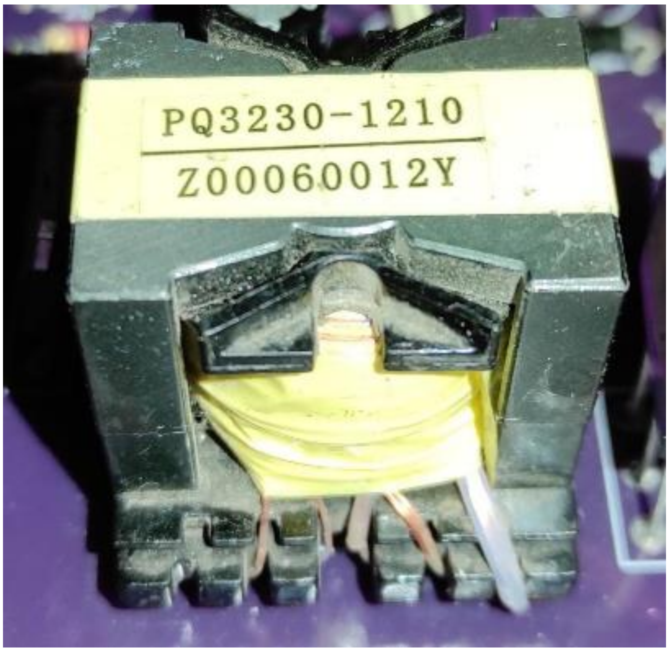
We tried our best to minimize the size of hardware. The size of our switch Mode charger is 4 by 4 inches. We have tested each component and before going into process of soldering. We have made a two layered PCB in order to minimize the size of hardware , decrease the path length and thus to work in efficient way.

2.1.1 Components:

These are the brief detail of each component hat we have used in our Switch Mode Charger,

2.1.2 Flyback Transformer:

We have used flyback transformer **PQ 3230in** our project.



Fly back transformer is a high frequency transformer, as fly back transformer works on high frequency, it makes the size of transformer smaller than the ordinary transformer.

As by the relation:

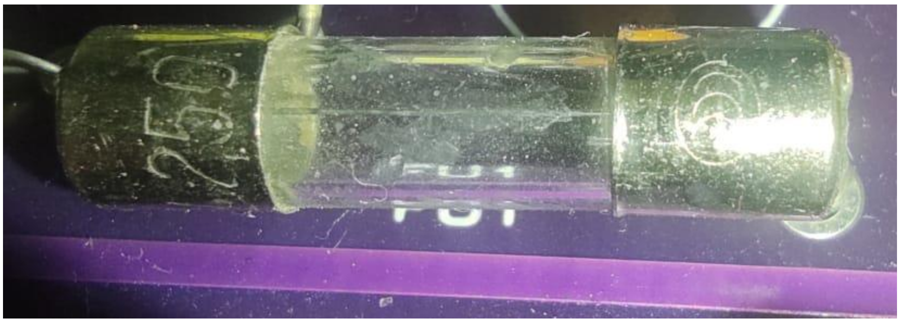
Xc= 1/(2 pie Fc)

Flyback transformer is more efficient than ordinary transformer, ordinary transformer efficiency is expected to be 30 to 40 percent, but the flyback transformer has an approximately efficiency of 85 to 90 percent

Flyback transformer gives a compact design to our Switch mode Charger as it decrease the size, takes less place and is much lighter in weight as compared to ordinary transformer.

2.1.3Protecting Fuse:

Wehave used a fuse (3amp 250 volts) for the purpose of protection.



Fuse in our project serve the initial protection for Switch Mode Charger. It will save the circuit board from any heavy loss, if there is any technical fault by manufacture in the board or some fluctuation in the voltage than the fuse will break.

2.1.4X2 Capacitor:

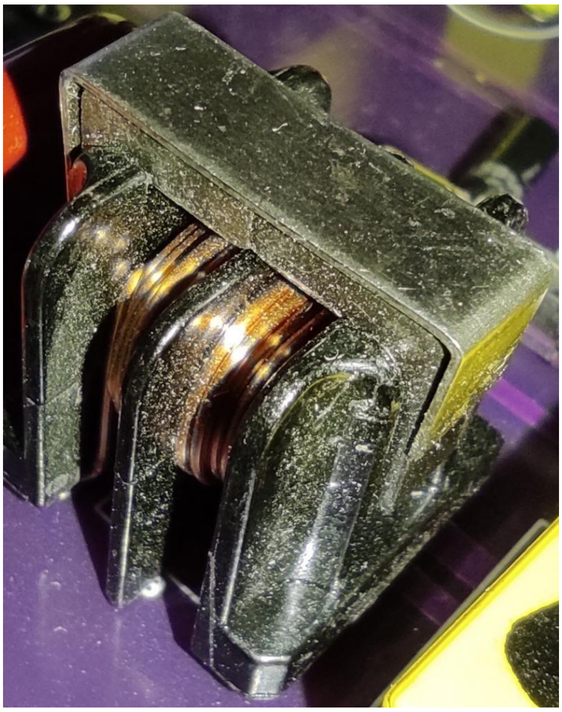
We have used **GS-L 0.1UF(K) X2 250V** capacitor in Switch mode charger

The position of this capacitor is right after the fuse , it has high reliability to prevent active and passive flammability, strong self healing , high voltage strength, low capacity fading, low impedance and strong interference suppression. The operation temperature can reach more than 110 degree C.

This X2 capacitor is an AC capacitor, as we are dealing with AC voltages initially, so we have used this capacitor.

2.1.5 EMI filter:

we have used an EMI filter for the purpose of to make the input AC waveform clean.



An EMI filter usually contains capacitor and inductor connected to form LC circuits. The purpose of inductor is to pass DC or low frequency currents while it stops very high frequency current content.

2.1.6 Metalized polypropylene film capacitor:

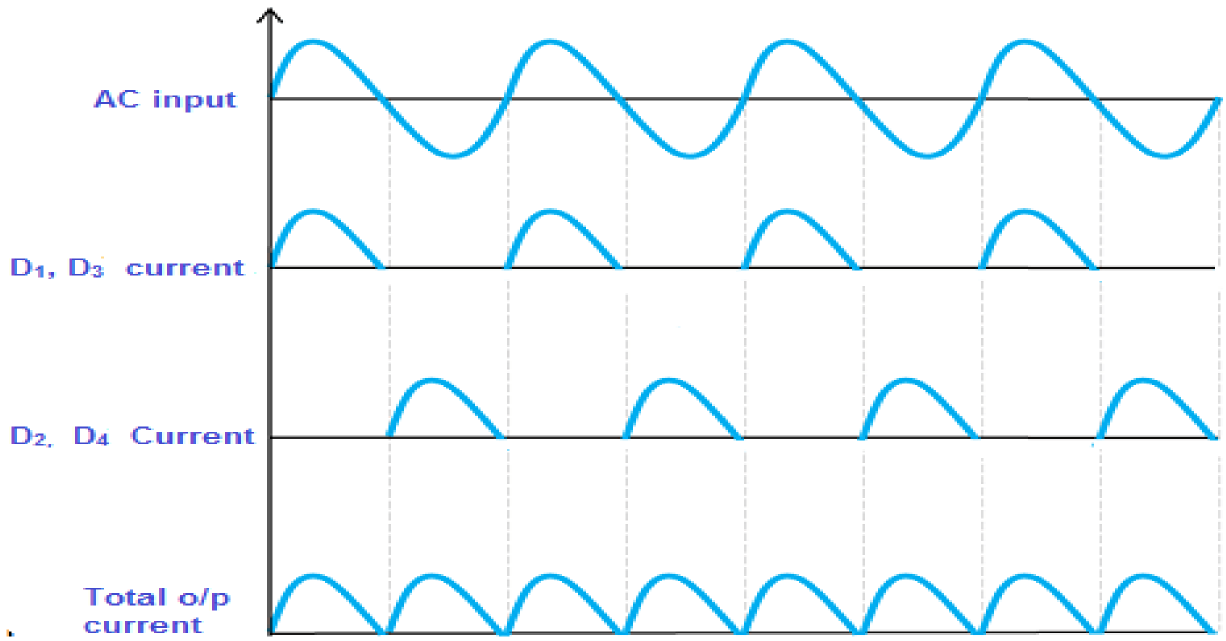
We have used ***Cbb22 105j400V Capacitor*** RC Buck LED Bulb Dedicated · Type: Film capacitor -Deviation: ±5% (J) ±10% (K) as Metallized polypropylene film capacitor.

Metallized film capacitors are constructed from two metallized films with a dielectric layer of plastic film. To function as electrodes, a very thin (0.03 m) vacuum-deposited aluminium metallization is placed to one or both sides. To deal with the high input voltage, this capacitor is employed as a high voltage capacitor.

2.1.7 Diode Grid:

We have use grid of four diodes, right after the capacitor.

The purpose of diode grid is to do rectification of the AC waveform. These 4 diodes will do full wave rectification to AC signal.The negative part of the waveform will be emitted and thus we will get pulsating DC voltage. The voltage value at this point is still high, almost 400V.

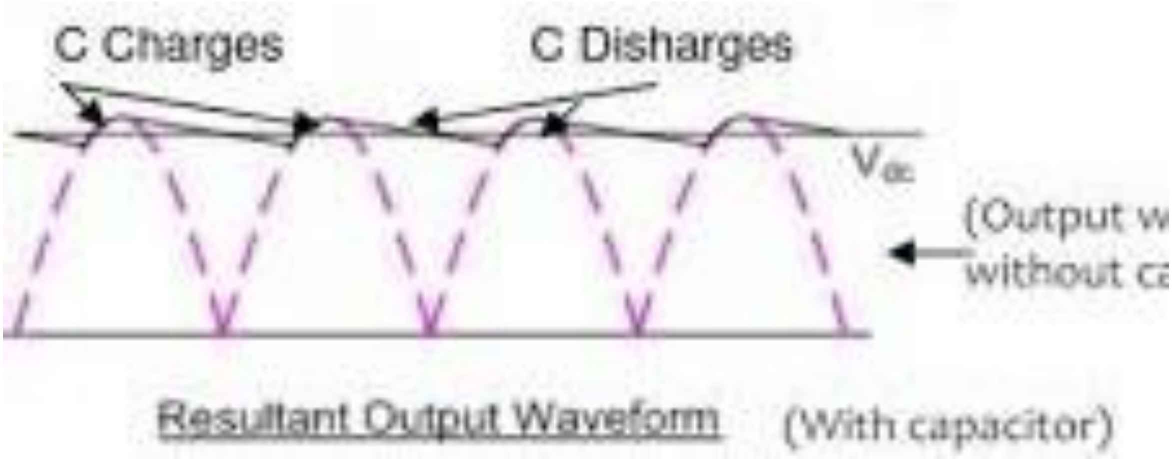


The figure shows how the gird of 4 diodes will work.

2.1.8 High Voltage Capacitor:

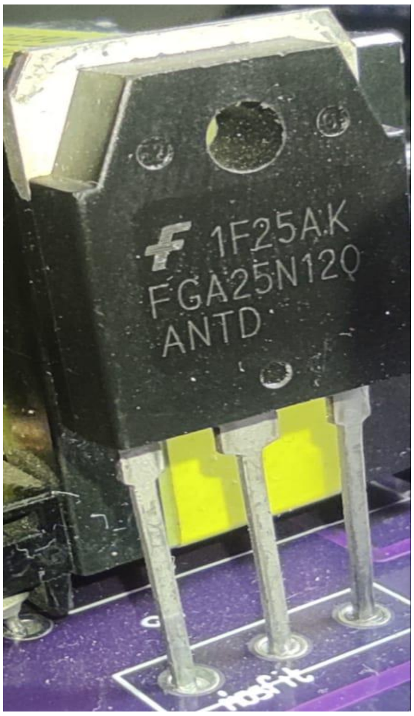
We have used high voltage capacitor of Value 100 micro Farad and 450V

The purpose of using high voltage capacitor is to deal with the high voltage Pulsuating DC which we got after rectification. This high voltage capacitor will get the almost upper smooth layer of high voltage waveform.



2.1.9 Switching Transistor (MOSFET):

We have used switching transistor as MOSFET of **model 1F25AK**



MOSFET has 3 terminals which are drain, gate & source. MOSFETs are easily used for switching applications to control a load. There are 2 types of enhancement mode MOSFETs which are categorized as N-channel & P-channel MOSFET. We will use an N-channel MOSFET to control a load in this video, to turn on a MOSFET we need to provide sufficient gate to source voltage to the MOSFET so that its input capacitor charges & to turn off a MOSFET, we remove gate to source voltage from the MOSFET & discharge the input capacitor. There are a lot of inductive loads which we use in many of our circuits. The best inductive loads are a motor, relays, transformers, and speakers etc. Well, before we jump off to the MOSFET behavior we should know some basics related to the inductors. We have seen the working of inductors in many of my dc-dc converter videos.

Let’s brush up this concept once again. This is the basic diagram of a circuit where MOSFET is used as a low side switch and inductive load is connected to the supply & its other terminal connected to the drain of the MOSFET which controls turning on and off an inductive load. When the gate to source threshold voltage is applied, drain to source voltage goes to zero, current flows through the circuit & MOSFET turns on. but when we remove the gate to source voltage, we see a sudden voltage spike in the drain to source voltage of the MOSFET and this voltage comes back to normal supply voltage and MOSFET turns off. We turn on the MOSFET again in the 2nd pulse, we provide gate to source voltage & drain to source voltage goes to zero. After this, when we turn off the MOSFET, this voltage spike comes again and goes back to normal supply voltage. This behavior keeps repeating at every turn on & turn off cycle. Well, these spikes are present in the waveform for a very short amount of time which are of a very high amplitude and sometimes it goes beyond the safe operating area of the drain to source voltage limitation of the MOSFET and this MOSFET will damage, which will short all the MOSFET terminals within small period of time.

Well, this happens because the inductor opposes the change in current, whenever the MOSFET is turned on or off there is change in the flow of current in the circuit. The inductor stores the electromagnetic energy inside of it. So, when the MOSFET is turned on the current flows through the inductor & when we turn off the MOSFET.

2.1.10 NTC:

We have used NTC of Model **103** in our project.

There are two different groups of Thermistors NTC and PTC so the difference between these two groups is that NTC's they will have a negative temperature coefficient andPTC would have a positive temperature coefficient and so we're going to draw this is going to look something like this just a quick little chart here so we have assistants here and we have temperature here so PTC thermistors could look something like this PTC so starts out at a lower resistance at a lower temperature and then as temperature rises and the resistance will go up and NTC is just exactly the opposite so it will start out at a higher resistance and as the temperature rises the resistance will go down PTC thermistors are often used for example for current limiting so you can use it as a protection many multimeters etc. have PTC's on the inputs for limiting them and typically something like poly fuses then typically it will look more like this so you will have its fairly constant resistance in the PTC and then you will have a sharp rise at a certain temperature so you know that the current is going to be limited and it's going to protect whatever input output you're using at this PTC for okay

So, what I have here is a couple of examples of NTC thermistors get a camera to focus here I think you can see those here, so they are quite different they aredesigned for two completely different purposes this is a very large disc typeand what we have here is a 10k NTC Finisher, so it's typically used fortemperature measurements so it will have a reasonably well controlled change ofresistance over temperature so you can get a reasonably accuratetemperature measurement using one of these this one here is typically usefor limiting in Rus current so power supplies for example if you have largecapacitors for filtering you can put one of these in series and the enrouteinrush current will be limited.

2.1.11 Short-Key Diode:

We have used Short-key Diode of model **LT 9219A.**

Schottky diodes are produced to be used in computers, RF and rectifier applications that need high switching speed to respond to these rapid changes. Like the Silicon diode, which consists of normal doped PN structure, Schottky diode has an anode and a cathode pin. This diode also has a white stripe at the cathode pin. If the current is going from the anode to the cathode, the diode allows the current to flow and prevents it from going in the opposite direction. Here, a question has come to your mind, what is the difference between this diode and a normal silicon diode. So, let's examine the difference one by one. First, let's start with how the symbol of the Schottky diode is. Its symbol is as you see it here. Here's how you can remember the symbol. Instead of a line at the cathode pin of the diode symbol, there is an S-like but angular shape. Schottky diodes are not only produced with two pins, but also with three pins as here. In these diodes, the cathode pins of two Schottky diodes are combined. In other words, there are two Schottky diodes inside these three-pin ones. Looking at the internal structure, these diodes have lower forward voltage drop compared to ordinary silicon PN junction diodes. Normal Silicon diodes consist of combining P-type and N-type doped semiconductors, as here. The junction point, which is the neutral region of the P and N structure, is wide. Schottky diode, on the other hand, consists of combining the N-type doped semiconductor with a metal-clad P-doped semiconductor.

In addition, the junction points in the middle, that is, the neutral zone, is thinned and it is easier for the current to exceed the neutral zone. It consists of a metal/semiconductor combination. Here, the P-type region usually consists of a metal anode such as gold, silver, platinum, tungsten, molybdenum, or chromium. Thus, it can provide conduction at much lower forward voltage levels than normal PN type Silicon diodes. We can compare the two types of diodes as follows. There is a normal PN-shaped diode made of Silicon on the left, and a Schottky diode formed as a Metal/Semiconductor on the right. A voltage between about 0.6V and 0.7V is needed for the normal diode made of silicon on the left to conduct, while a voltage between 0.2V and 0.3V is sufficient for the Schottky diode, which is made up of Metal/Semiconductor combination, to conduct. You may have a question on your mind, friends. You can say what would happen if there was such a small difference.

Now we will look at the advantages of this one by one. Especially in communication systems, operations are carried out with voltages at milli volt levels. Therefore, even such a difference in the systems there is very important. First, let's examine the differences in the power they expend. For example, let's assume that a current of 10A flows through the silicon diode on the left. A voltage value of 0.7V is needed for it to transmit. In other words, 0.7V will be measured on it when it turns on.

If we calculate the power consumed by this diode; It will be a value like 7W from theformula **P=VxI**.

Let a current of 10A flow through the Schottky diode on the right in the same way.

Let's assume that a voltage value of 0.3V is needed for this to transmit. The power consumed by this shock diode will be 3W from the formula **P=VxI**. From these results, we can see that the wasted power value on the Schottky diode is less.

If this power value is in a circuit with higher current, it will create much higher differences.Therefore, the low value of this power, which is wasted on the Schottky diode, will provide an advantage in terms of efficiency.

2.1.12 Low Voltage Capacitor:

We have used a capacitor of low voltage of specification **1000 micro-Farad 25V**

The capacitor is similar to a battery in that both store electrical energy. The capacitor is a much simpler device that cannot produce new electrons but only stores them. However, capacitors can do things that batteries cannot, as we will demonstrate here. For the purposes of this animation, we will focus on different parts of the current propagating through the wires at different times when we close the switch because it discharges much more slowly than a capacitor with the same charge Maintaining an electric field capacitors may be helpful for storing and fast discharging electricity, for example, to power an electric motor, as we'll demonstrate below. First, we must charge the capacitor by shutting the switch. We build a circuit that comprises the capacitor and the battery, and electrons move from the battery to the capacitor, where they are stored. A yellow light reflects the plate's rising charge; for every electron obtained by the negative plate, an electron is lost by the positive plate, keeping the capacitor in balance. The red glow indicates the positive charge maintained by the plate, which grows with each separating electron. The capacitor continues to charge until it reaches the voltage of the battery powering it. We can run a little engine. These electrical currents power the pulley to lift the weight until the charge dissipates. When the electrons on the capacitor's negative terminal are drawn to its positive terminal, they rush along the path that leads straight through the motor. Even though the battery and the capacitor attempted this task with the same amount of charge, only the capacitor successfully powers the motor lifting the weight because it discharges much more quickly.

2.1.13 Low Voltage & Low Capacitance Capacitors:

We have used 3 Capacitors of Low Voltage and Low Capacitance of following models, **2A22k, 104J100, 2A222k.**

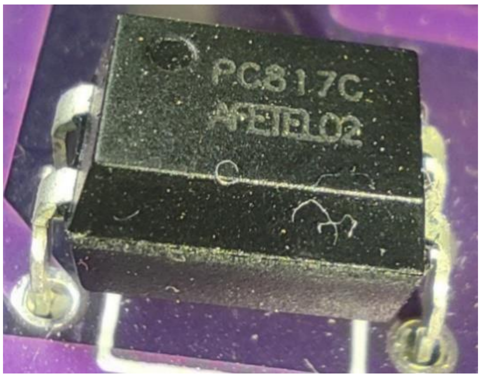
2A222K: Has following characteristics: Capacitance: 2.2nF, 2200pF, 0.0022uF

104J100: Has following characteristics: 100V 104J 0.1 micro Farad

We have used these capacitors to get the filtration of signal after it has passed through the Short-key diode.

2.1.14 Opto-Coupler:

We have used an Opto-Coupler of model **PC817**.



So, this optocoupler is also known as an opt-isolator or photocoupler. So, this optocoupler is the circuit or the component, which optically couples the signal of one circuit to the other circuit. And since two circuits are coupled optically, so electrically, the two circuits are isolated. And both circuits can have different ground. So, this optocoupler is very useful wherever we want to provide electrical isolation betweenthe two circuits. For example, when we want to couple the signal from the low voltage circuit to the high voltage circuit, then with the help of the optocoupler, it is possible to do that. Or in the case, where we want to protect a very important low voltage circuit from the other circuit which is prone to the high voltage spike and the noise, then the optocoupler can be used. So, the optocoupler ensures that there is electrical isolation between the two circuits. And with the electrical isolation, it is even possible to avoid the ground loops. So, now let's see, what is inside this optocoupler.

And let's understand how this optocoupler works. So, on one side, it consists of an infrared LED or IR LED, which is made up of Gallium Arsenide. And on the other side, it consists of a light-sensitive device, which detects the light that is emitted from the LED.

So, to optimize the coupling between the two elements, this LED and the photo-sensitivedevice are enclosed tightly in a single package. Moreover, their spectral response or the wavelengths are also tightly matched. So, in this optocoupler, on the input side, this LED converts the electrical signal into the light signal and on the output side, this photo-sensitive detector receives the light signal and converts it back into the electrical signal.

So, whenever, the light falls on this photodetector, then the photocurrent gets generated. And in this case, this photo-detector acts like a closed switch.And in a way, it allows the flow of current. And the same current also flows through the external load or the external device which relates to the photo-sensitive device.

Now, in the absence of this electrical signal, the LED will remain in OFF condition. And in this case, no photocurrent will get generated on the detector side. And therefore, this photo-sensitive device will act as an open circuit. And therefore, no current will flow through the external circuit on the output side. So, in this way, with the help of the optocoupler, it is possible to optically couple the signal from one circuit to the other circuit. So, in this way, with the help of the optocoupler, the low voltage circuit can be connected to the high voltage circuit, and yet they can be kept electrically isolated.

And if we talk about the optocoupler ICs then this PC 817 and this 4N25 are very well-known general-purpose optocoupler ICs. And in these optocoupler ICs, the photosensitive element is the phototransistor. But in general, in the optocoupler ICs, a photosensitive element could be a photodarlington pair, aphoto SCR, or even photo TRIAC. So, depending on the application and the requirement, the optocouplers with the different photosensitive detectors can be used.

For example, in AC applications, the photo TRIAC or the photo- SCR based optocouplersare used. But in this video, we will only talk about the phototransistor-based optocoupler. Now, in this optocoupler, the input could be an analog signal or the digital signal. So, like the normal transistor, for the digital input signal, the photo transistor is used in the saturation region. While, for the analog signal, it is used in the linear or the active region. Now, for the analog signal, even if we used the phototransistor in the active region, then also some sort of non-linearity may appear in the output.

Because in case of the optocoupler, the generated photocurrent is not linearly proportional to the LED optical power over the entire current range.So, for such applications, where high linearity is required, the linear optocouplers are readily available. So, this type of linear photo-coupler consists of two photo-transistor.

So, the photo-current, which is generated in the reference phototransistor is used asfeedback signal. So, the generated photocurrent in the reference phototransistor is used as a control signal to drive the LED. And in this way, it is ensured that the output photo-current of the phototransistor is linearlyproportional to the LED optical power. So, depending on the usage and the application, various types of photocouplers are available. For example, for fast switching applications, high-speed optocouplers are readily available. Or in applications, where the digital output is required, the optocoupler with the logic output can be used.

So, depending on the application, one should select the optocoupler. Now, speaking about the applications, let's see some of the important applications of the photocoupler. So, as I said, since the optocoupler provides galvanic isolation, so in general it can be used to provide the electrical isolation between the two circuits. Apart from that, it can be used to prevent the very important low voltage circuit from the voltage spike, noise, or even from the ground loop. Moreover, using the optocoupler, it is possible to control the high-voltage circuit using digital logic or the microcontroller.

And yet, it is possible to maintain the electrical isolation between the two circuits. And they are extensively used in the communication system, in power supplies as well as in the Solid-state relays.

2.1.16 TL431:

TL431 is actually a variable reference ZENER diode, and it can be used in so many circuits.

Let's check few circuit examples that you can make with this component, and you will see how useful it can be for so many applications. Fixed value current limiter, voltage reference or variable voltage reference, it can be used as a undervoltage or over voltage protection or as a delay timer and much more. So, stay till the end of the video and learn everything about this component and see all the examples I must show you. So, let's get started. The normal ZENER diode usually has a voltage reference that we can find in the datasheet. If this reference voltage is for example 5V, what this component will do in this configuration, is to allow the needed amount of current to pass towards ground, in such a way that the output will be regulated at 5V. But if you want a different voltage at the output, you need to change the diode by one that has that reference voltage. That's why we use the TL431, because this one has a variable regulation voltage that can be changed on the third pin. So, let's see the first circuit with this component. As you can see, contrary to a normal diode which has 2 pins, this one has 3 pins, anode, cathode and the reference voltage. So, from that circuit we can make this one here. The problem is that the TL431 could consume a maximum of only 100mA, with more than that, it will burn out. And the voltage reference could be from 2.5V up to 36V. So, with this circuit right now, since the reference is connected at the output, the value will be the minimum voltage of the TL431 which is 2.5V. To limit the current and not burn the IC I have this 330ohms resistor at the input. So, the current that passes through the IC is 29mA if the input is 12V. Here I have this circuit mounted and as you can see the input is 12V. But if I measure the output, it is stable at 2.5V. This was the first example. But now, what if I want the output to be different that 2.5V. Let's see the second example. Well, instead of connecting the reference pin at the output, we add a voltage divider. Now the output value would be equal to 2.5V multiplied by 1 plus the ratio between these two resistors. So for example if the resistors are both of 10K, the output would be 2.5 multiplied by 2, so it would be 5V. Changing the value of these resistors you can get any output from 2.5 up the 36V but have in mind the output can't be higher than the input, obviously. I have this same circuit mounted on my breadboard. But now, for the third example, instead of adding fixed value resistors, let's add a potentiometer. Now we can change the output value just by varying the potentiometer value. Here I have this simple circuit mounted on my breadboard. As using the potentiometer, I can change the value at the output.

This output is not affected by the input. As you can see, I change the input but the output is stable at the same value since the IC is making the regulation by consuming more or less current. But for all these examples, the current was limited to under 100mA using that input 330ohms resistor to protect the IC. What if now, we want to connect at this regulated output a load that needs 300mA for example. Since the circuit can only give up to 100mA, well we wouldn't be able to supply our load. That's why we have this next example. For the fourth example we have this constant current limiter using the TL431. In this case, the IC will control the voltage at the base of a transistor in such a way that the passing current value is always the same value. Let's see how. For example, if we have a supply of 8V and we need to limit the current at let's say 500mA. I add a 15 ohms resistor in series with the load. As you can see, now only 500mA are flowing. But the problem with this setup is that the current value will change with the input voltage value. Look, as I increase or decrease the input, the current value also changes. What we want is a fixed value current limiter. For that we use this circuit. The current value is fixed and is equal to this formula where V ref is 2.5V. And to calculate the R1 value we use this formula where V plus is the input supply which in my case is a TIP31 and this one has a gain of around 30 as mentioned in its datasheet.

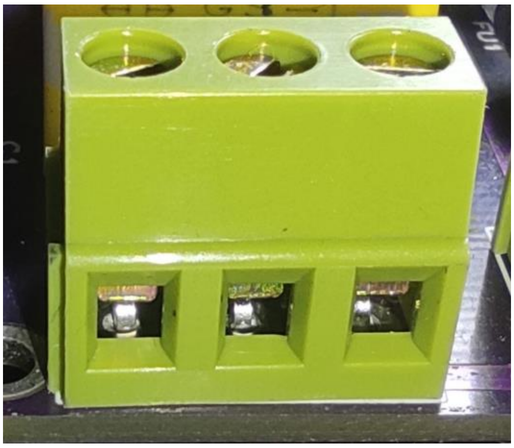
Make sure you add a heat dissipator and also make sure you know the limits of that transistor, otherwise you might burn it out. Ok, let's see the next example circuit and this is called an undervoltage protection. We've seen something similar on the battery charger circuit where the IC will stop the charging process if the voltage was above 4.2V. But in this case, we want to turn off the output if the voltage is below a certain voltage. We will use this circuit and the cutoff voltage is equal to 2.5V multiplied by 1 plus the ratio between these two resistors. For example, with 2k and 1K, the cutoff voltage would be 7.5V. When the input is below that voltage, the TL431 will power off the transistor gate so the load is not powered. I mount this circuit on my breadboard.

I connect a load at the output and supply the circuit at 3V, but the load is still OFF. I start increasing the input voltage and when I get above 7.5V, as you can see, the load is now powered on. And if I get back to below 7.5V, the load is once again OFF. That's how you can make an undervoltage protection circuit. You also have the circuit from the for the battery balancer which is pretty much the same. Check that video in order to learn more.

TL431 for the sixth example is a delay timer. This would be the circuit. Using this capacitor, the IC can regulate the current flow in such a way that it will control the time it takes the capacitor to charge or discharge. The delay is given by this formula where V ref is once again 2.5V. By changing the capacitor or resistors values, you can control the delay time. I mount this circuit on a breadboard and supply it at 12V. After X seconds, time the LED turn on. I push the button and once again, after X seconds, the LED turns on. Here I have the same circuit but with a smaller capacitor value. Now the delay time is only X seconds. So, as you can see you can use the TL431 as a voltage reference, also as a variable voltage output, you can use it as a shunt regulator and control the current value, you can use it for undervoltage or overvoltage protection and charging batteries, use it in power supplies and use it as a delay timer for any of your projects where you need these applications

2.1.17 Connectors:

Input Connector: we have used this green color connector 3 pin connector for our input, the central pin has no connection , the central pin will serve the purpose of isolation for two input pins that are at two corners



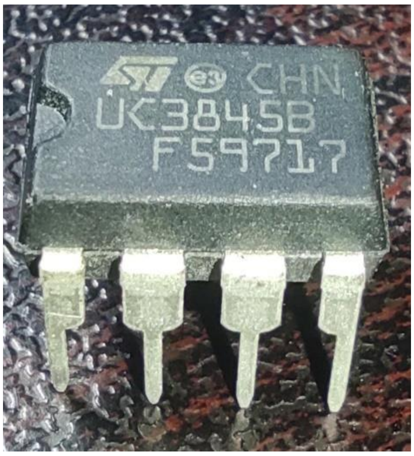
Connectors for IC: We have used a grid of 8 connectors in order to get connections with the IC, these 8 pins are going to connect with the IC, and thus this 8 pin grid of connectors will serve the purpose of controlling buss.

Output Connectors: We have used blue color 3 pin connector for our output.

The central pin has no connection, the central pin will serve as isolation between two input corner pins.

Integrated Chip:

We have used **UC3845B** as our controlling IC.

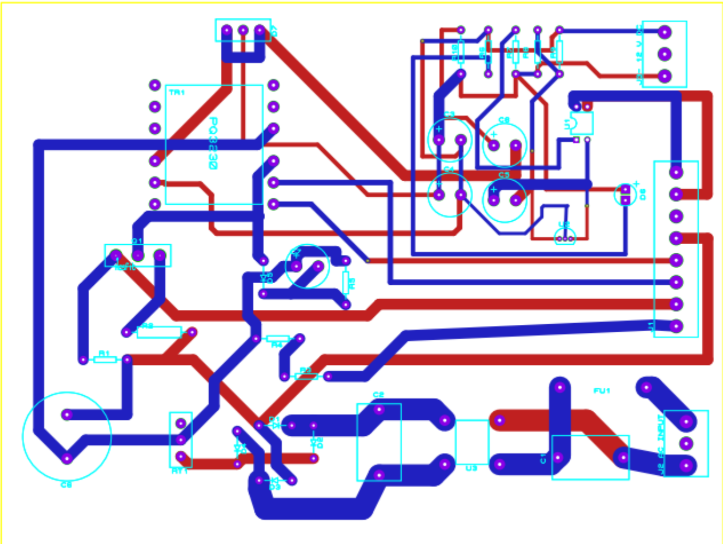


UC3845 will act as a controller for the transistor, it will change the frequency of transistor. It will also receive the feedback from opto-coupler and adjust the desired frequency to the transistor.

Chapter 3: Software Implementation:

3.1 PCB Designing:

We have designed our PCB on Proteus**,**



We have designed a 2 layered PCB the upper layer is showing by blue color and the lower layer is shown by red color.

3.1.1 PCB Printing:

For printing of PCB board we did its fabrication from abroad, as there is no economically feasible opportunity in our country to fabricate a 2 layer PCB.

JLCPCB:

We got our PCB design into fabrication process through **JLCPCB.** It is an online PCB manufacturing company in **Hong Kong**.

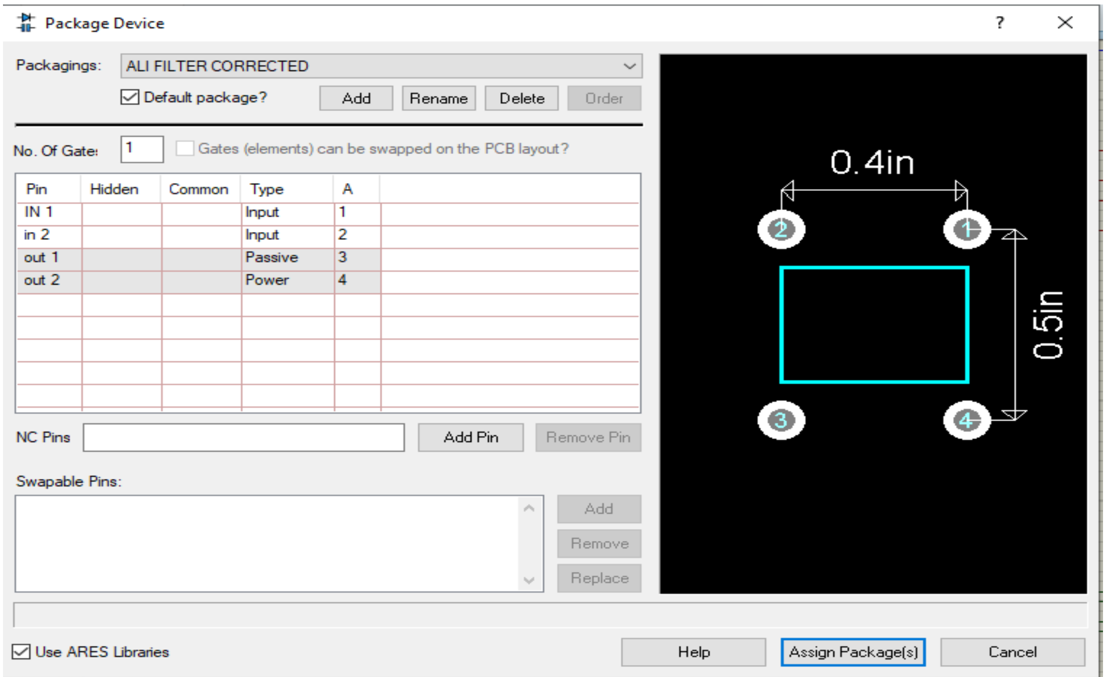
We got our PCB delivered to our address within 20 days of order.

3.2 Designing of Packages:

We have designed many new packaged as was available in proteus.We have taken the dimensions of each component and then have designed it.

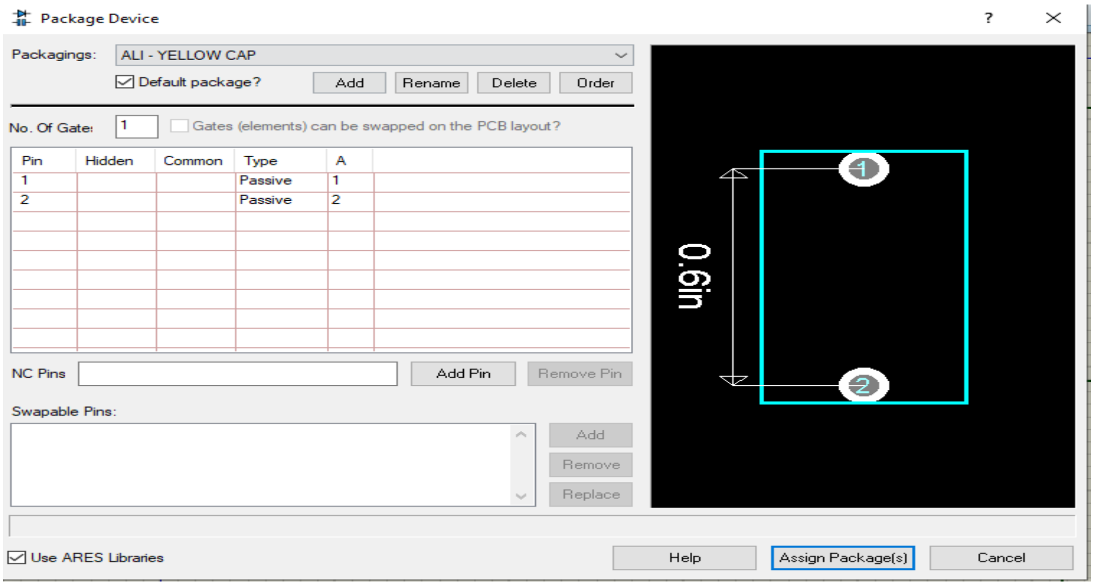
3.3 Filter package:

We have taken the dimensions of the filter and then has designed its package.



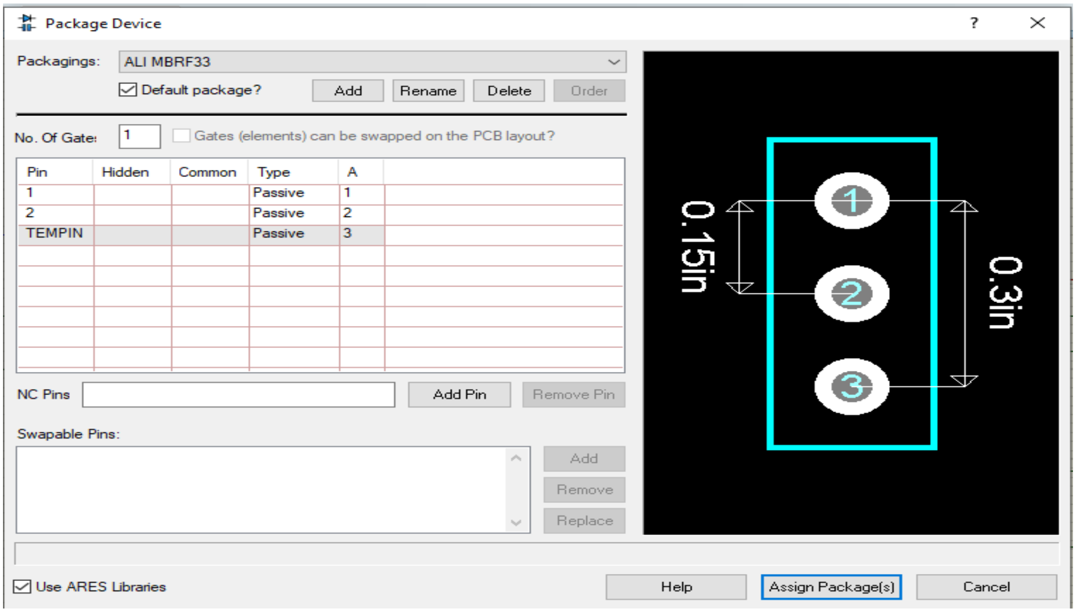
3.3.1 Fuse package:

We have taken the dimensions of the fuse and then has designed its package.



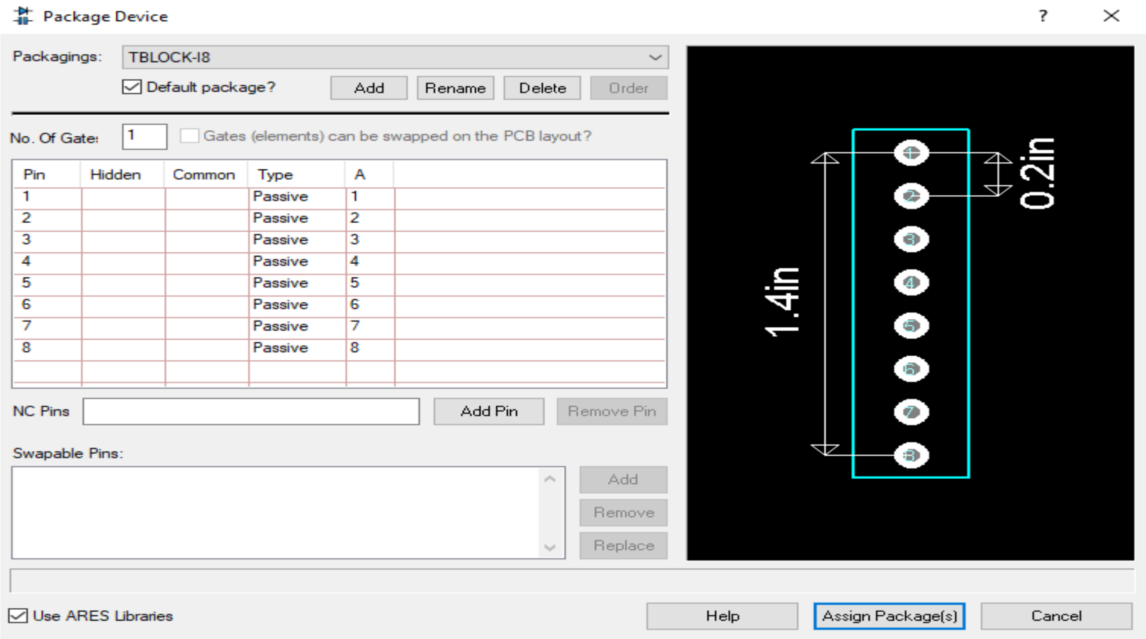
3.3.2 NTC package:

We have taken the dimensions of the NTC and then has designed its package.



3.3.3 Connector package:

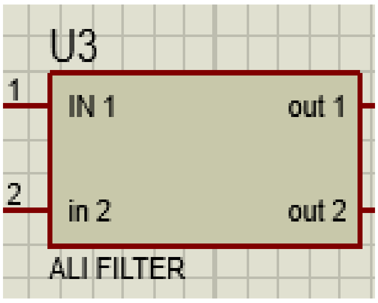
We have taken the dimensions of the Connector and then has designed its package.



3.3.4New Symbols Making:

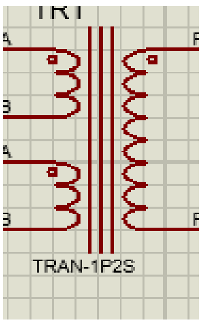
3.3.5 Filter Symbol:

We have made filter symbol, as it was not available in proteus



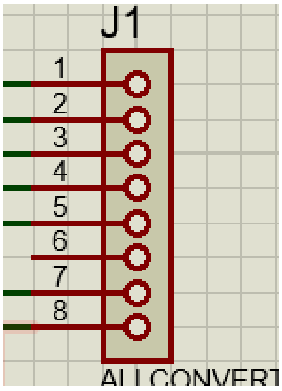
3.3.6 Flyback transformer Symbol:

We have made flyback transformer symbol, as it was not available in proteus.



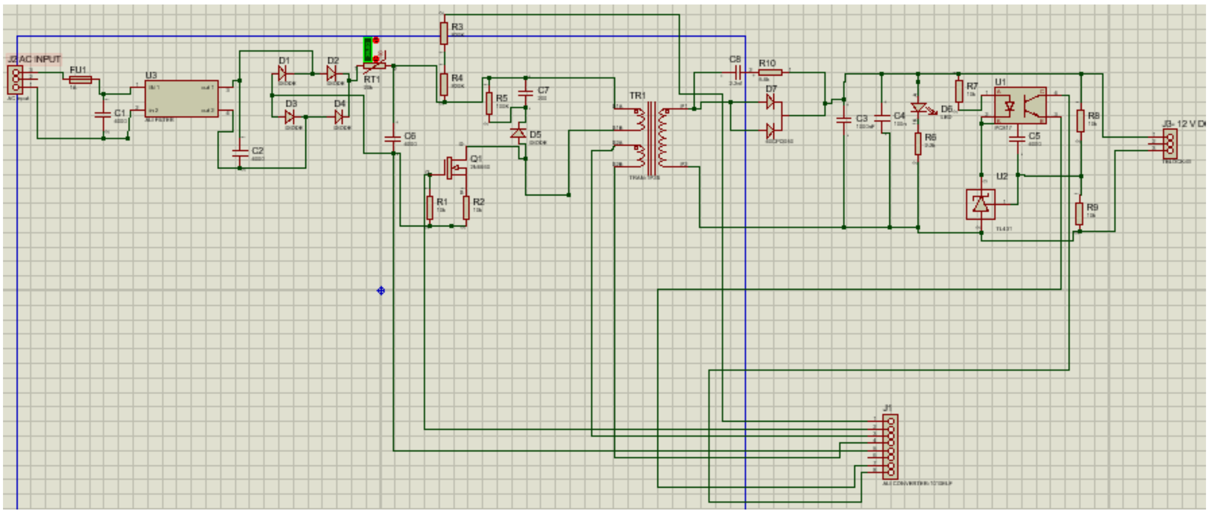
3.3.7 Connector Symbol:

We have made connector symbol, as it was not available in proteus.



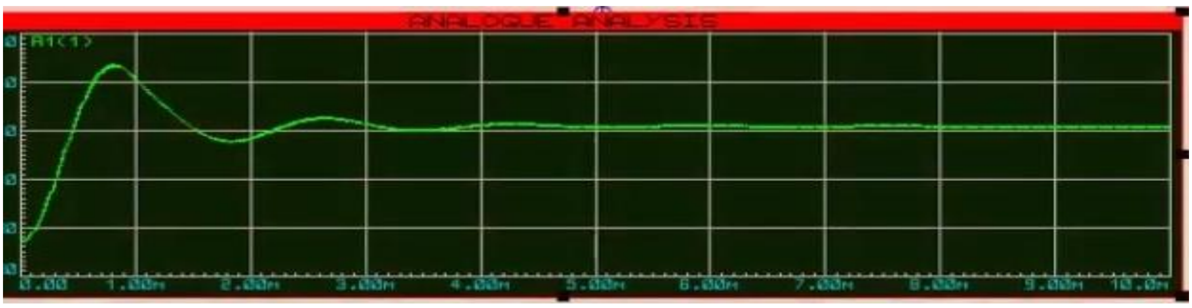
3.3.8 Proteus Circuitry:

We have made this proteus circuit for PCB designing**.**



3.3.9 Proteus results:

This is the result of what we are getting from proteus after making circuitry on PCB.



Chapter 4: Hardware Implementation

In the input circuit of a power supply, passive components protect the electronic component from excessive current and voltage as well as ensure electromagnetic compatibility, all of which are crucial considerations for today's portable applications that demand long battery life. Since its impact on performance is usually disregarded, the choice of components used in switch-mode power supplies (SMPS) is crucial. These parts—resistors, capacitors, and inductors—are utilised to manage heat, size, output power, and device cost.

Switch-mode power supplies transmit electric energy from capacitors and inductors at high frequency. SMPS are more affordable to produce, smaller, and lighter.

While there are several components in SMPS, a few key devices include:

4.1Capacitors:

Capacitors store energy, filter it, compensate for it, and conduct soft-start programming. The effective series resistance is used to calculate the overriding loss for capacitors in SMPS systems (ESR). The physical structure of a capacitor, the resistance of internal interconnects, and even the behaviour of the substance employed as an insulator between capacitor plates all contribute to ESR. Many capacitors are extremely heat sensitive, and one purpose of ESR is to dissipate heat when a current flows into or out of a capacitor. When selecting capacitors for SMPS systems, the ESR of the component is often the most critical specification—even more significant than the component's basic capacitance rating.

The DC connection cannot function without capacitors. They stabilise the DC link voltage and smooth the rectifier's ripple voltage. All rectifiers produce an output voltage with ripple superimposed on the DC, but each rectifier's output voltage has a different magnitude, waveform, and frequency. The potential for lower productivity or shortened equipment life, interference with process instrumentation, and electromagnetic contact with nearby buildings, which causes heating and increased losses, are all drawbacks of ripple.

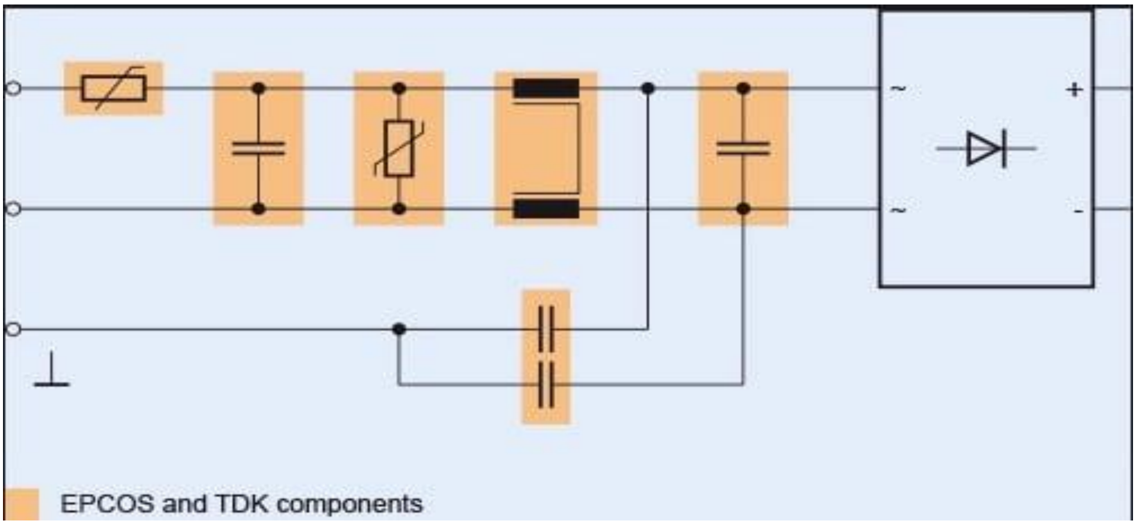
DC link capacitors subject the rectifier and power line to excessively high input currents as soon as they are turned on, perhaps destroying the rectifier diode or blowing the power fuse. Use inrush current limiters (ICL) with negative temperature coefficient (NTC) thermistors for a progressive power up to prevent this. NTC ICLs' resistance decreases to zero once they have been sufficiently heated by the current flow. For each required current strength, the EPCOS NTC thermistors of the B57*S series have a corresponding ICL.

Because of their high CV value, EPCOS aluminium electrolytic capacitors are particularly suited to this task; they enable today's small power supplies to be readily installed. The capacitors stand out for their extremely high ripple current capacity, which is paired with low ESR and ESL values, resulting in decreased inherent heating. Radial versions or snap-in kinds with two or four pins are utilised depending on the needed output and voltage of the connection circuit. The capacitors have voltage ratings ranging from 10 V DC to 600 V DC and maximum operating temperatures ranging from 85° C to 140° C.

Two screw-terminated EPCOS aluminium electrolytic capacitors' permitted rated voltage was increased from 550 V DC to 600 V DC. The extremely compact components have a capacitance range of 680 µF to 6800 µF and are suitable for temperatures up to 85 C. Instead of the former 550 V DC, the new snap-in series (B43541*) at temperatures up to 85° C has a rated voltage of 600 V DC with capacitance values ranging from 47 µF and 270 µF.

Types with a higher rated voltage for temperatures up to 105° C are among the range's additions. While snap-in type ratings have grown from 500 V DC to 550 V DC, screw-terminal type ratings have increased from 450 V DC to 500 V DC. Because fewer series capacitors need to be connected in the link circuit, developers benefit because mounting requirements and costs are reduced.

On the other side, the DC link may be stabilised using EPCOS MKP film capacitors. The B3267* high-power series and the B3277* high-density series are intended for voltages ranging from 450 V DC to 1300 V DC and capacitances ranging from 0.47 F to 110 F. They are self-healing and have a very long operating life, just like other EPCOS film capacitors. Local metallization vaporization is caused by overvoltage dielectric failures, but the capacitor is still fully operational.



EPCOS and TDK components in a power supply's input circuit safeguard the electronic device against overcurrent and overvoltage, ensuring EMC.

4.2PTC Thermistors:

In contrast to the previously described NTC thermistors, positive temperature coefficient (PTC) thermistors defend against current surges caused by a short circuit. When exposed to large currents, these components heat up and develop a high resistance. They, like ICLs, are introduced directly into the power input's current route. The B5910*J series is available in leaded or packed variants and spans regularly used current levels.

4.3 Varistors

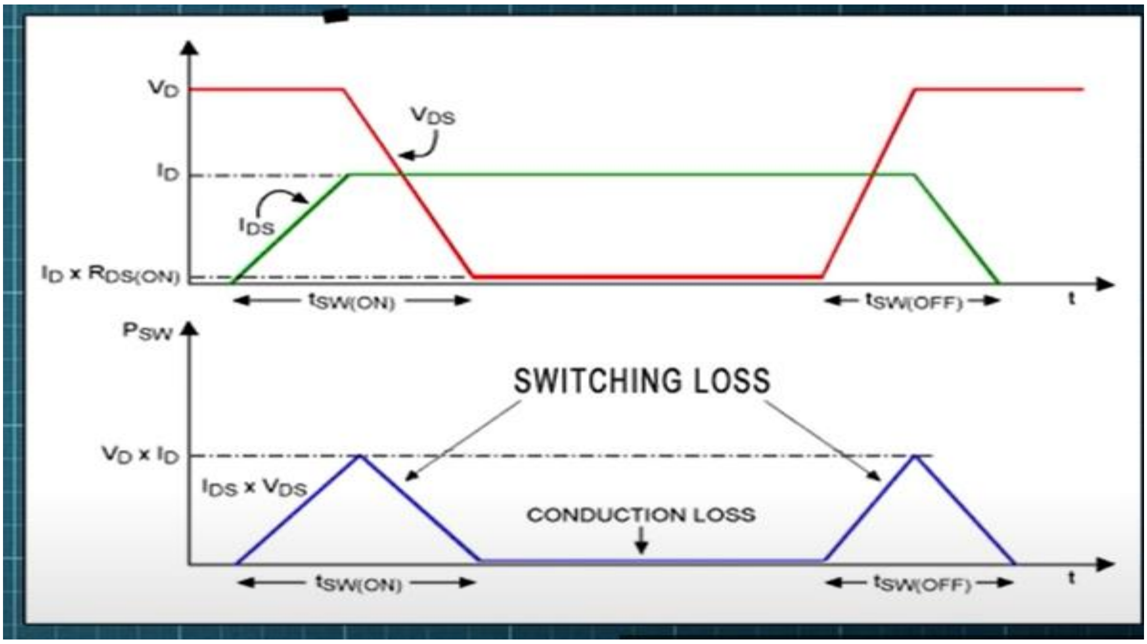
Metal Oxide Varistors (MOVs), commonly known as varistors (variable resistors), are ceramic-based parts that are used to protect delicate electronics from dangerous overvoltage situations. Varistors are voltage-dependent resistors, which means that when the voltage rises, so does their resistance. When connected in parallel with the electrical component or circuit that needs to be protected, a varistor creates a low-resistance shunt as the voltage rises. Lightning, inductive load switching, and electrostatic discharge are typical overvoltage causes (ESD).

EPCOS has a wide variety of varistors available, including leaded and SMD counterparts, ThermoFuse kinds, and Multilayer SMDs.

- Leaded and SMD equivalents come in voltage ranges of 11 to 1000 Vac, surge current ratings of 100 A to 100 kA, energy ranges of.3 to 6000 joules, and new 125° high-temperature variations.
- ThermoFuse varistors feature surge current ratings up to 10,000A and voltage ratings between 130 and 1000 Vac. A thermally coupled fuse and a varistor disc are linked in series inside a plastic box. The thermal fuse triggers when the varistor overheats, removing it from the circuit.
- Multilayer SMD types are offered in case sizes 0201 through 2220 and come with surge current ratings of up to 1200 amps and voltage ranges of 4 to 60 volts.

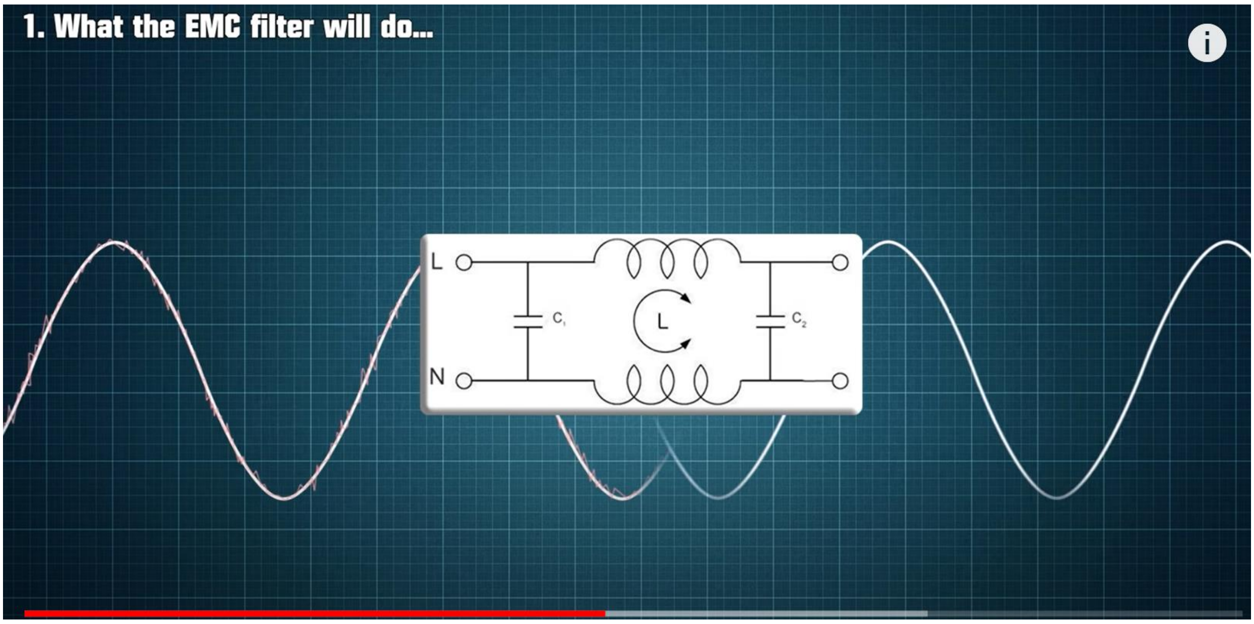
4.4 Transistors:

These work in convotation mode so we reduce the dissipated power that's because mosfet will dissipate small power when in saturation or cut-off mode it only dissipates lot of power when we switch from saturation to cut-off or from cut-off to saturation so that's how we can get an efficiency a lot higher than linear power supplies less weight using small transformers and a lot more power because the output can now have thicker copper wires that don't have to be that long with a teacup or wire we can regulate the output and also have a decent current value but this will come at a cost because the circuit of these supplies is a lot more complex so let's study the schematic of a basic switch mode power supply these supplies would usually have five parts you can see here from a to e a is the main input protection.

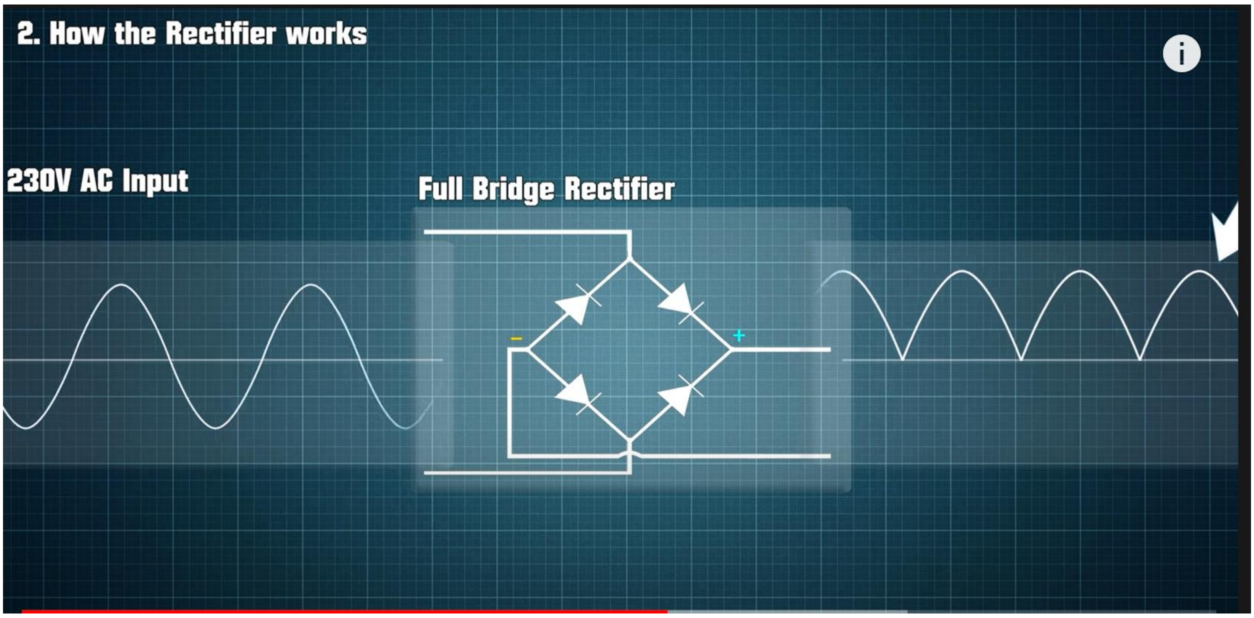


4.5 Rectification:-

Rectification is the process of converting an alternating current waveform to a direct current waveform, resulting in a new signal with just one polarity. In this sense, it is similar to the ordinary definition of the word, where "to correct the situation" implies "to set something straight."

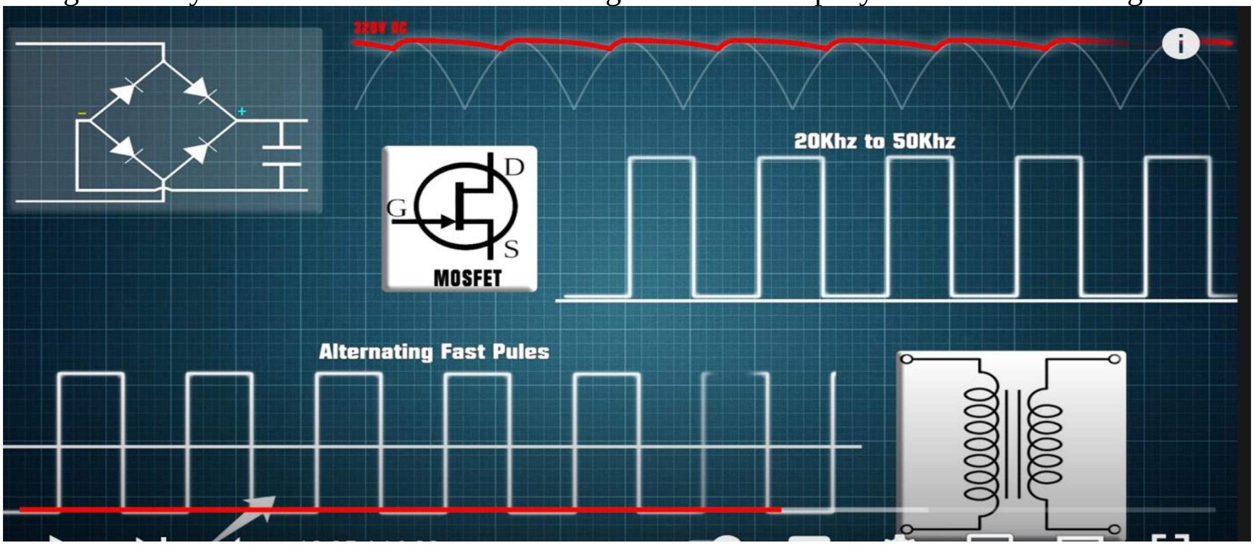


Basically rectifier do the rectification of signal.



4.6 Mosfet:-

A type of insulated-gate field-effect transistor known as a metal-oxide-semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is created by carefully controlling the semiconductor oxidation, usually silicon. The voltage at the gate terminal controls the electrical performance of the device; this ability to change the conductivity by the applied voltage may be used to change or amplify electrical signals.

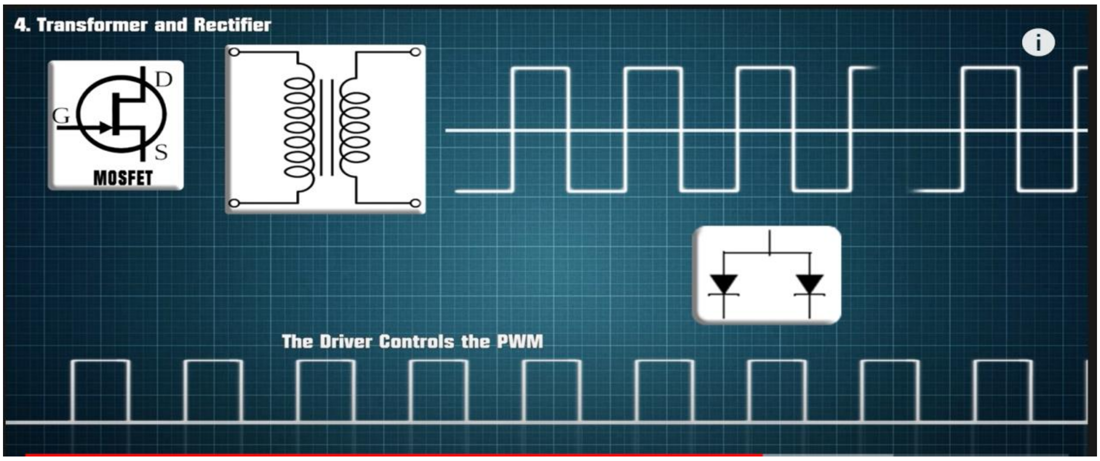


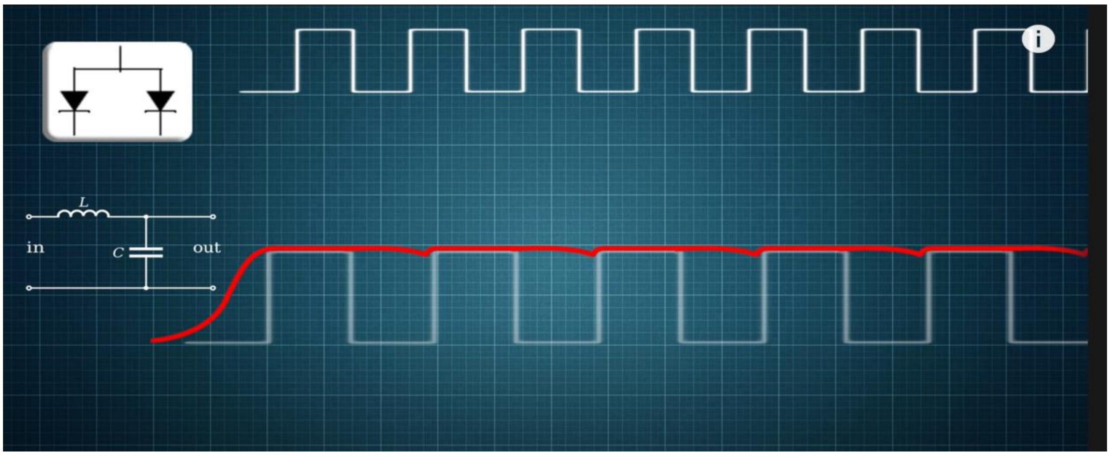
4.7 Transformer and rectifier:-

A device that steps up or steps down the voltage to move electrical energy from one alternating-current circuit to one or more other circuits. In order to run low-voltage devices like doorbells and toy electric trains, transformers are used to decrease the voltage of conventional power circuits. They are also used to raise the voltage from electric generators in order to transfer electricity over long distances.

Transformers change voltage via electromagnetic induction, which causes current to be induced in a second coil known as the secondary when the magnetic lines of force (flux lines) expand and contract with changes in current flowing through the primary coil. By multiplying the main voltage by the turns ratio, the secondary voltage is obtained, which is the ratio of the number of turns in the secondary coil to the number of turns in the primary coil.

For the most effective energy transmission, impedance-matching transformers are employed to match the impedances of a source and its load. In order to isolate a piece of equipment from the power source out of safety concerns, isolation transformers are frequently utilised.





4.8 Flyback:

A gapped-core coupled inductor is a flyback transformer. Energy is stored in the gap of the core throughout each cycle when the input voltage is applied to the primary winding. The load is then powered once it is switched to the secondary winding. Flyback converters employ flyback transformers to provide circuit isolation and voltage transformation. The most popular option for low-cost, high-efficiency isolated power supply solutions up to 120 Watts is a flyback transformer. They provide circuit isolation, several outputs, and either positive or negative output voltage options. Additionally, they are controllable under a variety of input voltage and load conditions. The flyback topology, unlike the other isolated topologies, does not require a separate output filter inductor since the energy is stored in the transformer. As a result, the circuit requirements are made simpler and fewer components are needed. This article discusses flyback transformers and the uses to which they are most appropriate.

4.8.1 Purpose of flyback transformer:

Energy is stored in the transformer's magnetic field during the first half of the switching cycle and released to the secondary winding(s) connected to the load during the second half of the cycle. The gapped-core design of flyback transformers enables significant energy storage without over saturating the core. In contrast to other topologies, flybacks transport energy from the primary to the secondary indirectly by storing it. Flyback transformers are sometimes referred to as coupled inductors since they have a gapped core and store energy there.

4.8.2 Working principle:

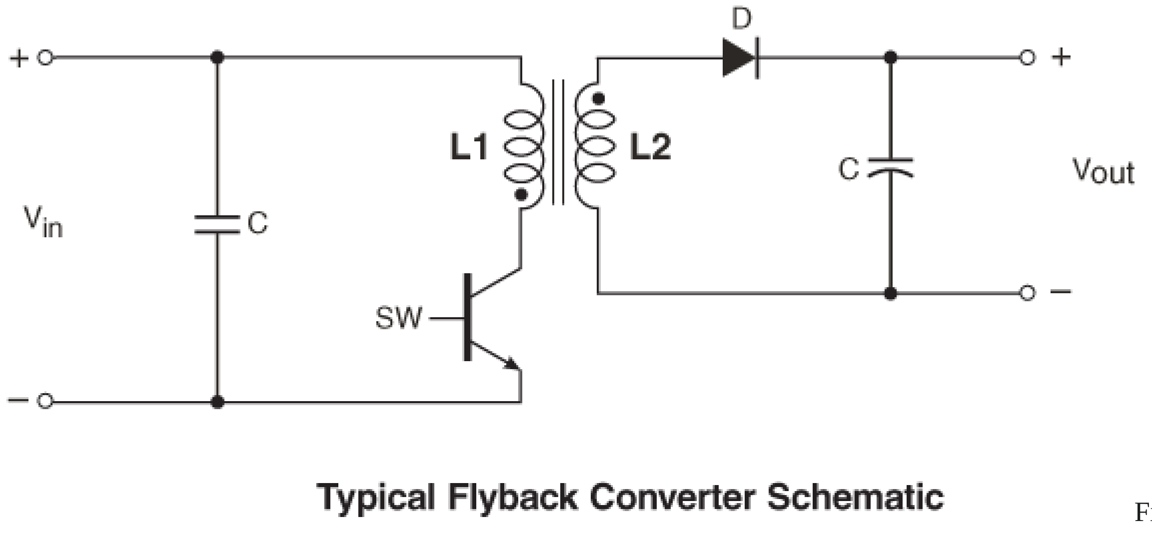


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Figure 1: represents a typical flyback circuit.

The switch (SW) in a flyback converter that is used the most frequently is a MOSFET (Metal Oxide Semiconductor Field Effect Transistor), while a bipolar transistor, GaN (gallium nitride), or SiC (silicon carbide) are also occasionally employed. The flyback controller opens and closes the switch at the appropriate duty cycle to achieve the required output voltage. A duty cycle of less than 0.5 is typical for flyback transformers. This equation states that the required output voltage may be produced by a variety of turns ratio and duty cycle combinations:

$V_{out} = V_{in}*(N_s/N_p)*(D/(1-D))$ where:
V_{out} is the output voltage
V_{in} is the input voltage
N_s = secondary turns
N_p = primary turns
D = duty cycle = $t_{on}/(t_{on} + t_{off})$

The fundamental flyback cycle consists of the following components:

- Current flows through the transformer primary when the FET (Field Effect Transistor) SW is closed (ON). As a result, a magnetic field is produced, which forces energy into the core. In order to ensure that no energy is sent to the secondary when the switch is closed, the combination of winding polarity (shown by the polarity dots) reverse biassed the output diode (load). Current in the primary steadily increases throughout this cycle phase to store energy (= $\frac{1}{2}LI^2$).
- The magnetic field collapses when the FET is switched off (OFF), releasing stored energy into the secondary winding and ultimately the load. When the switch is closed, the secondary current is at its peak and slopes downward as the stored energy is transferred to the load.

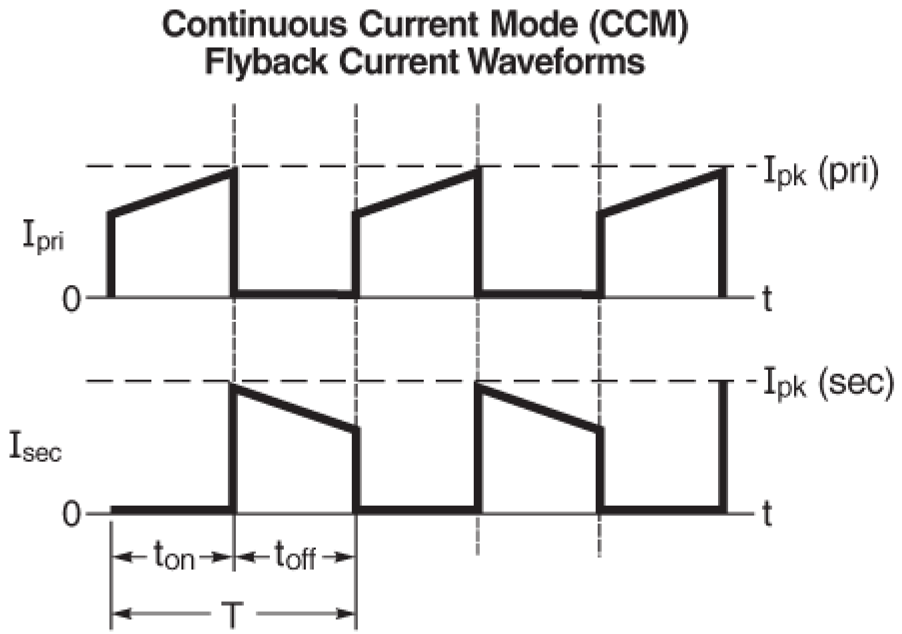
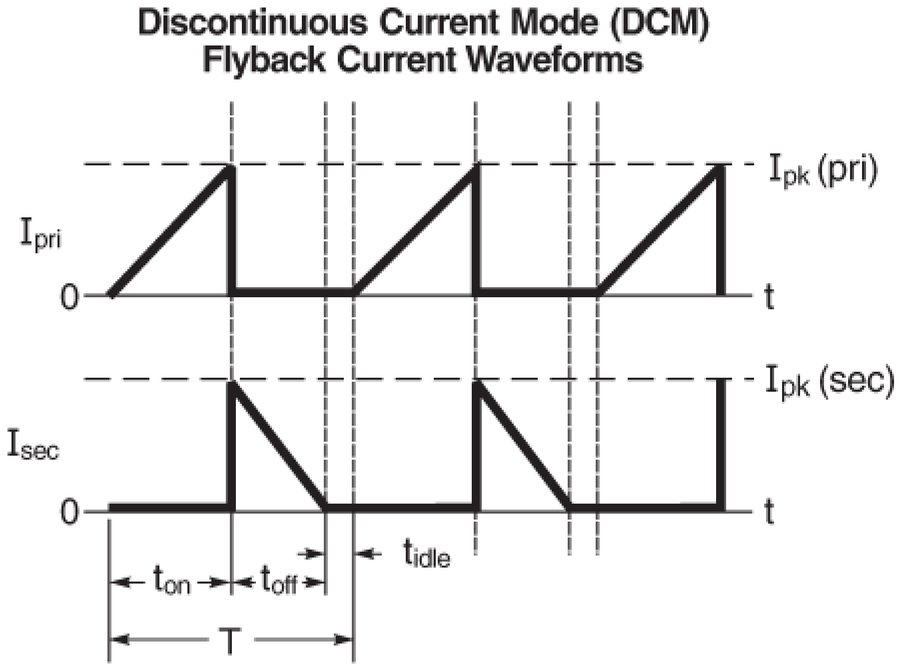


Figure 2



If the FET is turned back on before all of the flyback energy has been transmitted to the secondary, the secondary current never gets close to zero. Continuous conduction mode is the term for this (CCM). A sample CCM waveform is shown in Figure 2. The secondary current approaches zero before the conclusion of the period if the flyback energy is completely discharged to the secondary before the FET is turned back on, creating a "idle time" (tidle) throughout the cycle. The discontinuous conduction mode is what is used in this (DCM). A sample DCM waveform is shown in Figure 3. For CCM, DCM, or both, transformers can be created. Flyback transformers may operate in both CCM and DCM modes, depending on the input voltage.

When building a flyback transformer, the highest (peak) primary current need is created by the worst-case circumstance of maximum load at the lowest input voltage. Choose a transformer with a peak primary current (Ipk) or primary saturation current (Isat) that is significantly higher than the projected peak primary current for your application. If the peak primary current flow of the application exceeds the transformer rating, core saturation will cause the primary inductance to decline. If the load demands additional energy at this moment, the transformer's energy storage capacity will be surpassed, and the load will not get the needed energy. As a result of this, the peak primary current (Ipk) or primary saturation current (Isat) of a flyback transformer is a significant metric.

4.8.3 Uses:

You can use Flyback transformers in many applications, including:

- DC-DC power supplies
- Telecom
- LED Lighting
- Power over Ethernet (PoE)

- Capacitor charging
- Battery charging
- Solar Microinverters
- AC-DC power supplies

For a variety of applications that call for low cost, small size, and high efficiency, flyback transformers are readily accessible off-the-shelf. They are frequently used in DC-DC controllers in the 37 to 72 Vdc telecommunications (telecom) voltage range, as well as at extended voltages ranging from 2 to 400 Vdc and the standard AC line input voltage range (85 - 265 Vac).

When the output current and power are less than 10 amps and 100 watts, respectively, flyback transformers are generally used. Flyback transformers from Coilcraft range in power from a few Watts to about 120 Watts and are available off-the-shelf. When greater current and power are needed, forward-mode, push-pull, and half-bridge/full-bridge topologies are more effective.

4.9 Safety and precautions:

If switch mode charger is not correctly operated or installed properly then it may be result in very dangerous results. To get rid of any hazardous conditions, following conditions must be followed properly.

4.9.1 Charger Related:

- Do not use the charger if it is covered or if airflow is restricted in any way. Install the charger in a well-ventilated, cool, and dry location.
- Do not use the charger in a damp or wet environment. When installation in a boat, check sure there is no bilge water splash.
- Do not obstruct the ventilation or cooling fan apertures.
- There should be at least 6 inches of clearance all around the device, and installation and wiring must adhere to local and national electrical laws. Installation and wiring should be performed by a licenced electrician.
- Improper installation on a boat might cause corrosion. It is strongly advised that installation on the boat be performed by a boat electrician.
- Turn off the charger's AC input power before attaching or detaching batteries or other DC loads, or when working on the charger.
- Before adjusting the Dip Switch settings, disconnect the AC input power.
- The charger's chassis is linked to the power cord plug's earth ground pin. Check that the earth ground pin of the AC receptacle supplying the charger is connected to ground.
- Avoid using an adaptor. If a grounding type receptacle is not available, do not use this charger until a certified electrician instals the right outlet.
- If the power cable is damaged, do not use the charger.

4.9.2 Battery Related:

- • To lessen the chance of a battery explosion, follow these recommendations as well as those on the battery.
- • Never smoke or let an open spark or flame near the battery or engine.
- • Only charge Lead Acid batteries (Flooded / Absorbed Glass Mat (AGM) / Gel Cell). Other types of batteries, such as Nickel Cadmium (NiCad), Nickel-Metal Hydride (Ni-MH), Dry-Cell, and so on, should not be charged. Other types of batteries may explode and cause bodily damage.
- • Never try to charge a frozen battery.
- • Working in close proximity to lead acid batteries is hazardous. During regular functioning, batteries emit explosive gases. When mounting the charger near a battery or in a battery compartment, take the appropriate safety measures (Follow safety instructions given by the battery manufacturer).
- Never put the charger immediately above or below the battery being charged; the battery's gases or fluids will corrode and destroy the charger. Place the charger as far away from the battery as the DC cords will allow. Install in a separate compartment from the batteries.

4.9.3 IMPORTANT SAFETY INSTRUCTIONS:

- Read all directions and cautionary signs on the battery charger, battery, and product using the battery before using it.
- Caution: To limit the risk of fire, place this battery charger on a non-combustible surface such as brick, concrete, or metal.
- Danger: electric shock danger. Before service, unplug the charger from the battery and ac power. Turning off the charger has no effect on reducing this danger.
- Danger: electric shock danger. Touch no uninsulated ac or dc connections or uninsulated battery terminals.
- Caution: Only charge batteries with the same kind, voltage, cell number, and amp-hour capacity as specified on the label. Other types of batteries may explode, inflicting physical harm and property damage. Change the charger settings before charging any other type of rechargeable battery as recommended by that battery manufacturer.
- Danger: To avoid electrical shock, do not contact any uninsulated ac or dc parts. Check that all electrical connectors are in excellent working order. Connectors that are damaged, rusted, or do not establish appropriate electrical contact should not be used. The usage of a broken or faulty connection may result in overheating or electric shock.
- Caution: lead-acid batteries emit explosive gases. Do not detach the dc charging wire from the batteries while the charger is running to avoid arcing or burning. Away from batteries, keep sparks, flames, and smoking materials.
- Always use eye protection when working near batteries. Wrenches and other metal items should not be placed over the battery terminals or battery top. The battery may arc or explode as a result.
- Caution: batteries emit hydrogen gas, which might cause an explosion if ignited. Never use an open flame, smoke, or cause sparks near a battery. When the battery is charging in a confined space, air the area.

- Caution: lead-acid batteries contain sulfuric acid, which can burn you. Avoid getting acid in your eyes, on your skin, or on your clothing. If you come into touch with your eyes, rinse them immediately with clean water for 15 minutes and seek medical assistance.
- Caution: This item should only be programmed or serviced by a skilled service expert.
- Caution: Do not use the charger if it has been hit hard, dropped, or otherwise damaged. Examine and repair as needed by a skilled service technician.
- Caution: Do not attempt to dismantle the charger. A skilled service technician should inspect the charger. An explosion, electric shock, or fire may ensue from faulty charger re-assembly. 20. Caution: Ensure that the battery system is adequately rated in terms of voltage, amp-hours, and type ("wet", "gel", etc.) for this charging system.

Chapter 5: Experimental Results

5.1 Results:

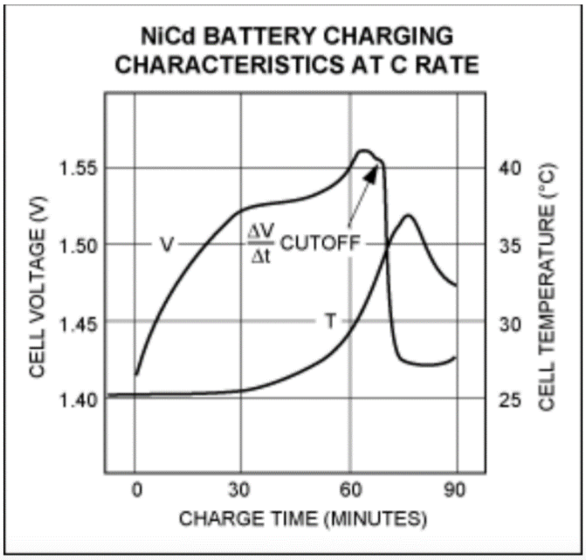
Our final result after multiple iterations is shown below

It is discussed the DC-DC converter. A brief theoretical background is provided, as well as the basic operating concept of a complete bridge converter circuit and its transformer design. A simulation model and the converter's hardware implementation are discussed. The converter's measurement and simulation findings are reported. The simulation circuit reached a maximum energy efficiency of 82 percent, whereas the actual hardware circuit obtained a maximum energy efficiency of 72 percent. The converter circuit is implemented using a coreless PCB step up power transformer built by Mid Sweden University. The power transformer obtained a maximum energy efficiency of 90% when switching the frequency range of 1-4 MHz.

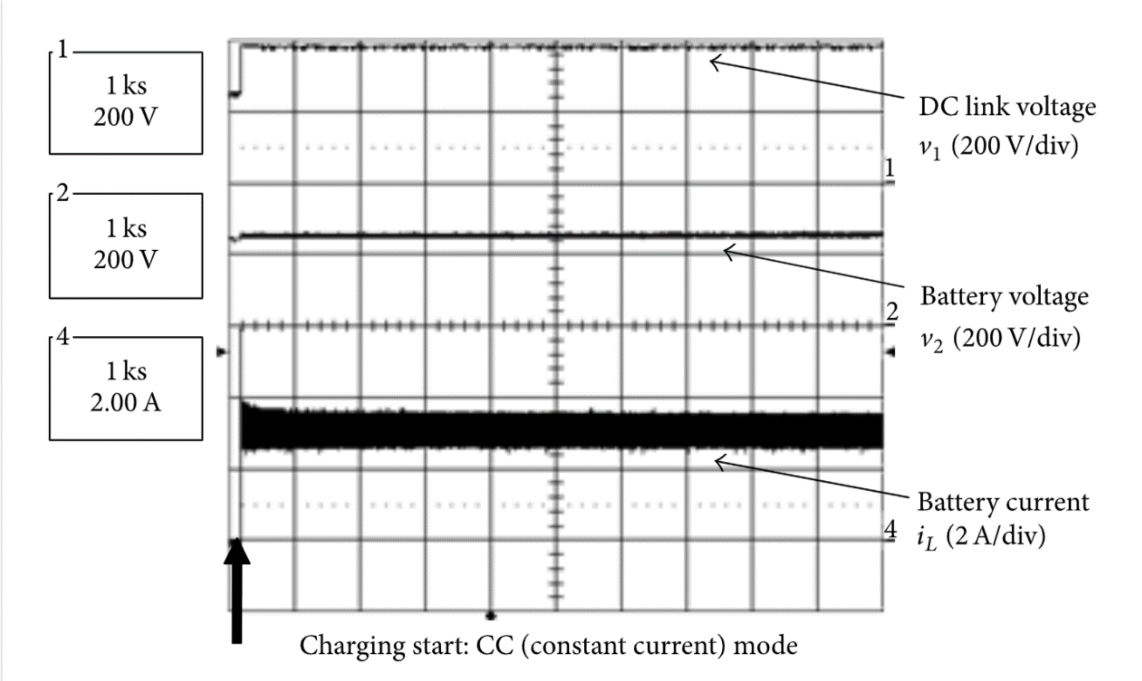
The suggested battery charging system was built utilising the buck converter described in the preceding section. The electrical specifications are provided in Figure below, which depicts the front-view of the implemented system.

This temperature increase can be detected and used as a signal to stop charging, but that measurement requires a thermal sensor to be in close proximity to the battery, which is not always possible. Changes in the terminal voltage of the battery, which is a sensitive indication of internal temperature changes, can also be used to detect temperature increases. Thus, charging a battery results in a positive slope in the voltage versus time figure. When a NiCd battery gets full charge, the positive slope becomes negative, and when a NiMh battery reaches full charge, it becomes zero (flat).

The graph below depicts the terminal voltage vs. time for a charged NiCd battery. The time scale for slope change, which varies according to battery size, is determined by the thermal time constant of the battery and its enclosure. It is also affected by the charge rate (i.e., the charging current), as temperature rise and rate of rise are functions of the battery's thermal capacity and power provided (which, in turn, is a function of charging current).



Wave test forms for both CC and CV modes are shown in the image below. DC power supply and batteries are installed to generate 240 V of DC link voltage. The buck-boost converter is used to charge batteries. Charging power is intended to be 3 A, maximum charging power is 10 A, and the temperature is kept below 50 ° C. As shown in Figure 6, when the battery power approaches the battery voltage, the charging mode changes from a constant current (CC) to a constant voltage (CV). As a result, SOC as a charging performance metric is tested to be greater than 95% with a efficiency of 96.35.5732 conversion


1
1 ks
200 V
2
1 ks
200 V
4
1 ks
2.00 A
DC link voltage
v_1 (200 V/div)
Battery voltage
v_2 (200 V/div)
Battery current
i_L (2 A/div)
Charging start: CC (constant current) mode

Chapter 6: Conclusion and Future Work

6.1 Conclusion:

We first made circuit of switch mode charger then implemented on proteus and designed PCB Circuit. We did everything that asked to implement under the supervision of our supervisors. So we were required to achieve 12V but we achieved 12V DC at the output. The purpose of this study was to develop and build a "12Volts battery charger" for future generation automobiles. The charger was designed after a quick presentation of background information.

Linear and switch mode power supply principles are presented. Both power sources' advantages and disadvantages are looked at. High frequency power MOSFETs, PCB transformers, and smaller EMI filters are some of the key components of a high frequency SMPS design that are explored. Thanks to improvements in power MOSFET technology and the creation of high frequency multilayered PCB power transformers, it is now feasible to design isolated converters that operate at high frequencies and with low power consumption. There are various challenges in the design of high frequency switching converters, despite the fact that increasing switching frequencies can lower the size of SMPS.

Construction of a half-DC-DC conversion bridge is under investigation. Discussion of the bridge circuit converter theater base, basic operating principle, and converter design. Added to the feature are hardware implementations and a simulation model for half-bridge bridge converters. PCB sliding power converter is used in the converter. The PCB isolation transformer also provides separate gate signals to the upper side MOSFETs. Specification and energy efficiency of transformers are both provided. The PCB step-by-step power converter used in construction has a power output of 96 percent at switching frequencies of 2.6 MHz. Up to 40W output power, the power efficiency of the converter is tested.

Switching frequencies for the converter can reach 3 MHz. Around 82 percent is thought to be the greatest energy efficiency. This research assesses the losses in a converter and serves as the initial step in the design of forward converters in the MHz frequency band.

Two feedback techniques are utilised in the half bridge converter covered in Chapter 2. Analysis is done on the measurements for both feedback systems. Opto-coupler feedback can be used to predict the output voltage, but it is exceedingly expensive and temperature-sensitive.

After that, the 12Volts off board battery charger was upgraded and tested with three batteries connected to the series. Charger operated as expected. The finished device was able to control the DC power supply to 12.613 DC, an excellent result that was exactly the same as the simulation results.

6.2 Future Work:

EMI is an important issue for almost all electronic devices. High-order harmonics are produced when switching frequency is increased as well as sudden variations in current levels (di / dt) or voltage (dv / dt), which trigger EMI and affect SMPS Electromagnetic Compliance (EMC). EMC design is an essential requirement for SMPS. As a result, it is important to limit EMI so that the product is built in accordance with EMC requirements. There are several ways to do this, including filtering, protection, and isolation, among others. The design of the EMI filter for one or two DM stage and CM noise reduction to enable high frequency frequencies will be the focus for future development. Filters will be defined, and their signal behavior will be investigated.Battery charging level indicator

- Battery health indicator
- Addition of USB port(5 volt) for Mobile-Phone charging
- Efficiency improvement
- More Compactness

6.3 References

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