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Design of Uninterruptible Power Supply and It's Applications

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ABSTRACT

Uninterruptible power supply (UPS) can range from a 9 volt battery all the way to an extremely large and costly battery system. The UPS sits between a power supply such as a wall outlet and a device like a computer to prevent undesired features that can occur within the power source such as outages, sags, surges, and bad harmonics from the supply to avoid a negative impact on the device. The standby UPS is a battery backup to fill in the void of power loss, while the ferroresonant stand by couples the battery back up with the power supply by a transformer, where the transformer acts as a buffer from the power supply to the stand by supply. The line interactive UPS uses an inverter converter only, with a power supply the stand by battery is charged up, and with a loss of the primary power supply, the inverter converter switches over to the battery back up with a much quicker switching time that the stand by UPS. The surge protection circuits is that it can withstand the spikes at a defined specific level. After a duration, the circuit may get destroyed. Static Bypass switches are used to bypass the UPS normal operation, in cases of high inrush or fault conditions. Manual bypass switches are an added benefit to allow service and isolation for safety purposes. A signal can be separated very easily at demodulation and noise can be also separated easily .The lead acid batteries are used in UPS systems which are oversized and this batteries are not suitable for high temperatures. So, These are replaced by the Lithium-ion batteries which are used to work in harsh environmental conditions. These lithium-ion batteries gives long life when compared to the lead acid battery based system.

KEYWORDS: UPS 1, Surge protection circuit 2, Static bypass switches 3, Lithium ion batteries4

INTRODUCTION

Every electrical and electronic equipment needs to be energized by means of a power supply. In most cases the power is required to be delivered to the load circuit at steady or fixed voltage. However, stability of such main power supply is a source of concern because insufficiency of power outage have always posed major setbacks to individuals and organizations which depend on sensitive electronic equipment that require constant power supply. Such interruption of mains supply has caused serious inconveniences especially in highly sensitive devices such as computers, medical equipment and industrial research laboratories where interruption of power could spell danger. In order to protect such sensitive electronic systems from inactivity resulting from power failure, it is necessary to provide an alternative power source, which will automatically power the system in the event of mains failure.

[1] The Uninterruptible Power Supply (UPS) is an electronics device which supplies power to a load when main supplies or input power source fails. It not only acts as an emergency power source for the appliances, it serves to resolve common power problems too. Any UPS has a power storage element which stores energy in the form of chemical energy like the energy is stored in batteries. It is like energy is stored in the form of motion in a flywheel. That is why these devices are also called battery backup or flywheel backup. The UPS not only provides emergency power, they also help to sort out common power related issues like providing protection from input power interruptions, protection from over voltage, output voltage regulation and stabilization avoids damage to hardware caused by over currents and voltage spikes. Many UPS models also continuously regulate the input power. Avoids data loss and damage. In fact, without a UPS, data stored on devices subject to sudden shutdowns can be corrupted or completely lost. If a power management software is also used, the UPS allows and facilitates the controlled shutdown of the system. ensures the availability of networks and other applications while avoiding downtime. When used in conjunction with power generators, ensure that they have enough time to ignite in the event of a power failure. Arshad,Naveed, and Usman Ali [1] have stated Transformer also maintains output on its secondary briefly when a total outage occurs. The inverter then goes on line so quickly that it is operating without any interruption in power. Aamir, Kalwar, and Mekhilef [2] have stated The line interactive UPS "interacts" with the AC power line to smooth out the waveform and correct the rise and fall of the voltage. Lim, et al. [3] have stated The battery only starts when the power fails, therefore the "Standby" has a very high efficiency, small size and low cost.

[1] K. Asakura, M. Shimomura and T. Shodai [4] have stated Electrochemical batteries are used in UPS applications, since a long time, to ensure a stable power supply of the network-connected devices during power outages. Chaturvedi and N.A., [5] have stated With the decrease of the initial cost, Li-Ion battery is now becoming more and more popular in many applications like energy storage, UPS and hybrid electric vehicles. N. Hiroshi and H. Ippei, [6] have stated Li-ion batteries are capable to provide huge peak power for short period of time, as well as lower period of time. G. Zanei, E. Cevenini, H. Ruff and O. Ulibas, [7] have stated The change of temperature of even 5 degrees from the standard 25 degrees would have a significant impact on the battery lifetime and electrical performance. A.-I. Stan, et al. [8] have stated Besides their use in the area of consumers, Li-ion batteries have begun to enter slowly into the back-up power supply applications because of their appealing characteristics such as fast response, high efficiency and long lifetime.

A. Problem formulation

The problem with UPS systems is that they can be expensive, require regular maintenance, have limited runtime, can have a negative environmental impact, can be bulky and heavy, may not be compatible with all equipment, and can produce noise or heat. These issues can make it challenging for businesses and individuals to choose and use UPS systems effectively. The backup time you need, your battery's capacity (in amp-hours), the battery's voltage, and your total load. The formula is straightforward:

Backup time (hours)= Battery Capacity (Ah) * Input Voltage/Total load

Lithium-ion batteries for UPS are cheaper in the long run because they do not require active maintenance and can last long. The back-up time can be increased by changing the batteries which gives more efficiency and which can operate in harsh conditions. The problems that can be corrected are voltage spike (sustained over voltage), Noise, Quick reduction in input voltage, Harmonic distortion and the instability of frequency in mains.

B. Objective

The objective of UPS is to keep power levels consistent and prevent fluctuations that could harm digital or mechanical equipment and the UPS. Not only when main supply is in ON condition but in OFF conditions also helps in the function of the surge protection and noise filtering. The size and capabilities of a UPS system depends on the protected equipment size, which can range from a single computer to a large data center, building complex or city. It absorb relatively small power surges and smooth out noisy power sources.

SMPS AND INVERTER OPERATION:

In an SMPS 220v AC to 12v DC, the input voltage of 220 volts AC is first rectified to DC using a rectifier circuit.

The DC voltage is then filtered using a capacitor to remove any ripple or noise in the signal.

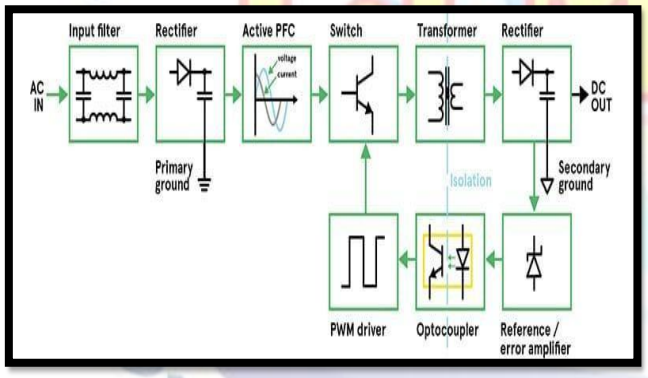
Next, the filtered DC voltage is fed to a high-frequency switching circuit that controls the flow of current through a transformer. The switching circuit rapidly turns on and off a transistor, which controls the current flow through the transformer.

The transformer then steps down the voltage to the required output voltage of 12 volts DC. The output voltage is monitored by a feedback circuit that adjusts the switching circuit to maintain a stable output voltage.

Finally, the output voltage is filtered again using a capacitor to remove any remaining ripple or noise in the signal before being supplied to the load (such as an electronic device). The entire process is highly efficient and compact, making SMPS 220v AC to 12v DC an ideal choice for various applications.

OPERATION OF SMPS:

The SMPS (Switched Mode Power Supply) board is a type of power supply that uses high-frequency switching to convert AC voltage to DC voltage with high efficiency. Circuit diagram of SMPS is shown in figure 3.1



Circuit diagram for SMPS

The SMPS board typically consists of several components, including a rectifier circuit, a filter capacitor, a switching transistor, a transformer, and a feedback circuit. The rectifier circuit converts the AC voltage to DC voltage, which is then filtered by the capacitor. The switching transistor controls the flow of current through the transformer by rapidly turning on and off. The transformer then steps up or steps down the voltage depending on the requirements of the output voltage.

The feedback circuit monitors the output voltage and adjusts the switching transistor to maintain a stable output voltage. The SMPS board can provide different output voltages and currents depending on the design and application requirements. It is commonly used in electronic devices such as computers, TVs, and other consumer electronics due to its high efficiency and compact size.

The SMPS that are also called as rectifiers and we have mainly two types of rectifiers one is uncontrolled rectifier and controlled rectifier.

INVERTER: A power inverter, inverter or inverter is a power electronic device or circuitry that changes direct current (DC) to alternating current (AC).[1] The resulting AC frequency obtained depends on the particular device employed. Inverters do the opposite of rectifiers which were originally large electromechanical devices converting AC to DC.

The input voltage, output voltage and frequency, and overall power handling depend on the design of the specific device or circuitry. The inverter does not produce any power; the power is provided by the DC source.

A power inverter can be entirely electronic or may be a combination of mechanical effects (such as a rotary apparatus) and electronic circuitry. Static inverters do not use moving parts in the conversion process.

OPERATION OF INVERTER

The working of an inverter involves converting DC power from a battery or other DC source into AC power that can be used to power electronic devices. Here is a step-by-step process of how a 12V DC to 220V AC inverter works.

- The inverter is connected to a 12V DC power source, such as a battery or solar panel.
- The inverter uses electronic components such as transistors, capacitors, and diodes to convert the DC power into AC power.
- The inverter uses PWM technology to control the voltage and frequency of the AC output. This ensures that the AC output waveform is stable and of the desired frequency.

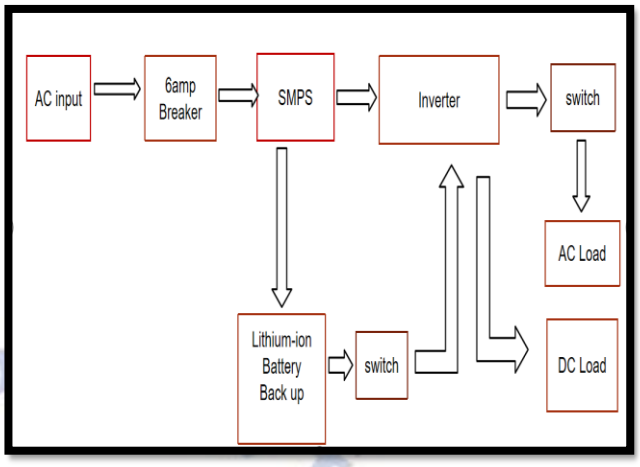
The AC output waveform is filtered to remove any unwanted noise or distortion. This ensures that the AC output is clean and stable.

OUTLINE OF THE PROJECT

The main out line of Uninterruptible power supply is given here, it contains SMPS or rectifier to convert the

220-240V AC supply to the 12V DC supply and the lithium-ion batteries are used for the storage of the power which gives as the backup power to the load then inverter is used to convert the 12V DC to the 220V AC supply to use the load. we use the filters, capacitors, transistors and diodes for conversion of DC power to AC power. The static bypass switch is used to transmit the main power to the load whenever the failure occurs in the inverter of the UPS.

UPS (Uninterruptible Power Supply) is an electrical device that provides emergency power backup to critical equipment or systems in case of power failure or voltage fluctuations. The battery is the core component of the UPS system that stores energy and provides power backup during power outages. The inverter converts the DC power stored in the battery into AC power that can be used by the connected equipment. The charger charges the battery when the power supply is available and keeps it ready for use during a power outage. The power that we are getting from the main source have an fluctuations and the disturbances over the supply to maintain the voltage stability and the quality of power the capacitors and diodes are used in the SMPS or Rectifier .the filtered DC voltage is fed to a high-frequency switching circuit that controls the flow of current through a transformer. The switching circuit rapidly turns on and off a transistor, which controls the current flow through the transformer. to get the stable voltage. The output voltage is monitored by a feedback circuit that adjusts the switching circuit to maintain a stable output voltage. The UPS system also includes other components such as a transfer switch, surge suppressor, and monitoring software. The transfer switch automatically switches the power source from the utility grid to the UPS system during a power outage. The surge suppressor protects the connected equipment from voltage spikes and surges. The monitoring software provides real-time information on the UPS system's performance, battery status, and other critical parameters.



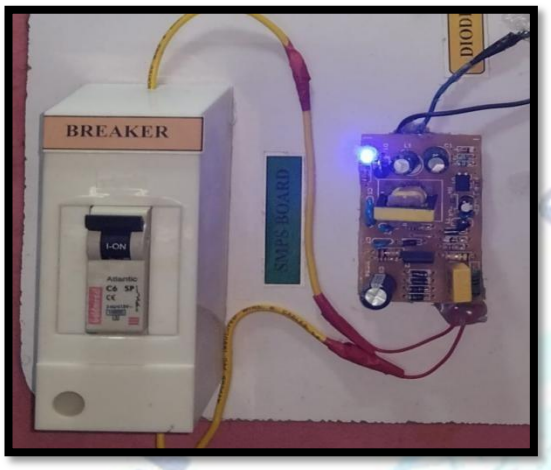
Block diagram of UPS

Implementation:

UPS (Uninterruptible Power Supply) is an electrical device that provides emergency power backup to critical equipment or systems in case of power failure or voltage fluctuations. The UPS has a battery that stores energy and provides backup power when the main power source fails. In general most of the UPS are having the lead acid batteries. so, to improve the efficiency of the UPS as well as the battery life time and the efficiency of the power we are using the lithium-ion batteries. Lithium-ion batteries are currently used in most portable consumer electronics such as cell phones and laptops because of their high energy per unit mass relative to other electrical energy storage systems. They also have a high power-to-weight ratio, high energy efficiency, good high-temperature performance, and low self-discharge. Most components of lithium-ion batteries can be recycled. The battery is the core component of the UPS system that stores energy and provides power backup during power outages. UPS (Uninterruptible Power Supply) systems are designed to provide backup power in the event of a power outage or other electrical disturbance. The construction of a UPS system typically involves several key components, including the rectifier, battery, charger and inverter. The construction for uninterruptible power supply by using lithium-ion batteries is as follows:

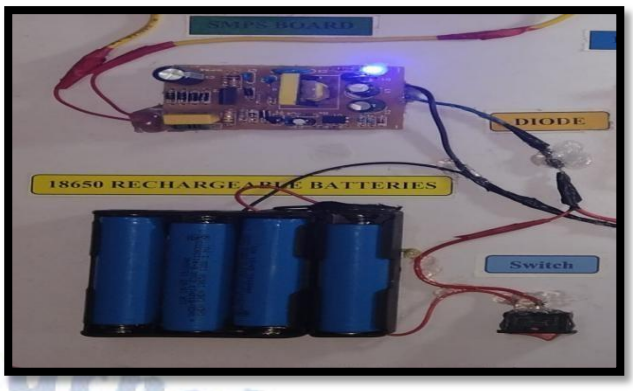
STEP-1 : The ac power supply of 220-240V is given to the SMPS board which acts as the rectifier that converts the 220V AC supply to the 12V DC power. The step-

down transformer is used to convert high voltage level to the low voltage level. For the safety of the SMPS we use breaker that gives the voltage stability and trips whenever the fluctuations occurs over the main supply. shown in figure



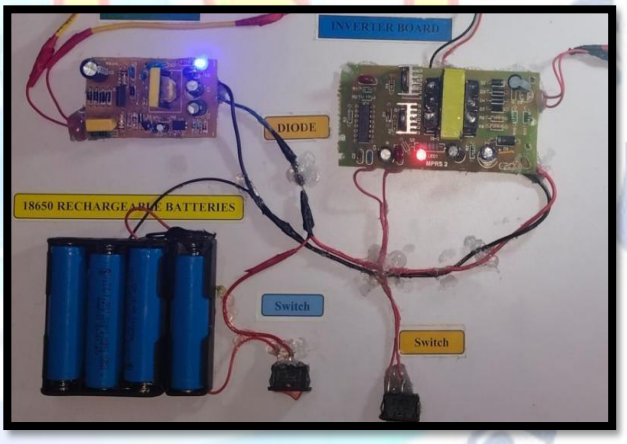
AC power supply to the SMPS

STEP-2 : The input voltage of 220 volts AC is first rectified to DC using a rectifier circuit. The DC voltage is then filtered using a capacitor to remove any ripple or noise in the signal. Next, the filtered DC voltage is fed to a high-frequency switching circuit that controls the flow of current through a transformer. The switching circuit rapidly turns on and off a transistor, which controls the current flow through the transformer. The transformer then steps down the voltage to the required output voltage of 12 volts DC. After the rectification of 220V AC to 12V DC. The power goes to the back-up batteries with the help of the 1N4007 diodes which allows the flow of power in one direction and acts as the OFF mode in the reverse bias to protect the SMPS. Here, we use the 18650 Lithium-ion batteries which is more efficient, give more life time and these batteries can be replaced easily when compared to the lead acid batteries. Figure DC. After the rectification of 220V AC to 12V DC. The power goes to the back-up batteries with the help of the 1N4007 diodes which allows the flow of power in one direction and acts as the OFF mode in the reverse bias to protect the SMPS. Here, we use the 18650 Lithium-ion batteries which is more efficient, give more life time and these batteries can be replaced easily when compared to the lead acid batteries. Figure shows the charging of batteries.



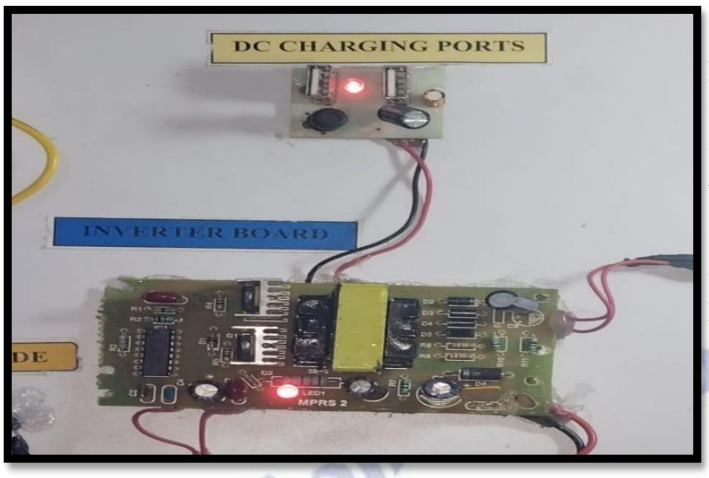
charging of Lithium-ion batteries

STEP-3 : Here we use four 18650 rechargeable batteries. each ,battery has an capacity of 3.7v and 1200mAh power. these four batteries are connected in series with each other .so, these batteries gives approximately 14.8 - 15V DC power as an input to the inverter.Li-ion batteries are becoming increasingly popular for UPS systems due to their high energy density, long cycle life, and low maintenance requirements. Here we use switch that to control the flow of power to the inverter from the batteries which can reduce the current consumption while charging the batteries. shown in figure 4.



DC power supply to the inverter

STEP-4 : The lithium-ion batteries gives an approximate power of 15V DC. So, the power is given to the inverter and inverter takes 12V DC as the input to compensate this we use the capacitors, filters, transistors and diodes. Heat sink is used to cool the circuit components by dissipating the excess heat to prevent overheating, premature failure, and improve the reliability and performance of the components. then the compensated DC power is connected to the DC charging ports which are useful to charge the mobiles, laptops and other electronic devices. Figure 4.6 shows the DC charging ports



connection of DC charging ports

STEP-5 : The power supplied from the main power supply is also given to the inverter through SMPS and there will be the stand by position of the batteries whenever the main power failures then batteries gives power supply to the load through inverter. here, approximately we are getting the 15V DC power from the batteries. So, According to the inverter requirement to compensate the voltage level the transistors, capacitors, and diodes to convert the DC power into AC power. The step up transformer is used to convert the low voltage to the high voltage. The inverter uses PWM technology to control the voltage and frequency of the AC output. This ensures that the AC output waveform is stable and of the desired frequency. The inverter regulates the voltage of the AC output to ensure that it is within safe limits for the connected devices.

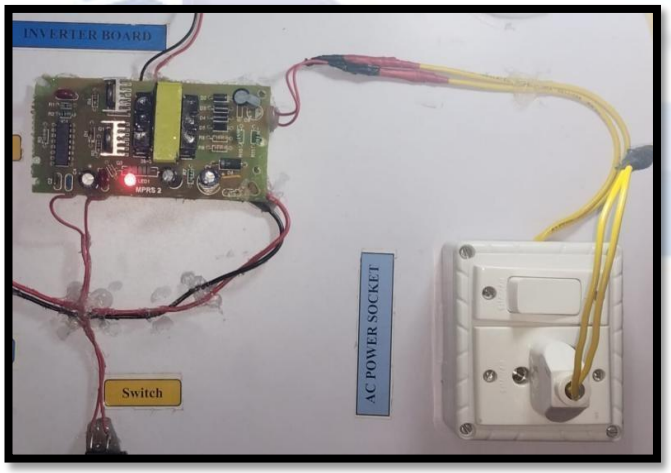


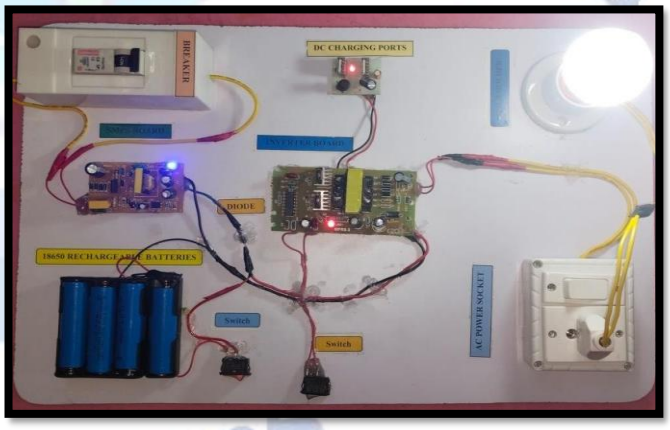
Fig connection of AC power socket

So, finally the inverter gives the output voltage of 220-240V AC to use the power we are using an AC power socket box where the loads are connected. shown in figure 4.7

STEP-6 : A 5 watt LED bulb is used as the ac load for the power socket box which can be operated by the switch and here we can use the both ac load as well as the dc charging ports simultaneously. both the loads are used without any fluctuation and any interruption at the load areas. The continuous flow of power will be generated over the loads for improving the efficiency of the system. Figure 4.8 shows the ac load.

Figure : AC load

STEP-7 : The implementation of a UPS system requires careful planning, design, and installation to ensure uninterrupted power supply to critical equipment or systems. We can use the load of AC and DC according to the ratings of the uninterruptible power supply. When all the components are connected then figure 4.9 below shows the complete implementation of the uninterruptible power supply.



Final implementation

working: The working process of uninterruptible power supply is given below. The connections are made as per construction. When the AC power supply is available, the UPS system charges the battery bank and powers the connected load through the rectifier. The rectifier converts the incoming AC power into DC power, which charges the battery bank and powers the inverter.

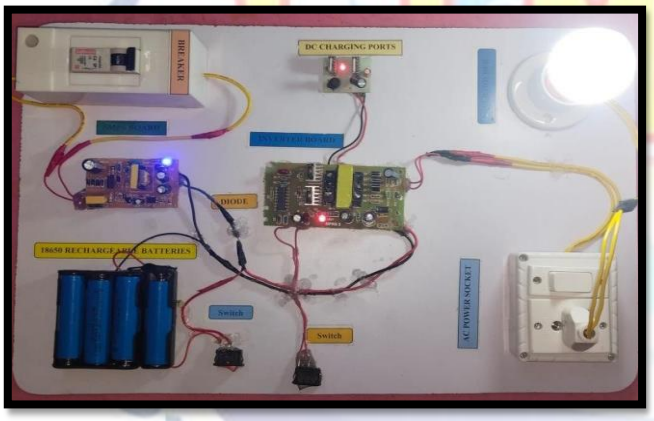
In the event of a power outage or failure, the UPS system switches to battery power through the static switch. The

inverter then converts the DC power from the battery bank into AC power, which powers the connected load. The UPS system typically provides a few minutes of backup power, allowing time for critical systems to be shut down safely or for a generator to start up also include surge protection and voltage regulation to protect connected equipment from power spikes and fluctuations.

OPERATION OF LOAD WHEN MAIN SUPPLY IS ON:

When the main power supply is on, the UPS (Uninterruptible Power Supply) works in standby mode. The UPS continuously monitors the incoming AC power from the main source and charges its internal battery. The UPS also conditions the incoming power by regulating the voltage and filtering out any electrical noise or spikes. This helps to protect sensitive equipment from damage due to power fluctuations.

If there is a power outage or interruption, the UPS switches to battery power almost instantly, providing uninterrupted



When main power supply is in on condition

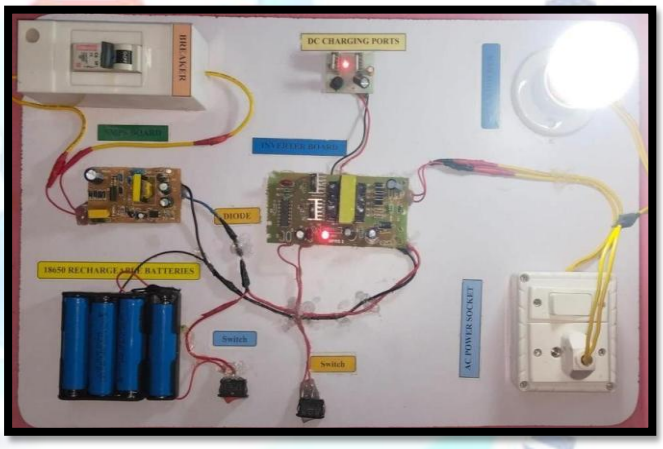
power to the connected devices. The switch from mains power to battery power is seamless and the connected devices do not experience any disruption. Once the main power supply is restored, the UPS switches back to standby mode and resumes charging its internal battery. This ensures that the UPS is always ready to provide backup power in case of an outage or interruption.The blue led light in the SMPS board shows the flow of main power supply into the UPSif the led bulb glows then the main supply is available. As shown in figure .

OPERATION OF LOAD WHEN MAIN SUPPLY IS OFF

When the main power supply is off, the UPS switches to battery power to provide uninterrupted power to the connected devices. The UPS uses its internal battery to convert DC power to AC power, which is then supplied to the devices.

The amount of time the UPS can provide backup power depends on the capacity of the battery and the power consumption of the connected devices. It is important to choose a UPS with a sufficient battery capacity to provide backup power for the required duration. Once the battery power is depleted, the UPS will shut down and the connected devices will no longer receive power. It is important to monitor the battery status of the UPS and replace the battery when necessary to ensure reliable backup power.

As we know that led bulb present in the SMPS board shows the condition of main power supply. If the led bulb does not glow means then there will be the failure in the main power supply. The condition of load is shown in figure 4.11 when the main power supply is failure.



When main power supply is in off condition

CONCLUSION

UPS systems are essential for ensuring uninterrupted power supply to critical equipment and systems in various industries. They provide protection against power outages, voltage fluctuations, and other electrical disturbances that can cause damage or downtime. The choice of UPS system depends on the specific needs of the application, including the load size, runtime requirements, and budget. While traditional lead-acid batteries have been the standard for UPS systems, lithium-ion batteries are becoming increasingly popular due to their superior performance and environmental benefits. Investing in a reliable UPS system with the appropriate battery technology can help businesses and

organizations minimize downtime, prevent data loss, and protect their assets.

The use of lithium-ion batteries in UPS systems provides several advantages over traditional lead-acid batteries. Lithium-ion batteries have a longer lifespan, are more energy-efficient, and require less maintenance. They also have a higher power density, which means they can provide more power in a smaller size. Additionally, lithium-ion batteries are more environmentally friendly as they are recyclable and do not contain toxic materials. Despite their higher cost, the benefits of using lithium-ion batteries in UPS systems make them a worthwhile investment for businesses and organizations that require reliable backup power.

Future Scope: The future scope of UPS using lithium-ion batteries is promising. As the demand for reliable backup power systems continues to grow, UPS systems using lithium-ion batteries will become more prevalent. With advancements in technology, lithium-ion batteries are becoming more affordable and accessible, making them a popular choice for UPS systems.UPS systems using lithium-ion batteries looks bright, with continued advancements in technology making them more efficient, reliable, andcost-effective.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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