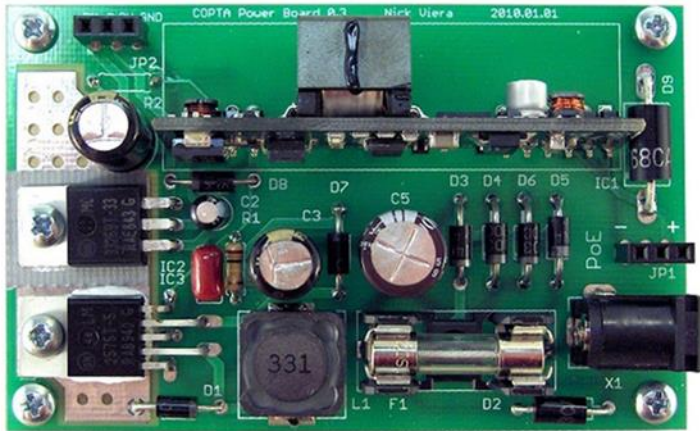


Biomedical Equipment Servicing

Level – II

Based on September 2021, Curriculum Version-II



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Acronyms

AC	Alternative Current
CRT	Cathode Ray Tube
DC	Direct Current
IC	Integrated Circuit
LAP	Learning Activity Performance
LPS	Linear Power Supply
MoH	Ministry of Health
MoLS	Ministry of Labor and Skill
PCB	Printed Circuit Board
PSU	Power Supply Unit
SMPS	Switched mode Power Supply

Introduction to Troubleshooting AC/DC Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as **electric power converter**.

Around 95% of the electronic equipment's are powered from low voltage DC supplies. The source will be either a battery or a power supply converting AC mains into one or more low voltage DC supplies. Electronic components require a DC supply that is well regulated, has low noise characteristics and provides a fast response to load change. There are many small sections present in the electronic devices such as Computer, Television, Cathode ray Oscilloscope, Medical equipment's, etc. but not all of those sections need 230V AC supply, which we get.

Troubleshooting is a logical, systematic process that is able to determine "what" happened, "why" it happened and a method to develop effective fixes for the "why" it happened. Therefore, this module aims to provide the trainees with the knowledge, skills and attitudes required to prepare, identify faulty part, test and repair AC/DC power supply.

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Module units:-

- Preparing work station for troubleshooting
- Single phase and three phase power outlets
- Maintaining power supply unit
- Testing and inspecting repaired power supply unit

Learning objectives of the Module

At the end of this session, the students will able to

- Prepare product and work station for troubleshooting
- Test and inspect single phase and three phase power outlets
- Identify and maintain faulty parts of power supply unit
- Test and inspect repaired power supply unit

Module Learning Instructions:

- Read the specific objectives of this Learning Guide.
- Follow the instructions described below.
- Read the information written in the information Sheets
- Accomplish the Self-checks
- Perform Operation Sheets
- Do the “LAP test”



Unit One: Preparing Station for Troubleshooting

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Power supply
- Preparing troubleshooting workplace
- Preparing and checking required materials ,tools and equipment
- Obtaining parts and materials

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify power supply
- Prepare troubleshooting workplace
- Prepare and check the required materials ,tools and equipment
- Obtain parts and materials

1.1 Power Supply

A power supply is an electrical device that supplies electric power to an electrical load. The primary function of a power supply is to convert electric current from a source to the correct voltage, current, and frequency to power the load. As a result, power supplies are sometimes referred to as **electric power converter**.

The power supply unit is the part of the hardware that is used to convert the power provided from the outlet into usable power to many parts inside an electrical device. Every energy supply must drive its load, which is connected to it.

Depending on its design, a power supply unit may obtain energy from various types of energy sources, like electrical energy transmission systems, and electromechanical systems such as, generators and alternators, solar power converters, energy storage devices such as a battery and fuel cells, or other power supply.

There are two types of power supplies existed, those are AC power supply and DC power supply. Based on the electrical device's electric specifications it may use AC power or DC power. AC power supply application (Home and office outlets are usually AC) and DC power supply application (Almost all electronics equipment's run on DC).

1.1.1 Need for Power Supplies

Around 95% of the electronic equipment's are powered from low voltage DC supplies. The source will be either a battery or a power supply converting AC mains into one or more low voltage DC supplies. Electronic components require a DC supply that is well regulated, has low noise characteristics and provides a fast response to load change. There are many small sections present in the electronic devices such as Computer, Television, Cathode ray Oscilloscope etc. but not all of those sections need 230V AC supply, which we get.

Instead, one or more sections may need a 12v DC while some others may need a 30v DC. In order to provide the required dc voltages, the incoming 230v AC supply has to be converted into pure DC for the usage. The **Power supply units** serve the same purpose.

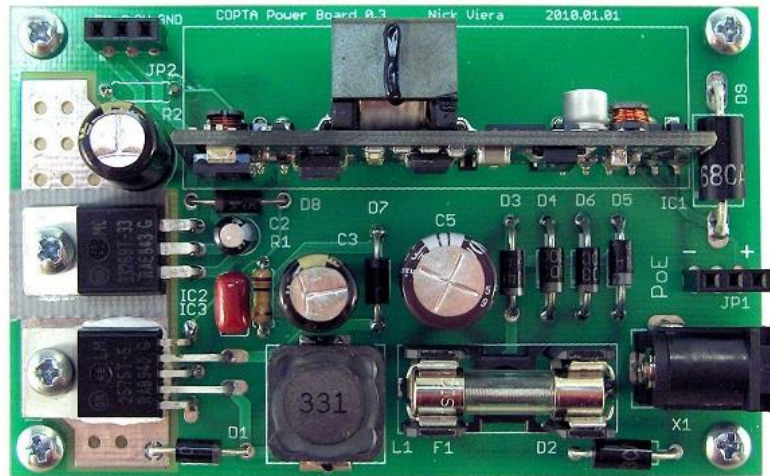


Figure 1.1: Real Power supply

1.1.2 Types of Power supply

A. Linear Power Supply

The Linear Power Supply LPS is the regulated power supply, which dissipates much heat in the series resistor to regulate the output voltage, which has low ripple and low noise. This LPS has many applications.

A linear power supply requires larger semiconductor devices to regulate the output voltage and generates more heat resulting in lower energy efficiency. Linear power supplies have transient response times up to 100 times faster than the others do, which is very important in certain specialized areas.

A typical linear power supply unit consists of the following.

- **Transformer:** - an input transformer for the stepping down of the 230v AC power supply
- **Rectifier:** - A Rectifier circuit to convert the AC components present in the signal to DC components.
- **Smoothing** - A filtering circuit to smoothen the variations present in the rectified output.
- **Regulator:** - A voltage regulator circuit in order to control the voltage to a desired output level.
- **Load:** - the load, which uses the pure dc, output from the regulated output.

Block Diagram of a Power Supply Unit

The block diagram of a Regulated Power supply unit is as shown below.

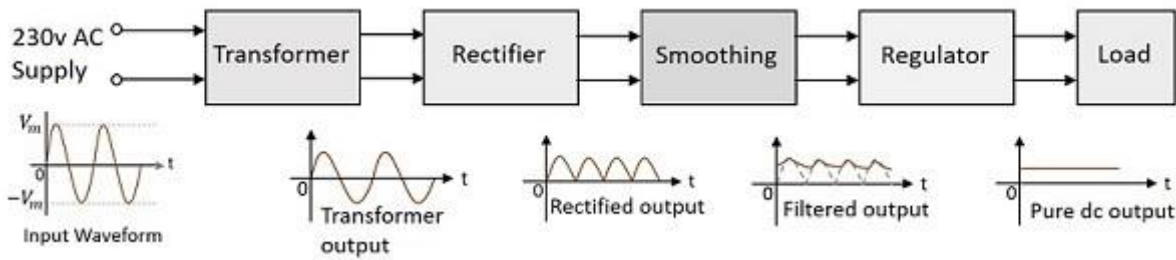


Figure 1.2: Block diagram of linear power supply

i) Transformer

Transformers are used to increase or decrease the line voltage. A transformer has a **primary coil** to which **input** is given and a **secondary coil** from which the **output** is collected. Both of these coils are wound on a core material. Usually an insulator forms the **Core** of the transformer. The following figure shows a practical transformer.

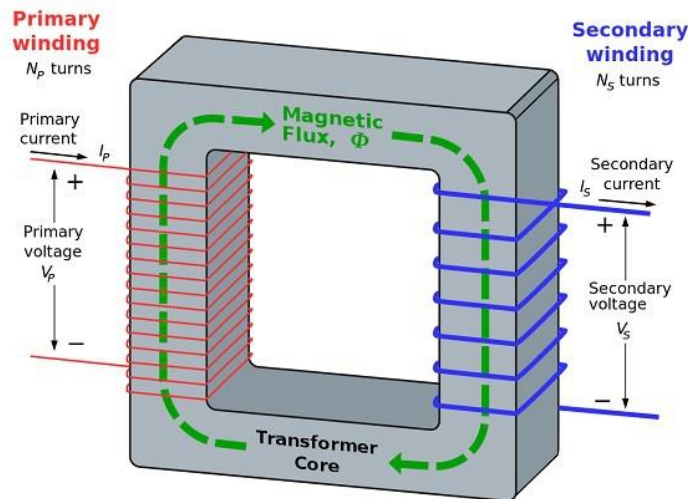


Figure 1.3: Transformer

From the above figure, it is evident that a few notations are common. They are as follows –

N_p = Number of turns in the primary winding

N_s = Number of turns in the secondary winding

I_p = Current flowing in the primary of the transformer

I_s = Current flowing in the secondary of the transformer

V_p = Voltage across the primary of the transformer

V_s = Voltage across the secondary of the transformer

ϕ = Magnetic flux present around the core of the transformer

Transformer in a Circuit

The following figure shows how a transformer is represented in a circuit. The primary winding, the secondary winding and the core of the transformer are also represented in the following figure.

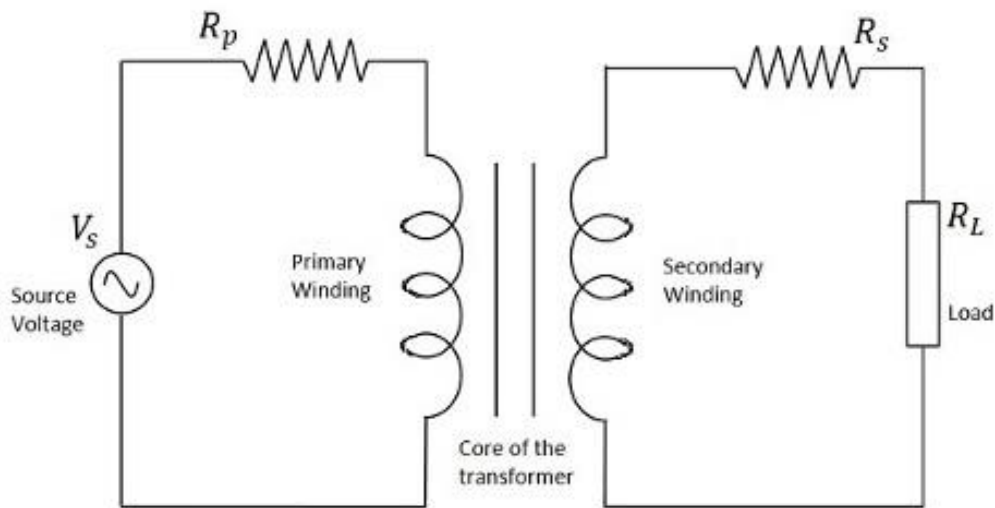


Figure 1.4: Primary winding, secondary winding, and core transformer

Hence, when a transformer is connected in a circuit, the input supply is given to the primary coil so that it produces varying magnetic flux with this power supply and that flux is induced into the secondary coil of the transformer, which produces the varying EMF of the varying flux. As the flux should be varying, for the transfer of EMF from primary to secondary, a transformer always works on alternating current AC. Depending upon the number of turns in the secondary winding, a transformer can be classified as either a Step-up or a **Step-down** transformer.

Step-up Transformer

When the secondary winding has more number of turns than the primary winding, then the transformer is said to be a **Step-up** transformer. Here the induced EMF is greater than the input signal. The figure below shows the symbol of a step-up transformer.

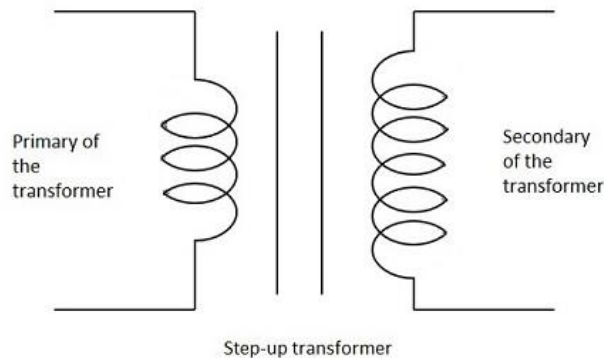


Figure 1.5: The symbol of step up transformer

Step-Down Transformer

When the secondary winding has lesser number of turns than the primary winding, then the transformer is said to be a **Step-down** transformer. Here the induced EMF is lesser than the input signal. The figure below shows the symbol of a step-down transformer.

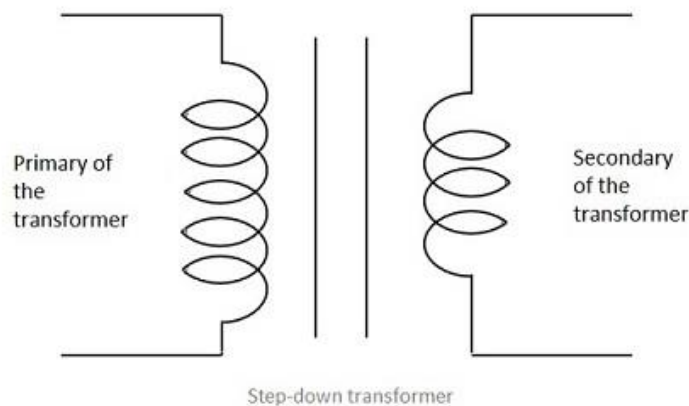


Figure 1.6: The symbol of step down transformer

In our Power supply circuits, we use the **Step-down transformer**, as we need to lessen the AC power to DC. The output of this Step-down transformer will be less in power and this will be given as the input to the next section, called **rectifier**. We will discuss about rectifiers in the next chapter. Whenever there arises the need to convert an AC to DC power, a rectifier circuit comes for the rescue. A simple PN junction diode acts as a rectifier. The forward biasing and reverse biasing conditions of the diode makes the rectification.

ii) Rectification

The process of converting alternating current (AC) to pulsed direct current (DC) is called **Rectification**. An alternating current has the property to change its state continuously. This is understood by observing the sine wave by which an alternating current is indicated. It raises in its positive direction goes to a peak positive value, reduces from there to normal and again goes to negative portion and reaches the negative peak and again gets back to normal and goes on.

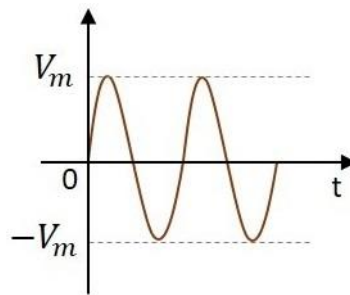


Figure 1.7: AC wave form

During its journey in the formation of wave, we can observe that the wave goes in positive and negative directions. Actually, it alters completely and hence the name alternating current.

However, during the process of rectification, this alternating current is changed into direct current DC. The wave, which flows in both positive and negative direction until then, will get its direction restricted only to positive direction, when converted to DC. Hence, the current is allowed to flow only in positive direction and resisted in negative direction, just as in the figure below.

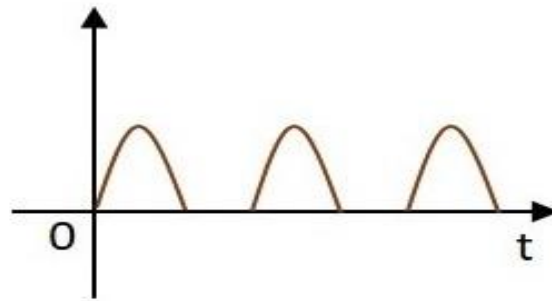


Figure 1.8: Pulsated DC wave form

The circuit that does rectification is called as a **Rectifier circuit**. A diode is used as a rectifier, to construct a rectifier circuit.

Types of Rectifier circuits

There are two main types of rectifier circuits, depending upon their output. They are

1. Half-wave Rectifier
2. Full-wave Rectifier

A Half-wave rectifier circuit rectifies only positive half cycles of the input supply whereas a Full-wave rectifier circuit rectifies both positive and negative half cycles of the input supply.

1. Half-Wave Rectifier

The name half-wave rectifier itself states that the **rectification** is done only for **half** of the cycle. The AC signal is given through an input transformer which steps up or down according to the usage. Mostly a step down transformer is used in rectifier circuits, to reduce the input voltage.

The input signal given to the transformer is passed through a PN junction diode that acts as a rectifier. This diode converts the AC voltage into pulsating dc for only the positive half cycles of the input. A load resistor is connected at the end of the circuit. The figure below shows the circuit of a half wave rectifier.

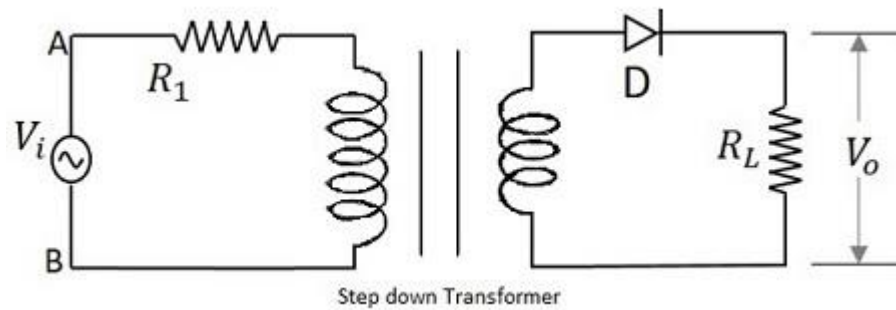


Figure 1.9: Half wave rectifier circuit

Working of a Half-Wave Rectifier (HWR)

The input signal is given to the transformer, which reduces the voltage levels. The output from the transformer is given to the diode, which acts as a rectifier. This diode gets **ON conducts** for positive half cycles of input signal. Hence, a current flows in the circuit and there will be a voltage drop across the load resistor. The diode gets OFF **doesn't conduct** for negative half cycles and hence the output for negative half cycles will be, $i_D=0$ and $V_o=0$

Hence, the output is present for positive half cycles of the input voltage only *neglecting the reverse leakage current*. This output will be pulsating which is taken across the load resistor.

Waveforms of a HWR

The input and output waveforms are as shown in the following figure.

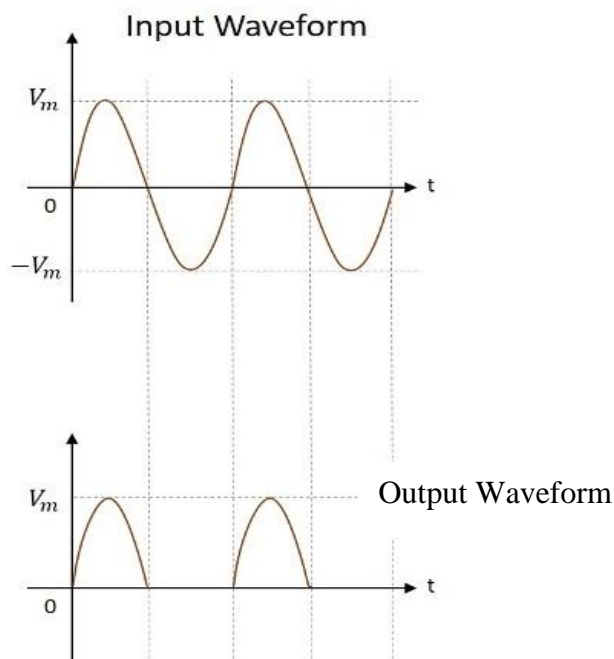


Figure 1.10: Half wave rectifier pulsating DC input and output waveform

Hence, the output of a half wave rectifier is a pulsating dc.

Ripple factor is defined as the amount of AC content present in the output DC. Pulsating direct current (PDC) is a periodic current, which changes in value but never changes in direction. PDC has some characteristics of both AC and DC. Like an AC, wave the voltage of a PDC wave continually varies, but like a DC wave, the sign of the voltage is constant. Half-wave rectifier or a full-wave rectifier commonly produces pulsed DC from AC.

- V_{dc}, V_{av} :- DC output voltage or average output voltage.
- V_{peak} :- Peak value of input phase voltage.
- V_{rms} :- the output voltage of root mean square value
- **For half wave rectifier:-**

- $V_{dc} = \frac{V_{peak}}{\pi} = 0.318V_{peak}$

- $V_{peak} = V_{rms} * \sqrt{2}$

- $V_{dc} = \frac{V_{rms} * \sqrt{2}}{\pi} = 0.45V_{rms}$

Advantages and Disadvantages of Half Wave Rectifier

Advantages of half wave rectifier

- Cheap
- Simple
- Easy to use
- Low number of components

Disadvantages of half wave rectifier

- More amount of ripple content
- Transformer utilization factor is very low
- Rectification efficiency is low

2. Full wave rectifier

A Rectifier circuit that rectifies both the positive and negative half cycles can be termed as a full wave rectifier as it rectifies the complete cycle. The construction of a full wave rectifier can be made in two types.

They are

- a) Center-tapped Full wave rectifier
- b) Bridge full wave rectifier

Both of them have their advantages and disadvantages. Let us now go through both of their construction and working along with their waveforms to know which one is better and why.

a) Center-tapped Full-Wave Rectifier

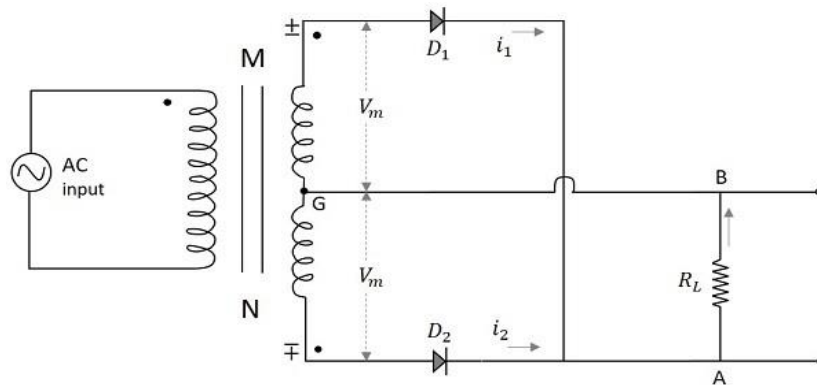
A rectifier circuit whose transformer secondary is tapped to get the desired output voltage, using two diodes alternatively, to rectify the complete cycle is called as a **Center-tapped Full wave rectifier circuit**. The transformer is center tapped here unlike the other cases.

The features of a center-tapping transformer are –

- The tapping is done by drawing a lead at the mid-point on the secondary winding. This winding is split into two equal halves by doing so.
- The voltage at the tapped mid-point is zero. This forms a neutral point.

- The center tapping provides two separate output voltages which are equal in magnitude but opposite in polarity to each other.
- A number of tapings can be drawn out to obtain different levels of voltages.

The center-tapped transformer with two rectifier diodes is used in the construction of a **Center-tapped full wave rectifier**. The circuit diagram of a center tapped full wave rectifier is as shown below.



Circuit diagram of a center-tapped full wave rectifier

Figure 1.11: Center-tapped full wave rectifier circuit

Working of a Center-tapped full wave rectifier (CT- FWR)

The working of a center-tapped full wave rectifier can be understood by the above figure. When the positive half cycle of the input voltage is applied, the point M at the transformer secondary becomes positive with respect to the point N. This makes the diode D_1 forward biased. Hence current i_1 flows through the load resistor from A to B. We now have the positive half cycles in the output

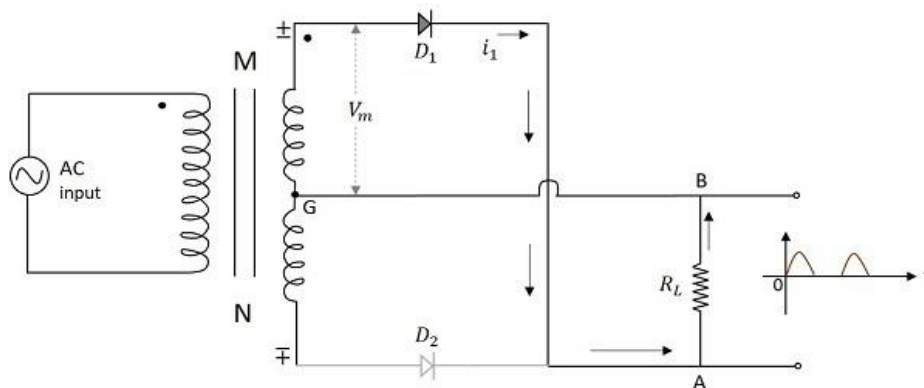


Figure 1.12: Center-tapped full wave rectifier output waveform during the positive half cycle

When the negative half cycle of the input voltage is applied, the point M at the transformer secondary becomes negative with respect to the point N. This makes the diode D_2 forward biased. Hence current i_2 flows through the load resistor from A to B. We now have the positive half cycles in the output, even during the negative half cycles of the input.

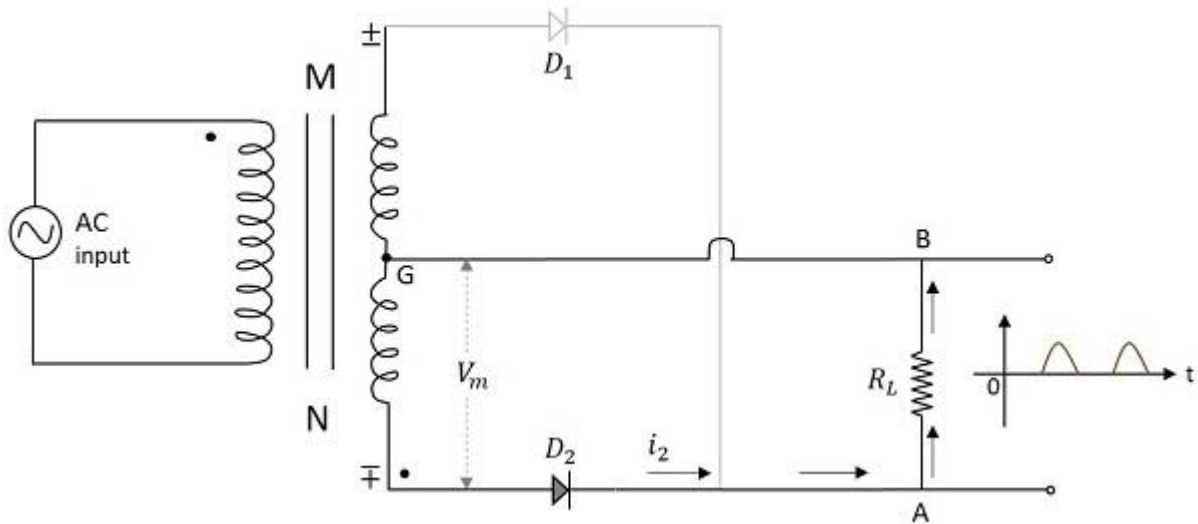


Figure 1.13: Center-tapped full wave rectifier output waveform during the negative half cycle

Waveforms of CT FWR

The input and output waveforms of the center-tapped full wave rectifier are as follows.

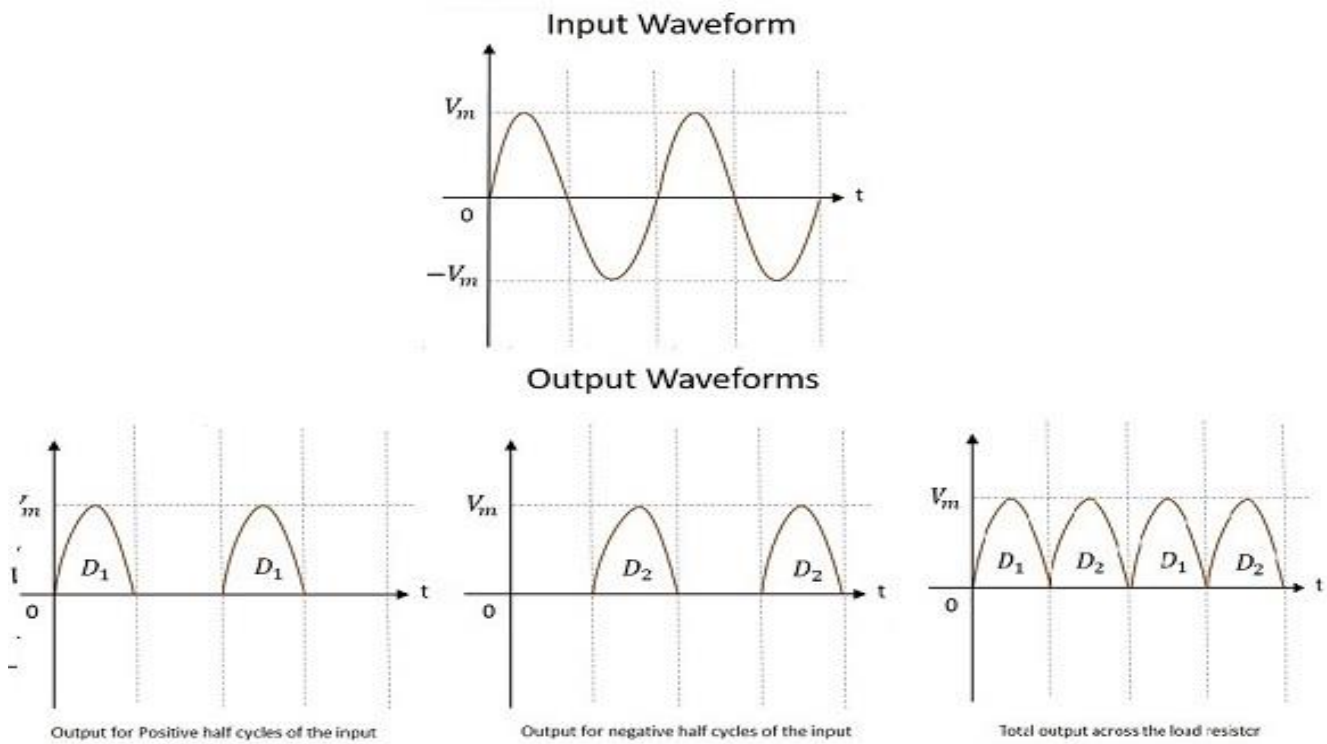


Figure 1.14: Center-tapped full wave rectifier waveform

From the above figure, it is evident that the output is obtained for both the positive and negative half cycles. It is also observed that the output across the load resistor is in the **same direction** for both the half cycles.

Disadvantages

There are few disadvantages for a center-tapped full wave rectifier such as –

- Location of center-tapping is difficult
- The dc output voltage is small
- PIV of the diodes should be high

The next kind of full wave rectifier circuit is the **Bridge Full wave rectifier circuit**.

a) Bridge Full-Wave Rectifier

This is such a full wave rectifier circuit, which utilizes four diodes connected in bridge form so as not only to produce the output during the full cycle of input, but also to eliminate the disadvantages of the center-tapped full wave rectifier circuit.

There is no need of any center tapping of the transformer in this circuit. Four diodes called D_1 , D_2 , D_3 and D_4 are used in constructing a bridge type network so that two of the diodes conduct for one-half cycle and two conduct for the other half cycle of the input supply. The circuit of a bridge full wave rectifier is as shown in the following figure.

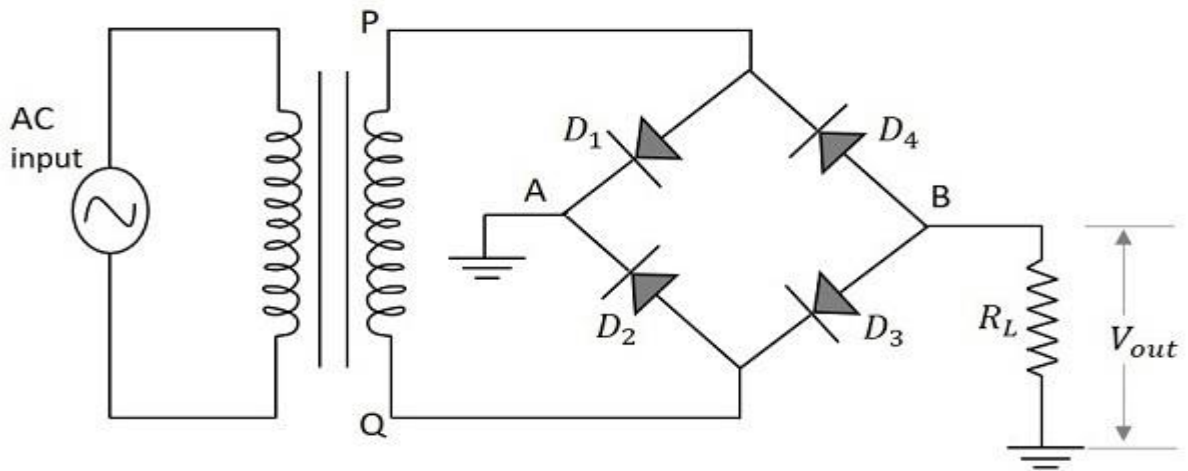


Figure 1.15: Bridge rectifier circuit

Working of a Bridge Full-Wave Rectifier

The full wave rectifier with four diodes connected in bridge circuit is employed to get a better full wave output response. When the positive half cycle of the input supply is given, point P becomes positive with respect to the point Q. This makes the diode D_1 and D_3 forward biased while D_2 and D_4 reverse biased. These two diodes will now be in series with the load resistor.

The following figure indicates this along with the conventional current flow in the circuit.

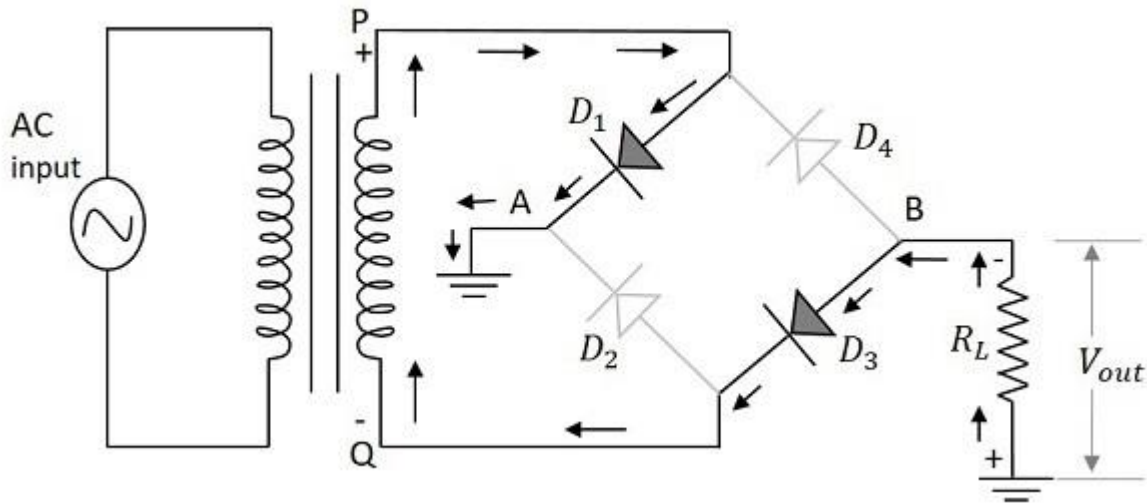


Figure 1.16: Bridge rectifier circuit during the positive half cycle

Hence, the diodes D_1 and D_3 conduct during the positive half cycle of the input supply to produce the output along the load resistor. As two diodes work in order to produce the output, the voltage will be twice the output voltage of the center tapped full wave rectifier.

When the negative half cycle of the input supply is given, point P becomes negative with respect to the point Q. This makes the diode D_1 and D_3 reverse biased while D_2 and D_4 forward biased. These two diodes will now be in series with the load resistor.

The following figure indicates this along with the conventional current flow in the circuit.

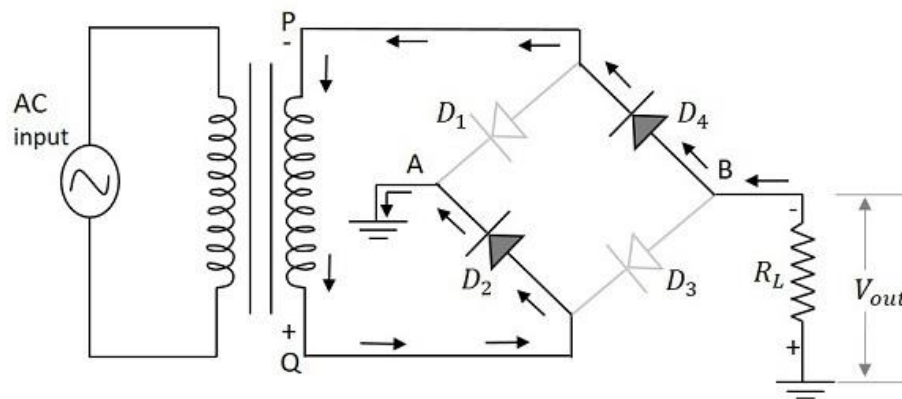


Figure 1.17: Bridge rectifier circuit during the negative half cycle

Hence, the diodes D_2 and D_4 conduct during the negative half cycle of the input supply to produce the output along the load resistor. Here also two diodes work to produce the output voltage. The current flows in the same direction as during the positive half cycle of the input.

Waveforms of Bridge Full-Wave Rectifier (FWR)

The input and output waveforms of the center-tapped full wave rectifier are as follows.

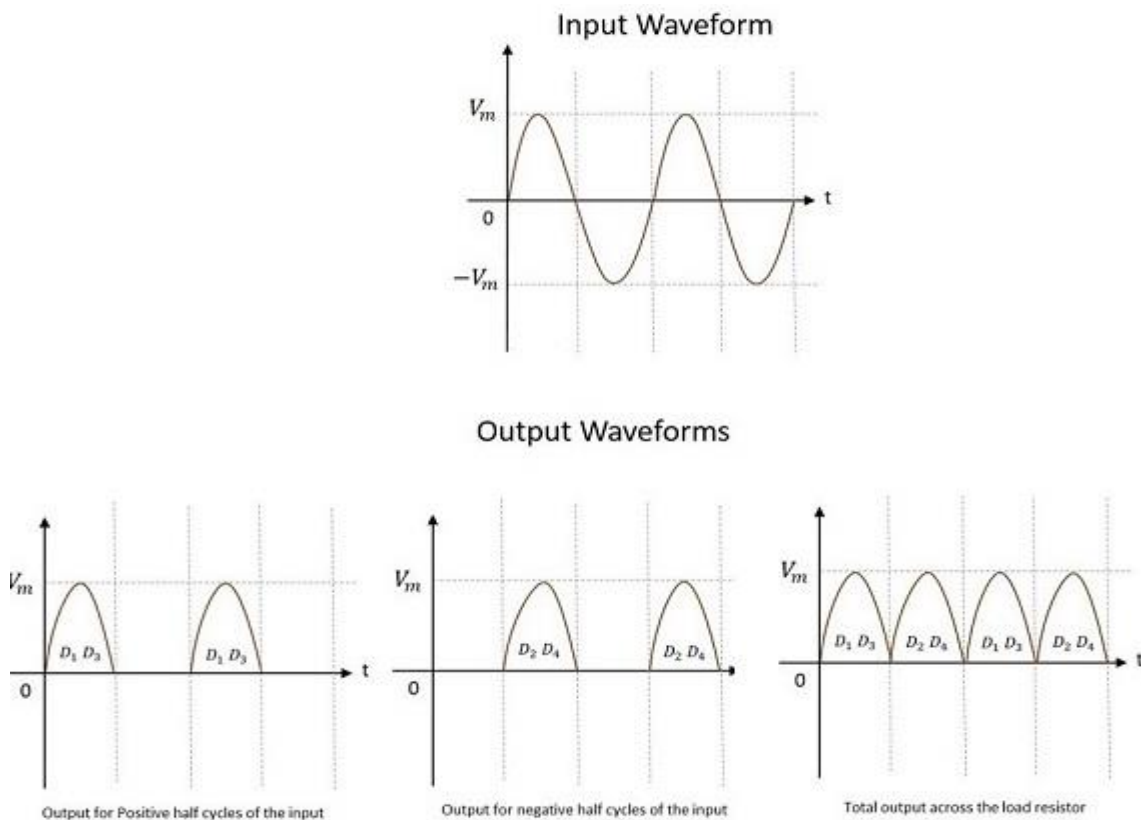


Figure 1.18: Bridge rectifier output waveform

From the above figure, it is evident that the output is obtained for both the positive and negative half cycles. It is also observed that the output across the load resistor is in the **same direction** for both the half cycles.

Advantages

There are many advantages for a bridge full wave rectifier, such as –

- No need of center tapping
- The dc output voltage is twice that of the center-tapper FWR.
- PIV of the diodes is of the half value that of the center-tapper FWR.
- The design of the circuit is easier with better output.

Half-Wave Vs. Full-Wave Rectifier

After having gone through all the values of different parameters of the full wave rectifier, let us just try to compare and contrast the features of half-wave and full-wave rectifiers.

Table 1.1: Comparison of half wave rectifier, center tapped FWR, and bridge FWR

Terms	Half Wave Rectifier	Center Tapped FWR	Bridge FWR
Number of Diodes	1	2	4
Transformer tapping	No	Yes	No
Peak Inverse Voltage	V_m	$2V_m$	V_m
Maximum Efficiency	40.6%	81.2%	81.2%
Average / dc current	I_m/π	$2I_m/\pi$	$2I_m/\pi$
DC voltage	V_m/π	$2V_m/\pi$	$2V_m/\pi$
RMS current	$I_m/2$	$I_m/\sqrt{2}$	$I_m/\sqrt{2}$
Ripple Factor	1.21	0.48	0.48
Output frequency	f_{in}	$2f_{in}$	$2f_{in}$

The block diagram of power supply clearly explains that a filter circuit is needed after the rectifier circuit. A rectifier helps in converting a pulsating alternating current to direct current, which flows only in one direction. Until now, we have seen different types of rectifier circuits.

The output of all these rectifier circuits contains some ripple factor. We have also observed that the ripple factor of a half wave rectifier is greater than that of a full wave rectifier.

iii) Filters

Why do we need filters?

The ripple in the signal denotes the presence of some AC component. This ac component has to be completely removed in order to get pure dc output. Therefore, we need a circuit that **smoothens** the rectified output into a pure dc signal.

A **filter circuit** is one that removes the ac component present in the rectified output and allows the dc component to reach the load.

The following figure shows the functionality of a filter circuit.

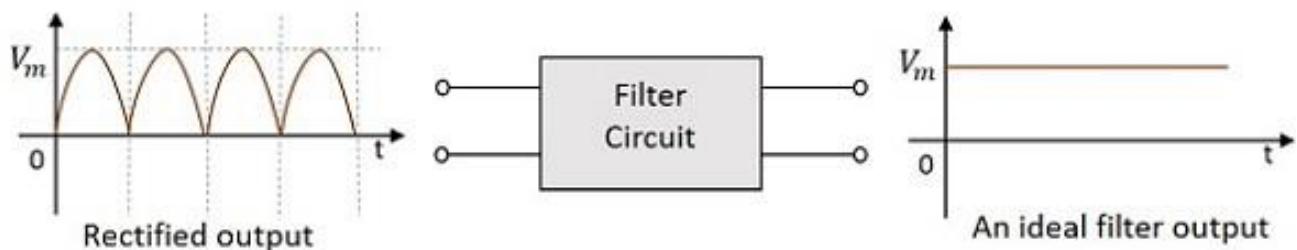


Figure 1.19: Rectified output, filter circuit, and an ideal filter output

A filter circuit is constructed using two main components, inductor and capacitor. We have already studied in Basic Electronics tutorial that

- An inductor allows **dc** and blocks **ac**.
- A capacitor allows **ac** and blocks **dc**.

Let us try to construct a few filters, using these two components.

A. Series Inductor Filter

As an inductor allows dc and blocks ac, a filter called **Series Inductor Filter** can be constructed by connecting the inductor in series, between the rectifier and the load. The figure below shows the circuit of a series inductor filter.

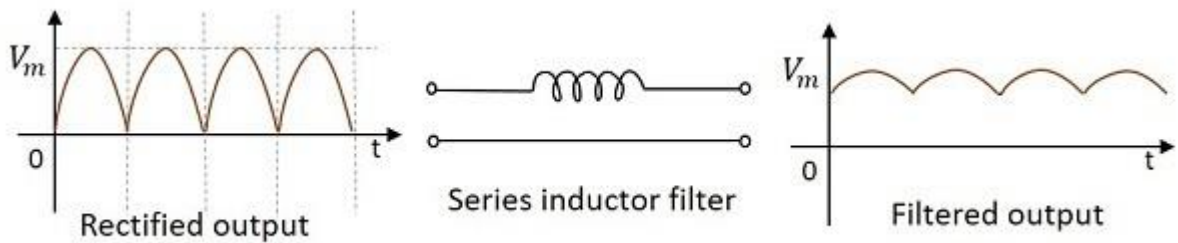


Figure 1.20: Rectified output, series inductor filter, and filtered output

The rectified output when passed through this filter, the inductor blocks the ac components that are present in the signal, in order to provide a pure dc. This is a simple primary filter.

B. Shunt Capacitor Filter

As a capacitor allows ac through it and blocks dc, a filter called **Shunt Capacitor Filter** can be constructed using a capacitor, connected in shunt, as shown in the following figure.

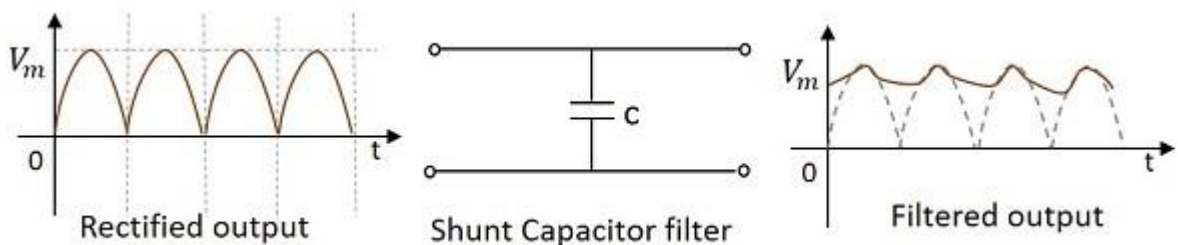


Figure 1.21: Rectified output, shunt capacitor filter, and filtered output

The rectified output when passed through this filter, the ac components present in the signal are grounded through the capacitor that allows ac components. The remaining dc components present in the signal are collected at the output.

The above filter types discussed are constructed using an inductor or a capacitor. Now, let's try to use both of them to make a better filter. These are combinational filters.

C. L-C Filter

A filter circuit can be constructed using both inductor and capacitor in order to obtain a better output where the efficiencies of both inductor and capacitor can be used. The figure below shows the circuit diagram of a LC filter.

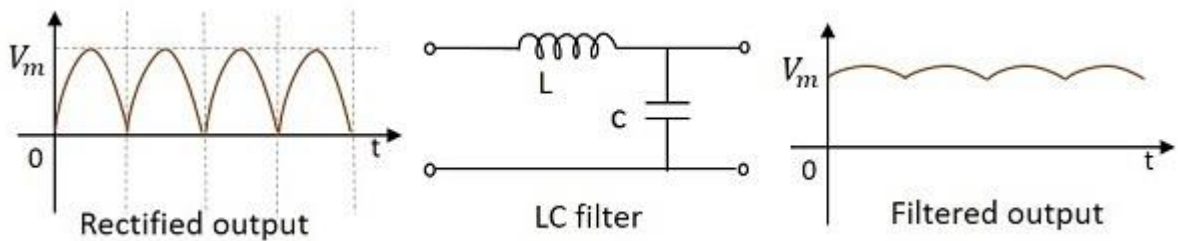


Figure 1.22: Rectified output, LC filter, and filtered output

The rectified output when given to this circuit, the inductor allows dc components to pass through it, blocking the ac components in the signal. Now, from that signal, few more ac components if any present are grounded so that we get a pure dc output.

This filter is also called as a **Choke Input Filter** as the input signal first enters the inductor. The output of this filter is a better one than the previous ones.

D. Π - Filter *Pi*filter

This is another type of **filter** circuit, which is very commonly used. It has capacitor at its input and hence it is also called as a **Capacitor Input Filter**. Here, two capacitors and one inductor are connected in the form of π shaped network. A capacitor in parallel, then an inductor in series, followed by another capacitor in parallel makes this circuit.

If needed, several identical sections can also be added to this, according to the requirement. The figure below shows a circuit for π Filter *Pi-filter*

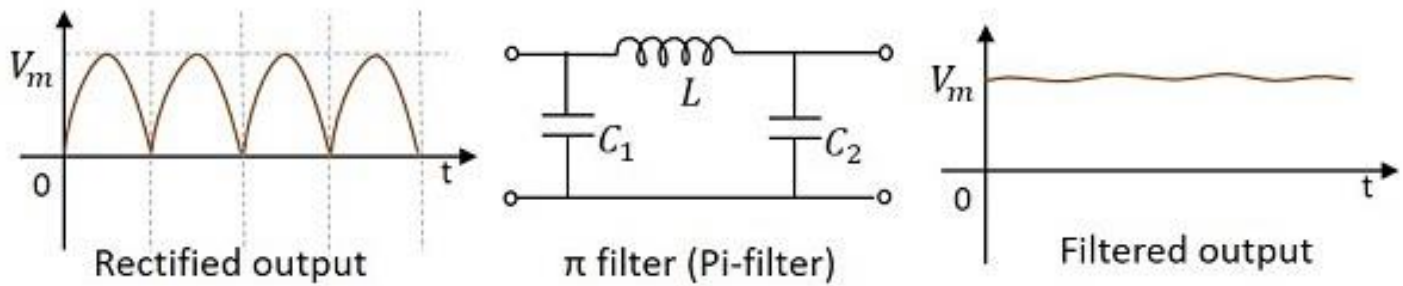


Figure 1.23: Rectified output, Pi- filter, and filtered output

Working of a Pi filter

In this circuit, we have a capacitor in parallel, then an inductor in series, followed by another capacitor in parallel.

- **Capacitor C_1** – this filter capacitor offers high reactance to dc and low reactance to ac signal. After grounding the ac components present in the signal, the signal passes to the inductor for further filtration.
- **Inductor L** – This inductor offers low reactance to dc components, while blocking the ac components if any got managed to pass, through the capacitor C_1 .
- **Capacitor C_2** – Now the signal is further smoothened using this capacitor so that it allows any ac component present in the signal, which the inductor has failed to block.

Thus we, get the desired pure dc output at the load.

The next and the last stage before load, in a power supply system is the Regulator part. Let us now try to understand what a regulator is and what it does.

iv) Regulator

For a power supply to produce a constant output voltage, irrespective of the input voltage variations or the load current variations, there is a need for a voltage regulator.

A voltage regulator is such a device that maintains constant output voltage, instead of any kind of fluctuations in the input voltage being applied or any variations in current, drawn by the load. The following image gives an idea of what a practical regulator looks like.

Types of Regulators

Regulators can be classified into different categories, depending upon their working and type of connection.

Depending upon the type of regulation, the regulators are mainly divided into two types namely, line and load regulators.

- **Line Regulator** – the regulator which regulates the output voltage to be constant, in spite of input line variations, it is called as **Line regulator**.
- **Load Regulator** – the regulator which regulates the output voltage to be constant, in spite of the variations in load at the output, it is called as **Load regulator**.

Depending upon the type of connection, there are two types of voltage regulators. They are

- Series voltage regulator
- Shunt voltage regulator

The arrangement of them in a circuit will be just as in the following figures.

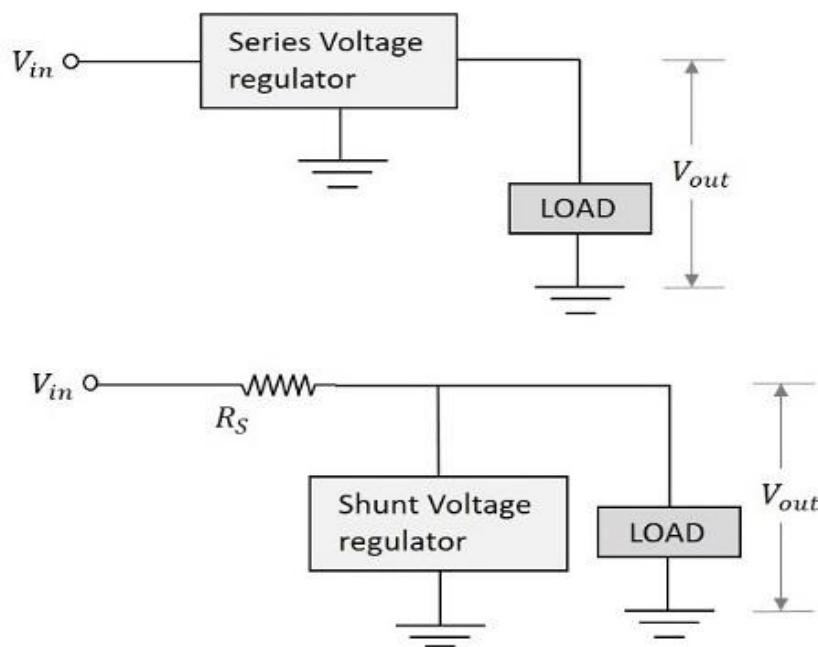


Figure 1.24: Series and shunt voltage regulator

a. Zener Voltage Regulator

A Zener voltage regulator is one, which uses Zener diode for regulating the output voltage. When the Zener diode is operated in the breakdown or **Zener region**, the voltage across it is substantially **constant** for a **large change of current** through it. This characteristic makes Zener diode a **good voltage regulator**.

The following figure shows an image of a simple Zener regulator.

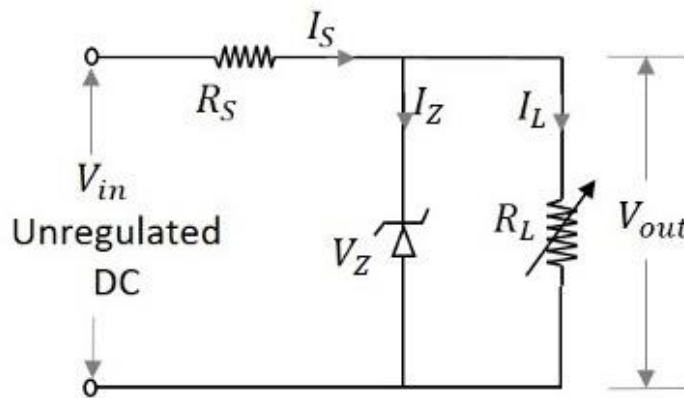


Figure 1.25: Zener voltage regulator circuit

The applied input voltage V_i when increased beyond the Zener voltage V_Z , then the Zener diode operates in the breakdown region and maintains constant voltage across the load. The series-limiting resistor R_S limits the input current.

Working of Zener Voltage Regulator

The Zener diode maintains the voltage across it constant in spite of load variations and input voltage fluctuations. Hence, we can consider 4 cases to understand the working of a Zener voltage regulator.

Case 1 – If the load current I_L increases, then the current through the Zener diode I_Z decreases in order to maintain the current through the series resistor R_S constant. The output voltage V_o depends upon the input voltage V_i and voltage across the series resistor R_S

This is can be written as

$$V_o = V_{in} - I R_S$$

Where I is constant. Therefore, V_o also remains constant.

Case 2 – If the load current I_L decreases, then the current through the Zener diode I_Z increases, as the current I_S through R_S series resistor remains constant. Though the current I_Z through Zener diode increases it maintains a constant output voltage V_Z , which maintains the load voltage constant.

Case 3 – If the input voltage V_i increases, then the current I_S through the series resistor R_S increases. This increases the voltage drop across the resistor, i.e. V_S increases. Though the current through Zener diode I_Z increases with this, the voltage across Zener diode V_Z remains constant, keeping the output load voltage constant.

Case 4 – If the input voltage decreases, the current through the series resistor decreases which makes the current through Zener diode I_Z decreases. But the Zener diode maintains output voltage constant due to its property.

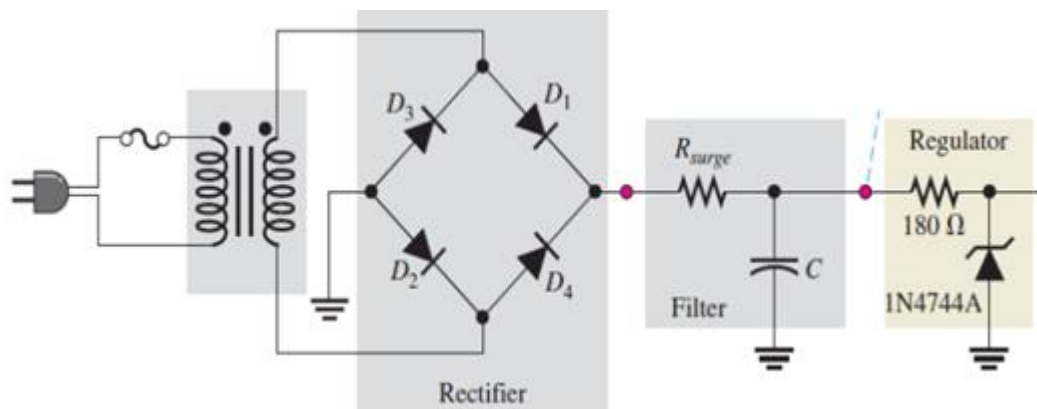


Figure 1.26: linear power supply using zener voltage regulator

Limitations of Zener Voltage Regulator

There are a few limitations for a Zener voltage regulator. They are –

- It is less efficient for heavy load currents.
- The Zener impedance slightly affects the output voltage.

Hence, a Zener voltage regulator is considered effective for low voltage applications. Now, let us go through the other types of voltage regulators, which are made using transistors

b. Transistor Series Voltage Regulator

This regulator has a transistor in series to the Zener regulator and both in parallel to the load. The transistor works as a variable resistor regulating its collector emitter voltage in order to maintain the output voltage constant. The figure below shows the transistor series voltage regulator.

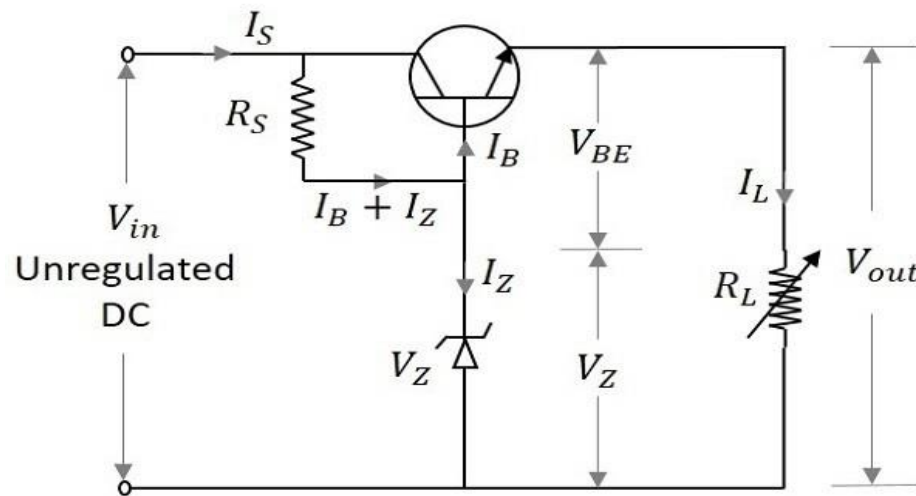


Figure 1.27: Transistor Series Voltage Regulator circuit

With the input operating conditions the current through the base of the transistor changes. This affects the voltage across the base emitter junction of the transistor V_{BE} . The Zener voltage V_Z that is constant maintains the output voltage. As both of them are maintained equal, any change in the input supply is indicated by the change in emitter base voltage V_{BE}

Hence, the output voltage V_o can be understood as

$$V_o = V_Z + V_{BE}$$

Working of Transistor Series Voltage Regulator

The working of a series voltage regulator shall be considered for input and load variations. If the input voltage is increased, the output voltage also increases. However, this in turn makes the voltage across the collector base junction V_{BE} to decrease, as the Zener voltage V_Z remains constant. The conduction decreases as the resistance across emitter collector region increases. This further increases the voltage across collector emitter junction V_{CE} thus reducing the output voltage V_o . This will be similar when the input voltage decreases.

When the load changes occur, which means if the resistance of the load decreases, increasing the load current I_L , the output voltage V_O decreases, increasing the emitter base voltage V_{BE} . With the increase in the emitter base voltage V_{BE} the conduction increases reducing the emitter collector resistance. This in turn increases the input current that compensates the decrease in the load resistance. This will be similar when the load current increases.

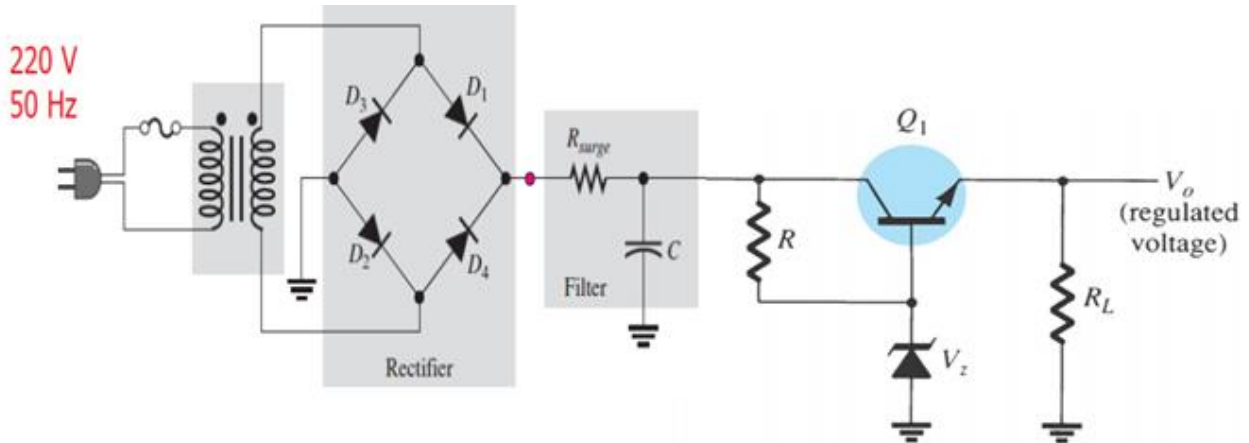


Figure 1.28: linear power supply using series voltage regulator

Limitations of Transistor Series Voltage Regulator

Transistor Series Voltage Regulators have the following limitations –

- The voltages V_{BE} and V_Z
- Are affected by the rise in temperature.
- No good regulation for high currents is possible.
- Power dissipation is high.
- Power dissipation is high.
- Less efficient

To minimize these limitations, transistor shunt regulator is used.

c. Transistor Shunt Voltage Regulator

A transistor shunt regulator circuit is formed by connecting a resistor in series with the input and a transistor whose base and collector are connected by a Zener diode that regulates both in parallel with the load. The figure below shows the circuit diagram of a transistor shunt regulator.

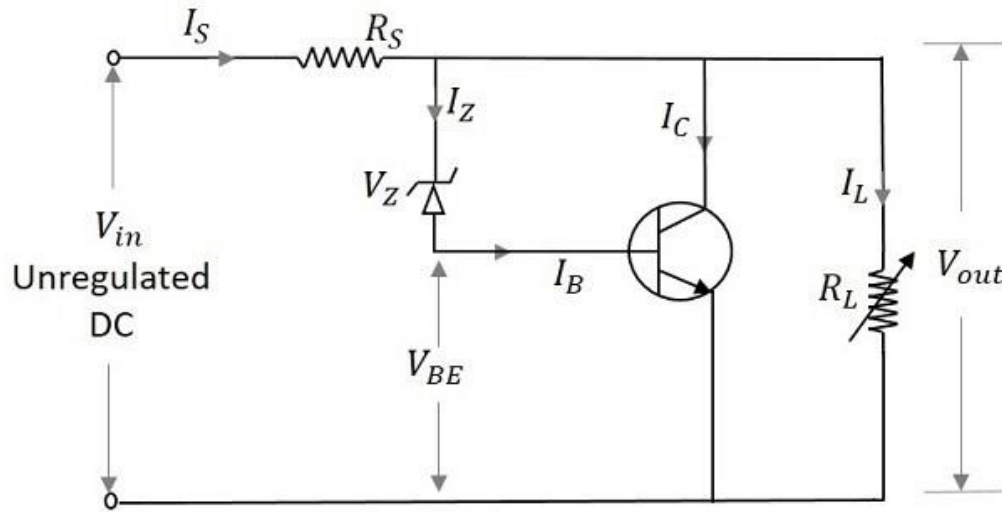


Figure 1.29: Transistor Shunt Voltage Regulator circuit

Working of Transistor Shunt Voltage Regulator

If the input voltage increases, the V_{BE} and V_O also get increased. However, this happens initially. Actually when V_{in} increases, the current I_{in} also increases. This current when flows through R_S , causes a voltage drop V_S across the series resistor, which also gets increased with V_{in} . But this makes V_O to decrease. Now this decrease in V_O compensates the initial increase maintaining it to be constant. Hence, V_O is maintained constant. If the output voltage decreases instead, the reverse happens.

If the load resistance decreases, there should be decrease in the output voltage V_O . The current through the load increases. This makes the base current and collector current of the transistor to decrease. The voltage across the series resistor becomes low, as the current flows heavily. The input current will be constant.

The output voltage appears will be the difference between the applied voltage V_i and the series voltage drop V_S . Hence, the output voltage will be increased to compensate the initial decrease and hence maintained constant. The reverse happens if the load resistance increases.

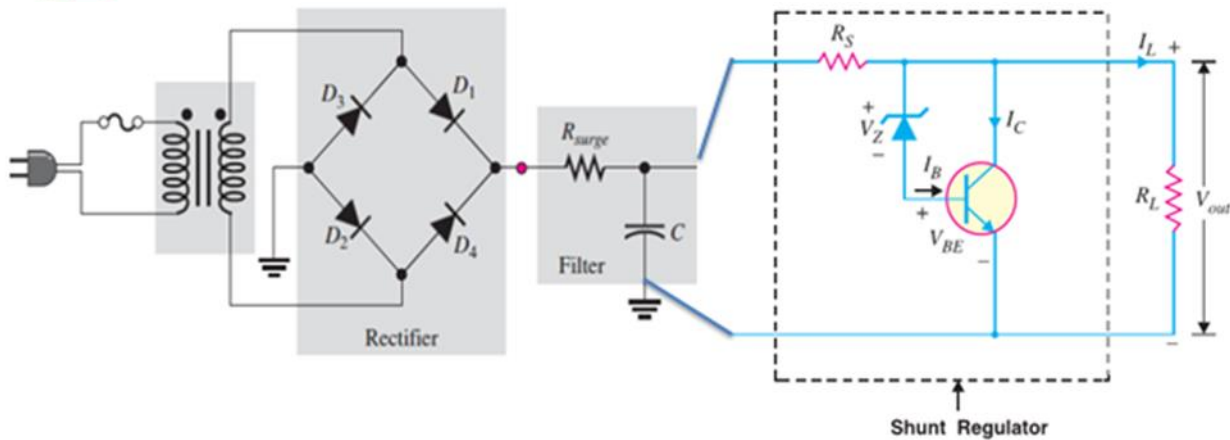


Figure 1.30: linear power supply using shunt voltage regulator

d. IC Regulators

Voltage Regulators are now a days available in the form of Integrated Circuits *ICs*. These are in short called as IC Regulators. Along with the functionality like a normal regulator, an IC regulator has the properties like thermal compensation, short circuit protection and surge protection that are built into the device.

Types of IC regulators

IC regulators can be of the following types –

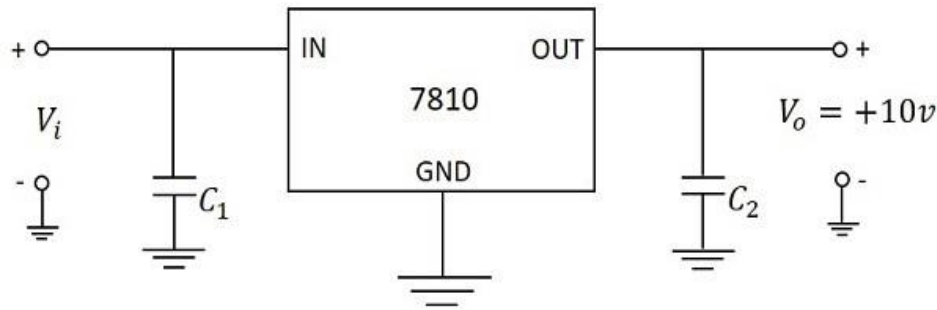
- I. Fixed Positive voltage regulators
- II. Fixed Negative voltage regulators
- III. Adjustable voltage regulators
- IV. Dual-tracking voltage regulators

Let us now discuss them in detail.

I. Fixed Positive Voltage Regulator

The output of these regulators is fixed to a specific value and the values are positive, which means the output voltage provided is positive voltage.

The most used series is 78xx series and the ICs will be like IC 7806, IC 7812 and IC 7815 etc. which provide +6v, +12v and +15v respectively as output voltages. The figure below shows the IC 7810 connected to provide a fixed 10v positive regulated output voltage.



Fixed Positive Voltage Regulator

Figure 1.31: Fixed Positive Voltage Regulator

In the above figure, the input capacitor C_1 is used to prevent unwanted oscillations and the output capacitor C_2 acts as a line filter to improve transient response.

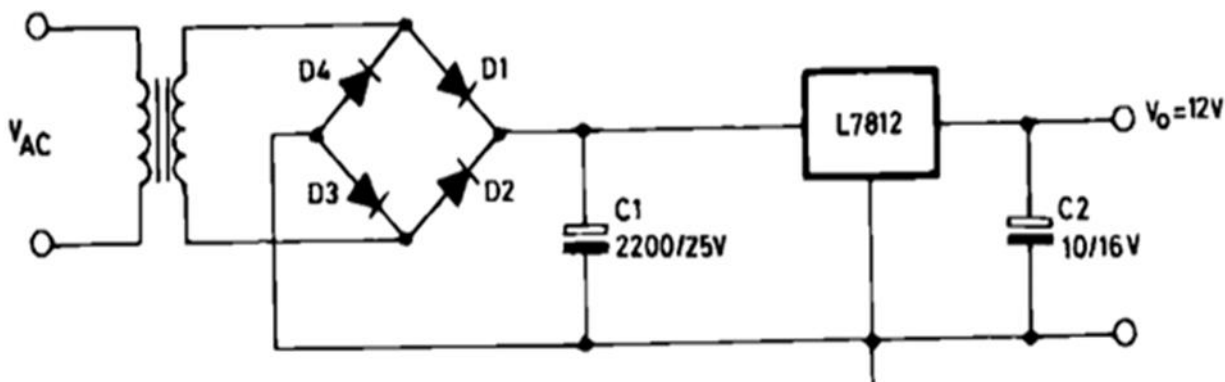


Figure 1.32: linear power supply using fixed positive voltage regulator (7812)

II. Fixed Negative Voltage Regulator

The output of these regulators is fixed to a specific value and the values are negative, which means the output voltage provided is negative voltage.

The most used series is 79xx series and the ICs will be like IC 7906, IC 7912 and IC 7915 etc. which provide -6v, -12v and -15v respectively as output voltages. The figure below shows the IC 7910 connected to provide a fixed 10v negative regulated output voltage.

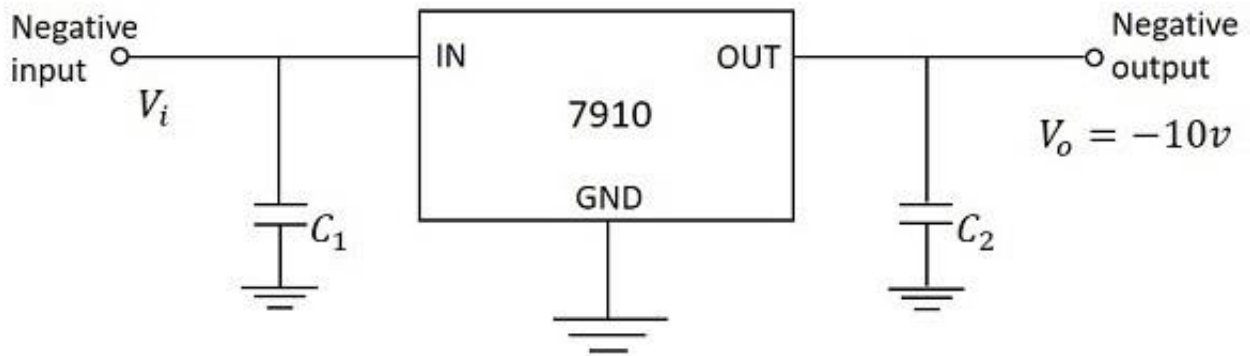


Figure 1.33: Fixed Negative Voltage Regulator

In the above figure, the input capacitor C_1 is used to prevent unwanted oscillations and the output capacitor C_2 acts as a line filter to improve transient response.

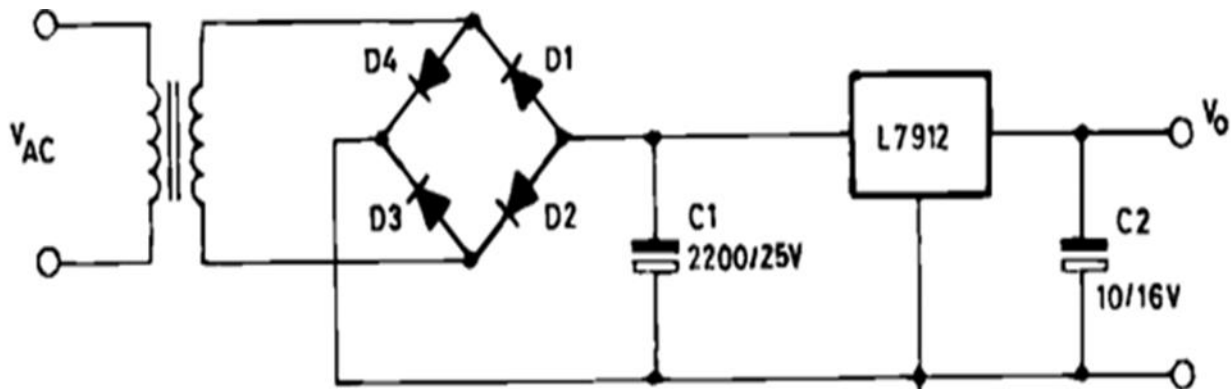


Figure 1.26: linear power supply using fixed negative voltage regulator (7912)

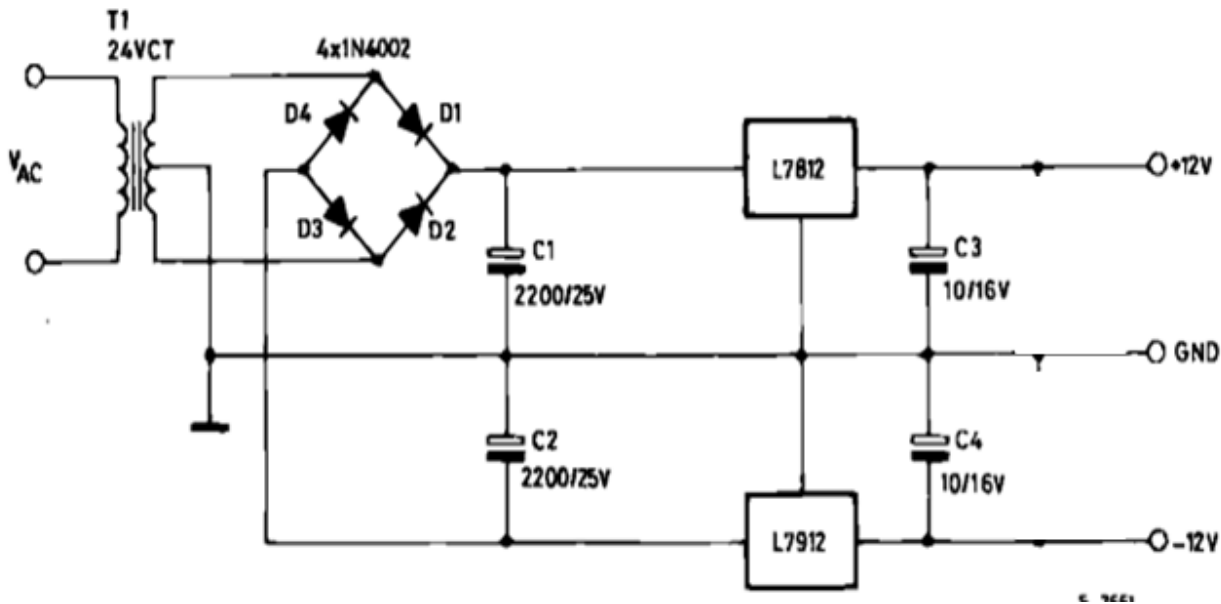


Figure 1.34: linear power supply using dual voltage regulator (7812 and 7912)

III. Adjustable Voltage Regulators

An adjustable voltage regulator has three terminals IN, OUT and ADJ. The input and output terminals are common whereas the adjustable terminal is provided with a variable resistor which lets the output to vary between a wide range.

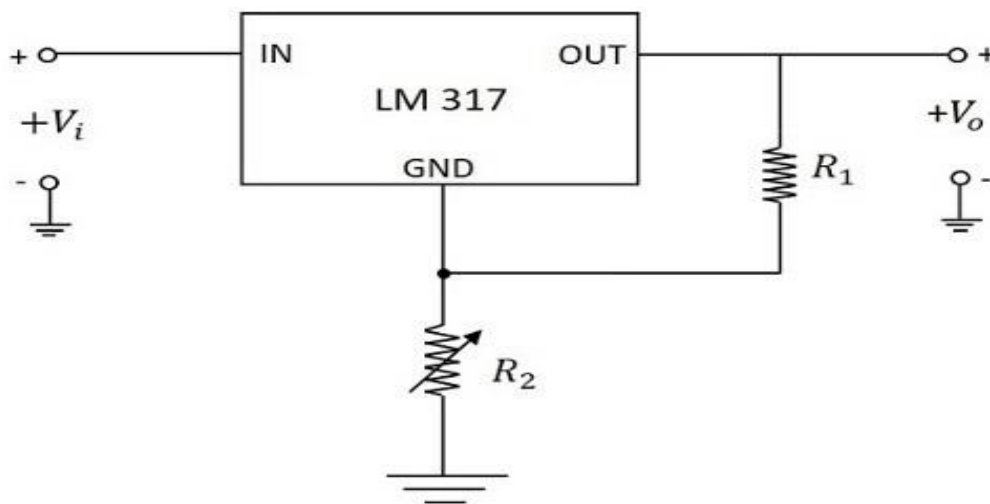


Figure 1.35: Adjustable Voltage Regulators

The above figure shows an unregulated power supply driving a LM 317 adjustable IC regulator that is commonly used. The LM 317 is a three terminal positive adjustable voltage regulator and can supply 1.5A of load current over an adjustable output range of 1.25v to 37v.

The topics discussed until now represent different sections of power supply unit. All these sections together make the **Linear Power Supply**. This is the conventional method of obtaining DC out of the input AC supply.

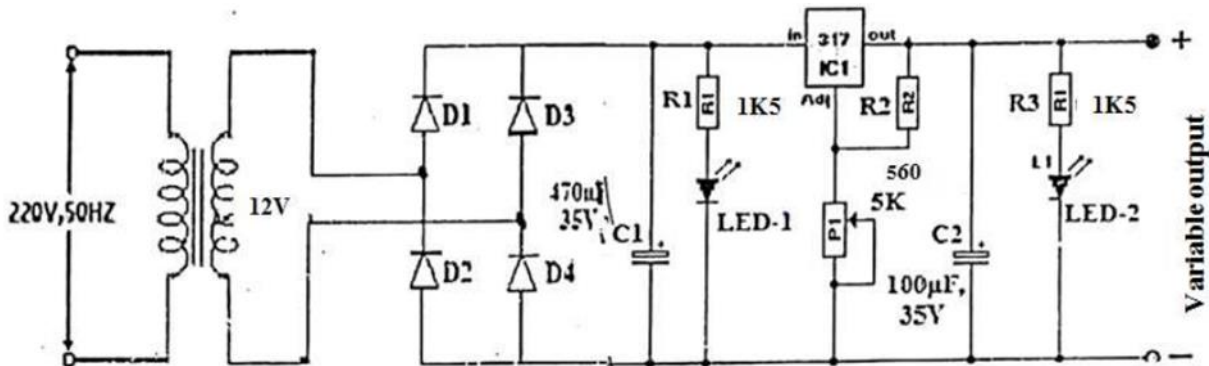


Figure 1.36: linear power supply using adjustable voltage regulator

Advantages of LPS

- + The power supply is continuous.
- + The circuitry is simple.
- + These are reliable systems.
- + This system dynamically responds to load changes.
- + The circuit resistances are changed to regulate the output voltage.
- + As the components operate in linear region, the noise is low.
- + The ripple is very low in the output voltage.

Disadvantages of LPS

- The transformers used are heavier and large.
- The heat dissipation is more.
- The efficiency of linear power supply is 40 to 50%
- Power is wasted in the form of heat in LPS circuits.
- Single output voltage is obtained.

We have already gone through different parts of a Linear Power supply. The block diagram of a Linear Power Supply is as shown in the following figure.

In spite of the above disadvantages, Linear Power Supplies are widely used in low-noise amplifiers, test equipment, control circuits. In addition, they are also used in data acquisition and signal processing.

All the power supply systems that need simple regulation and where efficiency is not a concern, the LPS circuits are used. As the electrical noise is lower, the LPS is used in powering sensitive analog circuitry. But to overcome the disadvantages of Linear Power Supply system, the Switched Mode Power Supply *SMPS* is used.

B. Switched Mode Power Supply *SMPS*

The disadvantages of LPS such as lower efficiency, the need for large value of capacitors to reduce ripples and heavy and costly transformers etc. are overcome by the implementation of Switched **Mode Power Supplies**.

The working of SMPS is simply understood by knowing that the transistor used in LPS is used to control the voltage drop while the transistor in SMPS is used as a **controlled switch**.

Working

The working of SMPS can be understood by the following figure.

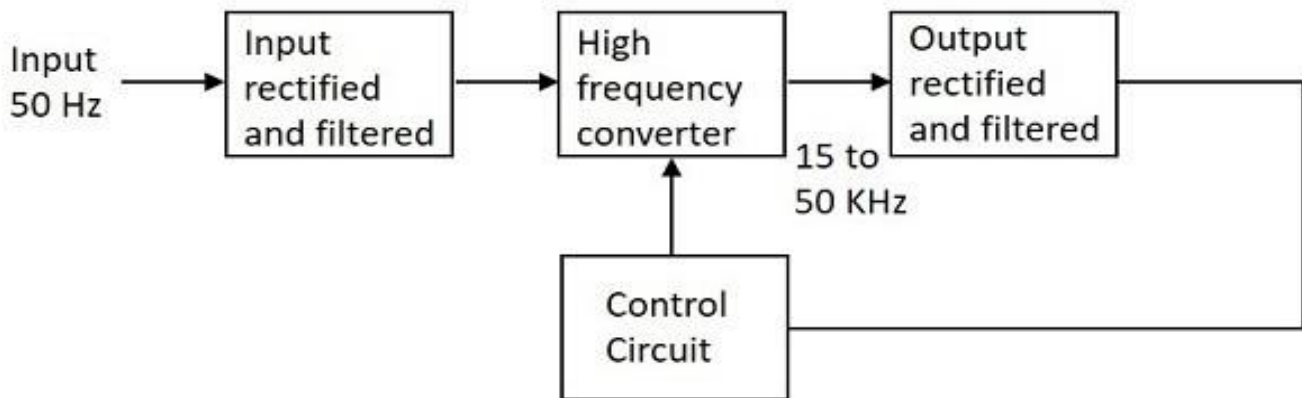


Figure 1.37: Simple block diagram of SMPS

Let us try to understand what happens at each stage of SMPS circuit.

Input Stage

The AC input supply signal 50 Hz is given directly to the rectifier and filter circuit combination without using any transformer. This output will have many variations and the capacitance value of the capacitor should be higher to handle the input fluctuations. This unregulated dc is given to the central switching section of SMPS.

Switching Section

A fast switching device such as a Power transistor or a MOSFET is employed in this section, which switches ON and OFF according to the variations and this output is given to the primary of the transformer present in this section. The transformer used here are much smaller and lighter ones unlike the ones used for 60 Hz supply. These are much efficient and hence the power conversion ratio is higher.

Output Stage

The output signal from the switching section is again rectified and filtered, to get the required DC voltage. This is a regulated output voltage which is then given to the control circuit, which is a feedback circuit. The final output is obtained after considering the feedback signal.

Control Unit

This unit is the feedback circuit which has many sections. Let us have a clear understanding about this from the following figure.

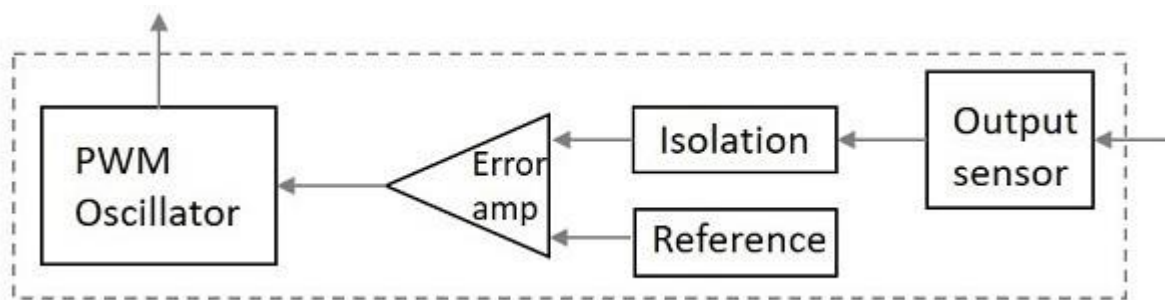


Figure 1.38: Control unit of SMPS

The above figure explains the inner parts of a control unit. The output sensor senses the signal and joins it to the control unit. The signal is isolated from the other section so that any sudden spikes should not affect the circuitry. A reference voltage is given as one input along with the signal to the error amplifier which is a comparator that compares the signal with the required signal level.

By controlling the chopping frequency the final voltage level is maintained. This is controlled by comparing the inputs given to the error amplifier, whose output helps to decide whether to increase or decrease the chopping frequency. The PWM oscillator produces a standard PWM wave fixed frequency.

We can get a better idea on the complete functioning of SMPS by having a look at the following figure.

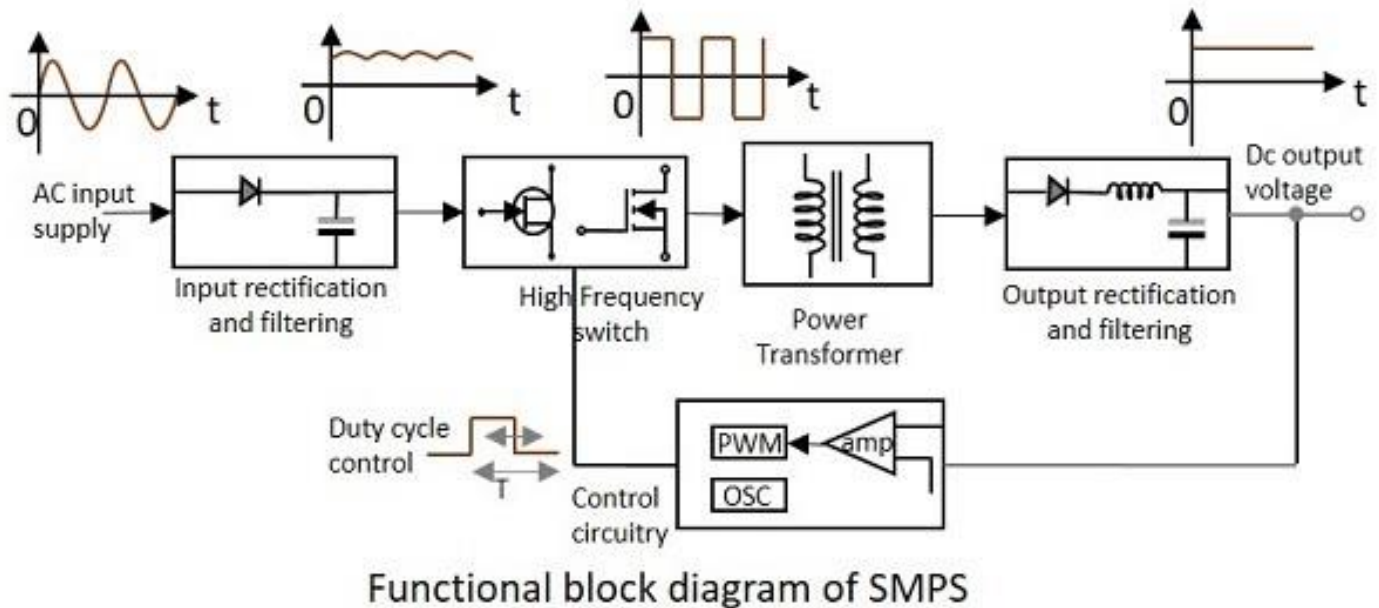


Figure 1.39: Functional block diagram of SMPS

Identifying electronic components in different types of SMPS

This will help you to be familiar with the sections and components used in SMPS and provides an information in preparing troubleshooting and repairing SMPS.



Figure 1.40: typical LCD Monitor SMPS

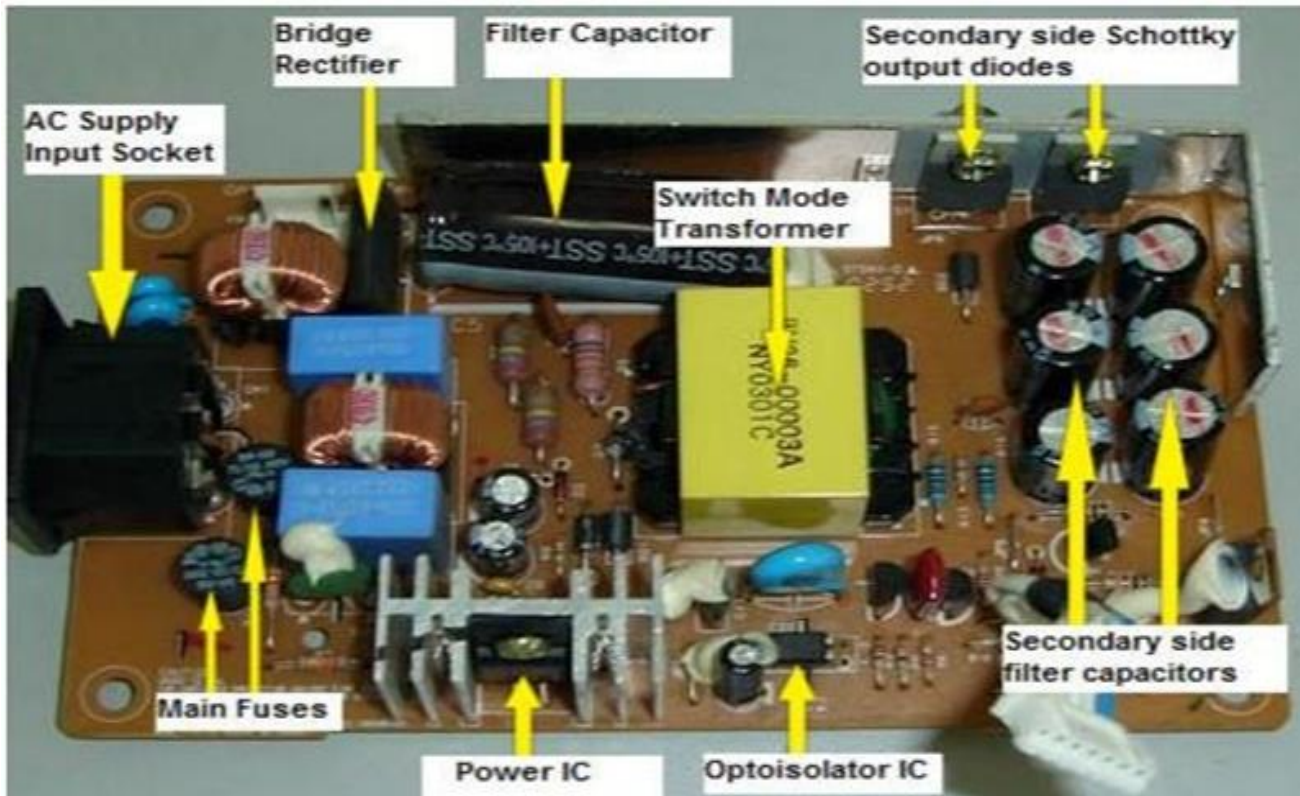


Figure 1.41: SMPS Board

Functions and schematic diagrams of SMPS Circuits

All of the power supply functions are almost the same, which is to produce an output voltage for various secondary circuits.

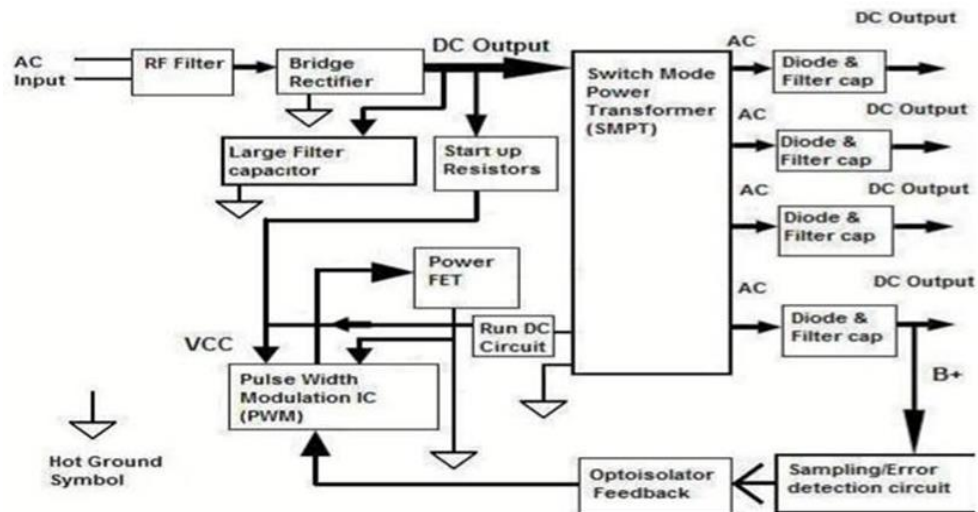


Figure 1.42: Block Diagram of a Typical SMPS

There are many types of SMPS in the market and it is impossible to explain all of them in this in topic. However, it will help to guide you with the help of schematic diagram, so that once you have understood how each circuit functions in SMPS then there will be no problem in repairing all types of SMPS because many SMPS in the market are the same, except that some uses more components while others use fewer. Generally, SMPS consists of 11 main circuits in order to form the complete set. Each one of the circuits malfunction could Cause problems in SMPS. This information sheet uses the LCD Monitor SMPS and some equipment schematic diagrams as a guide to explain how each of these circuit functions and possible causes of faults. The main circuits are:

1. Input protection and EMI Filtering Circuit
2. Bridge Circuit
3. Start Up and Run DC Circuit
4. Oscillator Circuit
5. Secondary output Voltage Circuit
6. Sampling Circuit
7. Error Detection Circuit
8. Feedback Circuit
9. Protection Circuit
10. Stand-by Circuit
11. Power Factor Correction (PFC)Circuit

1. Input protection and EMI Filtering Circuit

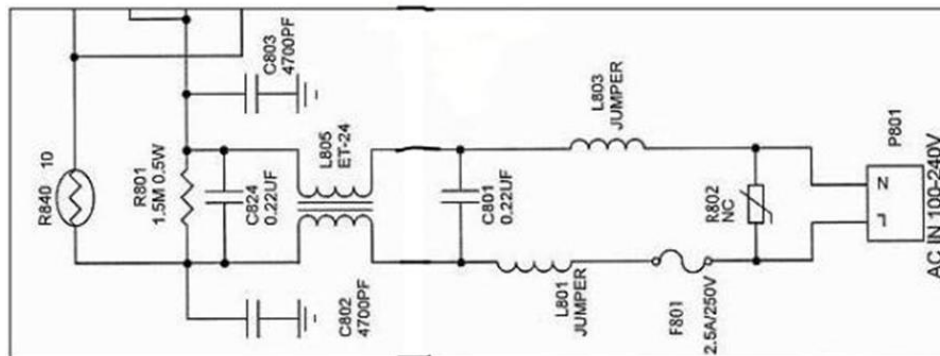


Figure 1.43: Input protection and EMI Filtering Circuit

- ✓ The first circuit where AC supply enters the SMPS

- ✓ The Varistor, R802 protects the power supply from transient voltage resulting from lightning strikes of power surge.
- ✓ The fuse F801 protects against faults and effectively isolates from the power supply.
- ✓ Capacitor C801 and C824 are X capacitors used to reduce the differential mode EMI.
- ✓ Resistor R801 discharges C801 and C824 on AC removal, preventing potential user shock.
- ✓ Inductor L805 is used in filtering common mode EMI from coupling back to the AC source.
- ✓ Thermistor R840 limits the initial peak inrush current drawn by the circuit at start up.

1. Bridge Circuit

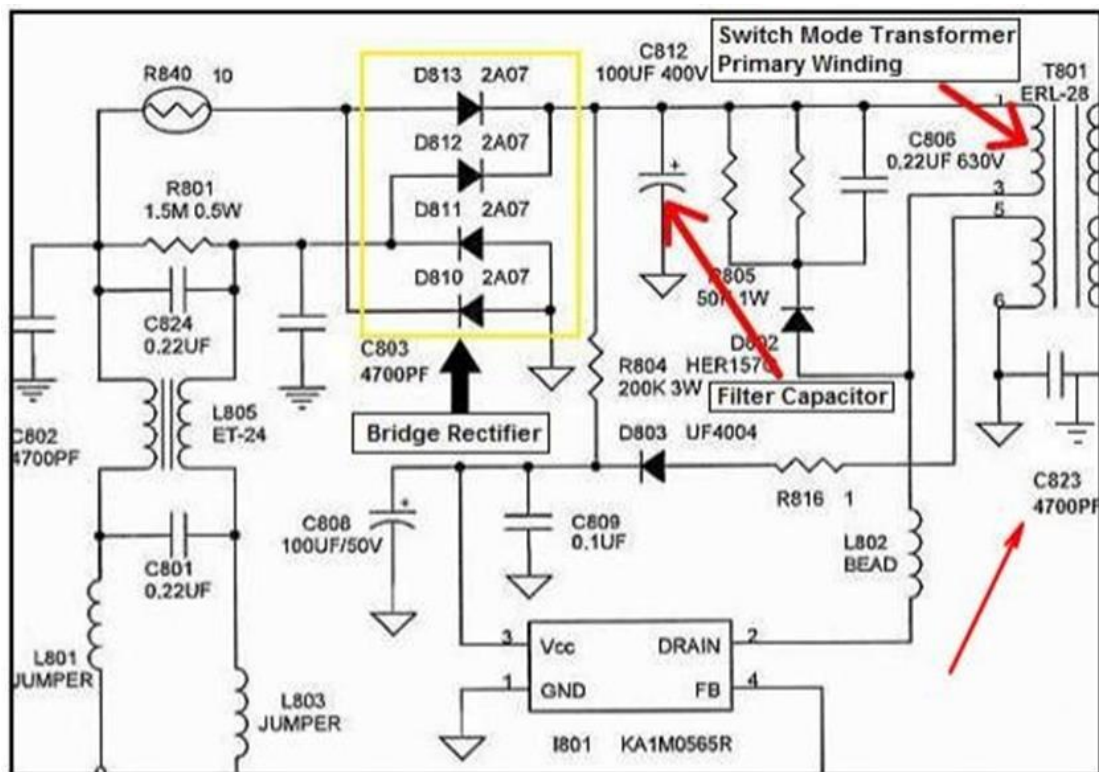


Figure 1.44: SMPS Bridge Circuit

- ✓ It consists either 4 individual diodes or a single package rectifier and a filter capacitor.
- ✓ It converts the incoming AC to DC voltage and the filter capacitor (usually 220uF,400v) removes the ripples and provides DC to the primary winding of switch mode power transformer.
- ✓ In some power supply capacitors, you could see they are connected across each diode.

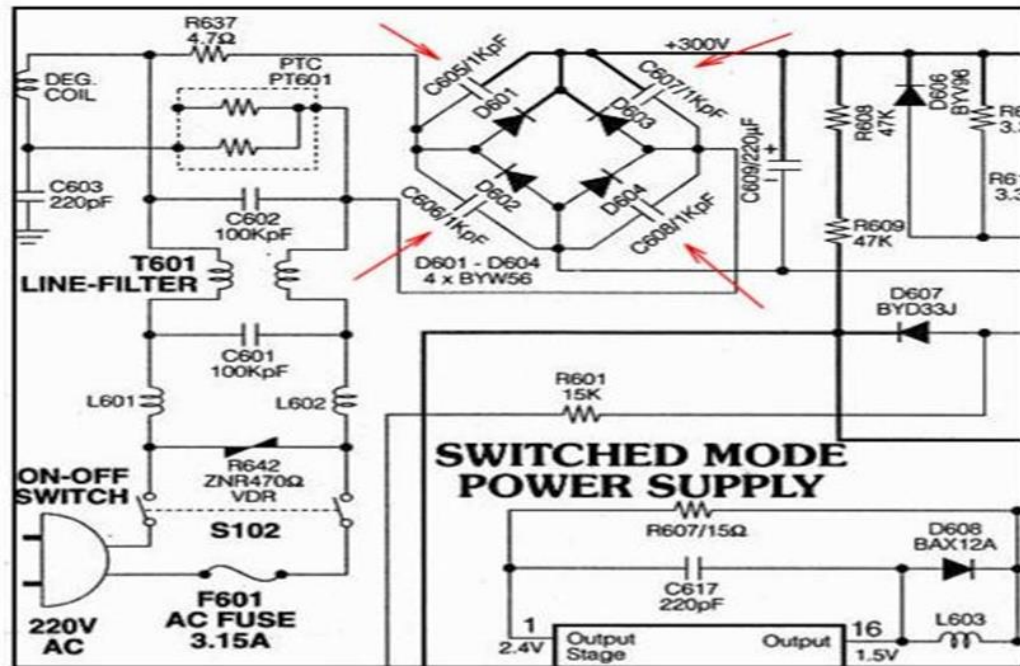


Figure 1.45: Capacitors Connected across Bridge Circuit

2. Start Up and Run DC Circuit

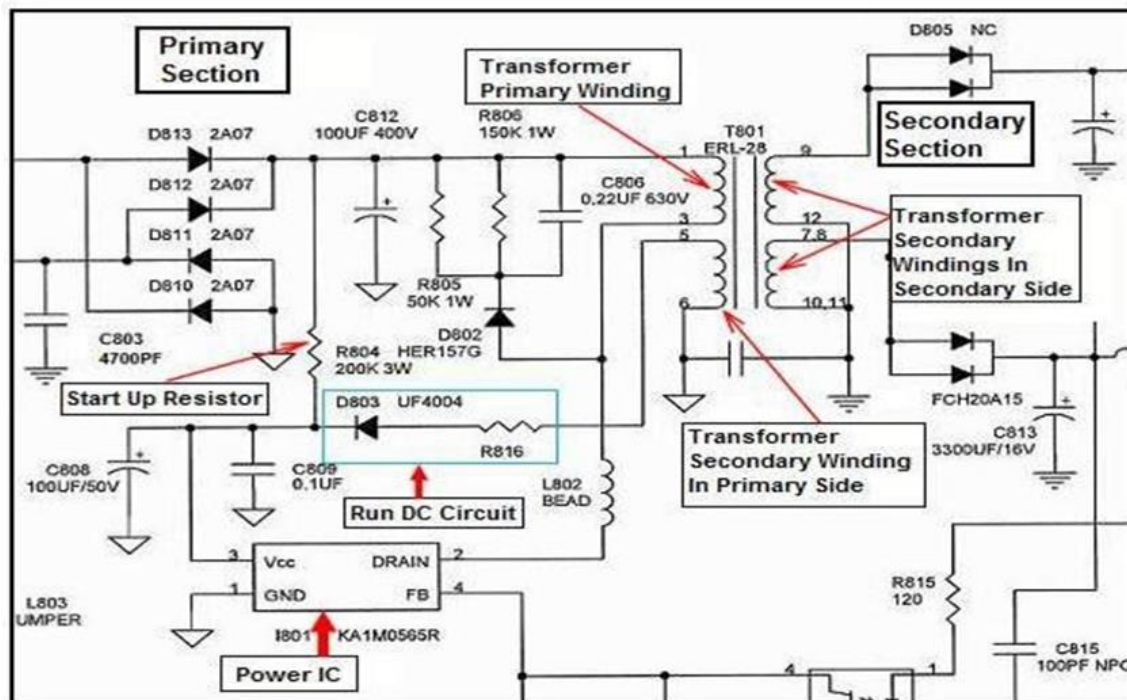


Figure 1.46: Start Up and Run DC Circuit

3. Oscillator Circuit

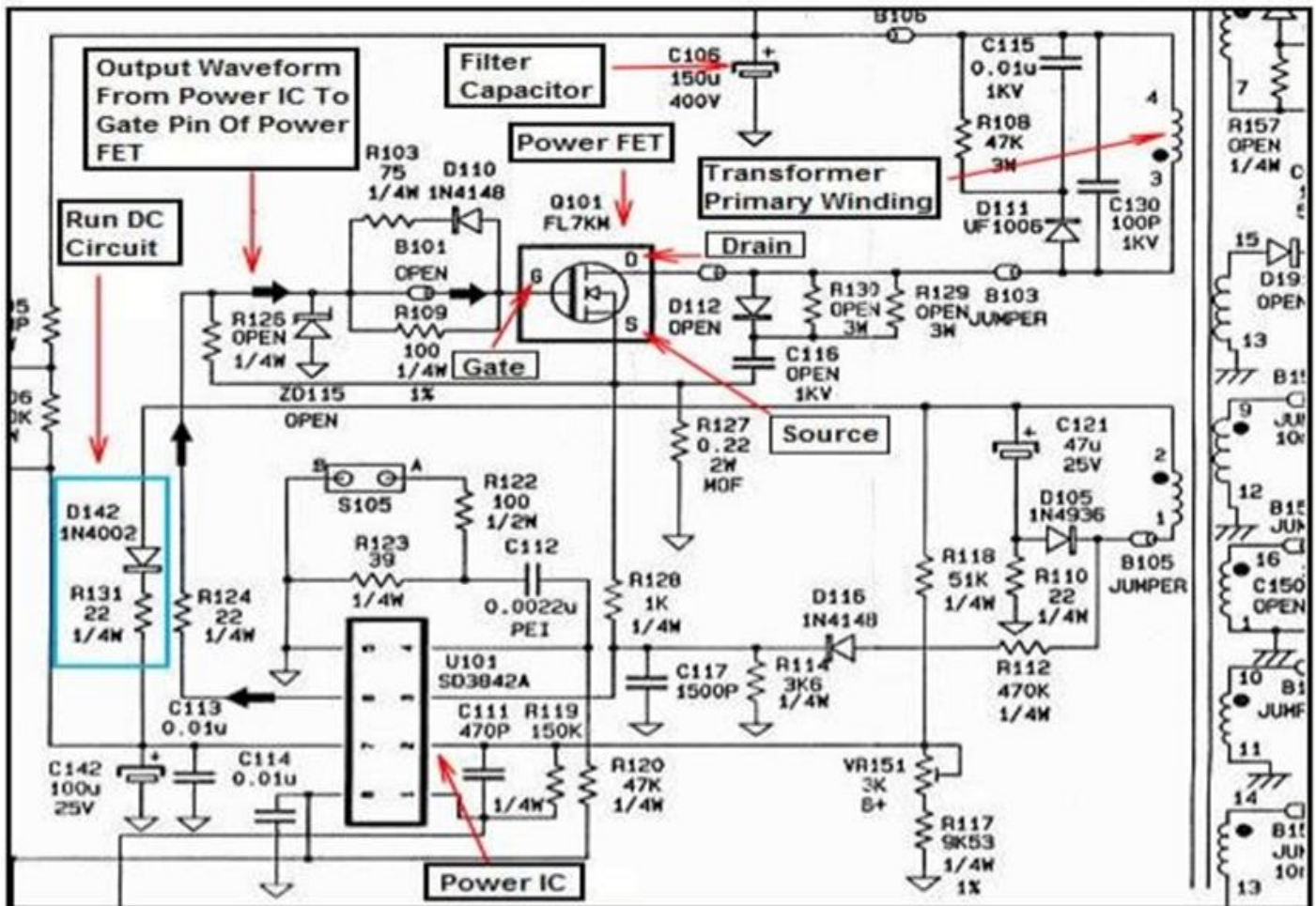


Figure 1.47: SMPS Oscillator Circuit

4. Secondary output Voltage Circuit

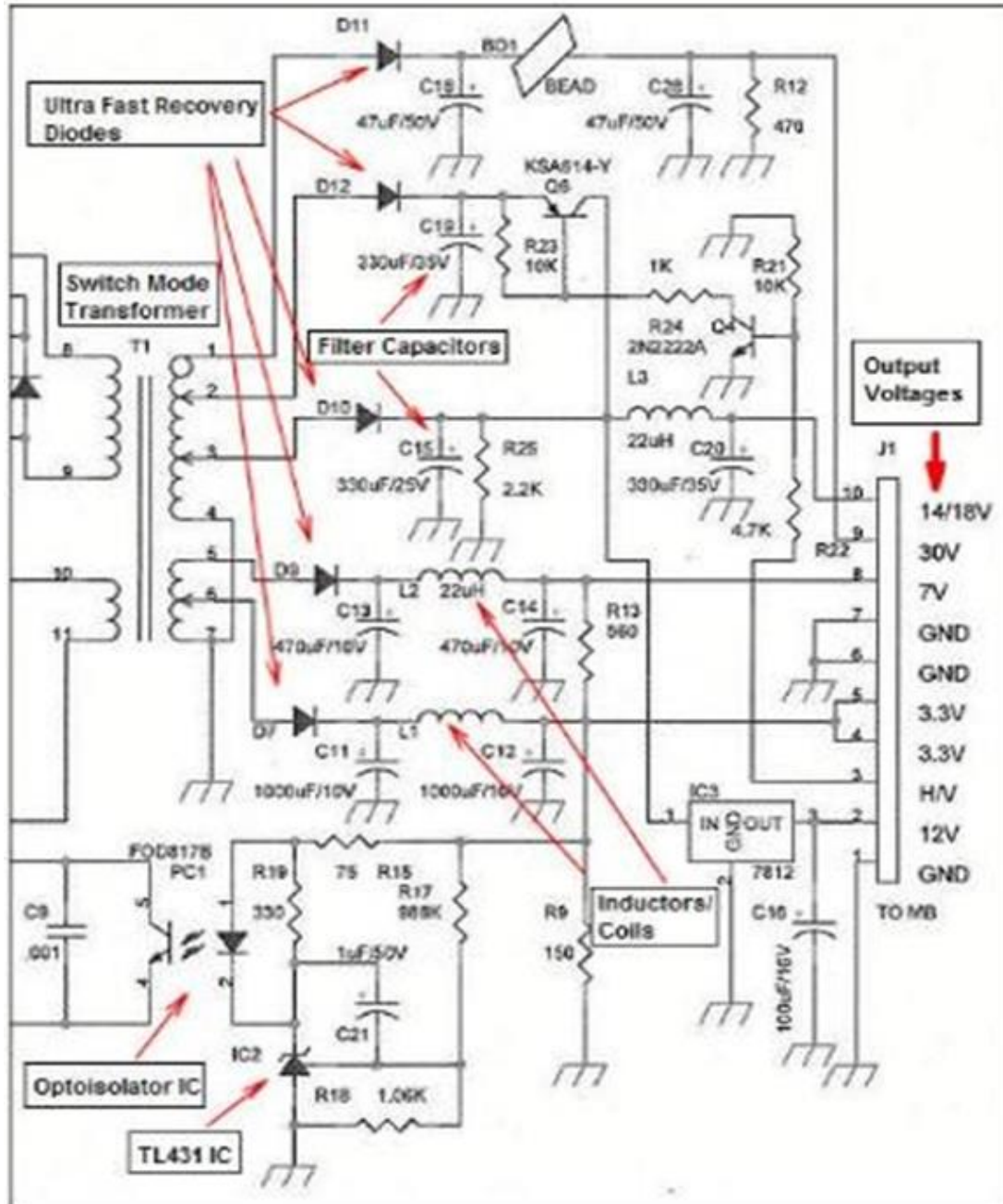


Figure 1.48: Receiver Secondary Output Voltage Side Circuit



5. Sampling Circuit

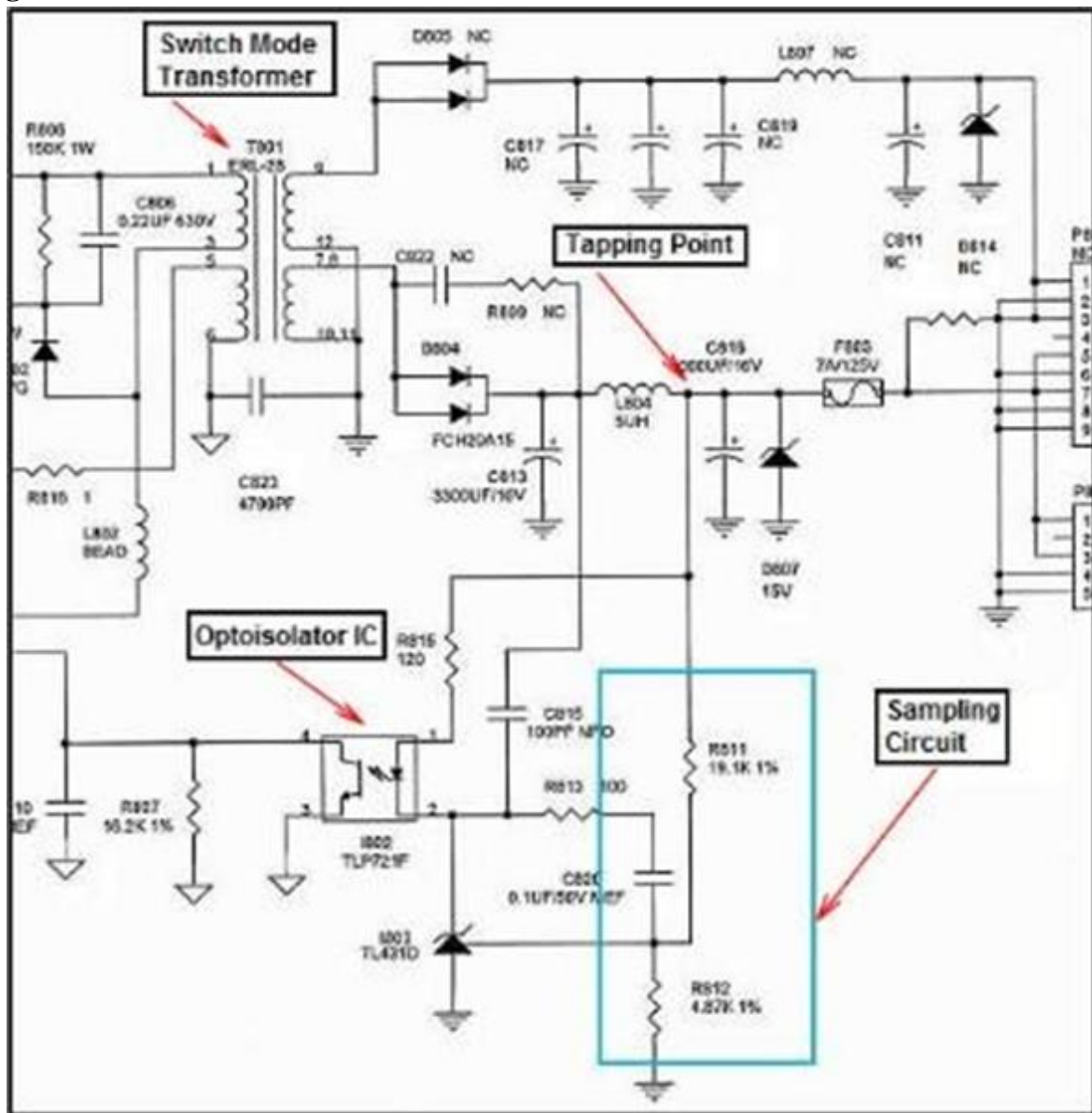


Figure 1.49: SMPS Sampling Circuit



6. Error Detection Circuit

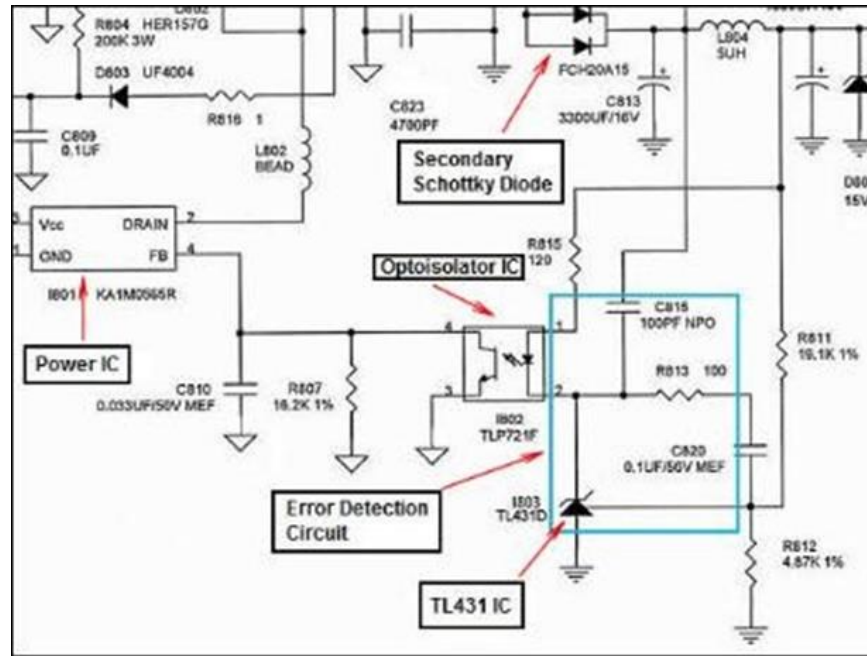


Figure 1.50: Error Detection Circuit

7. Feedback Circuit

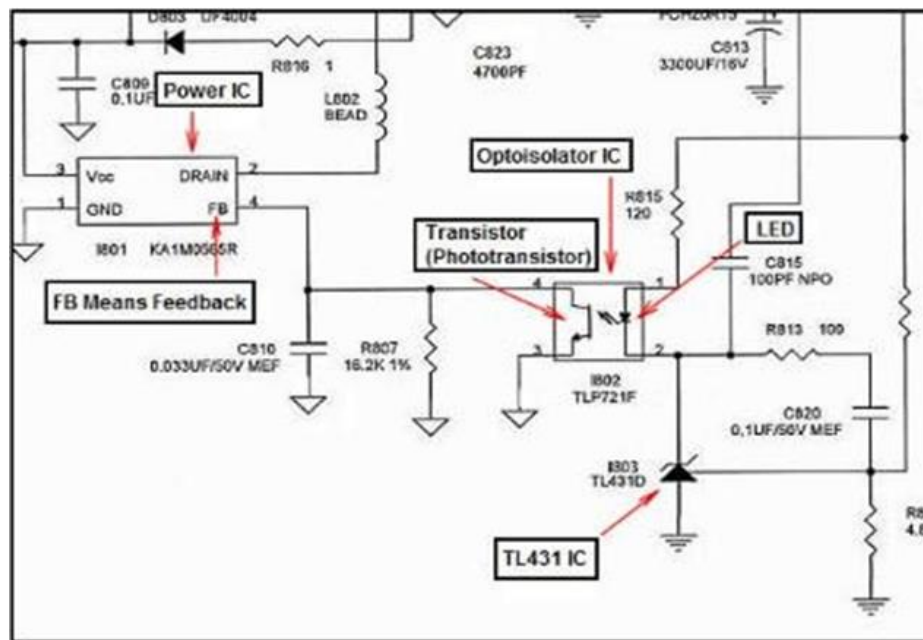


Figure 1.51: Feedback Circuit

8. Protection Circuit

Do you know that SMPS has one or more protection circuit? The protection circuit is designed to protect the components by shutting down either part or all of the power supply in the event problem occurs. There are four common types of protection circuits that can be used by SMPS conditions. They are surge protection (SP), over voltage protection (OVP), over current protection (OCP) and Thermal shut down protection (TSDP).

A. Surge Protection Circuit

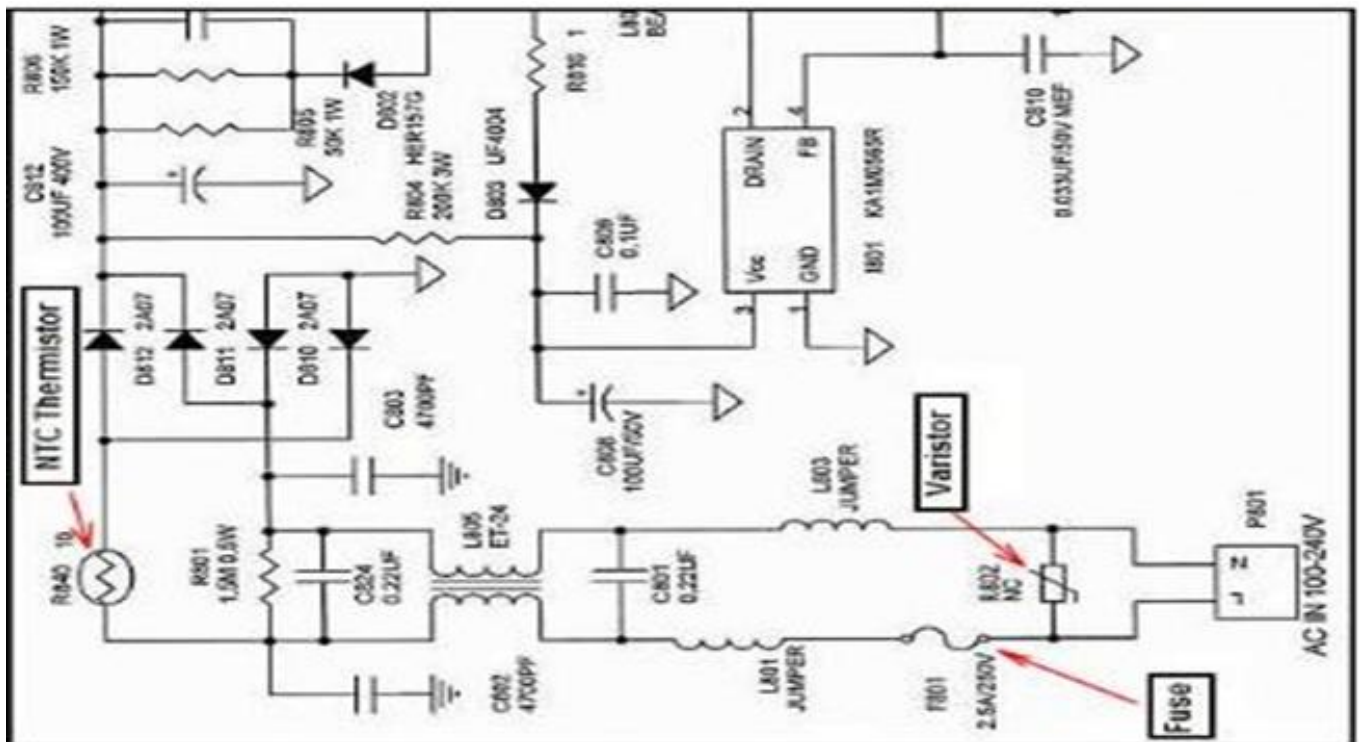


Figure 1.52: Surge Protection Circuit

B. Over Voltage Protection Circuit

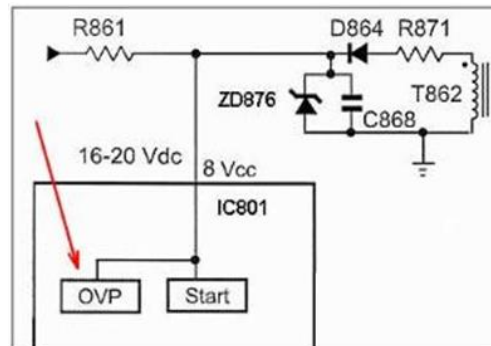


Figure 1.53: Over Voltage Protection Circuit

C. Over Current Protection Circuit

The over current sensing resistor can increase in resistance value and cause a false shutdown. The value may be increased slightly and cause an intermittent shutdown. The value is usually very small from 0.1 ohm to about 1 ohm and you can test the exact value.

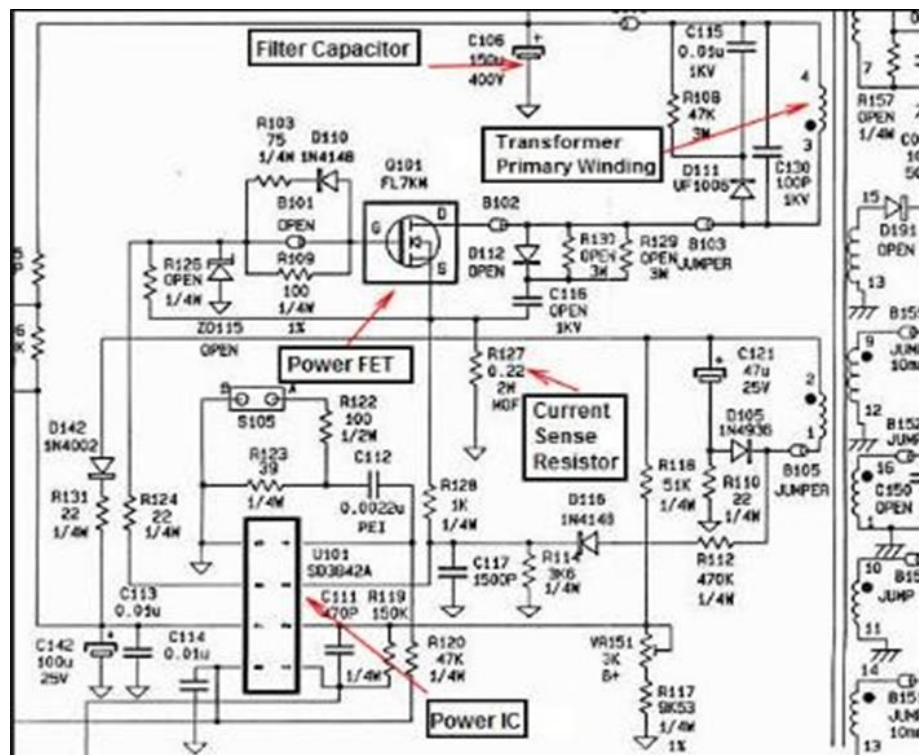


Figure 1.54: Over Current Protection Circuit

D. Thermal shutdown Protection Circuit

The thermal shutdown function is a circuit that prevents deterioration and breakdown due to a significant increase in ambient temperature and heat generation of the device itself due to an unintended large current load.

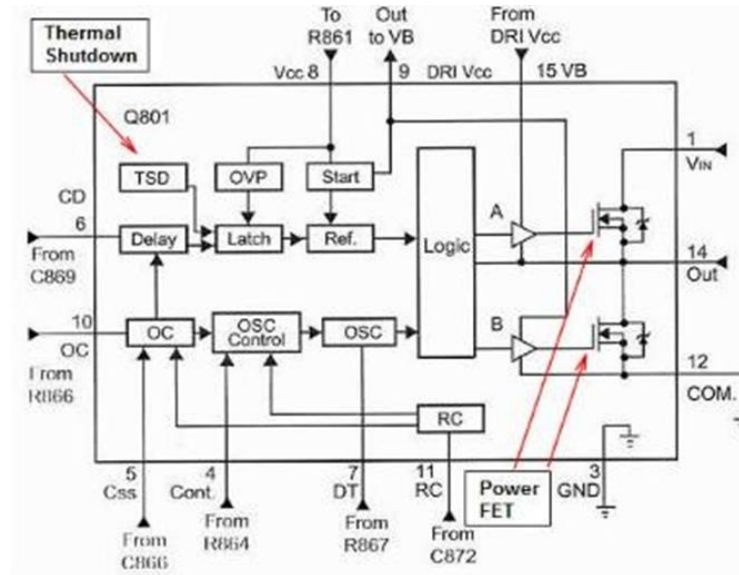


Figure 1.55: Block Diagram of a Thermal Shutdown Protection Circuit

9. Standby Circuit

Standby mode helps conserve power when a computer or electronic device is not in use, without fully powering if off. A solid or flashing amber light on the body of the device usually indicates standby mode.

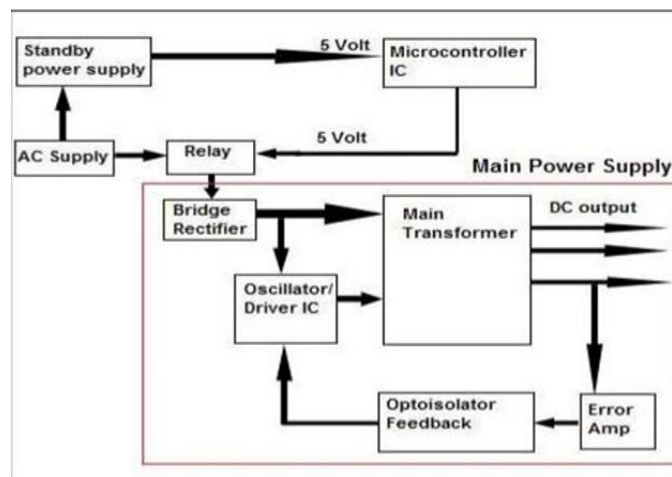


Figure 1.56: Block Diagram of a Standby Circuit

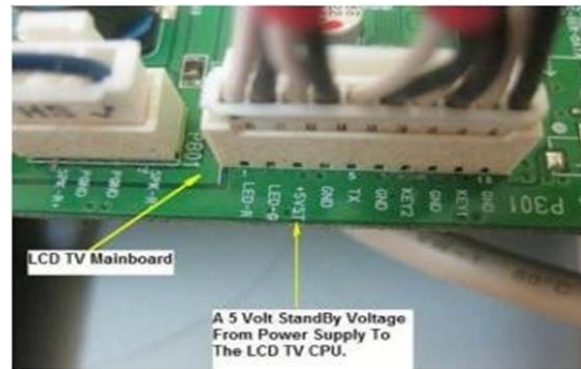


Figure 1.57: A 5V Stand by voltage

A power factor correction (PFC) circuit intentionally shapes the input current to be in phase with the instantaneous line voltage and minimizes the total apparent power consumed. While this is advantageous to utility companies, a PFC circuit also provides benefits in end applications

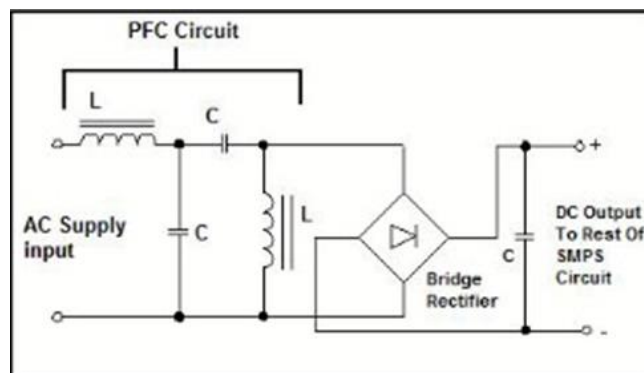


Figure 1.58: Passive PFC

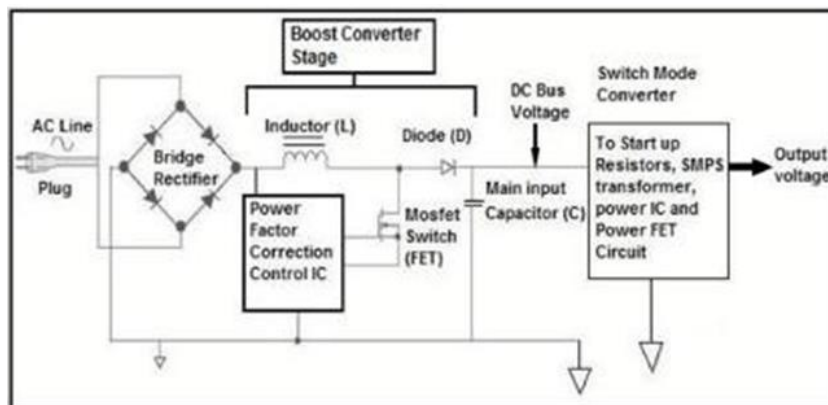


Figure 1.59: An Active PFC

The SMPS is mostly used where switching of voltages is not at all a problem and where efficiency of the system really matters. There are few points that are to be noted regarding SMPS. They are

- SMPS circuit is operated by switching and hence the voltages vary continuously.
- The switching device is operated in saturation or cut off mode.
- The output voltage is controlled by the switching time of the feedback circuitry.
- Switching time is adjusted by adjusting the duty cycle.
- The efficiency of SMPS is high because, instead of dissipating excess power as heat, it continuously switches its input to control the output.

Disadvantages

There are few disadvantages in SMPS, such as

- The noise is present due to high frequency switching.
- The circuit is complex.
- It produces electromagnetic interference.

Advantages

The advantages of SMPS include,

- + The efficiency is as high as 80 to 90%
- + Less heat generation; less power wastage
- + Reduced harmonic feedback into the supply mains
- + The device is compact and small in size.
- + The manufacturing cost is reduced.
- + Provision for providing the required number of voltages

Applications

There are many applications of SMPS. They are used in the motherboard of computers, mobile phone chargers, HVDC measurements, battery chargers, central power distribution, motor vehicles, consumer electronics, laptops, security systems, space stations, etc.

1.2 Preparing troubleshooting workplace

A power supply is an electronic circuit or a device that converts the primary electric power in to ac or

dc needed by different types of electronic circuit. A power supply may be implemented as a discrete, standalone device or as integral device that is hard wired to its load and designed to provide various ac and dc voltages. Therefore, all electronic equipment's require a source of DC power for normal operation.

The power supply circuit produces the DC voltage needed to operate electronic components. Of course, batteries can be and are used in portable equipment, but in larger systems, where considerable power is needed, batteries are an inconvenience and expensive. Electronic circuits normally require a different type and value of voltage than is available from standard 220V AC wall socket.

Troubleshooting is a logical, systematic process that is able to determine "what" happened, "why" it happened and a method to develop effective fixes for the "why" it happened. The purpose of troubleshooting is to prevent the equipment and machinery from repeat incidents and failures. Reasons for defects in electronic circuits in general are always high currents, high voltages and power losses with the development of big heat. All this applies to power supplies. That is why troubleshooting in electronic equipment should always start with checking the voltage(s) of the power supply.

1.2.1 OH&S policies and procedures

- **Hazard and risk assessment**

Hazards exist in every workplace in many different forms: sharp edges, falling objects, flying sparks, chemicals, noise and a myriad of other potentially dangerous situations. The Occupational Safety and Health Administration (OSHA) require that employers protect their employees from workplace hazards that can cause injury.

Controlling a hazard at its source is the best way to protect employees. Depending on the hazard or workplace conditions, OSHA recommends the use of engineering or work practice controls to manage or eliminate hazards to the greatest extent possible. For example, building a barrier between the hazard and the employees is an engineering control; changing the way in which employees perform their work is a work practice control.

When engineering, work practice and administrative controls are not feasible or do not provide sufficient protection, employers must provide personal protective equipment (PPE) to their employees and ensure its use. Personal protective equipment, commonly referred to as “PPE”, is equipment worn

to minimize exposure to a variety of hazards. Examples of PPE include such items as gloves, foot and eye protection, protective hearing devices (earplugs, muffs) hard hats, respirators and full body suits.

- **The Requirement for PPE**

To ensure the greatest possible protection for employees in the workplace, the cooperative efforts of both employers and employees will help in establishing and maintaining a safe and healthful work environment.

In general, you should:

- Properly wear PPE,
- Attend training sessions on PPE,
- Care for, clean and maintain PPE, and
- Inform a supervisor of the need to repair or replace PPE.

Specific requirements for PPE are presented in many different OSHA standards.

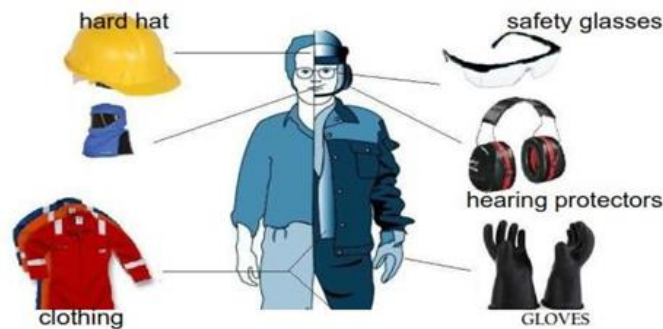


Figure 1.60: Personal Protective Equipment

- **The Hazard Assessment**

A first critical step in developing a comprehensive safety and health program is to identify physical and health hazards in the workplace. This process is known as a “hazard assessment.” Potential hazards may be physical or health-related and a comprehensive hazard assessment should identify hazards in both categories.

Examples of physical hazards include moving objects, fluctuating temperatures, high intensity lighting, rolling or pinching objects, electrical connections and sharp edges. Examples of health hazards include overexposure to harmful dusts, chemicals or radiation.

The hazard assessment should begin with a walkthrough survey of the facility to develop a list of potential hazards in the following basic hazard categories:

- Impact
- Penetration
- Compression (roll-over),
- Chemical,
- Heat/cold,
- Harmful dust,
- Light (optical) radiation, and
- Biological

In addition to noting the basic layout of the facility and reviewing any history of occupational illnesses or injuries, things to look for during the walkthrough survey include:

- Sources of electricity
- Sources of motion such as machines or processes where movement may exist that could result in an impact between personnel and equipment
- Sources of high temperatures that could result in burns, eye injuries or fire
- Types of chemicals used in the workplace
- Sources of harmful dusts
- Sources of light radiation, such as welding, brazing, cutting, furnaces, heat treating, high intensity lights, etc.
- The potential for falling or dropping objects
- Sharp objects that could poke, cut, stab or puncture
- Biologic hazards such as blood or other potentially infected material.

When the walkthrough is complete, the employer should organize and analyze the data so that it may be efficiently used in determining the proper types of PPE required at the worksite. It is definitely a good idea to select PPE that will provide a level of protection greater than the minimum required to protect employees from hazards.

The workplace should be periodically reassessed for any changes in conditions, equipment or operating procedures that could affect occupational hazards. This periodic reassessment should also include a review of injury and illness records to spot any trends or areas of concern and taking appropriate corrective action. The suitability of existing PPE, including an evaluation of its condition and age, should be included in the reassessment.

Documentation of the hazard assessment is required through a written certification that includes the following information:

- Identification of the workplace evaluated;
- Name of the person conducting the assessment;
- Date of the assessment; and
- Identification of the document certifying completion of the hazard assessment

Electrical Hazards

When electrical systems break down what are the primary hazards and the consequences to personnel's are:-

- Electric shock
- Exposure to Arc-Flash
- Exposure to Arc-Blast
- Exposure to excessive light and sound energies

Secondary hazards may include burns, the release of toxic gases, molten metal, airborne debris and shrapnel. Unexpected events can cause startled workers to lose their balance and fall from ladders or jerk their muscles possibly causing whiplash or other injuries.

1.2.2 Implementation of safety regulations

In the performance of your duties, you come across many potentially dangerous conditions and situations. You install, maintain, and repair electrical and electronic equipment in confined spaces where high voltages are present. Among the hazards of this work are injury caused by electric shock, electrical fires, and harmful gases. In addition, you must include improper use of tools among these hazards. Common sense and carefully following established rules will produce an accident-free naval career.

Whenever you are working on any electronic equipment, your own safety has to come first. Every electronic technician must always take safety precautions before he or she starts work. Electricity must be handled properly, or else it can injure or cause fatalities. Here are some basic steps that show you how to avoid accidents from occurring.

a) Electrical Shock

Once you open up a set cover, you are actually exposing yourself to the threat of electric shock. Always keep in mind that safety has to come first. A serious shock may stop your heart and if large electric current flows through your body, you will receive serious burns.

Electric current travels three basic pathways through the body:-

3. *Touch Potential (hand/hand path)*

- ✓ The current travels from one hand through the heart and out through the other hand. Because the heart and lungs are in the path of current, ventricular fibrillation, and difficulty in breathing, unconsciousness, or death may occur.

4. *Step Potential (foot/foot path)*

- ✓ The current travels from one foot through the legs, and out of the other foot. The heart is not in the direct path of current but the leg muscles may contract, causing the victim to collapse or be momentarily paralyzed.

5. *Touch/Step Potential (hand/foot path)*

- ✓ The current travels from one hand, through the heart, down the leg, and out of the foot. The heart and lungs are in the direct path of current so ventricular fibrillation.

Even though there may be no external signs from the electrical shock, internal tissue or organ damage may have occurred. Signs of internal damage may not surface immediately; and when it does, it may be too late. Any person experiencing any kind of electrical shock should seek immediate medical attention. Using the correct personal protective equipment (PPE) and following safe work practices will minimize risk of electrical shock hazards.

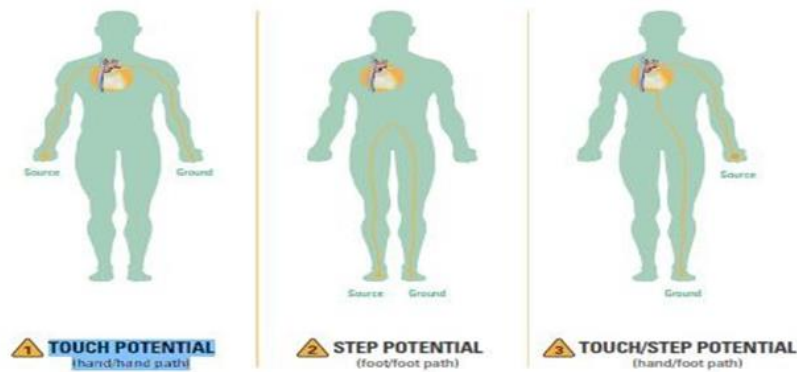


Figure 1.61: Illustrates the path of current through the body.

Here are some rules, which should help you to avoid electricity hazards.

- ✓ Always turn off the equipment and unplug it before you begin to work.
- ✓ If you have to run tests while the equipment is operating, turn the equipment on, make your test carefully, and then turn the equipment off again.
- ✓ Wear rubber bottom shoes or sneakers.
- ✓ Try to do the work with one hand, while keeping the other in your pocket. That keeps the possible current paths away from the heart.
- ✓ Do not attempt repair work when you are tired or rushed.
- ✓ Always assume that all the parts in the power supply are “HOT”
- ✓ Use only plastic screwdriver for shock protection during service operation.

b) Discharging Switch Mode Power Supply (SMPS) Capacitors

Most SMPS have a resistor to drain the charge in the main filter capacitor. However, some resistors may fail and the capacitor can hold this charge even after you have turned off the equipment. This capacitor has a range of about 150uf to 330uf at 400 working voltage.

Before you start to work on a power supply, always turn off the power and discharge the capacitor. You can do this by placing a resistor across the two legs of the capacitor. The resistor value can be around 2.2 to 4.7 kilo ohms 10watt. It takes only a few seconds to fully discharge a capacitor. Double-check the capacitor with a voltmeter after every discharge.

Note / Warning

Do not discharge capacitor with screwdriver because: -

- ✓ It may melt the tip of the screwdriver.
- ✓ It will damage the capacitor and its terminal.
- ✓ If we are too near to the point of discharge, the heavy spark generated may cause injury to our eyes.

c) Hot Ground Problem

Modern equipment consists of two grounds, one of which is a “hot” ground while the other is a “cold” ground. Hot ground is in the primary side of a switch mode power supply while the cold ground is the equipment ground.

Be careful when taking voltage measurements around these grounds. For example, if you want to check the primary circuit of a power supply with power on, always ground your meter or scope to the hot ground, while check the secondary side using the cold ground.

If the “Hot” ground is not used and you use only the cold ground, the voltage measurement might not be correct and it may destroy your meter. One way to prevent this is to use an “isolation transformer”.

d) Isolation Transformer

When servicing any electronic equipment, always use an isolation transformer to protect yourself from an electrical shock. During servicing, the isolation transformer is connected between the equipment and ac power line. An isolation transformer is a transformer that has a 1:1 turn ratio to provide the standard line voltage at the secondary outlet. This means that it does not change the voltage. The transformer still produces 240V AC at its outputs, but both sides of this AC lines are independent of ground. If you were to accidentally touch one of these outputs, you would be protected. The isolation transformer must be rated to handle the power of any equipment connected to it. Typical ratings are 250 to 500W.

Note: A variable transformer is not an isolation transformer.

e) High Voltage

Monitors and TV have sections that use very high DC voltages. The high voltage is needed to be applied to the CRT to attract the electron beam to the phosphor. This high voltage could be as low as 12,000 volts in a monochrome Monitor or as high as 30,000 volts in large color monitor. Fly back Transformer is the part that is

used to generate the high voltage. The high voltage circuit inside a Monitor or TV can give you a dangerous electric shock and causes you to jerk violently. You could cut yourself by accidentally knocking on sharp chassis edges. Be familiar with the high voltage circuits before you work on any high voltage equipment.

f) X-Radiation

An X-ray is a form of radiation produced when a beam of electrons strikes some material at a relatively high speed. The only source of X-ray in a modern Monitor or TV is from the CRT. Prolong exposure to X-ray can be harmful. However, the CRT does not emit measurable X-ray if the high voltage is at the high voltage adjustment value only. When high voltage is excessive, then only X-ray is capable of penetrating the shell of the CRT, including the lead in glass material.

g) Wearing Goggles

The CRT has a complete vacuum inside. It must be handled carefully and safely. Always wear goggles, to protect the eyes from flying glass, in the event of an implosion when removing and old tube from the set and installing a replacement.

Do not lift the CRT by the neck; instead hold the CRT with both hands on the heavy glass front of the tube. Also be sure to place the CRT facing downwards on a soft surface.

h) Electrostatically Sensitive Devices (ESD)

Integrated circuits (IC) & some field-effect transistors are examples of ESD devices. These components can be easily damaged by static electricity. There are several techniques, which can reduce the incidence of component damage, caused by static electricity.

- Immediately, before handling any ESD devices drain the electrostatic charge from your body by touching a known earth ground.
- Store ESD devices in conductive foam pad until installation in circuit
- Wear a grounding strap, attached to your wrist.
- Use only a grounded tip soldering iron to solder or de-solder ESD devices. (Some suggest using a battery-powered soldering iron when working on ESD circuits).

i) Fire

Before returning the equipment to the user, every reasonable precaution is taken to avoid fire hazards. Be sure to use only direct replacements and not one that defeats some safety measure. For example, the fuses in your equipment are carefully designed. Fuses must be replaced only with the same size, type and ratings. Should you install a fuse that is too large than the original rating, chances are that the equipment will be flammable?

j) Lifting

Some equipment like TV, Hi-fi or Monitor can easily weight around 15 to 30 kilogram. Many problems arise when lifting this equipment from the floor. Wrong posture when lifting equipment may cause acute back pain. The right way to lift is keep your back straight and upright, and use your legs to supply the lifting power.

k) Ventilation

Be sure that your work place has good ventilation. Prolong exposure or excessive inhalation of vapors from chemical spray and fumes from lead may cause damage to your nervous system or body.

1.2.3 Basic electrical safety rule concepts

Electrical Safety in the workplace can only be attained when trainees (workers) and companies diligently follow OSHA and industry accepted standards and regulations. It is our sincere hope and desire that this handbook has been helpful in informing the reader of the importance of Electrical Safety while providing methods and information on how to effectively and safely reduce electrical hazards.

- Unless there is a compelling safety issue such as life-support equipment, alarm systems, hazardous location ventilation, or lighting required for safety, OSHA requires that circuits be de-energized and the system be placed in an Electrically Safe Work Condition before any work is performed.
- When placing equipment in an Electrically Safe Work Condition always follow proper Lockout/tag out procedures.
- An Electrical Hazard Analysis must be performed on all circuits 50 volts and higher that may be worked on while energized.
- The Hazards must be identified and warning labels must be applied to all equipment that may be worked on while energized.
- Trainees must be trained on the equipment, hazards and safety precautions, and be certified as “qualified” to work on energized equipment. Training and certification must be documented.

- All work performed on energized equipment must be preceded by a job briefing and a signed Energized Electrical Work Permit.
- When working on or approaching energized circuits, proper protective clothing must be worn. The minimum flame retardant clothing, safety glasses, and protective gloves and equipment must meet OSHA and NFPA 70E guidelines. Protective insulating blankets and mats are also used to minimize exposure.
- Be certain there is adequate lighting for the tasks to be performed. Portable lighting must be fully insulated so that it will not accidentally cause short circuits when used near energized components.
- Use barricades or barriers to warn unqualified individuals from entering the area.
- Be prepared for the unexpected. Make sure emergency communications and trained medical personnel are available if something goes wrong.
- Use current-limiting overcurrent protective devices wherever possible to reduce the potential electrical hazards.

1.3 The required materials, tools and equipment's used for repairing power supply

The following materials, tools and equipment's used for repairing power supply should be check for their appropriateness and normal state for specific operation.

Table 1.2: The required materials and their specifications for troubleshooting AC/DC power supply

S.N	Consumable Materials	Specifications	Remark
1	Copper Wires		
2	Stranded Wires		
3	Diodes		
4	Capacitor		
5	Resistor		
6	Solder		
7	Transistor		
8	Freezer spray		
9	IGBT Transistor		
10	Zener Diode		
11			

Table 1.3: The required tools and their specifications for troubleshooting AC/DC power supply

S.N	Tools	Specifications	Remark	
1	Utility knife/stripper			
2	Wrenches (assorted)			
3	Allen wrench/key			
4	Screws (assorted)			
5	Pliers (assorted)			
6	Ball-peen hammer			
7				

Table 1.4: The required equipment's and their specifications for troubleshooting AC/DC power supply

S.N	Equipment's	Specifications	Remark
1	Multi meter	Digital/ Analog	
2	Single phase power supply		
3	Conventional E-I Transformer	220V/50/60Hz	
4	Soldering iron		
5	ESD-free work bench with mirror	1m by 2m	
6	Vernier Caliper	Digital/Analog	
7	Micrometer	Digital	
8	Isolation Transformer	1:1/220V/50/60Hz	
9	Variable Transformer	0-220V/50/60Hz	
10	Capacitance Meter	Digital	
11	Blue ESR Meter	Digital	
12	Blue Ring tester	Digital	
13	Oscilloscope	Digital/ Analog	

Recommended test equipment for successful Power supply Repair

i. Isolation Transformer

Be aware that the disadvantage of power supply is that they can be very dangerous to work on it, especially switching mode. This is because the HOT side of the AC line essentially goes to all power supply components on the primary side of transformer. If you accidentally touch anything in this primary power side circuit and ground at the same time, there would be a path for electricity to flow through your body and could receive a severe electrical shock.

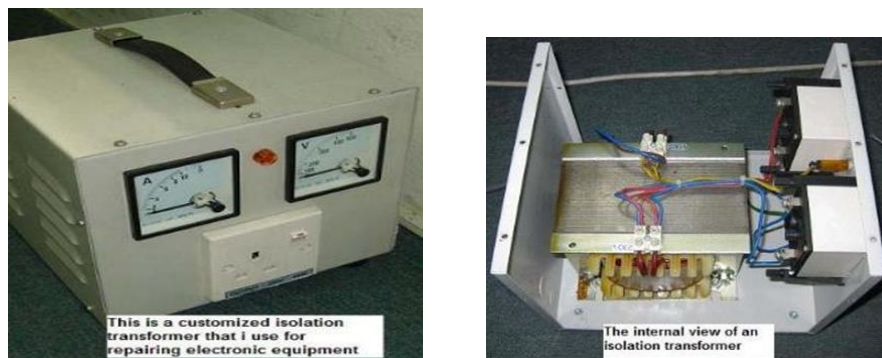


Figure 1.62: Isolation Transformer

When servicing any electronic equipment, which includes the SMPS, always use an isolation transformer to protect yourself from an electrical shock. During servicing, isolation transformer is connected between the equipment and the ac power supply line. It has a 1:1 turn ratio to provide the standard line voltage at the secondary outlet.

ii. Variable Transformer

The Variable Transformer (Variac) provides undistorted variation of AC voltage.



Figure 1.63: Variable Transformer

Note: Variable Transformer is not Isolation Transformer.

iii. Digital Capacitance Meter

It is necessary to determine a capacitor values and it is usually displays the capacitance in microfarad(uf), Nano Farad(nf) OR Pico Farad (pf).



Figure 1.64: Digital Capacitance Meter

iv. Blue ESR Meter

Blue ESR Meter measures capacitor equivalent series resistance (ESR) in the circuit. ESR is a very important quality and performance characteristic of capacitors greater than 1uF. This meter makes quality measurements, which are often impossible to check with capacitance meters.

An ESR meter is a two-terminal electronic measuring instrument designed and used primarily to measure the equivalent series resistance (ESR) of real capacitors; usually without the need to disconnect the capacitor from the circuit, it is connected to.



Figure 1.65: Blue ESR Meter



v. Blue Ring tester

It is used to test any high-Q inductive, low loss component. It is especially useful for doing a quick check on fly back transformers, line output transformers and other inductive components like deflection yoke windings and SMPS transformers.



Figure 1.66: Blue Ring tester

vi. Oscilloscope

The oscilloscope is one of the most useful test instruments used for electronic circuit design, electronics manufacture, test, service, and repair. The function of an oscilloscope is to be able to display waveforms on some form of display. In the normal mode of operation time is displayed along the X-axis (horizontal axis) and amplitude is displayed along the Y axis (vertical axis). In this way it is possible to see an electronic waveform on an oscilloscope as it may be envisaged.



Figure 1.67: Analogue and digital Oscilloscope

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			August 2022

1.4 Preparing and obtaining parts and materials needed

Introduction

Before starting troubleshooting the technician (you) should have to prepare and obtain the required materials, tools and equipment is needed for task as they are listed in the previous information sheet No3 and also, you should have to use the tools and test equipment's properly and safely.

1.4.1 Tools requirements

Tools are the basic requirement of a service technician, without tools, one cannot even open the cabinet and have access to the circuits. Some of the tools required for the tasks are described below.

a) Utility knife



Figure 1.68: Utility knife

b) Wrenches

A wrench's main function is to hold and turn nuts, bolts, caps, screws, plugs and various threaded parts.

Applying excessive torque will strip or damage those threads, so quality wrenches are designed to keep leverage and intended load in safe balance.

Users should not put "cheaters" on wrenches to increase leverage. The proper size wrench should be used. Too large a reach will spread the jaws of an open-end wrench, damage the points of a box, or socket wrench. When possible, a wrench should be pulled, not pushed.



Figure 1.69: Different types of wrenches

c) Screwdrivers

Screws are made in different sizes, and they are designed to be turned by screwdrivers of the corresponding sizes. You will need a good set of screwdrivers with both Philips and flat slotted heads. Many people have the habit of trying to turn a screw with whichever screwdriver they have. Most screws can be turned easily if you use a screwdriver of the right size. A power screwdriver is also useful in electronic servicing because some equipment has numerous screws, that your hand will get tired unscrewing them.



Figure 1.70: Philips & Flat Screwdrivers

d) Long-Nose Pliers

A long-nose plier is needed to remove components once they are de-soldered from the PCB board. They are very useful for reaching into tight spaces inside the equipment. For example, components located under the belly of the CRT are very difficult to remove without pliers.



Figure 1.71: Combination, Long-nose and adjustable pliers

e) Wire Cutters

Wire cutters are useful for cutting wires, wire ties, and lead on large parts, such as resistors and capacitors.



Figure 1.72: Wire-cutter

f) Wire Strippers

Before you can make connections with a piece of wire, you must “strip” away the plastic insulation on a wire. Resist the temptation to strip insulation using wire cutters. Even if insulation should be removed successfully, wire cutters often leave a nick or pinch in the conductor, which later might fatigue and break.



Figure 1.73: Wire Strippers

g) Spray Cleaner

The wiper at a variable resistor might accumulate dust after operating for a certain amount of time. This can result in all types of erratic or intermittent circuit problem. A spray cleaner can be used to solve this kind of problem. However, if symptom persists, replace the variable resistor.



Figure 1.74: Spray Cleaner

h) Magnifying Lamp

A magnifying lamp not only provides light, but also makes it easier to read component marking especially the surface mounted components (SMD) and small resistor color code. A magnifying lamp also can be used to check for cracks, broken solder joints or burnt components in a PCB board.



Figure 1.75: a magnifying lamp

i) Brush

You may use a toothbrush to look for intermittent or bad connection in a PCB board. Simply run the toothbrush over the PCB board until you push the bad connection into working. Most of the time you can locate the fault using this way.



Figure 1.76: Toothbrush

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j) Ball Peen Hammers

Ball peen hammers are used with small shank, cold chisels for cutting and chipping work, rounding over rivet ends, forming unhardened metalwork and similar jobs not involving nails. The striking face diameter should be approximately $3/8$ " larger than the diameter of the head of the object being struck. The hammer is designed with a regular striking face on one end and a rounded or half ball or peen on the other end taking the place of a claw.



Figure 1.77: Ball Peen Hammer

1.4.2 Equipment's requirements

i) Soldering Irons

Transistor and ICs can easily be destroyed by overheating. For this reason, you must choose carefully when you select a soldering iron for use with digital circuit like CMOS IC. Use a low-powered iron, with a rating of about 30 watts. Do not use a high-powered iron, because it can easily overheat an IC or other parts. If you overheat a trace on a circuit board, the heat can cause the trace to lift from the board. Soldering tips can be manufactured in a wide range of shapes and sizes. Before you select the best tip for the job, you must understand the ideal soldering conditions. Remember to turn off the equipment before you make any solder repairs.



Figure 1.78: Soldering Irons

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ii) Soldering Iron Holders

If you have a soldering iron with no switch, (some soldering irons have a switch, where each press will increase the power from 30w to 120w), it will remain hot all the time when it is plugged in. Sometimes the solder iron becomes too hot and it melts the plastic case of the soldering iron. The holder is often formed into a spiral, with lots of air space to radiate the heat from the iron and to prevent the soldering tip from touching other parts, which can sometimes cause fire.



Figure 1.79: Soldering Iron Holder

iii) De-soldering pump (solder sucker)

A tool for removing solder when de-soldering a joint to correct a mistake or replace a component.



Figure 1.80: Solder sucker

1.4.3 Consumable materials requirements

1) Solder

Solder is related by the proportion of lead to tin. For example, “60/40” solder is 60% tin and 40% lead. Most solders are manufactured with a hollow center, which contains “flux”. As at needed for electronic troubleshooting.

Solder melts; the flux cleans the parts and prevents oxidation to ensure a good connection. Always use resin-core solder and under no circumstances should you use paste flux containing acids or solvents or use solder containing acid flux. Harsh solvents destroy delicate components leads and circuit traces.



Figure 1.81: Solders

2) Solder remover wick (copper braid)

- This is an alternative to the de-soldering pump shown below



Figure 1.82: Solder remover wick (copper braid)

3) Different electrical and electronic components

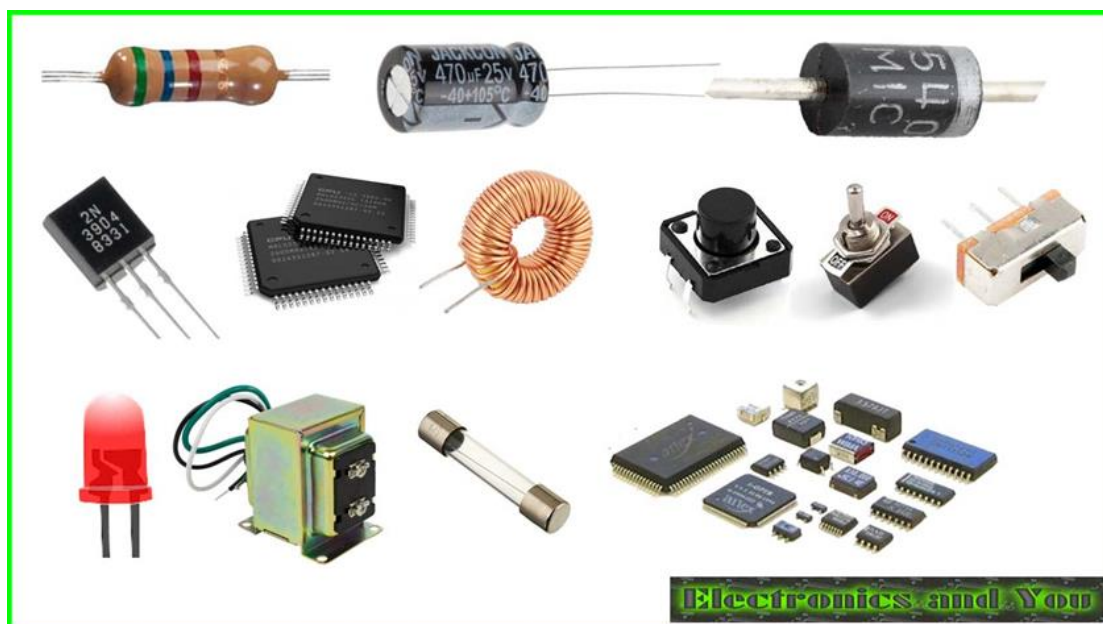


Figure 1: 83: Different types of electrical and electronic components

Self-check 1

Direction I: Say True if the statement is correct and false if the statement is incorrect.

No	Questions	Answer
1	A first critical step in developing a comprehensive safety and health program is known as a “hazard assessment.”	
2	Fluctuating temperatures and pinching objects are examples of health hazards	
3	Trouble shooting means finding the problem that occur in the Equipment	
4	In a step potential contact, current travels from one hand through the heart and out through the other hand.	
5	In a touch/step potential contact, current travels from one hand, through the heart, down the leg, and out of the foot.	

Direction II: Choose the best answer

- _____ is necessary to determine a capacitor values and it is usually displays the capacitance in microfarad (μ F), nano farad, (nF) or pico farad (pF).
 - isolation transformer
 - Variable transformer
 - Digital Capacitance Meter
 - Blue Ring tester
- During servicing, _____ is connected between the equipment and the AC power supply line.
 - isolation transformer
 - Variable transformer
 - Digital Capacitance Meter
 - Blue Ring tester

3. _____ Is used to test shorted coils/windings of the SMPS

A. isolation transformer C. Digital Capacitance Meter

B. Blue ESR Meter D. Blue Ring tester

✓ Voltage across LED2 = _____ V

Unit Two: Single Phase and Three Phase Power Outlets

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Single phase and three phase power outlets
- Troubleshooting procedures
- Testing instruments
- Identifying faulty parts

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify single phase and three phase power outlets
- Follow troubleshooting procedures
- Identify and prepare testing instruments
- Identify faulty parts
- Fix faulty outlets
- Test maintained power outlets

2.1 Single phase and three phase power outlets

Electrical outlets (also known as outlets, electrical sockets, plugs, and wall plugs) allow electrical equipment to connect to the electrical grid. The electrical grid provides alternating current to the outlet.

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a) Single phase power outlet

- Single-phase power is a two-wire alternating current (ac) power circuit. Typically, there is one power wire the phase wire and one neutral wire, with current flowing between the power wire (through the load) and the neutral wire.



Figure 2.1: Single-phase outlet

b) Three phase Power Outlet

- Neutral – Three phase power lead normally has 3 Phases (L1, L2 & L3) and an Earth (closest to the key on the plug or socket)



Figure 2.2: Three phase Power Outlet

Single-phase vs three phase power outlet

- In a single-phase power supply, it only requires two wires, namely Phase and Neutral. On the other hand, a three-phase power supply only works through three wires, including three-conductor wires and a neutral wire.

- In a single-phase connection, the flow of electricity is through a single conductor. A three-phase connection, on the other hand, consists of three separate conductors that are needed for transmitting electricity.
- In a single-phase power supply, it only requires two wires, namely Phase and Neutral. On the other hand, a three-phase power supply only works through three wires, including three-conductor wires and a neutral wire.

AC power plugs and sockets connect electric equipment to the alternating current (AC) mains electricity power supply in buildings and at other sites. Electrical plugs and sockets differ from one another in voltage and current rating, shape, size, and connector type. Different standard systems of plugs and sockets are used around the world.

2.2 Troubleshooting Procedures

Diagnosis is the systematic approach to find where and what type of fault occur in a system and troubleshooting/repair is the activity of correcting the fault and enabling the system to restore to its normal operation condition.

Troubleshooting is a logical, systematic process that is able to determine "what" happened, "why" it happened and a method to develop effective fixes for the "why" it happened.

Why do we troubleshoot? o prevent the equipment and machinery from repeat incidents and failures

To find fault of a system, systematic and logical approach should be followed. The fault of the system should be observed and tested on each sub-system of input and output by following logical order (flow) of the process in the system.

Trouble shooting procedure is important to reduce the time required for maintenance and troubleshooting is done easily if we have a theoretical knowledge about the equipment.

Troubleshooting procedures consists of the following five Steps:

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- Preparation
 - Step 1 Observation
 - Step 2 Define Problem Area
 - Step 3 Identify Possible Causes
 - Step 4 Determine Most Probable Cause
 - Step 5 Test and Repair
- Follow-up

Preparation

- Before you begin to troubleshoot any piece of equipment, you must be familiar with safety rules and procedures for working on electrical equipment.
- Be Safe!
- Turn off power, ground yourself, and use gloves when appropriate
- Next, gather information regarding the equipment and the problem.
- Be sure you understand how the equipment is designed to operate it.
- Operation or equipment manuals and drawings are great sources of information and are helpful to have available.
- If there are equipment history records, you should review them to see if there are any reoccurring problems

Step 1: Observation

- “What Happened?”
- Most faults provide obvious clues as to their cause.
- Through careful observation and a little bit of reasoning, most faults can be identified as to the actual component with very little testing.

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- When observing malfunctioning equipment, look for visual signs of mechanical damage such as indications of impact, chafed wires, loose components or parts lying in the bottom of the cabinet.
- Look for signs of overheating, especially on wiring, relay coils, and printed circuit boards.
- Do not forget to use your other senses when inspecting equipment.
- The smell of burnt insulation is something you would not miss.
- Listening to the sound of the equipment operating may give you a clue to where the problem is located.
- Checking the temperature of components can also help find problems, but be careful while doing this, some components may be alive or hot enough to burn you.
- Pay particular attention to areas that were identified either by history or by the person that reported the problem.
- Here is a note of caution! Do not let these mislead you, past problems are just that past problems, they are not necessarily the problem you are looking for now.
- In addition, do not take reported problems as a fact; always check for yourself if possible.
- The person reporting the problem may not have described it properly or may have made their own incorrect assumptions.
- Be sure you understand how the equipment is designed to operate.
- Note the condition of the equipment as found.
- You should look at the state of the relays (energized or not), which lamps are lit, and the auxiliary equipment is energized or running etc.
- This is the best time to inspect the equipment (using all your senses). Look for signs of mechanical damage, overheating, unusual sounds, smells, etc.
- Test the operation of the equipment including all of its features.
- Make note of any feature that is not operating properly.

- Make sure you observe these operations very carefully.
- This can give you a lot of valuable information
- Regarding all parts of the equipment

Step 2: Define the Problem Area

- At this stage you apply logic and reasoning to your observations to determine the problem area of the malfunctioning equipment.
- Often times when equipment malfunctions, certain parts of the equipment will work properly while others not.
- The key is to use your observations (from step 1) to rule out parts of the equipment or circuitry that are operating properly and not contributing to the cause of the malfunction.
- You should continue to do this until you are left with only the part(s). If faulty, it could cause the symptoms that the equipment is experiencing.
- To help you define the problem area you should have a schematic diagram of the circuit, in addition to your noted observations.
- Starting with the whole circuit as the problem area, take each noted observation and ask yourself, "what does this tell me about the circuit operation?"
- If an observation indicates that a section of the circuit appears to be operating properly, you can then eliminate it from the problem area.
- As you eliminate each part of the circuit from the problem area, make sure to identify them on your schematic. This will help you keep track of all your information.

Step 3: Identify Possible Causes

- Once the problem area(s) have been defined, it is necessary to identify all the possible causes of the malfunction.
- This typically involves every component in the problem area(s).

- It is necessary to list (write down) every fault which could cause the problem no matter how remote the possibility of it occurring.
- Use your initial observations to help you do this.
- During the next step you will eliminate those which are not likely to happen.

Step 4 – Determine the Most Probably Cause

- Once the list of possible causes has been made, it is then necessary to prioritize each item as to the probability of it being the cause of the malfunction.
- The following are some rules of thumb when prioritizing possible causes.
- Although, it may seem to be possible for two components to fail at the same time, it is not very likely. Start by looking for one faulty component as the culprit.
- The following list shows the order in which you should check components based on the probability of them being defective:
 1. Components that burn out or have a tendency to wear out: i.e. mechanical switches, fuses , relay contacts, and light bulbs. (Remember, fuses burn out for a reason. You should find out why before replacing them.)
 2. Coils, motors, transformers, and other devices with windings: These usually generate heat and with time, can malfunction.
 3. Connections: especially screw or bolted type. Over time, these can loosen and cause a high resistance. In some cases, this resistance will cause overheating and eventually will burn open. Connections on equipment that is subject to vibration are especially prone to coming loose.
 4. Defective wiring: Pay particular attention to areas where the wire insulation could be damaged causing short circuits. Do not rule out incorrect wiring, especially on a new piece of equipment.

Step 5 – Test and Repair

- Once you have determined the most probable cause, you must either prove it to be the problem or rule it out – by inspection/observation or by using test instruments
 - ✓ Test Instruments: used to help narrow the problem area and identify the problem component.
 - ✓ Specialized instruments designed to measure various behaviors of specific equipment
 - ✓ General instruments (i.e. multimeters)
- Important Rule: when taking meter readings, predict what the meter will read before taking the reading.
 - ✓ Use the circuit schematic to determine what the meter will read if the circuit is operating normally.
 - ✓ If the reading is anything other than your predicted value, you know that this part of the circuit is being affected by the fault.
- Depending on the circuit and type of fault, the problem area as defined by your observations, can include a large area of the circuit. It creates a very large list of possible and probable causes.
 - ✓ Use a “divide and eliminate” approach to eliminate parts of the circuit from the problem area.
 - ✓ The results of each test provides information to help you reduce the size of the problem area, until the defective component is identified.
- Once you have determined the cause of the faulty operation of the circuit, replace the defective component.
- After replacing the component, you must test operate all features of the circuit, to be sure you have replaced the proper component and that there are no other faults in the circuit.
- It can be very embarrassing to tell the customer that you have repaired the problem only to have him find another problem with the equipment just after you leave.

Follow-Up

- Not an official step of the troubleshooting process, but it should be done once the equipment has been repaired and put back in service.
- Try to determine the reason for the malfunction.
 - ✓ Did the component fail due to age?
 - ✓ Did the environment the equipment operates in cause excessive corrosion?
 - ✓ Are there wear points that caused the wiring to short out?
 - ✓ Did it fail due to improper use?
 - ✓ Is there a design flaw that causes the same component to fail repeatedly?
 - ✓ Through this process, further failures can be minimized.
- Many organizations have their own follow-up documentation and processes.
- If you determine there was human performance (or user error) involved in the equipment issue, the troubleshooter needs to step out of the “equipment analysis” role and interview people who have interacted with the equipment or machinery in question.
- May need to properly train end users on equipment usage.

2.2.1 General troubleshooting Guidelines

The ultimate goal of troubleshooting is to get the equipment back into operation. This is a very important job because the entire production operation may depend on the troubleshooter's ability to solve the problem quickly and economically, thus returning the equipment to service.

Although the actual steps the troubleshooter uses to achieve the ultimate goal may vary, a few general guidelines should be followed.

There are often cases where a familiar piece of equipment or system breaks down. In those cases, an abbreviated five-step troubleshooting process can be used to find the fault, get the system up and running. It is important to note that, although it is a five-step approach, the same basic guidelines of the seven-step troubleshooting method are followed. The steps are simply combined to be specific to the problem at hand.

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The general guidelines for a good troubleshooter to follow are:

- ✓ Work quickly
- ✓ Work efficiently
- ✓ Work economically
- ✓ Work safely and exercise safety precaution

2.2.2 Troubleshooting techniques or methods

Once the symptom is identified, the reasons that cause it have to be determined. The choice of which method to use depends on the circuit complexity, on symptoms, and on the personal preferences of the technician. The most common troubleshooting techniques are listed below:

a) Power check

- ✓ It is amazing how many times a simple issue such as a blown fuse or a flat battery is the cause of a circuit malfunction. Initially, therefore, ensure that the power cord is plugged in and that the fuses are not blown
- ✓ If the circuit is battery powered, make sure that the voltage level is acceptable. If a power supply rectifier is present, check the level of the voltage at the output and make sure that the circuit is powered with the correct polarity.

b) Visual inspection

- ✓ This inspection is part of the so called sensory checks. Sensory checks rely on the human senses to detect a possible fault.
- ✓ The visual inspection of the PCB is the simplest troubleshooting technique (which is very effective in many of the cases). The soldered joints have to be inspected thoroughly. If any doubts exist about the quality of a certain joint, it has to be re- soldered.
- ✓ The PCB has to be inspected visually for any burnt components. Sometimes, components that overheat leave a brownish mark on the board. They can be used as ‘starting points’ in the troubleshooting process and the reasons why they overheat have to be determined.

- ✓ It is bad practice simply to replace such components, without trying to find out what actually caused the component to overheat. In many cases, the reason is a faulty (or out of range) component near the failed component. It also has to be replaced.

c) Using a sense of touch

- ✓ This is another sensory check. Overheated components can be detected by simply touching them. However, this check has to be performed with extreme caution. The circuit has to be turned off, and some time allowed for the large capacitors to discharge. Always touch the components with the right hand only.
- ✓ This is important because in the case of Electric shock it is less likely that the current will pass through the heart. If possible, Wear insulated shoes. In addition, care should be taken not to burn the fingers. Using the sense of touch is a very useful troubleshooting technique in circuits, where everything seems to work properly for A while, and then the circuit fails, due to overheating of a certain component. Identifying such components helps to detect the possible cause of the fault.
- ✓ Special freezing sprays are available, which allow instant freezing of components. If the circuit begins to operate properly immediately after the heated component is sprayed, this is an indication that this component is causing the circuit failure. Before replacing the component, further investigation is needed to determine what caused the overheating in the first place.

d) Smell check

- ✓ When certain components fail due to overheating it is possible in most cases to detect a smell of smoke. This is usually the case, if the technician happens to be there at the time the accident occurred. If not, it is usually possible to detect the failed component by visual inspection afterwards.

e) Component replacement

- ✓ This troubleshooting method relies mostly on the operator's skills and experience. Certain symptoms are an obvious indication of a particular component failure. This statement is especially true for an experienced electronic technician.

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- ✓ For example, some TV service technicians can unmistakably identify the failed component in a TV set (even before opening it), by just briefly examining the symptoms.
- ✓ Component replacement is a good troubleshooting technique for an experienced electronics technician, as it saves a lot of time and money. Moreover, this technique guarantees the success of the repair, because if enough components are replaced, eventually the faulty one will be replaced too. However, it is recommended that the amateur technician initially applies some logical thinking to the troubleshooting process.

f) Signal Tracing

- ✓ This troubleshooting technique is not the most common one, but it is the most desirable, as it requires intelligent and logical thinking from the troubleshooter.
- ✓ This method is based on the measuring of the signal at various test points along the circuit. A test point in the circuit is the point, where the value of the voltage is known to the operator.
- ✓ This troubleshooting technique relies on finding a point, where the signal becomes incorrect. Thus, the operator knows that the problem exists in that portion of the circuit, between the point where the signal becomes incorrect, and the point where the signal appeared correct for the last time.
- ✓ In other words, the operator constantly narrows the searched portion of the circuit, until he finds what caused the fault.
- ✓ There are two basic approaches in conducting the signal tracing. In the first approach, the signal check starts from the input, checking consecutively the test points towards the output. The checks are carried out, until a point when an incorrect signal is found.
- ✓ The second approach is to start from the output and to work backwards towards the input in the same manner until a correct signal appears.

2.3 Testing Instruments

Using Multimeter

There are two types of Multimeter: Digital and analogue. A Digital Multimeter has a set of digits on the display and an analogue Multimeter has a scale with a pointer (or needle). You really need both types to cover the number of tests needed for designing and repair work. We will discuss how they work, how to use them and some of the differences between them.



Figure 2.3: Digital and Analogue Multimeter

Analogue and digital Multimeter have either a rotary selector switch or push buttons to select the appropriate function and range. Some Digital Multimeter (DMMs) are auto ranging; they automatically select the correct range of voltage, resistance, or current when doing a test. However, you need to select the function.

Precaution

- Before making any Measurement, You need to know what you are checking.
- If you are measuring voltage select the AC range (10v, 50v, 250v, or 1000v) or DC range (0.5v, 2.5v, 10v, 50v, 250v, or 1000v).
- If you are measuring resistance, select the Ohms range (x1, x10, x100, x1k, x10k). If you are measuring current, select the appropriate current range DC mA 0.5mA, 50mA, 500mA. Every Multimeter is different however the photo below shows a low cost meter with the basic ranges.

The most important point to remember is this:

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- You must select a voltage or current range that is bigger or **HIGHER** than the maximum expected value, so the needle does not swing across the scale and hit the "end stop."
- If you are using a DMM (Digital Multi Meter), the meter will indicate if the voltage or current is higher than the selected scale, by showing "OL" this means "Overload."
- If you are measuring resistance such as 1M on the x10 range the "OL" means "Open Loop" and you will need to change the range. Some meters show "1" on the display when the measurement is higher than the display will indicate and some flash a set of digits to show over-voltage or over-current. A "-1" indicates the leads should be reversed for a "positive reading."
- If it is an AUTO RANGING meter, it will automatically produce a reading; otherwise, the selector switch must be changed to another range.
- The black "test lead" plugs into the socket marked "-" "Common", or "Com," and the red "test lead" plugs into meter socket marked "+" or "V-W-mA."
- The third banana socket measures **HIGH CURRENT** and the positive (red lead) plugs into this. You **DO NOT** move the negative "-" lead at any time.

Measuring Voltage

Most of the readings you will take with a Multimeter will be Voltage readings. Before taking a reading, you should select the highest range and if the needle does not move up scale (to the right), you can select another range. Always switch to the highest range before probing a circuit and keep your fingers away from the component being tested.

- If the meter is Digital, select the highest range or use the auto-ranging feature, by selecting "V." The meter will automatically produce a result, even if the voltage is AC or DC.
- If the meter is not auto-ranging, you will have to select if the voltage is from a DC source or if the voltage is from an AC source. DC means Direct Current and the voltage is coming from a battery or supply where the voltage is steady and not changing and AC

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means Alternating Current where the voltage is coming from a voltage that is rising and falling.

- You can measure the voltage at different points in a circuit by connecting the black probe to chassis. This is the 0v reference and is commonly called "Chassis", "Earth", "Ground", or "0v."
- The red lead is called the "measuring lead" or "measuring probe" and it can measure voltages at any point in a circuit. Sometimes there are "test points" on a circuit and these are wires or loops designed to hold the tip of the red probe (or a red probe fitted with a mini clip or mini alligator clip).
- You can also measure voltages across a component. In other words, the reading is taken in parallel with the component. It may be the voltage across a transistor, resistor, capacitor, diode or coil. In most cases, this voltage will be less than the supply voltage.



Figure2: measuring the voltage using analogue meter

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Figure 2.4: Measuring the voltage using digital meter.

Measuring Voltage in a circuit

You can take many voltage-measurements in a circuit. You can measure "across" a component, or between any point in a circuit and the positive either rail or earth rail (0v rail). In the following circuit, the 5 most important voltage-measurements are shown. Voltage "A" is across the electret microphone. It should be between 20mV and 500mV. Voltage "B" should be about 0.6v. Voltage "C" should be about half-rail voltage. This allows the transistor to amplify both the positive and negative parts of the waveform. Voltage "D" should be about 1-3v. Voltage "E" should be the battery voltage of 12v.

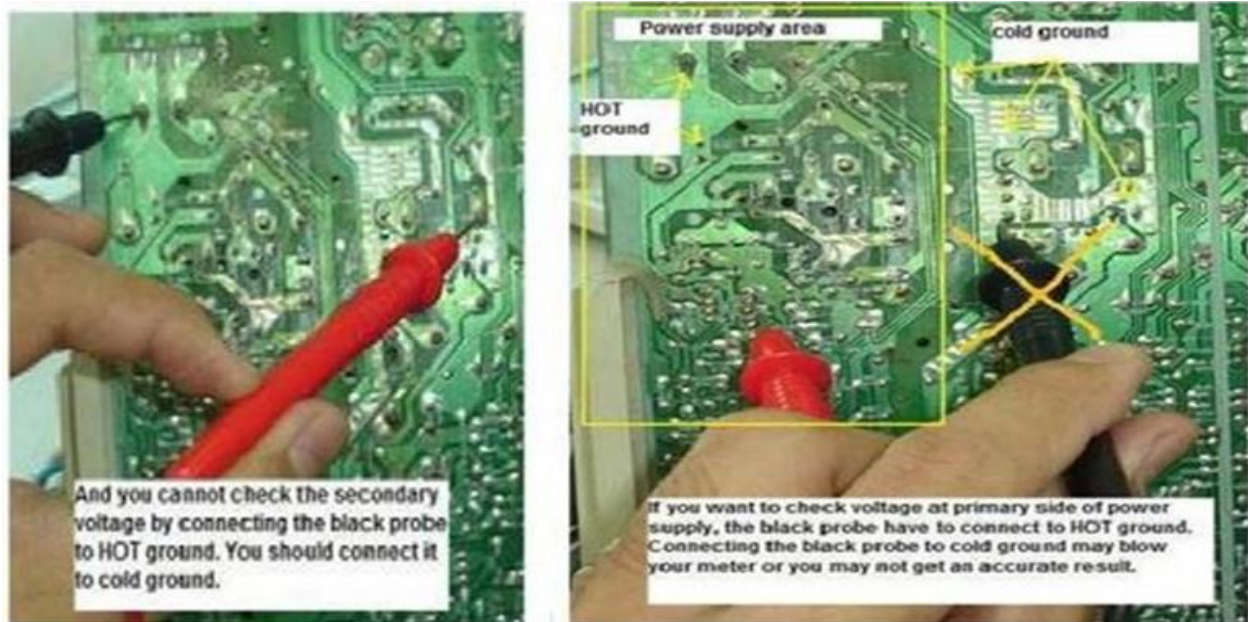


Figure 2.5: Measuring Voltage in a circuit



Figure 2.6: Measuring Voltage from single-phase power outlet

2.4 Identifying fault parts

Fault in electrical equipment or apparatus is defined as an imperfection in the electrical circuit due to which current is deflected from the intended path. In other words, the fault is the abnormal condition of the electrical system, which damages the electrical equipment and disturbs the normal flow of the electric current.

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a) Safety considerations

Before we outline the basic steps for faultfinding on some simple electronic circuits, it is vitally important that you are aware of the potential hazards associated with equipment, which uses high voltages or is operated from the AC mains supply.

Whereas many electronic circuits operate from low voltage supplies and can thus be handled quite safely, the high AC voltages present in mains operated equipment represent a potentially lethal shock hazard.

The following general rules should always be followed when handling such equipment:

1. Switch off the mains supply and remove the mains power connector whenever any of the following tasks are being performed:
 - Dismantling the equipment
 - Inspecting fuses
 - Disconnecting or connecting internal modules.
 - De-soldering or soldering components.
 - Carrying out continuity tests on switches, transformer windings, bridge rectifiers, etc.
2. When measuring AC and DC voltages present within the power unit take the following precautions:
 - Avoid direct contact with incoming mains wiring.
 - Check that the equipment is connected to an effective earth.
 - Use insulated test prods.
 - Select appropriate meter ranges before attempting to take any measurements.
 - If in any doubt about what you are doing, switch off at the mains, disconnect the mains connector and think.

b) Fault Finding Procedures

Faultfinding is a disciplined and logical process in which ‘experimental fixing’ should never be anticipated. First, you need to verify that the equipment really is faulty and that you haven’t overlooked something obvious (such as a defective battery or disconnected signal cable). This may sound rather obvious but in some cases, a fault may simply be attributable to maladjustment or misconnection. Furthermore, where several items of equipment are connected together, it may not be easy to pinpoint the single item of faulty equipment.

The second stage is that of gathering all relevant information. This process involves asking questions such as:

- In what circumstances did the circuit fail?
- Has the circuit operated correctly before and exactly what has changed?
- Has the deterioration in performance been sudden or progressive?
- What fault symptoms do you notice?

The answers to these questions are crucial and, once the information has been analyzed, the next stage involves separating the ‘effects’ from the ‘causes’. Here you should list each of the possible causes. Once this has been done, you should be able to identify and focus upon the most probable cause. Corrective action (such as component removal and replacement, adjustment or alignment) can then be applied before further functional checks are carried out. It should then be possible to determine whether or not the fault has been correctly identified. Note, however, that the failure of one component can often result in the malfunction or complete failure of another.

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Self-check 2

Direction II: Say TRUE if the statement is correct or FALSE, if the statement is incorrect

1. The first step in troubleshooting is Observation.
2. Knowledge of the normal equipment display will enable you to recognize the abnormal display,
3. Visual inspection is part of the so-called sensory checks.
4. Component replacement method relies on the skills unexperienced technician.
5. Signal Tracing uses sensor to detect a failed component through smell of smoke.

Direction II: Write your answer clearly

1. Write and explain the troubleshooting steps
2. Write the difference between single phase and three phase power outlet
3. List the most common troubleshooting techniques

Operation sheet-1

Operation Title: Measuring the AC Input of a single phase Power outlet

Instruction: In workshop, measure voltage output from wall outlet.

Purpose: to measure voltage output from wall outlet

Required tools and equipment: Multimeter

Precautions:

- Never touch the pin of power outlet
- Hold the test probes tightly.

Procedures:

- Step 1. Identify the two AC pins of wall outlet.
- Step 2. Set your Voltmeter in AC range.
- Step 3. Place the test probes to the two AC pins of the wall outlet.
- Step 4. Read the voltage measurement properly.
- Step 5. Interpret the readings

Quality criteria:

- Safety
- Using of measuring instruments

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LAP Test 1

Name: _____

Date: _____

Time started: _____

Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 15 minutes.

Task 1: measure the voltage from single phase wall outlet

Unit Three: Maintaining Faulty Parts of Power Supply Unit

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Identifying faulty parts of power supply unit
- Explaining identified defects and faults
- Documenting results of diagnosis and test
- Replacing and repairing defective parts/components
- Soldering repaired or replaced parts

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify of faulty parts using test instruments
- Explain identified defects and faults
- Document results of diagnosis and test
- Replace and repair defective parts/components
- Solder repaired or replaced parts
- Clean repaired units

3.1 Identifying faulty parts of power supply unit

No matter what type of power supply you are repairing, the faults (problems) fall into the following six categories: -

- a) No Power
- b) Low Output Voltage
- c) High Output Voltage
- d) Power Cycling/Blinking
- e) Power Shutdown and
- f) Intermittent Power Problem

Once you have understood the Common Faults or problems, then you can use the necessary step to isolate, troubleshoot and repair any power supplies.

a) No Power

In power supply, this fault has two categories

- i. Dead and Silent with fuse blown and
- ii. Dead and Silent with fuse good

To identify this problem, the following symptoms are existing

- Switch on the equipment (SMPS)
- Make sure that the AC Power cord is properly connected
- Observe the LED light indicator.
- If there is no light you got the symptom then,

Test procedures:

- Open the cover observes the fuse.
- Test the fuse with your ohmmeter.

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- Test The bridge rectifier and The power FET and
- The secondary diode



Figure 3.1: Basic Way of fault finding for no power

b) Low Output Voltage

The Symptom:

- Low power output
- No LED light

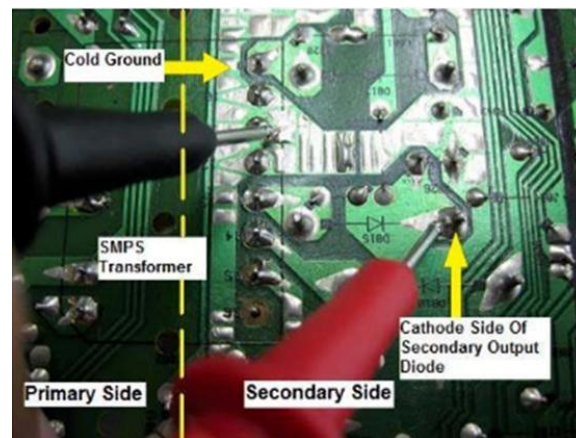


Figure 3.2: Low Output Voltage test

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c) High Output Voltage Symptoms

- An increased value of secondary output voltage (Example, from 12V to 15V)

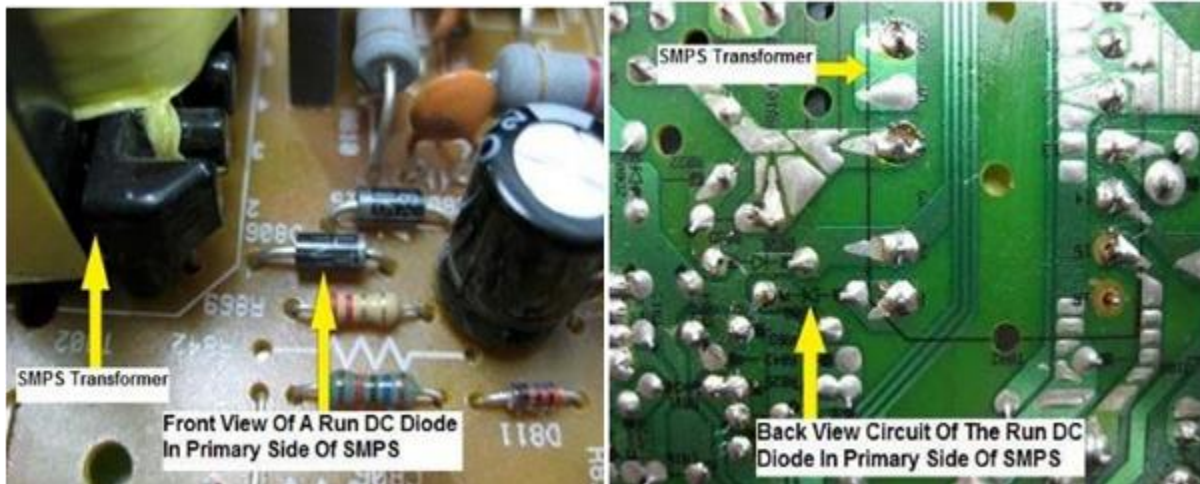


Figure 3.3: Run DC Circuit Diode and Its location in the primary side of SMPS

d) Power Cycling/Blinking Symptoms

- The equipment LED Blinks.

e) Power Shutdown Symptoms

- Producing too HIGH output voltage that can burn the equipment and other electronic circuitry.
- The SMPS shutdown itself whiles you ON.

f) Intermittent Power Problem Symptoms

- The SMPS sometimes works and sometimes do not work properly.

Fault analysis

Fault analysis requires a good theoretical knowledge and analytical thinking. It is not something, which can be studied from books, but has to be acquired through constant troubleshooting and experimenting. The basic question in fault analysis is ‘What would the symptoms in the circuit be, if the component X is faulty?’ For each specific application, there are no ready answers to this question. If there were, many books devoted to industrial electronics would be meaningless.

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However, there are certain rules, which can be adhered to, during the troubleshooting process. One of the tasks of this manual is to teach you some of these basic rules.

As an example, let us examine a bridge rectifier, to illustrate the process of fault analysis. The block circuit of a bridge rectifier that is working properly is shown in Figure 3.4. It consists of a transformer, a rectifier, and a filter. The voltages, taken with an oscilloscope at each test point are depicted in the figure.

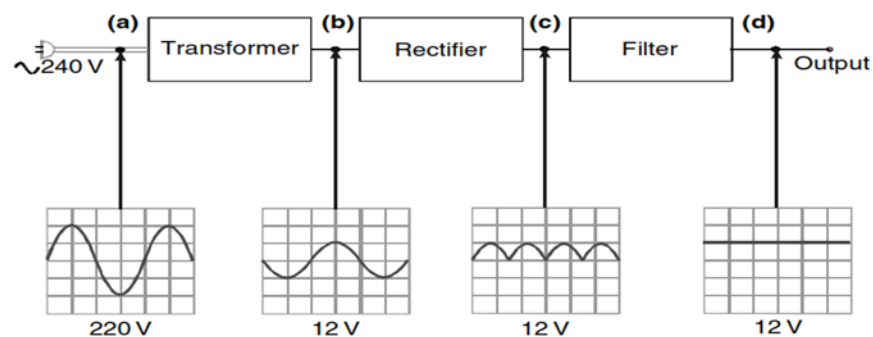


Figure 3.4: Block diagram of a rectifier in good working order

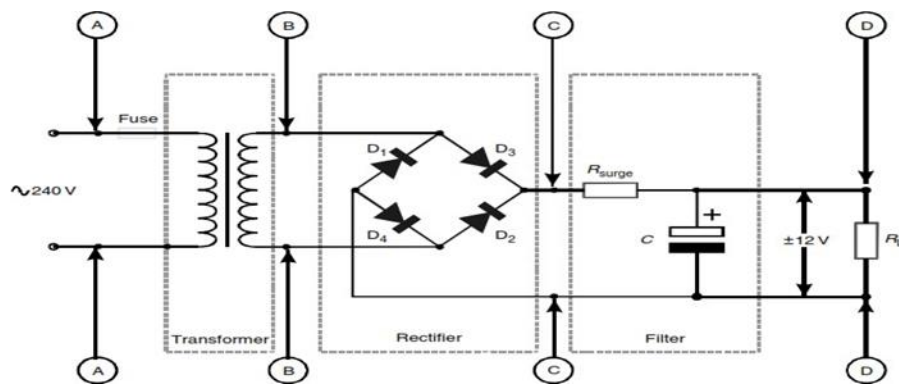


Figure 3.5: a circuit diagram of the bridge rectifier

Analyses of all possible faults in this circuit are given below:

i) Faulty capacitors

There are three possible problems. The capacitor could be shorted, opened, or leaky. If the capacitor is shorted, it effectively brings both terminals of the load resistor together and therefore

the output voltage is zero. This is illustrated in Figure 3.6 (a). If the capacitor is open (Figure 3.6(b)), it does not filter the output voltage supplied from the rectifier. The waveform of the voltage, at the output, remains the same as the waveform of the voltage, after the rectifier. Therefore, the waveforms at points C and D are identical. The only difference is that the amplitude of the voltage at the point D is smaller, due to the voltage drop across the resistor R_{surge} . Finally, if the capacitor is leaky the output voltage will appear with increased ripples on the output (Figure 3.6 (c)).

A leaky capacitor appears as if there is a leakage resistor, connected to it in parallel. The leakage resistor decreases the time for a discharge, thus the voltage ripples increase at the output.

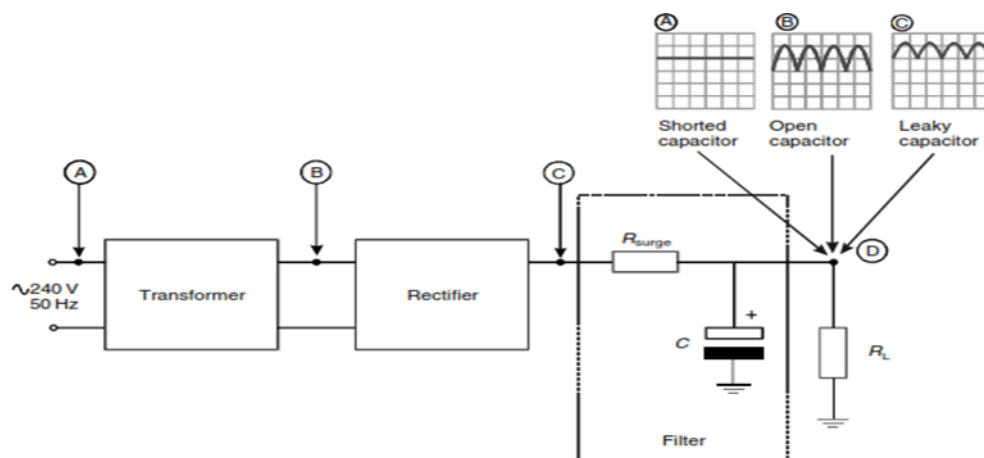


Figure 3.6: Symptoms of a faulty capacitor

ii) Faulty Resistor (R_{surge})

There is only one possible faulty condition, namely a blown resistor R_{surge} (R_{surge} appears as an open circuit). This occurs, when an excessive current flows through it. An excessive current flows through R_{surge} if the output terminals are short-circuited or if the capacitor is shorted. In both cases when R_{surge} blows, it brakes the circuit and prevents the diodes (which are more expensive than the resistor) from burning too. The output voltage in this case is zero. Before replacing R_{surge} , ensure that the capacitor, or the output terminals of the circuit, is not shorted and that the conductive paths of the PCB are not shorted out.

iii) Shorted diode

Shorted diode appears as a jumper between the points of the connection, as it conducts the current in both directions. Figure 3.7 illustrates the current that flows in the circuit, when the diode D4 is shorted out. During the positive half-period, the current flows through D3 and D4 as normal. The shortened diode exhibits a zero resistance in both directions and it appears for the circuit, as if it is simply forward-biased. Thus, the positive half-period appears as normal at the point C. However, during the negative half- period the picture changes. The current now flows through D1 and D4 instead of flowing through the rest of the circuit, because these two diodes, connected in series, provide a path of least resistance. Effectively the secondary winding is short-circuited and an excessive current flows through it. Thus, the diode D4 can be damaged quickly, due to overheating. The increase in the current in the secondary winding increases the current in the primary winding. If the circuit is properly fused, the fuse on the primary winding should blow. If this is not the case, the diode D 1 overheats (and even possibly burns) and the voltage at the test, point C has the form shown in Figure 3.7 Analytical thinking is required to analyze what happens in the circuit when some other diode shorts out, or when two or more diodes short out simultaneously.

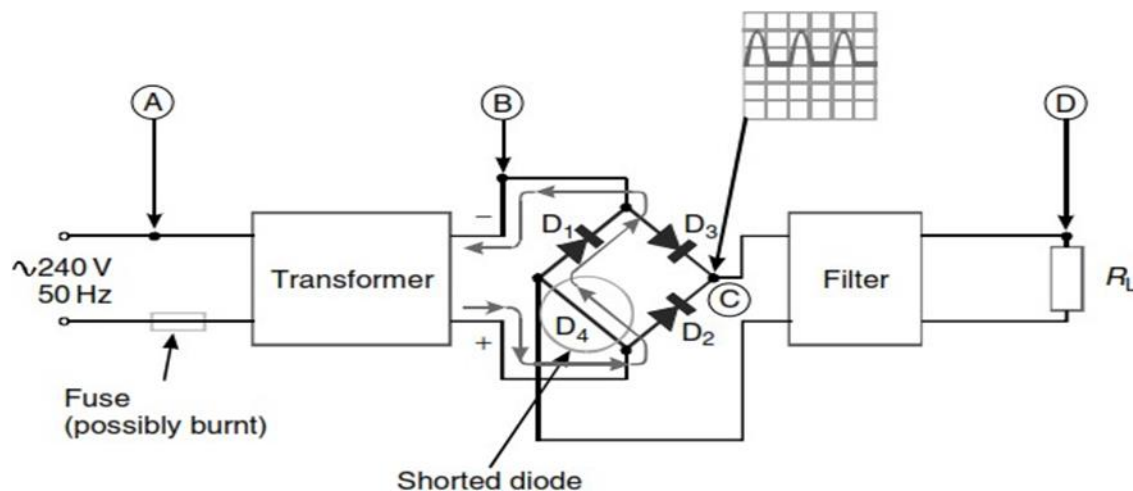


Figure 3.7: Symptoms of a shortened diode

iv) Open diode

Let us assume that the same diode (D4) is open. No current flows through an open diode in both directions. During the negative half period, this diode appears to the circuit to be reverse-biased, and therefore it has no impact on the output voltage. However, during the positive half-period, the path for the current is broken and no voltage appears at the output. In other words, the circuit works as a half-wave rectifier. This can be detected by, the larger ripples in the output voltage. In addition, the frequency of the ripples is 50Hz Instead of 100Hz. This is illustrated in Figure3.8 Similarly; the circuit can be analyzed for other open diodes.

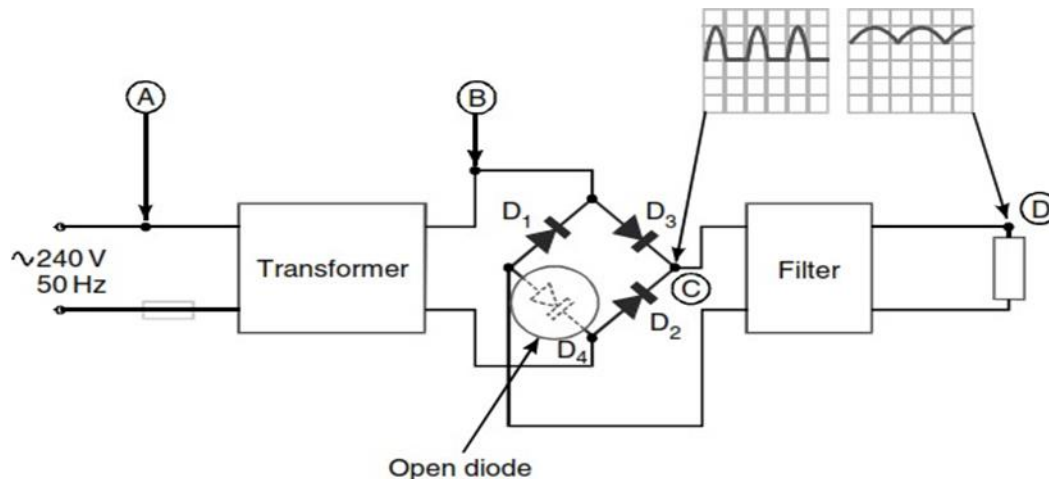


Figure3.8: Symptoms of an open diode

v) Faulty transformer

This is not a common fault, though if the rest of the circuit appears in a good working order, the transformer has to be checked. Several faults are possible: the primary or the secondary windings can be open or partially shorted. If one of the windings is open, no voltage is applied to the rest of the circuit. This obviously results in 0 V at the output. If the primary winding is partially shorted, the turn's ratio of the transformer is effectively increased. The voltage on the secondary

winding is also increased; thus, the level of the voltage at the output of the circuit is higher. A partially shorted secondary winding decreases the turn ratio of the transformer. The voltage supplied to the rectifier is lower; thus, the level of the circuit output voltage is also lower.

vi) Blown fuse

As was mentioned earlier, this occurs when one of the diodes is shorted. Thus, before replacing the fuse, the diodes have to be checked. A partially shorted primary or secondary winding of the transformer can also increase the current to a level, where the fuse blows. Thus, the transformer also has to be tested before replacing the fuse.

vii) Testing BJTs

Sometimes the transistor itself may not be faulty, but due to faults in the external circuitry, it may not operate correctly. For example, a cold junction on the transistor base terminal effectively isolates the base from the rest of the circuit. Therefore, the bias voltage on the transistor is 0 V, which will drive it into a cutoff. When checking such a transistor from the component side of the PCB, it will appear to be functioning correctly. Yet, the signal is not present at the output.

To better understand how to troubleshoot a biased BJT, consider the amplifier stage example shown in Figure B.6. It is built on the transistor 2N3946. According to the data sheets, β_{DC} for this transistor is in the range of 50–150. Therefore, we can assume that β_{DC} for the specified transistor is 100. The bias voltages are chosen $V_{BB} = 3\text{ V}$ and $V_{CC} = 9\text{ V}$. Performing some simple calculations, we can determine that:

$$V_{BE} = 0.7\text{ V}$$

$$I_B = \frac{3\text{ V} - 0.7\text{ V}}{56\text{ K}\Omega} = \frac{2.3\text{ V}}{56\text{ K}\Omega} = 41.4\text{ }\mu\text{A}$$

$$I_C = \beta_{DC} I_B = 100(41.1\text{ }\mu\text{A}) = 4.1\text{ mA}$$

$$V_C = 9\text{ V} - I_C R_C = 9\text{ V} - (4.1\text{ mA})(1\text{ K}\Omega) = 4.9\text{ V}$$

The voltages and the component values are specified in the Figure 7.6. All the measured voltages are with respect to the ground. If the circuit operates correctly, the following voltages should be measured: +0.7 V in point A, +4.9 V in point B, and 0 V in point C.

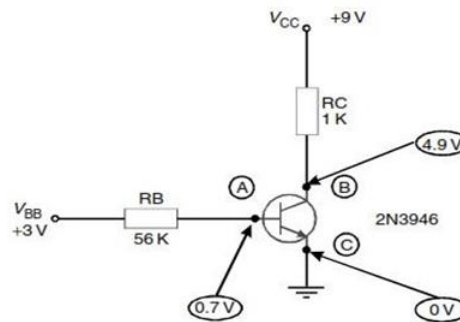


Figure 3.9: Troubleshooting a single amplifier stage

First, the transistor has to be checked. If the transistor is not defective, the PCB has to be inspected visually for mechanical defects, burned components, and badly soldered joints. Finally, the voltages on the transistor terminals have to be measured.

Three typical abnormal conditions may occur due to faults in the external circuitry. They are illustrated in Figure 3.10. Measuring the voltages on the transistor terminals can help to more effectively detect these faults. If the voltage at point B is only several mV instead of the normal +0.7 mV, then this is an indication that the base of the transistor is open (Figure 3.10(a)). The soldered joints at the base of the transistor and at R_B have to be checked. The value of the R_B has to be measured. Any external circuitry, leading to the base of the transistor has to be inspected for badly soldered joints and for components that are out of tolerance.

If the meter reads a few mV on the collector terminal (point B) it is an indication that the collector is not connected to the rest of the circuitry (Figure 3.10(b)). At the same time, the voltage on the base terminal should be around 0.7 V, as the base-emitter PN junction is forward-biased. The soldered joints on the collector and the collector resistor to the PCB have to be inspected. The value of R_C has to be measured. Any component, connected to the collector resistor, has to be checked.

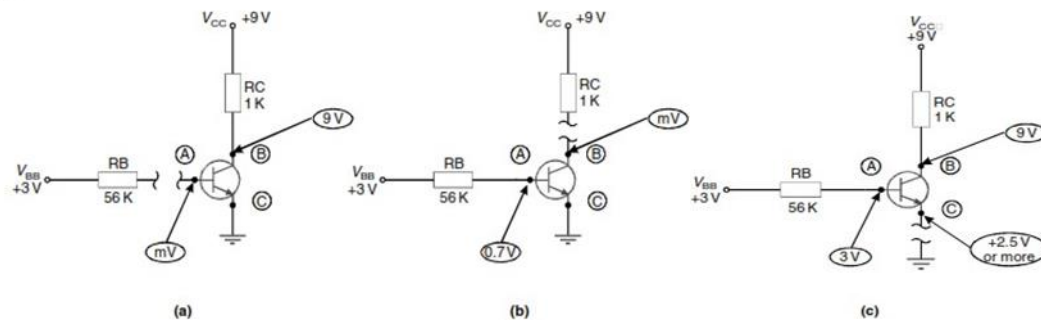


Figure 3.10 Typical abnormal conditions in a biased BJT: (a) Open base; (b) Open collector; (c) Open emitter

If there is an open ground connection, the symptoms are as follows: +3 V at the base terminal and +9 V at the collector terminal, as there is no collector and no emitter currents (Figure 3.10(c)). The voltage measured at the emitter is +2.5 V or more. This occurs because the internal resistance of the measuring voltmeter provides a forward current path. It flows from VBB, through RB, the base-emitter junction and through the measuring voltmeter to the ground. Thus, the voltmeter registers the voltage drop across the PN junction. The soldered joint on the emitter has to be checked. All external circuitry connected to the emitter also has to be checked and tested.

3.2 Explaining identified defects and faults

Explaining common Faults found on power supply using Pictures

1. No Power Fault

- Case No 1 no power
- ✓ Shorted Non-Polar Capacitor



Figure 3.11: Shorted Non Polar Capacitor at CRT Board

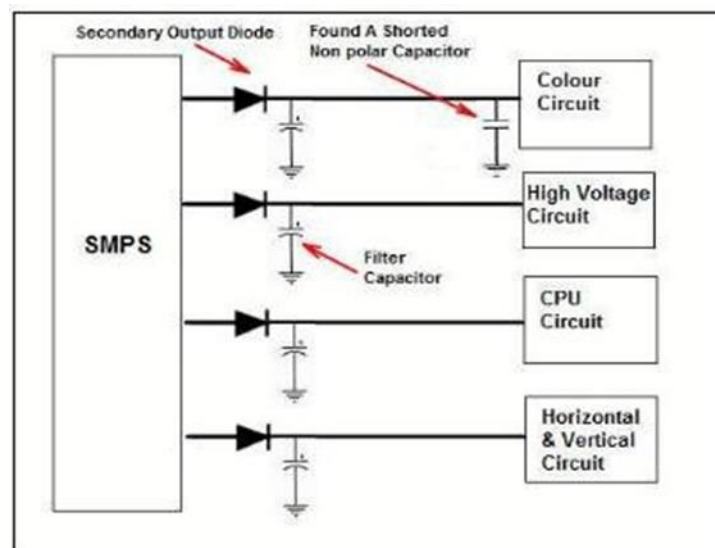


Figure 3.12: The Location of a Shorted Non Polar Capacitor

- ✓ Case No 2 no power
 - ✓ Startup resistor is opened
 - ✓ Shorted Power IC

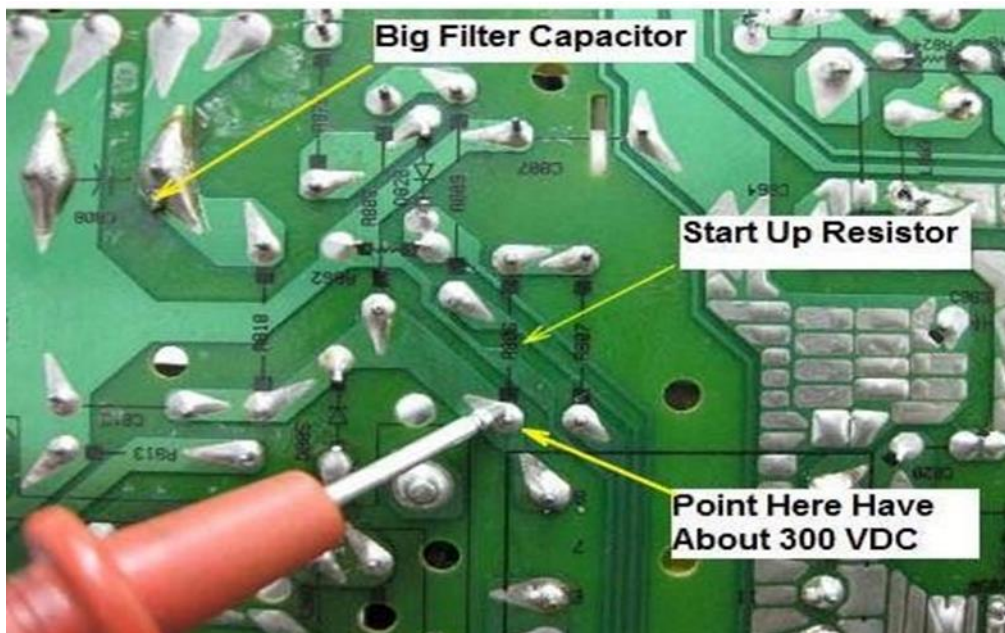


Figure 3.13: Voltage tracing at point of startup resistor

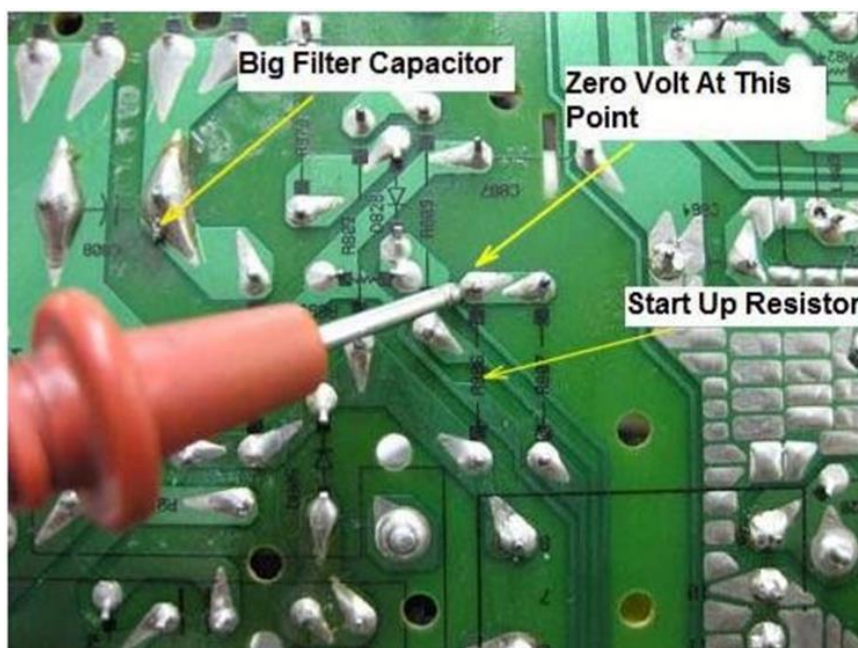


Figure 3.14: Zero Volts after the Startup Resistor

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- Case No3 no power
 - ✓ Shorted Zener diode
 - ✓ Shorted Power IC
 - ✓ Optoisolator IC Breakdown

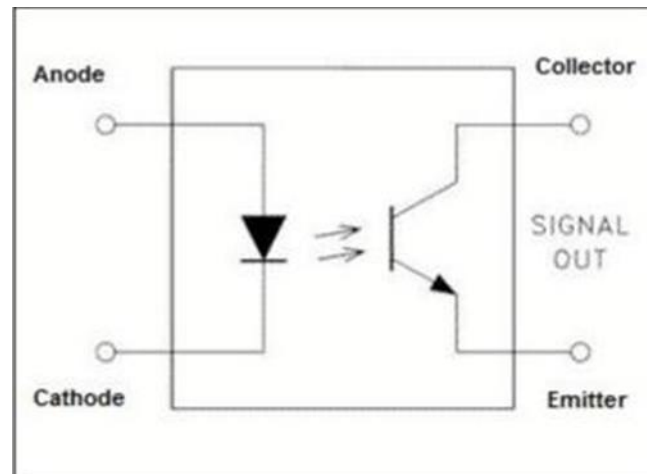


Figure 3.15: Optoisolator IC

Case No 4 Low Output Voltage

- Shorted or bad Component in the down stream
- Leaky transistor at the secondary side
- Partial shorted primary winding
- Bad Electrolytic capacitor
- Shorted emitter collector pin of Optoisolator IC

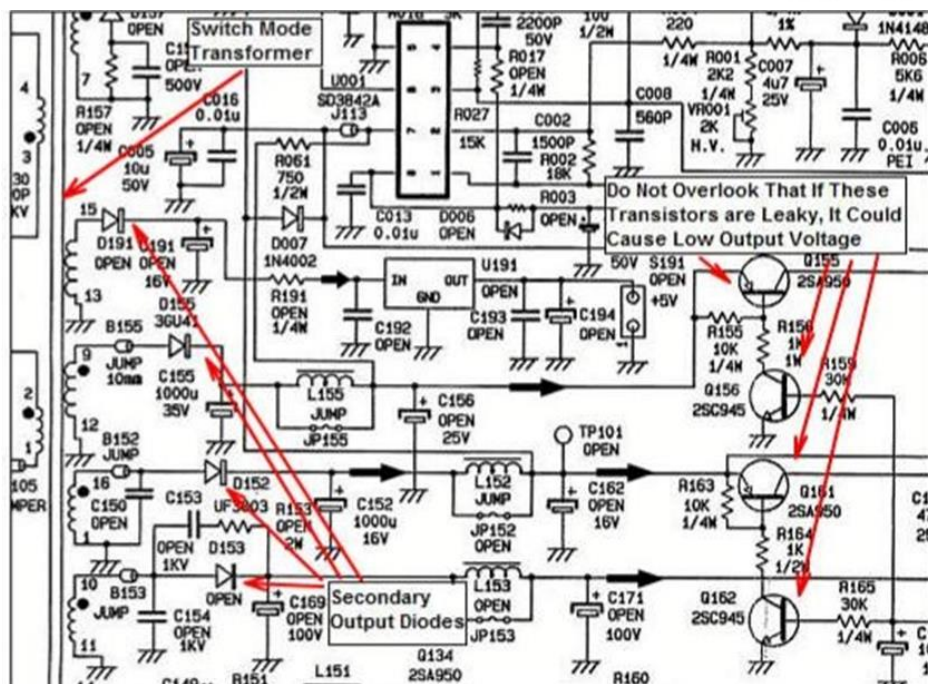


Figure 3.16: Bad Component in the downstream

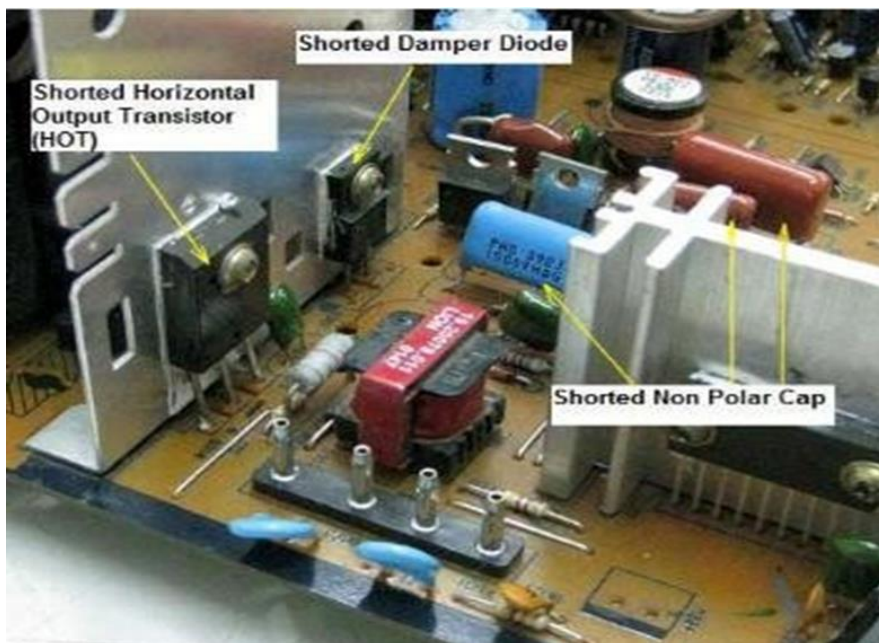


Figure 3.17: Shorted Component in the downstream

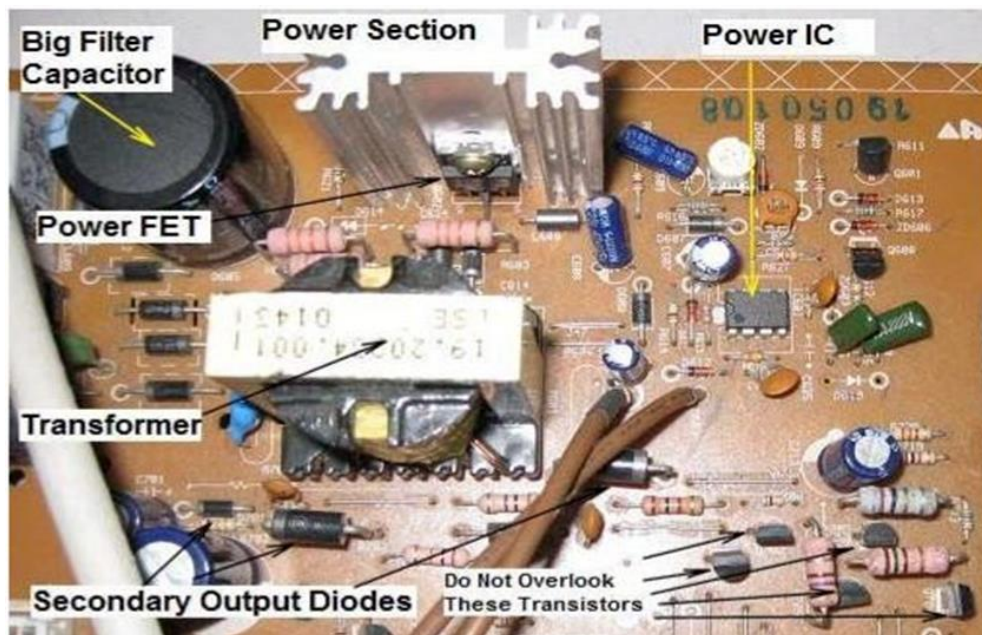


Figure 3.18: Leaky transistor at the secondary side

- Case No.5 No Power
 - ✓ Tiny break in one of the secondary line

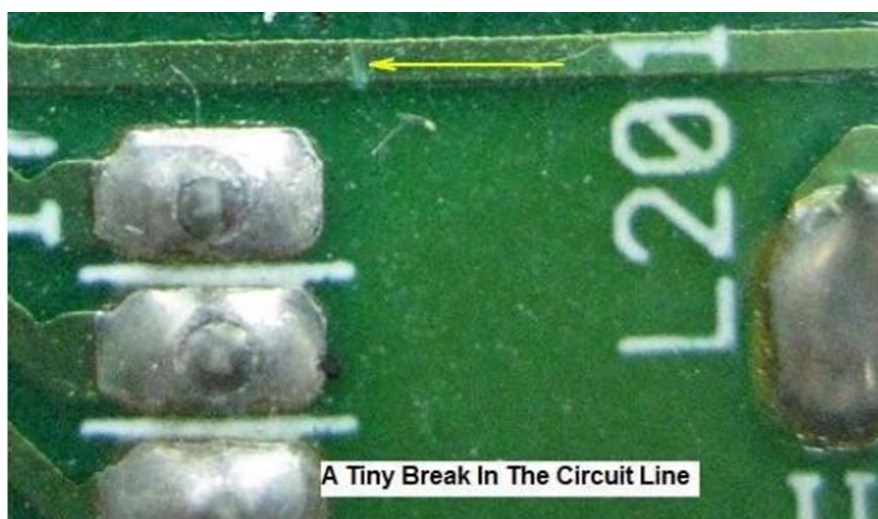


Figure 3.19: Tiny break in one of the secondary line or Circuit

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3.3 Documenting results of diagnosis and test

Documentation is a record or the capturing of some event or thing so that the information will not be lost.

3.3.1 Maintenance documentation

- ✓ Preventive maintenance is documented, Maintenance performed at other times, with the exception of routine cleaning, is documented.
- ✓ The documentation includes: description of the maintenance; date it was done; and
- ✓ Name of the service representative and company, or name of the analyst if maintenance provided internally

3.3.2 Documenting Repair equipment

- The documentation includes:
 - ✓ Initials of the analyst, and the date the problem was observed, description of the problem;
 - ✓ Date and initials of the analyst or service represent at performing the repair; synopsis of the repair; and
 - ✓ Cost of repair, copy of the invoice and any additional information (not required).

3.3.3 Documenting report

1. The establishment of the report and recording of the condition and repair of the transformers is required for a good maintenance program.
2. A preventive maintenance system will operate satisfactorily with the following records.
 - i) **An equipment record**
 - ✓ This may be simply a card, which contains the basic information of a transformer itself such as the serial number, the location, size, etc.
 - ii) **A repair record card**

- ✓ This may keep a running record as to costs of maintaining a transformer. It is the essential diagnostic record for avoiding future difficulties.
- 3. Without these records, it would be very difficult for a preventive maintenance program to work.

3.4 Replacing and repairing defective parts/components

Troubleshooting and repairing SMPS can be easy but you will get frustrated if you could not locate the spare parts. Sometimes the repair job can be done in few minutes. However, when finding the original parts, you may end up spending more time to locate the parts than when you do the repair work on SMPS. In order to make things easier, you may visit the blog at <http://www.JestineYong.com> under the category of Electronic suppliers to get the components you want.

If possible, get back the same part number to avoid repeating failure in SMPS that you have repaired and also to maintain the specifications within acceptable limits with respect to line isolation and to minimize fire hazards. However, if you still could not get the exact replacement parts for substitution please refer to any semiconductor data books to search for replacement.

In data, books there would be suggestions as to which part numbers are suitable for replacement. This kind of data book is necessary for anyone who works in electronic repair line. Apart from that, you could also find your own replacement by comparing the specification between the original and the replacement transistor. Always look for the replacement that has the same or higher specification in terms of voltage and Ampere and Wattage.

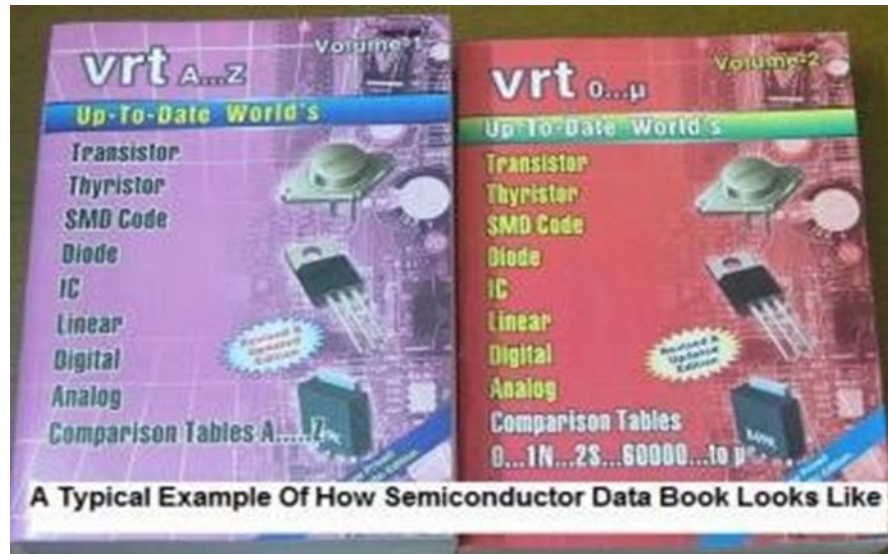


Figure 3.20: Semiconductor Replacement data book

Note: Always use original part numbers for replacement purposes!

3.4.1 Replacing defective parts/components

Once the fault location and the type of faulty component is identified in the fault diagnosis section, obviously the next task is to correct (trouble shoot) it. It is act of connecting the disconnecting circuit or replacing the faulted component with the same type, rate and size components. The selection of components according to their correct specification and soldering skill are determining factor for the replacement is effective.

To replace the defective component:

- ✓ Prepare soldering tools and equipment's, new component to be replaced
- ✓ Remove the defective one by applying correct disordering technique.
- ✓ Put in place the new component in the correct direction (keep correct polarity)
- ✓ Solder it by applying good soldering technique

Safety

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- ✓ Take care of not to touch high voltage side
- ✓ Wear apron, Glove, safety shoe
- ✓ Follow all cautions, warnings, and instructions marked on the equipment.
- ✓ Ensure that the voltage and frequency rating of the power outlet matches the electrical rating labels on the system.
- ✓ Use properly grounded power outlets.
- ✓ Disconnect the power before you replace/repair the faulty device, Discharge capacitor first before replacing it.

i) **Replacing a capacitor**

Always replace a capacitor with the exact same type. A capacitor may be slightly important in a circuit or it might be extremely critical. A manufacturer may have taken years to select the right type of capacitor due to previous failures. A capacitor just does not have a "value of capacitance." It may also have an effect called "tightening of the rails." In other words, a capacitor has the ability to react quickly and either absorb or deliver energy to prevent spikes or fluctuations on the rail.

This is due to the way it is constructed. Some capacitors are simply plates of metal film while others are wound in a coil. Some capacitors are large while others are small. They all react differently when the voltage fluctuates. Not only this, but some capacitors are very stable and all these features go into the decision for the type of capacitor to use.

You can destroy the operation of a circuit by selecting the wrong type of capacitor. No capacitor is perfect and when it is charged or discharged, it appears to have a small value of resistance in series with the value of capacitance. This is known as "ESR" and stands for Equivalent series resistance. This effectively makes the capacitor slightly slower to charge and discharge.

We cannot go into the theory on selecting a capacitor, as it would be larger than this book so the only solution is to replace a capacitor with an identical type. However, if you get more than one

repair with identical faults, you should ask other technicians if the original capacitor comes from a faulty batch. Some capacitors are suitable for high frequencies, others for low frequencies.

Remember:

- ✓ Please do not use any replacement that has smaller capacitance value and lower Voltage than the original one. Otherwise, the equipment may not work and in worst cases, it could blow up the Capacitor.

ii) Replacing Transistor

If you cannot get an exact replacement, refer to a transistor substitution guide to identify a near equivalent.

The important parameters are:

- ✓ Voltage
- ✓ Current Wattage
- ✓ Maximum frequency of operation

The replacement part should have parameters equal to or higher than the original. Points to remember:

- ✓ Polarity of the transistor i.e. PNP or NPN.
- ✓ At least the same voltage, current and wattage rating
- ✓ Low or high frequency type.
- ✓ Check the pin out of the replacement part
- ✓ Use a de-soldering pump to remove the transistor to prevent damage to the printed circuit board.
- ✓ Fit the heat sink.
- ✓ Check the mica washer and use heat-sink compound Tighten the nut/bolt - not too tight or too loose.

- ✓ Horizontal output transistors with an integrated diode should be replaced with the same type.

iii) Replacing a Diode

It is always best to replace a diode with the same type but quite often, this is not possible. Many diodes have unusual markings or colors or "in-house" letters.

This is only a general guide because many diodes have special features, especially when used in high frequency circuits. However, if you are desperate to get a piece of equipment working, here are the steps:

- ✓ Determine if the diode is a signal diode, power diode, or zener diode. For a signal diode, try 1N4148.
- ✓ For a power diode (1 amp) try 1N4004. (for up to 400v) For a power diode (3 amp) try 1N5404. (for up to 400v) For a high-speed diode, try UF4004 (for up to 400v)

If you put an ordinary diode in a high-speed application, it will get very hot very quickly. To replace an unknown zener diode, start with a low voltage such as 6v2 and see if the circuit works. The size of a diode and the thickness of the leads will give an idea of the current capability of the diode. Keep the leads short as the PC board acts as a heat-sink. You can also add fins to the leads to keep the diode cool.

iv) Replacing IGBT/SCR:

- ✓ As for this component, use the explanation of the bipolar transistors to find the equivalent part number or replacement.

v) Replacing Power IC

- ✓ It is always recommended to Replace Power IC with the original part number, in fact if you carefully study the internal specification of the Power IC, you could get a replacement.
- ✓ Although there are, some successes in finding a replacement and you can face a problem with replacement Power IC.

vi) Switch Mode Power transformer(SMPT)

There is no Equivalent SMPT in the market because every SMPT are created unique in terms of winding. Some SMPT have tow out puts while some have many outputs and the volt/ampere produced is different. The only way you can get is through the equipment distributors.

vii) Optoisolator IC

- ✓ By referring the data sheet download from the internet; you can find the equivalent part number.
- ✓ The famous 4N35 part number can easily substituted by many other Optoisolator IC part number.
- ✓ This 4N35 IC is quite common and can be easily found from any electronic shops.

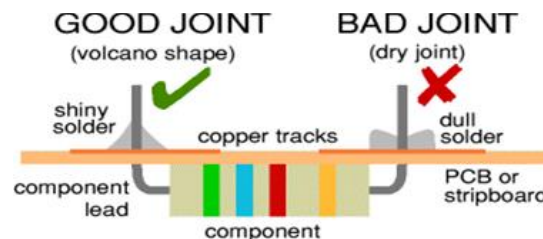
3.5 Soldering repaired or replaced parts

Safety Precautions:

- Never touch the element or tip of the soldering iron.
 - ✓ They are very hot (about 400°C) and will give you a nasty burn
- Take great care to avoid touching the mains flex with the tip of the iron.
 - ✓ The iron should have a heatproof flex for extra protection. An ordinary plastic flex will melt immediately if touched by a hot iron and there is a serious risk of burns and electric shock.
- Always return the soldering iron to its stand when not in use.
 - ✓ Never put it down on your workbench, even for a moment!
- Work in a well-ventilated area.
 - ✓ The smoke formed as you melt solder is mostly from the flux and quite irritating. Avoid breathing it by keeping you head to the side of, not above, your work.
- Wash your hands after using solder.
 - ✓ Solder contains lead, which is a poisonous metal.

Preparing the soldering iron:

- Place the soldering iron in its stand and plug in.
 - ✓ The iron will take a few minutes to reach its operating temperature of about 400°C.
- Dampen the sponge in the stand.
 - ✓ The best way to do this is to lift it out the stand and hold it under a cold tap for a moment, then squeeze to remove excess water. It should be damp, not dripping wet.
- Wait a few minutes for the soldering iron to warm up.
 - ✓ You can check if it is ready by trying to melt a little solder on the tip.
- Wipe the tip of the iron on the damp sponge.
 - ✓ This will clean the tip.
- Melt a little solder on the tip of the iron.
 - ✓ This is called 'tinning' and it will help the heat to flow from the iron's tip to the joint. It only needs to be done when you plug in the iron, and occasionally while soldering if you need to wipe the tip clean on the sponge.



You are now ready to start soldering:

- Hold the soldering iron like a pen, near the base of the handle.
 - ✓ Imagine you are going to write your name! Remember to never touch the hot element or tip.
- Touch the soldering iron onto the joint to be made

- ✓ Make sure it touches both the component lead and the track. Hold the tip there for a few seconds and...
- Feed a little solder onto the joint.
 - ✓ It should flow smoothly onto the lead and track to form a volcano shape as shown in the diagram. Apply the solder to the joint, not the iron.
- Remove the solder, then the iron, while keeping the joint still.
 - ✓ Allow the joint a few seconds to cool before you move the circuit board.
- Inspect the joint closely.
 - ✓ It should look shiny and have a 'volcano' shape. If not, you will need to reheat it and feed in a little more solder. This time ensure that both the lead and track are heated fully before applying solder.

Using a heat sink:

Some components, such as transistors, can be damaged by heat when soldering so if you are not an expert it is wise to use a heat sink clipped to the lead between the joint and the component body. You can buy a special tool, but a standard crocodile clip works just as well and is cheaper.



Figure 3.21: A standard crocodile clip

Soldering Advice for Components:

It is very tempting to start soldering components onto the circuit board straight away, but please take time to identify all the parts first. You are much less likely to make a mistake if you do this!

1. Stick all the components onto a sheet of paper using sticky tape.
2. Identify each component and write its name or value beside it.
3. Add the code (R1, R2, C1 etc.) if necessary.

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4. Resistor values can be found using the resistor color code, which is explained on our Resistors page. You can print out and make your own Resistor Color Code Calculator to help you.
5. Capacitor values can be difficult to find because there are many types with different labeling systems! The various systems are explained on our Capacitors page.

Some components require special care when soldering. Many must be placed the correct way round and the heat from soldering easily damages a few. Appropriate warnings are given in the table below, together with other advice, which may be useful when soldering.

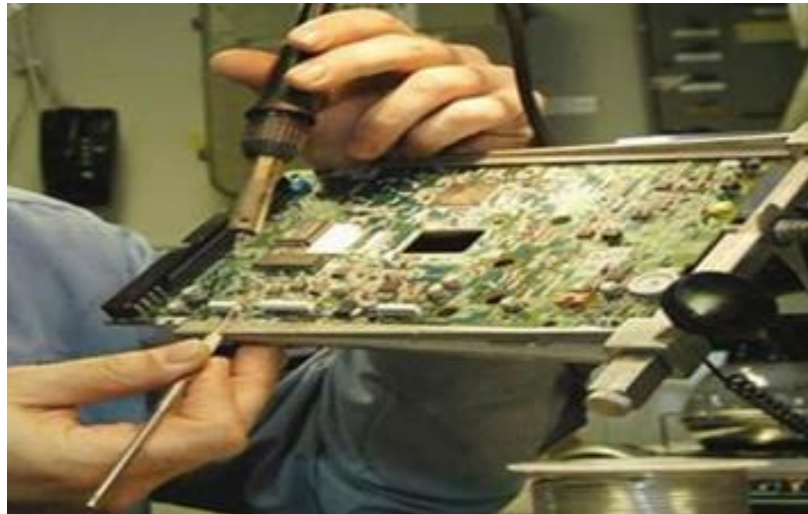


Figure 3.22: Soldering a component

Self-check 3

Direction I: choose the best answer

1. The first step in measuring voltage at the filter capacitor
 - A. Identify the positive and negative pins of the Filter Capacitor
 - B. Discharge the big Filter Capacitor.
 - C. Set Your Voltmeter in DC range
 - D. Place the BLACK test probe to the negative pin of the Filter Capacitor.
 - E. Read the voltage measurement properly.
2. The best point to test the AC input is:
 - A. At the terminals of the power cable
 - B. At the two pins of the capacitor
 - C. At the two pins of the zener diode
 - D. At the two pins of the bridge rectifier
 - E. None
3. _____ Cause to a blow fuses in Power Supply.
 - A. One of the diodes is shorted
 - B. A partially shorted primary of the transformer
 - C. A partially shorted secondary winding of the transformer
 - D. High Current flow in the fuse
 - E. All of the above

Direction II: Give Short answer

1. Explain the common Faults occur in power supply.
2. Define Documentation
3. List maintenance document contents

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Operation sheet-2

Operation Title: Measuring the secondary output voltage a switch mode power supply

Instruction: In workshop, measure secondary voltage output from switch mode power supply.

Purpose: to measure voltage output at secondary voltage output from switch mode power supply.

Required tools and equipment: Multimeter

Precautions:

- Never touch the pin of power outlet
- Hold the test probes tightly otherwise, if it touches other parts it can blow the main fuse and may create a loud bang that can harm you.
- Discharge the big Filter Capacitor before you test or remove it otherwise, you will blow the meter.

Procedures:

Step 1: Set your Multimeter in DC range.

Step 2: Identify the secondary output diode cathode side.

Step 3: Place the RED test probe to the Secondary Output Diode Cathode Side.

Step 4: Place the BLACK test probe to Cold (Chassis) Ground

Step 5: Switch on the power carefully.

Step 6: Read the voltage measurement properly.

Step 7: Compare the readings and the expected output voltage.

Quality criteria:

- Safety
- Using of measuring instruments

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LAP Test 2

Name: _____

Date: _____

Time started: _____

Time finished: _____

Instruction I: Given necessary templates, tools and materials you are required to perform the following tasks within 30 minutes.

Task 1: measure the voltage the secondary output voltage a switch mode power supply

Unit four: Testing and inspecting repaired power supply unit

This learning unit is developed to provide the trainees the necessary information regarding the following content coverage and topics:

- Inspecting and testing of repaired power supply units
- Housekeeping procedures
- Waste materials disposal
- Documenting and informing work completion

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Inspect and test of repaired power supply units
- Observe of housekeeping procedures
- Dispose waste materials
- Document and inform work completion

4.1 Inspecting and testing of repaired power supply units

Inspection is an organized examination or formal evaluation exercise. In engineering, inspection involves the measurements, tests, and gages applied to certain characteristics concerning an object or activity.

The results are usually compared to specified requirements and standards for determining whether the item or activity is in line with these targets.

Some inspection methods are destructive; however, inspections are usually nondestructive. Nondestructive examination (NDE), or nondestructive testing (NDT), are a number of technologies used to analyze materials for either inherent flaws (such as fractures or cracks), or damage from use. Some common methods are visual, microscopy, liquid or dye penetrant inspection, magnetic particle inspection, eddy current testing, x-ray or radiographic testing, and ultrasonic testing.

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4.1.1 Final Visual Inspection

Visual inspection provides a means of detecting and examining a variety of surface flaws, such as corrosion, contamination, surface finish, and surface discontinuities on joints (for example, welds, seals, and solder connections).

Visual inspection is also the most widely used method for detecting and examining surface cracks that are particularly important because of their relationship to structural failure mechanisms. Even when other inspection techniques are used to detect surface cracks, visual inspection often provides a useful supplement.

For example, when the eddy current examination of process tubing is performed, visual inspection is often performed to verify and more closely examine the surface disturbance. In some instances, acid etching can be used to reveal structures that would not be visible to the naked eye. Given the wide variety of surface flaws that may be detectable by visual examination, the use of visual inspection can encompass different techniques, depending on the product and the type of surface flaw being monitored.

The methods of visual inspection involve a wide variety of equipment, ranging from examination with the naked eye to the use of interference microscopes for measuring the depth of scratches in the finish of finely polished or lapped surfaces.

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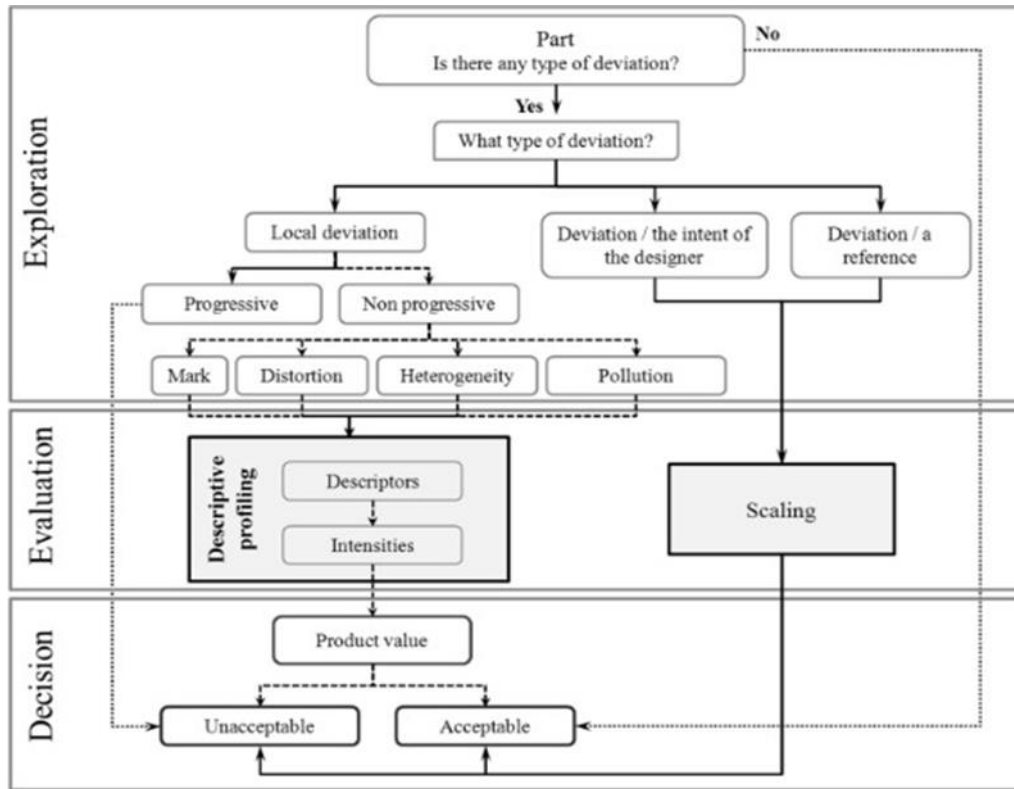


Figure 4.1: Visual inspection process

4.1.2 Inspection records

1. The establishment of the report and recording of the condition and repair of the transformers is required for a good maintenance program
2. A preventive maintenance system will operate satisfactorily with the following records.
 - An equipment record
 - ✓ This may be simply a card, which contains the basic information of a transformer itself such as the serial number, the location, size, etc.
 - A repair record card
 - ✓ This may keep a running record as to costs of maintaining a transformer.
 - ✓ It is the essential diagnostic record for avoiding future difficulties.
 - An inspection checks list or inspector's record

- ✓ This may be simply a listing of the points to be checked on a transformer and the establishment of the time that these checks should be made.
3. Without these records, it would be very difficult for a preventive maintenance program to work, because the knowledge gained from regular inspections would be quickly lost.

4.1.3 Testing quality standards

The transformer is ready to install to its place in the equipment do that:

- ✓ Disconnect power from the equipment
- ✓ Place the repaired transformer to its place in correct position
- ✓ Fix it with its fixing accessories, i.e. install securely the mechanical installation.
- ✓ Perform the electrical connection, i.e. connect the primary and secondary leads to its previous connection points.
- ✓ Clean the equipment with blowers and cleaning rags (clothes)
- ✓ Inspect the repaired and any other components of the equipment.

Check for wear out, broken, burned parts and any sign of abnormality electrical components or mechanical parts. If there, something seems to be wrong (abnormal), perform additional investigation closely to prove or disprove the expectation. If there is loosen part, components that need replacement, or mechanical moving parts that need lubrication take for all appropriate remedial action.

- ✓ The equipment to power source and perform input output voltage measurement. Test the equipment for correct operation (functional test of the equipment).

4.2 Housekeeping Procedure

A clean workplace is necessary for a safe work environment – accidents and injuries are avoided and productivity is improved where good housekeeping is a daily occurrence. Such procedures will help promote the best use of limited space, keep material storage to a minimum, decrease energy costs, and minimize property damage.

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If the following procedures are adhered to, housekeeping should not be a hazard that students, guests, faculty, and staff are exposed to:

a) Walking Surfaces:

- Floors should be maintained in a safe, clean condition by:
 - ✓ Sweeping up any dust, dirt, trash, glass, etc
 - ✓ Mopping up any standing water/non-hazardous spills
 - ✓ Displaying a “Wet Floor Sign” where there is wet floor (includes removing the “Wet Floor Sign” when the floor has dried)
 - ✓ Keeping extension cords/hoses/ropes off the floor
 - ✓ Keeping walk-off mats and rugs flat on the floor (not bunched up)

b) Electrical Safety:

- Clearance of 36 inches maintained around all electrical panels (including no combustible storage in electrical closets)
- Equipment in need of repair (split/taped up electrical cords, missing GFCI prongs, etc.) should be tagged and removed from service immediately, and either scheduled for repair or replaced
- Electrical panels kept shut and covers replaced after work has been completed

c) Chemical Safety and Hazard Communication:

- Flammable chemicals (ex.- gasoline) should be kept in sealed containers and kept in storage locations that are equipped to handle flammable materials
- All chemical containers should be labeled correctly, including secondary containers (ex. –spray bottles containing water should be labeled “water”)

d) Material Storage:

- Access should be maintained for the following:
 - ✓ Adequate, safe clearance in aisles/walkways by keeping them free of excess equipment, storage, tools, etc.

- ✓ Ensure access to emergency equipment such as Eyewash/Safety Showers, Safety Data Sheet Stations, Fire Alarm Pull Stations, Fire Extinguishers, Fire Alarm Control Panels, Exit Doors, etc.
- ✓ Ensure access to shelving units – items should not be placed in front of shelves so that employees must climb or reach over the items

e) Other best practices include:

- Centralize storage locations of like-materials
- Essentially, tools and equipment related to a specific routine job should be kept in/around the area of work.
- Do not cram materials and/or equipment into small mechanical rooms/fan rooms/shared space. If there is not adequate room to walk around with the materials stored in the space, please make arrangements with your supervisor to store the materials elsewhere.
- Avoid excessive accumulation of materials by keeping an inventory (amount of product and location of storage) for all tools, equipment, chemicals, furniture, etc.
- When stacking/storing materials, ensure they are stacked in a safe and secure manner, while maintaining an 18 inch clearance below sprinkler heads.
- Upon completion of a task, clean up debris and organize the work station so that the next person can start with a clean work area. Clean any tools, machines, and equipment after each use.

4.3 Disposing waste materials

- ✓ Electronic waste (sometimes called e-waste) is a term used to describe electronics that are nearing the end of their useful life and are discarded, donated, or recycled. Although donating and recycling electronic devices conserves natural resources, you may still choose to dispose of e-waste by contacting your local landfill and requesting a designated e-waste drop off location. Be aware that although there are many options for disposal, it is your responsibility to ensure that the location chosen is reputable and certified

- ✓ Disposal of E-waste is electronic waste. This includes old computers and their components, cell phones, digital cameras and other electronic gadgets. There often are heavy metals and other hazardous components inside the electronics that require special care when disposing of them. They may also have personal information on the hard drives that can be copied, putting your identity at risk. This will require preparing the items for disposal.
- ✓ Contact the manufacturer of the product and ask if it accepts e-waste for disposal. Apple, for example, will accept your old computer for disposal when you purchase a new one from them. Some manufacturers accept other brands' e-waste for a small fee.
- ✓ Contact a nearby electronics retailer and inquire into its disposal programs. Best Buy in its stores such small items as cell phone batteries and hosts recycling weekends for e-waste. Other retailers also offer similar programs.
- ✓ Contact your city, county or private waste management office. Many offer e-waste programs or have e-waste events for customers. Contact private waste companies and recyclers to see if they accept e-waste.
- ✓ Research donation options. Such charities as Goodwill may accept your old electronics and computers as a donation. Some cell phone companies accept old phones and then donate them.
- ✓ Prepare your item for disposal. Remove any memory cards from phones or cameras. Reset the memory on the phone following the instructions in your model's manual. Erase everything on your computer's hard drive. Some recyclers will do this for you, but inquire about this service before bringing your e-waste to them.

4.4 Documenting and informing work completion

Documentation is a record or the capturing of some event or thing so that the information will not be lost.

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4.4.1 Maintenance documentation

Service contract or in-house preventive maintenance is documented. This documentation is required for annual maintenance. Maintenance performed at other times, with the exception of routine cleaning, is documented.

The documentation includes:

- Description of the maintenance;
- Date it was done; and
- Name of the service representative and company, or name of the analyst if maintenance provided internally

4.4.2 Repair equipment's are documented.

The documentation includes:

- Initials of the analyst, and the date the problem was observed,
- Description of the problem;
- Date and initials of the analyst or service represent at performing the repair;
- Synopsis of the repair; and
- Cost of repair,
- Copy of the invoice and any additional information (not required).

Reading the service manual

It is difficult to repair any piece of complicated equipment without some service literature. It is possible to repair electronic equipment without the service manual, but it can be very time-consuming. You can lose a lot of valuable servicing time if you are without a good service manual. The service manual is a set of document prepared by the manufacturer to help the service technician to repair or service that set of equipment. A well written manual is the best servicing aid. It contains the following information:

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- ✓ Describe how a circuit works
- ✓ Block diagram of the equipment
- ✓ Circuit diagrams
- ✓ Signal and voltage test points
- ✓ Adjustment procedure
- ✓ List of accessories
- ✓ List of spare parts with the part numbers, values, tolerances and ratings
- ✓ Fault diagnosis steps, generally in the form of flow charts
- ✓ Preventive maintenance layout
- ✓ Safety precautions to be observed while handling the equipment.

A service manual can be very expensive, but it is worth the investment. With the help of a service manual, a service technician or engineer can:

- ✓ Align, calibrate and test the equipment correctly to get the optimum output
- ✓ Locate a fault quickly
- ✓ Use the correct replacement part Conduct preventive maintenance correctly

By using the right service manual, as well as with the assistance of good tools, testing equipment and your own experience, you are set to multiply your troubleshooting power!

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Self-check 4

Direction I: Write the answer clearly

1. List the procedures to clean repaired units
2. Define visual inspection
3. Write the service manuals benefits

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