Voltage stabilizer and UPS

Objectives: At the end of this lesson you shall be able to
- **state the basic concept of stabilizer**
- **draw the block diagram and explain the function of each blocks**
- **state the working various types of voltage stabilizers**
- **state the basics of UPS system**
- **explain the block diagram of OFF line UPS and its various controls and functions**
- **explain the block diagram ON line UPS and advantages and disadvantages.**

Voltage stabilizer

It is an electrical supply device controlled by electronic circuit which gives the constant output voltage irrespective of the variation in the high input supply voltage or disconnect the output circuit if the input voltage is very low or very high.

Every electrical device is designed to operate at a certain rated voltage for optimum efficiency and maximum length of service. Power supply voltages should not drop or rise by more than 5% of rated voltage as per IS.

The effect of voltage variations in commonly used electrical appliances are given below.

Sl.No.	Name of the equipment	Low voltage	High voltage
1	Incandescent lamp	Lamp efficiency decreases if the voltage is decreased.	Life of the lamp decreases or the lamp fuses in extreme cases.
2	Fluorescent lamp	If voltage is too low, lamp will not light up.	Life of the tube/choke decreases.
3	Electric stove, electric iron, water heaters, toasters etc.	Increases the heating time as heat produced is low.	Shortens the life of heating elements or heating elements burnt out.
4	Fans, vacuum cleaners	Efficiency decreases.	Life of the equipment is decreased
5	Washing machines, refrigerators and air-conditioners	Motor of the machine will draw more current from the line that results in overheating of the motor which may lead to burn out.	The motor insulation may fail and draw excess current which can lead to burn out.
6	Radios and television sets	Poor quality of reception, picture will not be clear in the television sets.	Life of the equipment is decreased

Some of the electronic equipment such as colour television sets are designed by the manufacturers with built in electronic stabilizers like Switch Mode Power Supplies (SMPS). Hence there is no need to provide an additional external stabilizers for these equipments.

Types of AC voltage stabilizers

1 Stepped voltage stabilizer
   a) Manual
   b) Automatic relay type
2 Servo voltage stabilizer
3 Constant voltage transformer

Stepped voltage stabilizer

In the stepped voltage stabilizer, an auto-transformer is used for regulating the output voltage. A manually operated switch as in Fig 1 regulates the output voltage in the manual type. In automatic relay type stabilizers a sensing circuit actuates the relays which regulates the output voltage. The schematic diagram is in Fig 2 is for an automatic relay type stabilizer.

Fig 1

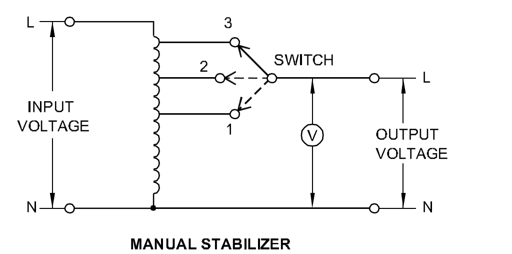
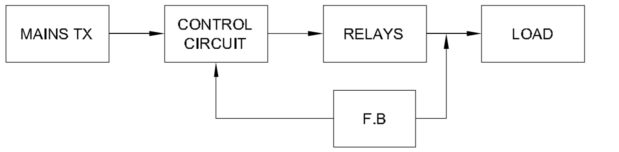


Fig 2



BLOCK DIAGRAM OF VOLTAGE STABILIZER

Mains Tx

This transformer supplies two level voltage i.e, low voltage and high voltage, which is to be supplied according to the needs. Some stabiliser working in buck boost operation to meet special application for load requirements. The auxiliary supply also provides for control circuit requirements by the mains transformer.

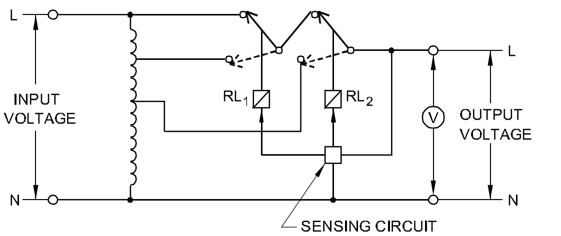
Control circuit

In the ordinary voltage stabilisers, control circuit regulate the relay operation, irrespect or output voltage. When input voltage falls below the set voltage H.T side relay will operate and incase high voltage condition LT side relay will operate and maintain the stipulated operate voltages. The relay operation controls by controlling relay coil supply which is set for separate DC regulated voltage levels.

Relays

It is a electromagnetic relay which operates two different coil voltage. the DC coil voltage decides which relay has to be operate depends on the input AC voltage supplied to the transformer. Fig 3 shows an automatic relay type stabilizer.

Fig 3



AUTOMATIC STABILIZER RELAY TYPE

Feed back

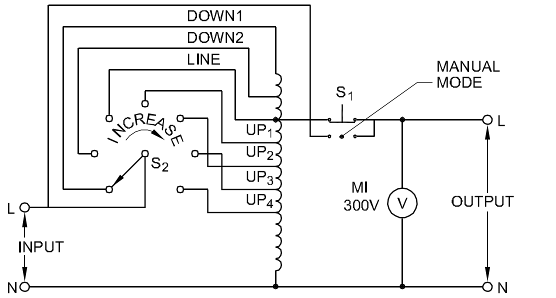
In non automatic voltage stabiliser DC voltage are taken on the feed back quantity, which operates the relay coil. The coil DC voltage will be two different voltage to activate the relay in case of low and high voltage AC input conditions.

Load

Load can be anything connected to the stabiliser. Some electrical equipments requires a constant input voltage to operate. such case a stabiliser is required. But in automatic stabiliser have the disadvantage of transient line (Change over to one voltage to other voltage level) which may cause the stabiliser to OFF condition few milli seconds.

Stepped voltage stabilizer - manual type : Fig 4 shows an auto-transformer in which the output voltage increases as the tap changing switch S_1 is turned clockwise. The output voltage can be seen by connecting a voltmeter in the output side as in Fig 4. Increasing or decreasing the output voltage near to the set value is possible by rotating the tap changing switch S_2 in the appropriate direction within ±10% of the desired output voltage. A push-button switch S_1 enables to measure the incoming voltage.

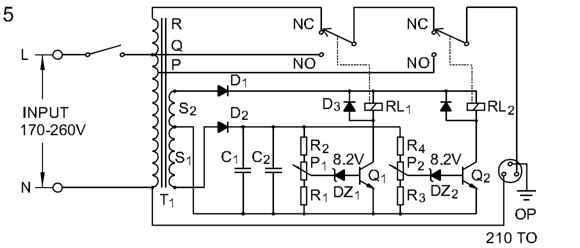
Fig 4



STEPPED VOLTAGE STABILIZER-MANUAL

Stepped voltage stabilizer - automatic type : Fig 5 shows a stepped voltage stabilizer of the automatic type operated by relays. T_1 is an auto-transformer with multiple tappings. S_1 and S_2 are two secondaries for relay operation. The secondary voltage of S_1 is rectified and filtered for the use of the sensing circuit while voltage S_2 is rectified and filtered for the use of the relay operation. P_1 and P_2 are pre-set resistors (variable resistors) used for adjustment. R_1, P_1 and R_2 provide sensing voltage to the zener diode. DZ_1 and R_3P_2 and R_4 to the zener diode DZ_2. Q_1 and Q_2 are two transistors used as switches. RL_1 and RL_2 are two relays.

Fig 5



STEPPED VOLTAGE STABILIZER-AUTOMATIC

When the input voltage is low, say less than 200V, both DZ_1 and DZ_2 do not conduct as the voltages at the preset tappings are less than their zener diode voltages. This causes both transistors to cut off and the relays are in the off position. At the off position of the relays, NO contacts of both the relays connect terminal R of the auto-transformer to output which results in booster output voltage.

When the input voltage increases above 210V, but below 240V voltage across S_1 increases proportionally. This increases the pre-set tap voltage, thereby the zener diode DZ_1 conducts and hence make the transistor Q_1 to ON. The relay RL_1 operates and connects the supply voltage directly to the output through NO. contact of RL_1 and NC contact of RL_2. By this operation the output voltage will be the same as the input voltage.

When the input supply voltage increases above 240V the zener diode DZ_2 gets voltage from P_2 and hence conducts which makes Q_2 to ON. This results relay RL_2 energise and output is taken from NO. point of RL_2. The output voltage reduces or bucks.

Usually 12V DC relays with the required current ratings of contacts are preferred for stabilizers. Diodes or capacitors are used across the relay coil to protect the transistors from reversed induced emf when the relays become OFF. LED indicators are sometimes used to indicate the mode of operation such as buck, normal, boost etc.

Stepped voltage stabilizers are available with different types of electronic circuits with one to three relays to provide an output voltage of 200-240V. They are specified for maximum input voltage variation and for their output, KVA ratings say 170 to 270 volts 1 KVA or 135 to 260 volts 0.5 KVA.

Some of the stabilizers are provided with over-voltage and under-voltage cut off to protect the connected equipment.

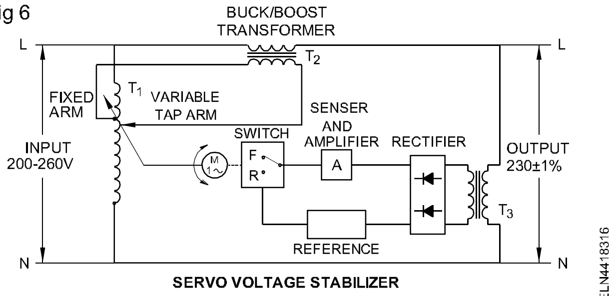
Applications : Stepped voltage stabilizers are used along with refrigerators, air conditioners, TVs, VCRs etc. Colour TVs with self-contained switch mode power supplies do not require voltage stabilizer as they are designed to operate from 130 to 260 volts.

Servo - voltage stabilizer

The servo voltage stabilizer employs a toroidal auto-transformer and a servo motor driven by a sensing circuit which senses the voltage. The difference between the output and nominal voltage is sensed by a sensing circuit which drives the servo motor. Any variations in mains cause the motor to move clockwise or anticlockwise thus correcting the voltage.

A servo voltage stabilizer is provided with three transformers function along with control circuits and a servo motor as in Fig 6. T_1 is a continuously variable toroidal auto-transformer (variac) driven by a servo motor M.

Fig 6



SERVO VOLTAGE STABILIZER

The output from the variac, drives a series buck/boost transformer T_2 so that boost takes place when the variable tap arm moves down and bucks the voltage when the arm moves up. The transformer T_3 provides the required reference voltage and sensing voltage for the electronic circuit which drives the motor.

When the output voltage is less than the reference voltage, the electronic circuit senses the difference, drives the motor in one direction which results in increase in the output voltage.

When the output voltage increases above the ratings, the motor is driven in the opposite direction so that the output voltage increases. When the voltage difference in output and the reference are equal, the servo motor is switched off by the circuit.

A servo stabilizer provides constant voltage to an accuracy around ±1% or ±0.5% and a correction range 10 to 30 volt/sec.

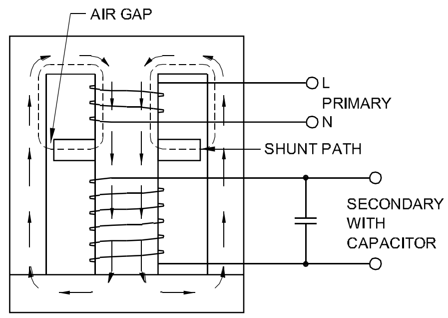
A servo stabilizer is more accurate and also costlier, and, therefore, used with costlier equipments such as computers, xerox machines, medical electrical equipments etc.

Constant voltage transformer

A constant voltage transformer works on ferro-resonant principle. The variation in the primary flux with an unsaturated iron core does not affect the secondary flux with saturated iron core. Thus, the secondary induced voltage remains relatively independent of the voltage impressed upon the primary winding.

In an ordinary transformer, the primary and secondary coils are closely coupled. Any change in primary voltage is directly transferred to the secondary in the ratio of the number of turns. In a CVT, the primary and secondary coils are loosely coupled. These are wound on separate sections of the transformer core as in Fig 7. In between the coils, a separate shunt path is provided for the flux to flow but an air gap is provided in the shunt path. A capacitor is provided in parallel with the secondary.

Fig 7



WINDINGS ARRANGEMENT IN CVT

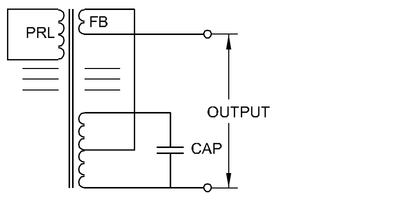
Now imagine what will happen when voltage is applied to the primary. Starting from zero, if the voltage increases slowly, initially, all the flux generated by the primary voltage will pass through the lower half of the transformer core because the air gap in the shunt path will prevent it from taking this path. This is shown by bold arrows in Fig 6. As a result, the rise in secondary voltage is proportional to the primary. But as voltage in the secondary coil rises, at a certain point the impedance of the coil will become equal to the impedance of the capacitor, i.e.

$$X_L = X_C \text{ or } 2\pi fL = \frac{1}{2\pi fC}$$

This is the condition of resonance, and at this point a high current will flow in the LC circuit. This high current will result in a sudden rise of voltage across the secondary (Fig 6), and the core in this section of the transformer will saturate.

Once the core gets saturated, it prevents the entry of further flux coming from the primary side. Therefore, any increase in flux due to increase in primary voltage has to take an alternate shunt path as in Fig 7. Hence, very little increase in the secondary voltage takes place. This little increase can also be nullified by a feedback-FB winding connected as in Fig 8. The output winding can be separated from the capacitor circuit if the voltage required is low or tappings can be taken out of the capacitor.

Fig 8

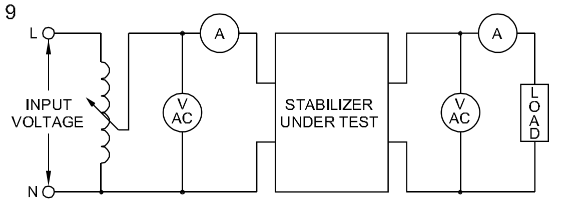


CVT WITH FEED BACK WINDING

CVT may not be suitable for an instrument in which SCR power supply is used or an inductor or a capacitor is coming in the AC circuit or a motor drawing a heavy in -rush current is used inside the instrument. But it is suitable for electronic machines such as TVs, computers, FAX machines etc.

Testing a stabilizer : To test a stabilizer for its operating range, a variac and rated load along with voltmeters/ ammeters are necessary. A simplified circuit for testing the stabilizer is given in Fig 9.

Fig 9



TYPICAL CIRCUIT FOR TESTING THE STABILIZER

By connecting the stabilizer as shown in the figure above and varying the input voltage to the range specified in the name-plate detail such as 170 to 260V or 130 to 270V etc. The output voltage should be satisfied with the specified voltage such as 200 to 240V. There should not be any undue heating or failures with the rated load for a continuous working.

Basics of UPS systems

Most people take the mains AC supply for granted and use it almost casually without giving the slightest thought to its inherent defects and the danger posed to sophisticated and sensitive electronic instruments. For ordinary household appliances such as incandescent lamps, tubes, fans, TV and fridge, the mains AC supply does not make much of a difference, but when used for computers, medical equipments and telecommunication systems, a clean, stable, interruption-free power supply is of utmost importance.

As more and more personal computers, word processors and data terminals find their way into small business, UPS systems that meet the power requirements and price range needs for small business and offices are being manufactured.

The ever increasing importance of computers in industry and commerce will increase the need for quality, high stability and interruption-free power supplies.

Earlier Data Operating System (DOS) does not have any shut- down procedure. So in case power failure it does not affect the operating system. Latest operating system Windows 9x and application softwares require proper shuting down and exit procedures. This procedures requires time which is provided by UPS in case of mains power failure.

UPS (Uninterrupted Power Supply) is the only solution available to an individual customer faced with the problem of ensuring high quality of power for critical loads. All UPS designs contain a battery charger to keep the battery fully charged by the power from mains. Small UPS normally comes with a sealed maintenance free (SMF) batteries which can provide 10 to 15 minutes of power backup, the backup time increases with the capacity of the battery. Tubular batteries or automotive batteries are used in medium and large capacity UPSs.

UPS classification

There are two broad categories of UPS topologies - OFF line, and ON line . These topologies differ in the way they serve the load when the mains is present and is healthy. They vary in features & pricing.

OFF-Line and ON-Line

OFF-Line UPS filters the mains and feeds it directly to the load for most of the time. When the mains is unhealthy, perhaps due to a slight drop in voltage, the load is switched by a fast relay, in typically less than half a cycle, to an inverter deriving its power from a battery. The inverter generates a square or stepped waveform to emulate the mains-satisfactorily for most computers. This particular technique represents the lowest cost solution.

Online UPS converts AC mains into DC before inverting again to AC to power the load with a synthetic sine wave. A battery connected across the DC link acts as the backup power source.

This gives a supply for the computer that totally isolates the input mains from the load, removing all mains noise and with no break when the mains fails.

Standby/OFF Line block diagram (Fig 10)

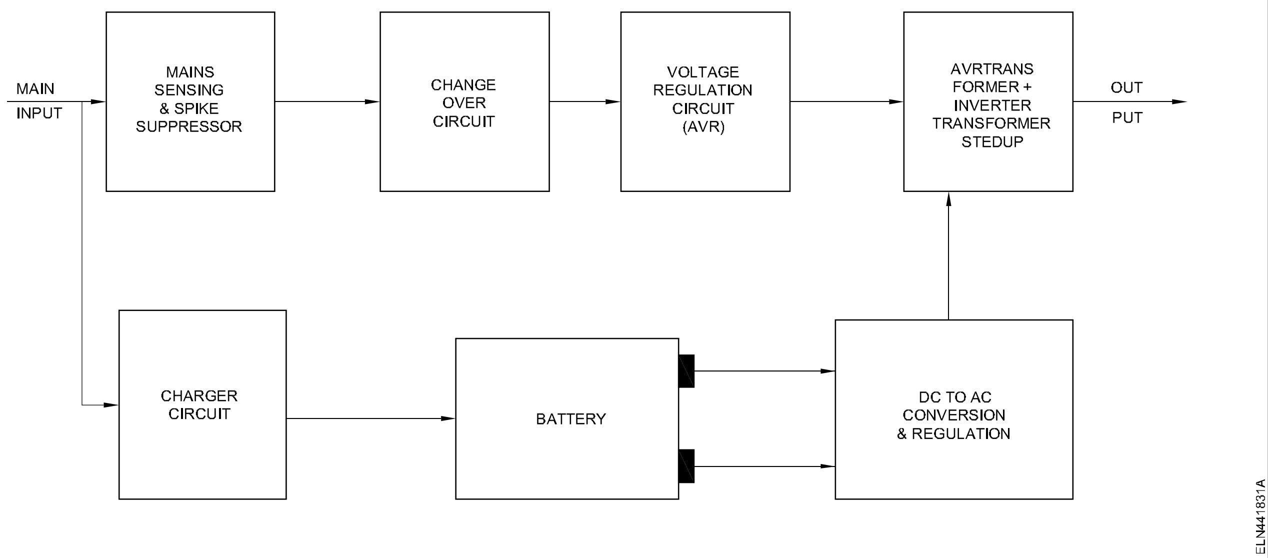
In the off line UPS, the load is connected directly to the mains when the mains supply is available. When working over voltage/under voltage conditions are detected on the mains, the off line UPS transfers the load to the inverter. When the line is present, the battery charger charges the battery and the inverter may either be shut down or will be idling. Thus in an off line UPS, there is a load transfer involved every time, the mains is interrupted and restored. This transfer is effected by change- over relays or static transfer switches. In any case there will be a brief period during which the load is not provided with voltage.If the load is a computer and the transfer time is more than 5ms, then there is a chance that the computer will reboot.

Some modified designs incorporate a limited range of voltage regulation by transformer tapping and a certain degree of transient protection by using RF filters and MOV's (Metal Oxide Varistor). Off line UPS is an economical and simple design and hence it is preferred for small rating, low cost units aimed at individual PC user's market. When the load is really a critical one an off line UPS is not acceptable. Usually square wave output off line UPS are available in market with lower loading capacities.

Advantages of OFF line UPS: High efficiency, small size, low cost.

Disadvantages: There can be change over complaint in offline UPS. Off line very much depends on battery. If battery fails entire system fails. Sometimes during change-over computer re-boots which causes loss of files. Another disadvantage is that output voltage will be a varying one. Usually in the range of 200V-240V and hence not suitable to all electronic gadgets.

Fig 10



Front panel indications and rear panel sockets/ switches used in UPS

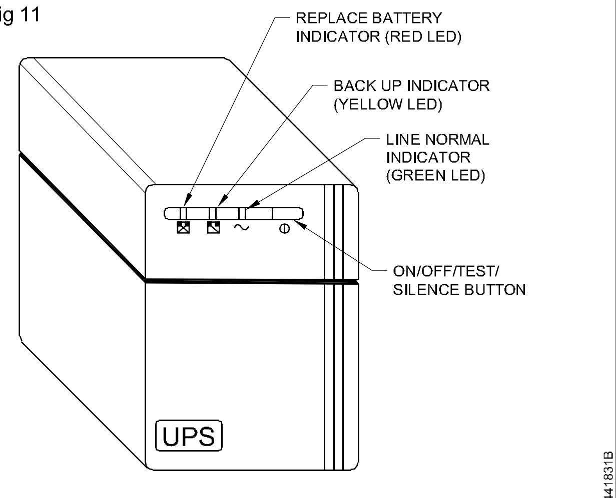
All UPS systems have

- Fuse/Fuse holder
- Switches
- Sockets
- Panel indicator (LED and Neon lamp)
- Meters (Volt/Ampere)

Fig 11 and 12 shows the front and rear panel controls/ sockets.

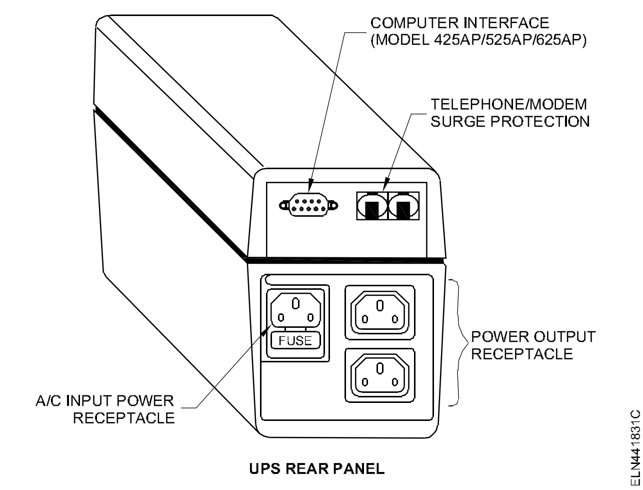
Switches: On/Off switch and reset switch are commonly used in UPS. Reset switch is used to cut off an overload circuit and restart the supply. This is a push to off switch. In normal position this switch keeps the circuit on and when pushed, it cuts off the circuit.

Fig 11



UPS FRONT PANEL

Fig 12



Socket: A common 5 Amp. or 15 Amps. three pin power output socket is used in UPS to provide UPS output to the various devices. One can connect an ordinary 5/15Amp. plug to the UPS output.

Different LED indications/buzzers that are used in UPS

Mains ON indication: It indicates mains input is present and UPS is working on mains.

Mains Low indication: It indicates that mains input is low and is below a rated value.

Mains high indication: It indicates mains input is high.

Inverter ON indication: It indicates that UPS is working in the battery mode and mains is absent.

To get the output from UPS switch ON the 'Inverter ON' switch.

UPS Trip indication: It indicates that UPS output is Off or tripped.

Overload indication: Which indicates that the load current is above a pre-determined value.

Overload buzzer: It beeps whenever overload occurs.

Low battery warning: It indicates battery voltage is below a pre-determined value along with a buzzer .

Battery charging indication: It indicates that battery is charging properly.

Output voltage low indication: It indicates that output voltage is below a pre-determined value.

General specifications & UPS protections

UPS are available from 500VA to 20KVA or above.VA is voltampere.

Power factor specification will be different for different manufactures. Suppose for 1 KVA UPS with a power factor 0.6 the load will be 1000 x0.6 = 600 watts.

Normally a single PC takes around 180 watts. There are sine wave, square wave and quasi square wave output UPS. Usually sine wave out UPS is better than square wave output UPS.

General specifications

Output capacity = Output capacity will be in volt amperes (VA)

Input voltage = 230V AC ±20%, 50 Hz single phase sine wave

Output voltage = 230V AC ±10%, 50 Hz square wave or sine wave

= 230V AC ±2%, 50 Hz (for ON-Line)

Battery = 7 AH, 12V Sealed Maintenance Free (SMF) for OFF-Line (depends on the capacity of the UPS)

= Tubular batteries from 40 AH to 160 AH (12V to 120V) for ON-Line (depends on the capacity of the UPS).

Availability of Automatic Voltage Regulation (AVR) feature.

Typical recharge time to charge 90% of the full capacity of the battery is 5 hours.

Different types of protection in UPS

Input fuse on mains: It protects the system from high voltage inputs, line disturbances and short circuiting etc.

MOV (Metal Oxide varistor) protection: MOV conducts when high input voltage appears thereby blowing the fuse

Polyester capacitor for lightening protection: This is connected across the transformer winding. It burns when lightening occurs and protects the transformer.

Fuses to protect the MOSFETS: MOSFETS are highly sensitive to rapid changing currents. These fuses are used to protect the MOSFET.

Charger fuse to protect the charger circuit: If any fault in charger circuit occurs, fuse blows to protect SCRs.

Output high voltage protection MOV: This MOV is connected across output sockets phase and neutral. If feedback circuit fails the output voltage will jump to more than 300 volts. In such situation the MOV conducts to protect the load.

Overload protection: It protects the UPS especially MOSFET/IGBT when output current exceeds a preset value (overloading the UPS). When this occurs, UPS output becomes OFF along with an indication.

Battery over charge/discharge protection: It protects the battery from charging to a high value (SMF batteries will charge upto 15.8V) and tubular batteries upto 14.1V. It also protects the battery from getting discharged below a level (low battery protection). If the battery voltage is discharged below 10.5V, then the UPS gets automatically switched OFF.

General tips for testing a UPS

- Connect the battery to the terminals using a fuse wire. If any fault occurs in testing the fuse will blow to protect the UPS.
- Do the testings on no load condition.
- Check the gate voltages of the two MOSFET banks it should be the same. If PWM gate pulses are not present gate voltage will be around 5.6V. If the PWM gate pulses are present then the gate voltage will be around 2-2.5 volts.
- Some frequency meters are designed to measure pure AC frequency only. If the UPS output is square wave, then the reading will not be correct. To mea- sure the correct frequency connect a 60/100W load at the output of the UPS. Then the frequency meter shows a near correct frequency.
- For overload setting in ON-Line UPS, the load current is calculated by dividing the maximum load with the output voltage. This can also be measured using a clamp meter on the output terminal. Overload is set at this value of load current.
- While using extension boxes either in the input or on the output of an UPS, ensure proper earth connection. Improper earthing may lead to poor line filtering and shock hazards.
- If number of MOSFETs are connected in parallel,care should be taken to see that all the MOSFETs are of the same Rds. For MOSFET Rds value (drain to source resistance) and current rating are important.

Changeover in OFF-Line UPS system

In this type of UPS, the relay controls the battery voltage which is applied for relay coils. If the battery voltage is too low then relay coil will not get sufficient supply to trigger the switch.This may lead to the absence of mains voltage, even if mains is present and is healthy. This type of OFF-Line systems are battery dependent.

Some OFF-Line systems are battery independent. The coil supply is provided by the mains itself. Mains supply is reduced and rectified. This rectified supply is given to the changeover relay coil . Battery low voltage does not affect the relay coil supply. This type of OFF-Line UPS provides mains output irrespective of the battery condition.

Isolation of inverter

Another important point is that the isolation of the inver ter section during the presence of mains , this is done by the change over relay. For inverter side isolation a switching transistor is used . This switching transistor controls the shut down pin voltage of oscillator IC. This transistor makes this pin high when mains is present.

Once shut down pin becomes high, oscillator IC stops generating pulses to MOSFETs. MOSFEET becomes OFF and inverter section becomes inactive. When mains failure occurs this pin voltage is changed by the transistor to generate gate pulses.

The inverter section of OFF-Line and ON-Line UPS are almost same expect in the mains section.

OFF-Line UPS employs a mains delay capacitor. This is a prevention to fast varying mains input voltage. If mains condition is changing rapidly (Mains ON/OFF) then the UPS has to switch alternately to battery mode and mains mode. Since MOSFET cannot respond to these fast varying currents it will burn.To avoid this, a delay capacitor in mains mode (.1Mf) to delay the mains input. As soon as mains is sensed by the opto coupler, mains on indication glows. Changeover relay will respond after a few seconds to mains because of this capacitor. Removing this capacitor decreases changeover time. But this may cause damage of MOSFET.

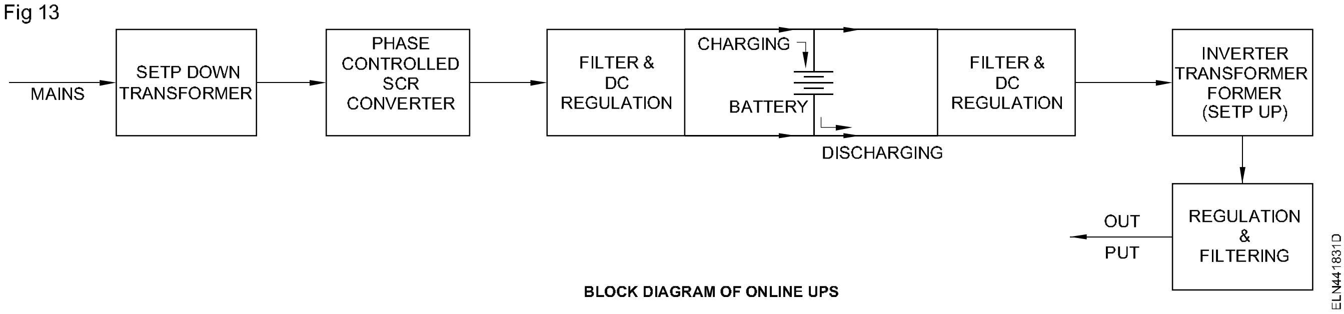
ON line UPS

In an ON line UPS, the inverter always supplies the load irrespective of whether mains power is available or not. The load is always left connected to inverter and hence there is no transfer process involved. When the mains power is present, it is rectified and applied in parallel with the battery. Hence all the supply system transients are isolated at the battery and the inverter always delivers pure sine wave of constant amplitude to the load.

Fig 13 represents a basic block diagram of an ON Line UPS.

In the block diagram (Fig 13), the mains input is stepped down to a lower level and applied to a thyristor based phase controlled AC to DC converter, employing firing angle(α) control. The PWM inverter which usually employs pulse width modulation using triangular/square wave carrier runs in battery mode. The output is filtered and given to the load. The PWM inverter is switched in the frequency range (50Hz) depending on the power rating and hence the DC side current drawn by the inverter will contain switching frequency components.

Fig 13



BLOCK DIAGRAM OF ONLINE UPS

Along with the charging current the second harmonic component of DC side current of the inverter also flows into the battery. This second harmonic is quite large in value and this represents unnecessary strain on the battery. This is one of the major disadvantages of this design since it affects the battery life adversely.

When the mains is present the load power flows though the converter, reaches the battery node and from there flows into the inverter i.e there is double conversion of power. The converter, Inverter and the two level shifting transformers incur power losses in this process. Hence the efficiency of this design is lower than the OFF line design.

In a properly designed control system the battery voltage is measured and compared with a set float voltage. The error is processed in a proportional controller and the processed error decides the charging current that should flow into the battery. Charging current will be a constant one for ON line UPS.

Often it is found that the battery is in discharge mode even when mains is present i.e the battery shares the load current with the mains. This happens when the mains voltage is low and/or the output is loaded to above 75%. The efficiency of ON line UPS can be increased by using boost type power factor correction circuit.

Advantages

- Constant output voltage (No AVR card) free from changeover problem.
- Constant charging current.

Disadvantages

- complex in design, lower efficiency, higher cost, bigger in size and strain on the battery.

Presets of an ON-Line UPS

The presets of ON Line UPS are different from the OFF Line.

ON-Line UPS presets

Output high cut preset: Suppose there occurs a failure in PWM or feedback section. The output voltage will jump above 300V AC. This much output voltage causes harm to the output load. To prevent this output high cut preset is used. When the output voltage reaches set limit, this preset cuts the output. To set this limit, increase the output voltage using the PWM output voltage control preset till it reaches 265V and set the output high cut preset to shut off the output.

Emergengy light

Objectives: At the end of this lesson you shall be able to
- **explain the block diagram of emergengy light**
- **explain the emergency light circuit diagram and charging of battery.**

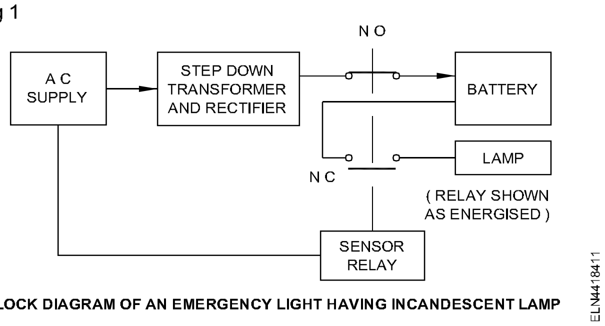
Emergency light

Emergency lighting system is commonly used in public building, work places, residences etc., The main function of the emergency lamp in the industry are

- to indicate ESCAPE routes
- to provide illumination to path ways and exit
- indicate the location of the fire fighting equipments.

The block diagram of an emergency light is in Fig 1. The circuit is discussed here are basic circuits without over charging protection for battery or trickle charging facility. Modern emergency lights have these facilities.

Fig 1



BLOCK DIAGRAM OF AN EMERGENCY LIGHT HAVING INCANDESCENT LAMP

As shown in the block diagram AC main supply is fed to the step down transformer, then it is rectified to charge the battery through a sensor relay. A lamp is connected in the battery circuit through the relay. When AC supply fails the relay enables the battery to the connected lamp circuit through the normally closed contact and the lamp will glow.

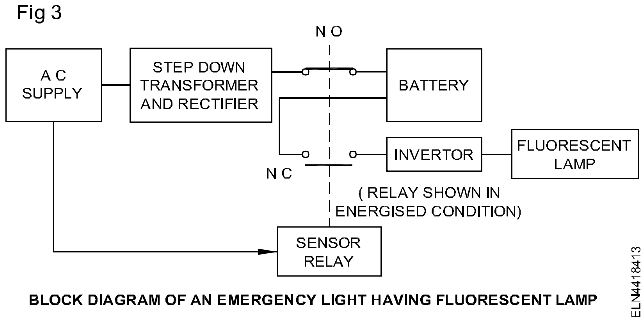
When the AC supply is restored, the battery will be getting charged through the normally open contact of the relay. The charging current is regulated by the series resistances of 2.2 ohm, 5 watt. as in Fig 2. The two LEDs, one is red and the other is green are provided in the circuit to indicate the presence of AC and the lighting of the lamp through the battery supply respectively.

One 1000 microfarad capacitor is used in the rectifier circuit to smoothen the output D.C. supply and one 10 microfarad capacitor is used across the relay to increase the efficiency of relay operation.

Emergency tube light circuit: The emergency light which is connected to an ordinary incandescent lamp will give less light. If the fluorescent tube is used in emergency light it will give about 3 times more light consuming same wattage. Hence most of the emergency lights are incorporated with fluorescent tube lights.

The inverter circuit is incorporated with the ordinary incandescent lamp could be replaced by a tube light as shown in the block diagram, (Fig 3). The tube light requires a high voltage for its operation. The inverter is used to convert DC supply to AC and then it is stepped up to light the fluorescent tube. The inverter circuit is made operative by the sensor (relay). When AC supply is not available, during power failure battery voltage operates the inverter, in which DC is converted to AC and then stepped up to high voltage to enable the fluorescent tube to light up.

Fig 3



BLOCK DIAGRAM OF AN EMERGENCY LIGHT HAVING FLUORESCENT LAMP

Fig 2

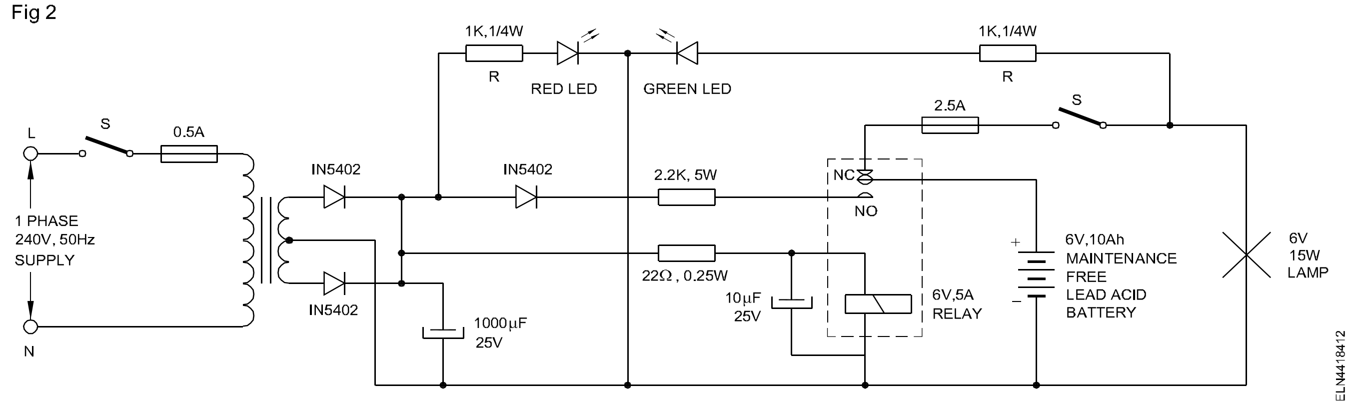
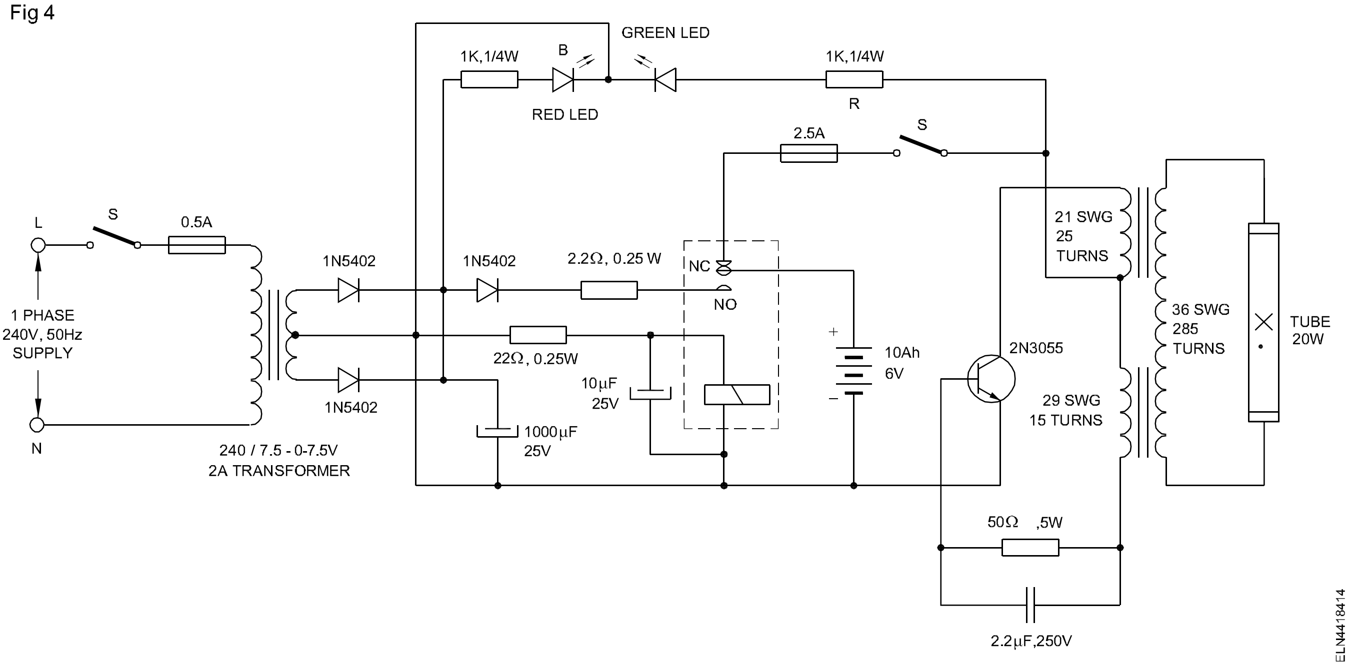


Fig 4



Inverters are basically transistorised oscillators as in Fig 4. They can be made to oscillate at the frequency of about 6.6 kHz. The frequency of the circuit can be changed by changing the value of resistor and capacitor in the circuit which is connected in the base of the transistor.

When the AC supply is resumed the sensor relay connects the battery terminals to the rectified DC circuit for charging and the inverter circuit is disconnected from the circuit by the relay.

For keeping the temperature of the power transistor within its temperature range suitable heat sink should be mounted over the power transistor.

Battery charger and inverter

Objectives: At the end of this lesson you shall be able to
- **explain the working of battery charger with the help of block diagram**
- **describe various batteries and its maintenance, rating, methods of charging**
- **explain the battery charging circuit and its auto-cut-off**
- **state the principle of inverter with the help of block diagram**
- **explain power inverter and input output voltage, frequency, power relations.**

Battery charger

Proper selection and maintenance of the battery is very essential for the proper working of battery wherever is used: such as inverter,UPS etc

Many types of battery used for different purpose.Each have more advantages and disadvantages.

Commonly the following four types of batteries are used with the inverter systems, UPS etc.

- Automobile batteries
- Tubular/Industrial lead acid batteries
- Sealed maintenance free (smf)batteries
- Nickel cadmium batteries

Automobile batteries

This type of batteries are commonly used in automobile, cars, trucks etc. It is cheapest of the other batteries used. It has many draw backs one major draw back with these batteries are during stand by use.(i.e) In long duration under float charger they develops positive grid corrosion, which will reduce the back up time provided by it.

A good quality of automobile lead acid battery has a life an of only about 250-300 full charge /discharge cycle.

Tubular/Industrial lead acid battery

This type of batteries are designed for the heavy duty charge required .

The operating life is more than 1000 charge/discharge cycles. These type of battery requires regular maintenance. Because of the acid in these batteries irritating smell gases and It can not be kept in computer rooms and other AC rooms.

Sealed maintenance free (SMF)batteries

These batteries are completely sealed, so they do not require any kind of regular maintenance. In side of battery, do not contain any wet acid, (ie) lead paste batteries. It is small in size, and it can be kept in the ac room along with inverter.

It is more expensive when compared to the other batteries. It is more sensitive than other batteries. If the operating temperature is more than 40 degree centigrade half the capacity and life of batteries are reduced to half.

Nickel cadmium batteries

These are very expensive batteries and used in defence, space, nuclear science etc applications.It has extra any life operation .

Rating of battery

Commonly the batteries are available in 6V,12V,24V,48V, and 120V and so on. Normally 6 ,12 and 24 V rating are mostly available. The capacity of the battery is rated the Ampere/Hour(AH)

The back up time depends on the AH capacity of the battery. higher the AH capacity more the back up time.

Charging of battery

The life of battery is very much depends on the charging method used to charge the battery.

Three types of charging used to change the batteries.

- Constant voltage
- Constant current
- Constant voltages- constant current

Constant voltage

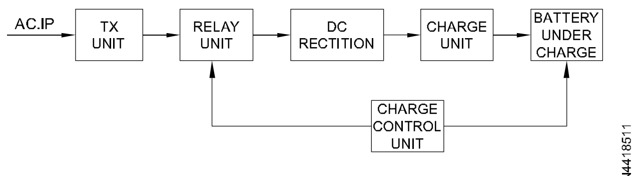
This type of charging method using series regulators is suitable for the SMF batteries but not useful in automobile and tubular lead acid batteries.

Constant current

This charging method using shunt regulators, is useful for automobile and tubular /Industrial lead acid batteries, but it can damage the SMF batteries by overcharging them.

A simplified block diagram of battery charger is explained to understand the function of battery charger. (Fig 1)

Fig 1



BLOCK DIAGRAM OF BATTERY CHARGER

Transformer

The mains transformer primary is connected through auto transformer and the supply to auto transformer controlled through relays. The automatic charge control supply is always present at the primary of charge control unit transformer.

Relay unit

The relay unit supplies the DC rectifier input supply to the required DC input to the battery for charging. This relay unit also cut-off the rectifier input AC in case of the battery is fully charged.

DC rectifier

This rectifier unit always is a full wave bridge rectifier to handle heavy charging current. High current metal rectifiers are found mostly used in this circuit, but high current capacity semi conductor diode are in use.

Charging unit

This indicates the charging current taken by the battery and it is controlled by ON-OFF switches. A test switch is provided to test the charging condition of the battery.

Battery section

The battery under charger is always to kept in a well ventilated room and also open the vent plug for easy evaporation of exhausted gases from cells.

Charge control unit

Once the battery fully charged; then the DC supply to battery to be cut-off automatically. The voltage sensing circuit enables the control unit to trip the AC input to the rectifier unit thereby stop the charging voltage.

Constant voltage

This type of charging method using series regulators is suitable for the SMF batteries but not useful in automobile and tubular lead acid batteries.

Constant current

This charging method using shunt regulators, is useful for automobile and tubular /Industrial lead acid batteries, but it can damage the SMF batteries by overcharging them.

Constant voltage and constant current

This charging method contains more advantages .This method is suitable for automobile and tubular /Industrial lead acid batteries and also for SMF batteries.

This method provide regulated charging to improve the battery life.

Charging operation of battery

When the mains A.C is available, the mains supply is connected to 0-240V taping of auto transformer through a relay.

The transformer works on step down which has 0-240 V, taping at the primary and 12-0-12 V at the secondary.

The voltage at the secondary is used to charge the batteries connected.

Trickle charging

In an inverter, when the mains A.C is available the battery get charged. After the battery is fully charged the charger is cut-off. After the battery get fully charged if the charger is not cut off then the battery will get damaged.

Trickle charging is a special charging method used to keep the battery constantly in full charge position by keeping the battery charged constantly.

This method of charging is slightly different from the normal charging method.

For trickle charging 100th part of the normal charging current is provided to the battery.

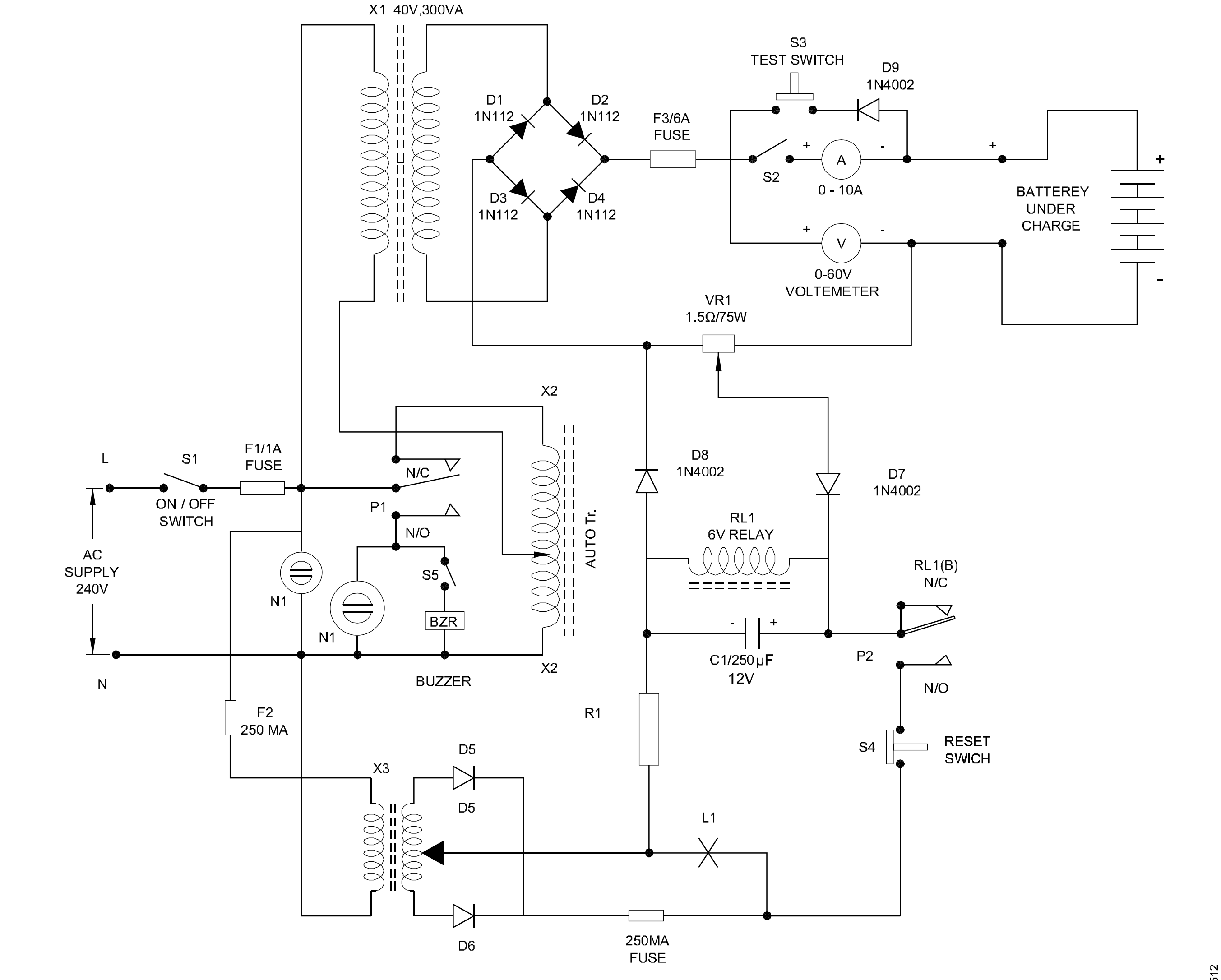
A Simple battery charger

The charger can charge 6V,12Vand 24V battery at Suitable current rate. This circuit has many protection built in it to protect the battery from overcharge and reverse polarity etc.

The charger consist of an auto transformer $X_{2,}$ (Fig 2) for supplying constant current and voltage.

A charger transformer 'X_1' is connected to the auto transformer and the secondary of the X_1 (Fig 2)is rectified through full wave bridge rectifier and supplied to the battery under charger through. Ammeter voltmeter and a potentiometer (Fig 2)

Fig 2



AUTOMATIC BATTERY CHARGER

A step down transformer X_3 is used to keep cut off relay is energised condition when the mains AC supply is cut off to the charger circuit. Relay RL_1 used to cut off the AC mains supply to the charger circuit. Pole $P_1$of relay RL_1 is connected to AC mains supply and pole P_2 is connected to cut off circuit.

Relay is energised by the centre tapping of potentiometer, which is set such that, the current in the charger circuit exceeds then it is energised and poles P_1& P_2 are connected to normally opened (NO)pin, switching 'Off' A/C mains supply to the circuit.

The test switch S_3 is connected to check battery polarity, reset switch S_4 is used to reset the charger, when any fault occurs. Then the charger is cut off and the Switch 'S_1' is mains ON/OFF switch.

A fully charged lead acid battery must be 2.1 volt/cell during on charge.It will increase upto 2.7V/cell.The voltage of a battery is multiple of the number of cells.

In discharged condition the voltage is 1.8V/cell,it should not be further discharged in this condition as it may permanently damage the cell.

E.g A 100AH (ampere hour)battery requires (100 AH/ 10Hr=10 Amp) 10 Amp. Charging current for 10 hours for fully charged. To get complete discharge at the rate of 5Amps will require 20 Hrs.

The fully discharged battery requires about 11/2 times more to get charged .If the battery is in dead (or)not in use for long time even in normal changing current is passed. These dead batteries require higher charge voltage to start the charging current.

Checking of battery

Acid level and specific gravity of electrolyte, will indicate the condition of battery whether it requires charging or not.

The hydro meter is used for checking the acid level in a battery .The scale in marked in the hydrometer from 1100 to 1300.when it is inserted in the battery, the reading

i) 1100-1150 -indicates battery is down

ii) 1200-1250- indicates battery is o.k.

iii) 1250-1300 indicates excess acid

Voltage testing

By using high rate discharge tester, the voltage the each cell must be 2.1V, If it indicates below than 1.8V, then it shows the battery is in fully discharged. It is still below 1.8V.Then the battery becomes dead condition.

Never connect the high rate discharge tester for long duration while checking voltage, it will load the battery heavily and the cell, will discharge.

If the electrolytic level down in the container shell of the battery, top up with distilled water. Never add electrolyte prepared separately to the battery.

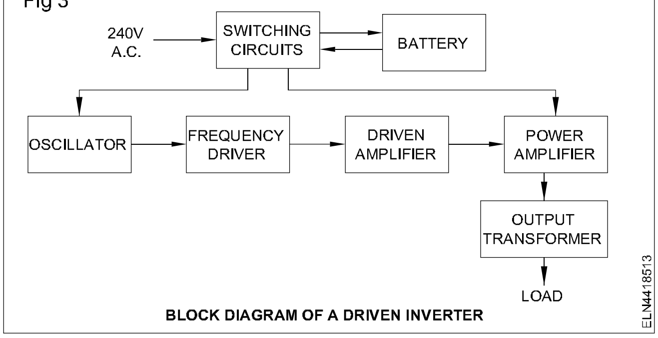
In a lead acid battery the electrolyte level of the battery should be checked and maintained every 15 days in summer season.

Inverter

It is an electronic device, which converts a D.C potential (voltages) normally derived from a lead-acid battery into a stepped-up AC potential (voltage) which is similar to the domestic AC voltage.

Locating the fault and troubleshooting of an inverters which provide sine wave outputs or the use of PWM(Pulse Width Modulation) technology is very difficult. (Fig 3)

Fig 3



BLOCK DIAGRAM OF A DRIVEN INVERTER

Switching circuits

It is the input stage of a inverter. This circuits supplying the power to further stages and connected to battery. The DC supply of battery in this supplies to the switching circuits for various needs.

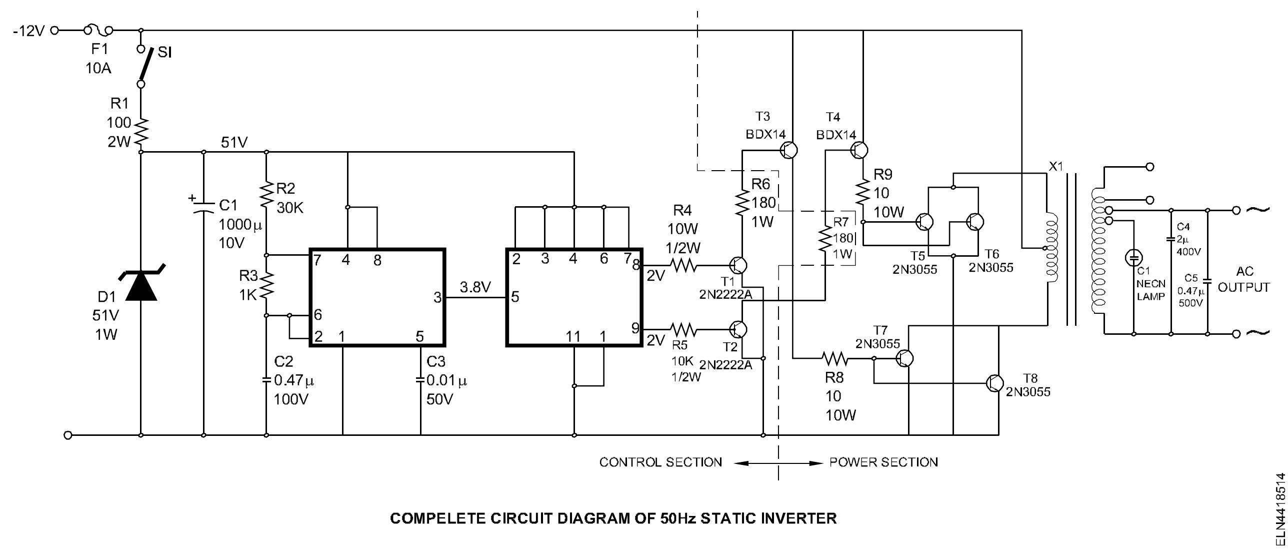
Oscillator

It is an electronic circuit which generates the oscillating pulses either through an IC circuit or a transistorized circuit. This oscillations are the production of alternate pulse of positive and negative (ground) voltage peaks of a battery and at a specified frequency (No.of positive peaks per second). These are generally in the form of square waves and the inverters are called square wave inverters.

The complete circuit diagram of a static 50Hz static inverter is in Fig 4.

The oscillator section of the inverter used a IC circuit to produce control signal frequency to the control and driner section. The received oscillating frequency is amplified to a high current level using power transistor or MOSFET.IC 7473(JK Flip type) used to power amplification and control the frequency to the driver transistors T1 and T2 driving the power transistor to the required level as in the Fig 4.

Fig 4



COMPELETE CIRCUIT DIAGRAM OF 50Hz STATIC INVERTER

The two parallel connected power transistor T5, T6 and T7, T8 are connected to the output transformer which is used to step up the low level AC from the amplifies stage into the specified level.

The transformer secondary is supplied the required level of AC 240V. The generation of the oscillations due to which the process of voltage induction is able to take place across the windings of the transformer.

The inverter does not produce any power and the power produced by DC source. The inverter requires a relatively stable power source capable of supplying of enough current for the intended power demands of the system.

An inverter can produce square wave, modified sine wave, pulsed sine wave, pulse width modulated wave (PWM) or sine wave depending on circuit design.

The inverters more than three stages are more complex and expensive. Most of the electric devices are working with pure sine wave and AC motors directly operated on non-sinusoidal power may produce extra heat, and have different speed-torque characteristics.