Lead-Acid Battery Characteristics Training System

Nvis 425

Product Tutorial

Ver 1.1

An ISO 9001: 2008 company

Designed & Manufactured in India by :

Nvis Technologies Pvt. Ltd.

141-A, Electronic Complex, Pardesipura, Indore - 452 010 India

Tel.: 91-731-4211500, E-mail: info@nvistech.com, Website : www.NvisTech.com

Nvis 425

CERTIFICATE OF COMPLIANCE

INTERNATIONAL CERTIFICATION SERVICES PVT. LTD.

This is to certify that the

QUALITY MANAGEMENT SYSTEM of

NVIS TECHNOLOGIES PVT. LTD.

141-A, Electronic Complex, Pardesipura, Indore - 452 010, Madhya Pradesh, India.

has been assessed and registered as complying with the requirements of the following International Standard:

ISO 9001:2015

The Quality Management System applicable to:

Scope : Design And Manufacture Of Didactic Products And Clean Technologies Products Such As Solar Solutions.

Registration No.	**: RQ91/7763**
Registered Date	**: 17th June, 2012**
Reassessment Date	**: 28th June, 2018**
Issue Date	**: 30th June, 2018**
Expiry Date	**: 16th June, 2021**

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Managing Director
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Accredited by Joint Accreditation System of Australia and New Zealand

Validity of this certificate is based on periodic audits of the management system defined by the above scope and is contingent upon prompt, written notification of significant changes to the management system and/or its components thereof shall be immediately communicated to ICS.
Further clarifications regarding the scope of this certificate and the applicability of ISO 9001:2015 requirements may be obtained at www.icsasian.com

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Lead-Acid Battery Characteristics Training System

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Introduction

Nvis 425 "Lead-Acid Battery characteristics Training System" introduces students to the operation of Lead-Acid battery. Hands-on experiments cover the charging and discharging characteristics of lead-acid battery.

Training system includes Data Acquisition System which is very useful for sensing and controlling Analog and Digital signals for charging and discharging characteristics. It facilitates the interfacing of real world signals with PC through USB bus.

Experimentation with Nvis 425 is an ideal platform to enhance education, vocational training, skills & development amongst our young minds.

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Features

- User friendly software
- Facilitates the interfacing of real world signals with PC through USB bus
- Real time and interactive training setup
- Includes DC Power source for Battery charging
- Built in Charge controller
- Provided Led-Acid battery
- Battery charge and discharge management techniques
- Provided with high quality Meters
- Battery Level Indicator to analyze battery capacity
- Provided load for discharging characteristics
- Fully demonstrate the structure and characteristics of Lead-Acid battery
- Designed considering all safety standard

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Technical Specifications

Operating voltage	:	230V±10% AC
Power Supply	:	5VDC
	:	15VDC
DAQ		
Analog Inputs	:	Inputs with 10 bit resolution
Analog Output	:	Output with 10 bit resolution
Counter	:	0 to 6 MHz (square wave)
PC Inter face	:	USB 2.0
Charge controller		
Voltage	:	12V
Current	:	10A
Battery		
Type	:	Lead-Acid Battery
Voltage	:	12V,
Capacity	:	7.5Ah
DC Voltmeter	:	20V
DC Ammeter	:	10A No.
Battery Level Indicator	:	Capacity 0-100%

Safety Instructions

Why is it important to know about electrical safety?

The coming pages will explain the importance of safety in day to day use and while performing experiments in lab. Afterwards Safety Precautions are given which

Must!!

be followed while using any electric circuit and performing Experiments In Lab

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Using Electricity and Electrical Appliances properly can help us avoid injury:

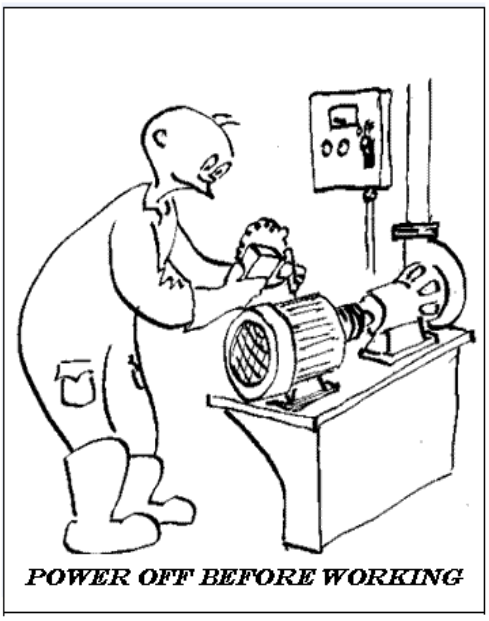
- Careless use of electric-powered appliances or tools can cause **Injuries.**
- **Shocks** caused due to contact with electric current passing through wires, appliances or tools. To avoid shock do not touch live wires and always wear rubber shoes.

- **Fire** resulting from over-heated wires, appliances or electric fixtures. So always use wires and electrical devices with correct specifications to avoid heating. The thicker wire is required to carry large current.

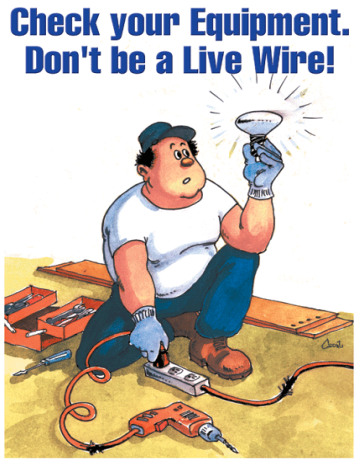
Following are some safety measures which should always be followed while working with electric system.

Carefully observe all safety measures to keep yourself safe.

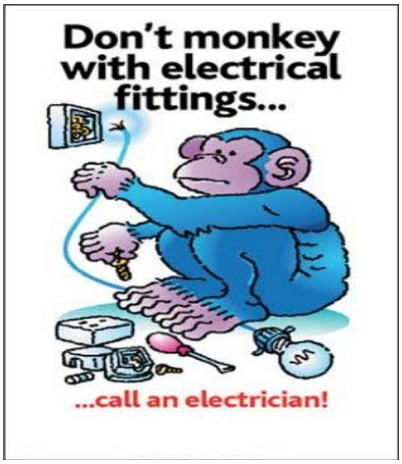
- Always shut off power to a circuit or device that you will be working on. This is the first thing you should do before working on any electrical circuit.



- After turning a circuit OFF, it's a good idea to check it again to be sure even it is OFF. Never assume that the circuit is OFF!



- If any part of the device is damaged, it should not be used and get repaired immediately.
- Never attempt electrical repairs or rewiring without proper experience. Always inform your supervisor and consult supplier.



- All tools and electric equipments should be unplugged when not in use and stored in dry areas.

- Tools and components must be clean and in good condition, with no cracks or exposed wires. Never use a patch chord whose wires are exposed. Use of such types of patch chords can cause shock and severe injuries.

- Avoid direct contact with the floor. Always wear rubber sole shoes. The rubber that you're wearing will prevent the electricity from creating complete circuit using your body as a path to the ground.
- Always refer user manual of the equipment under use
- Never use electrical devices or circuits if they are wet.

- Use three-pronged plugs instead of two-pronged ones. The third prong (below the top two) "grounds" the appliance. When a device is grounded, if it fails, the circuit will blow out immediately instead flowing to other places. So, whenever possible, use appliances that have three prongs unless it is stated in user manual to use 2 Pronged Plugs or provided with the equipment. Always refer user manual of the equipment under use. Electricity cannot travel through rubber. So, while using equipments that are potentially faulty or not grounded (no three-pronged plugs), wear strong rubber gloves.

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- Wires should never be run under carpets, wooden blocks, wet areas because if wire heats due to over current, It may fuse and cause fires.
- Chords should be firmly plugged into outlets - if the cord is loose it can cause spark and can damage the instrument.

- Do not pull the cord. Always turn off the machine and then pull the plug. In this way, you keep your electrical appliances in working order and avoid a possible short circuit.

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It's dangerous to put too many plugs into an outlet. Most household extension cords and wall adapters will only allow you to place up to six plugs to an outlet. If you use more than six plugs, the risk of power overloads and fires due to the wires getting too hot increases.

Till Now we have learned to follow the safety rules while using Electrical Circuits and Power Supplies.

Now,What to do in case of

Electrical Accident?

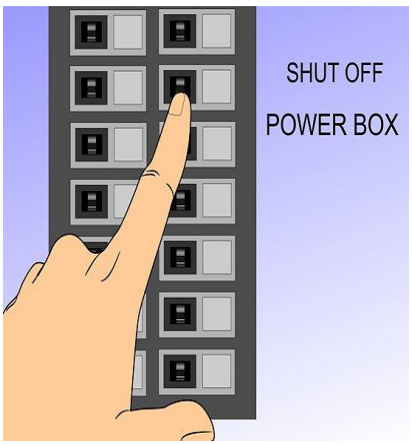
Do not endanger yourself- If the victim is still in contact with the electrical current, you must be careful to avoid being shocked yourself.

Self Precautions to Save the Victim

- Do not touch the victim. The current can pass through you also and you will not be in a position to help the victim.
- Do not touch the source of electricity.

Immediate action to be taken

Break the current. Before you can do anything else, you must get the victim free from the current. There are two ways to do this:



- Shut off the current at the power box. Turn off the current at the circuit breaker or fuse box. This is the preferred option.
- If no shut off is immediately available, use a non-conducting item to move the victim, such as a wooden broomstick, blanket, or rope. If they are holding onto a wire or other conductor, attempt to knock their hand(s) free with a wooden or non conducting stick or dry towel.

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Immediately call an ambulance or doctor to start the victim's treatment.

If the victim is unconscious, check to see if he is breathing and have a pulse. Electric shocks may knock the person unconscious, halt their breathing, and stop the heart. If the victim is not breathing, apply artificial breathing.

Do not attempt to move the victim unless they are in further danger. Other injuries may have occurred that you are unaware of.

Cover the victim in a blanket and stay with him until help arrives. Do not leave him

Theory

Lead Acid Battery

The battery which uses sponge lead and lead peroxide for the conversion of the chemical energy into electrical power, such type of battery is called a lead acid battery. The lead acid battery is most commonly used in the power stations and substations because it has higher cell voltage and lower cost.

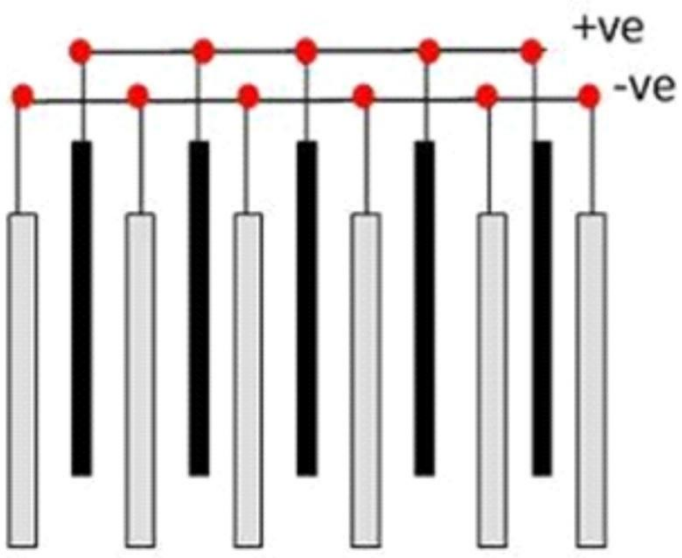
Construction of Lead Acid Battery

The various parts of the lead acid battery are shown below. The container and the plates are the main part of the lead acid battery. The container stores chemical energy which is converted into electrical energy by the help of the plates.

1. **Container:** The container of the lead acid battery is made of glass, lead lined wood, ebonite, the hard rubber of bituminous compound, ceramic materials or molded plastics and are seated at the top to avoid the discharge of electrolyte. At the bottom of the container, there are four ribs, on two of them rest the positive plate and the others support the negative plates.

   The prism serves as the support for the plates and at the same time protect them from a short-circuit. The material of which the battery containers are made should be resistant to sulfuric acid, should not deform or porous, or contain impurities which damage the electrolyte.

2. **Plate:** The plate of the lead-acid cell is of diverse design and they all consist some form of a grid which is made up of lead and the active material. The grid is essential for conducting the electric current and for distributing the current equally on the active material. If the current is not uniformly distributed, then the active material will loosen and fall out.



Arrangement of Plates in a Lead Acid Battery

The grids are made up of an alloy of lead and antimony. These are usually made with the transverse rib that crosses the places at a right angle or diagonally. The grid for the positive and negative plates are of the same design, but the grids for the negative plates are made lighter because they are not as essential for the uniform conduction of the current.

The plates of the battery are of two types. They are the formed plates or plante plates and pasted or faure plates.

Plante's plates are used largely for stationary batteries as these are heavier in weight and more costly than the pasted plates. But the plates are more durable and less liable to lose active material by rapid charging and discharging. The plantes plate has low capacity weight-ratio.

Faure process is much suitable for manufacturing of negative plates rather than positive plates. The negative active material is quite tough, and it undergoes a comparatively low change from charging and discharging.

3. **Active Material –** The material in a cell which takes active participation in a chemical reaction (absorption or evolution of electrical energy) during charging or discharging is called the active material of the cell. The active elements of the lead acid are

    1. **Lead peroxide (PbO_2)** – It forms the positive active material. The PbO_2 are dark chocolate broom in colour.
    2. **Sponge lead** – Its form the negative active material. It is grey in colour.
    3. **Dilute Sulfuric Acid (H_2SO_4)** – It is used as an electrolyte. It contains 31% of sulfuric acid.

    The lead peroxide and sponge lead, which form the negative and positive active materials have the little mechanical strength and therefore can be used alone.

4. **Separators –** The separators are thin sheets of non-conducting material made up of chemically treated lead wood, porous rubbers, or mat of glass fiber and are placed between the positive and negative to insulate them from each other. Separators are grooved vertically on one side and are smooth on the other side.

5. **Battery Terminals –** A battery has two terminals the positive and the negative. The positive terminal with a diameter of 17.5 mm at the top is slightly larger than the negative terminal which is 16 mm in diameter.

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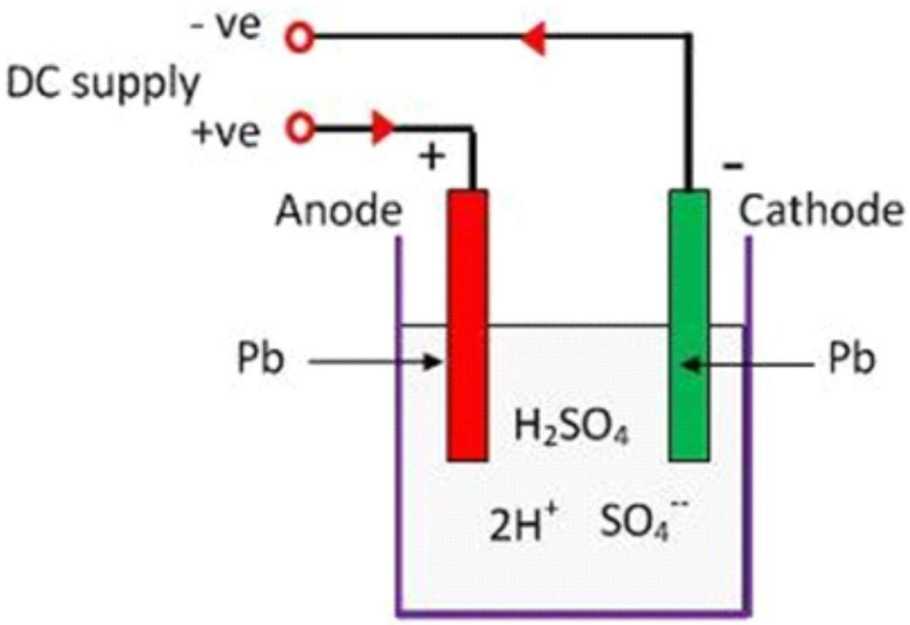
Working Principle of Lead Acid Battery

When the sulfuric acid dissolves, its molecules break up into positive hydrogen ions ($2H^+$) and sulphate negative ions (SO_4^{--}) and move freely. If the two electrodes are immersed in solutions and connected to DC supply then the hydrogen ions being positively charged and moved towards the electrodes and connected to the negative terminal of the supply. The SO_4^{--} ions being negatively charged moved towards the electrodes connected to the positive terminal of the supply main (i.e., anode)



Charging of Lead Acid Cells

Each hydrogen ion takes one electron from the cathode, and each sulphates ions takes the two negative ions from the anodes and react with water and form sulfuric and hydrogen acid.

The oxygen, which produced from the above equation react with lead oxide and form lead peroxide (PbO_2.) Thus, during charging the lead cathode remain as lead, but lead anode gets converted into lead peroxide, chocolate in colour.

If the DC source of supply is disconnected and if the voltmeter connects between the electrodes, it will show the potential difference between them. If wire connects the electrodes, then current will flow from the positive plate to the negative plate through external circuit i.e. the cell is capable of supplying electrical energy.

Chemical Action during Discharging

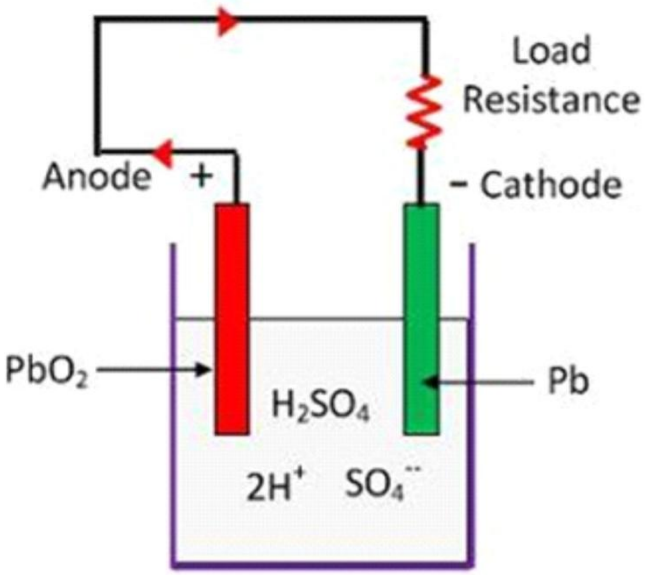
When the cell is full discharge, then the anode is of lead peroxide (PbO_2) and a cathode is of metallic sponge lead (Pb). When the electrodes are connected through a resistance, the cell discharge and electrons flow in a direction opposite to that during charging.

The hydrogen ions move to the anode and reaching the anodes receive one electron from the anode and become hydrogen atom. The hydrogen atom comes in contacts with a PbO_2, so it attacks and forms lead sulphate ($PbSO_4$), whitish in colour and water according to the chemical equation.

$$PbSO_4 + 2H = PbO + H_2O$$

$$PbO + H_2SO_4 = PbSO_4 + 2H_2O$$

$$\overline{PbO_2 + H_2SO_4 + 2H = PbSO_4 + 2H_2O}$$



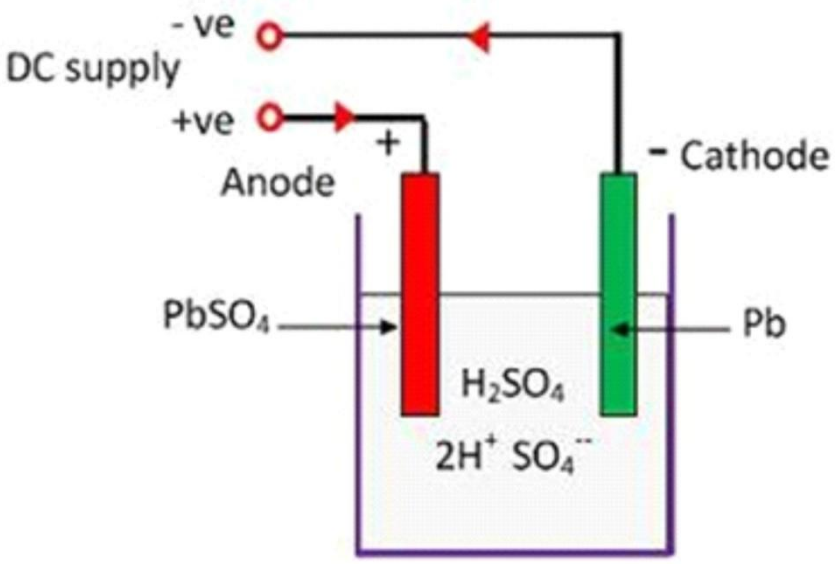
Discharging of Lead Acid Cells

The each sulphate ion (SO_4^{--}) moves towards the cathode and reaching there gives up two electrons becomes radical SO_4, attack the metallic lead cathode and form lead sulphate whitish in colour according to the chemical equation.

Chemical Action during Recharging

For recharging, the anode and cathode are connected to the positive and the negative terminal of the DC supply mains. The molecules of the sulfuric acid break up into ions of $2H^+$ and SO_4^{--}. The hydrogen ions being positively charged moved towards the cathodes and receive two electrons from there and form a hydrogen atom. The hydrogen atom reacts with lead sulphate cathode forming lead and sulfuric acid according to the chemical equation.

$PbSO_4 + 2H_2O + 2H = PbSO_4 + 2H_2SO_4$

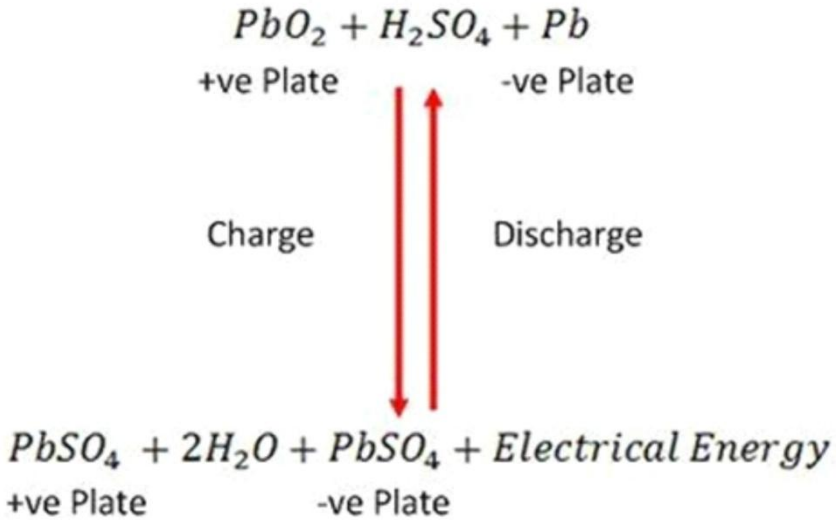


Recharging of Lead Acid Cell

SO_4^{--} ion moves to the anode, gives up its two additional electrons becomes radical SO_4, react with the lead sulphate anode and form leads peroxide and lead sulphuric acid according to the chemical equation.

$$PbSO_4 + 2H = H_2SO_4 + Pb$$

The charging and discharging are represented by a single reversible equation given below.



The equation should read downward for discharge and upward for recharge.

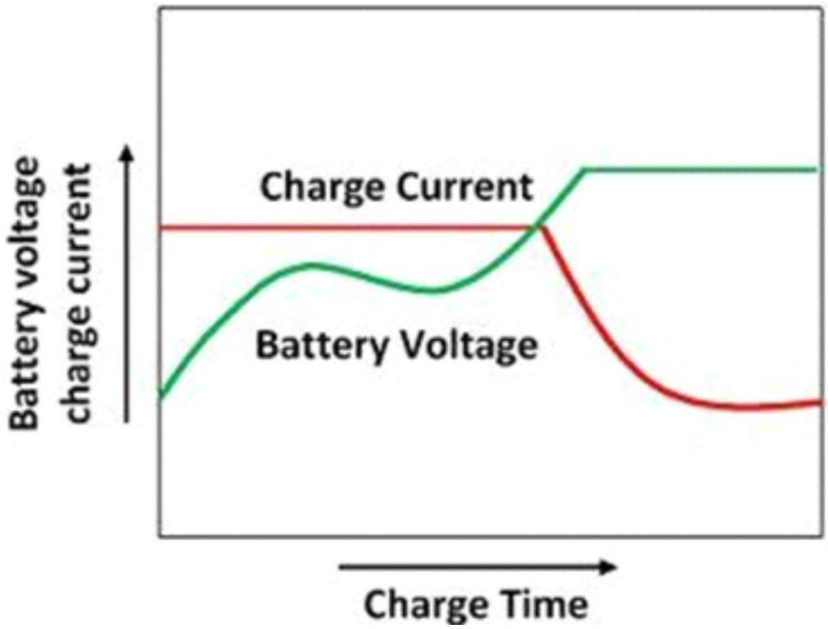
Lead-Acid Battery Charging Methods

The lead-acid battery stores chemical energy and this energy is converted into electrical energy whenever requires. The conversion of energy from chemical to electrical is known as the charging. And when the electric power changes into chemical energy then it is known as discharging of the battery. During the charging process, the current passes inside the battery because of chemical changes. The lead-acid battery mainly uses two types of charging methods namely the constant voltage charging and constant current charging.

Constant voltage Charging

It is the most common method of charging the lead acid battery. It reduces the charging time and increases the capacity up to 20%. But this method reduces the efficiency by approximately 10%.

In this method, the charging voltage is kept constant throughout the charging process. The charging current is high in the beginning when the battery is in the discharge condition. The current is gradually dropping off as the battery picks up charge resulting in increase back emf.



Constant Voltage Charging

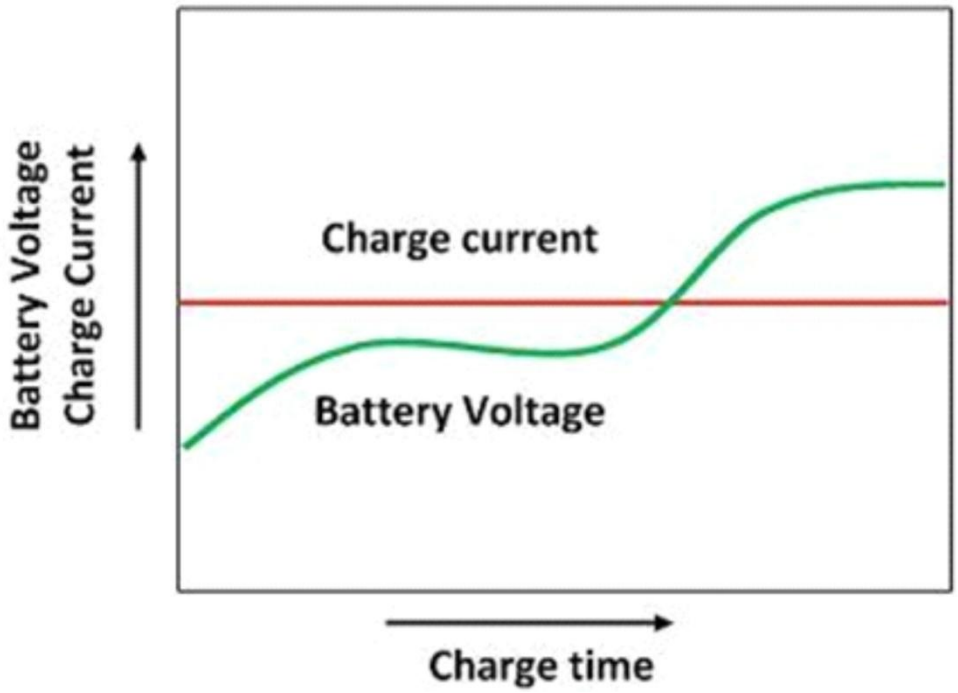
The advantages of charging at constant voltage are that it allows cells with different capacities and at the different degree of discharge to be charges. The large charging current at the beginning of the charge is of relatively short duration and will not harm the cell.

At the end of the charge, the charging current drops to almost zero because the voltage of the battery becomes nearly equal to the voltage of the supply circuit.

Constant Current Charging

In this method of charging the batteries are connected in series so as to form groups and each group charges from the DC supply mains through loading rheostats. The number of charging in each group depends on the charging circuit voltage which should not be less than the 2.7 V per cell.

The charging current is kept constant throughout the charging period by reducing the resistance in the circuit as the battery voltage goes up. In order of avoiding excessive gassing or overheating, the charging may be carried out in two steps. An initial charging of approximately higher current and a finishing rate of low current.



Constant Current Charging

In this method, the charge current is approximately one-eighth of its ampere ratings. The excess voltage of the supply circuit is absorbed in the series resistance. The groups of the battery to be charged should be so connected that the series resistance consumes as little energy as possible.

The current carrying capacity of series resistance should be greater than or equal to the required charging current otherwise, the resistance will overheat and burn out.

The group of batteries which is to be selected should have the same capacity. If the battery has a different capacity, then they will have to be set according to the least capacity

How to use Nvis 425 with PC Interface

Unpacking

After receiving your Nvis 425 package, please inspect its contents first. The package should contain the following items:

- Nvis 425 with accessories
- USB 2.0 Cable
- Product CD
- Patch cord

Set-Up Wizard CD

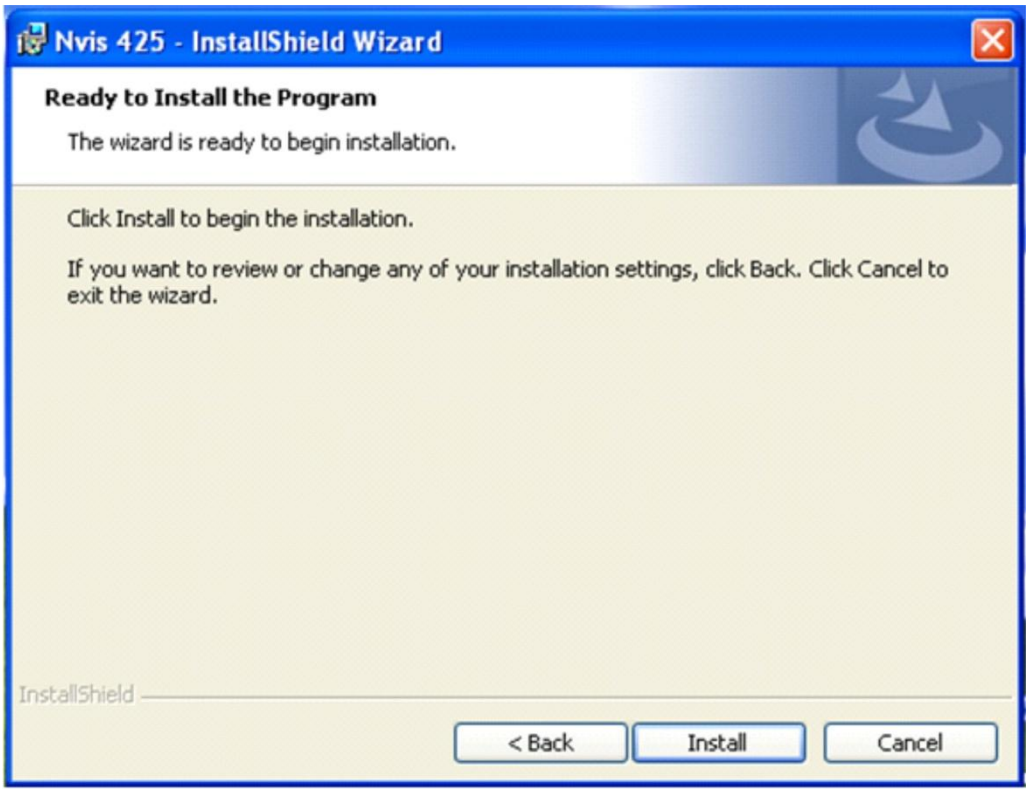
Step 1: Insert the CD into the CD drive of your computer. Open CD and Double click on Nvis 425 Setup icon is shown in figure

Step 2: Click Next

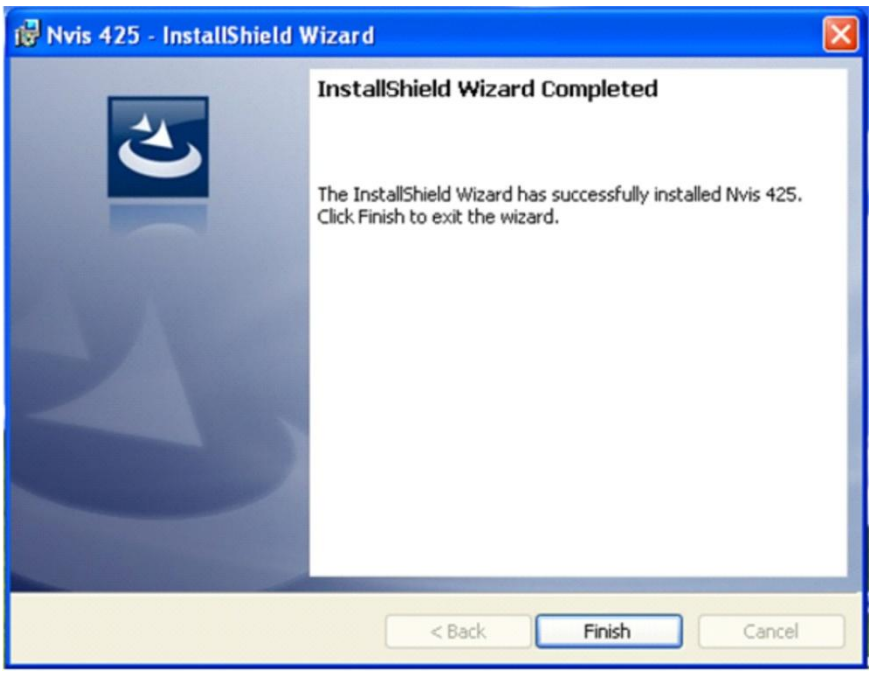
Nvis 425

Step 3: Accept the license agreement and click next.

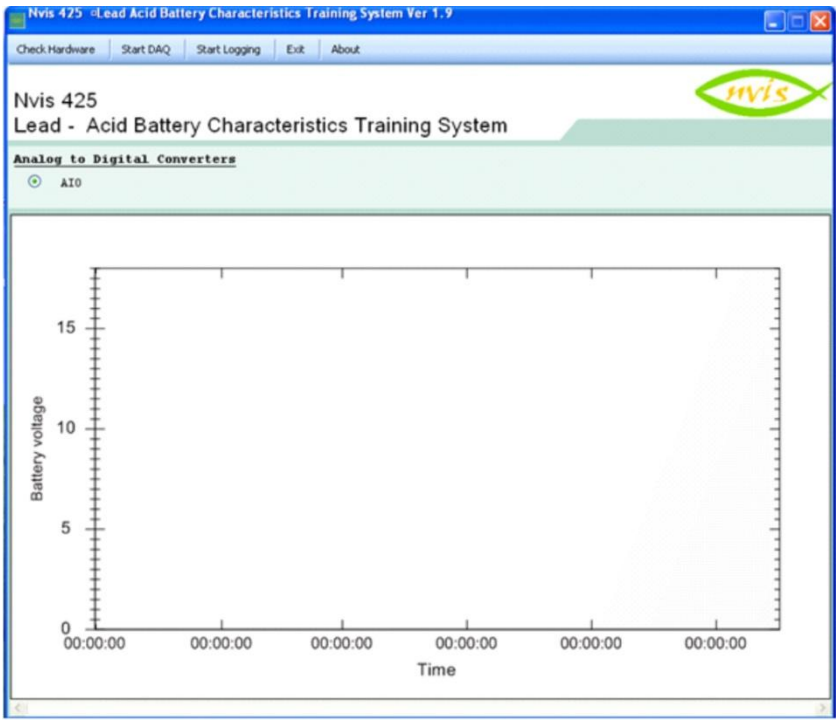
Step 4: Click on Install button. Installation gets start.



Step 5: Click on Finish button.



Step 6: After above step Nvis 425 window will open is shown in figure.



Step 7: Now connect Nvis 425 with PC using USB cable. Following screen will appeared**.**

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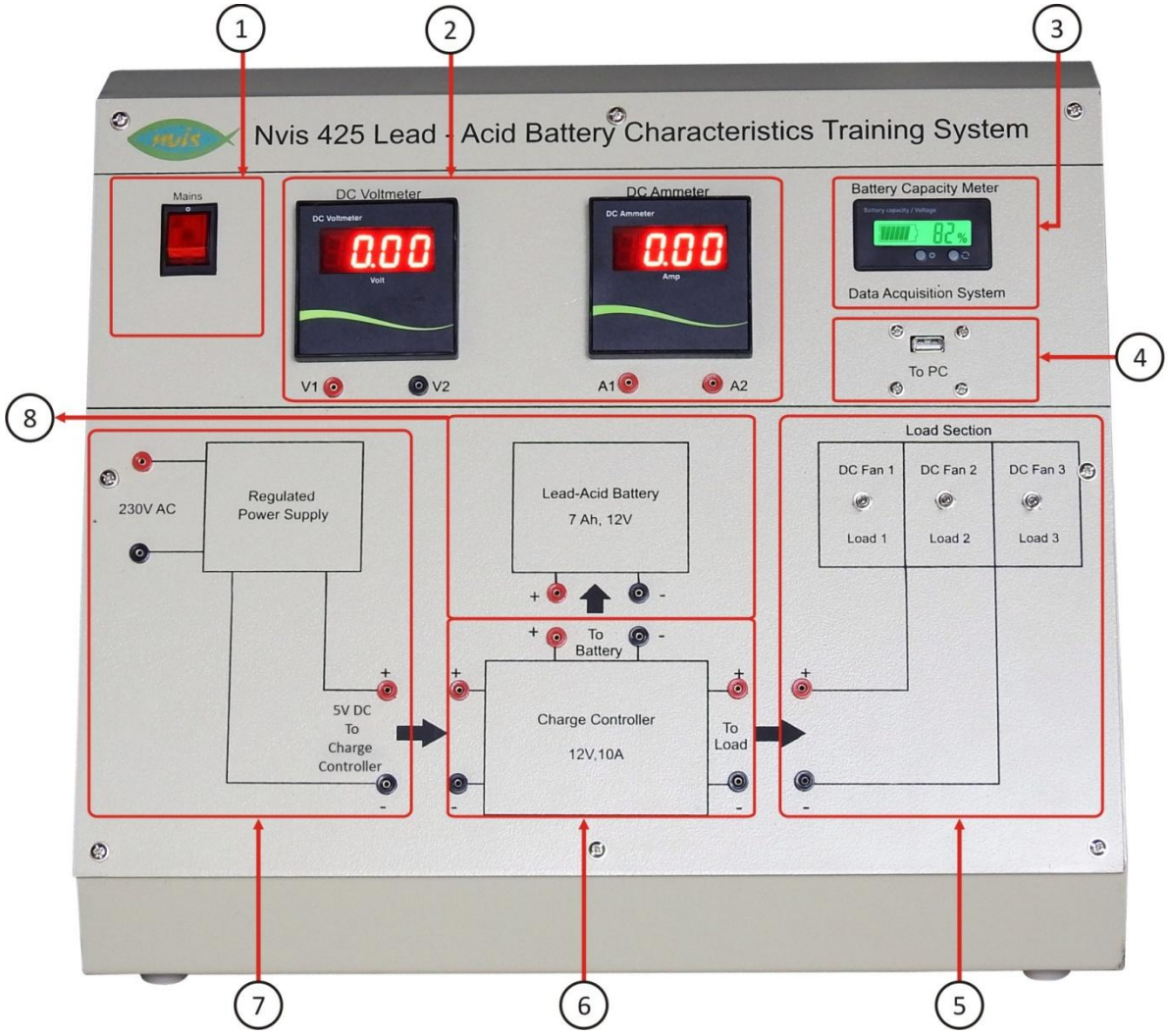
Experiment 1

Objective:

To understand the overall functioning of lead-acid battery testing

Equipments Required:

- Nvis 425
- Patch Cords
- DMM



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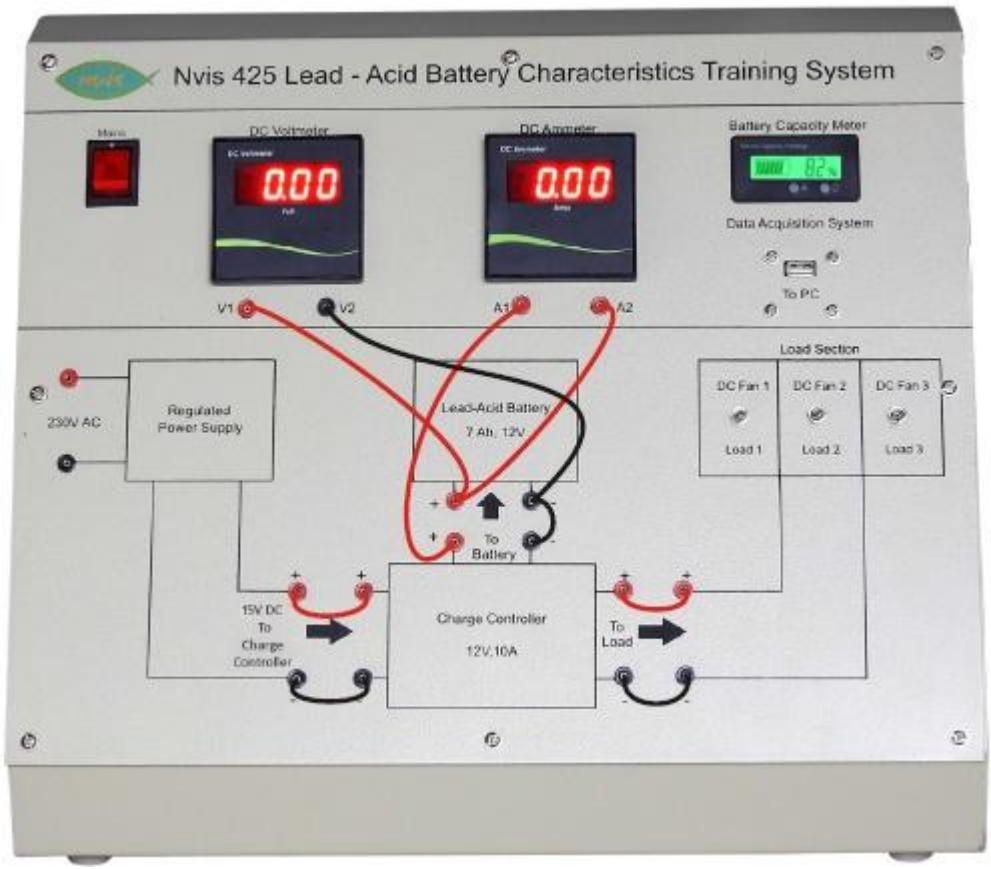
1. Mains to power ON
2. DC Voltmeter and DC Ammeter for Battery voltage and battery current measurement
3. Battery capacity meter to measure battery capacity and battery voltage
4. USB for PC interface to monitor battery characteristics
5. Load Section are used to discharge battery
6. Charge controller to control the battery charging and discharging
7. Regulated DC power Supply 15V for Battery Charging
8. Lead –Acid battery for charging and discharging characteristics

Circuit diagram:



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Procedure:

1. First of all make sure that the earthing of your laboratory is proper and it is connected to the terminal provided on back side of the panel.
2. Make sure that the single phase mains and switch of panel is at "off" position.

   It is to be remember that load switch should be off position
3. Connect single phase mains cord on the back side of control panel.

   Now check all section step by step
4. **For regulated power supply-**
   - Switch ON the mains and check AC voltage on regulated power supply input by using of DMM it should be 230V±10% AC.
   - Now check DC voltage on regulated power output (15V DC to charge controller) by using of DMM it should be between 14-15 V DC.
   - Switch "Off" the mains.
5. **For lead-acid battery-**

   Connect DMM to lead -acid battery +Ve and –Ve terminals and check battery voltage.
6. **For Charge controller and load section-**
   - Connect 15V regulated power supply outputs to +Ve and –Ve terminal of charge controller input as shown in fig.
   - Connect charge controller battery terminals (+Ve and –Ve) to battery +Ve and –Ve terminals.
   - Insert voltmeter across battery +Ve and –Ve terminals and connect ammeter in series for battery voltage and current measurement.
   - Now connect load terminals across charge controller out put
   - Switch On the mains and check charging and discharging (by increasing the load).
7. Switch "Off" the mains.

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Experiment 2

Objective:

To study the charging characteristics of lead-Acid Battery

Equipments Required:

- Nvis 425
- Patch Cords and USB cable (A to A type)
- Software CD
- PC (arrange from your laboratory)

Circuit diagram:

Procedure:

1. First of all make sure that the earthing of your laboratory is proper and it is connected to the terminal provided on back side of the panel.
2. Make sure that the single phase mains and switch of panel is at "off" position.

It is to be remember that load switch should be off position

3. Connect single phase mains cord on the back side of control panel.
4. Now make all connection as per connection diagram
5. Connect 15V regulated power supply outputs to +Ve and –Ve terminal of charge controller input as shown in fig.
6. Connect charge controller battery terminals (+Ve and –Ve) to battery +Ve and –Ve terminals.
7. Insert voltmeter across battery +Ve and –Ve terminals and connect ammeter in series for battery voltage and current measurement.

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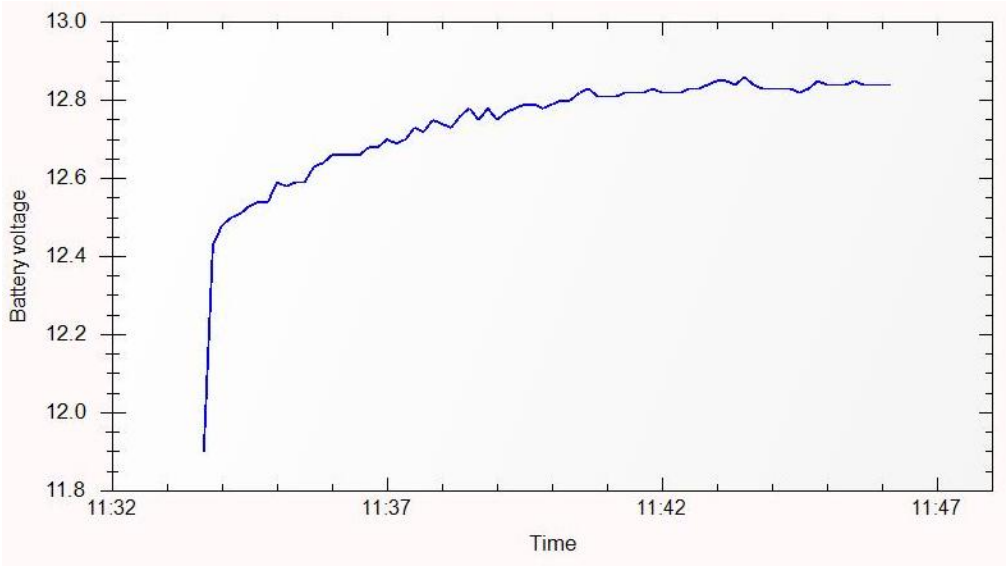
8. Now connect load terminals across charge controller out put
9. Keep battery capacity meter in % mode by pressing the switch on meter

   Note: It is to be remembering that Battery voltage should be between 11V to 11.3V for better charging characteristics.
10. Switch On the mains
11. Double click on Nvis 425 icon and Nvis 425 Lead-Acid Battery Characteristics Training System window will appear on screen.
12. Connect A to A USB cable between PC and Nvis 425 DAQ.
13. After open Nvis 425 software click on to Check Hardware. Hardware found window will open then click on to OK tab is shown in below figure

14. After above step click on “Start DAQ”.
15. After above step “Start DAQ” option change in “Stop DAQ” Means your DAQ will start for functioning.
16. Check charging characteristics of Lead-Acid Battery on screen.
17. Take screen print and save its characteristics.
18. For end the process single left click on TAB “Stop DAQ” in the menu bar. After click on “Stop DAQ” option will change in “Start DAQ” that means your DAQ will STOP.
19. We can measure the battery voltage and current during charging by voltmeter and ammeter
20. Switch “Off” the mains.



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Experiment 3

Objective:

To study the discharging characteristics of lead-Acid Battery

Equipments Required:

- Nvis 425
- Patch Cords and USB cable (A to A type)
- Software CD
- PC (arrange from your laboratory)

Circuit diagram:

Nvis 425

Procedure:

1. First of all make sure that the earthing of your laboratory is proper and it is connected to the terminal provided on back side of the panel.
2. Make sure that the single phase mains and switch of panel is at "off" position.

   It is to be remember that load switch should be off position
3. Connect single phase mains cord on the back side of control panel.
4. Now make all connection as per connection diagram
5. Connect 15V regulated power supply outputs to +Ve and –Ve terminal of charge controller input as shown in fig.
6. Connect charge controller battery terminals (+Ve and –Ve) to battery +Ve and –Ve terminals.
7. Insert voltmeter across battery +Ve and –Ve terminals and connect ammeter in series for battery voltage and current measurement.
8. Now connect load terminals across charge controller out put
9. Keep battery capacity meter in % mode by pressing the switch on meter

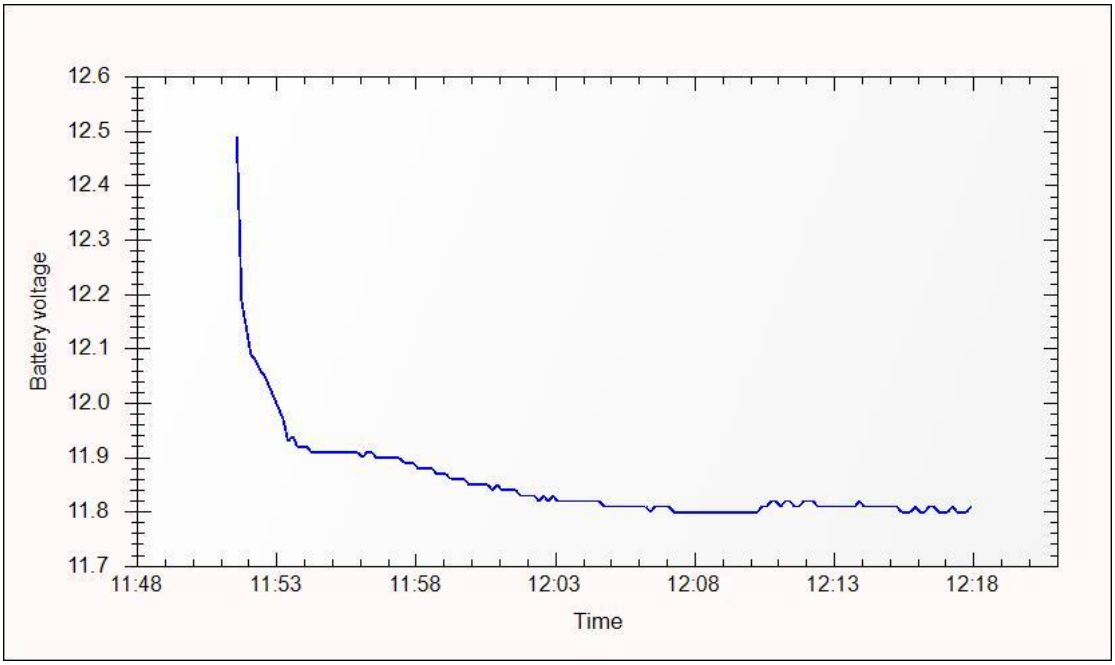
   Note: It is to be remembering that Battery voltage should be between 12.7 to 13.5V for better discharging characteristics.
10. Switch On the mains
11. Double click on Nvis 425 icon and Nvis 425 Lead-Acid Battery Characteristics Training System window will appear on screen.
12. Connect A to A USB cable between PC and Nvis 425 DAQ.

    After open Nvis 425 software click on to Check Hardware. Hardware found window will open then click on to OK tab is shown in below figure.

Nvis 425

13. After above step click on “Start DAQ”.
14. After above step “Start DAQ” option change in “Stop DAQ” Means your DAQ will start for functioning.
15. Check discharging characteristics of Lead-Acid Battery on screen.
16. Take screen print and save its characteristics.
17. For end the process single left click on TAB “Stop DAQ” in the menu bar. After click on “Stop DAQ” option will change in “Start DAQ” that means your DAQ will STOP.
18. We can measure the battery voltage and current during discharging by voltmeter and ammeter
19. Switch “Off” the mains.

Result:



Warranty

1. We guarantee this product against all manufacturing defects for **12 months** from the date of sale by us or through our dealers.
2. The guarantee will become void, if
   a. The product is not operated as per the instruction given in the Learning Material.
   b. The agreed payment terms and other conditions of sale are not followed.
   c. The customer resells the instrument to another party.
   d. Any attempt is made to service and modify the instrument.
3. The non-working of the product is to be communicated to us immediately giving full details of the complaints and defects noticed specifically mentioning the type, serial number of the product and date of purchase etc.
4. The repair work will be carried out, provided the product is dispatched securely packed and insured. The transportation charges shall be borne by the customer.

Note: Measuring instruments (Voltmeter, Ammeter & Wattmeter) do not include under warranty after first installation

List of Accessories

- 2 mm patch cord 12" Red .....6 Nos.
- 2mm Patch Cord 12” (Black) .....4 Nos.
- USB cable (A to A type).....1 Nos.
- Single Phase Mains Cord ..... 1 No.