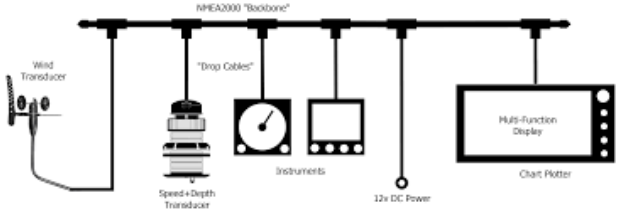
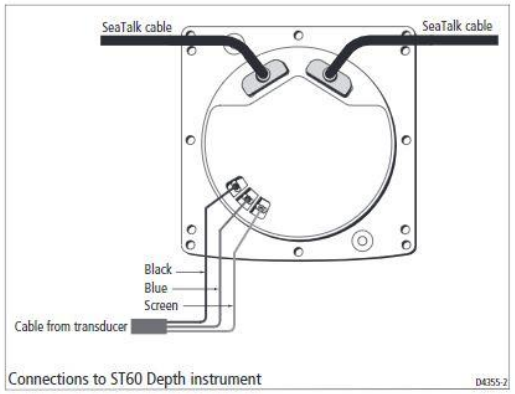
Welcome Back

REVIEW

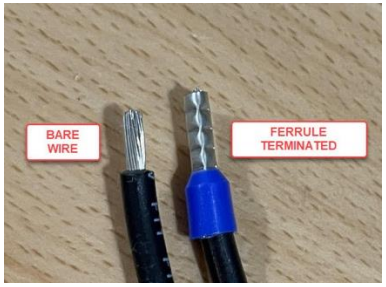
- Volts, Amps, Watts
- Ohms Law/Power Formula
- Using a DMM
- Conductors,
- OCP, AIS,T-Fuses
- Lithium Battery Requirements
- Crimping Wires

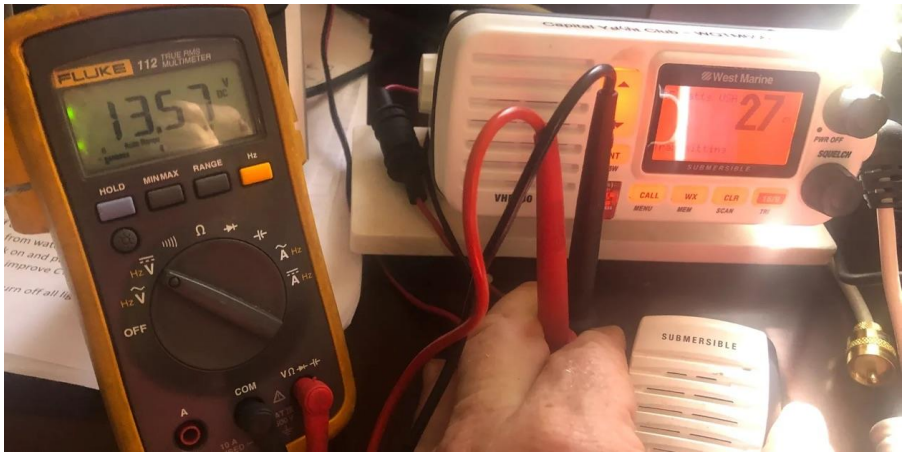
This Morning's Syllabus





- Review
- Battery Cables
- Corrosion
- Electronics
- Communications
- Show & Tell
- Labs
- Q&A





Battery Cables

- Sizing The Cable
- Choosing a Terminal
- Stripping
- Crimping
- Protecting
- ABYC Standards

Introduction to Marine Corrosion

- Anodes
- Cathodes
- ICCP
- What to Watch For
- When to ask for Help

What IS Corrosion??

The loss of METAL through an Electro-Chemical Process

What ISN'T CORROSION??

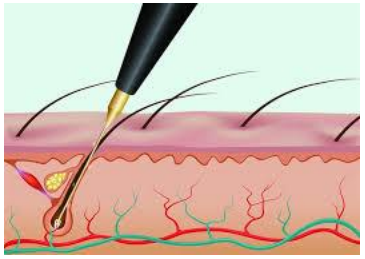
We do NOT have *electrolysis* on boats!

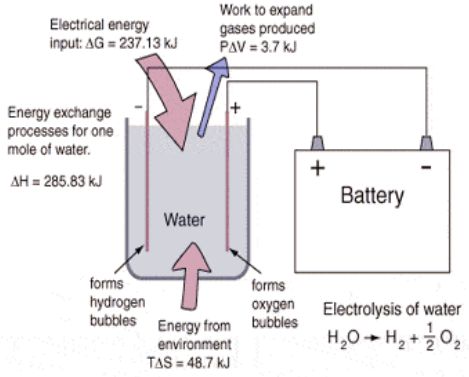
Let Me Explain That:

The US Dept of Energy defines Electrolysis as:

“the process of using electricity to split water into hydrogen and oxygen.”

It is also a popular method of hair removal using electricity… but it isn’t what causes metal loss on boats



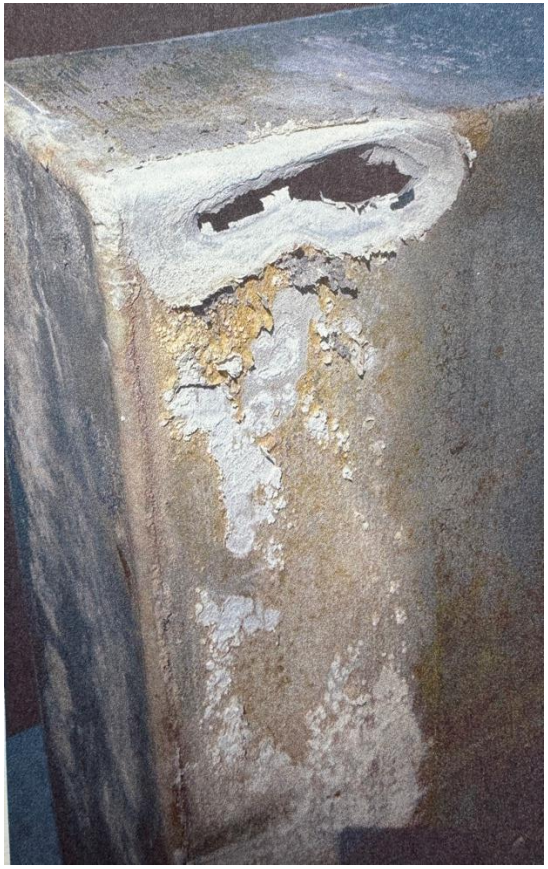


If It Isn't *Electrolysis*..
What Is It??

Many kinds of corrosion can damage a vessel or its gear. Today, we will focus on the most common:

- Galvanic Corrosion
- Stray Current (Electrolytic) Corrosion
- Simple Corrosion
- Poultice Corrosion
- Crevice Corrosion
- Microbial Corrosion

Of course, there are others as well…



A Few Definitions

Metal

Alloy

Anode

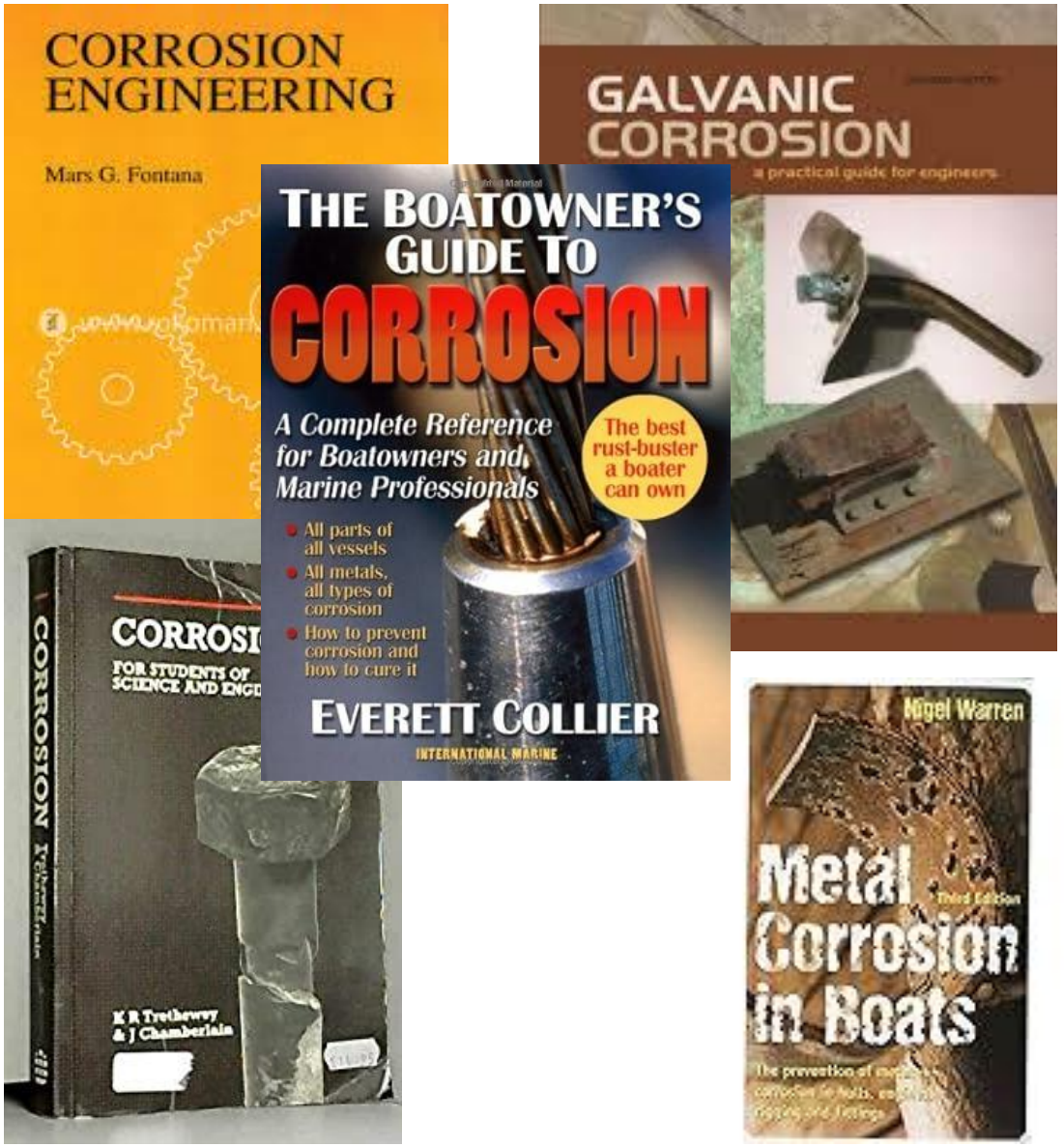
Cathode

Galvanic Series

Electrolyte

Conductive Path

Bonding



Metal

Noah Webster tells us that a metal is any of a class of elementary substances, as gold, silver, or copper, all of which are crystalline when solid and many of which are characterized by opacity, ductility, conductivity, and a unique luster when freshly fractured.

Alloy

A substance of two (2) or more metals intimately mixed such as:

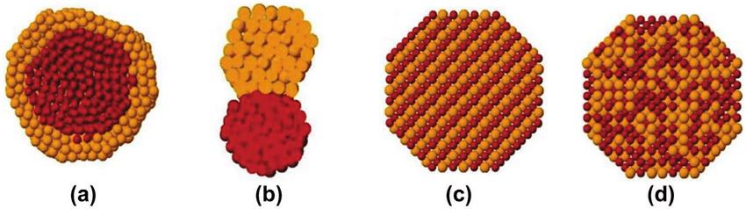
316 SS (chromium, nickel, molybdenum)

6061 aluminum (magnesium, silicon, chromium)

Monel (nickel, copper, manganese)

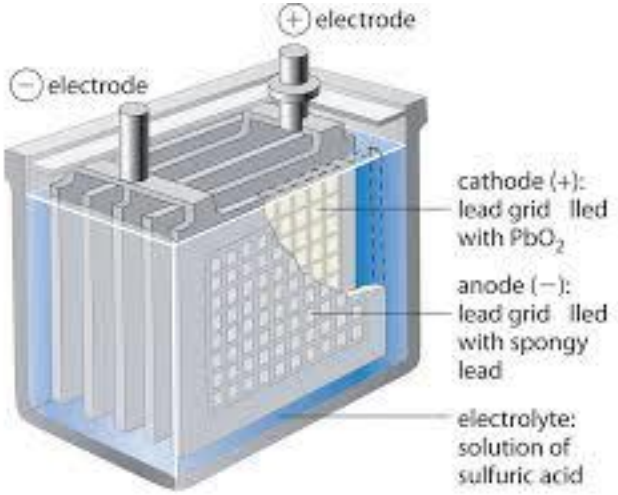
Brass (copper, zinc)

Bronze (copp



Anode

The metal (or electrode or terminal) that loses charged particles (Ions in our example). The Anode will always be **more negative** than the *cathode*



Cathode

Metal (or electrode or terminal) that MAY gain or attract particles Ions in this example), in that direction the particles (from the Anode) try to flow to

The Cathode will always be **LESS NEGATIVE** than the Anode, even if both are negative.

Electrolyte

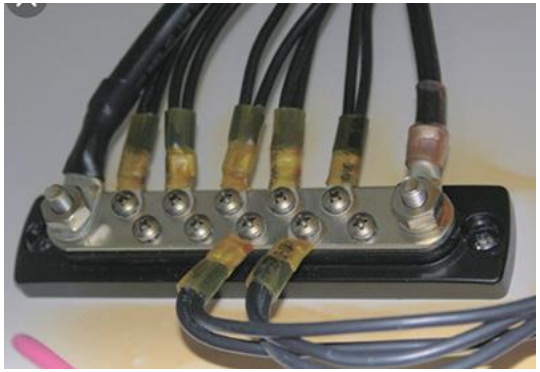
An aqueous (mostly water) solution that one or more metals are submerged in; in our case almost always *salt water*.

There can be more than one electrolyte path on a vessel, and often there are several.

Bonding

Connecting all under materials to a single anode to maintain managed control of the hull potential.

Recommended but not Required



Conductive Path

Electrons flow through conductors, usually but not always metals (carbon fiber is very conductive. For galvanic corrosion to exist there must be a path for electron flow (conductive path) as well as ion flow (electrolyte)

“LESS NEGATIVE”

- The critical concept to grasp
- Not always from Negative to Positive
- We are trying to be sure that we ‘shift’ the voltage, or potential, of our hull ‘downward’
- Galvanic Protection requires a negative shift of -200mv
- We will return to this several times.
- Key point: Negative to Less Negative

Galvanic Series

A tabular listing of the electrical potential of a metal in *seawater* as measured by a silver/silver chloride half-cell.

A table of metals ranging from the most anodic (Magnesium) to most Cathodic (Graphite/Carbon Fiber) is provided in the handouts.

Identifying Galvanic Corrosion

- Wasting of Anodes over a year
- Some excessive build-up on SOME underwater metals beyond a normal ‘patina’
- Some loss of anodic metals if protection has failed or become inadequate
- Confirmed with a ‘hull potential test’

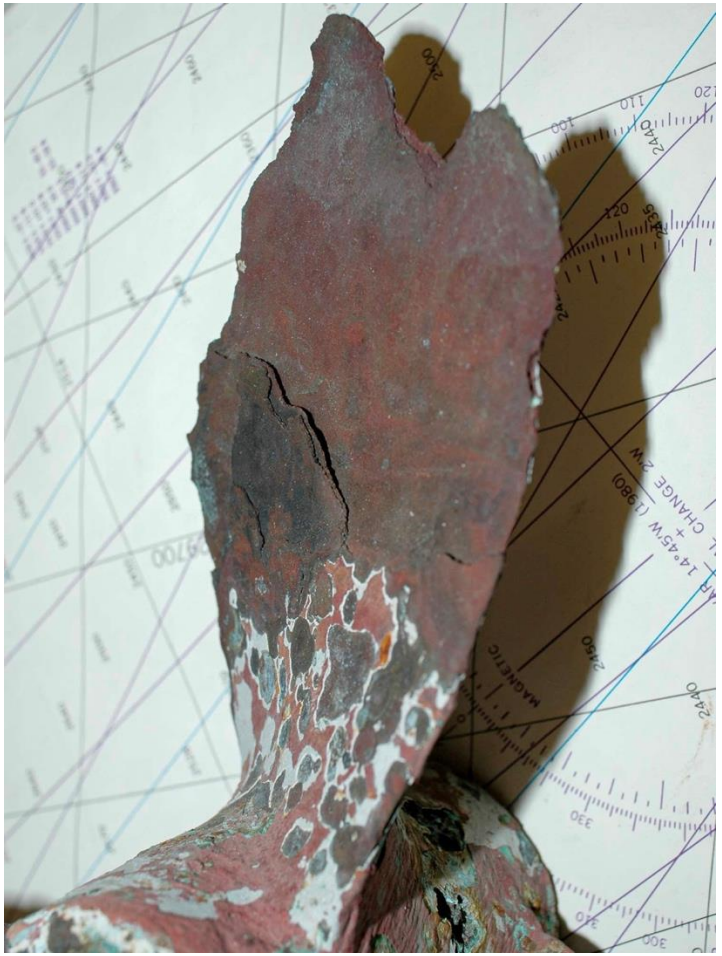
Visualizing Galvanic Corrosion (what else is wrong?)

Stray Current Corrosion (Electrolytic Corrosion)

- Caused by induced currents
- MUCH more virulent
- Can sink a boat in days
- Can destroy underwater metals in hours
- Can NOT be protected by Galvanic Isolators
- Is usually caused by a lack of maintenance

Let’s Look Again!

Maybe Two More:



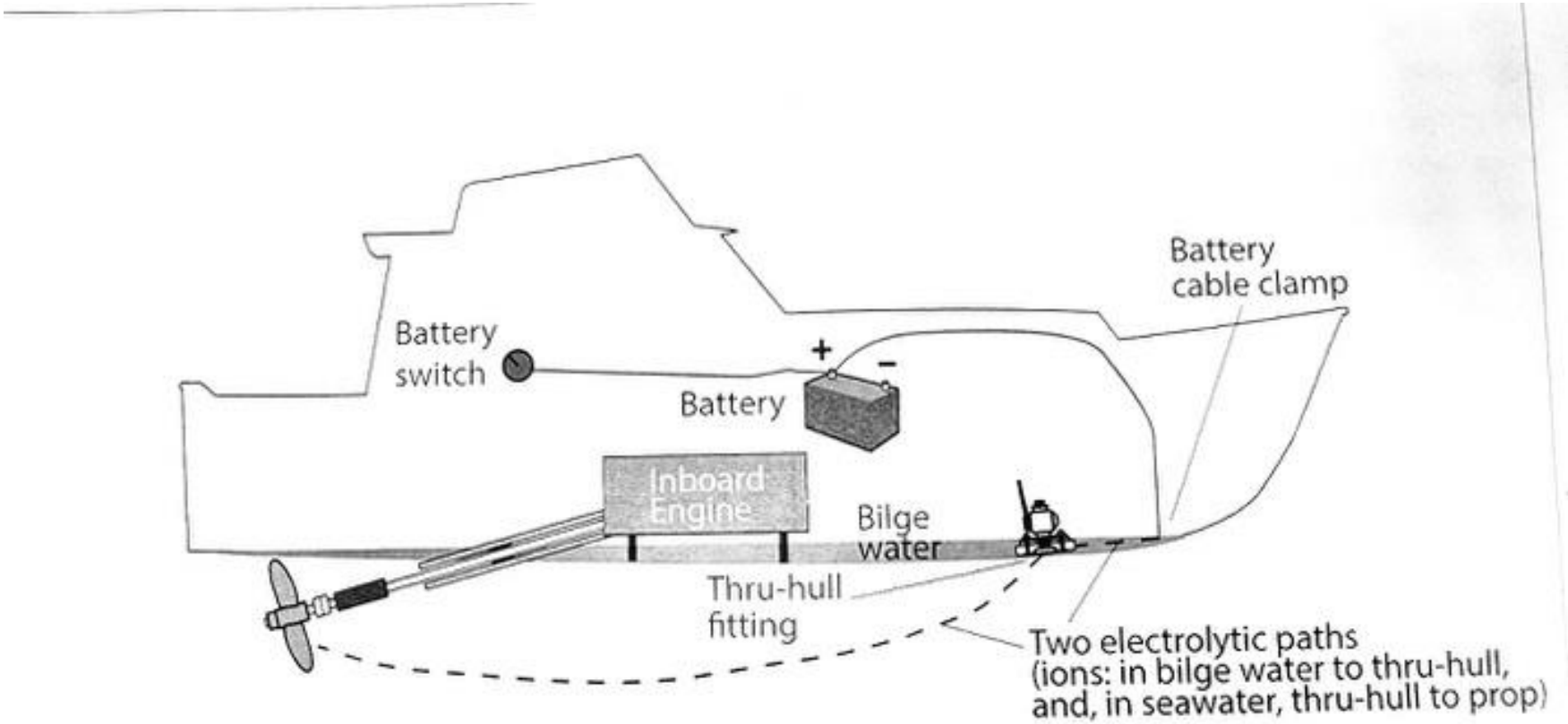
Now we have a POWER SOURCE

- Galvanic Corrosion ‘was the battery’
- Stray Current Corrosion ‘includes’ a battery
- Could be on your boat, might not be
- 12v or 24v usually

Sources of Stray Current

- Battery wire in bilge water
- Bilge Pump insulation failure
- Broken wire touching underwater metal
- Fault on dock or neighboring boat introduced by the GROUNDING conductor (green wire)
- Using a NON-marine battery charger OR an internal fault on battery charger

A common Stray Current Source



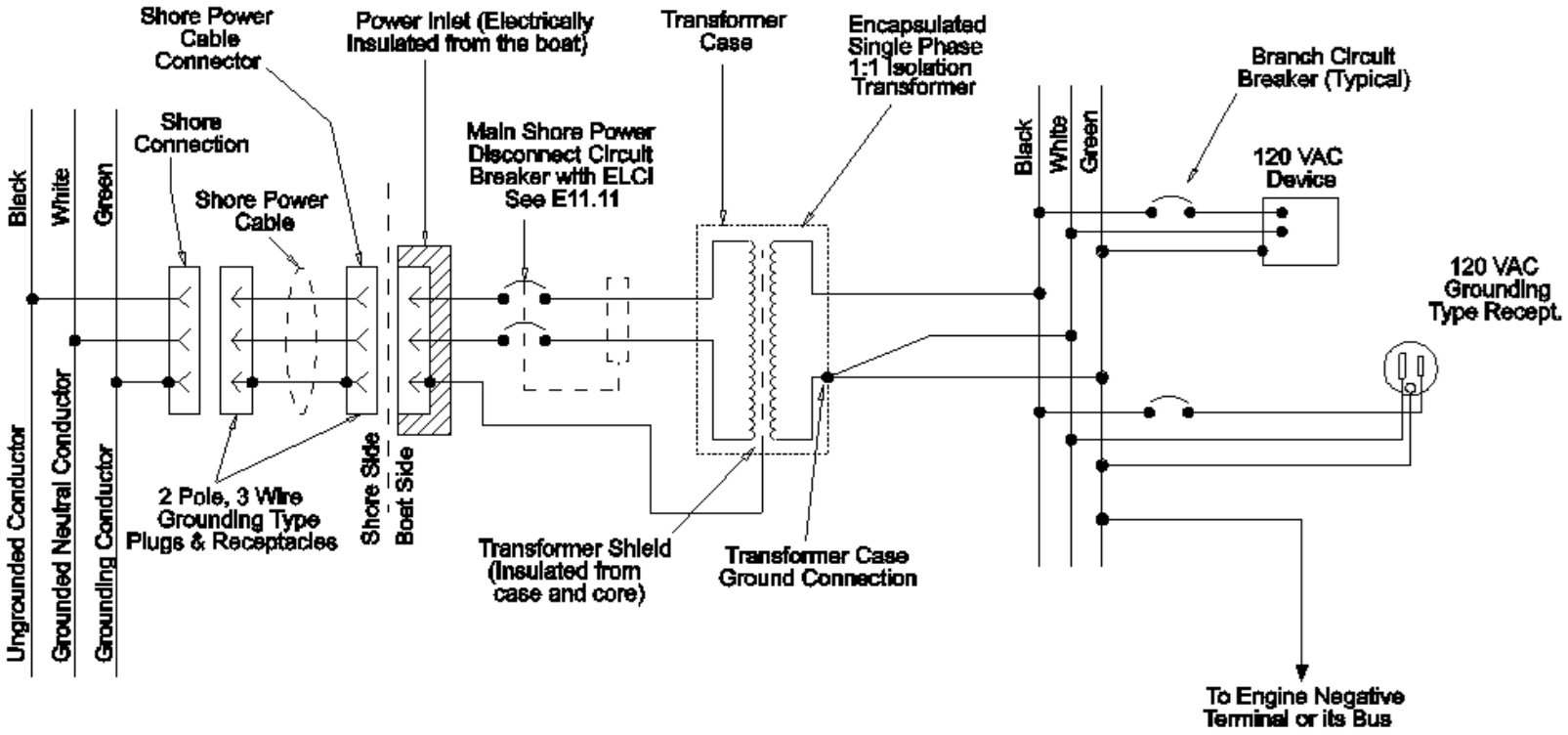
Protecting against Stray Current

- A Galvanic Isolator (always a good idea) won't help here as it can only block 1.2vdc (or so)
- An Isolation Transformer WILL protect you from dock side introduced stray currents and is ALWAYS recommended
- Constant attention to maintenance of your electrical system is the best approach

Isolation Transformers

- Charles (sadly out of business)
- Victron
- Hubbell/Acme
- Bridgeport Magnetics
- ASEA
- Others

Typical 1ph IsoTrans Installation



Typical Split Phase Installation

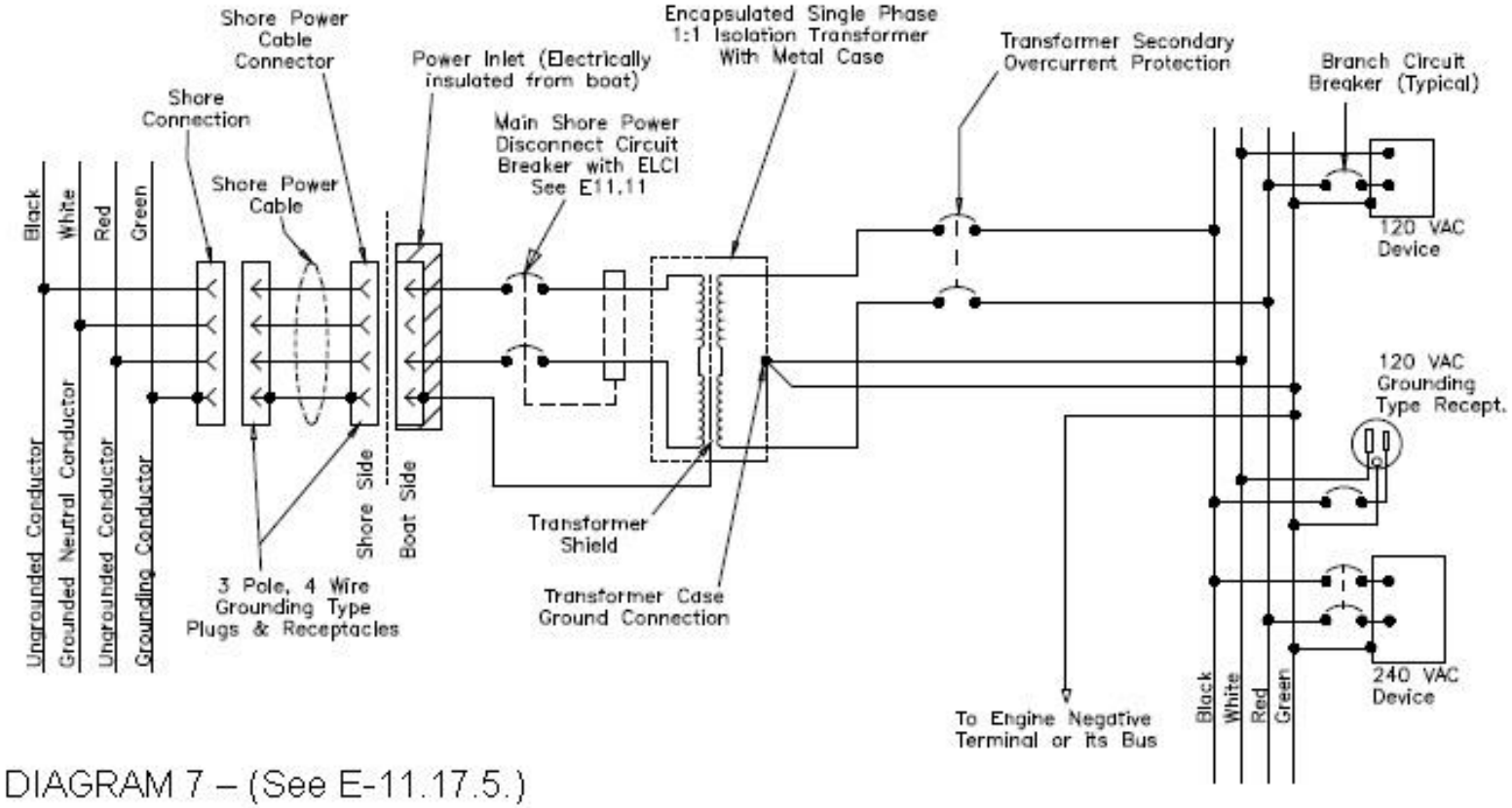


DIAGRAM 7 – (See E-11.17.5.)

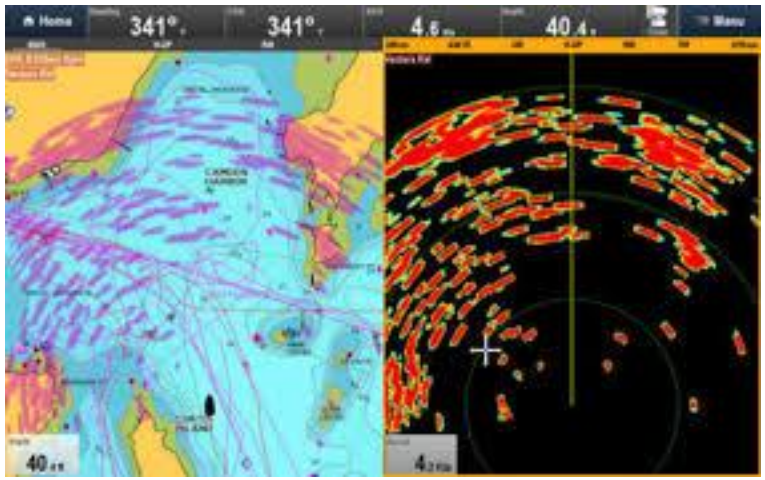
Discussion and Review

Electronics

- Traditional Instruments (Depth, Speed, Wind)
- MFD's Take the Stage
- The iPad/Tablet Revolution
- SeaTalk (1, 2, NG)
- NMEA (.180, .183, 2K)
- Multiplexers

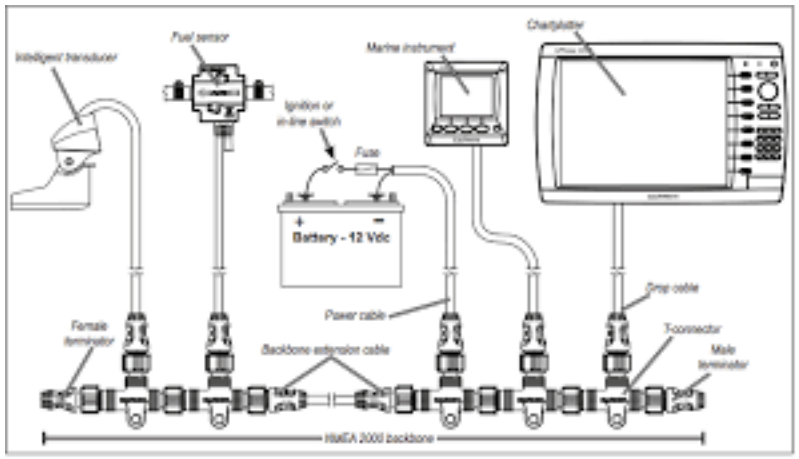
MFD's

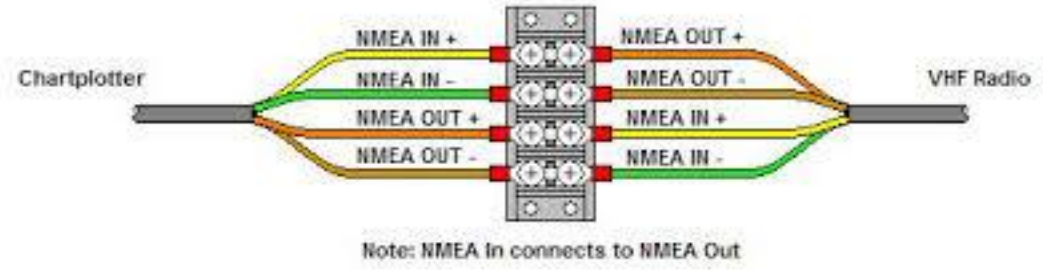
- Brand Preference
- Cartography
- Radar
- Integration
- Active Captain et. al.
- Options



NMEA

- .180
- .183
- 2K
- OneNet™
- SeaTalk™ and Similar





Communication

- VHF/FM Radio
- HF/SSB Radio
- Sat Options
- Weather
- Antennas
- Starlink®

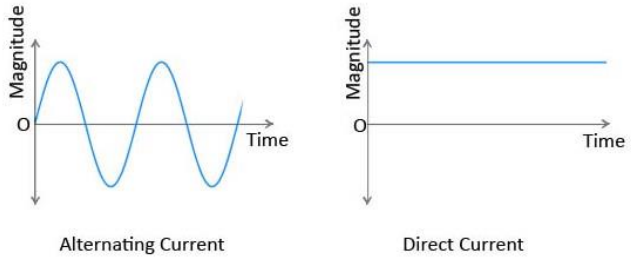
Show & Tell

LAB TIME
Corrosion

LUNCH

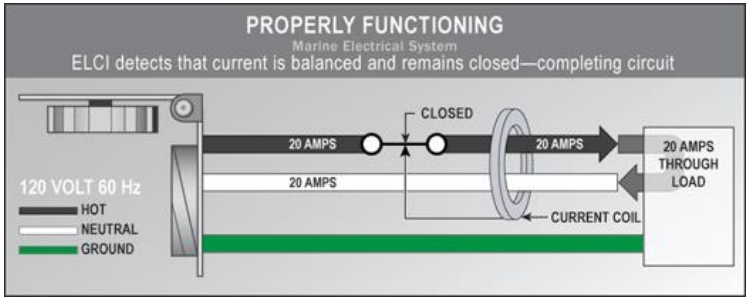
Home Stretch!

- Introduction to AC
- Voltage, Current, Phase, Power
- Ship & Shore
- Inverters
- Ground Faults
- Safety & Codes
- Labs
- Review of Class Goals
- Final Q&A

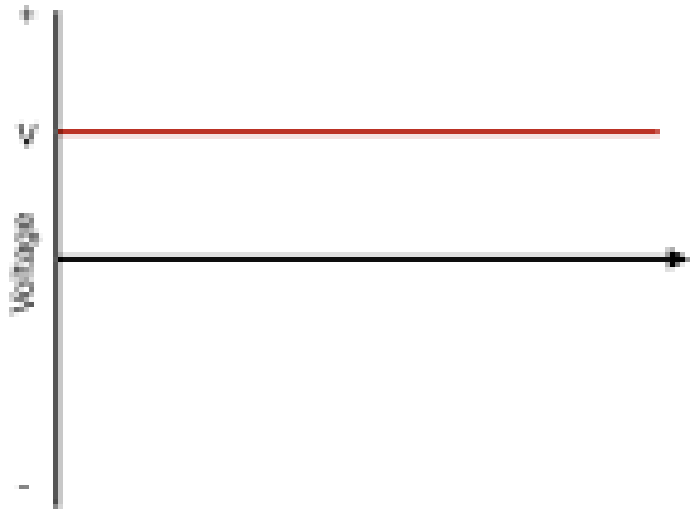
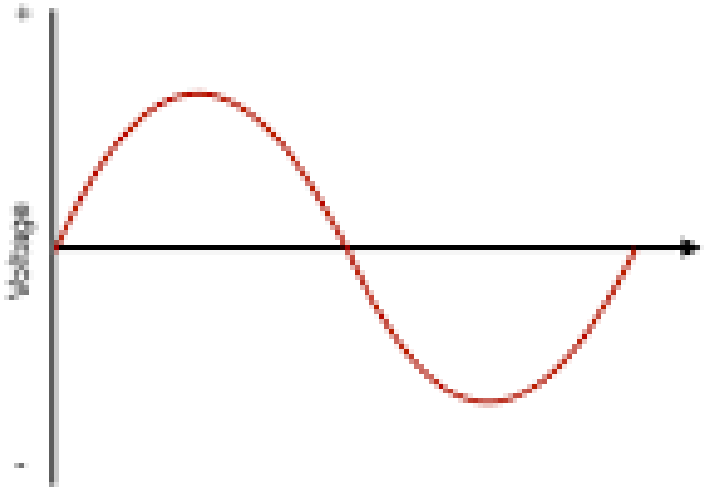


Alternating Current

Direct Current



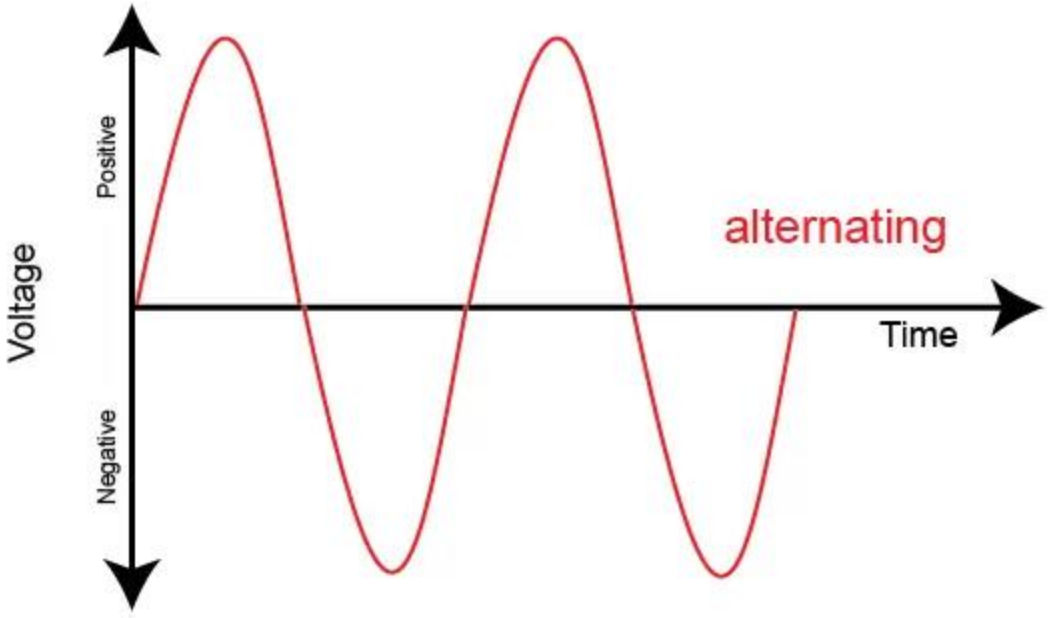
Measuring AC and DC

Direct Current	Alternating Current
	

Alternating Current

al·ter·nat·ing cur·rent

/ˈôltərˌnādiNG ˈkərənt/



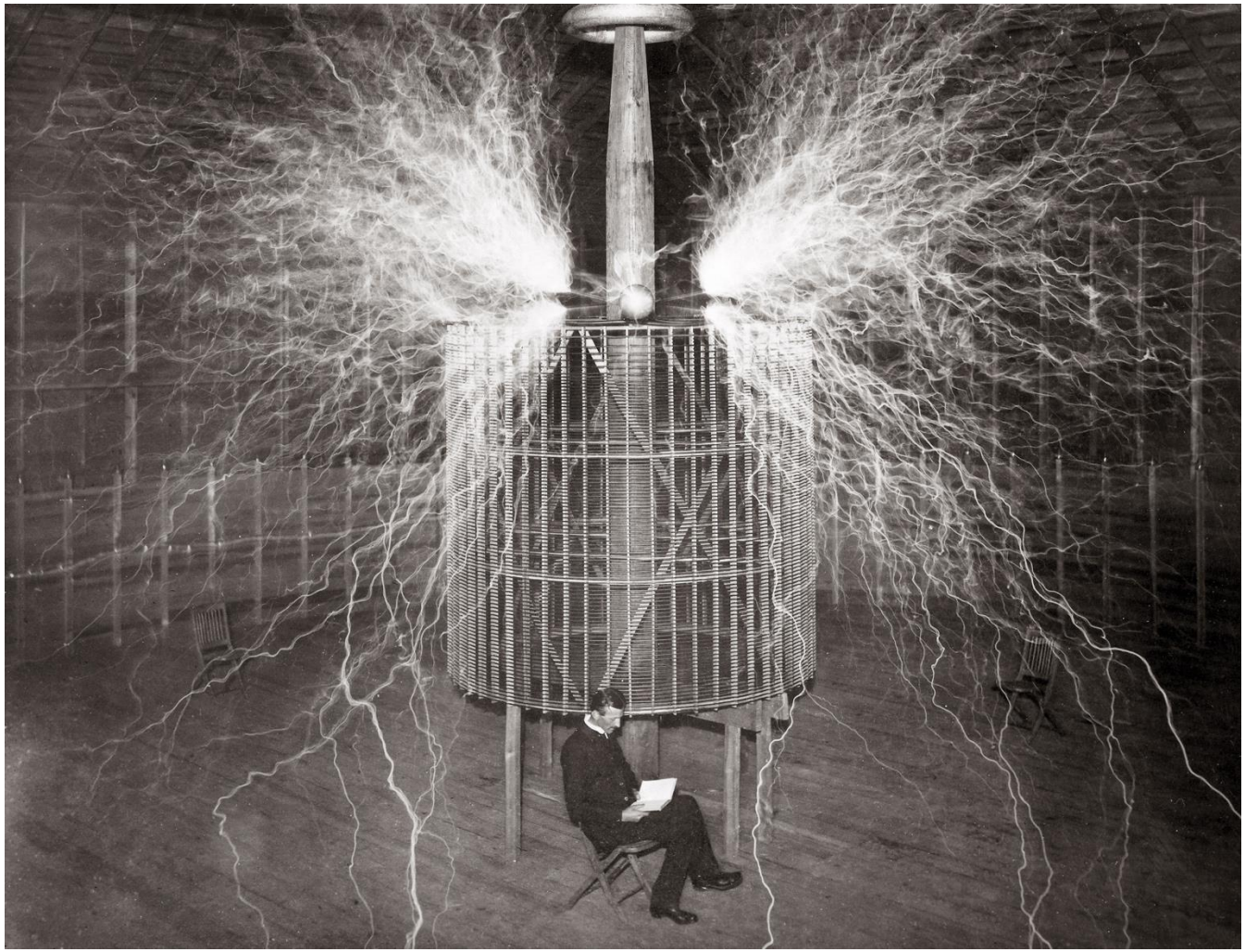
Tesla vs Edison

The ‘War of the Currents”

1893: Tesla won the bid to light the Chicago Worlds Fair

1896: The power plant at Niagra Falls

Alternating Current



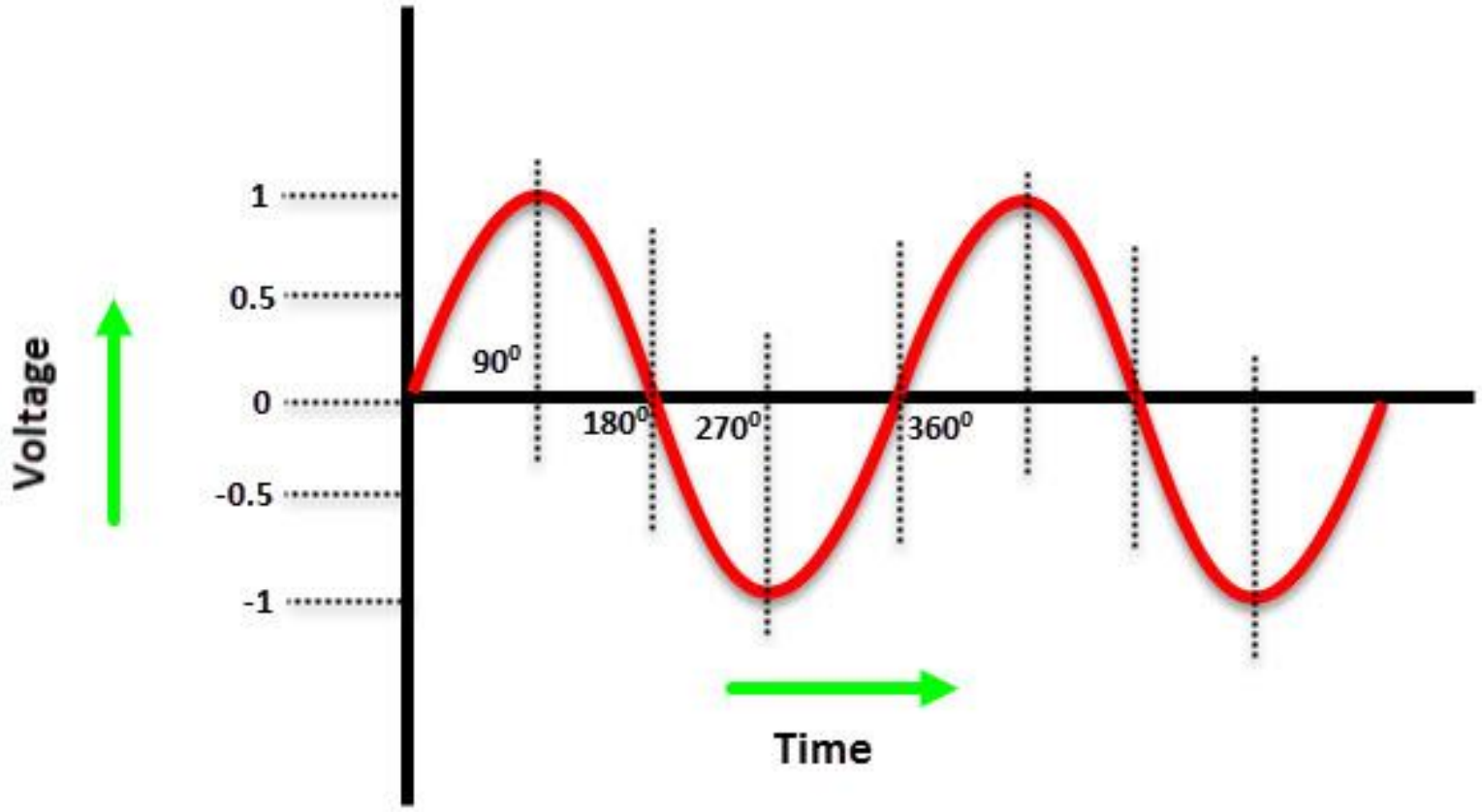
Voltage & Current Standards

- US: 120v Single Phase/240v “split phase” 60hz
- EU: 230v Single Phase 50hz
- Larger vessels use 3ph power up

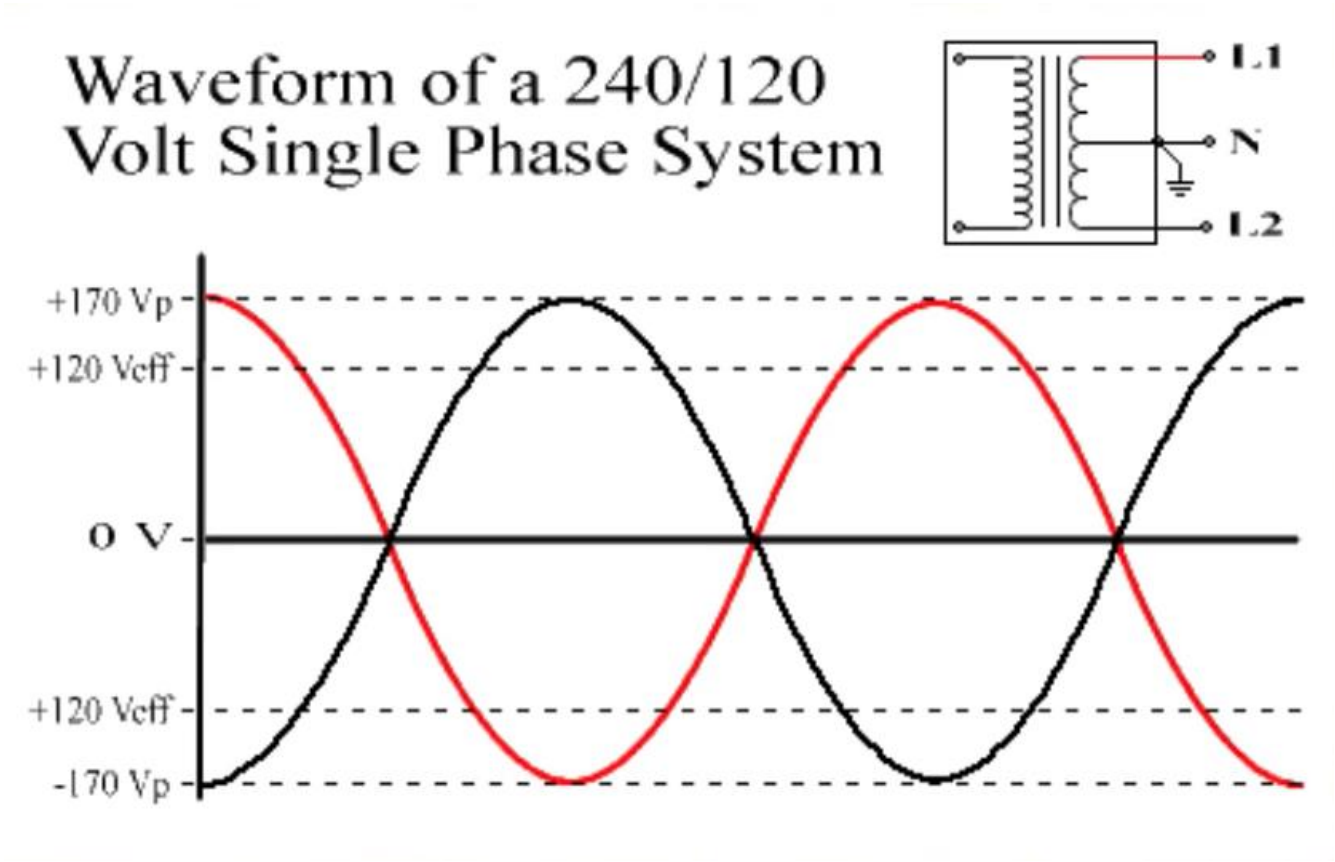
- US Docks: 30 and 50a
- EU Docks 16 and 32a

- Large docks up to 200a@480v!

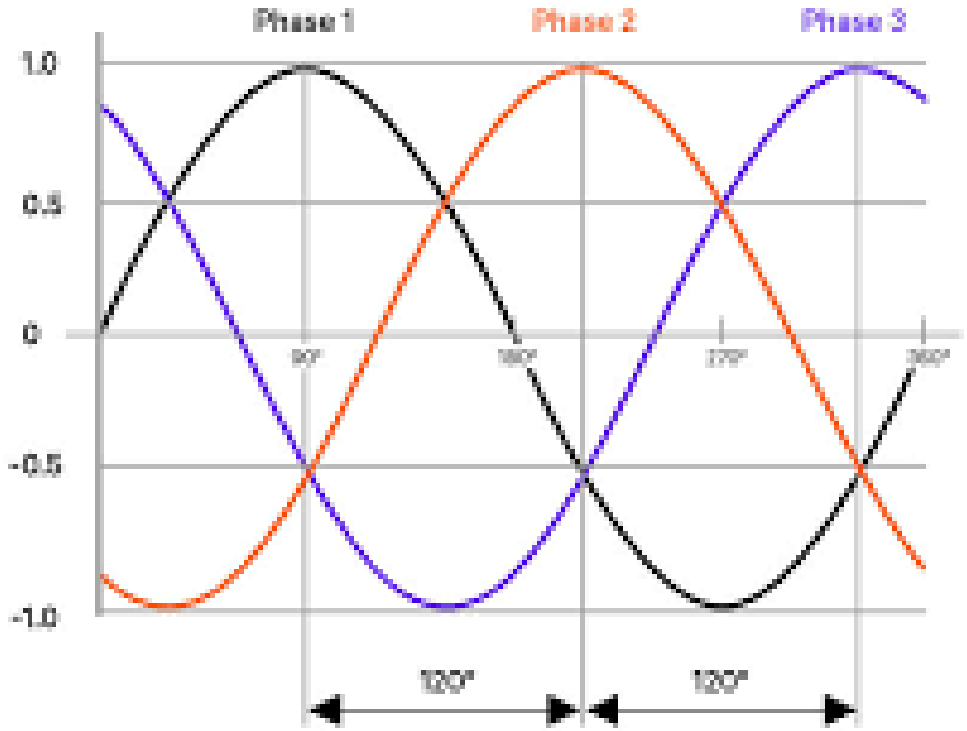
Single Phase



Split Phase


Waveform of a 240/120 Volt Single Phase System
L1
N
L2
+170 Vp
+120 Vcff
0 V
+120 Vcff
-170 Vp

Three Phase



Root Mean Square

$$I_{\mathrm{RMS}} = I_{\mathrm{p}} \sqrt{\frac{1}{T_2 - T_1} \int_{T_1}^{T_2} \frac{1 - \cos(2\omega t)}{2}\, dt}$$

$$= I_{\mathrm{p}} \sqrt{\frac{1}{T_2 - T_1} \left[\frac{t}{2} - \frac{\sin(2\omega t)}{4\omega} \right]_{T_1}^{T_2}}$$

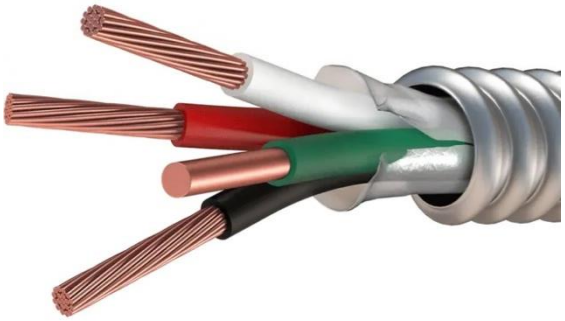
OR

Defined practically, the RMS value assigned to an AC signal is the amount of DC required to produce an equivalent amount of heat in the same load.

Conductor Phase and Ground

- Ungrounded Current Carrying Conductor
- Grounded Current Carrying Conductor
- Grounding Conductor

Ungrounded, Grounded, Grounding



Black, White, Red, Green
Brown, Blue, Green/Yellow

Main Breaker Panels

ELCIs and the 10’ Rule

Generators

Generators

- Belt vs Direct Drive
- RPM determines HZ
- Wiring Issues
- Grounding Issues
- Using a Gas Suitcase Genset (Honda 2200 et al) on a Boat
- Load Tests
- What Do You Have?

Inverters
Inverter/Chargers

- Becoming Ubiqitous
- Sine Wave
- Power Factor
- Key Options
- A rare “Buy This Brand” recommendation

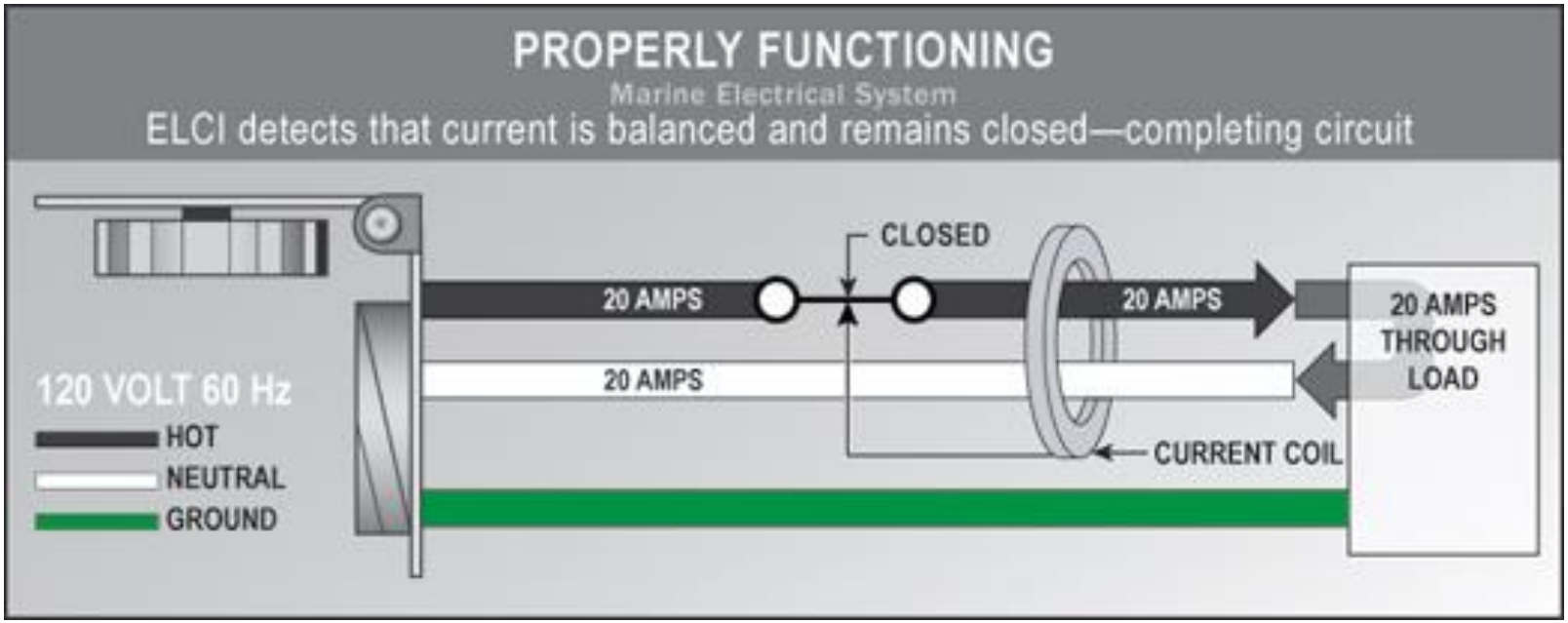
Safety

- The Codes, Regulations, and Recommendations are the MINIMUM
- Eye Protection Matters
- Good Tools are a SAFETY ISSUE
- A Few Good Stories

Ground Fault Circuit Interrupters

- Required where?
- How to test?
- EU vs US Standards
- Gas Boat?
- Some Additional Thoughts

ELCI's Finally Arrive

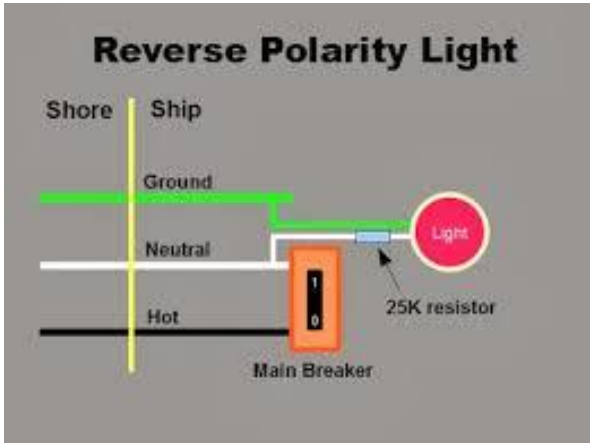


Measuring AC Electrical Leakage

Polarity in AC

Reverse Polarity at the Outlet

What is Reverse Polarity



Last Issues

- Sources for Parts
- Sources for Tools
- Sources for Information
- Recommended Technicians

Sources for Parts

- TE Connectivity
- MarineHowTo
- DigiKey
- Mouser
- PKYS
- Bay Marine

Sources for Tools

- MarineHowTo.com WebStore (Rod Collins)
- PKYS.com (Peter Kennedy Yacht Services)
- Ocean Planet Energy (Nigel Calder et al)
- TE Connectivity (Terminals and Tools)
- Pacer (Wire)
- FTZ & Temco *https://marinehowto.com/making-your-own-battery-cables/*

Sources for Information

- MarineHowTo.com (Rod Collins)
- Boat Electrical Systems (Facebook)
- CBW.LLC (My site, links for below coming!
- PANBO.COM (Electronics)
- BoatHowto.com (Nigel Online Classes)
- Steve D'Antonio Marine Consulting (Great!)
- James Coté Marine LLC (Lightning, more)

Sources for Technicians

- Ocean Planet Energy (Maine)
- Oxford Boatyard (MD Eastern Shore)
- MTS (Deale)
- Zimmerman Marine (MD, VA, NC, SC)
- Bradley Marine Services

Wrapping Up

- Double Checking the List
- Your Goals (and Mine)
- Final Questions
- Take Aways

CLASS DISMISSED
TGIF!