Wiring Your Boat

By Owen Youngblood

Editor's Note: This article is certainly not intended to be a "how to" tutorial. It is just one builder's experience in accepting the challenge as yet another boatbuilding learning experience.

Decision Factors

Wiring your own vessel can be a daunting venture. It can represent a significant chunk of both your project's budget and schedule. The decision to do it yourself instead of contracting it out should be based on your knowledge, skills, and capability.

Caution: The decision to wire all or any part of a boat is to not be taken lightly. A faulty wiring job can create significant fire, as well as potential electrocution hazards, especially on a metal boat. So the decision is very serious, indeed. When in doubt, default to having your wiring job handled by a qualified professional!

My choice was to do it myself. The reasons included that I was up for the challenge, possessed the technical skills and knowledge, wanted it done "right", and believed that my subsequent troubleshooting learning curve would be minimized as a result.

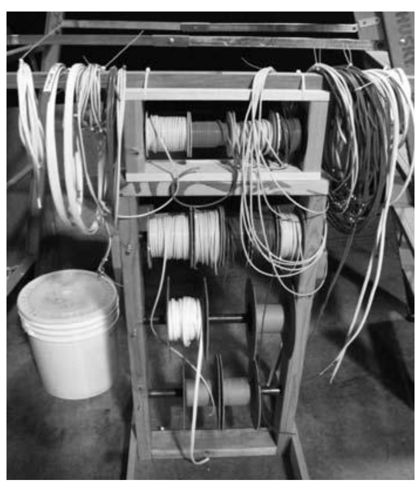
Know-How

The first step for someone like me to take on wiring their boat, and likely the most important one, was to equip myself with the knowledge needed to design and install the system. In my case, I needed to ensure that I was up to date with the latest American Boat & Yacht Council standards that pertain to electrical systems. An excellent ABYC primer article can be found in the June 2004 PassageMaker magazine by Steve D'Antonio. I encourage anyone who is even considering wiring their own vessel to obtain their own personal copies of the appropriate ABYC standards. And owning this stuff doesn't help you very much unless you study them as well! ABYC documentation is not a set of "how to" instructions. There are numerous excellent sources for that, although my experience is that no single book will suffice. My personal preference is Charlie Wing's Boatowner's Illustrated Electrical Handbook by (2nd edition, International Marine, McGraw-Hill), but there are many others. *Editor's Note: Check out the selection in the Ship's Store on our website for a great selection as well as great pricing!*

Panduit® helps organize wire bundles through engine room.

Planning

A project of this magnitude illustrates an old axiom that I learned a long time ago from an engineering manager colleague. He was a strong advocate of "plan your work; work your plan." So my next step was to plan and model the system that I would be building. This model is comprised of both basic schematics and a fairly simple PC-based spreadsheet.



A wire spool rack will help organize your work area (running low on wire…good sign that project is nearing completion!)

Many of the preliminary questions I had to answer in order to "load" this model included:

- Will there be a 120 volt AC system in addition to the 12 volt DC one?
- If so, what are the 120 volt AC needs that need to be accommodated?
- Will there be separate battery banks for the "house" system?
- If so, how will I isolate the two battery systems?
- Will the vessel incorporate an isolation transformer?
- Will the vessel incorporate an AC generator?
- Will the vessel incorporate an inverter?
- Where will the battery bank(s) be located?
- Where will the breaker panel(s) be located?
- What path will the major wire bundles take through the vessel? What interferences will I need to accommodate?
- …the list goes on.

A preliminary schematic should capture the electrical devices that are intended to be installed, the general routing of wires, location of battery banks, and location of breaker or fuse panels, disconnect switches as well as their respective locations.

The schematic will eventually need to reflect physical distances as this will be required for the calculation of wire gauges. And it is very important to keep the 12 VDC system's documentation separate from the 120 VAC systems. But there are places where the two "touch" each other, for example, at the battery charger and/or inverter. Another example is the vessel's bonding system. My spreadsheet model detailed every circuit that was to be installed in the vessel, both AC & DC. Not only did it clearly document all the circuits but it provided the necessary information required to determine breaker sizing, wire gauge, and information needed to determine what and how many wires I could bundle together. **See Figure 1** for a condensed version of the 12 Volt model. It's not all that complex; just a lot of circuits, wires, and breakers to track. There is a somewhat less complicated version for the 120 Volt system.

As a side note, I took the time to clean up my spreadsheet prior to using it as an illustration in this article. I ended up spending over 4 hours making corrections and tracking down information that I had not yet transferred to the model from my cryptic field notes. As I mentioned earlier, it is amazing how quickly we forget the myriad of details that were once in the forefront of our minds during the installation of a system. It reinforces the importance of good and timely documentation!

Figure 1 is an example of what my model looks like (this is only a portion of the 12 volt system). The wire ID columns capture the

				Wire ID #												
Beaker #	Breaker Label	Amps	Dash Panel Switch Label	Circuit Wire ID	DC +	DC-	Item	voltage drop	amps continuous	amps intermittent	round trip run length	thru engine room?	F-amps	wire ga	wire length	comments
A	WATER PRESSURE	15		01	R	Y	Domestic water pressure pump	10%		7.5	40	Yes	300	14	20	well within 14 ga. limits
B	PUMP GRAY WATER	15		05	R	Y	Graywater sump pump	10%		6.2	58	Yes	360	12	29	upgraded to 12 ga.
C	FWD CABIN LIGHTS	15		20	R	Y	Stateroom ceiling lights & heater fan	10%		5.0	60	Yes	300	14	30	assume 4 fixtures @20w ea
D	MAIN CABIN LIGHTS	15	ref. hidden for wire ID	25	R	Y	Feed from breaker panel to switch	10%		5.0	30	Yes	150	14	15	assume 4 fixtures @20w ea
E	AFT CABIN LIGHTS	15	ref. hidden for wire ID	49	R	Y	Feed from breaker panel to Buss 1	10%		11.7	48	Yes	560	14	24	assume 7 fixtures @20w ea..over F-amp goal so consider running negative wire to battery negative busbar.
F	HEAD LIGHTS	15	ref. hidden for wire ID	23	R	Y	Feed from breaker panel to Buss 1	10%		7.7	52	Yes	399	14	26	assume 4 fixtures plus 1 fan
G	DC REFRIGERATOR	15		02	R	Y	Refrigerator	3%	6.5		48	Yes	312	8	24	used 10 ga. Single wire to panel
H	ENGINE	20	feeds sw panel below	63	R	Y					12	No	168	14	6	
			ENGINE ROOM BLOWER	17	R	Y	Engine room blower	10%	10.0		56	Yes	560	12	28	assume 9" 737 CFM, <<10% voltage drop
			SALT WATER PUMP	04	R	Y	Shaft seal water	10%	4.0		44	Yes	176	16	22	upgraded to 14 ga.
I	GPS/PLOTTER	15		06	R	Y	Navigation Station Display	3%	6.7		10	No	67	14	5	
J	VHF	15		08	R	Y	2 VHF radios	3%	5.5		24	No	132	14	24	2 home runs..assume PH ceiling
K	DEPTH SOUNDER	15		16	R	Y	DMS Module	3%	2.5		20	No	50	16	10	DSM250
L	AUTOPILOT	15		14	R	Y	Autopilot computer (feeds autopilot pump)	3%	8.0		20	Yes	160	12	10	Accu-Steer HRP 10-12 (assume 8 amp)

Figure 1

unique identity of every wire in the system. The amps continuous and amps intermittent are used in aggregate to determine the conductor sizing from the battery bank to the main breaker panel. The F-amps calculator uses round-trip wire length multiplied by the amperage of the circuit to determine wire gauge extracted from a table elsewhere in the model, depending on the targeted voltage drop (3 vs. 10%).

After assembling my preliminary model and schematics, I established a couple of guiding principles. The first one was my decision to adhere to the ABYC standards. I ended up with very few deviations and these are documented for future reference in the event they ever came up in a future insurance survey. I joined ABYC a few years ago in order to obtain and study their documentation prior to my tackling the electrical systems. The other guiding principle I adopted was to seek professional help when needed. For the sake of personal safety as well as my vessel's system integrity, I left nothing to guess-work.

In my opinion, not every "jot and tiddle" is covered by ABYC or my favorite reference books. At some point in the project I had to exercise that dreaded tool called "judgment." One time I hit a wall on an ABYC interpretation and resorted to phoning two separate and well-known surveyors. Neither one knew the answer for certain but at least gave me their *opinion* as well as how they would treat the issue during a survey. A specific example where personal judgment comes into play is in determining which method to use when installing an isolation transformer. Numerous articles have been written by the experts on this topic and they don't all necessarily agree. An example of this debate is found in a well-written article in Professional Boat Builder by David Rifkin entitled "Transformers" (Issue 108, Page 114…digital issues can be accessed online at http://proboat.com).

Tools & Materials

I chose to use the very best tools and materials I could afford. This means crimping tools, wire, connectors, panels, switch gear, shrink tubing, and the like. Tools are expensive but good ones should last a lifetime (I swallowed hard when I ordered a battery cable lug crimper!). Purchasing supplies in larger quantities can result in significant unit cost savings. For example, crimp connectors are substantially less expensive in packages of 100.

Tools of the Trade

Lessons Learned

My experience wiring Boomer has been a good one but much more complicated than I earlier imagined. Yes, I would do it again given what I know today. Some lessons-learned, as well as what I consider to be personal best practices, might be of some value those of you who are pondering doing it yourself:

1) Do not splice. Not doing so results in all crimp connectors being located either at the source or at the use-end of the conductors. This will simplify troubleshooting in the future. It is a hard discipline to maintain when making long runs.

2) Keep 120 VAC and 12 VDC systems separated both physically and in your mind when installing them. One can burn but the other can kill!

3) Keep up with your system's documentation. It is amazing how quickly one forgets why or how something was wired 3 months in the past. And notes scattered from here to yonder quickly get lost or thrown out.

4) Don't paint yourself into a corner with respect to future needed wiring runs as well as reasonable access to all terminal blocks and other connection points. It will come back to haunt you.

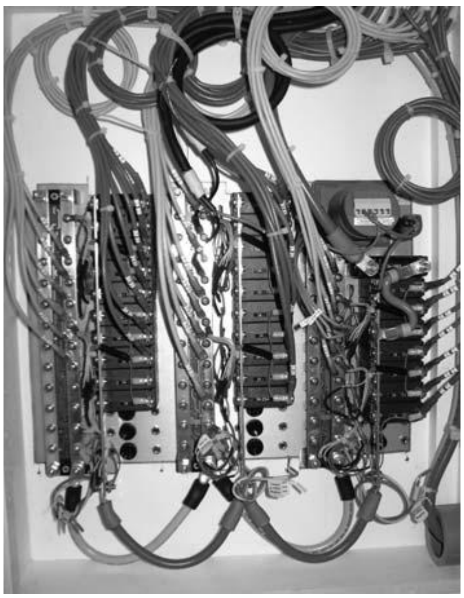
5) Take the DC voltage-loss calculations seriously and don't try to cheat in order to save a few bucks. Your voltage- sensitive systems will perform better and your lights will enable you to read at night!

6) Test new circuits as you complete each one with a VOM. Test them again once all circuits are completed, both AC & DC, prior to energizing.

7) Locate terminal blocks, bus bars, or any other wire termination points with future accessibility in mind. At some point you will need to get to that component!

8) Take the ABYC standards to heart. A lot of technical know-how and expertise has brought them to where they are today. Adherence to ABYC standards will give you added peace of mind with the safety and performance of your systems, as well as fewer ongoing insurance survey findings and recommendations.

9) Take pride in your work. Understand that some of your work will need to be reworked; that's part of the learning curve. I admit to my being a compulsive neat-freak. I insist on orderly routing of wire and work hard to avoid chaotic wiring arrangements. The benefit pays off when troubleshooting a problem.



12 VDC panel nearing completion

10) Avoid guesswork! Seek help from the pros when you get into a gray area or are simply stumped by an issue you don't understand.

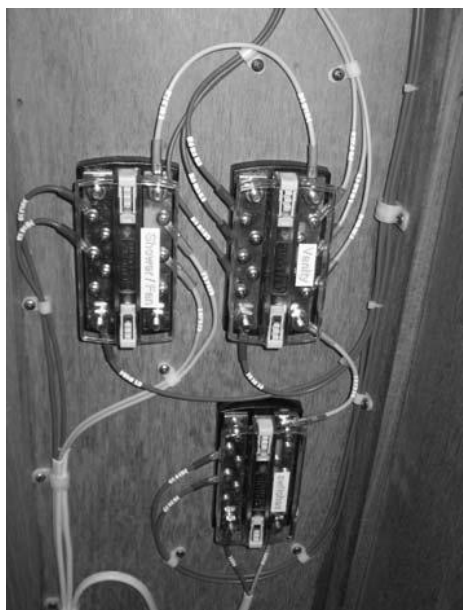
COST

The last item I would like to address is controlling cost. As mentioned earlier, the electrical systems in a vessel represent one of the most expensive components of the total cost of the project. There are not many options in getting around that other than limiting what one deems to be important on his/her boat (scope). Examples include:

- can I live without AC power while at anchor or cruising, thereby eliminating the need for an expensive gen-set and/or inverter?
- Is that microwave something we really need to enjoy our cruise?
- Am I willing to use a kerosene lamp to read by?
- Would having only 1 AC outlet in the cabin suffice?

And it pays to shop around when purchasing electrical supplies. Many places will work with you to set up a builder's account and that can result in significant discounts. And know that there is more than just one supplier of marine approved boat wire!

One very significant opportunity to control cost occurs during the planning phase of the project. I made the conscious decision, for example, to use duplex wire almost exclusively throughout the 12 VDC system due to my personal preference to land positive and negative at the breaker panel. A less expensive option would have been to employ more negative bus bars located close to the battery and device. If cost was the major driver then I would suggest spending more time during schematic layout in order to optimize the location of panels, switches, and battery banks. Then one can work to minimize the amount of duplex and, therefore, minimize the gauge and length of expensive wire runs.



Generous use of expensive bus bars…weighs traceability vs. cost

Summary

Be realistic with respect to your skills, knowledge, and capability when making your decision to wire your boat. And remember, like everything else required to finish your vessel, it will take you much longer than you think! A final point, for those of us who insist on doing it ourselves, is to consider hiring a professional consultant to monitor and/or inspect our work. We might sleep a little better at night as a result .