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)

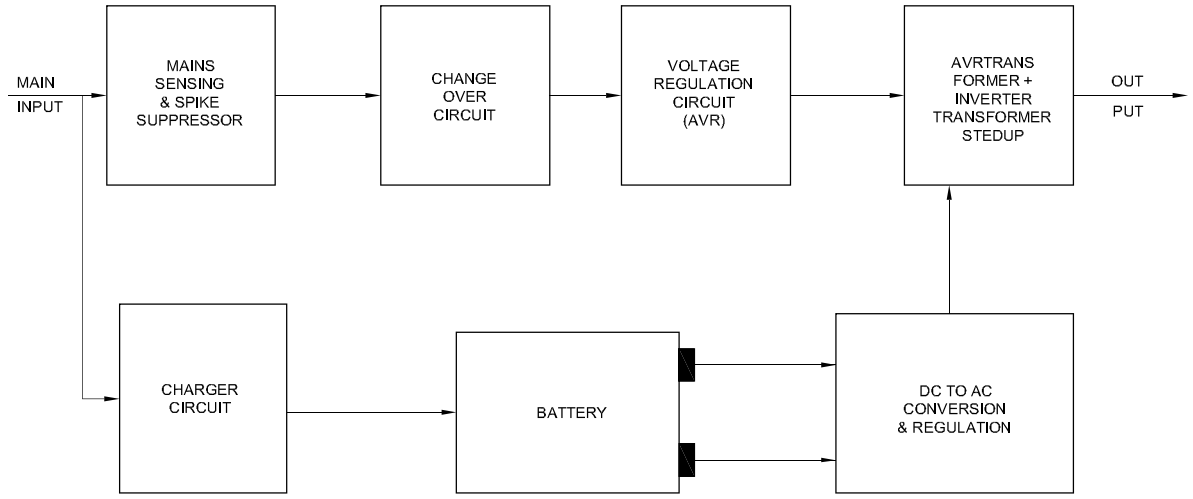
In the off line UPS, the load is connected directly to the mains when the mains supply is available. When working over voltage/under voltage conditions are detected on the mains, the off line UPS transfers the load to the inverter. When the line is present, the battery charger charges the battery and 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

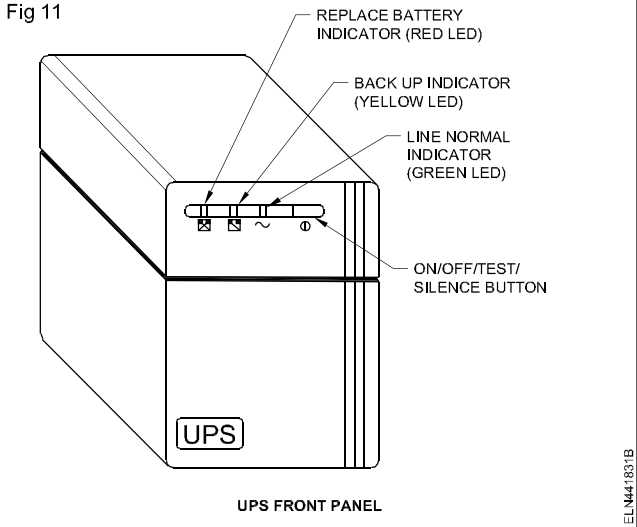
All UPS systems have

- 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.

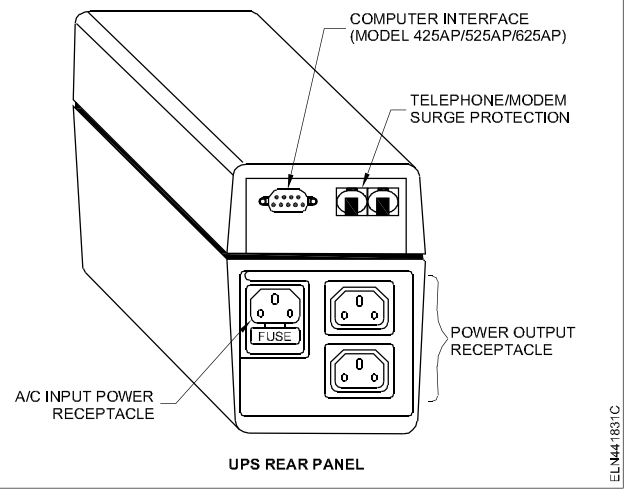
Switches: On/Off switch and reset switch are commonly used in UPS. Reset switch is used to cut off an overload circuit and restart the supply. This is a push to off switch. In normal position this switch keeps the circuit on and when pushed, it cuts off the circuit.

Fig 11



UPS FRONT PANEL

Fig 12



UPS REAR PANEL

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 capaci- tor decreases changeover time. But this may cause damage of MOSFET.

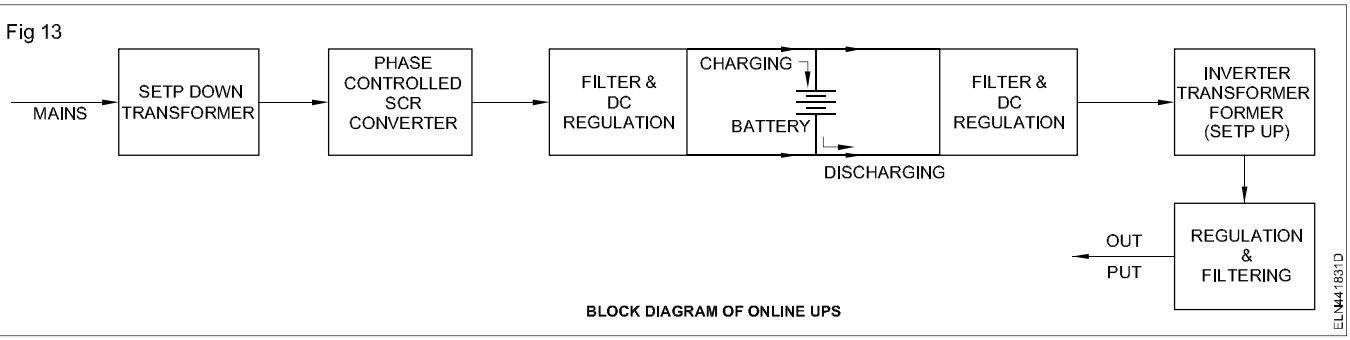
ON line UPS

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.**

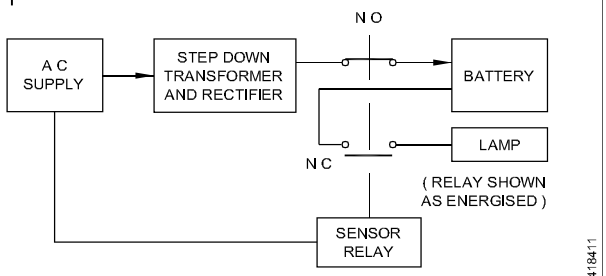
Emergency light

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.

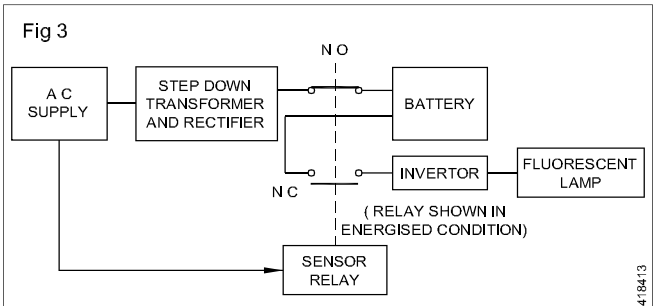
When the AC supply is restored, the battery will be getting charged through the normally open contact of the relay. The charging current is regulated by the series resistances of 2.2 ohm, 5 watt. as in Fig 2. The two LEDs, one is red and the other is green are provided in the circuit to indicate the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

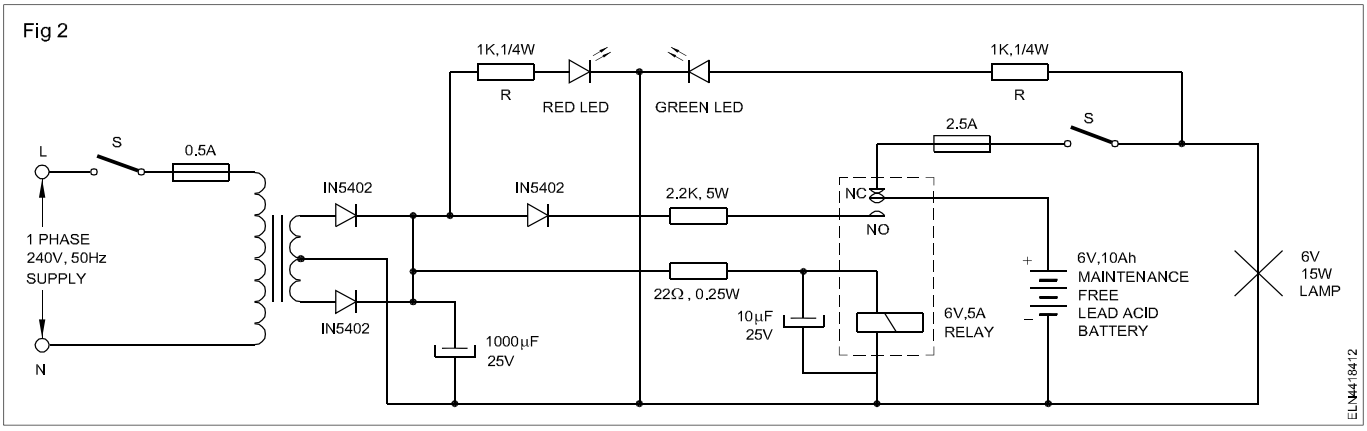
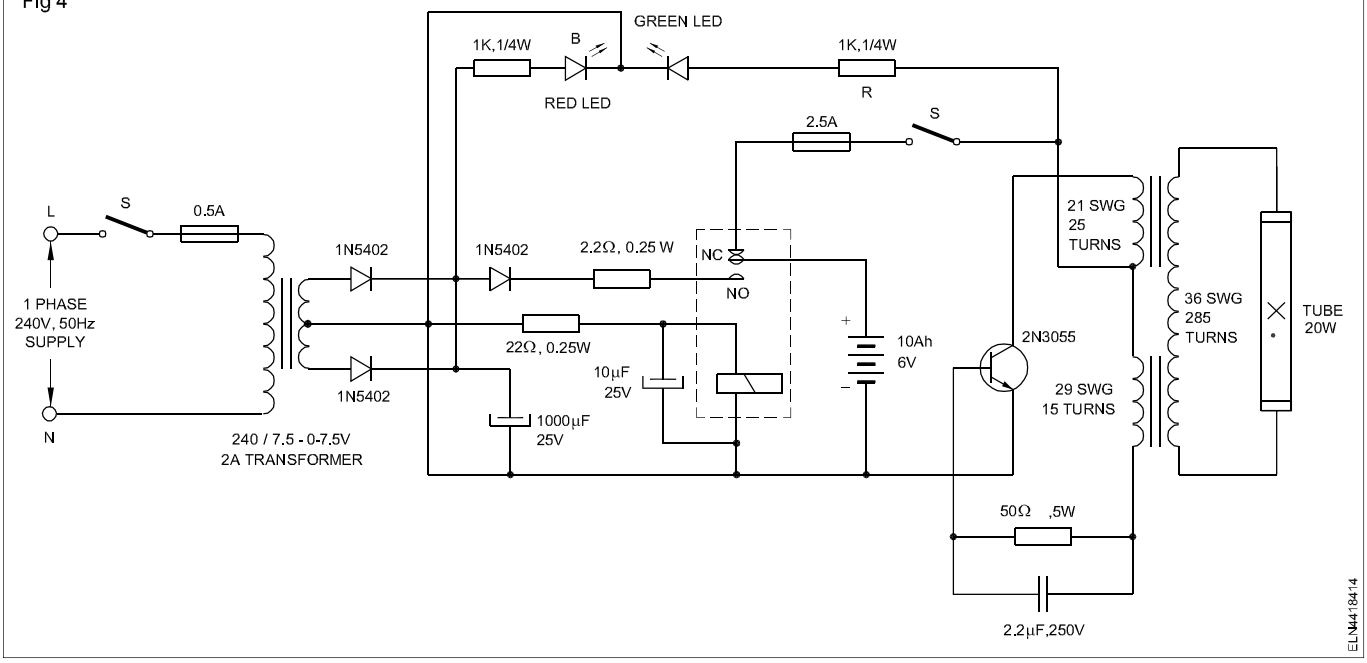


Fig 4



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.