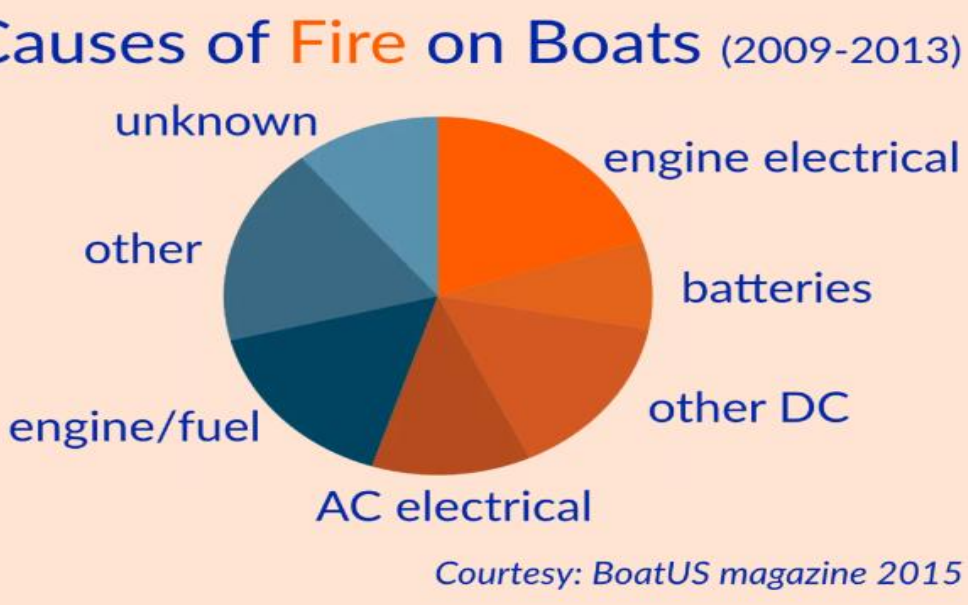
Introduction to Marine Electrical



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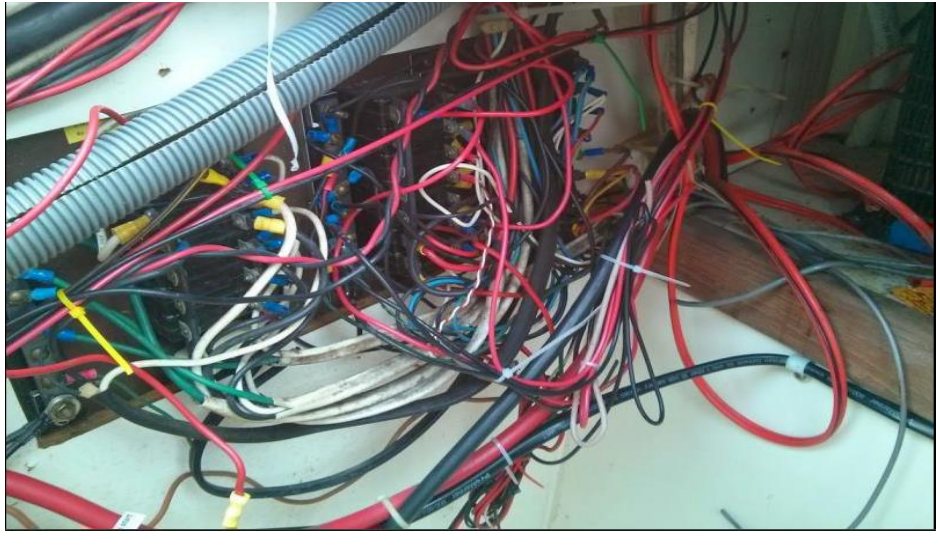
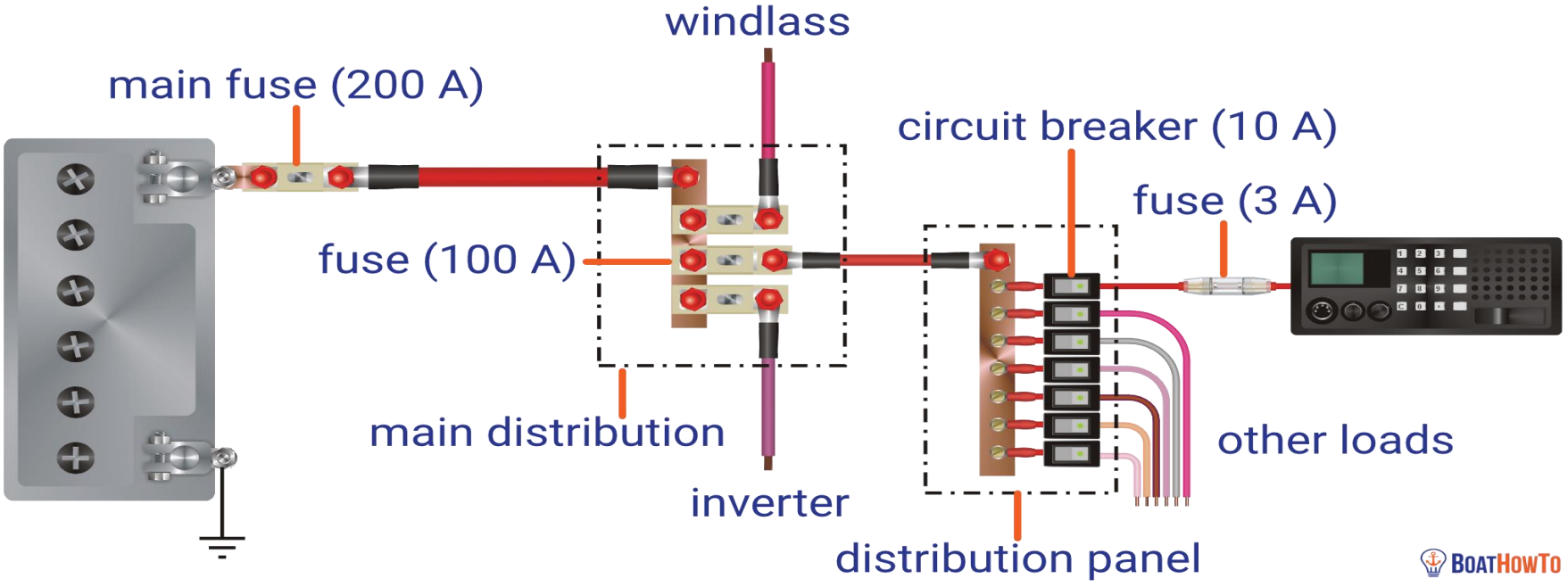
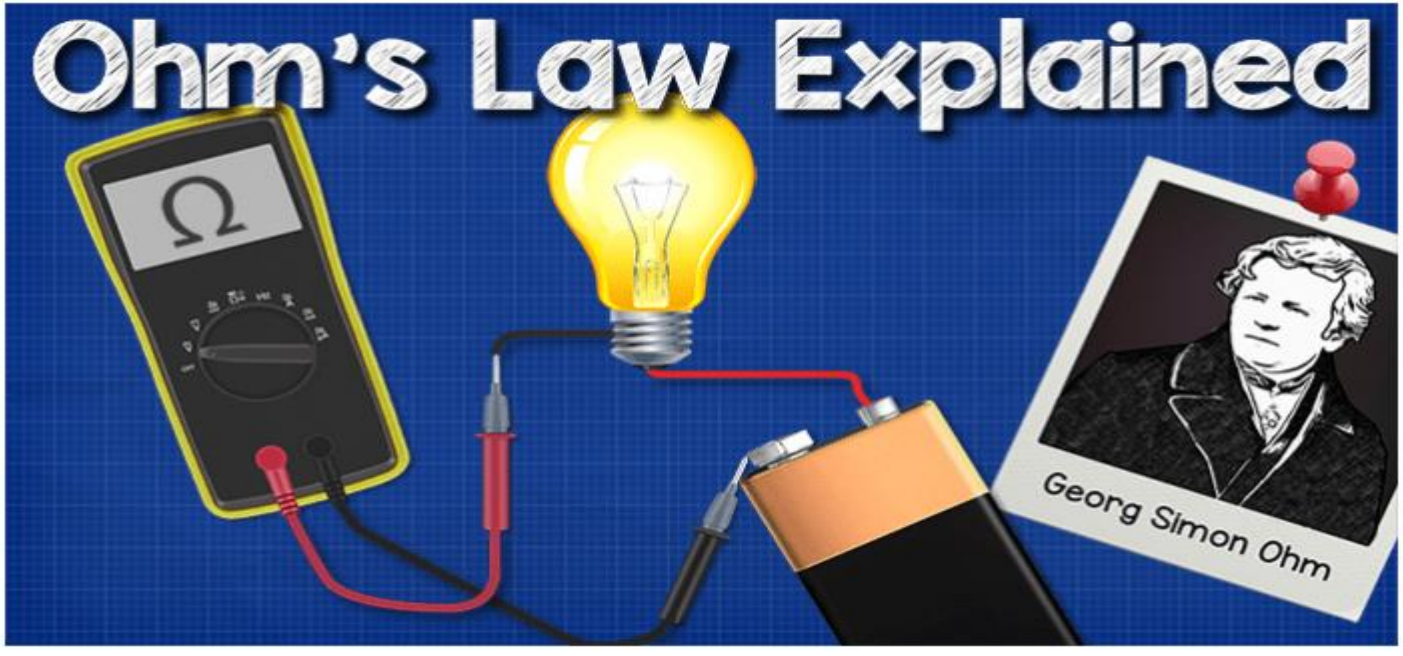


What not to do…

Fusing

The fuse protects the cable, not the device at the end. The Fuse must be at the start of the circuit and another if you drop cable size.





Voltage: (**E or V)** Is the potential difference between 2 points in a circuit – e.g. across a battery. Voltage is the conduit to carry current.

Current: (I) Amps Is the force that is carried by the voltage – eg. A strong running river has high current. A static river would have very little current.

Power: (P) Watts Is **E x I** Volts x Amps that is the resultant power of that river.

Resistance: (**R) Ohms** Is any resistance offered to the river. **R = E / I** Also think of it as load.

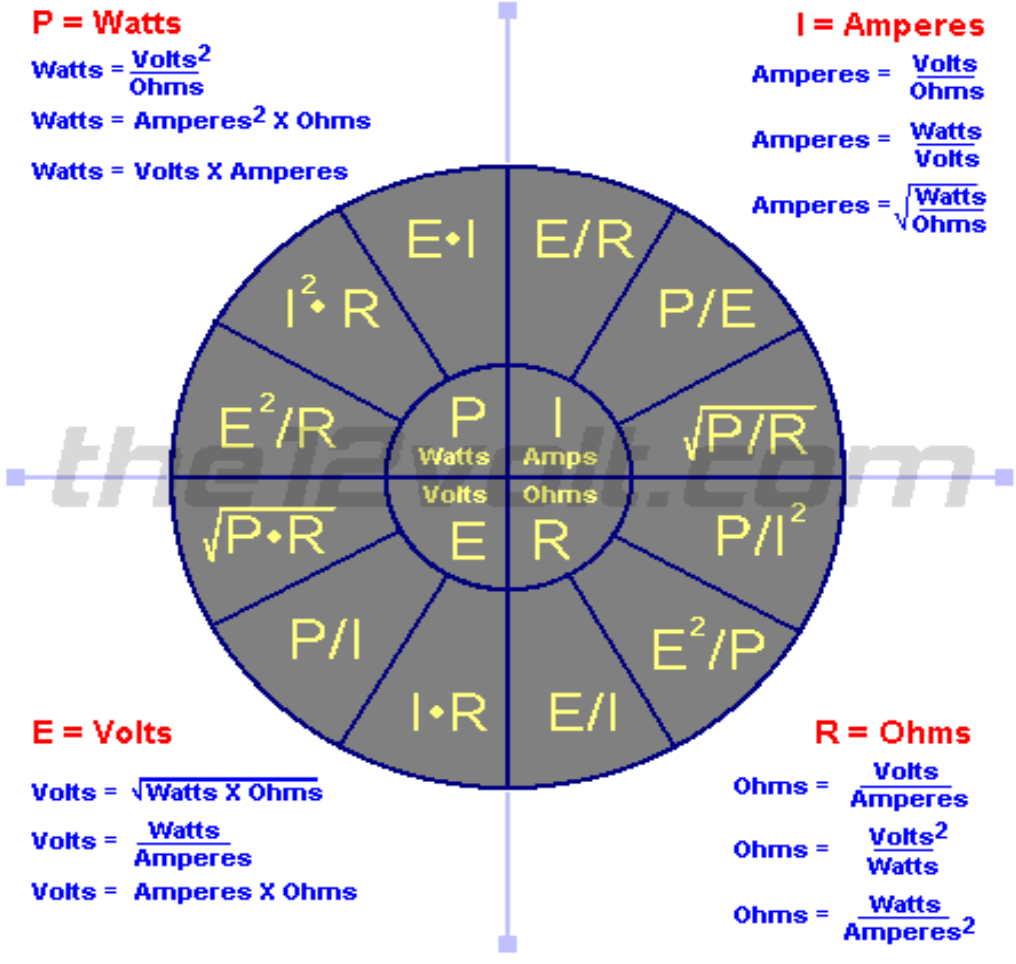
Amps = Watts / Volts

Calculate Amps of a 1200W Windlass
e.g A = 1200 / 12
= 100 Amps

Check a water heater element that is 600 W
The element is designed for 230V

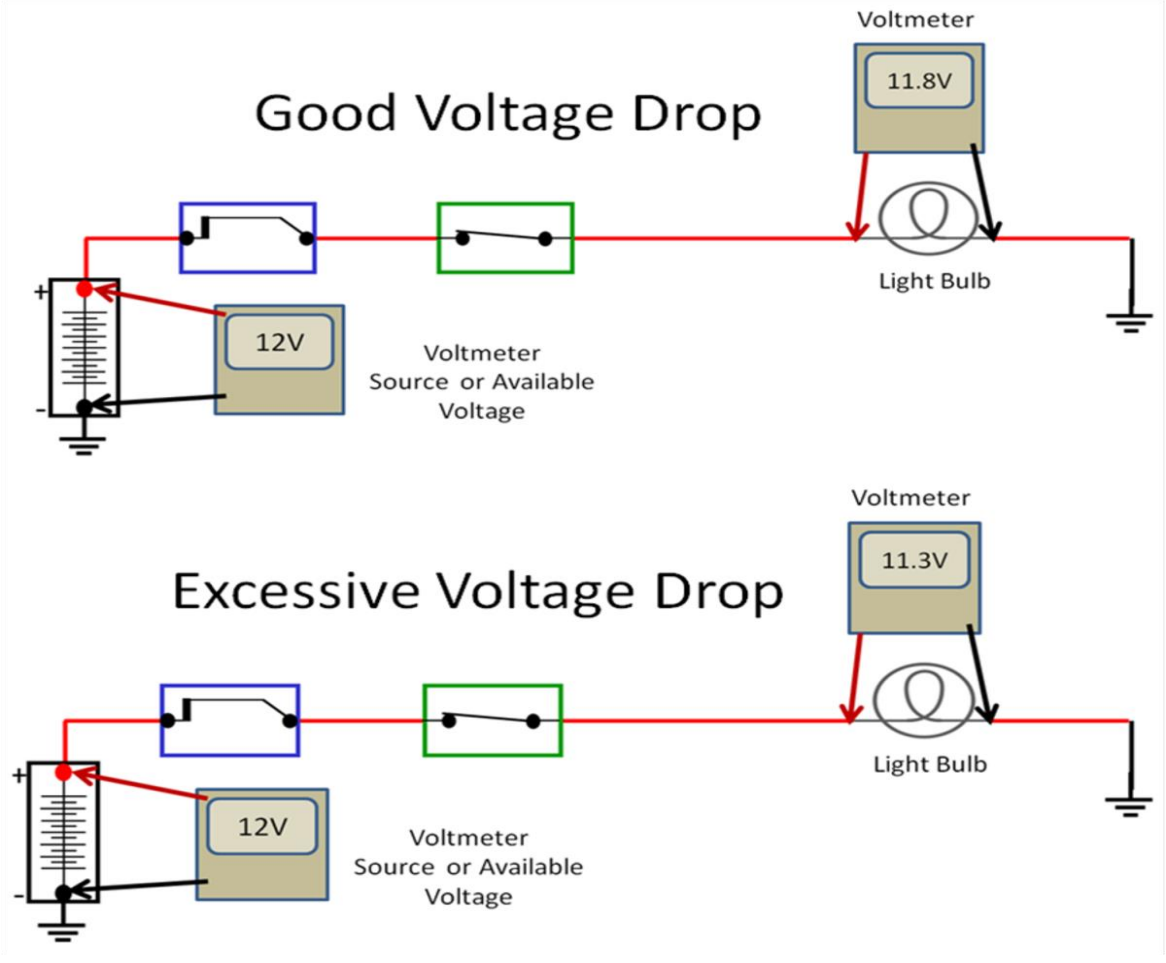
Therefore we can calculate what the resistance should be
Amps = Watts / Volts
2.6 = 600 / 230

Ohms = Volts / Amps
88 = 230 / 2.6

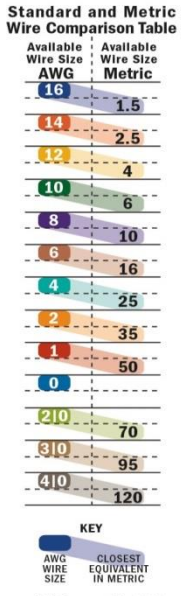


Voltage drop

Voltage drop is the enemy and is all to do with cable size



Cable calculator



CIRCUIT TYPE				CURRENT FLOW IN AMPS															
10% VOLTAGE DROP Non Critical		3% VOLTAGE DROP Critical		5A	10A	15A	20A	25A	30A	40A	50A	60A	70A	80A	90A	100A	120A	150A	200A
CIRCUIT LENGTH																			
0 to 20 ft.	0 to 6.1 M	0 to 6 ft.	0 to 1.8 M																
30 ft.	9.1 M	10 ft.	3.0 M	16 AWG	16 AWG	14 AWG	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	6 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	1 AWG	2|0 AWG
50 ft.	15.2 M	15 ft.	4.6 M		14 AWG	12 AWG	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	4 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG
65 ft.	19.8 M	20 ft.	6.1 M	14 AWG	12 AWG	10 AWG	8 AWG	6 AWG	6 AWG	4 AWG	2 AWG	2 AWG	2 AWG	1 AWG	1 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG
80 ft.	24.4 M	25 ft.	7.6 M	12 AWG	10 AWG	8 AWG	6 AWG	4 AWG	4 AWG	2 AWG	1 AWG	1 AWG	1 AWG	0 AWG	0 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG	
100 ft.	30.5 M	30 ft.	9.1 M		8 AWG	6 AWG	4 AWG	4 AWG	2 AWG	1 AWG	0 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	2|0 AWG	3|0 AWG	4|0 AWG		
130 ft.	39.6 M	40 ft.	12.2 M	10 AWG	6 AWG	6 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	2|0 AWG	3|0 AWG	3|0 AWG	4|0 AWG	3|0 AWG	4|0 AWG		
165 ft.	50.3 M	50 ft.	15.2 M			4 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	3|0 AWG	4|0 AWG	4|0 AWG	4|0 AWG	4|0 AWG			
200 ft.	61.0 M	60 ft.	18.3 M	8 AWG	4 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG	4|0 AWG							
		70 ft.	21.3 M																
		80 ft.	24.4 M	6 AWG	2 AWG	2 AWG	1 AWG	0 AWG	2|0 AWG	3|0 AWG	4|0 AWG								
		90 ft.	27.4 M																
		100 ft.	30.5 M																
		110 ft.	33.5 M																
		120 ft.	36.6 M																
		130 ft.	39.6 M																

Although this process uses information from ABYC E-11 to recommend wire size and circuit protection, it may not cover all of the unique characteristics that may exist on a boat. If you have specific questions about your installation please consult an ABYC certified installer.

Inrush current – Is the amount of starting Current. For a fridge for example it is 3 times the running current, therefore a 4 amp fridge will have an inrush current of 12 amps. A lamp does not have any inrush current.

Joints

Connecting cables on a boat – A soldering iron is banned excepting for very small cables, because solder contains acid and will cause corrosion. Further, it creates a solid joint which with vibration will break.

- Crimping is the preferred solution.

- Ideally a crimp without an insulator and then covered with heatshrink

- The connection should seal against moisture ingress, consider liquid tape or self amalgai

QUICK STUDY

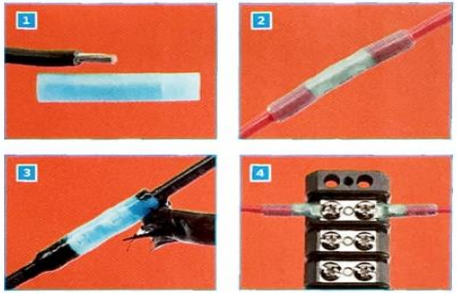
How to Make Marine Electrical Connections

The tools needed to make crimp connections are inexpensive, and the techniques used are simple. Still, every connection is a potential source of resistance or corrosion. Use these tips to help ensure better electrical connections for your next refit of repair. — Kevin Falvey

Crimpers
Typical hardware-store crimpers cut and tear into heat-shrink sheathing on crimps and also deflect when you squeeze them — usally deep in the bilge at the far end of your one-arm reach. Made of stamped steel, they make a narrower crimp — band than better crimpers — and built-in wire cutters stink! Pros pay $100 or more for quality racheting-style crimpers. For DIY work, a midgrade pair ($30) like these by Ancor is the minimum quality we recommend.

1 Stripping
Strip just enough insulation so the wire just fits the length of the terminal's barrel; removing excess insulation compromises the crimp mechanically and corrosionwise. Make sure you have not cut into wires with strippers, then cut the wire squarely and neatly at the end using diagonal cutters ("dykes") or the cutter on your strippers. Twist in clockwise a few turns to add rigidity. Insert the wire into the connector so the insulation butts against the metal crimp barrel.

Crimping
Strive to make a double crimp. Do not crimp at the ends of the connector. Make sure you are crimping the interior metal barrel; the plastic insulated covering overhangs this at the wire end of the connector. Make the first crimp one wire diameter in distance from the wire end of the barrel. Make the second crimp the same distance from the terminal end of the crimp. Test-pull every crimp by hand to make sure you "nailed it."



2 Shrink Connectors
Crimps with heat-shrink collars are a great way to stave off corrosion. After crimping, heat the connector's insulated barrel with a small torch or heat gun. Use indirect heat — don't roast it! You can use a lighter, but the torch affords better control — and can be used for the line splicing as a bonus. If using a heat gun, be careful where you place it because the nozzle stays hot for several minutes after you turn it off and will quickly melt upholstery or scorch fiberglass.

Shrink Tube
Shrink tube can be used when heat-shrink connectors are not available. It can also be used to add stiffness to wires connected to panels, switches and terminal blocks. Slide on the shrink tube before you crimp on the connector, and then heat as described with a torch or heat gun.

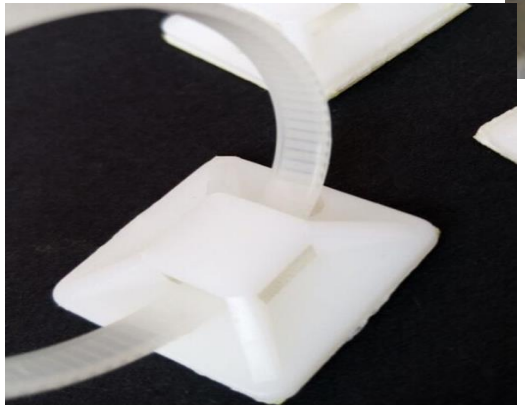
3 Liquid Electrical Tape
This product seals out moisture as well heat-shrink, in my experience. It can be messy to use, but it doesn't require a source of heat, and on windy days doing field repairs, heat-shrinking can be problematic even with a good torch, so I always carry some in my kit. Paint it on, then wait a few minutes for it to skin over.

Terminals
Butt splices join wire of the same diameter. To connect wire of different diameter, strip twice as much insulation from the thinner wire and double it back on itself to make the correct diameter. Connections to boards, panels and some switches are best made with ring terminals. Fork terminals can more easily slip off and fail over time.

4 Terminal Blocks
Sometimes, a terminal block makes more sense than a bunch of butt splices, especially if different wire sizes need to be connected together. They are especially handy for marine electronics and audio installations. Blue Sea Systems is one supplier that offers a range of sizes and lengths, and a number of connections to suit.

The Clear Choice
Better terminals use tinned copper, not aluminum. Scratch the surface of one to see; aluminum is silver all the way through. Also, only select terminals having nylon sleeves; vinyl sleeves crack all too easily. Nylon is easy to ID; you can see through it.

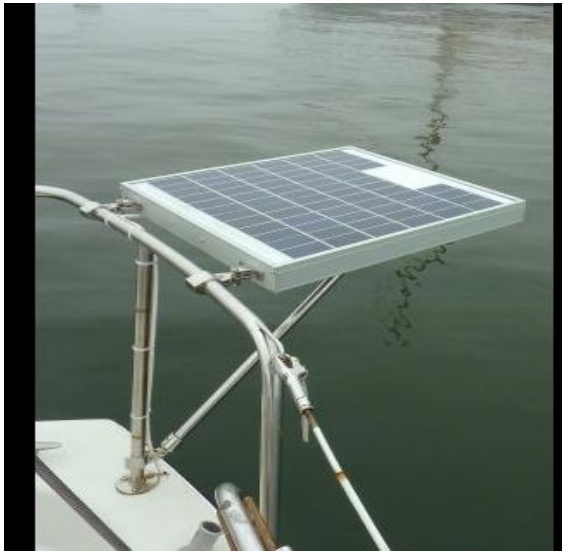
Protection of physical damage



Power Generation

- Alternator
  - Designed to charge the start battery only.
  - Use an Isolator to charge the House Battery
  - Produces AC voltage and is rectified via diodes to DC
  - Do not shutdown the engine with the ignition on
  - Most small engines produce approx. 60A at full load
  - The drive belt can often be a limitation which can slip
  - New engines use a serpentine belt (geared) and can produce 120A
  - Overheating can be an issue.

- Shore Power
  - Should be at least 10% of the battery to be charged.




SUNPOWER™
MODEL: SPR-E-Flex-50
Rated Power (Pmax)[1] (+/–3%) 50 W
Voltage (Vmp) 17.6 V
Current (Imp) 2.80 A
Open-Circuit Voltage (Voc) 21.5 V
Short-Circuit Current (Isc) 2.95 A
Maximum Series Fuse 15 A
CE
RoHS
Standard Test Conditions: 1000 W/m², AM 1.5, 25° C
Suitable for ungrounded, positive, or negative grounded DC systems
Field Wiring: Cu wiring only, min. 12 AWG/4 mm², insulated for 90° C min.
WARNING
SEVERE ELECTRICAL HAZARD
• Solar module has full voltage even in very low light.
• Installation should only be done by a qualified technician.
521846
www.sunpower.com
Patented as shown at www.sunpower.com/patents


PV CHARGE CONTROLLER
BATTERY STATE
Red: BAT. V < 12.6V
Red: BAT. V ≒ LVD
Green: BAT. V > 12.6V
Green: BAT. V ≒ Bulk Charging V (BAT. Full)
Orange: BAT. V < LVD V, Load Cut Off
WET TYPE BAT. ONLY
Red,Green: Equalization Charging
ONLY FOR 12V PV SYSYEM
DC LOAD
BATT.
PV
RESET
TEMP. SENSOR

Rules for Best Power Production

Keep the panels as perpendicular to the incoming sun's rays as possible., all panels will produce more power if they get direct sunlight.

Avoid shadows: The output of a panel (particularly a crystalline panel) drops dramatically when shadowed, even if only 10 percent of the panel is in shadow. A small shadow can reduce the panel's output by 50 percent or more. When something as large as a boom, radar scanner, or mast casts its shadow on a panel, your output goes down dramatically.

Keep your panels cool. It's not easy to keep a black surface cool in the sun, but panel output goes down as temperature rises, so if you can provide some ventilation on the backside of the panel, you may be able to pick up a five or ten percent increase.

Generally count on 6 hours average @70% efficiency of the panel. Therefore;
100w panel @20v = 5A * 6 hours = 30A @ 70% = 21A
In a 24 hour period if the day was sunny.

Victron Solar Panel 175W-12V Mono 1485x668x30mm series 4a
monocrystalline - Solar Panel 175W-12V Mono 1485x668x30mm series 4a

Specifications of the above Panel:

- Nominal Power (Pmpp): 175W
- Max Power Voltage (Vmpp): 19.4V
- Max Power Current (Impp): 9.03A
- Open Circuit Voltage (Voc): 23.7V
- Short Circuit Current (Isc): 9.89A
- Cell Type: Monocrystalline
- Number of cells in series: 36
- Max. system voltage: 1000V
- Temperature Range: -40°C to +85°C

Types of Solar controllers.

- Use a controller when the current will be > 1.5% of the battery, check that the panel has a diode built in though.

- With multiple panels wire them in series and use a MPPT (maximum power point tracking)

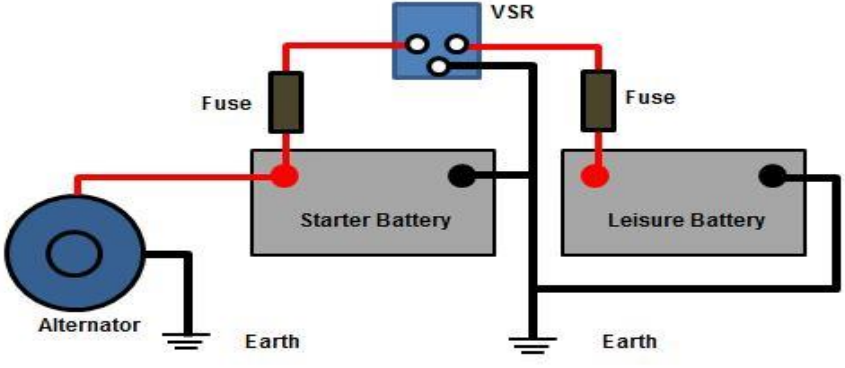
- MPPT converts unused volts to power

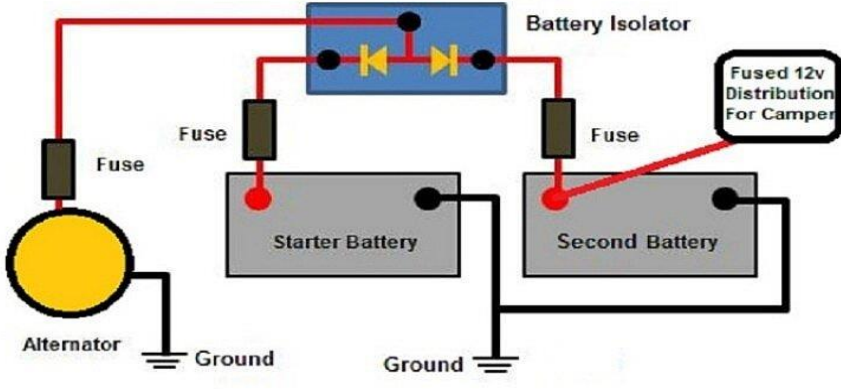
- PWM (pulse width modulation) converts unused volt to heat (Lower cost and best for smaller installs)

If low power draw connect the load to the regulator to protect the battery.

SmartSolar Charge Controller	MPPT 75/10	MPPT 75/15	MPPT 100/15	MPPT 100/20	MPPT100/20-48V
Battery voltage	12/24V Auto Select				48V
Rated charge current	10A	15A	15A	20A	20A
Nominal PV power, 12V 1a,b)	145W	220W	220W	290W	n. a.
Nominal PV power, 24V 1a,b)	290W	440W	440W	580W	n. a.
Nominal PV power, 48V 1a,b)	n. a.	n. a.	n. a.	n. a.	1160W
Max. PV short circuit current 2)	13A	15A	15A	20A	20A
Automatic load disconnect	Yes				
Max. PV open circuit voltage	75V		100V		
Peak efficiency	98%				
Self-consumption	12V: 25 mA 24V: 15 mA				15mA
Charge voltage 'absorption'	14,4V / 28,8V (adjustable)				57,6V (adj.)
Charge voltage 'float'	13,8V / 27,6V (adjustable)				55,2V (adj.)
Charge algorithm	multi-stage adaptive				
Temperature compensation	-16 mV / °C resp. -32 mV / °C				
Max. continuous load current	15A			20A	1A
Low voltage load disconnect	11,1V / 22,2V/44,4V or 11,8V / 23,6V/47,2V or Battery Life algorithm				
Low voltage load reconnect	13,1V / 26,2V/52,4V or 14V / 28V/56V or Battery Life algorithm				
Protection	Battery reverse polarity (fuse) / Output short circuit / Over temperature				
Operating temperature	-30 to +60°C (full rated output up to 40°C)				
Humidity	95%, non-condensing				
Data communication port	VE.Direct (see the data communication white paper on our website)				

Dual battery setup using an Isolator - Voltage Sensitive Relay (VSR) or Schotchy diodes





- Starting batteries rated in CCA (30 seconds)

- House Batteries rated in Amps
  - Lead Acid (Flooded)
  - AGM – Deep Cycle
  - Lithium – High performance – LifeP04

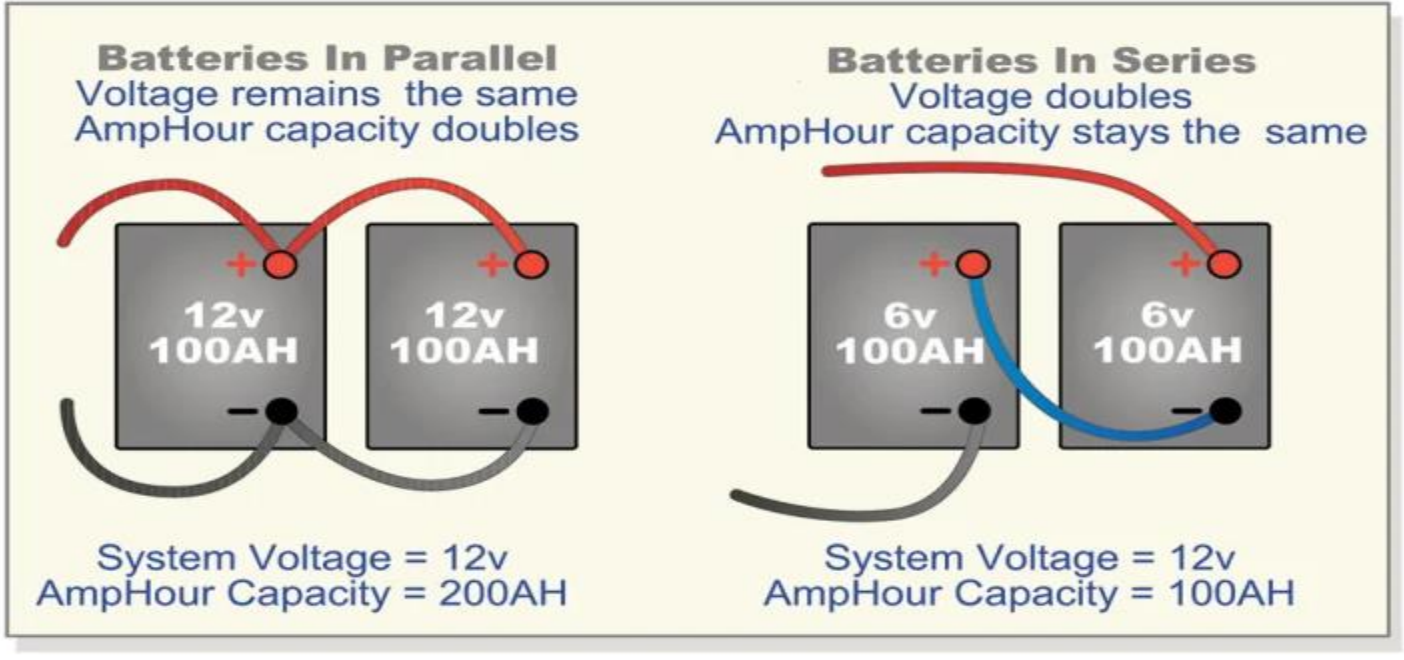
CCA = Cold Cranking Amps – even a small 680 can start a 70hp diesel – It is rated at 0 degrees for 30 seconds.

Reserve Capacity **(RC)** This is the number of minutes a fully charged battery will discharge 25 amps until the battery drops below 10.5 volts.

An amp hour **(AH)** is a rating usually found on deep cycle batteries. If a battery is rated at 100 amp hours it should deliver 5 amps for 20 hours, 20 amps for 5 hours, etc.

Notes regarding batteries
DoD (depth of discharge) 50% for a flooded battery and 75% for a good quality AGM, 90% for Lifep04
Go over the DoD and the battery life will deteriorate quickly.
Cat 4 and Under, all batteries must be a sealed type.
Ideally charge at 10% of the rated power
Don’t mix battery types if possible
Generally replace all your batteries in 1 go

Batteries in Parallel and Series




KAIWEETS
2000 Counts
114.5
KM100
DIGITAL MULTIMETER
OFF
10A
COM
VΩmA

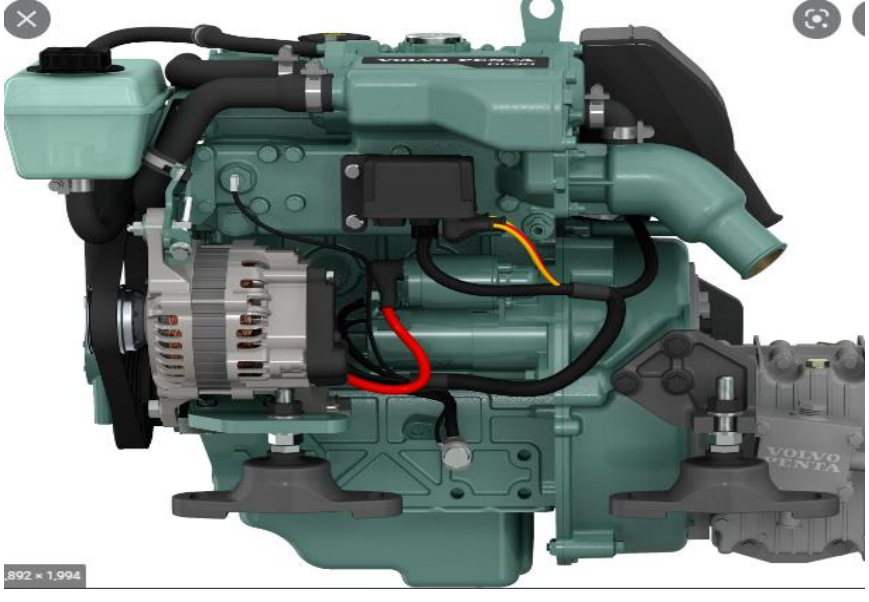

OFF
20M
2M
200k
20k
2k
200
20
2
600
200m
10
200m
20m
600V CAT III
10A
COM
VΩmA
MAX
10A/250V
MAX
200mA/250V


FLUKE

Fault Finding

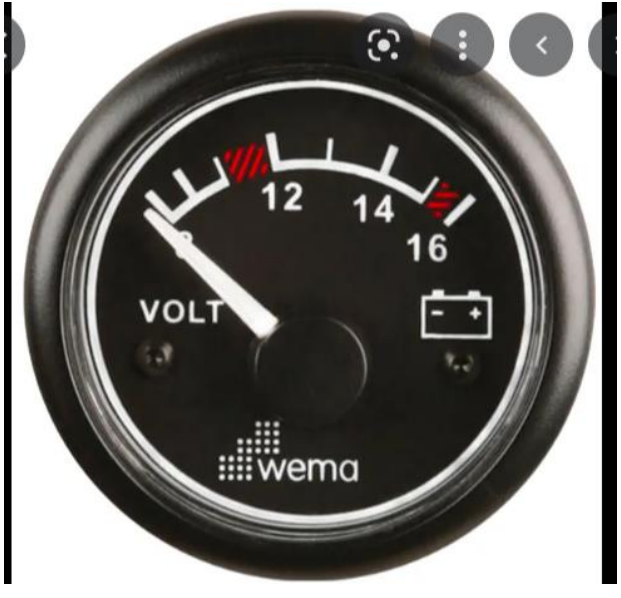
Motor wont start –

- Check the voltage of the battery, should be at least 12.5v
- Clean the terminals - file
- Check the common Negative on the engine block – often rusty
- Is the solenoid clicking?
- Try a jumper lead direct to the starter motor (bypass solenoid)



Batteries not charging

- Look for an increase in Volts when motor running or strong solar
- Consider borrowing a clamp meter
- Check belt to the Alternator
- Check Connections
- Have the Battery tested



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