Basic circuit design – From Battery, cables, fuses, control devices, motors

When you have chosen your kit or the model to build, take some time to decide what electrical items you are going to be using in the finished model.
Consider the following: Battery, fuses, switches, speed controller/s, drive motor/s, receiver, pump/s, winch motor/s and lights.

Plan ahead and choose the locations of key items before the model build gets too advanced, key items are ones which you need access to such as, battery, speed controllers, receiver, operating switches, fuses and connections.

Consider also the cable routes; it is important to run cables so that interference does not occur in the electronic parts of the model. Keep power cables away from servo leads, the receiver unit and aerial lead.

Consider also that during the model build you can install cable ways (a piece of tubing or trunking), or install the cables as you build, this ensures a nice tidy installation once you have the deck in place.

Install connectors at key points, this enables you to remove components, split sections (i.e. remove superstructure) and to enable fault finding.

Connections

An electrical wiring system in even a simple model can have over 10 connection points and it is important to consider how you are going to make your connections.
There are basically two ways to join wiring together or to join wires to your chosen connector, these are screw or crimp type terminals. If you do not have access to a crimp tool then try to borrow one.

As a rule do not use screw strip connectors as used for mains wiring, these types of connectors corrode quickly and if you put PVC insulation tape around them it makes it even worse due to condensation under the tape. If you do decide to use this type of connector always enclose it in a waterproof box with a removable lid.

Do take care as a poor connecting can lead to shorts or will create a high resistance which will fail due to overheating. Always use the correct type of connector to attach wires to your battery.

Layout – Isolation & general purpose switches

Install your electrical system in the following sequence as shown below and you should not go wrong:

1. Battery: Use correct battery connectors and silicone insulated cable.
2. Install Main fuse in battery lead: This should be sized to power the whole system but should be 1.5 times the maximum measured load.

3. Install a Fuse box to distribute individual fused supplies to your system
4. Wire from fuse box to control switches, speed controllers, receiver etc.

As a rule do not cut off the connectors on your chosen speed controller, always fit connectors on your wiring to suit the speed controller you are using. This is important as if you need to re-place the unit it is only a matter of un-plugging it.

Relays. If you use relays to switch power loads then always choose sealed types even if they are a little bit more costly to buy. Relays ideally should be installed in a sealed enclosure if possible.

Switches can be of any type but take care to shield the connections, either mount the switches in an enclosure or fit small sleeving to the wiring in order to insulate each terminal on the switch. Ideally they should be rated at 2 x the load current you intend to switch and should be rated for DC use.

Battery types:

There are many types of battery available for the model builder and the type of model and the space available will determine in part what battery is used.
Also the type of motor will decide what battery is used, as a rule general commutator type mo-tors will work happily with sealed lead acid or Ni Cad type batteries.

High current drain motors and brushless motors for fast electric type boats will require Ni Cad, NiMH, Li Ion or Lithium-Polymer type cells as these types of battery have very low internal im-pedances and will allow high currents to be drawn.

Sealed Lead acid batteries have higher internal impedance and therefore it is not good practice to allow very high currents to be drawn continuously as they are prone to overheating.

Battery tips: If you allow the following points to occur your battery life will be greatly shortened and you will loose available power rapidly.

1. Do not allow your battery to become completely exhausted if possible as this makes it difficult to bring the battery back up to full charge. Battery cells require to be maintained at a minimum voltage.
2. Do not leave your battery in a discharged state, always recharge as soon as you get home, this helps to keep the internal plates/cells in good order.
3. Do not short out your battery terminals. Rapid heating of the plates inside the battery occur and severe irreversible damage occurs.

Battery Size – What does the Ah of a battery mean and how to size a battery correctly?

Depending on the model, battery size is usually decided by two factors, the voltage required and the physical size and weight.

However there is a factor which not many modellers will consider that is the electrical size required:

To choose a battery to run a particular load for a chosen time period requires you to know some basic information:
1) You have to know what the running load is
2) You have to determine how long you anticipate you are going to be drawing load on the chosen battery.

Once you know the above use the following equation:
Load Current (I) x Hours run = A. H. (Amp hours)

For example; for a 12 volt battery: 5 amps x 1 hour = 5 Amp Hours

Voltage – Batteries in series and parallel – 12 & 24 volts

The voltage you will use is usually decided by the type of motors you decide to fit and any other items such as lights and pumps etc. Common voltages for model boats are 6, 7.2, 12 & 24 volts.

Once you know what voltages you need then choose the batteries to suit, for an all 6 or 12 volt system fit one battery, for a 12 and 24 volt system fit two 12 volt batteries in series one battery supplying the 12 volt requirement and the series pair supplying the 24 volt requirement.
Do not interconnect batteries of different types.

Current - What is it and why it is so important?

Current is the amount of electricity which flows when a Voltage pushes the current (I) through a load (Resistance), it is commonly calculated by using ohms law: Volts (V) = current (I) x Resistance (R)
Watts = Volts x Current (Amps)

Any low voltage battery has the capability of delivering very large currents and can easily burn out any of your models wiring system and components. A standard 12 volt sealed lead acid battery shorted out can deliver over 230amps and can destroy wiring in seconds.
Knowing this means you install wiring which does not have to be oversized but you know that in the event of a short circuit it will be protected.

This means the use of fuses; fuses in low voltage systems are basically only a piece of wire which melts when an over current occurs.
Do not be tempted to install circuit breakers, these are only for clean dry conditions and in a boat these will quickly fail, but you won't know this until your boat is on fire!
In order to select fuses and cables use the list below to buy cable and fuses for any particular application.

Measuring Load:
It is important to know what load you are to place on you battery, this also determines what fuse sizes you require to fit.

Start by bench testing your individual pieces of equipment and writing down the loads, you do not need to fit your speed controllers as these do not consume any significant power in themselves.

As a rule if you use lights allow the following current loads per unit:
LED (light emitting diode) allow 20mA per unit
Grain of wheat type lamps 6 & 12: allow 70mA per bulb (The currents vary between lamp manufacturers but this usually are the maximum)

Rule: When designing your system you will know the current for each part of the installation so ensure that:
The fuse is larger than the load, but the cable is larger than the fuse.

Fuses:

Always use fast acting fuses in 12 or 24 volt systems, time delayed fuses incorrectly installed can lead to damage.
You can use either miniature car type fuses and these are available between 3amps and 30amps.
For smaller loads a better choice is the small 20mm glass fuse which can be as small as 50mA and can be purchased in small steps up to 10amps.

Always fit a master fuse in the battery lead, it is a failsafe and is good practice. This should be sized at 1.5 times the maximum load of the system.

Always when testing your motor for current, try to load the motor by holding the shaft and watch the current, size the protective fuse so that it is the next size fuse up to the measured current.
This will ensure that the motor/s will run under load without the fuse failing, but if the motor is stalled due to the prop becoming fouled then the fuse would rupture due to the high currents drawn, this will protect your motor and speed controller.

Tips:

1. Know the maximum running load of the motor
2. If you have more than one motor then fit one fuse per motor
3. Size your speed controllers to be at least 1.5 times your fuse size

Cable sizes:
You do not need to over size cables if they are correctly sized for the load they are taking and are fused correctly.

Firstly cable is usually specified by a number: 32/0.20mm this means it has 32 strands of copper which is 0.2mm in diameter, each size can carry a specified current which must not be exceeded.

Secondly is the insulation, use PVC sheathed cables for general use and use silicon sheathed cables for high power circuits, high temperature or where there is movement or vibration.

Common cable sizes are as follows on next page:
Note: These are a guide as current values can vary between different manufacturers, type of sheath and number and size of internal strands.

Current Ratings for PVC or Silicone insulated Cables

10/0.10mm	0.07mm	= 500mA (500 mille amps)
7/0.20mm	0.22mm	= 1.4 amps
16/0.20mm	0.5mm	= 3amps
24/0.20mm	0.75mm	= 6 amps
32/0.20mm	1 mm	= 10 amps
30/0.25mm	1.5mm	= 16 amps
50/0.25mm	2.5mm	= 25 amps
56/0.30mm	4.0mm	= 41 amps

Fault finding If something goes wrong how do you find out what the problem is?

If something goes wrong and you find a fuse is blown, do not fit a new fuse straight away and hope for the best, if the system is designed correctly fuses only fail when a fault occurs.

If a specific fuse has failed such as lights or to a motor it is easy to find out what it is, but if you only have one fuse then the best way is to disconnect key items such as your lights and motor circuit and test these individually.

Use a multi meter set to ohms and measure the resistance across the terminals to each item, you may find that one particular item has a very low resistance, say 0.1 ohms this would indicate that this item or the wiring feeding it is faulty.

Tips:

1. Measure a good item such as a lamp or a motor so that you know what a good resistance reading should be, then you will know when measuring the components in the boat that if the reading is a lot lower than this the item is faulty.
2. Take care when measuring LED indicators as they conduct in one direction + to – and not in another. They should not conduct in both directions i.e. + to – and – to +.
3. Filament lamps have a specific resistance and if you have many lamps in parallel the measured resistance will be lower than it would be for one lamp. Tip; if when you have finished making your model and all is working correctly, use your ohm meter and measure the resistance of the lighting circuit and write this down, if this circuit fails you will know what the resistance reading should be.
4. If you have measured your motor current under load then the fuse should not have failed just because it was working hard, but check if the prop is seized, a stalled motor can appear as a short circuit. If in doubt disconnect the motor from the speed controller, test it using the meter, if you feel it should be ok power the motor directly through a fuse from the battery, if the fuse fails then you know the motor is faulty, if it runs but the motor fuse still fails in the model then it is your speed controller.