MARINE ELECTRICAL
CHARGING SYSTEMS

BY

DENNIS KRUG and JOHN CHADWICK

Topics

- Batteries
- Sizing your house battery bank
- Battery Charging Systems
  - Battery Chargers
  - Alternators
  - Solar
- Battery Combiners
- Battery Monitors
- Putting it all together

ABYC®

Setting Standards for Safer Boating

- American Boat & Yacht Council, Inc. (ABYC) develops the consensus safety standards for the design, construction, equipage, maintenance, and repair of small craft. The development of uniform standards is the basis for industry-wide comparisons of products and performance.
- ABYC standards are minimum requirements for a safe design, construction and repair. Boaters should insist that builders, repairers and installers use these ABYC standards as a minimum. Their boating experience will be enhanced and the image of the marine industry justifiably improved..

BATTERY SPECIFICATIONS

Ampere Hour Rating (Reference Rating)

- This is the number of amps which a battery can deliver for a 20-hour period. This test is also referred to as the 20-hour rate. The larger the ampere hour rating, the more power the battery can deliver over time.

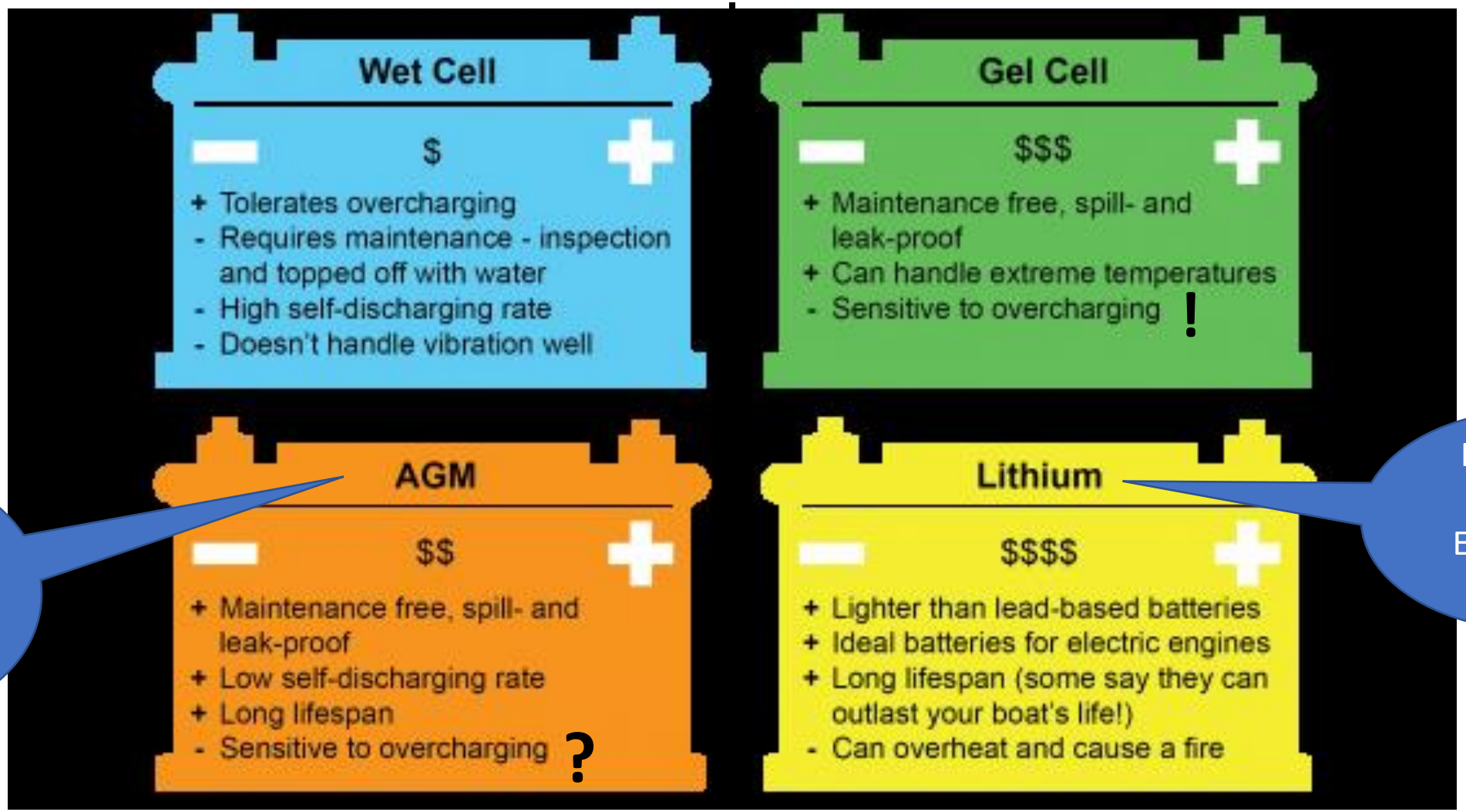
Marine Cranking Amps (MCA)

- This is the number of amps a battery can deliver at 32 degrees fahrenheit for 30 seconds, and maintain at least a voltage of 1.2 volts per cell. This differs from cold cranking amps which are measured at 0 degrees Fahrenheit.

Reserve Capacity (RC)

- This is the time, in minutes, for which a battery will deliver 25 amperes at 80 degrees fahrenheit. This represents the time which the battery will continue to operate essential accessories in the event of alternator or generator failure or while the key is off.

COMPARISON OF BATTERY TYPES

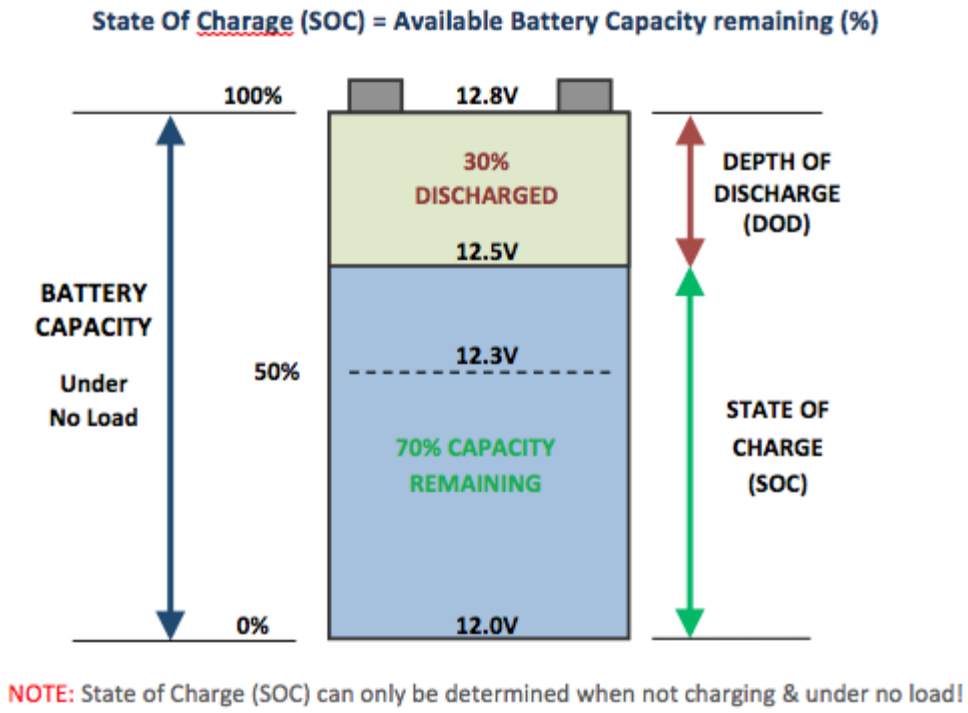


MUCH FASTER CHARGING *than wet cell*

MAY NEED NEW ELECTRICAL SYSTEM

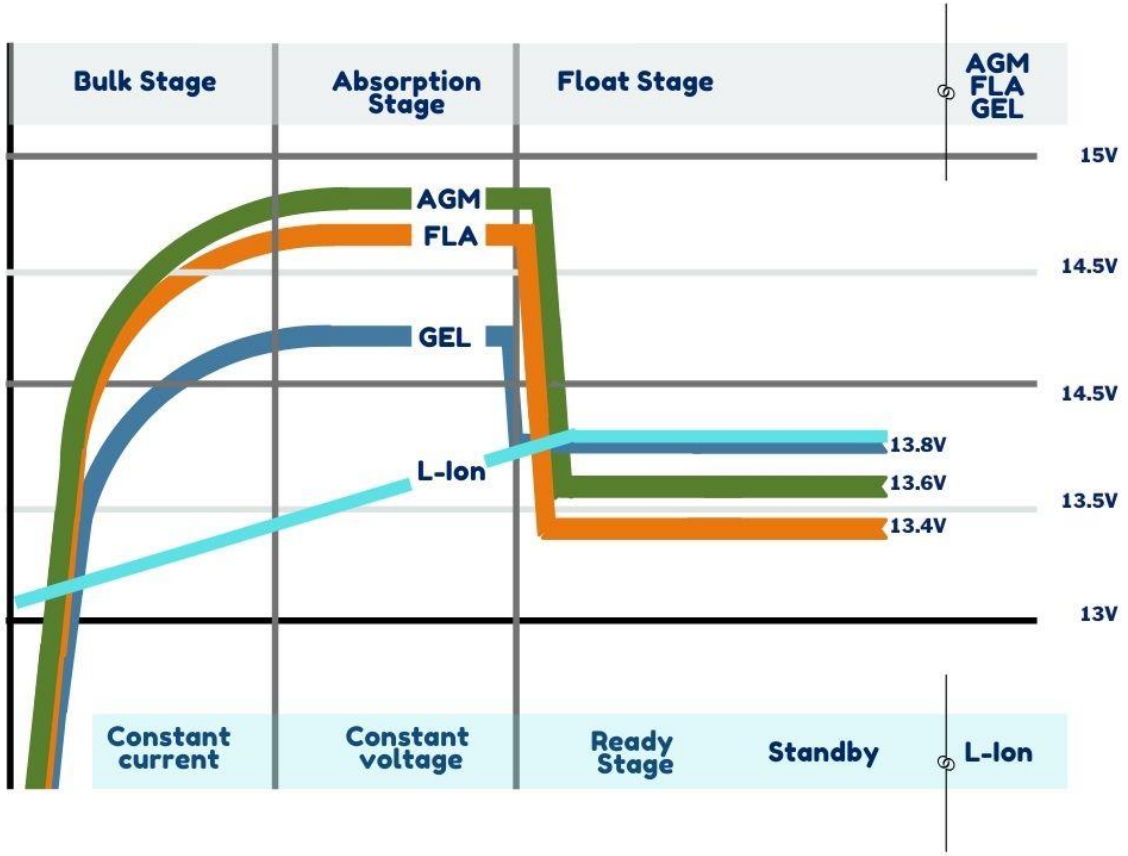
RECOMMENDED

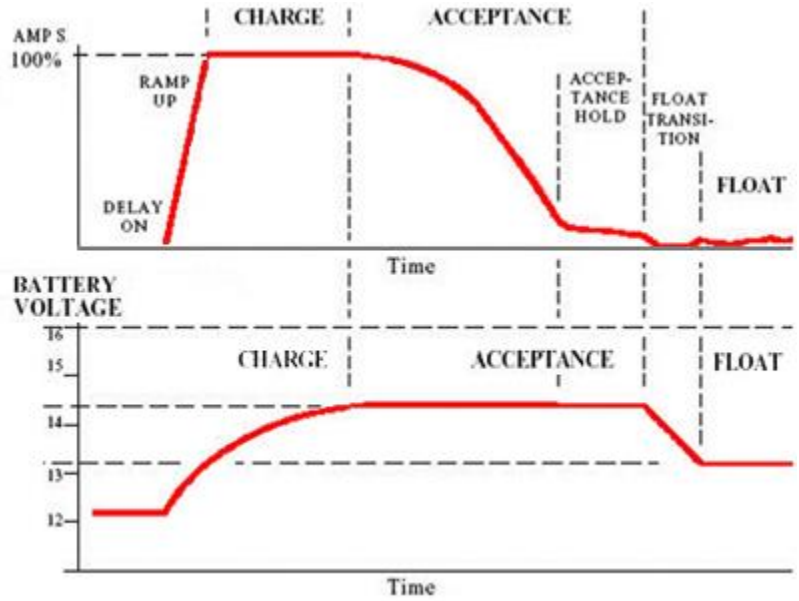
STATE OF CHARGE



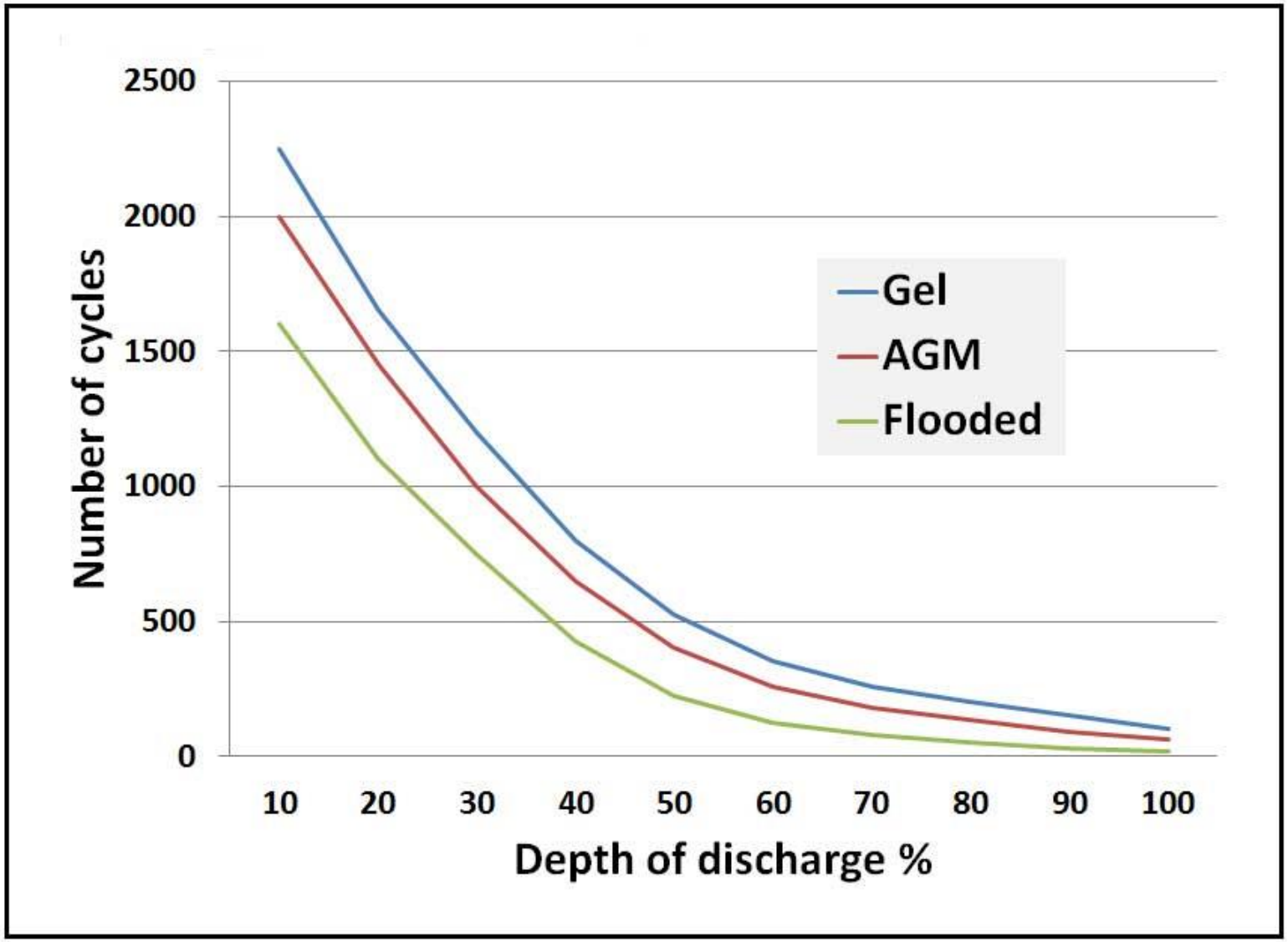
NOTE: State of Charge (SOC) can only be determined when not charging & under no load!

Charging Characteristics





HOW LONG WILL THEY LAST?



- Tips for Battery Longevity
  - Shallow discharges lead to a longer battery life.
  - Don't leave batteries deeply discharged for any length of time.
  - Charge batteries after each period of use.
  - Don't mix old batteries with new ones.
- How to Rapidly Kill a Battery
  - **Undercharging:** Consistently failing to fully recharge batteries leaves them with lead sulfate that hardens on their plates—they become sulfated—and gradually lose their ability to perform. Keep your batteries charged, and equalize your wet cell batteries every six to eight weeks in temperate climates, and more frequently in the tropics.
  - **Overcharging:** Especially fatal to Gel and AGM batteries, consistent overcharging (NOT equalization) boils the electrolyte out of the cells, and can even lead to thermal runaway, with the battery becoming hotter and hotter.
  - **Excessive deep discharge:** Don’t completely discharge a deep cycle battery if it can be avoided. The deeper the discharge the less life you will get from the battery.

Sizing Your House Battery Bank

Item	Watts	Amps	Hours use at anchor	Daily use at anchor Ahrs	Hours use underway	Daily use at Anchor Ahrs
Running lights	30	2.5			12	30
Anchor light	10	0.8	12	9.6		
Navigation electronics	30	2.5			12	30
VHF radio (standy)	3	0.25	24	6	24	6
Cabin lights	30	2.5	4	24	0.5	1.25
Galley						
Pumps						
Fans						
Entertainment system	120	10	3	30		
TOTAL				**70 Amp Hours**		**67 Amp Hours**

REFRIGERATION IS TYPICALLY THE LARGEST POWER USAGE, BETWEEN 60 – 80 AMP HOURS

It very much depends on:

(1) the type of refrigeration you have (which compressor, mostly);

(2) the size and quality of insulation of your frig; and

(3) the ambient temperature (more in summer and in the tropics).

MINIMUM BATTERY BANK SIZE FOR ONE DAY = (TOTAL AMP-HR USAGE)/(40%) = 70/0.40 = 175 AMP-HOURS

Sizing Your House Battery Bank

Group Size	Typical Ah Rating	Nominal Voltage
U1	34 - 40Ah	12 Volts
Group 24	70 - 85Ah	12 Volts
Group 27	85 - 105Ah	12 Volts
Group 31	95 - 125Ah	12 Volts
4-D	180 - 215Ah	12 Volts
8-D	225 - 255Ah	12 Volts
Golf Cart	180 - 225Ah	6 Volts
L-16	340 - 415Ah	6 Volts

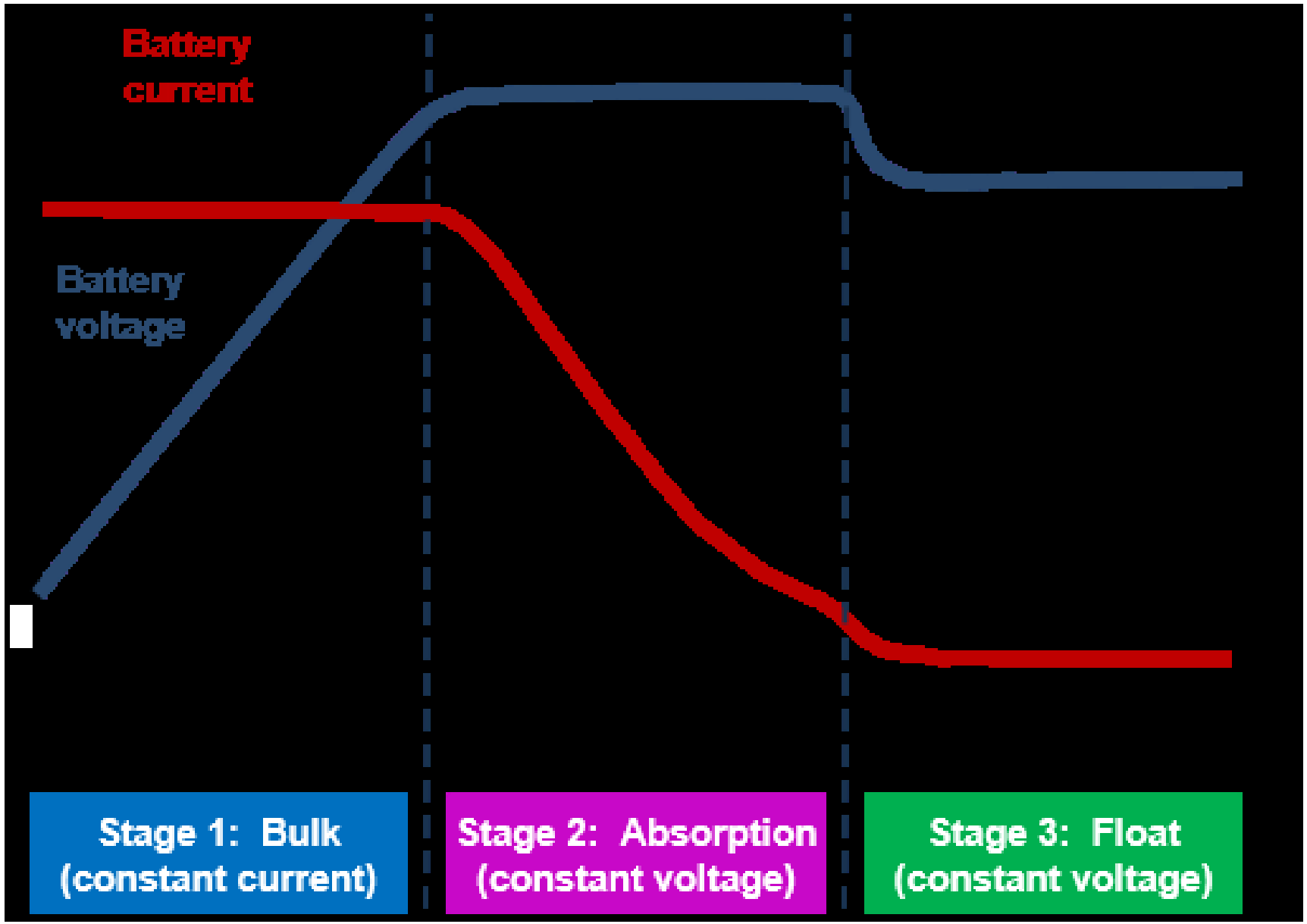
Battery Chargers

Ferroresonant Chargers

- The better chargers work ok on wet cell batteries
- Do not do a good job on AGM and Gel batteries
- May cause premature battery failure because of constant overcharging

If you have one, replace it

Three Stage Battery Charger



What size charger do I need?

- Deciding how big your charger needs to be is determined by the size and type of your batteries, and whether your boat has a continuous or intermittent source of AC power to run your charger.
- Boats that spend most of their week at a dock constantly hooked up to shore power require smaller chargers. You need enough capacity to run the continuous loads on your battery system, like DC refrigeration (frequently the biggest user of battery power) and lights, plus enough power to float-charge your batteries.
- A good rule is to have enough amperage to equal the sum of the DC loads plus 10 percent of the amp-hour capacity of the batteries.
- If you’re cruising or anchored out, and aren’t plugged in except

Battery Charger Wiring

MOUNTING

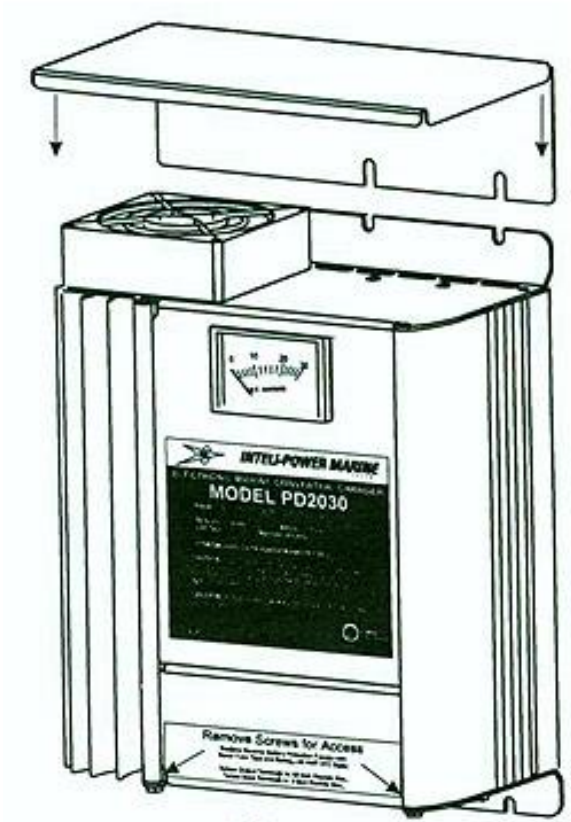


Figure 1

WIRING DIAGRAM

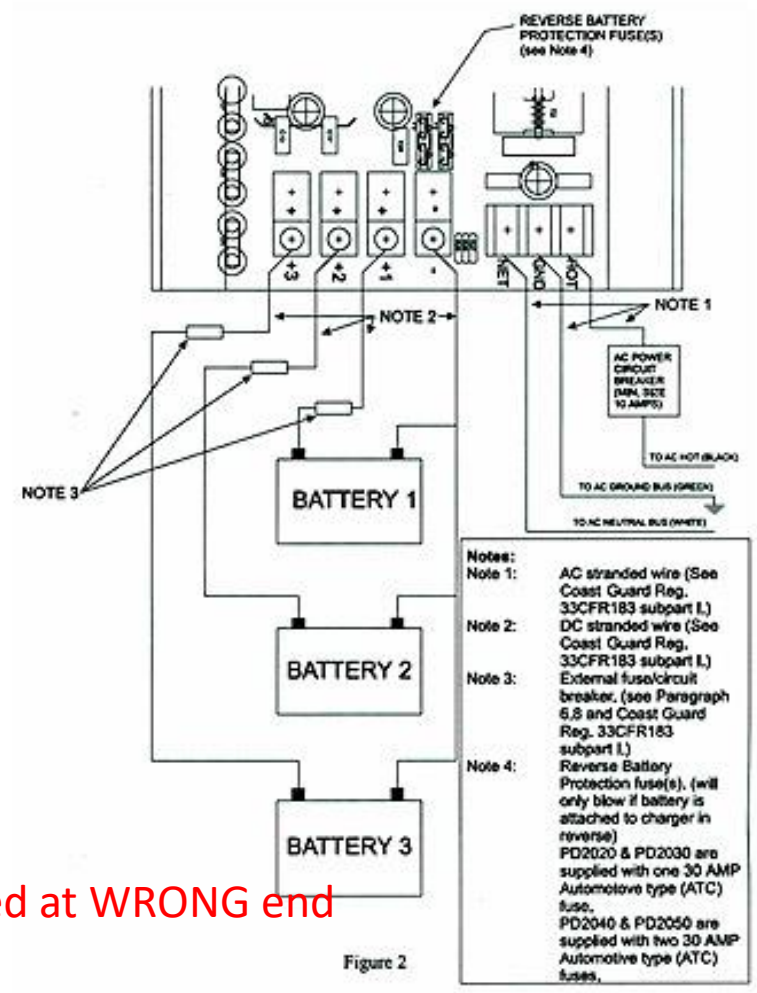
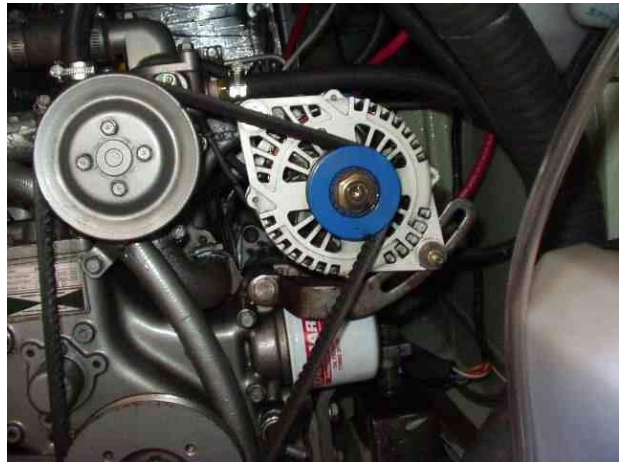


Figure 2

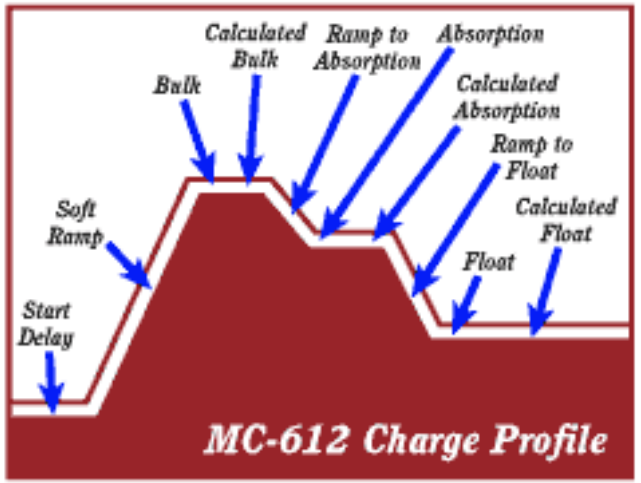
Note fuses are installed at WRONG end of wires!!

Alternators



- **Internal or external regulators**
- In automotive type alternators, current for the alternator is supplied by an internal regulator, which drives the alternator to a specific voltage value (usually about 14.1 volts), *which works great for a starting battery, just like the one in your car*.
- Deep cycle and sealed gel and AGM marine batteries require a more complex program of charging voltages to achieve their optimal charge. Multi-stage external voltage regulators, like the Balmar Max Charge and ARS-5 enable the alternator to vary charging voltages, based on the battery's temperature, chemistry (flooded, gel or AGM types) and level of discharge, <u>to ensure that batteries are recharged quickly and safely.</u>

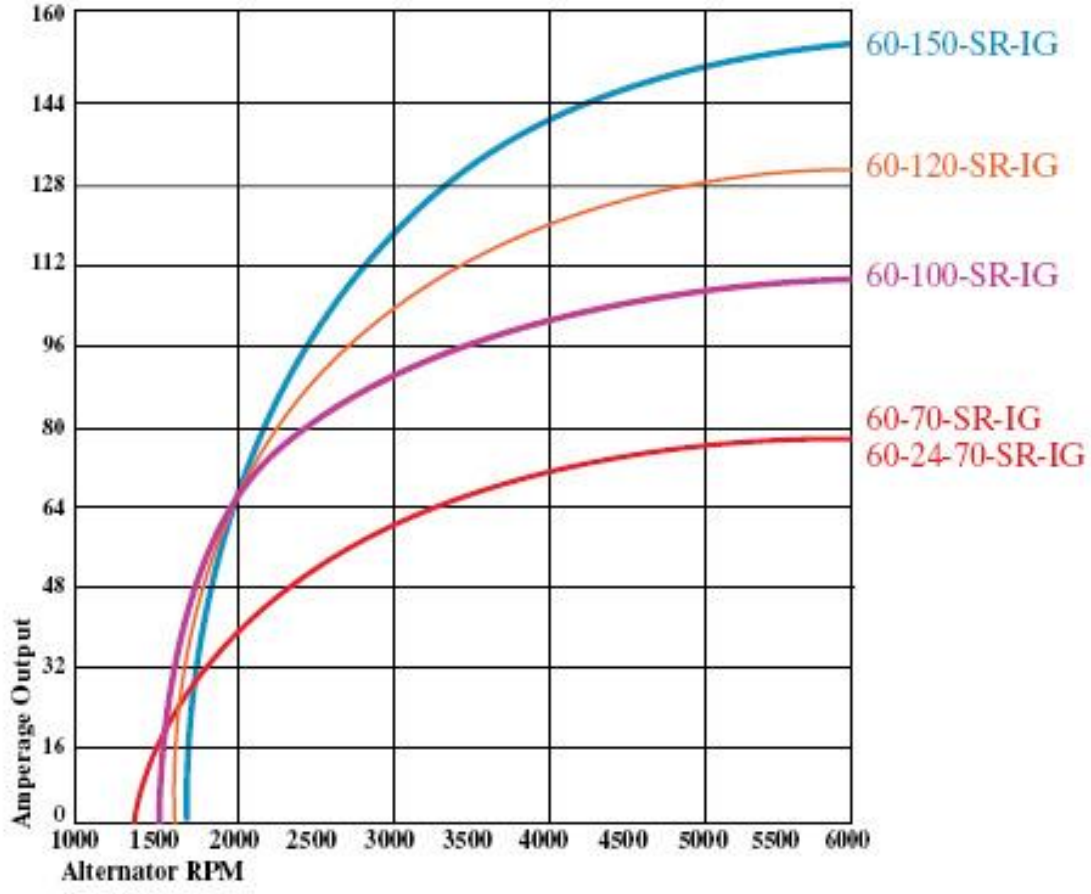
SMART REGULATORS



Preset Battery Programs:
1. Universal Factory, 2. Deep Cycle Acid
3. Gel, 4. AGM, 5. Standard Lead Acid
6. Optima, 7. Halogen/Voltage Sensitive

Advanced Programming:
1. Delay Time 2. Compensation Limit
3. Minimum Field Value
4. Bulk Voltage, 5. Bulk Time
6. Absorption Voltage
5. Absorption Time, 6. Float Voltage
7. Float Time, 8. Amp Manager
9. Equalize Voltage. 10. Equalize Time

Alternator Output Curve



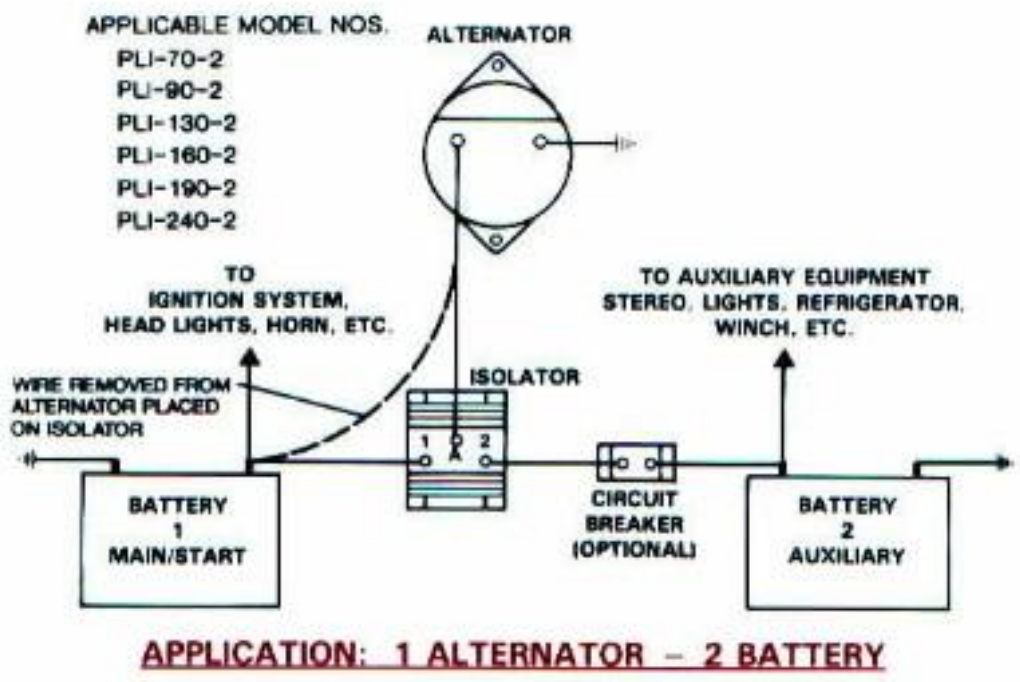
Alternator RPM is typically double engine RPM

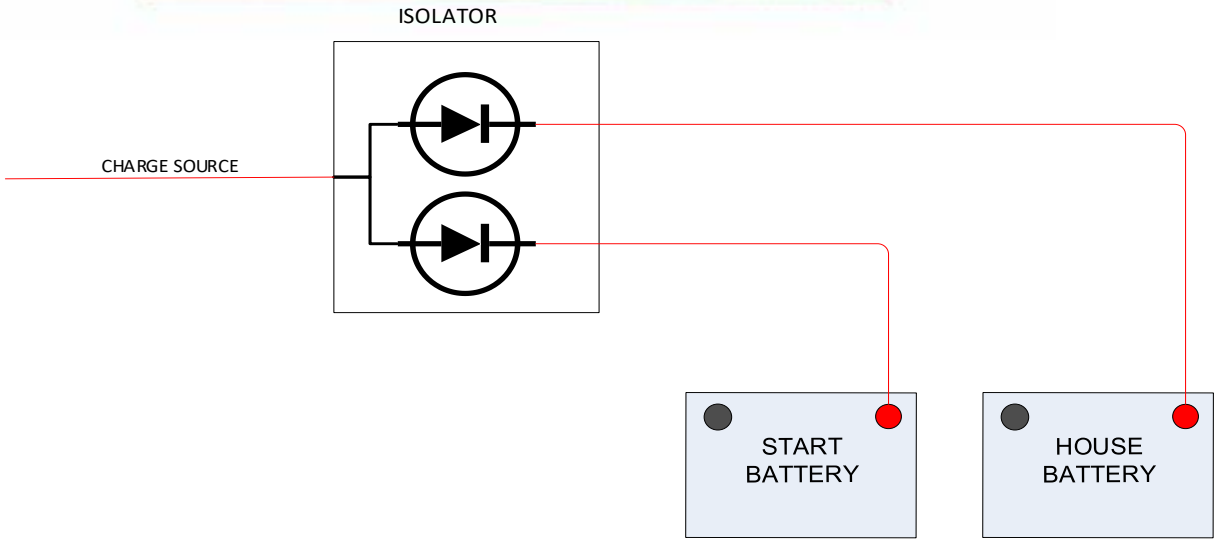
Alternators

- The Rule of thumb is that the alternator output in amps should not be less than 25% of the battery capacity in amp hours for lead batteries and 40% for AGM. This is the acceptance rate of the battery
- You can figure 1 hp (engine load) per 25 amps (12 volt) at maximum output.

Belt Type	Belt Width	Max. HP Load	Highest Recommended Output
Single Vee	3/8	3.5	80A @ 12V, 30A @ 24V
Single Vee	1/2	4.5	110A @ 12V, 45A @ 24V
Dual Vee	1/2	12	310A @ 12V, 220A @ 24V

Charging Multiple Battery Banks: The Battery Isolator





- IT'S IMPORTANT TO REMEMBER THAT IF A BATTERY ISOLATOR IS INSTALLED, VOLTAGE SENSING FOR THE ALTERNATOR MUST BE DONE AT THE BATTERIES, OR AT LEAST ON THE BATTERY SIDE OF THE ISOLATOR.
- THIS IS DUE TO THE INHERENT 0.7 V LOSS THROUGH THE ISOLATOR DIODES.
- ALSO, ISOLATORS MUST BE RATED FOR THE MAXIMUM ALTERNATOR CURRENT OUTPUT

- Battery Isolators are made with two or more silicon diodes that act like check valves. The diodes will pass current from the charging source to the batteries, but will not pass current backward from one battery to the other or back to the charging source.

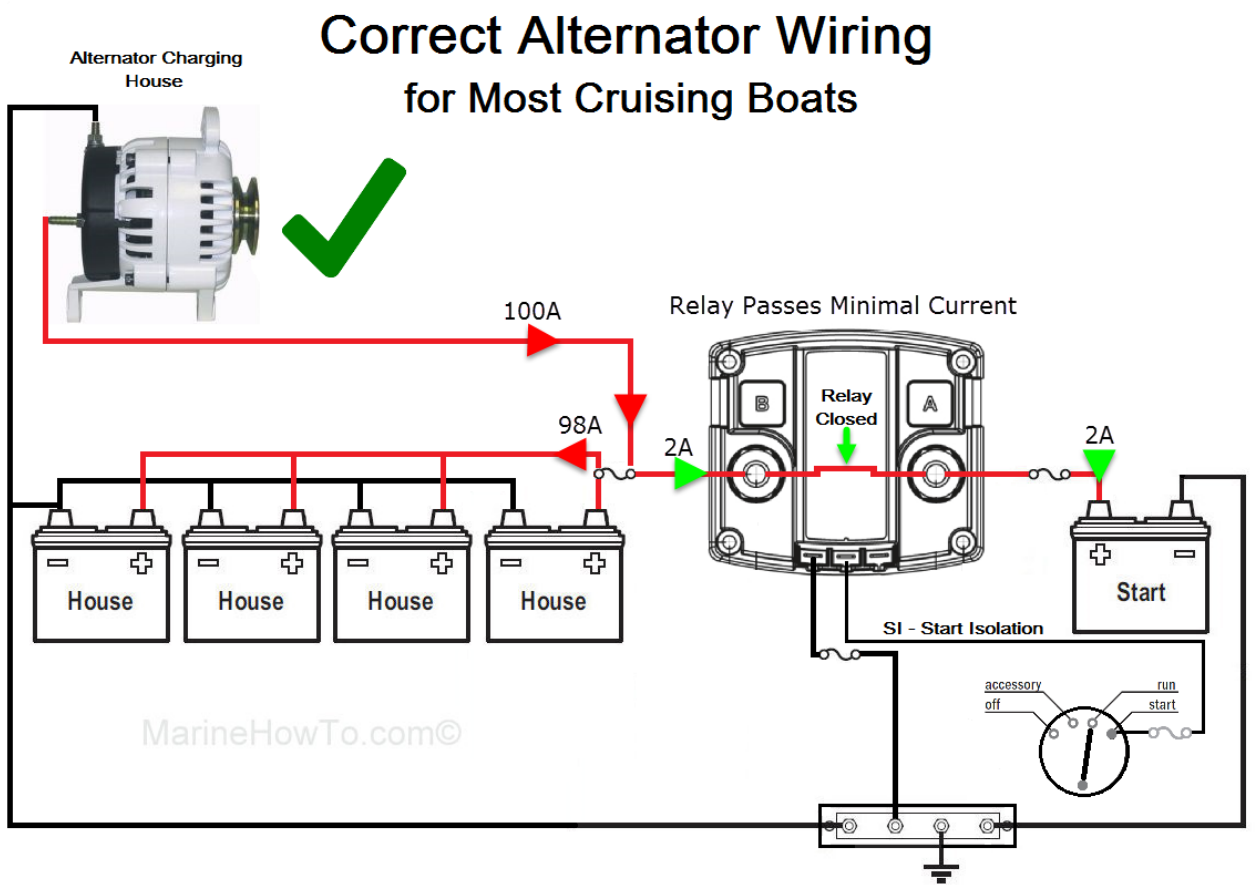
A Better Way to Charge Multiple Batteries:

BATTERY COMBINERS

- Automatically combines battery banks during the charging cycle and isolates under discharge
- Activates from any charging source - alternators, battery chargers, or solar panels
- Requires circuit protection device at batteries

- The ACR has two parts:
- A relay – a switch that is activated by an electrically powered magnetic coil.
- An electronic circuit that senses the voltage level of the boat's batteries and signals the relay switch:
- Closed when voltage is high (the ACR's COMBINE voltage)
- Open when voltage is lower (the ACR's UNDERVOLTAGE voltage)

Battery Combiner Diagram



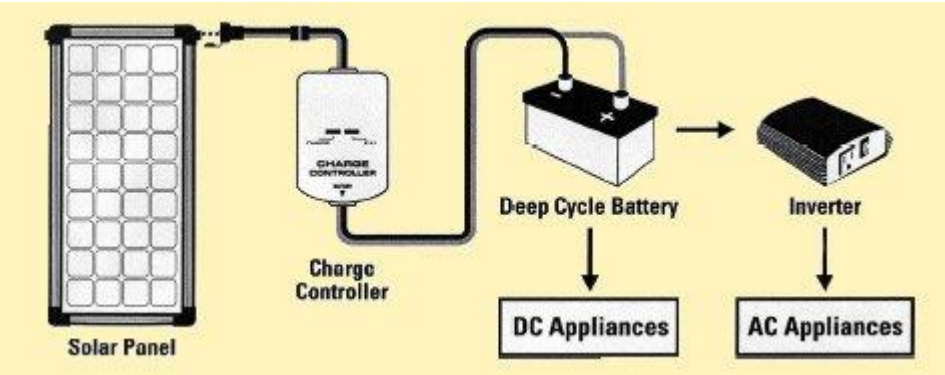
Marine Solar Systems

Most marine solar systems consist of three major components:

•Solar panels produce the charge.

•Charge controller or regulator regulates the charge going into the battery and prevents overcharging.

•Batteries store the energy created by the solar panels.



- Simple Rules for Best Power Production
- **Keep the panels as perpendicular to the incoming sun's rays as possible**. We understand that if you've mounted panels on a boat on a mooring, you may not be able to guarantee that they are pointing towards the sun, but all panels will produce more power if they get direct sunlight. This is a compelling reason to mount panels on cruising boats so that they can be aimed in the appropriate direction, no matter what the season, course, or latitude.
- **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.

- **The first step in designing your solar charging system is to define what you want to accomplish with it.**

  In order to properly design and select your system, you will first need to define what your needs are. They can be as simple as keeping the battery topped off while the boat is on a mooring or as complex as being fully self-sustaining. Which of the following closest meets your needs?

  A. Keep the batteries charged while on a mooring.

  B. Supplement current power generation capability. (Run my engine less to charge the batteries)

  C. Generate all the power needed while at anchor.

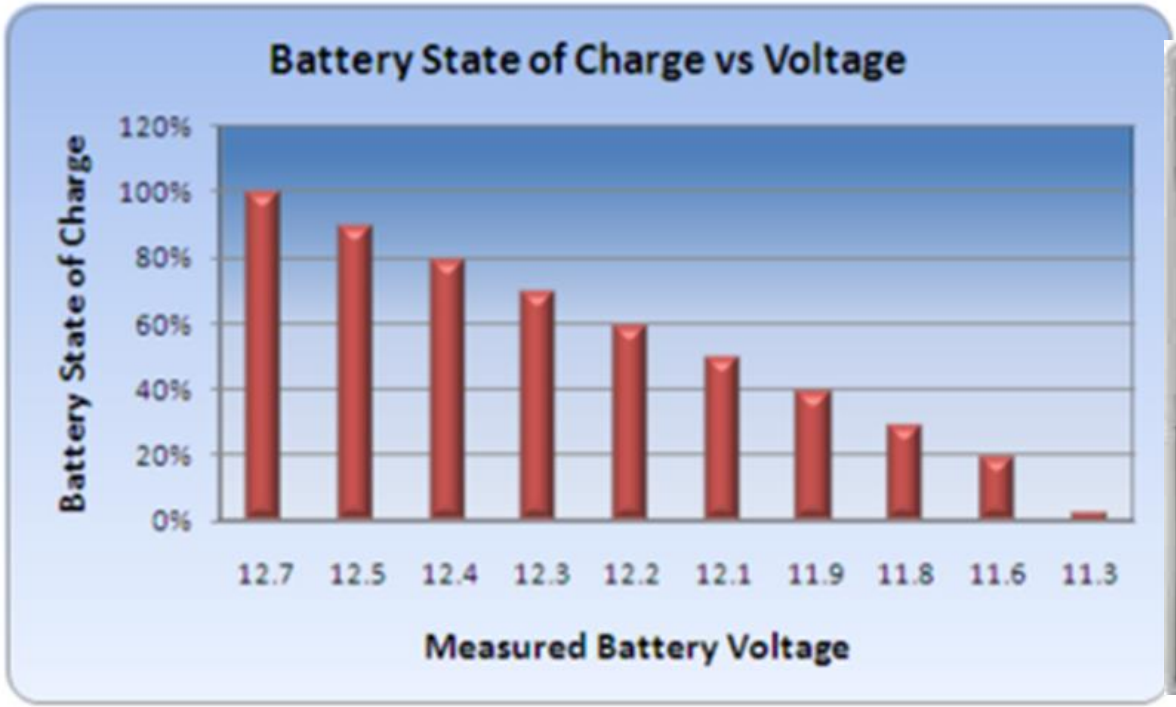
  D. Generate all the power needed on passage and at anchor.

- Choosing solar panels is largely determined by their size and where/how they can be effectively and conveniently mounted onboard

- How to wire the system and choose the best type and number of controllers is more complex.

- Do your research
  - Article “Sizing and Selecting Solar Controllers” Professional Boat Builder April/May 2021

How do you know if your batteries are properly charged?

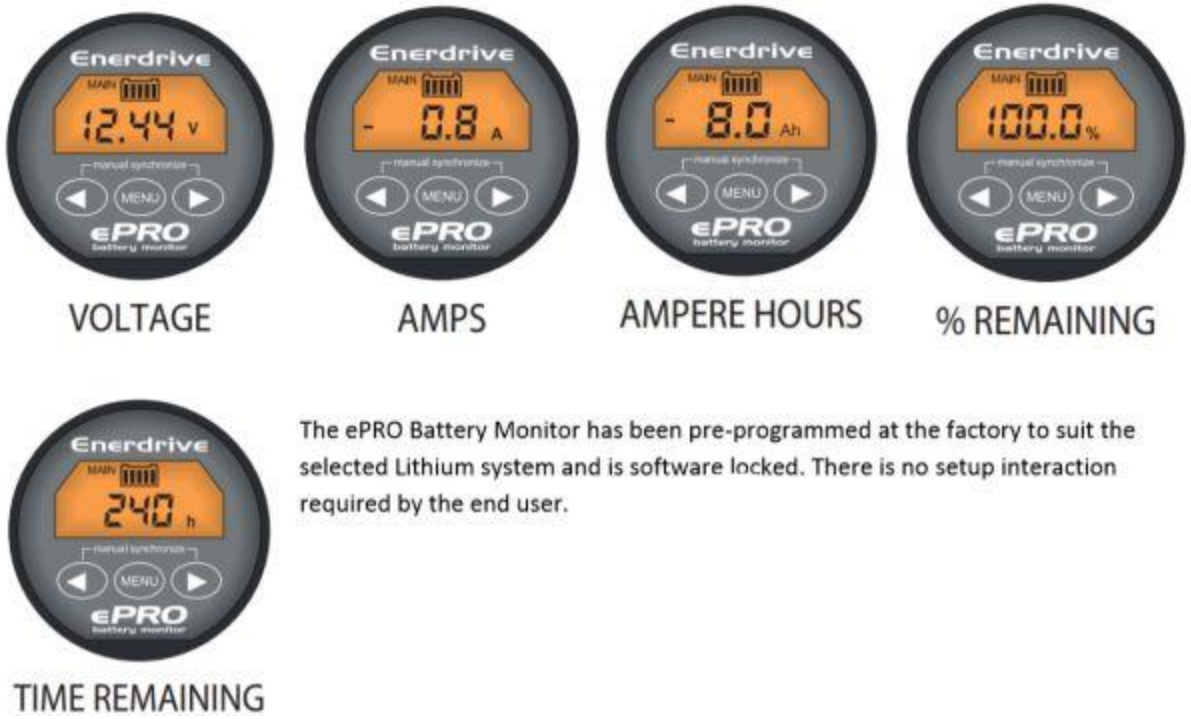


This is only valid if the batteries have been at rest (no load or charge) for at least several hours!!

Battery Monitors

- Read your battery bank like a fuel gauge *in real time*
- Provides critical information about the status of your battery bank:
  - State of Charge
  - Amp-Hours Used
  - Voltage
  - Current

What they tell you



The ePRO Battery Monitor has been pre-programmed at the factory to suit the selected Lithium system and is software locked. There is no setup interaction required by the end user.

One of the things you'll learn from the monitor is that, at anchor, charging multiple times a day is more effective than one long time.

PUTTING IT ALL TOGETHER