Section 4: Extra Low Voltage Equipment

4.1 Common terms	3
4.2 Series and parallel circuits	5
4.3 Methods of protection	8
4.4 Extra Low Voltage (ELV) systems	9
4.5 Stray currents	10
4.6 Battery charging alternators	11
4.7 Charging system failures	12
Answers to check your progress	15

© OTEN, 2002/229/03/2003 P0026536

© OTEN, 2002/229/03/2003 P0026536

4.1 Common terms

Here are some common terms used for electrical supply.

Voltage

Unit	=	Volt (V)	Symbol	=	E

The volt is the unit of electromotive force (EMF) and potential difference (PD) that is, the available force or potential to cause a current to flow through a conductor.

Current

Unit	=	Ampere (A)	Symbol	=	I

The amount of electrons flowing through a conductor.

Resistance

Unit	=	OHM (Ω)	Symbol	=	R

All conductors resist the flow of electric current (except super conductors) converting a portion of the electrical energy into heat (see Section 5.2).

Power

Unit	=	Watts (W) or Joules	Symbol	=	P

The amount of work done in one second with a potential difference of one volt and a constant current of one ampere.

$P = E \times I$ $P = I^2 x R$ $P = E^2/R$

© OTEN, 2002/229/03/2003 P0026536

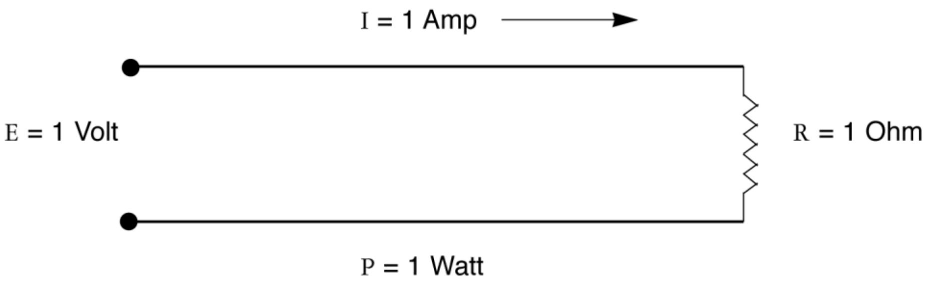
OHMS Law

The ratio of the potential difference (volts) between the ends of a conductor and the current flowing through the conductor is constant. This ratio is called the resistance of the conductor and is expressed as:

$$R = \frac{E}{I}$$

In the following diagrams:

(b)



$$\begin{aligned} R &= \frac{E}{I} \\ &= \frac{1}{1} \\ &= 1 \text{ ohm} \end{aligned}$$

(b)

$$\begin{aligned} R &= \frac{E}{I} \\ &= \frac{24}{2} \\ &= 12 \text{ ohms} \end{aligned}$$

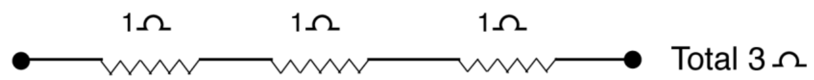
© OTEN, 2002/229/03/2003 P0026536

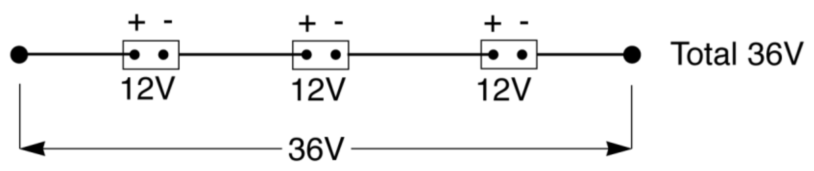
4.2 Series and parallel circuits

In case of batteries, Series and parallel connections are made when a large storage capacity is needed but a single battery would be too heavy or cumbersome to handle.

Series circuits

If two or more resistors, batteries are connected in line with each other, they would be connected in series and the total resistance or voltage would be the sum of the individual components added together.





A series connection is made by linking the positive pole of one battery to the negative post of the other, and then using the remaining positive terminal on one and negative terminal on the other to make the connection to the boat's circuits.

When in series, the total amp-hour capacity of the two batteries together remains the same as the amp-hour rating of either one, but the output voltage is doubled.

If you had 3, 12 volt lamps you could connect them in series and then connect them to a 36 volt battery however, if one fails they will all go out because the series circuit will be broken.

A 12 volt lead acid battery would have 6 × 2 volt cells connected in series.

© OTEN, 2002/229/03/2003 P0026536

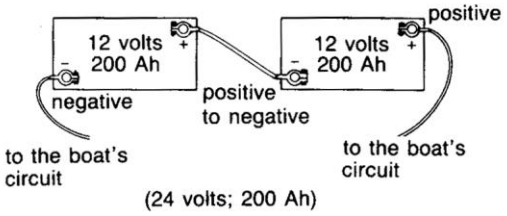
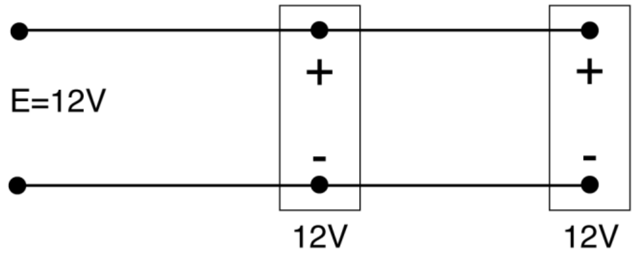


Figure 1: Batteries in series

Parallel Circuits



If you connect lights in parallel the voltage across each light would be the same but the total current or power used would be the sum of the current or power in each path.

Refer to Ohms Law where:

$$\text{Resistance} = \frac{Voltage}{Current}$$

$$R = \frac{E}{I}$$

The total power used would be 36 watts.

The resistance of the circuit would be equal to the sum of the resistance of each path.

From the example above, the Ohms Law formula can be converted to:

$$R = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3}$$ (ie 3 paths of resistance)

$$R = \frac{1}{12} + \frac{1}{12} + \frac{1}{12}$$
$$= \frac{3}{12}$$
$$= 4 \text{ ohms}$$

© OTEN, 2002/229/03/2003 P0026536

In case of batteries, a parallel connection is made by linking the positive poles of two or more batteries, and also linking the negative posts.

In the case of two batteries in parallel, they still have the same voltage, but there is an increase in the capacity. That is, if the batteries were each rated at 100 A.H., in parallel they would increase the capacity to 200 A.H. This means the batteries could be used for twice the time but when charging, the battery with the highest terminal voltage will regulate the charger which means the battery with the lower terminal voltage will never reach a fully charged condition.

Batteries should only be connected in parallel for short periods or emergencies.

Eg.When you jump start your motor car, you connect the two batteries in parallel.

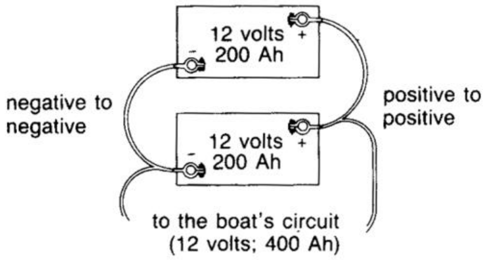


Figure 2: Batteries in parallel

© OTEN, 2002/229/03/2003 P0026536

4.3 Methods of protection

To protect circuits (and users) from electrical accidents, the first priority is that the system must be a two wire insulated return. This means that no part of the circuit is connected to any ground or equipment. The system is completely isolated including engine sensors, starter motors and alternators.

There would be a main two pole isolator and fuses or circuit breaker adjacent to the battery bank. This would be an enclosed type so that no sparks or arcs could risk battery explosion. An ammeter is often installed here also to verify that the safe battery discharge level is not exceeded.

A volt meter is also installed so that the battery charger voltage and charge condition can be monitored.

From the main switchboard, power would be distributed to various switch/fuse combinations or circuit breakers which would either supply circuits to items of equipment or other distribution boards.

An earth indication system would also be fitted in this switchboard.
All circuits must be protected with two pole isolator.

© OTEN, 2002/229/03/2003 P0026536

4.4 Extra Low Voltage (ELV) systems

Any system with a voltage below 110 V is known as an Extra Low Voltage (ELV) system. Systems where the voltage is between 110V and 240V are known as Low Voltage systems. The following is a diagram of a typical extra low voltage system:

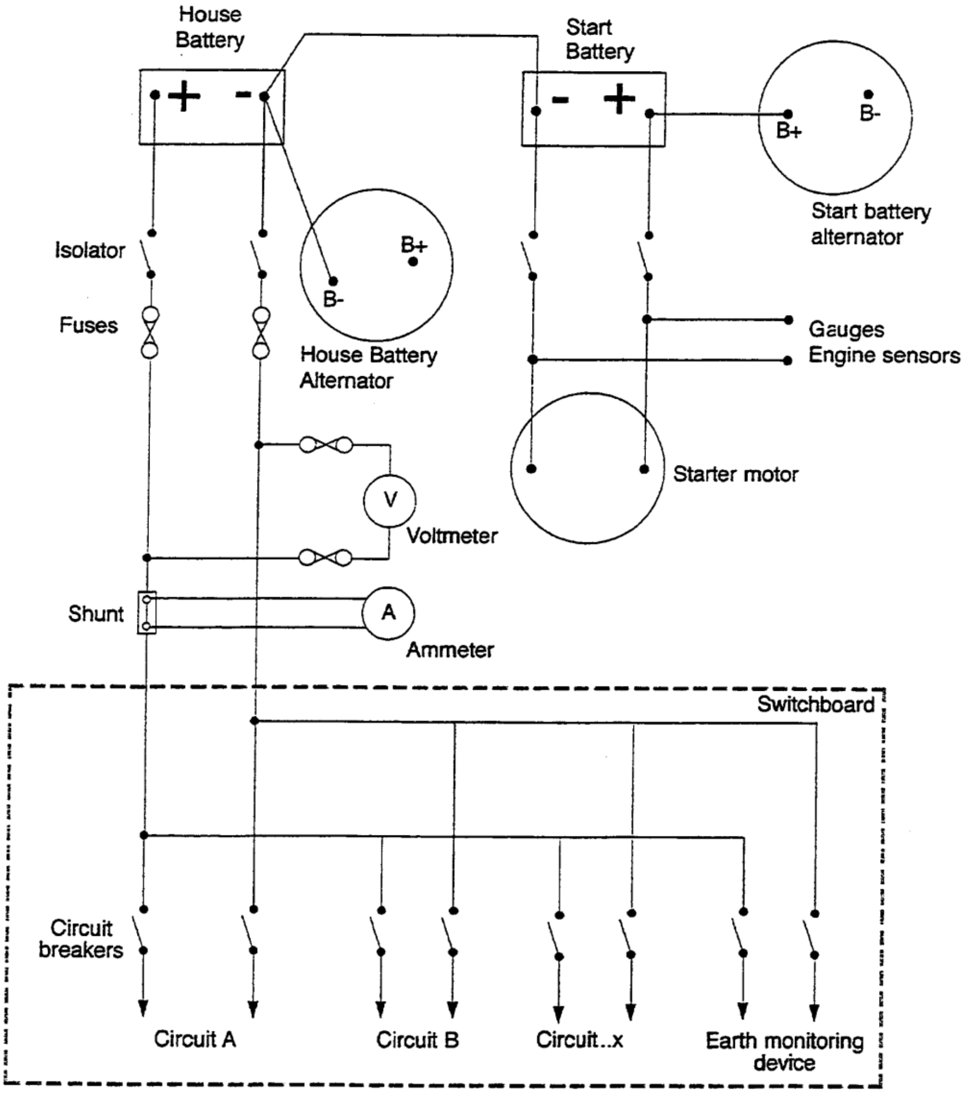


Figure 3: An extra low voltage system

© OTEN, 2002/229/03/2003 P0026536

4.5 Stray currents

When operating electric motors for pumps and other equipment, a magnetic field is produced around and about the motor. This field creates an electrolytic reaction with the sea water, which causes corrosion of the metal hull.

It is for this reason that sacrificial anodes are located on the parts of the vessel most likely to be affected by this reaction. These anodes are made of materials such as zinc, which corrode before the metal hull or other parts. The anodes must be replaced regularly. Any faults which may produce stray current must be rectified as soon as possible.

Stray currents are leakage currents which occur when a conductor has an earth fault.

These faults are usually caused by moisture in junction boxes or other components, and from damaged cable insulation. They are often too small to trip circuit breakers or other protection devices.

Stray currents create electrolytic corrosion which will increase corrosion rates on hulls and sacrificial anodes and will degrade the galvanic protection system.

Because of the effects of stray currents, it is necessary to regularly check the earth monitoring system as it is imperative that the earth faults be rectified as soon as practical.

There are other complicated methods of detecting stray currents. Use a specialist contractor to confirm any suspicions.

© OTEN, 2002/229/03/2003 P0026536

4.6 Battery charging alternators

Battery charging alternators are basically a 3 phase A.C. alternator which produces one DC output.

Most alternators have a charging voltage of 14V which is sufficient for lead acid batteries but insufficient for alkaline batteries which require 15.5V—16V.

The charging rate is controlled by the regulator which monitors the output voltage of the alternator and varies the field voltage in responses to load variations.

The battery will absorb a large current until the battery charge level is approximately 50 per cent. When this is achieved the regulator starts to limit the voltage.

The charge current will level off as the battery voltage level rises.

© OTEN, 2002/229/03/2003 P0026536

4.7 Charging system failures

Checking the output initially depends on the lamp and the regulator.

Check that the voltage across the main and the negative terminals rises to approximately 14 V. No voltage indicates either a total failure of the alternator or the regulator, a lower voltage indicates that some diodes have failed or there is a regulator fault. It is also possible that the brushes in the alternator are not seated properly on the slip rings.

If the voltage is okay, check the voltage at the battery to ensure that the terminal connections, leads and isolation diodes (if installed), are satisfactory.

There are two methods of regulator sensing:

1 **Machine sensing method:**

   This method monitors the output voltage and adjusts the alternator output value to approximately 14 volts. This method does not allow for voltage drops in the charging circuit caused by terminal connections, undersized wiring, isolation diodes (if installed).

2 **Battery sensing:**

   This method measures the voltage at the battery and adjusts the alternator output voltage to compensate for voltage drops in the charging circuit so that the correct voltage is supplied to the battery.

If the warning light does not operate when the ignition is turned on, check for a lamp fault or a connection fault at the lamp or the D+ terminal. If these are okay, the alternator excitation diodes maybe faulty.

In an emergency, if there is a faulty regulator or a partial diode failure, the regulator can be disconnected and a full field voltage connected to achieve maximum output.

© OTEN, 2002/229/03/2003 P0026536

Practical Activity

Locate the battery system on your vessel. Show your facilitator how the batteries are connected. Explain the installation.

What is the purpose for installing more than one battery?

What are the benefits?

Discuss protection methods used on your vessel with your facilitator. Identify any further work which could prove beneficial.

Check all the system fuses and circuit breakers to ensure they are in satisfactory condition, replacing any which are suspect.

© OTEN, 2002/229/03/2003 P0026536

Check your progress

1 What is a Series and a Parallel Circuit?

2 What is OHM 's Law?

3 What is meant by a two wire Insulated Return System?

4 What is an ELV and a LV System?

5 What is Stray Current, how are they generated, what is the effect of Stray Current and what monitoring and protection facility is provided for Stray Current?

6 What can be done in an emergency situation when battery charging system fails?

Check your answers over the page.

© OTEN, 2002/229/03/2003 P0026536

Answers to check your progress

1 If two or more resistors, batteries are connected in line with each other, they would be connected in series and the total resistance or voltage would be the sum of the individual components added together.

If you connect lights in parallel the voltage across each light would be the same but the total current or power used would be the sum of the current or power in each path.

2 The ratio of the potential difference (volts) between the ends of a conductor and the current flowing through the conductor is constant. This ratio is called the resistance of the conductor and is expressed as:

$$\text{Resistance} = \frac{Voltage}{Current}$$

$$R = \frac{E}{I}$$

3 This means that no part of the circuit is connected to any ground or equipment. The system is completely isolated including engine sensors, starter motors and alternators.

4 Any system with a voltage below 110 V is known as an Extra Low Voltage (ELV) system. Systems where the voltage is between 110 V and 240 V are known as Low Voltage systems.

5 Stray currents are leakage currents which occur when a conductor has an earth fault.

These faults are usually caused by moisture in junction boxes or other components, and from damaged cable insulation. They are often too small to trip circuit breakers or other protection devices.

Stray currents create electrolytic corrosion which will increase corrosion rates on hulls and sacrificial anodes and will degrade the galvanic protection system.

Because of the effects of stray currents, it is necessary to regularly check the earth monitoring system as it is imperative that the earth faults be rectified as soon as practical.

6 In an emergency, if there is a faulty regulator or a partial diode failure, the regulator can be disconnected and a full field voltage connected to achieve maximum output.

© OTEN, 2002/229/03/2003 P0026536