

Basic Marine Electrics and Troubleshooting

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Agenda

A few bootstrap terms to get started

Managing expectations

Battery fundamentals

Charging batteries

Introduction to marine 12 volt circuits

Basic marine 12 volt systems

Troubleshooting marine 12 volt systems

Battery Management

First a few electrical terms

Voltage (V)

- The pressure of the circuit, without pressure there is no output!

Current (I)

- You increase voltage (pressure) to increase the current flowing measured in amps

Power (P)

- The work being done, measured in watt (Power = voltage x current)

Ampere-hours
(Ah)

- The amount of current (amps) a battery will delivery and the time (hours) it delivers the current (Ah=current x Hrs)

First a few electrical terms

Battery

- A source of electrical energy

Starting battery

- The battery for starting or cranking engines (Cranking battery)

House battery

- The battery providing electrical loads when the engine is not running (Deep cycle battery)

Rate of discharge

Rate of charge

- 20 amp load for $\frac{1}{2}$ hour reduces your battery by 10 Ah

State of charge

- Indication of available battery capacity measured in percent (fully charged = 100%)

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Managing Expectations

2 What battery capacity do I require?



Discharge



Charge



1 How much electrical energy do I consume?




3 What charge current and charge time do I require?

Managing expectations

3 questions you should be able to answer


Consumption (all scenarios)

(1) How much electrical energy do I consume?



Battery capacity

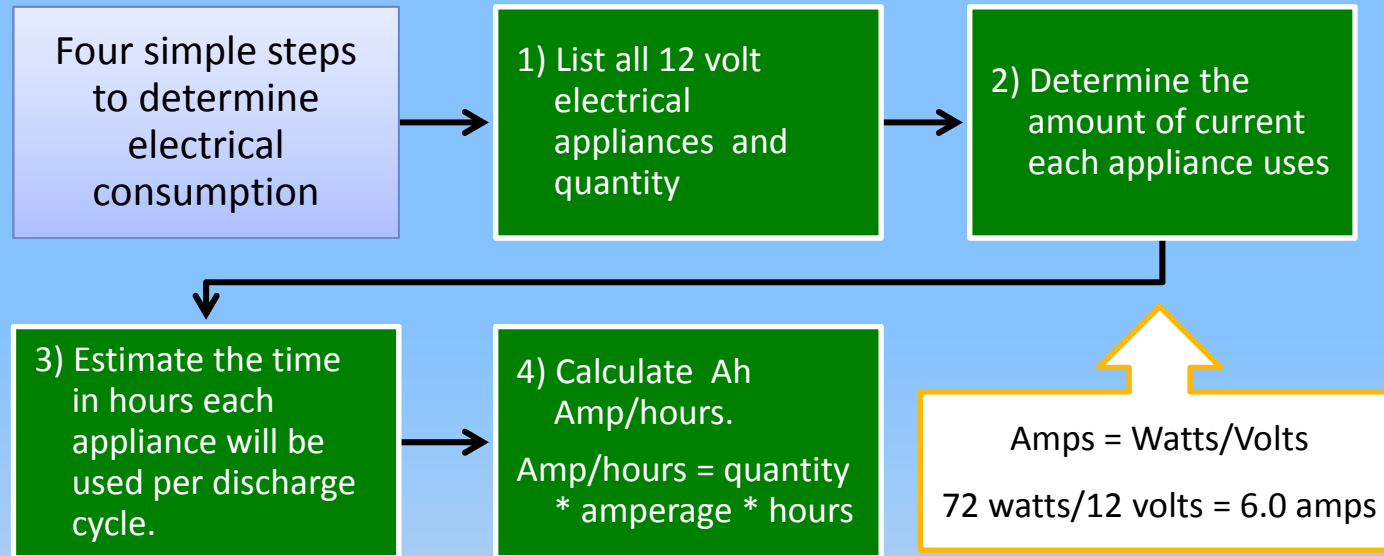
(2) What battery capacity do I require to support my consumption?



How to charge batteries

(3) What charge type, charge current and charge time do I require?

1 Consumption per cycle



(1) Appliance	(1) Quantity	(2) Current (amps)	(3) Time Used (Hrs)	(4) Total (Ah)
Cabin lights	8	1.5 A	1.0 Hrs	12 Ah
VHF (receive)	1	0.3 A	24 Hrs	7 Ah
Fresh water pump	1	2.5 A	0.5 Hrs	1 Ah
Navigation lights	3	0.9 A	12.0 Hrs	11 Ah
Refrigerator	1	6.0A	24/3 Hrs	48Ah
Total Amp-Hours (Ah) usage per discharge cycle				79 Ah

Typical appliance loads

12 Volt Appliance	Amps (typical)
Anchor Light	2.0
Anchor light (LED)	0.25
Anchor windlass	40-300
Autopilot standby (drive)	1 (30)
Bilge blower	2.5
Bilge pump	5.0
Cabin fan	0.2 – 1.0
Cabin lights (incandescent)	1.5 – 3.5
Cabin lights (halogen)	1.6 – 2.0
Cabin lights (LED)	0.3
Fluorescent light	0.7 – 1.8
Depth sounder	0.1 – 0.5
Fresh water pump	5.0

12 Volt Appliance	Amps (typical)
GPS	0.5 – 1.0
Log	0.1
Masthead (incandescent)	2.0
Radar	4.0 – 8.0
Refrigerator	5.0 -8.0
Navigation lights	2.5
Spotlight	10.0
Deck lights	8.0
HF radio RX (TX)	2.0 (25 -35)
VHF radio RX (TX)	1.0 (5.0 -6.0)
Stereo HiFi	1.0
Instrument slave (each)	0.1
Instrument master	0.3 – 1.0

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Some battery facts

A battery does not store electrical energy, it converts chemical energy into electrical energy by electrochemical reaction

You shorten the specified life of your battery by undercharging and conversely by overcharging

Specified battery life is shortened by discharging below 50% of capacity

Batteries are inefficient, you need to replace 10% to 20% additional amp-hours to recharge your batteries

The voltage difference between a fully charged and fully discharged battery is approximately 1.0 volt (12.6 v to 11.6v).

More battery facts

The greater the discharge rate, the less battery capacity available

- 100Ah battery discharging at 65A for 1 hour will exhaust battery providing **65Ah**
- 100Ah battery discharging at 5A for 20 hours will provide **100Ah**

A deeply discharged battery struggles supplying power to high amperage device, however may supply sufficient power to a low amperage device

- Open circuit voltage of **12.5 Volts**

• Starter Motor	11.09 volts	231 amp	2562 watts
• Light bulb	12.49 volts	1 amp	12.5 watts

- Open circuit voltage of **12.0 Volts**

• Starter Motor	10.00 volts	200 amp	2000 watts (-22%)
• Light bulb	11.90 volts	1 amp	11.9 watts (-5%)

More battery facts

When charging a battery, the charge voltage must be higher than the fully charged voltage, typically 13.8 to 14.0 volts

- Greater the voltage difference between charge device and battery, greater the charge current

A deeply discharged battery can absorb as much as 30% of its capacity, until it starts gassing (14.4 volts)

- 10% charge rate, reaches gassing voltage at 8 hours and will be 85% charged
- 40% charge rate, reaches gassing voltage at 1.3 hours and will be 55% charged

The most practical charging rate for a quick recharge is 20% to 30% of the battery capacity until it reaches the gassing voltage

More battery facts

A battery accepts more charge amps at 50% discharge than at 25% discharge

- Battery acceptance rate tapers to just a few amps as it approaches fully charged.
- A 100 Ah battery at 50% capacity, accepts 17 amps
- The same battery at 75% capacity, accepts 7 amps

The charge time from 50% to 80% is much shorter than the time it takes from 80% to fully charged

(Q2) What battery capacity

Discharging your battery below 50% will significantly shorten its specified life expectancy

- 50% capacity should be your operational discharge limit

The charge rate of a battery decreases above 80% of charge

- For a 100Ah battery, 17A at 50% and 7A at 75%
- Both time and cost to charge double above 80%

Therefore the efficient capacity of a battery is 30% of its Ah capacity.

- For a 100 Ah battery you should only budget on 30 Ah discharge before recharging.

Battery capacity (Ah), needs to be at least three (3) times your usage between charges

Battery fundamentals

What type of battery is best suited for my type of sailing, what performance should I expect and what additional battery facts should I be aware of?

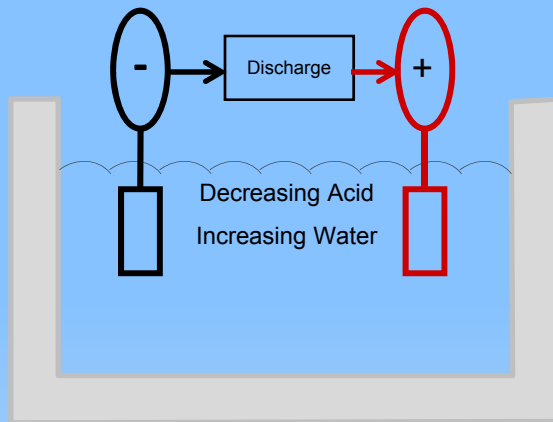
- The basic battery
- Battery types, (applications & construction)
- Understanding battery ratings
- Life expectancy
- Connecting batteries
- Battery maintenance

Galvanic series table (salt water)

Metals and alloys	Range in Volts	
Zinc	-0.98	-1.03
Aluminum Alloys	-0.76	-1.0
Cadmium	-0.70	-0.73
Mild Steel	-0.60	-0.71
Stainless Steel Type 410 (active)	-0.46	-0.58
Stainless Steel Type 316 (active)	-0.43	-0.54
Naval Brass	-0.30	-0.40
Copper	-0.30	-0.57
Lead Tin Solder	-0.28	-0.37
Admiralty Brass	-0.28	-0.36
Silicone Bronze	-0.26	-0.29
Stainless Steel Type 401 (passive)	-0.26	-0.35
Stainless Steel Type 316 (passive)	-0.00	-0.10

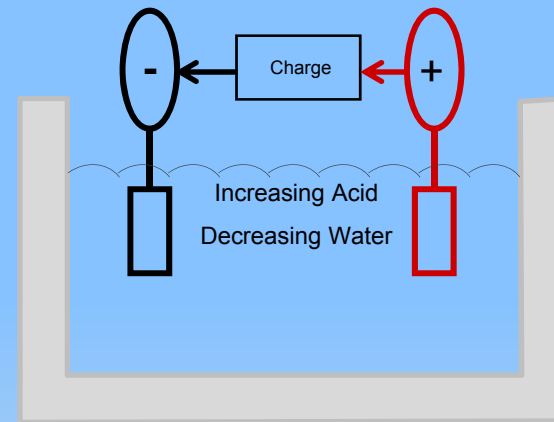
Aluminum Stainless steel joints in salt water produce 0.66 to 1.0 Volts

The basic battery



Decreasing Sponge Lead
Increasing Lead Sulfate

Decreasing Lead Oxide
Increasing Lead Sulfate

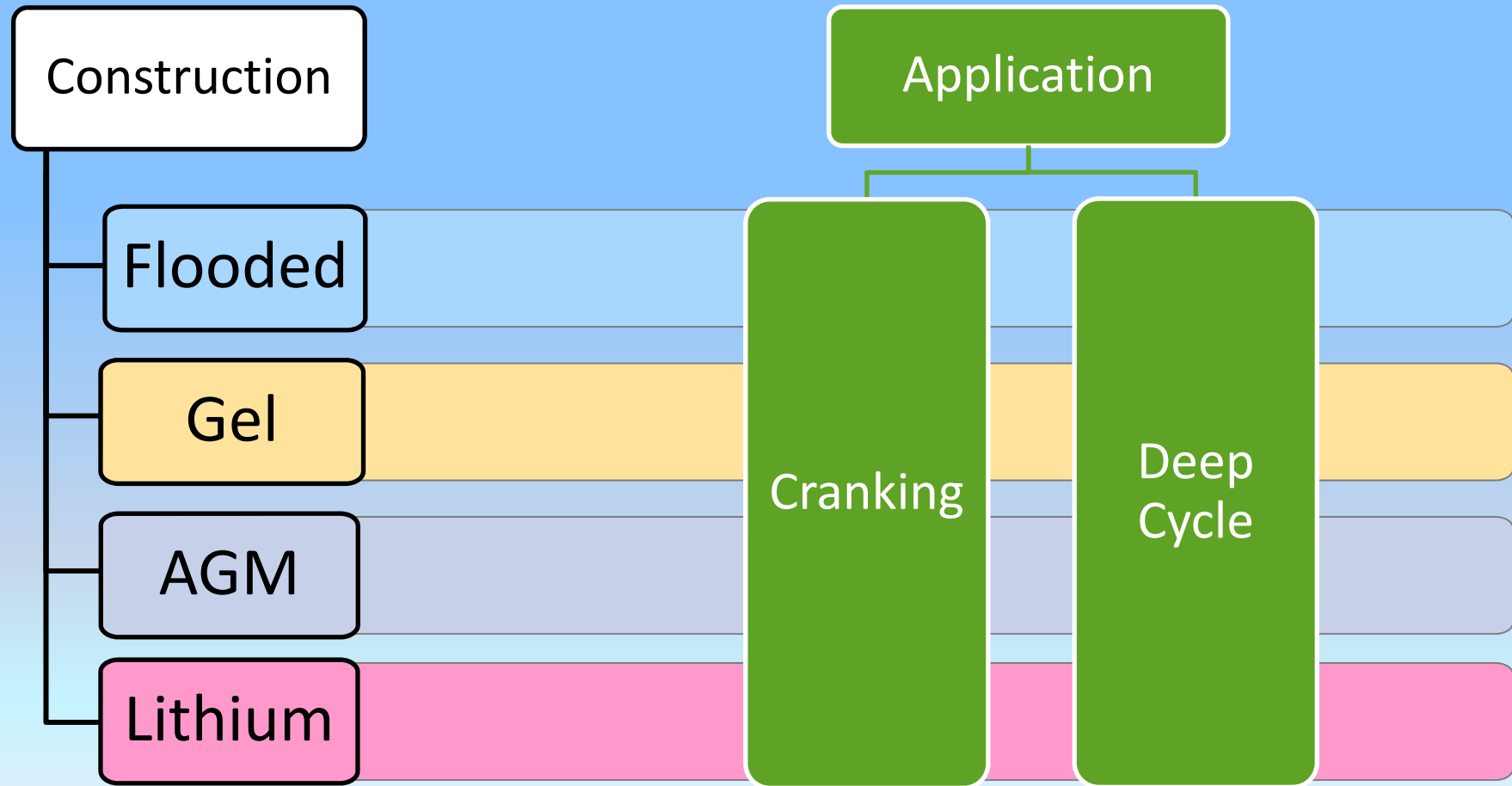


Increasing Sponge Lead
Decreasing Lead Sulfate

Increasing Lead Oxide
Decreasing Lead Sulfate

- A battery does not store electrical energy, it converts chemical energy into electrical energy by electrochemical reaction.
- For a lead acid battery, the fully charged voltage of each cell is **2.1 volts**
- A 12 volt battery consists of 6 cells. The battery terminal voltage will be **12.6 volts** (6 x 2.1) when fully charged

Construction & Application



Battery applications

Cranking

- High current for short periods and rarely deeply discharged
- Small thin plates producing very high current for short bursts
- Begin failing after 50 cycles of greater than 50% discharge

Deep-cycle batteries

- Moderate current for long periods with many discharge cycles
- Rugged, thick plates
- Expect up to 1,000 cycles for a quality deep-cycle battery

Battery Construction



Flooded



Maintenance free
(sealed flooded)



Gel (electrolyte is gelled)



Absorbed Glass Matt (AGM)

Flooded Batteries



The traditional battery construction consisting of lead and lead oxide plates immersed in a liquid electrolyte of sulfuric acid and water.



Often used as automotive starting batteries and some deep cycle batteries such as Golf Cart batteries



Require continuous maintenance to monitor and replenish evaporated water following loss of hydrogen and oxygen

Maintenance Free Batteries

A maintenance free version of the flooded cell, has hardened plates to reduce water loss during charging.

This plate hardening raises internal resistance preventing rapid charging, therefore lower acceptance rate

With the battery sealed, it is impossible to check electrolyte levels or measure specific gravity.

If subjected to excessive charging, the electrolyte will boil off causing premature failure

Gel Batteries

A sealed battery with a gel electrolyte rather than liquid as found in the flooded cell.

Because they are sealed their construction and chemistry is intended to significantly reduce gassing.

This battery must not be allowed to gas.

While they will accept high charging currents they are **very sensitive to high charging voltages**.

Gel batteries must not be charged above 14.1 volts or they will be destroyed. Normal flooded batteries charge at 14.4 volts.



Absorbed Glass Matt Batteries

Similar construction to gel, sealed, and can be installed on their side.

Some consist of soft thin rolled up plates (Optima) resulting in greatly improved resistance to vibration.

AGMs have very low internal resistance and can therefore accept very high charge rates, high acceptance rate.

Maintain a higher terminal voltage during discharge making them more suited for large inverters and sensitive electronics.

As they are not sensitive to charge voltages, standard constant rate charges can be used.



Understanding battery ratings specific to application

Cranking

- CCA, Cold Cranking Amps
 - Is the maximum discharge a 12 volt battery can deliver for 30 seconds at 0°F
 - $525 \text{ CCA} \times 0.5 \text{ minutes} = 262.5 \text{ amp-minutes}$ divided by 60 minutes is 4.3 Ah
- CCP, Cold Cranking Power
 - Same as CCA
- MCA, Marine Cranking Amps
 - Same formula as CCA except rated at 32°F

Higher the CCA or MCA the better for cranking

Understanding battery ratings specific to application

Deep Cycle

- Reserve Capacity sometimes called Peak Capacity
 - Time a battery can supply 25 amps at 80°F to an end point of 10.5 volts
 - Reserve capacity of 160 minutes x 25 amps = 4000 amp minutes or 66.6 Ah
- Amp-hour rate (20 hour rate)
 - Amps required to drain a battery to 10.5 volts over a period of 20 hours at 80°F
 - A battery rated at 100Ah is capable of delivering 5 amps for 20 hours, or 10 amps at 10 hours

Life expectancy

it's all about cycles

When purchasing deep cycle batteries it is important to know the life expectancy in cycles

A battery completes one cycle when it is discharged and then fully charged

The number of cycles depends on the depth of discharge, rate of charge, the recharge method and quality of the battery

When purchasing deep cycle batteries, compare cost per specified cycle in addition to battery price

Battery Life Cycles (50%)

Type	Cycles
Cranking	25 – 50
Flooded deep cycle	250 – 350
Gel	500
6 volt Golf cart	700
High quality AGM	900 - 1700

Actual AGM estimated cycle life

4,000 cycles @ 10% DOD

3,800 cycles @ 20% DOD

3,500 cycles @ 30% DOD

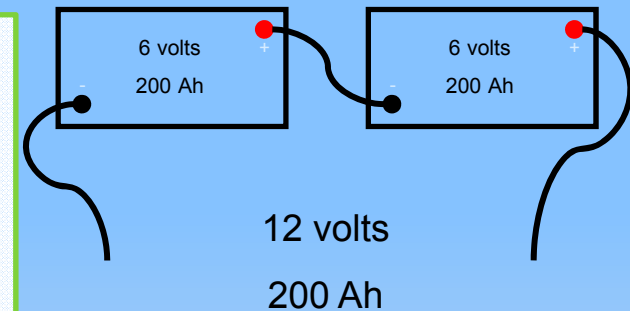
2,500 cycles @ 50% DOD

1,500 cycles @ 80% DOD

Connecting Batteries

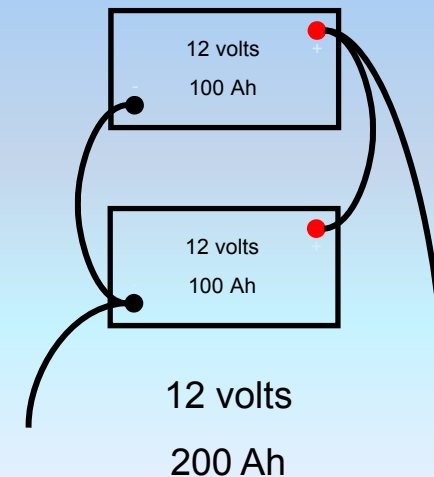
Batteries in series

- Increase voltage by connecting batteries in series, connect positive of one to the negative of the other
- **Two 6 volt 200 Ah batteries in series will yield one 12 volt 200 Ah battery configuration**



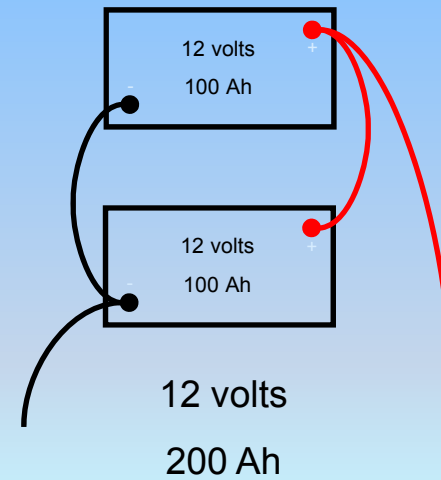
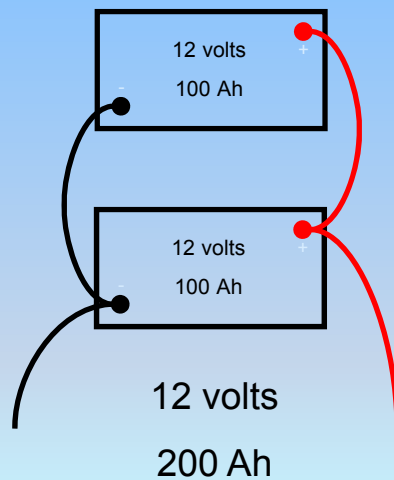
Batteries in parallel

- Increase amp-hours (Ah) by connecting batteries in parallel, connect the positive terminals of two or more batteries and also the negative terminals of two or more batteries
- **Two 12 volt 100 Ah batteries in parallel will yield one 12 volt 200 Ah battery configuration**



Connecting batteries

1. Make sure the same current flows through each battery
 - Current will follow the path of least resistance
2. Do not combine old with new
3. Do not combine unlike chemistries



Battery maintenance

Wet cell batteries must be periodically topped up with distilled water and specific gravity recorded

Keep tops of batteries clean, especially the terminals

Periodically remove battery connections clean the terminals and reconnect

Always keep batteries at full charge when not in use

Regularly monitor the battery voltage, especially during charge cycles on any form of sealed battery

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Charging batteries

the 3rd question

“Each morning I find my batteries are heavily discharged, they appear to have less and less charge available”.

- “I thought I fixed the problem by adding batteries and yet a week later I find the batteries are in a discharged state again”

If we have matched our battery capacity with daily electrical requirements, Ah = 3 times daily usage, then we have a charge rate (amps and or time) issue.

(a) what charge device/s (b) what charge current and (c) how long?

(a) Devices

(b) Current

(c) Time

Alternators
and their
regulators

240 volt
battery
chargers

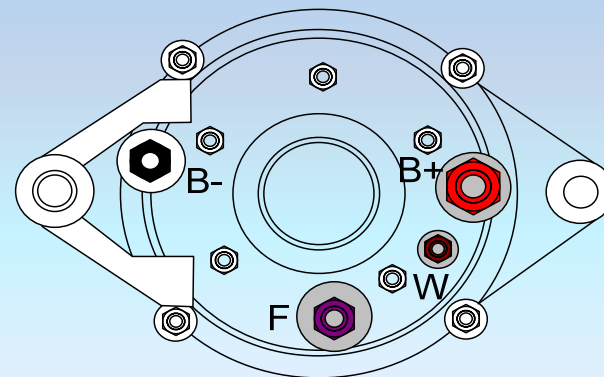
Solar panels

Wind
generators

Alternators

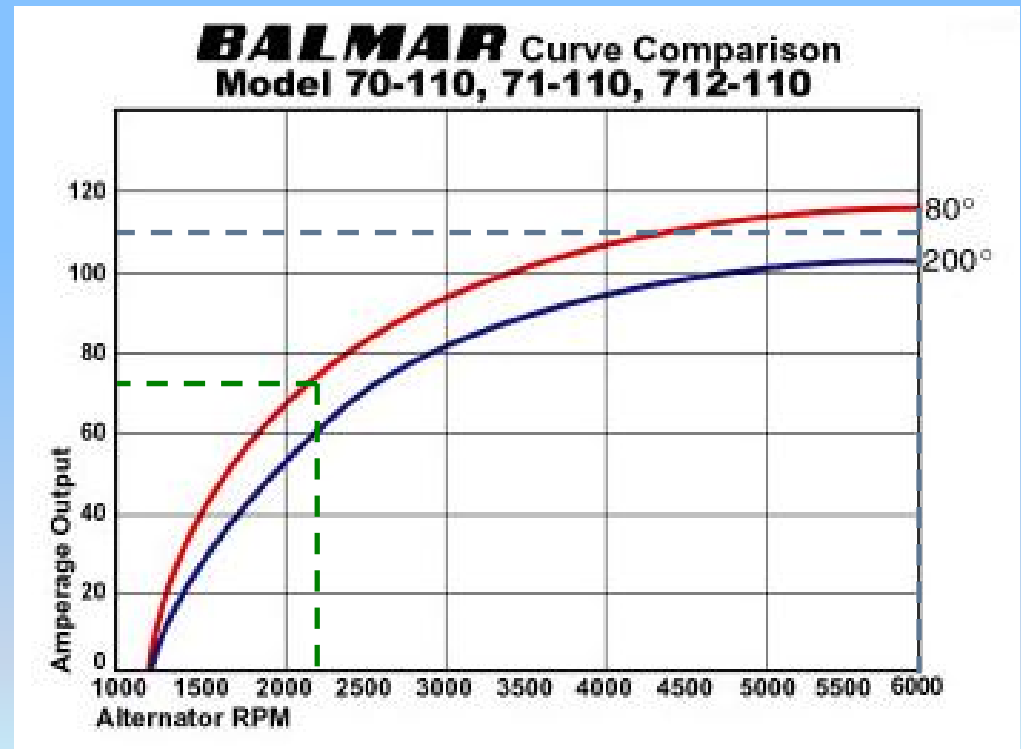
Alternators are an inexpensive and reliable method of charging batteries, mass produced, every car and truck has one, most boats have at least one sometimes two.

There are automotive and marine versions. Marine versions are continuously rated, sometimes fully enclosed, always with a negative power stud, so does not rely on the engine block for return current.

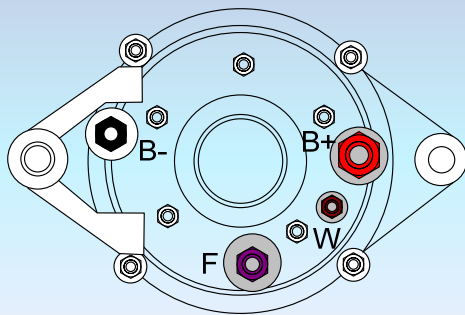
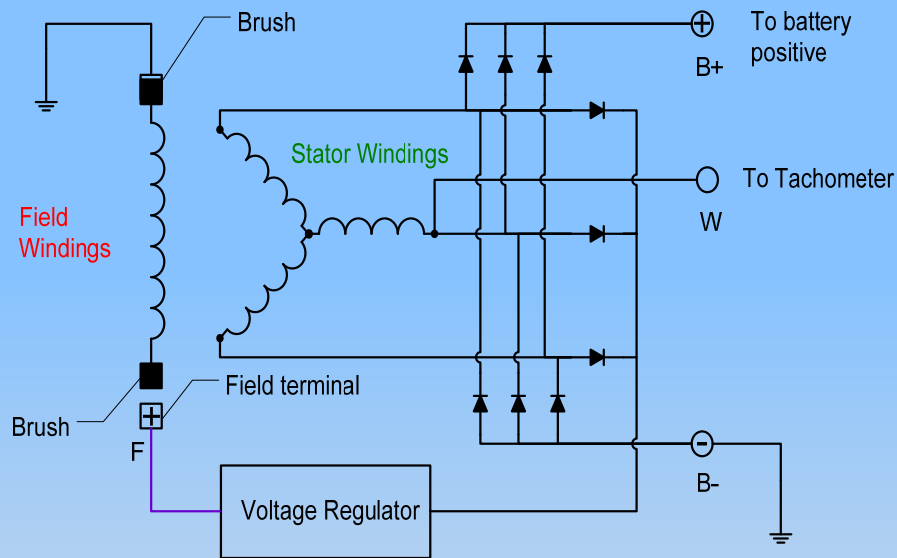


Alternator output

- Assume Balmar 110 Amp alternator with 1 to 3 pulley ratio
 - Alternator turns 3 revolutions for every 1 engine revolution
- At 800 rpm (engine) this alternator will provide 75 amps
- While at 2,000 rpm (engine) this alternator will provide the rated output of 110 amps



Alternators



- They work by passing a rotating field (**field winding**) over a stationary winding (**stator windings**).
- A variable current in the rotating field winding of approximately 1 amp will produce up to 100 amps in the stationary windings.
- The variable field current is controlled by the regulator, thereby controlling the alternator output voltage.
- The output from the stationary windings is alternating current, and is converted into direct current (DC) by a diode rectifier.

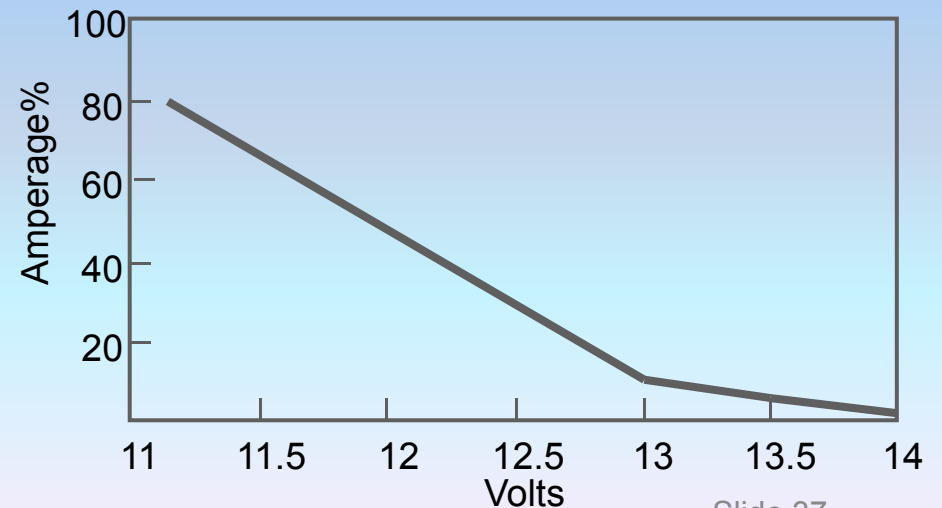
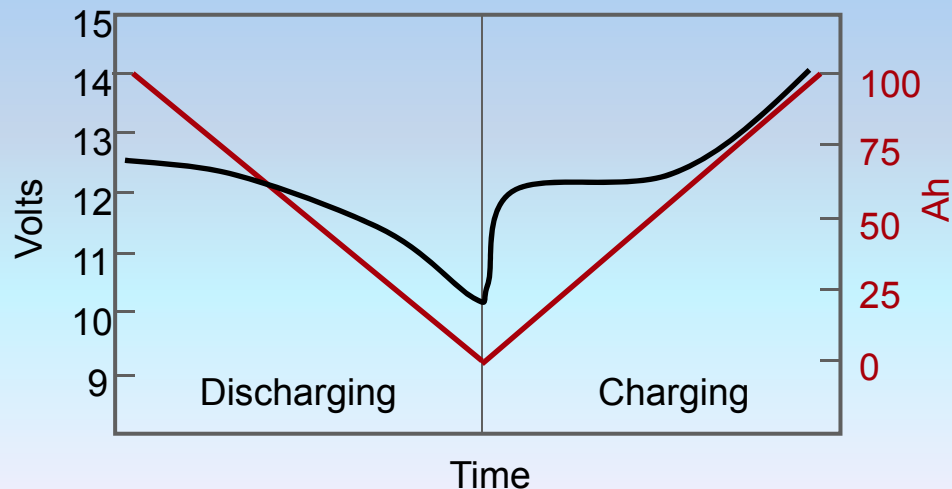
Constant voltage regulator

Automobile Regulators

- The alternator, not the battery provides energy to vehicle electrical system with engine running
- Designed to provide large current initially and reduce current as voltage increases
- Avoids overcharging, gassing of hydrogen and oxygen

Known as a constant voltage regulator

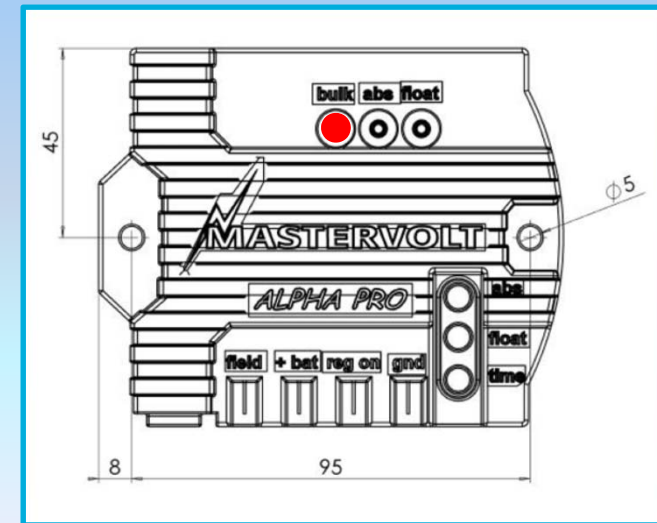
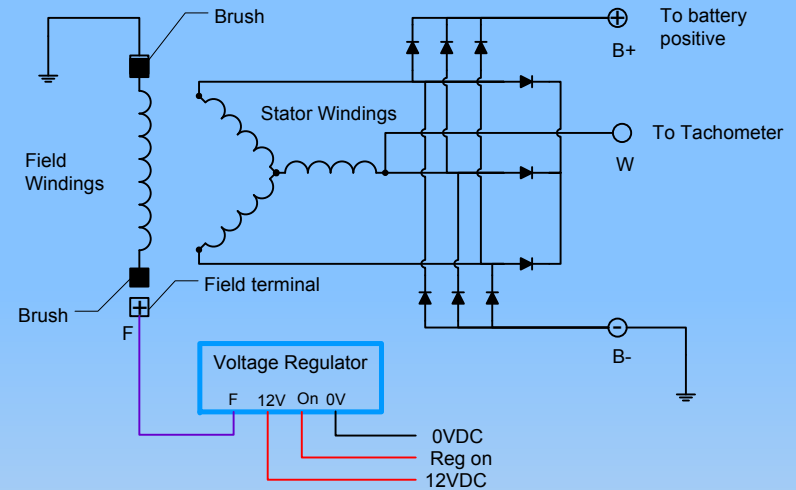
Great for cranking batteries, very bad for deep cycle batteries



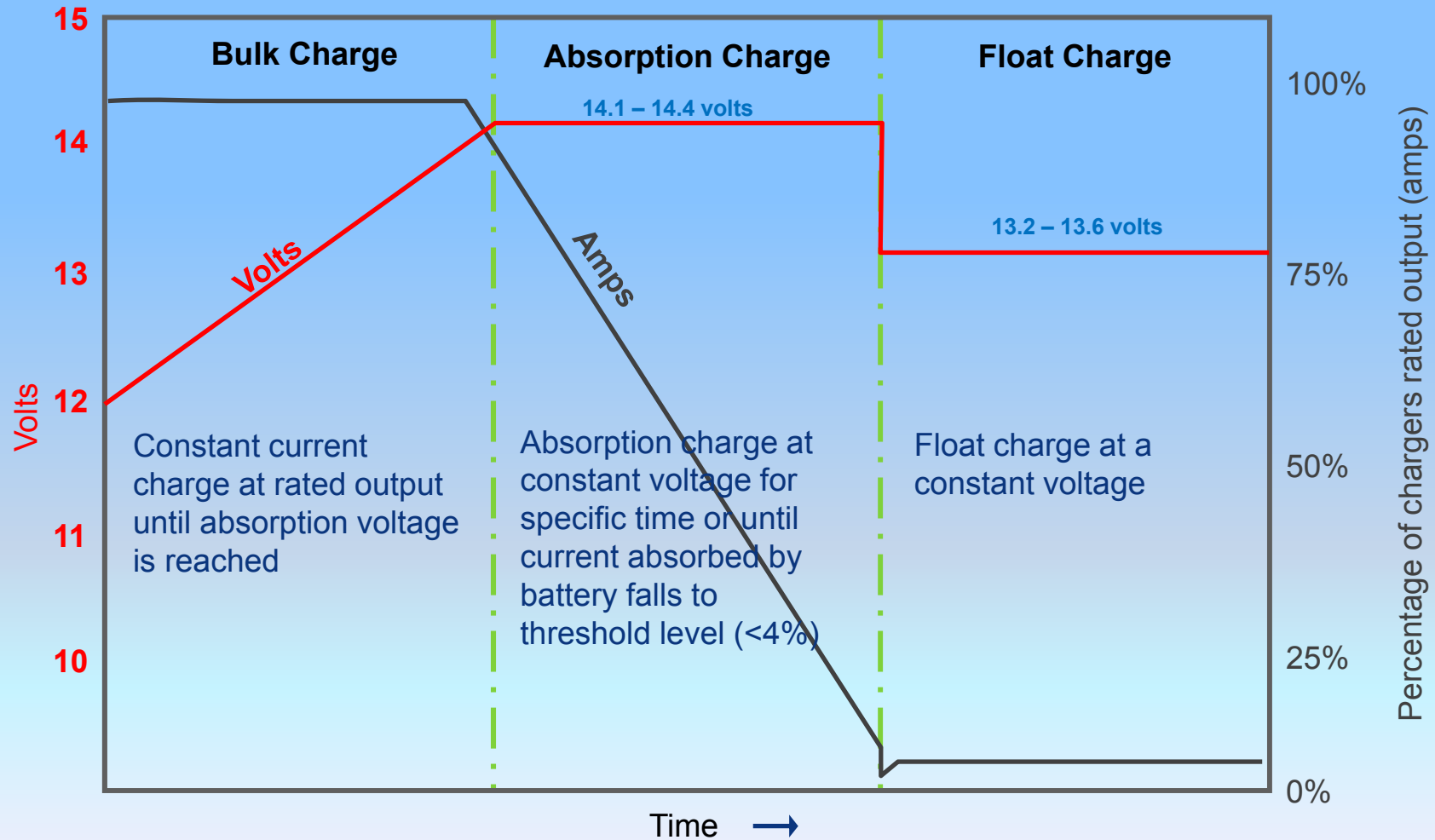
Alternator with smart regulator

Standard alternator with smart regulator makes a very efficient charge device

- Internal constant voltage regulator replaced with external smart regulator
- Provides bulk, absorption and float charge phases
- Constant current in bulk phase reduces charge time to less than 1/4 of constant voltage regulator



Multi stage regulator



240 Volt AC battery chargers

- 240 Volt AC multi-stage battery chargers provide a constant charge current, 50 amp means 50 amps when in bulk charge phase
- Ideally suited for deep cycle batteries (flooded, gel and AGM)
- Suited for charging at marinas and where on board 240 volt AC generation is available
- Sometimes integrated with large inverters



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Slide 40

Solar Panels

- Each cell generates about 0.45 to 0.5 volts so 32 cells are required to charge a 12 volt battery (14 to 16 volts)
- Solar panel must be at 90° to the sun for maximum output, a shadow can reduce output as much as 60%
- Prime sunlight is 9:30 am through 3:00 pm, 6 hours per day
- At 3 to 7 amps an hour for 6 hours per day, typically 18 Ah to 42 Ah, so not a bulk charge device
- They are very good float charge devices preventing self discharge during unattended periods



Wind generators

- Dependent on wind strength, marginal in many areas, very good in trade wind areas (10knts - 1.6A, 29knts - 9.5 A)
- In consistent wind areas can produce up to 150Ah per day, so a viable charge option
- Selection should be based on output and noise level!



Q3 Charging your batteries?

There are three parts to the question;

What charge current?

25% to 30% of your battery capacity plus your average usage in amps is the most efficient charge current
(can be increased with high acceptance rate batteries, AGM)

The most efficient charge strategy is a multi stage charger combination of alternator and mains charger.

If you discharge to 50% of battery capacity and recharge to 85%, you need to replace 35% of battery capacity plus inefficiencies (10%)

What devices should I use?

- Assume battery capacity 200Ah and average current drain 5 amps
- 30% of 200Ah = 60 amps plus average current of 5 amps = 65 amps
- You require a charge system of approximately 65 amp

- Alternator/s (smart regulator)
- Gensets with 240 volt AC charger
- Wind and solar can be treated as incremental

- $35\% \times 110\% = 39\%$ of battery Ah divided by charge current is the charge time
- Scenario above, charge time = $(39\% \times 200\text{Ah}/60 \text{ amps}) = 1.3 \text{ hour}$

How long do I charge?

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Understanding electrical circuits

What are the parameters of a 12 volt circuit?

How do I measure these parameters and how do I apply them to the diagnosis of a 12 volt system?

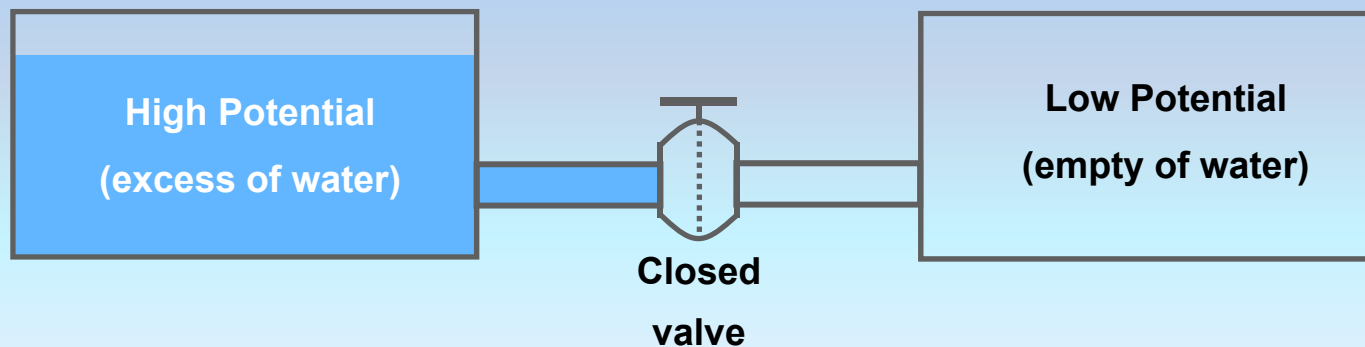
1. The water tank analogy
2. Ohm's law (current, voltage and resistance)
3. Diagnostic instruments
4. Measuring volts
5. Basic electrical circuits (series circuits, parallel circuits and circuits that bypass control switches)

Water tank analogy

Electricity has three parameters: Voltage, Current and Resistance

Voltage

- A force (voltage) pushing the electrical current (electrons) against an opposition or resistance, the load plus cable and connector resistance
- Voltage is the unit of measure of potential difference (symbol V)
- In the water analogy, the force is a head of water, pushing against a closed valve



Water tank analogy

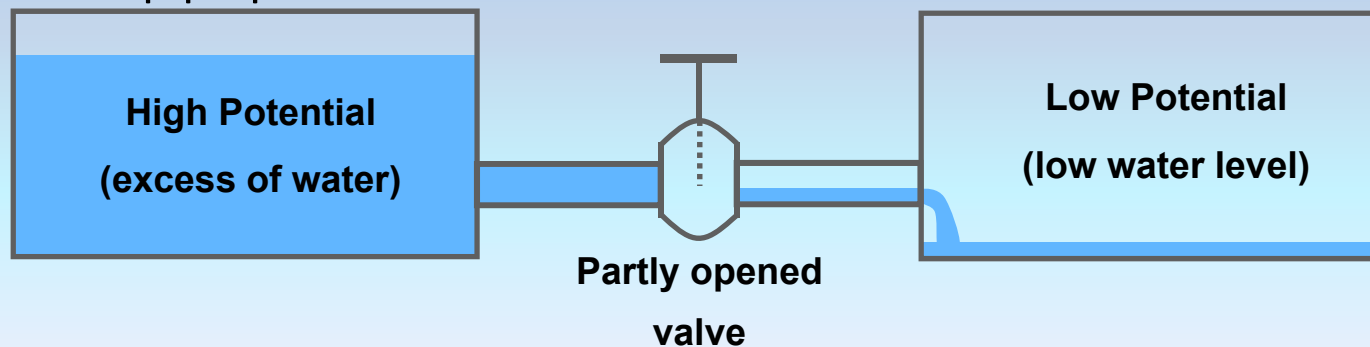
Current

- Is the flow of free electrons past a point in the circuit
- Ampere (amp) is the unit of measure of flow rate (symbol I)

Resistance

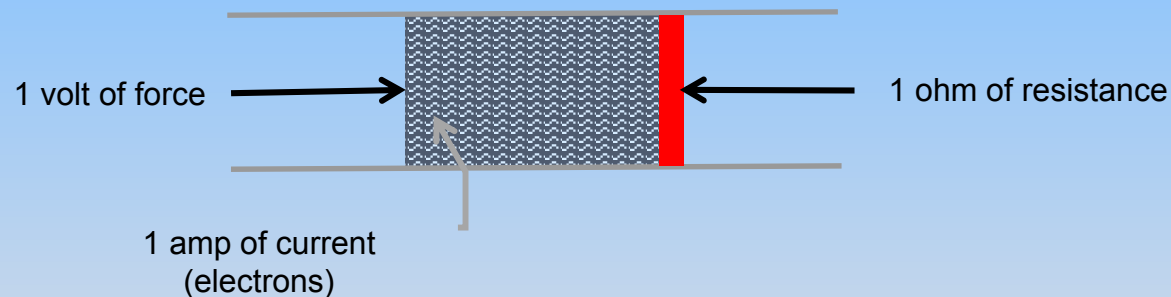
- The opposition to flow of electricity is called resistance, unit of measure is ohm, (symbol R)
- All material in a circuit provides resistance to the current

In the water analogy, head of water is the Voltage, water flow rate is Current, valve and pipe present Resistance



Ohm's Law

- A mathematical relationship exists between the amount of voltage, current and resistance in an electrical circuit
 $V \text{ (volts)} = I \text{ (amperes)} \times R \text{ (ohms)}$
- It takes one volt of applied pressure to move one ampere of electrical current against one ohm of resistance



- Ohm's law can be written in several different forms:
 $I = V/R$ $R = V/I$ $V = I \times R$
- **Power**, measured in watts is the **work** being done or the pressure times the current being passed
Power = Voltage times Current, $P = V \times I$ (746 W = 1HP)

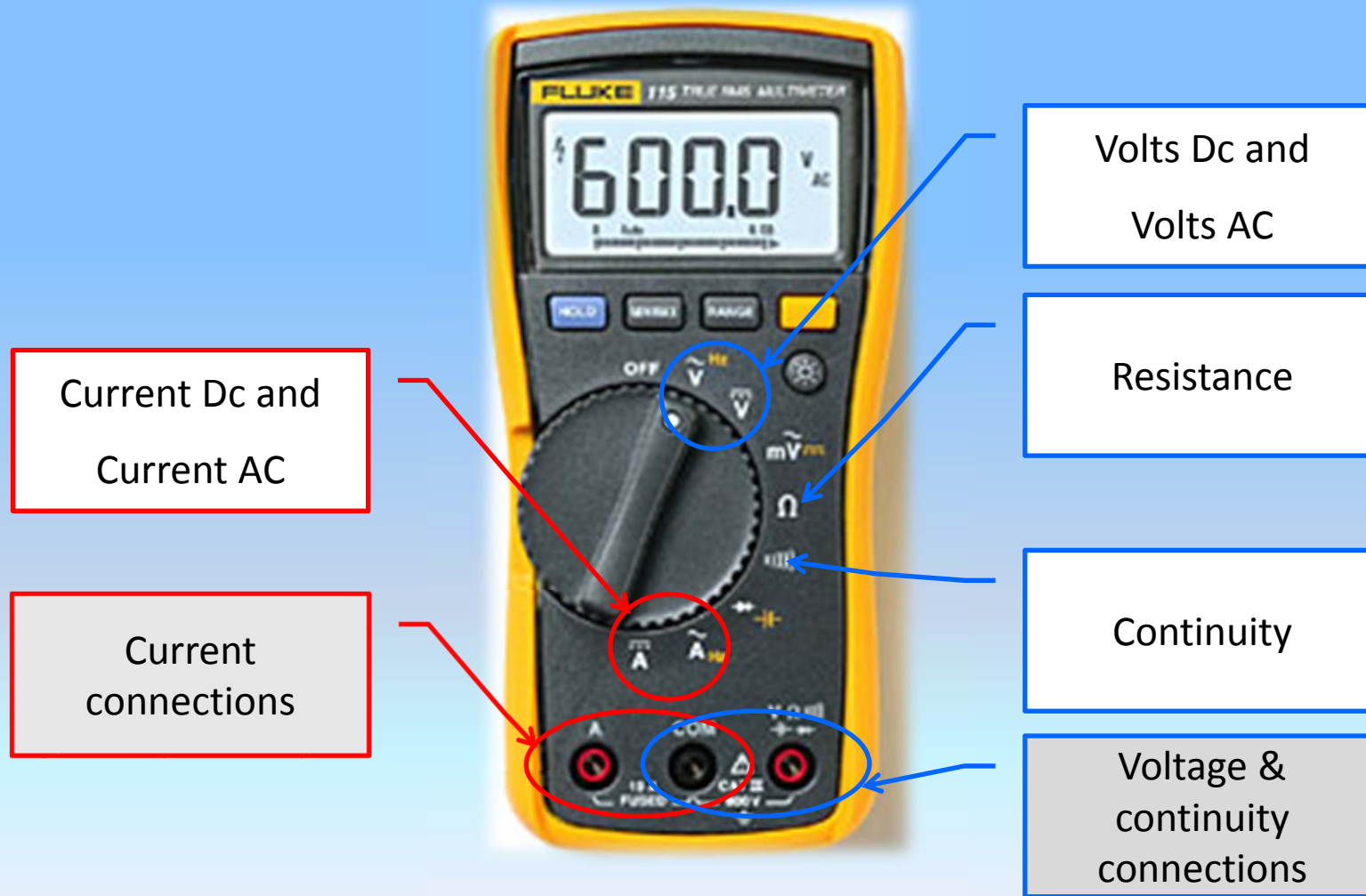
Diagnostic instruments

You can only see electricity in the form of lightning and sparks, feel it when shocked, so an instrument is required to troubleshoot electrical circuits.

- The multimeter is the most common instrument and is used to measure, amps, volts and ohms (AVO)
- Tong meters are excellent ammeters however only as a supplement to multimeters
- A test lamp can be used to measure voltage



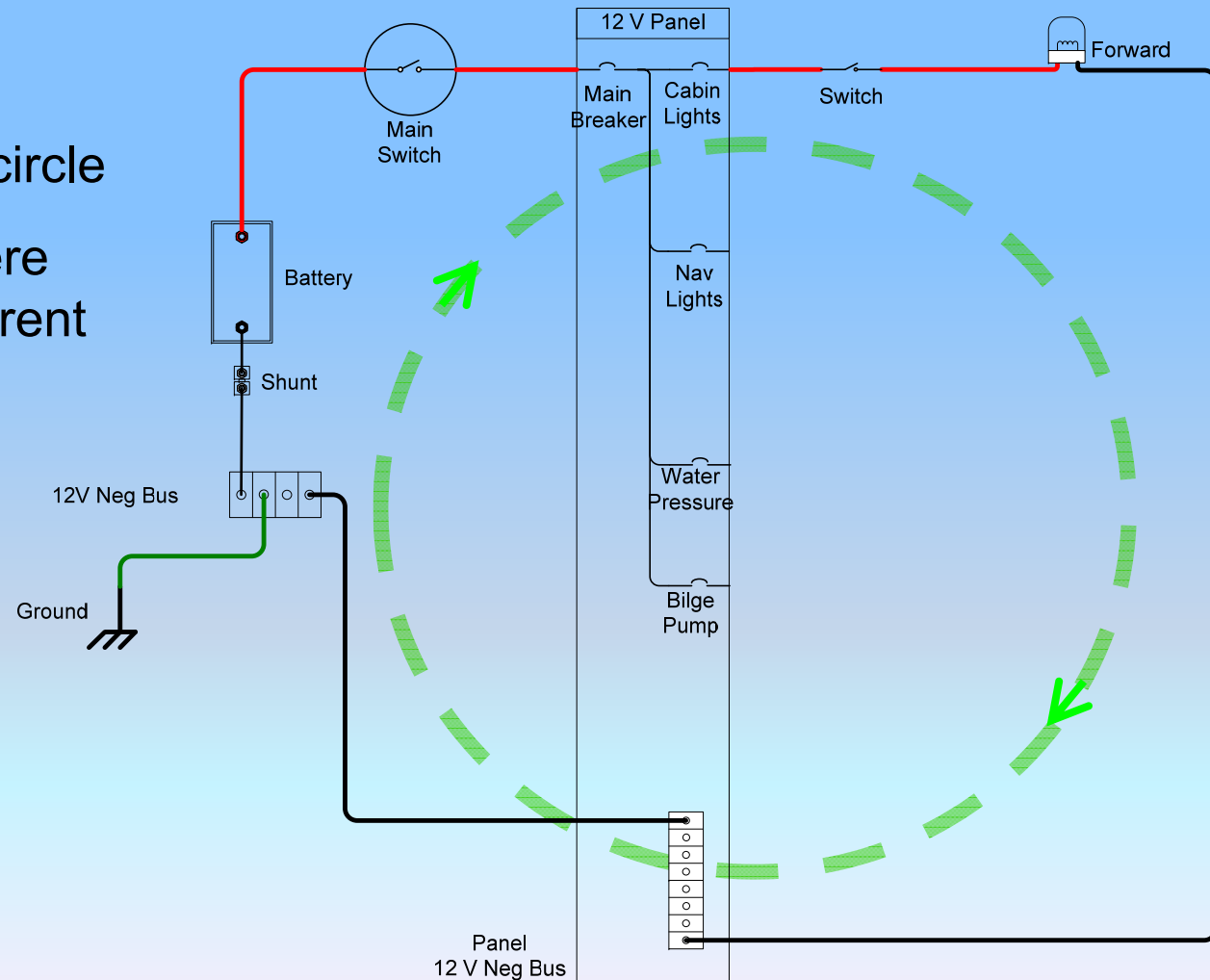
Multimeter selection options



Basic marine electrical circuits

Series circuit

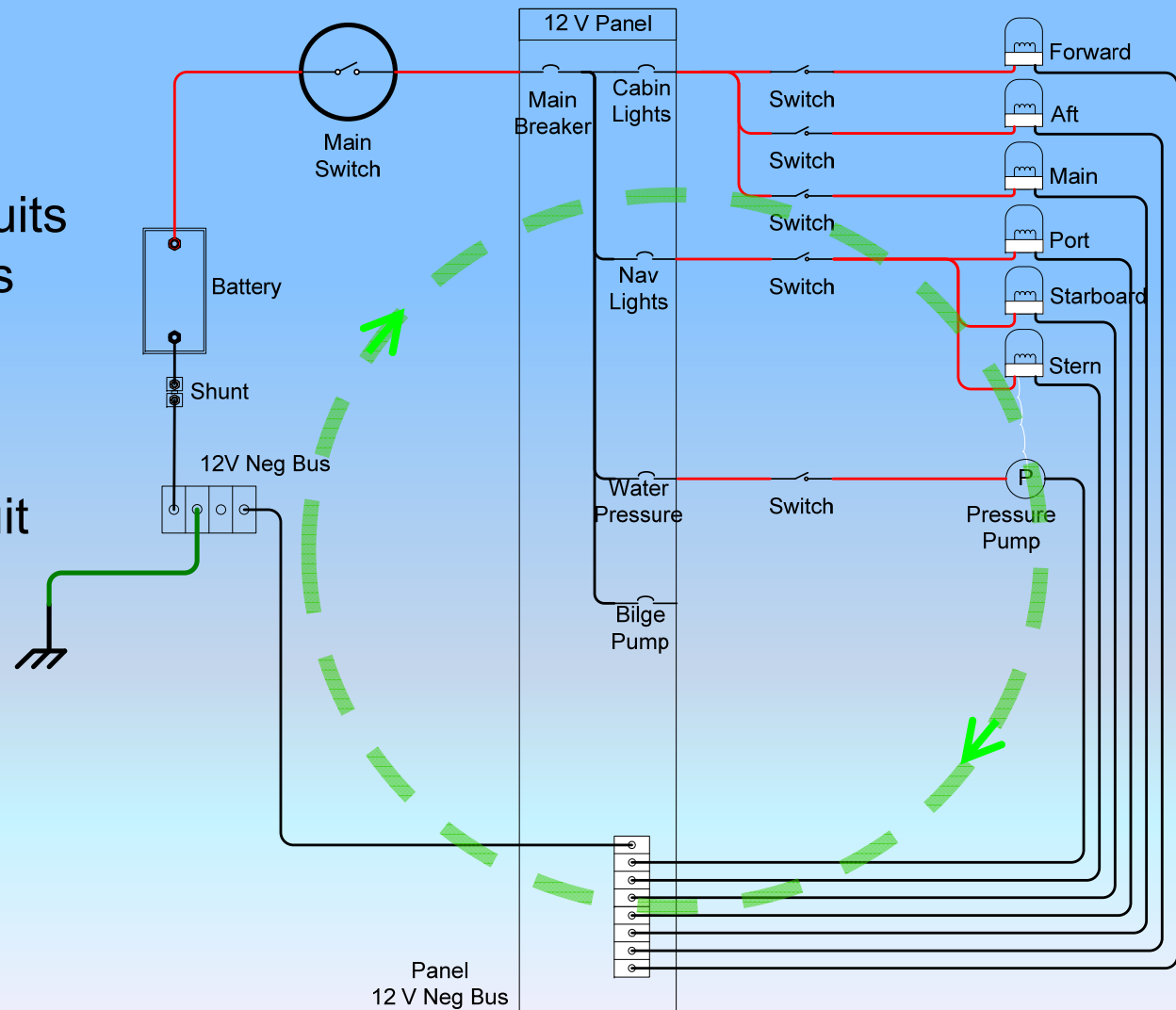
- Think of it as a circle
- A break anywhere will interrupt current flow



Basic marine electrical circuits

Parallel circuits

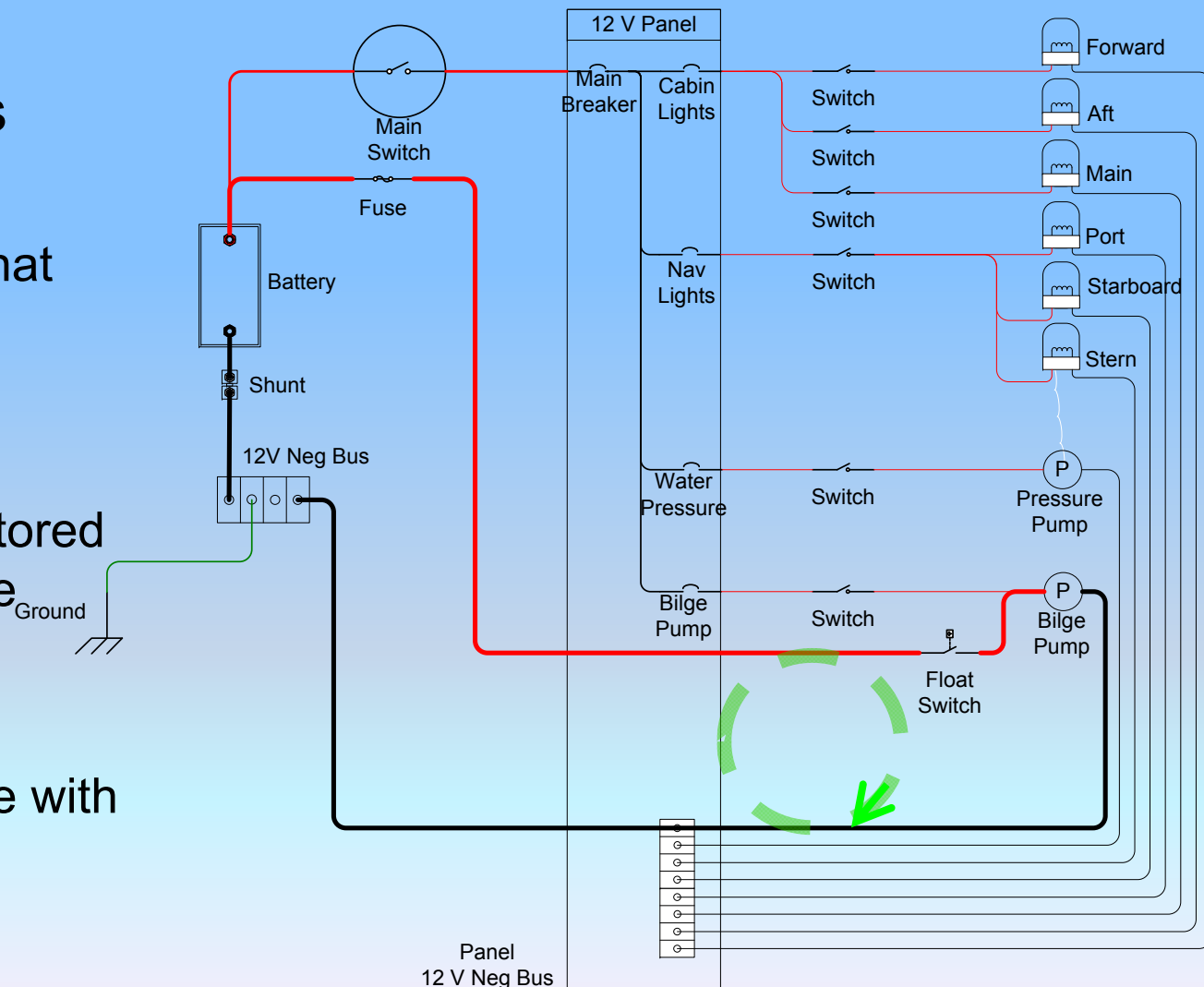
- A set of series circuits with common paths
- Makes for easier troubleshooting
- Think of each circuit as a circle



Basic marine electrical circuits

24 Hour Circuits

- Emergency and standby circuits that bypass the main switch
- Bilge pumps, appliances with stored parameters, shore based battery chargers, etc.
- Just another circle with different controls



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Basic marine 12 volt systems

What are the basic components of a marine electrical system?

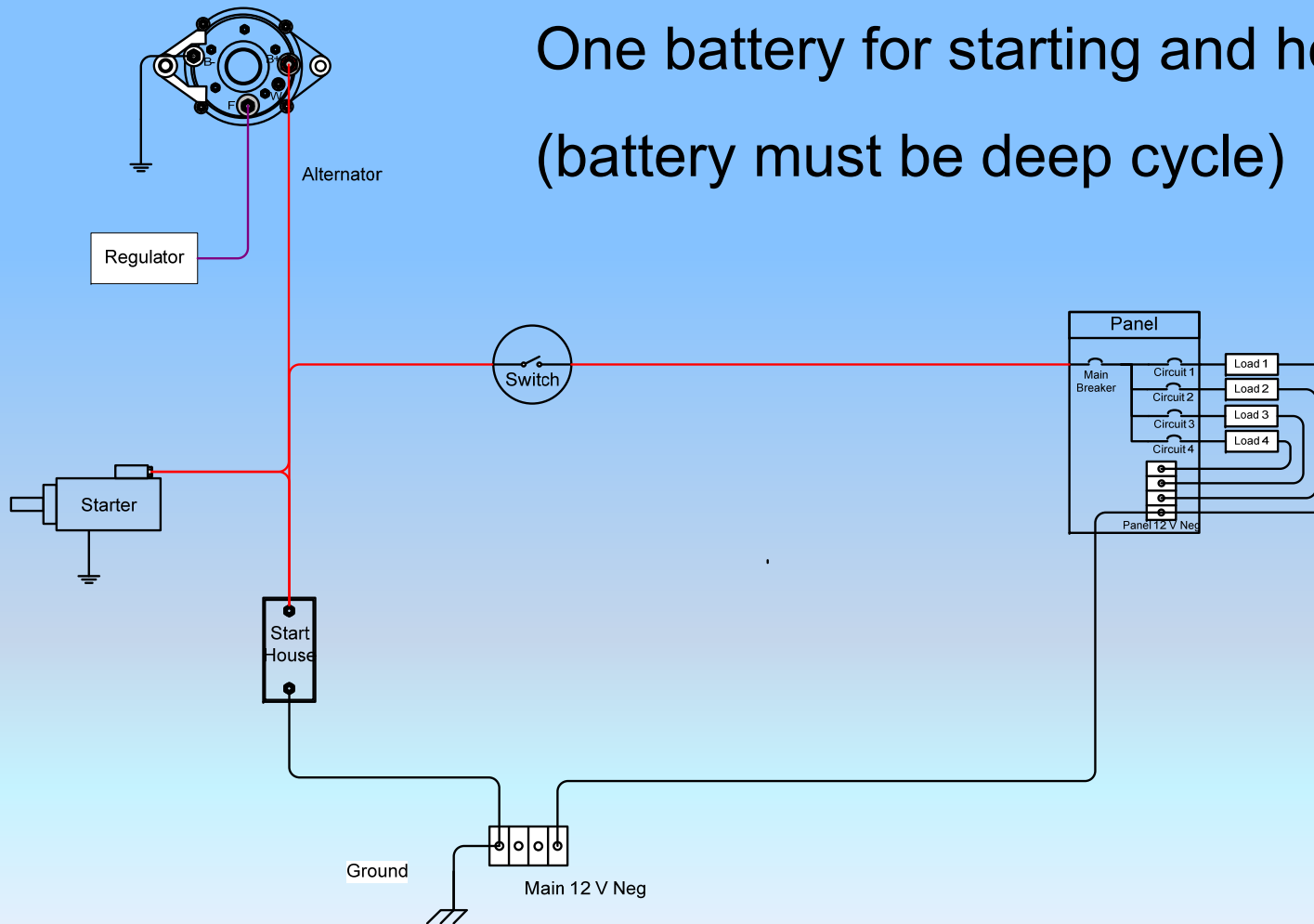
What are the functions of these components and how do I identify them?

Understanding these questions is a prerequisite to diagnosing your 12 volt system.

- Basic marine 12 volt system scenarios
- Cranking (starting) circuit
- Charging circuit
- Battery combiners
- House circuit

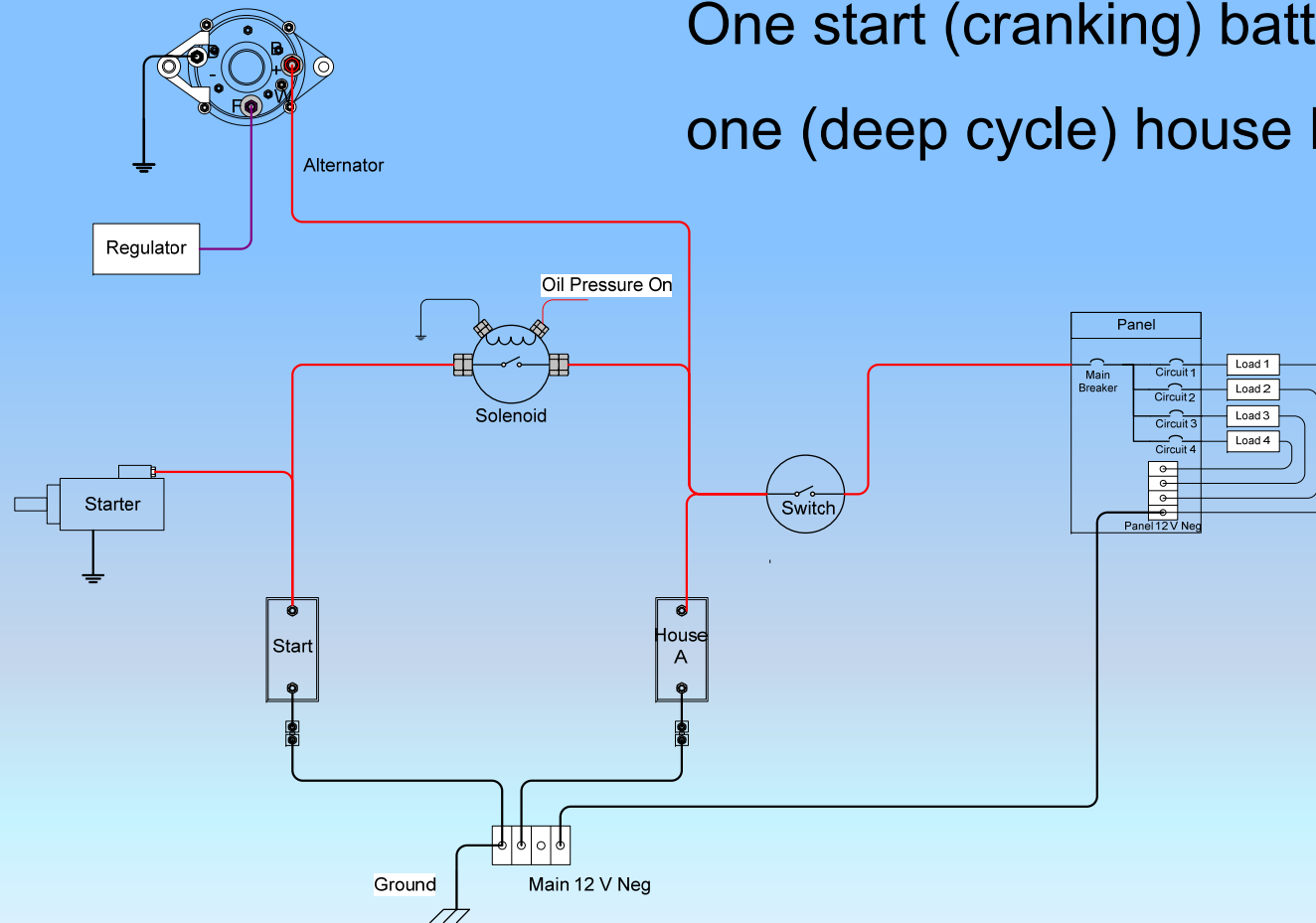
Basic 12 marine volt system scenarios

One battery for starting and house
(battery must be deep cycle)



Basic marine 12 volt system scenarios

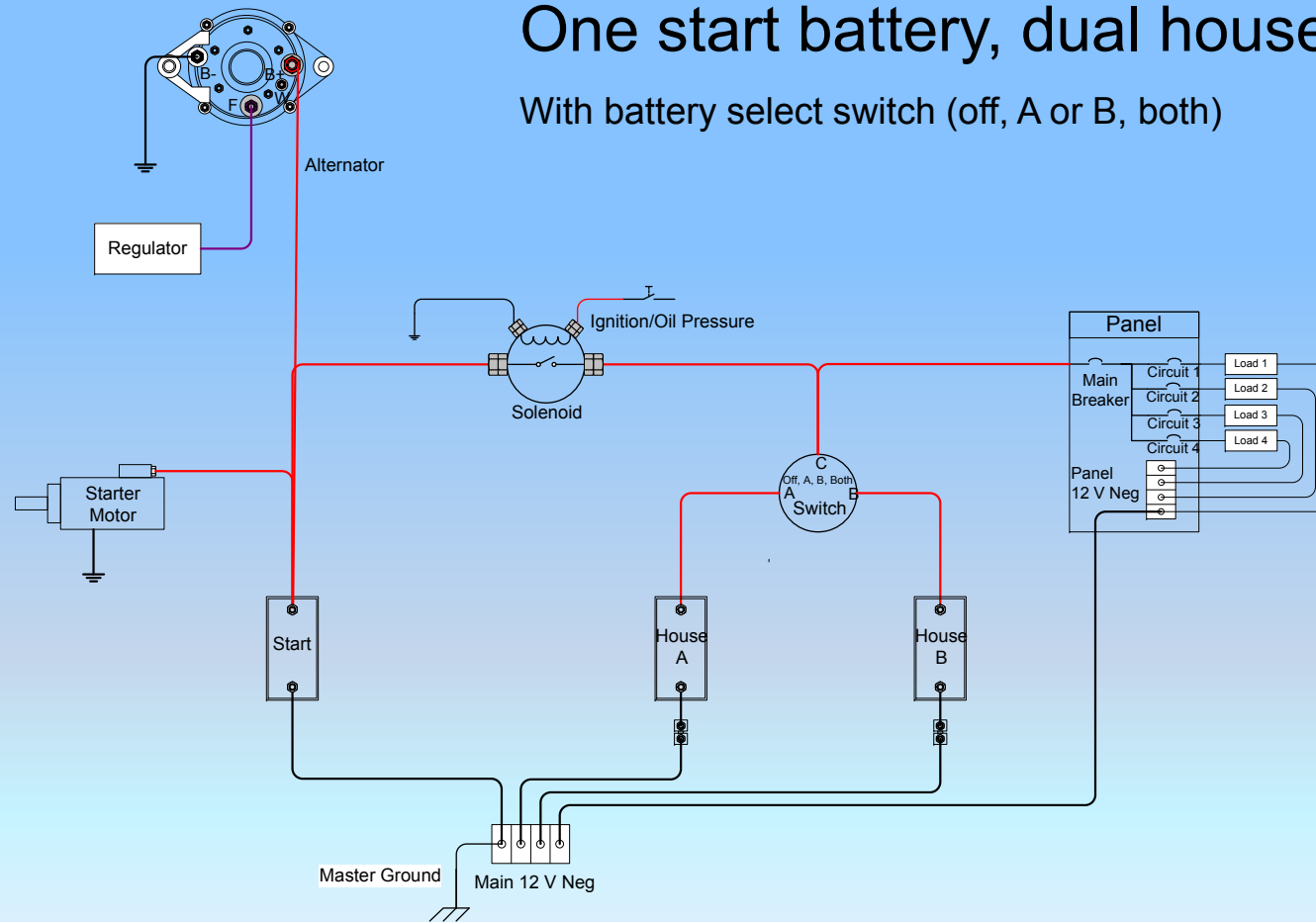
One start (cranking) battery,
one (deep cycle) house battery



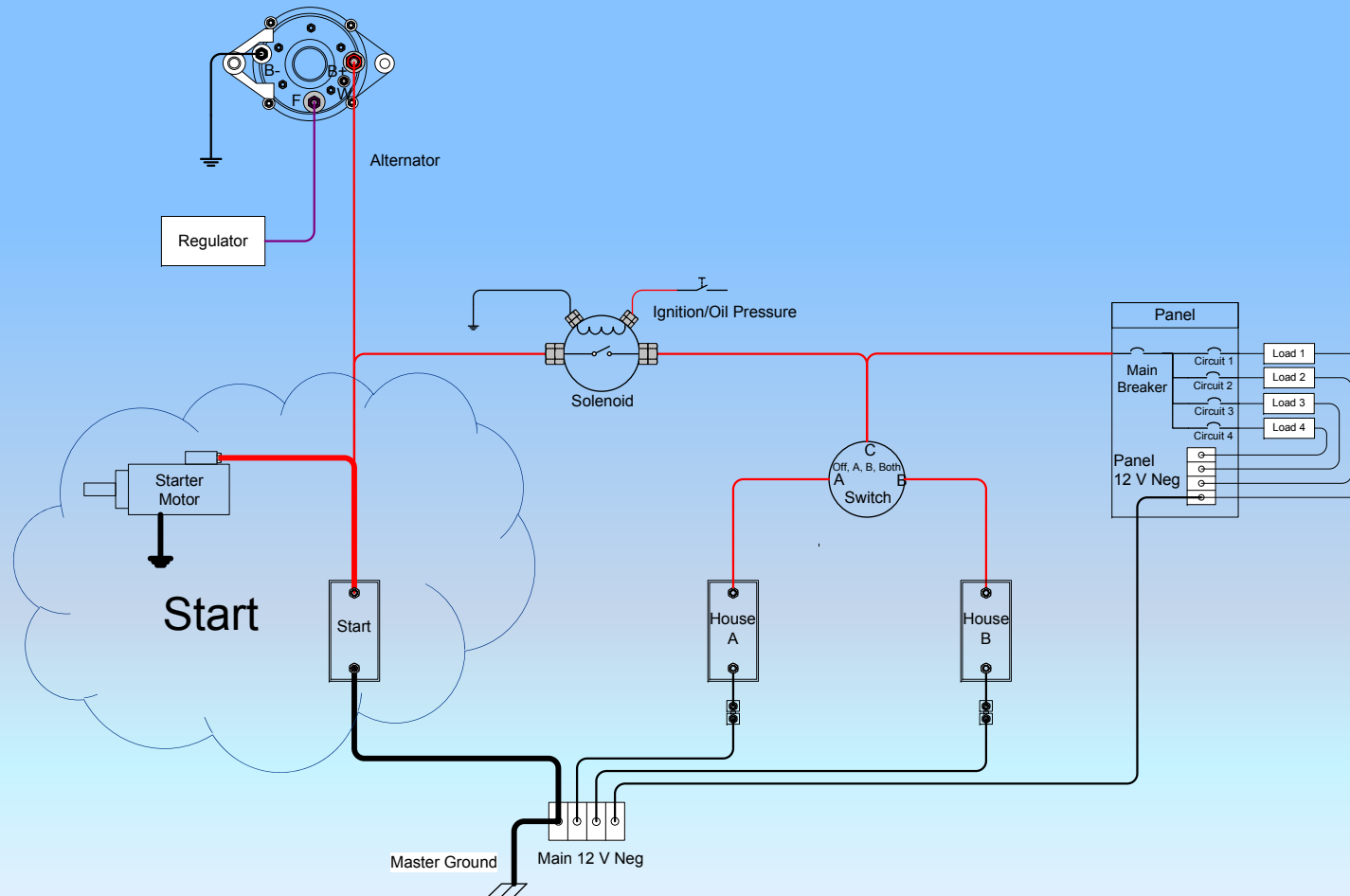
Basic marine 12 volt system scenarios

One start battery, dual house batteries

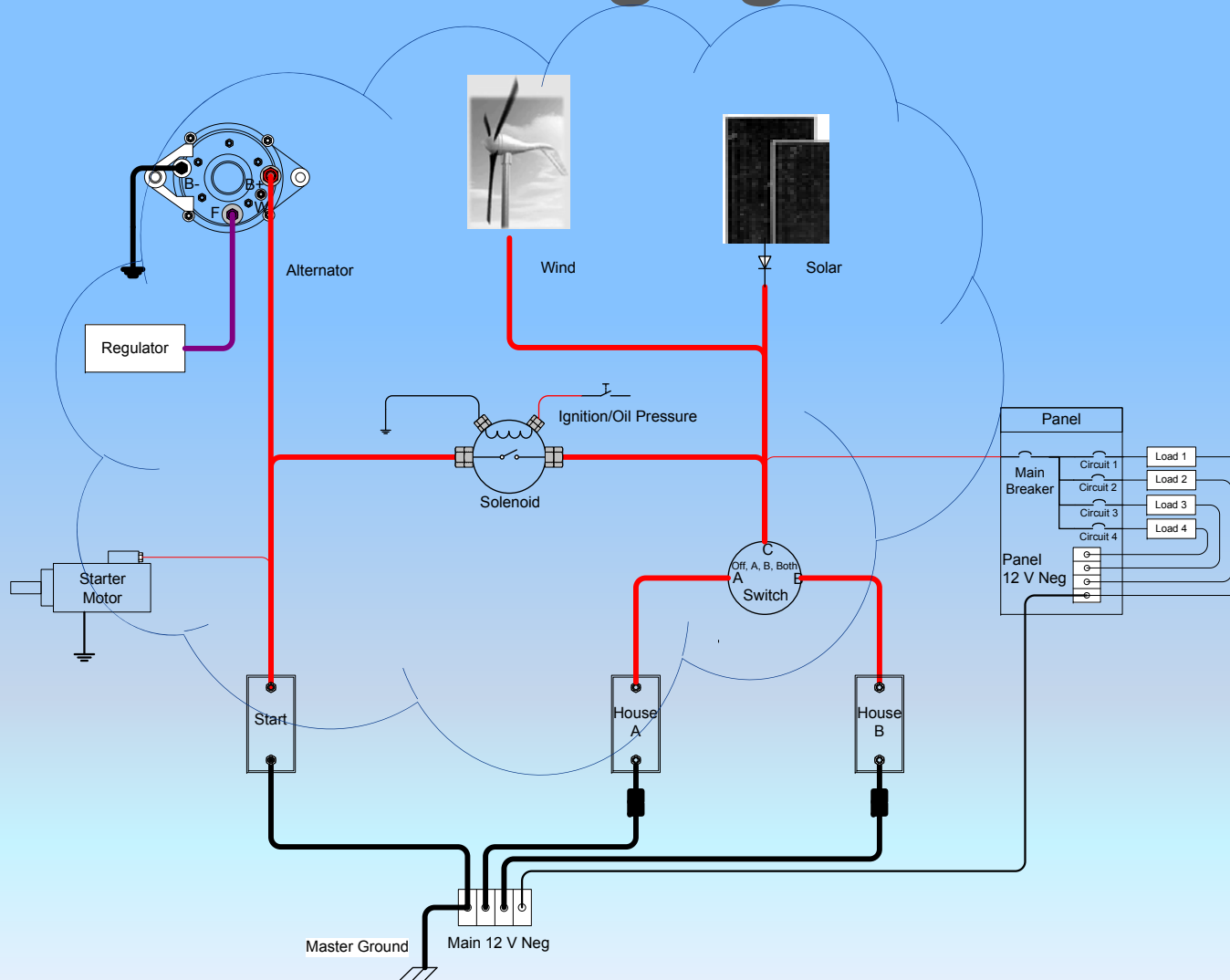
With battery select switch (off, A or B, both)



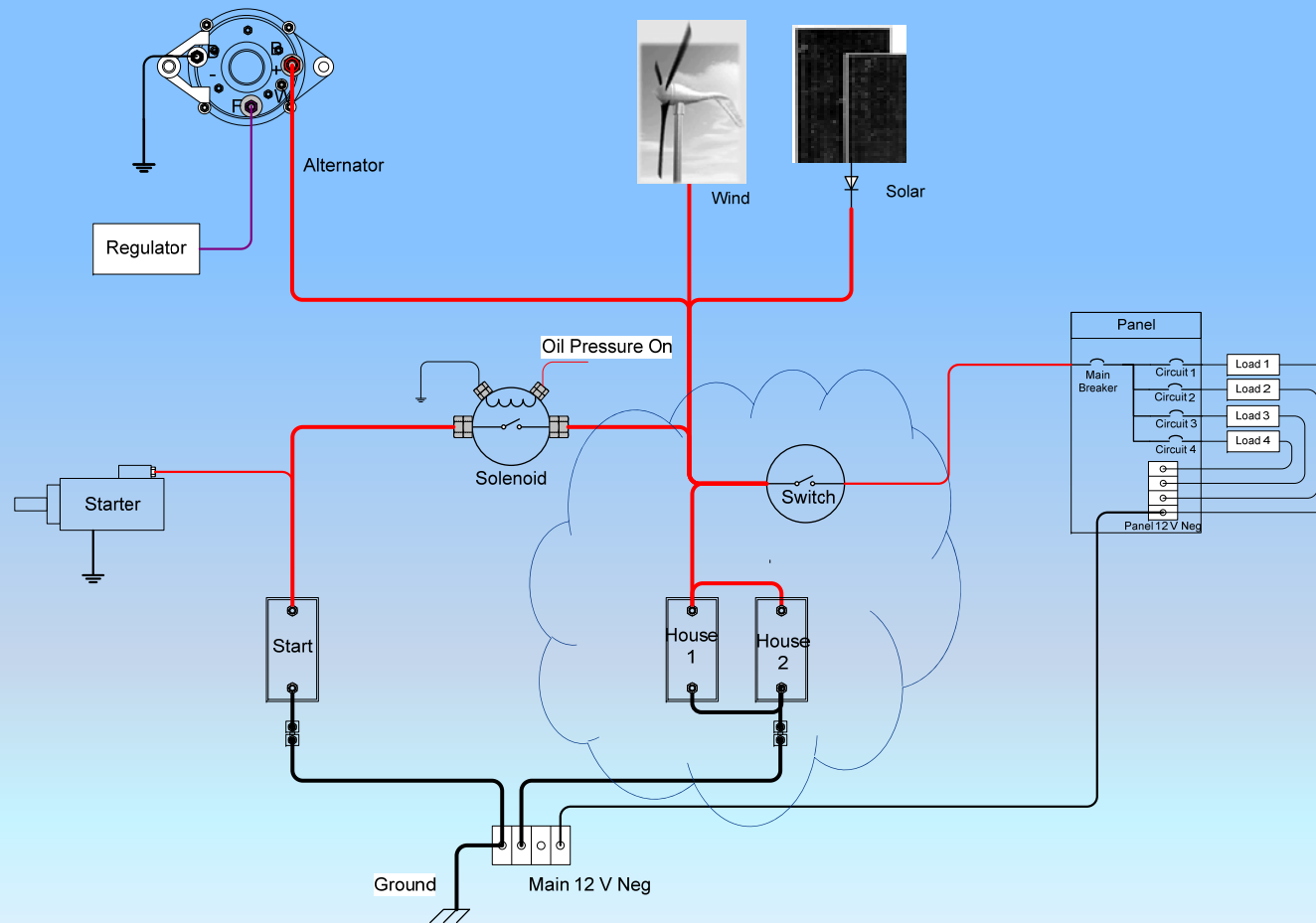
The cranking circuit



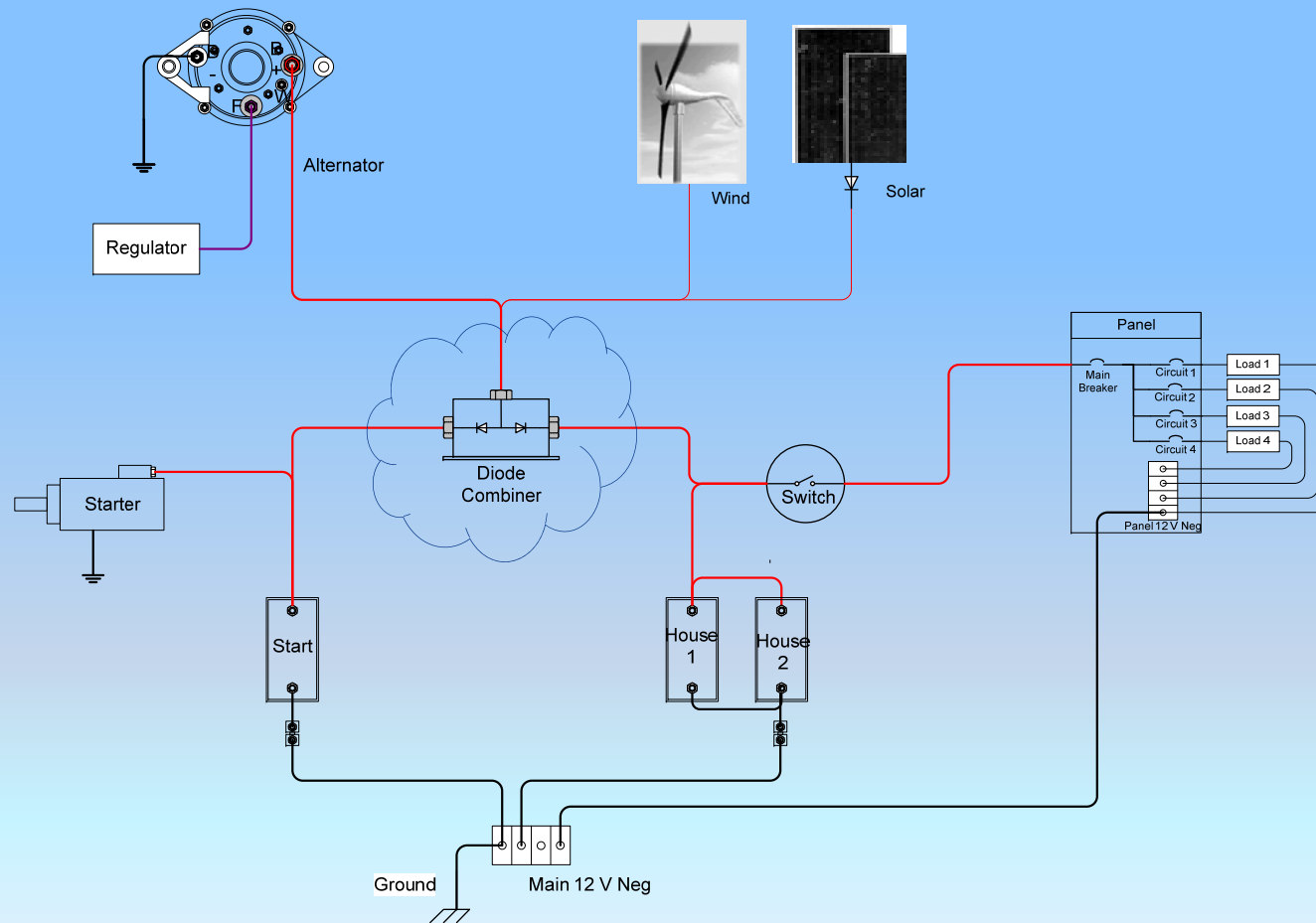
The charging circuit



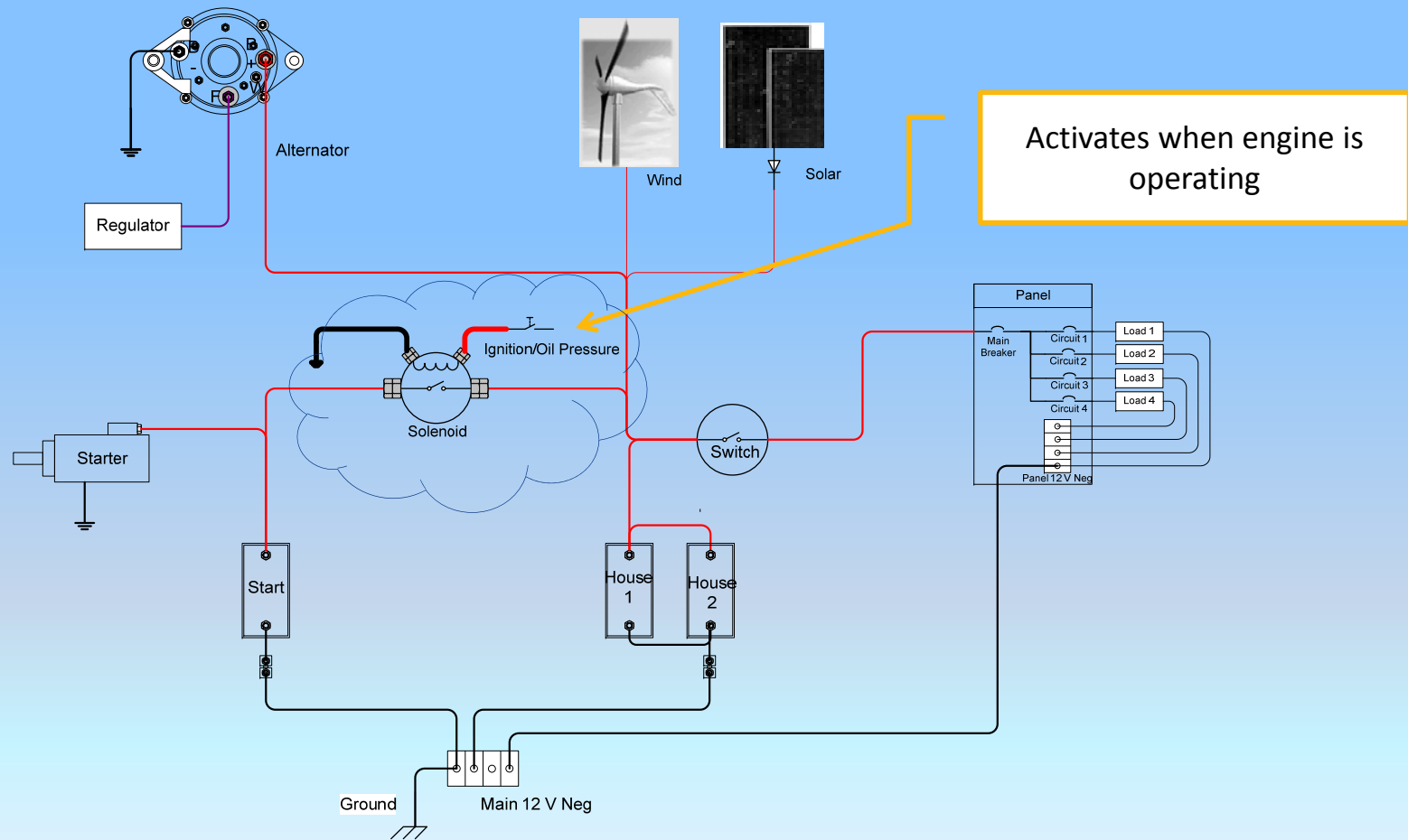
Charging circuit (alternate)



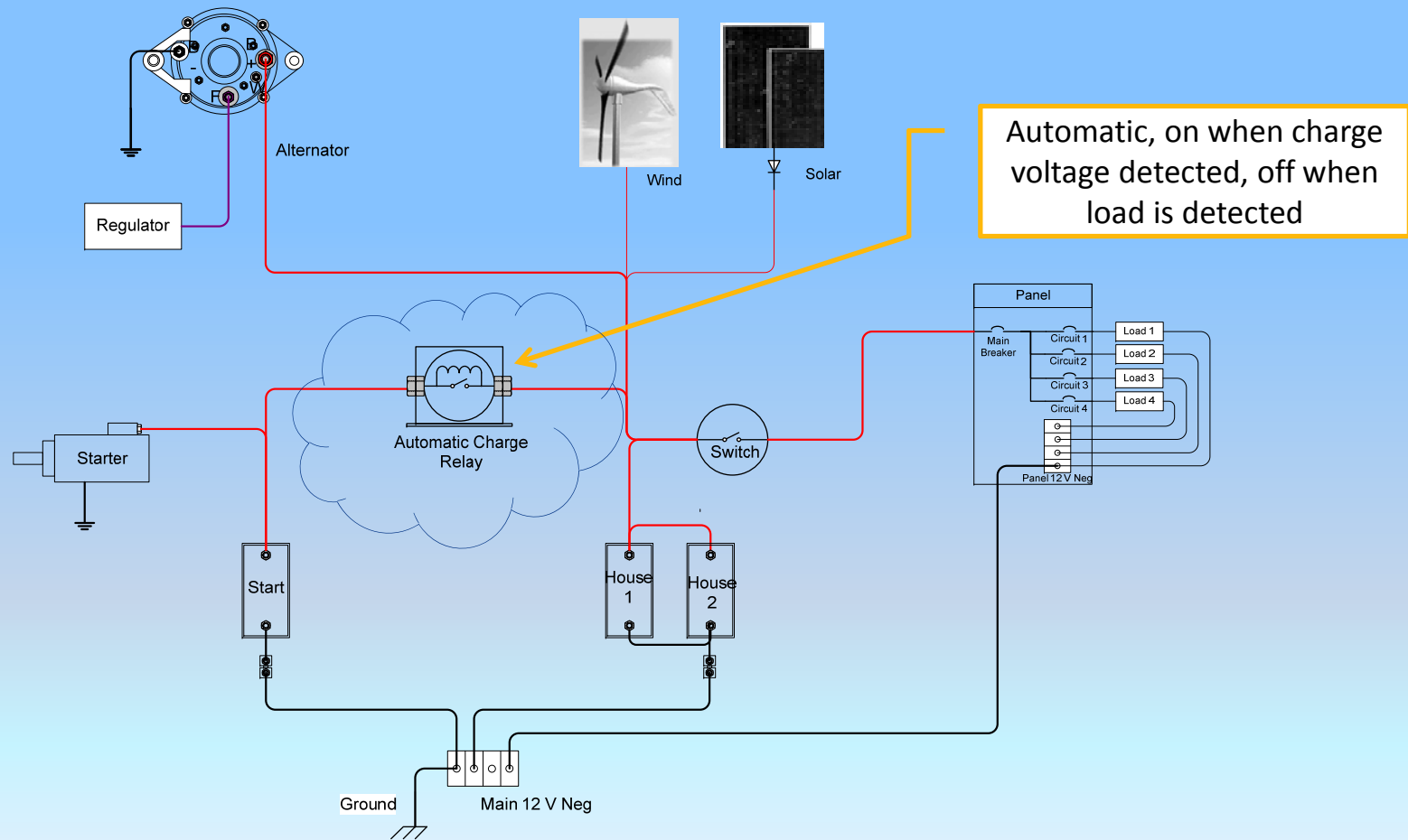
Battery combiner (diode)



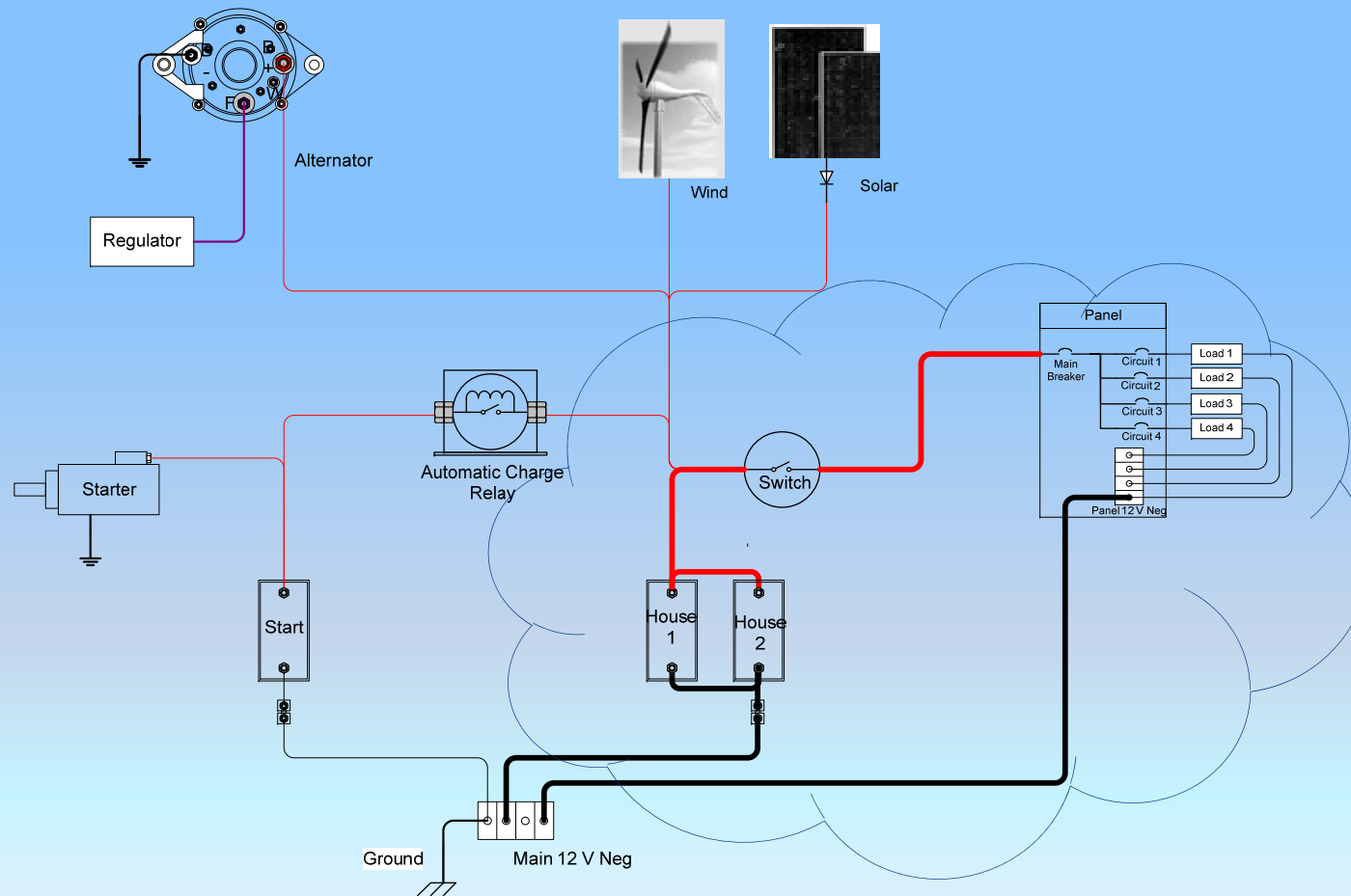
Battery combiner (solenoid)



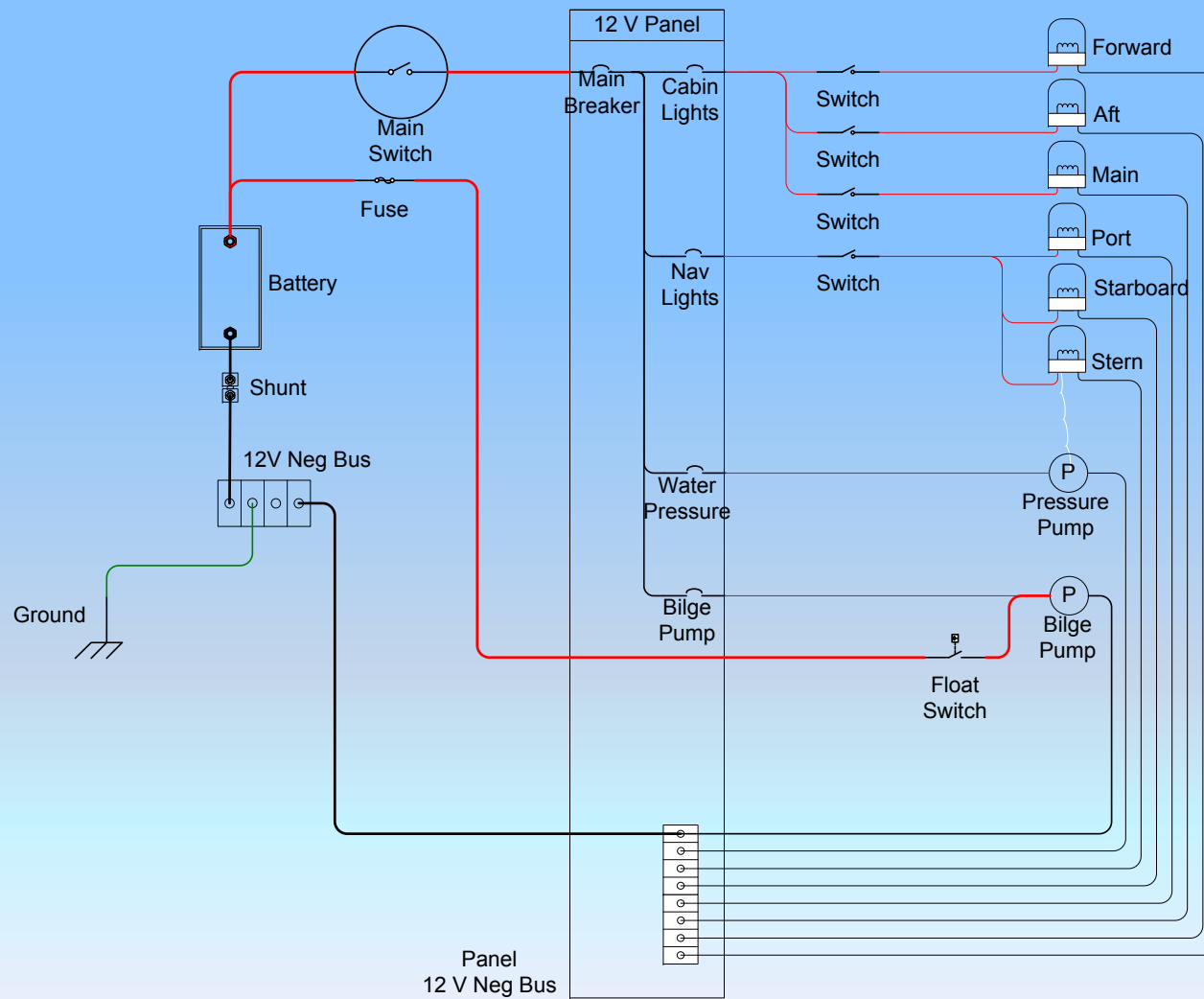
Battery combiner (ACR)



House circuit



House circuit detail



Agenda

A few bootstrap terms to get started

Managing expectations

Battery fundamentals

Charging batteries

Introduction to marine 12 volt circuits

Basic marine 12 volt systems

Troubleshooting marine 12 volt systems

Battery Management

Troubleshooting 12 volt systems

If you understand the capabilities of your 12 volt system, the components, and know your way around the basic circuit, you are ready to start troubleshooting your 12 volt system.

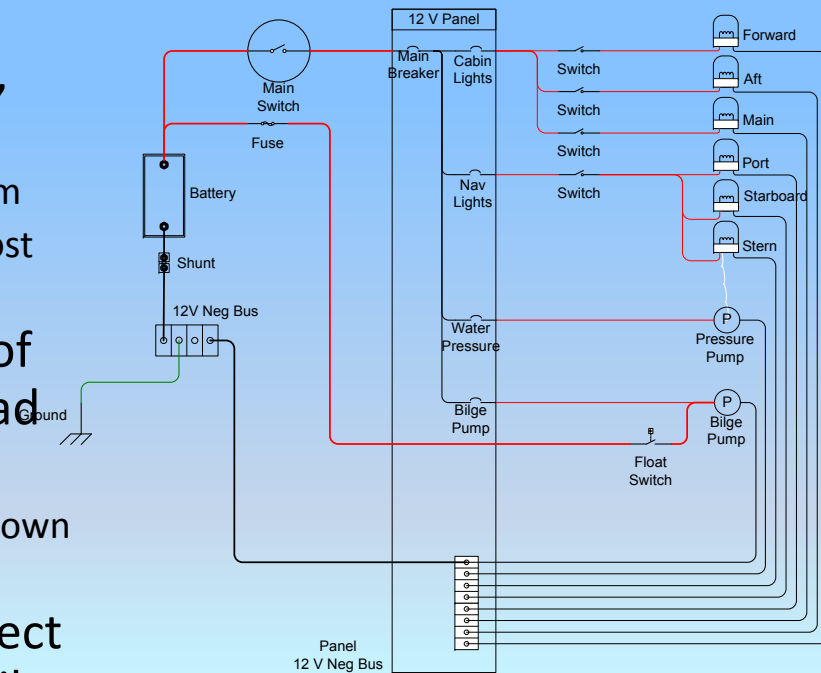
1. Basic troubleshooting
2. Finding a break or open circuit
3. Finding a short circuit
4. Troubleshooting parallel circuits
5. Troubleshooting charging circuits
6. Troubleshooting batteries
7. Troubleshooting alternators

Basic troubleshooting

Never leave port without a multimeter, test lamp and **spares**

There are three fundamentals in locating any electrical fault:

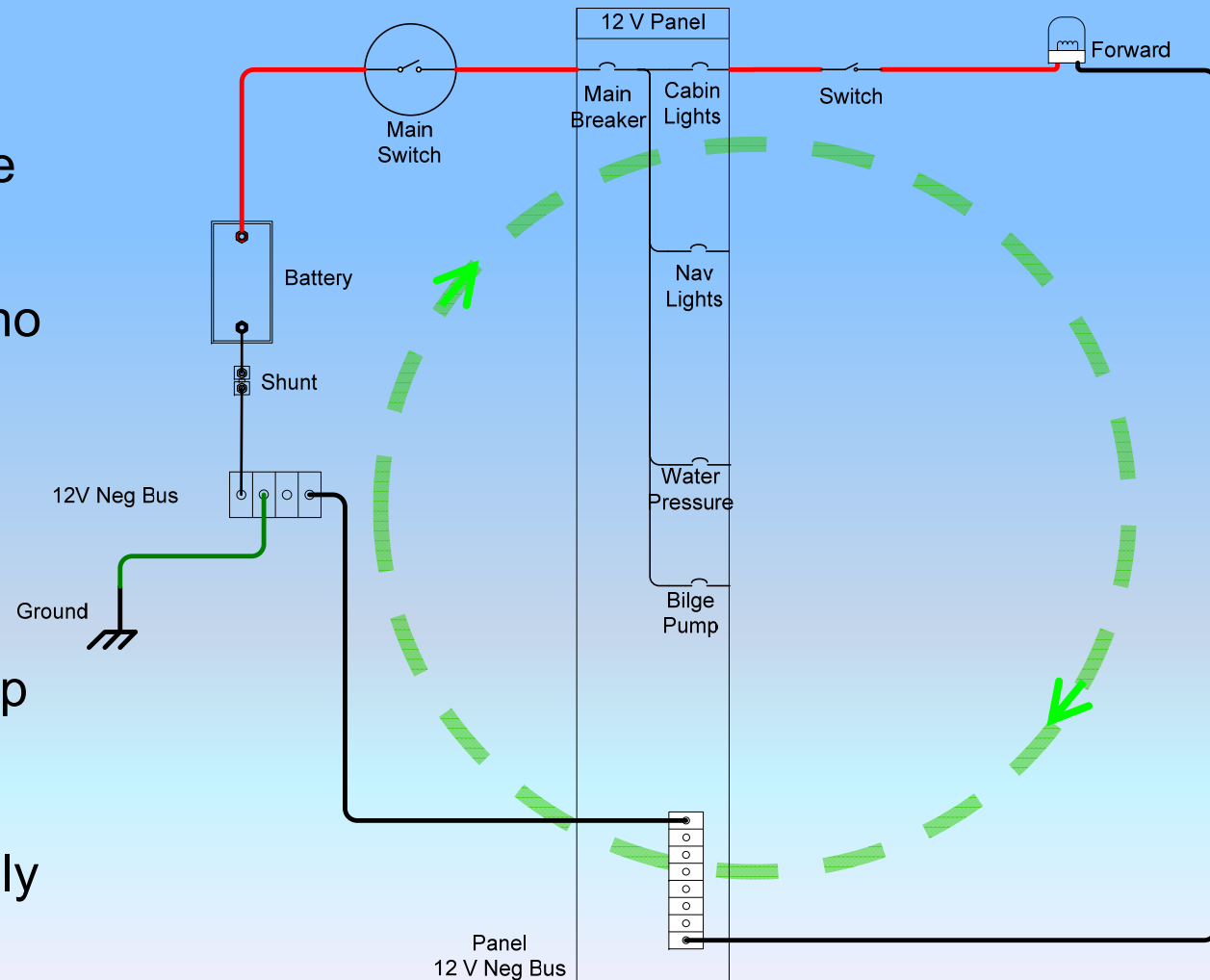
1. Establish a common starting position, such as the battery condition
 - This provides a known reference to work from
 - Voltage (the pressure in the circuit) is the most important measurement
2. Always maintain one common point of reference, example move one test lead at a time
 - This will ensure you introduce only one unknown at each step
3. Slice the circuit into halves as you select consecutive test points, continue until fault located
 - This is the fastest way of searching through any set of unknowns



Basic Troubleshooting

Series circuit

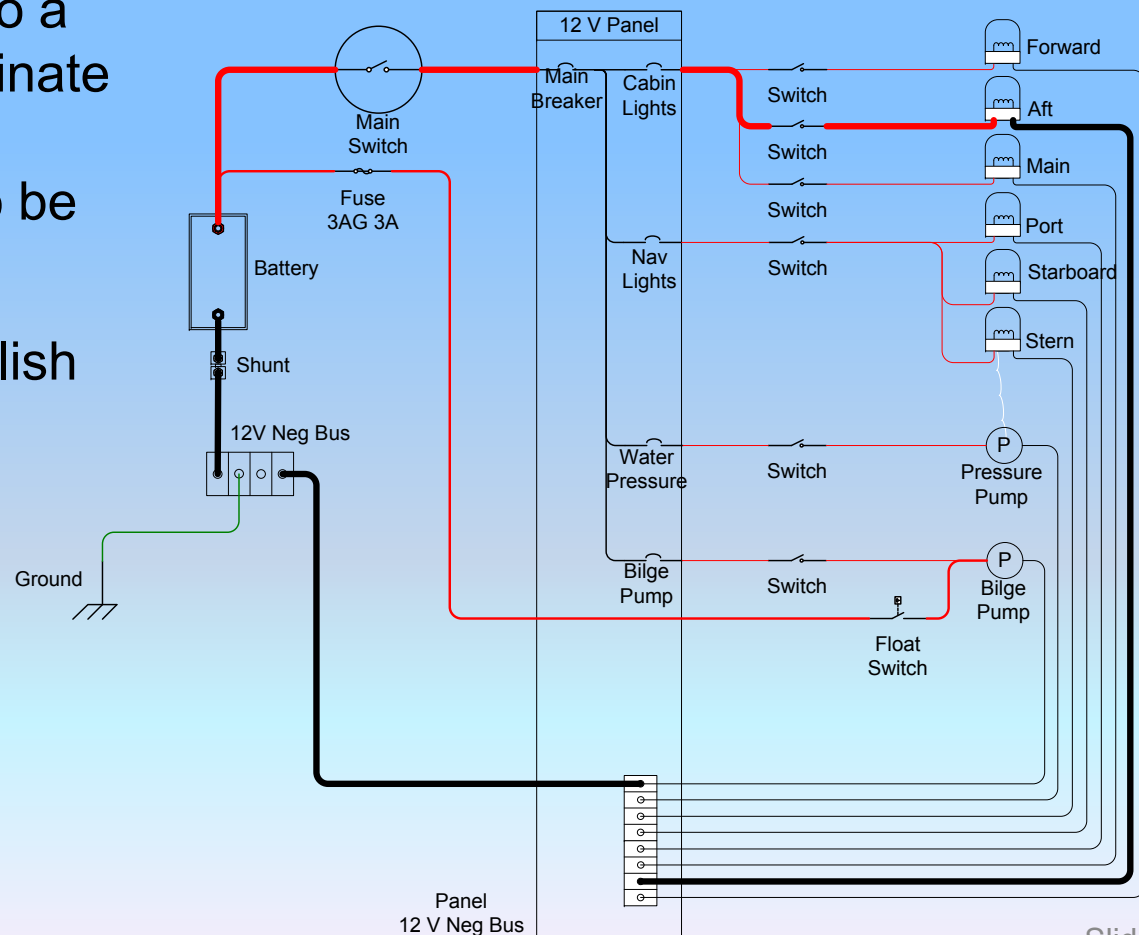
- Think of it as a circle
- Without Voltage (Pressure) there is no current
- A break anywhere will interrupt current flow
- A short circuit will trip a circuit protection device (fuse or breaker) and possibly discharge batteries



Troubleshooting parallel circuits

Reduce the problem to a single circuit and eliminate common circuits components known to be operational.

Where possible establish and use a common reference point.



Troubleshooting Batteries

There are five ways to check the state of charge and or health of a battery

In the case of wet cells, measure the specific gravity of the electrolyte

Open-circuit voltage test

Perform a load test to determine if battery is capable of delivering high currents

Perform a capacity test to determine the actual Ah capacity of your battery

Monitor Volts, Amps and Ahr with an amp-hour meter

Troubleshooting batteries

Specific gravity test

- Measure and record the specific gravity of each cell
- If cell readings vary by greater than 0.050 specific gravity or the lowest cell is less than 1.225, charge the battery
- Charge the battery until all cells are greater than 1.225 specific gravity. If this is not achieved in all cells the battery has one or more defective cells, change the battery

Approximate State of Charge (at 80°F, 26.7°C)				
Charged	1.225 Initial full charge	1.265 Initial full charge	1.280 Initial full charge	1.300 Initial full charge
100%	1.225	1.265	1.280	1.300
75%	1.185	1.225	1.240	1.255
50%	1.150	1.190	1.200	1.215
25%	1.115	1.155	1.170	1.180
Discharged	1.080	1.120	1.140	1.160

Troubleshooting batteries

Open circuit voltage test

If battery has been on charge, apply a heavy load for 30 seconds, disconnect the battery, allow to sit for 15 to 30 minutes and measure the terminal voltage.

Open Circuit Voltage	Percent Charge
12.6 plus	100%
12.45 – 12.6	75 - 100%
12.24 – 12.45	50 – 75%
12.06 – 12.24	25 – 50%
11.7 – 12.06	0 – 25%
11.7 or less	0%

Troubleshooting batteries

Load test

A battery can show a full or nearly full charge on both an open-circuit voltage test and a specific gravity test, yet fail to deliver high current.

In this case the battery should be load tested.

This test requires a specialized test device that loads the battery at 3 to 4 times its normal load for a 10 second period and measures the terminal voltage.

If you suspect your battery is not delivering the specified load, have a professional perform a load test.

Troubleshooting batteries

Capacity test

If you suspect your battery is not delivering the specified amp-hours then you should run a capacity test.

1. The battery is first brought to full charge
2. The test start time is noted
3. It is then discharged at $1/20^{\text{th}}$ of its rated amp-hour capacity (e.g., 10 amps on a 200Ah battery). The load is established by turning on the required number of incandescent lamps.
4. Run the test until the battery terminal voltage falls to 1.75 volts per cell (10.5 volt for a 12 volt battery)
5. Record the elapsed time and multiply the current by the elapsed time to give amp-hours (Ah)
6. The battery must be immediately recharged.

You have now confirmed the Ah capacity of your battery.

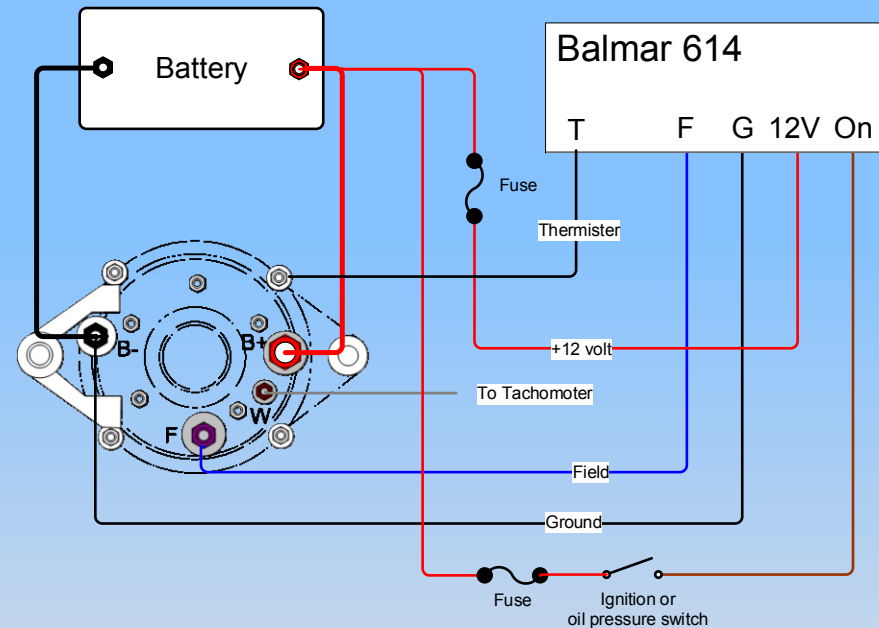
Troubleshooting batteries

Battery fails to keep a charge

- Fully charge the battery and record its open circuit voltage and specific gravity
- Place it on open circuit for three days by disconnecting both battery cables
- Measure the open circuit voltage and specific gravity
 - If voltage drops by greater than 0.20 volts or 35 specific gravity points (0.035) there is an internal short.
 - Replace the battery

Troubleshooting alternators

1. Eliminate mechanical problems, loose belts etc.
2. With alternator spinning, voltage at battery should be > 12.6 volts
3. If battery voltage ≤ 12.6 , alternator not charging
4. Check, regulator +12v and “reg-on”, both should be 12 volt, if not correct
5. If regulator is turned on (4), disconnect field and connect 12 w lamp from alternator field to 12 volt
6. If alternator voltage increases to >12.6 volt, faulty regulator
7. If alternator voltage did not increase to >12.6 volt, fault alternator



Caution: Never disconnect alternator B+ or B- when alternator is spinning, this will destroy alternator internal diodes

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Battery management

What is your 12 volt battery state of charge?
And how do you manage it?

Specific gravity test
(flooded batteries only)

Open circuit voltage test
(difficult because 1 volt difference between 100% and 0.0% charge)

Monitor charge cycle with voltage and current measurements
(only possible with multi stage regulator)

Amp-hour battery management instrument
(Recommended)

Specific gravity test

Approximate state of charge (at 80° F, 26.7 ° C)

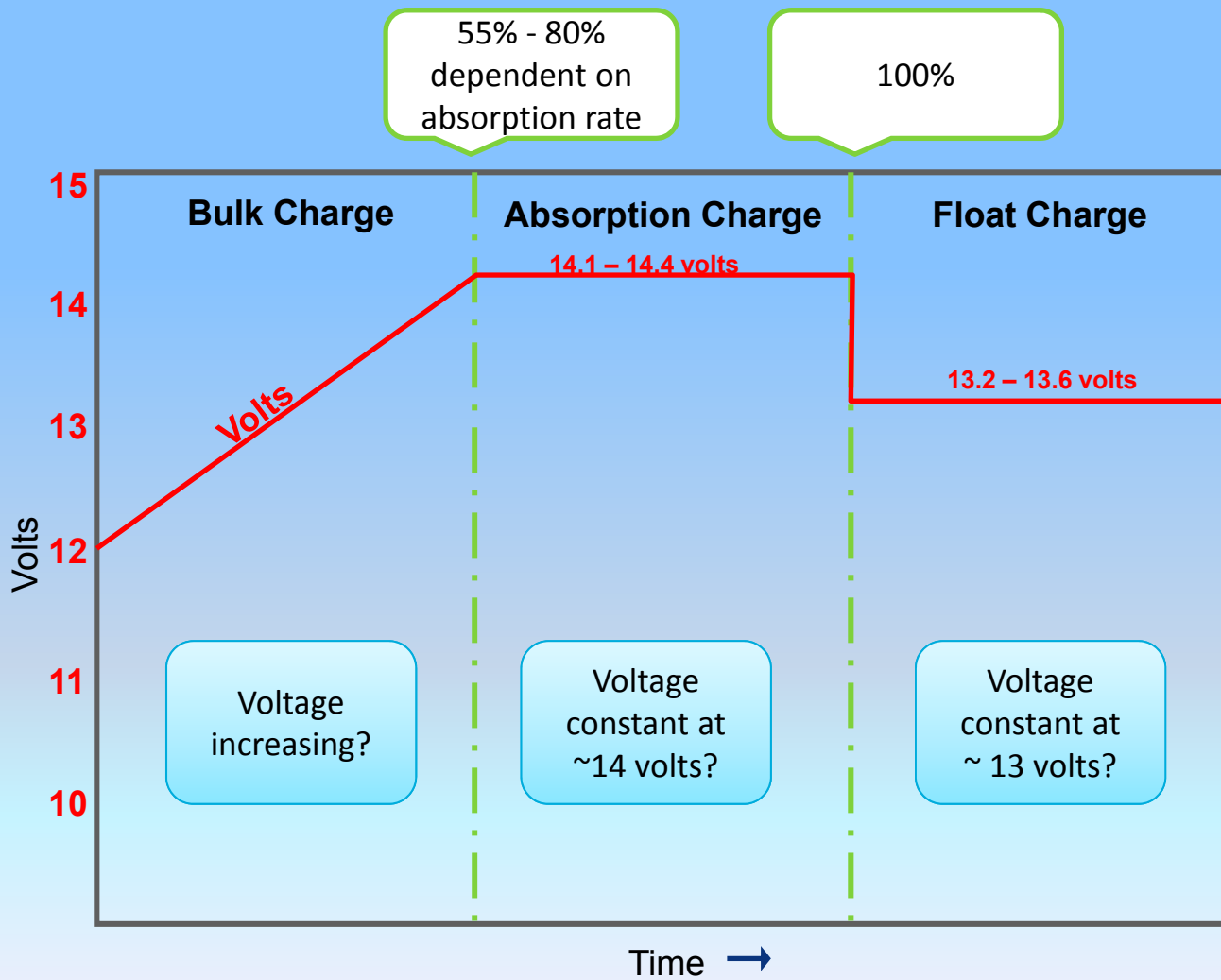
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25%	1.115	1.155	1.170	1.180
Discharged	1.080	1.120	1.140	1.160

Open circuit voltage test

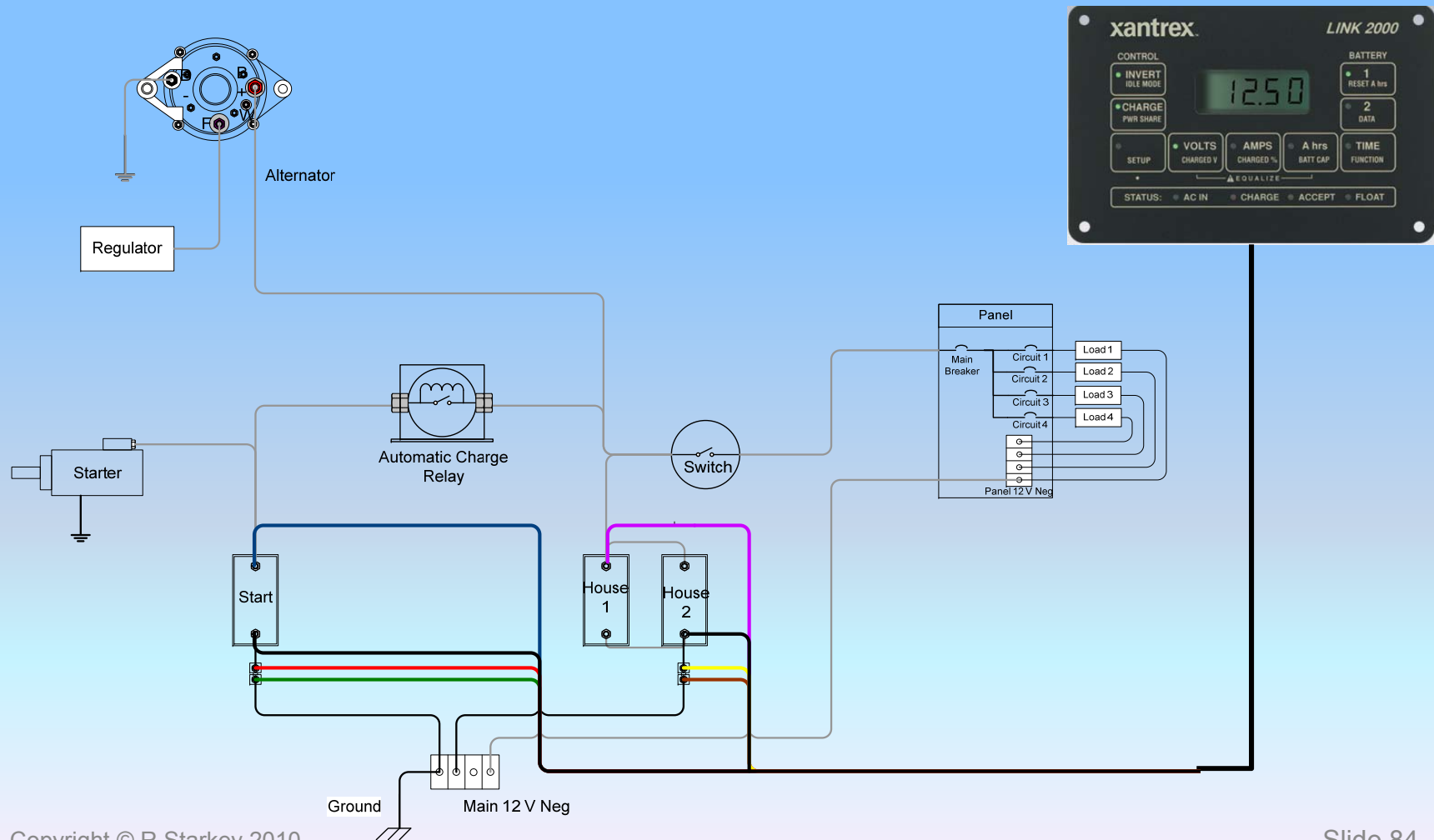
Open Circuit voltage	Percent charge
12.6 plus	100%
12.45 – 12.6	75% – 100%
12.24 – 12.45	50% - 75%
12.06 – 12.24	25% - 50%
11.7 – 12.06	0 – 25%
11.7 or less	0%

Apply moderate load for 15 minutes, disconnect battery, allow to sit for 15 minutes and measure terminal voltage

Monitoring charge cycle



Amp-hour battery management



Battery management options

	CruzPro VAH60	CruzPro VAH65	CruzPro VAH60	Microlog DMM-1	Xantrex Link 10
Banks	1	3	3	2	1
Display	Volts, Amps, Ah	Volts, Amps, Ah	Volts, Amps, Ah	Volts, Amps	Volts, Amps, Ah
Current drain	0.018	0.018	0.035	0.002	0.028
NEMA 183	Yes	Yes	Yes	No	No
Warranty	1 year	1 year	1 year	1 year	1 year
Battery Capacity	Yes	Yes	Yes	No	Yes
Charge efficiency	Yes	Yes	Yes	No	Yes
Time to go	Yes	Yes	Yes	No	Yes

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