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MULTI-BANK POWER SUPPLY SYSTEM FOR SMALL TOWED HYDROPHONE ARRAYS

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INTRODUCTION

Passive acoustic monitoring is quickly becoming a standard component of shipboard cetacean population surveys. Power supplies on survey vessels are often electronically noisy and result in poor quality recordings. An independent battery-powered voltage supply is regularly necessary for high quality recordings. Here we describe the design of a simple system to provide independent, single-sided 12 V power for a towed hydrophone system, such as the Southwest Fisheries Science Center's (SWFSC) Acoustic Recording System (ARS, Rankin et al. 2011) and hydrophone arrays. This system allows for simultaneous use of one battery bank while charging a depleted battery bank. This multi-battery bank system was successfully field tested by SWFSC for four and a half months during the 2014 California Current Cetacean and Ecosystem Assessment Survey (CalCurCEAS), and is based upon an original design Pacific Islands Fisheries Science Center (PIFSC) has been using since 2011.

DESIGN

Our multi-battery bank system is comprised of three main sections (Figure 1):

A) Power control and monitoring system
B) Battery banks (two)
C) Charging system

A complete supply list for this system is given in Appendix A. In the schematic (Figure 1), each section of wire is given a name that corresponds to its purpose (detailed in Appendix B). Wires hooked up to the battery monitor are given names provided in the monitor's manual. Other wires are labeled by their section and charge. For instance, wire section +A1 is the first positive wire in section A. All wiring is based on the specifications required for the specific components used in this design; consult users' manuals for connecting to alternative components.

A) Power control and monitoring system

The power control and monitoring system includes the voltage meter, shunt, wire splitter, and two switches (for 12 V positive and ground). In this design these components were housed within the ARS for user convenience (Figure 2); alternative mounting locations can be considered.

Section A's wiring is very detailed but a correct hook up is vital to avoid shorting out the system. The shunt has two sides, system and battery, which are separated by a copper alloy (Figure 3 and Figure 4). Each side of the shunt has two terminals, one small and one large. In case of a power surge within the battery bank system, the copper alloy within the shunt will melt, severing the connection between the power supply and the expensive hardware within the ARS powered through the fuse box. The splitter takes current from one wire and delivers it to multiple locations. Current from the fuse box is directed through the splitter towards the battery monitor and the 1-2-All switch.

The battery monitor reads the remaining power in the battery bank and should be mounted so the technician can easily determine if charge is required. Wire hookups at the back of the battery monitor are labeled and the user manual should be consulted to ensure proper function. For this design, we use six of the eight Xantrex* battery monitor wire terminals, right to left (Figure 5):

- + (positive power supply) to the splitter.
- - (negative power supply) to the small terminal on the shunt's battery side.
- Vm (main power supply) to the first positive terminal on battery bank 1.
- Va (aux power supply) to the first positive terminal on battery bank 2.
- I- (negative current sense) to the small terminal on the shunt's battery side.
- I+ (positive current sense) to the small terminal on the shunt's system side.

The Xantrex battery monitor manual refers to the battery banks as 'main' and 'aux,' though both banks are used equally to power the acoustic system. 1-2-all switches designate the battery banks as either 1 or 2 (Figure 6). To avoid further confusion, the main bank is always battery bank 1, and the aux bank is always battery bank 2.

B) Battery Bank

Each battery bank contains two or more 12 V batteries, depending on system power requirements. Our system uses a maximum 45 amps every day (Table 1). To maximize battery life battery banks should not be discharged below 50% (Calder & Wing, 2005). Therefore, our 45 amp system would require a 90-100Ah battery bank. We used 2 @ 75 Ah batteries per bank for a total of 150 Ah which provided sufficient power for additional components, if needed. For example, ships with excessive electrical noise may require powering computers and monitors (which have a higher amp usage rating) with the battery bank system. The PIFSC version of this system includes four 12 V @ 75 Ah batteries per bank, 300 Ah total, which is sufficient to power their towed array system, computers and monitors. The Ah capacity per battery bank should reflect the power requirements of the acoustic monitoring system.

Battery banks are designated as 1 and 2 (Figure 7 and Figure 8). The length of wires is dependent on your set up. To reduce wire clutter when possible, we have used dual wire AWG 8 gauge, two wires wrapped together in a protective sheath.

C) Charging System

The charging system consists of a Xantrex TrueCharge2 battery charger mounted on a plank of wood with two switches, for 12 V positive and ground (Figure 9). A dual switch allows one battery bank to charge while another powers the ARS.

* Use of brand names in this report does not imply endorsement by NOAA or the US Government. Other brands with similar properties can be substituted.

USE

The 1-2-all power switches allow for safe and seamless transition from battery bank 1 to battery bank 2, vice versa, or the 'all' if both banks are low. In the 'off' position, power is shut off from the rest of the ARS, including the fuse box which provides power to all of the ARS's hardware devices and the array. To switch a battery bank on the negative switch should be engaged first and then the positive. To turn the system off, first turn off the positive switch and then the negative.

The TrueCharge2 has more options than we are using, such as providing simultaneous charge to three separate battery banks. Please see the manual for more details. We do not recommend charging the same battery bank in current use, as this may introduce noise to the recordings.

ACKNOWLEDGEMENTS

We would like to thank Yvonne Barkley of Pacific Islands Fisheries Science Center for help, contributions, and guidance related to the original PIFSC design. Thanks to Jay Barlow, for laying some of ground work for this design and overseeing its construction. Also Jennifer Keating and Eric Keen provided helpful comments on this report.

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Calder, N., & Wing, C. (2005). *Boatowner's mechanical and electrical manual: how to maintain, repair, and improve your boat's essential systems*. Adlard Coles Nautical.

Rankin, S., and J. Barlow. (2011). Acoustic recording system: a portable hardware system for shipboard passive acoustic monitoring of cetaceans using a towed hydrophone array. SWFSC Administrative Report, LJ-11-01.

Table 1. Total Ampere Hour (Ah) load required for the SWFSC towed hydrophone array system.

Equipment	*Quantity*	*Amp Usage Rating*	*Max Hours of Daily Use*	*Total Load (Ah)*
Magrec Amplifier/Filter*	3	0.4	14	16.8
NI-DAQ USB X Series	1	0.8	14	11.2
FireFace UC	1	0.95	14	13.3
Battery Monitor	1	0.03	14	0.42
Inline custom hydrophone array	1	0.06	14	0.84
End custom hydrophone array	1	0.07	14	0.98
TOTAL				**43.54**

* http://ecologicuk.co.uk/ (Mention of brand names in this report does not imply endorsement by NOAA or the U.S. Government.)

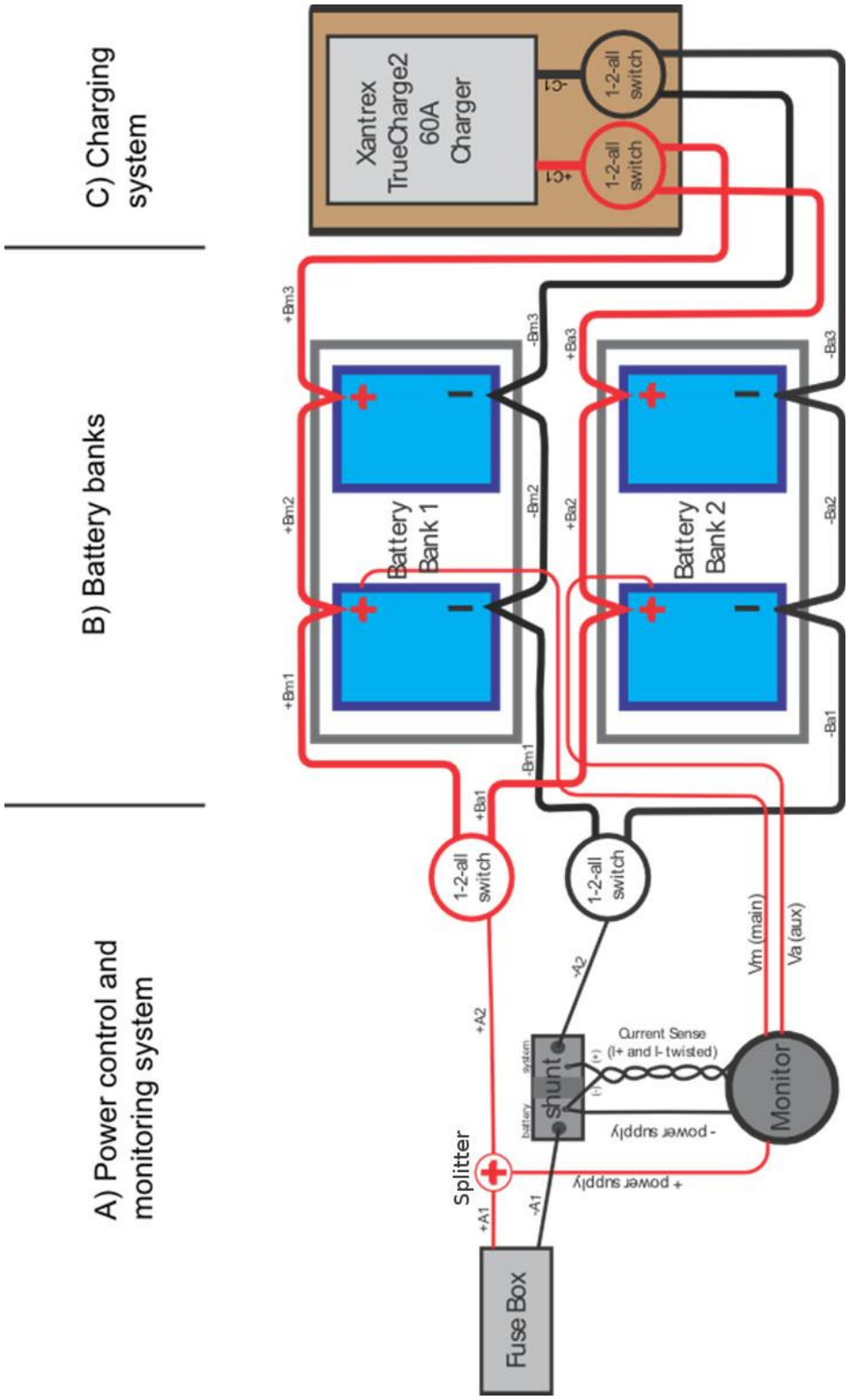

Figure 1. Schematic of a multi-battery bank system consisting of three subsystems: A) power control and monitoring system, B) battery banks, and C) charging system. Thinner lines represent AWG 12/14 wire, while thicker lines indicate AWG 8 wire.

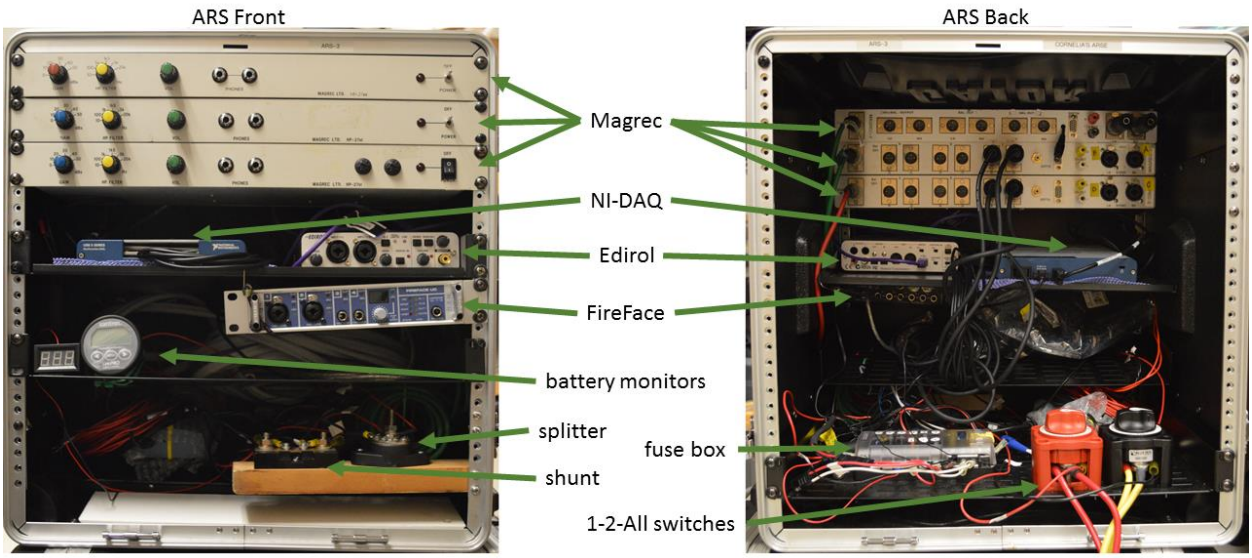

Figure 2. Front and back view of the Acoustics Recording System (ARS). Components outlined in Section A are located on the bottom and middle shelves (battery monitor, splitter, shunt, fuse box, and the 1-2-All switches). The Magrecs (amplifier), NI-DAQ (500 kHz audio interface), Edirol (96 kHz audio interface) and FireFace (192 kHz audio interface) are components of A/D conversion of the hydrophone sound stream. The battery bank system is monitored within an ARS using the battery monitor. Within the ARS, AWG 12/14 wire is used.

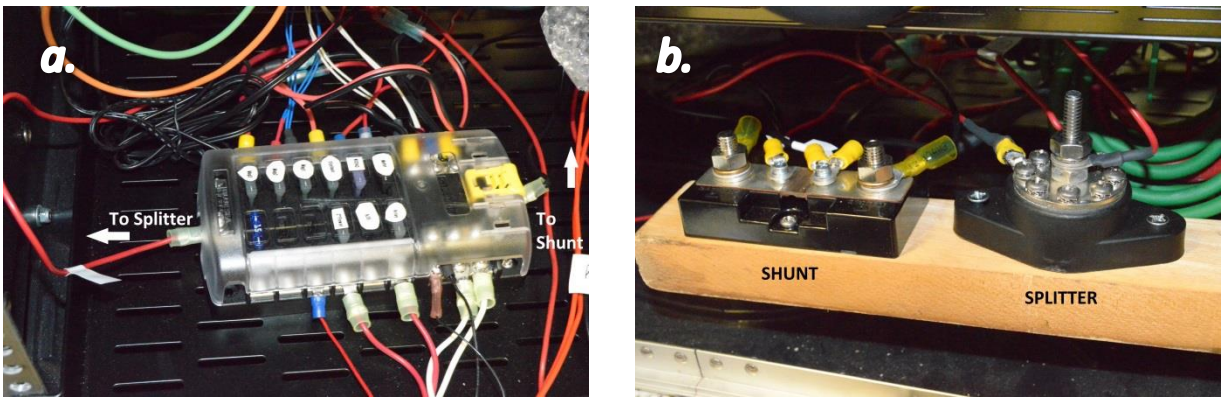

Figure 3. Fuse box (a) wires +A1 and -A1 with power leads to the splitter and shunt (b). The shunt and the splitter have to be isolated and protected from coming into contact with any metal, or the battery bank could short out. In our set-up, these sections are mounted on a piece of wood and covered by a piece of PVC.

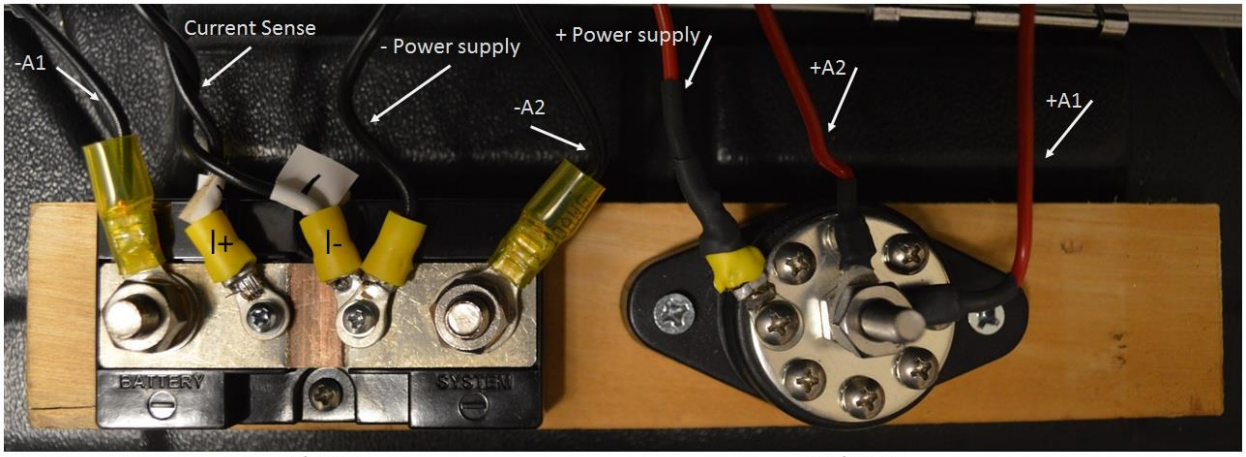

Figure 4. The - power supply and I- wire attach to the smaller terminal on the side of the shunt labeled 'battery', the larger terminal connects the fuse box. On the side of the shunt labeled 'system', the I+ wire connects to the smaller terminal, while the larger terminal is connected to the negative 1-2-all power switch via wire –A2.

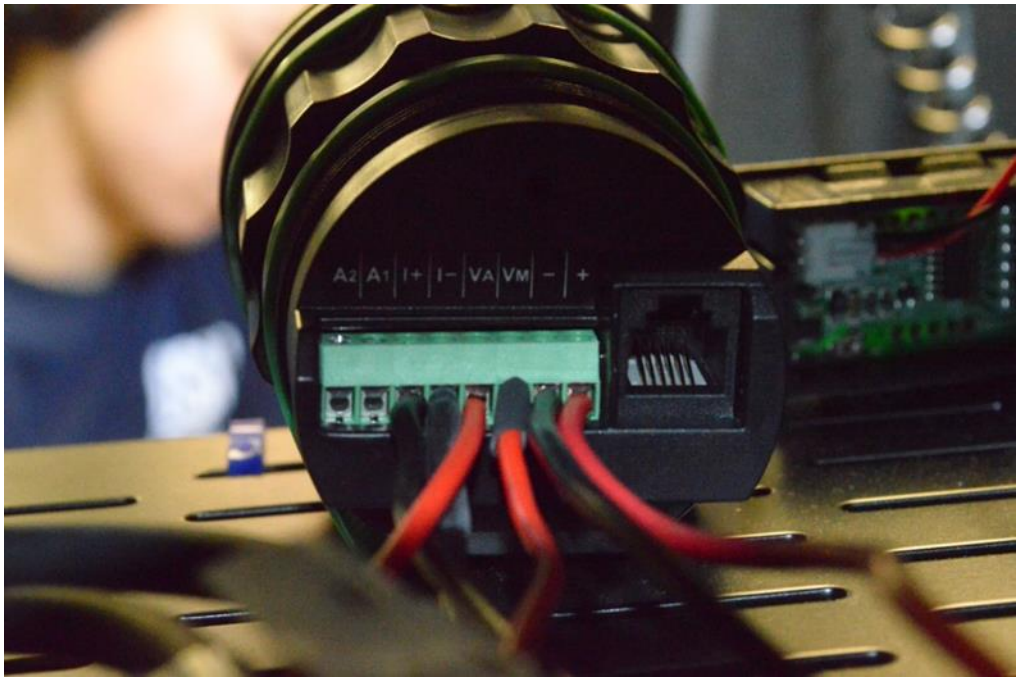

Figure 5. Detailed wiring setup for battery monitor (back of monitor is shown with all used wires connected). This wiring diagram is related to the Xantrex LinkPRO monitor; please see manual for more information on this set up.

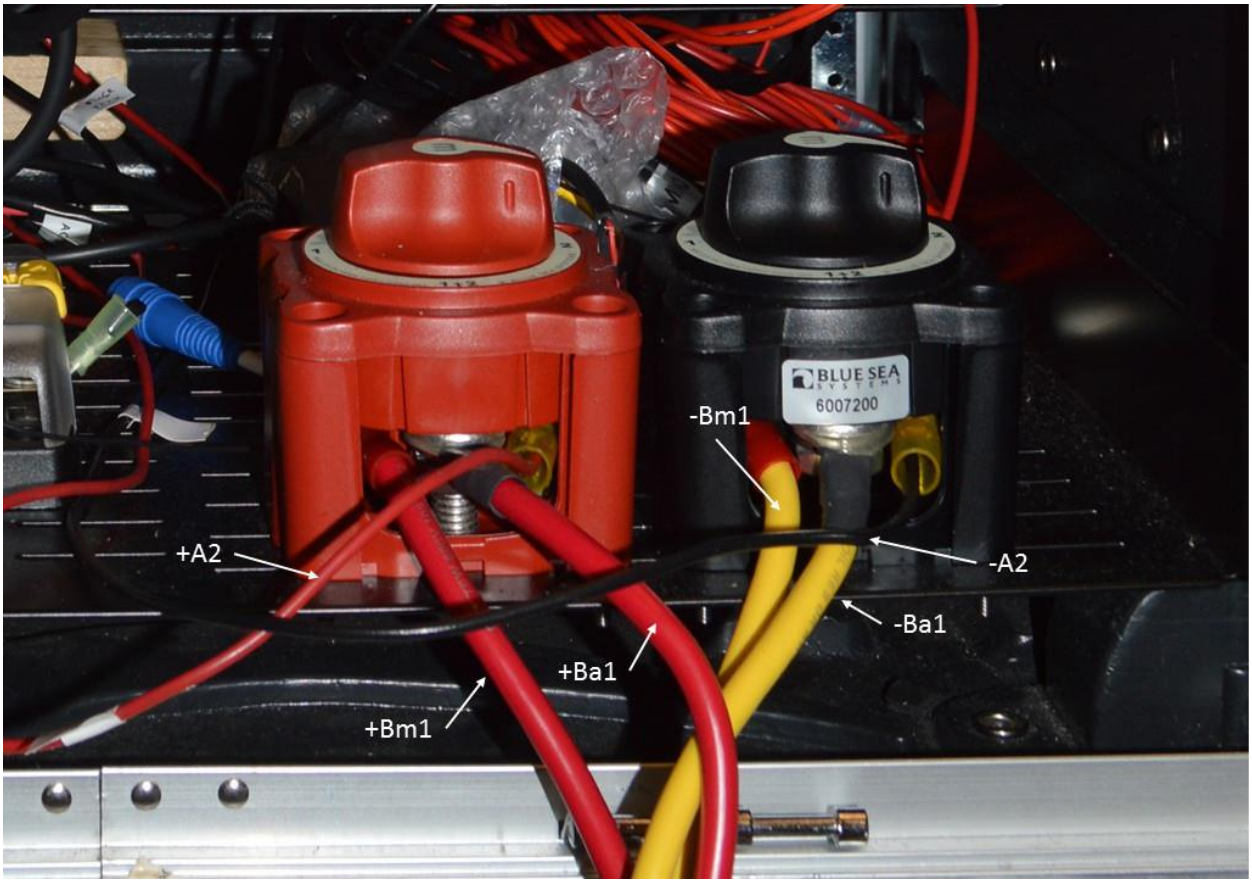

Figure 6. Positive and negative 1-2-all switches mounted in the ARS in an accessible place, currently set to battery bank 1. Thicker wires connect to battery banks, while the thinner wires connect to splitter and shunt.

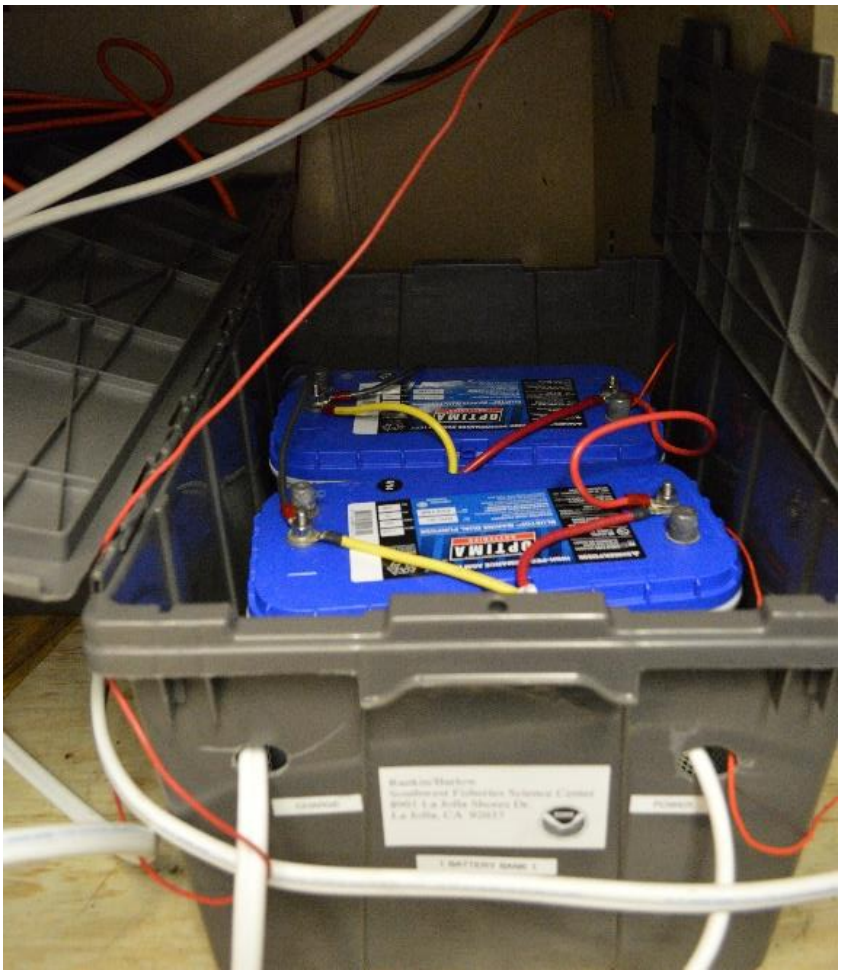

Figure 7. Battery bank 1 connected to the system within a bin. There are two 12 V batteries within each bin. Designate which bank is to be battery bank 1 (main) and which is to be battery bank 2 (aux).

Figure 8. Battery bank 1 with connecting wires in section B. Cables +Bm1 and Vm (main) (and, respectively, +Ba1 and Va (aux)) are both connected to the first terminal within the battery bank, as seen in the lower right corner (first positive battery terminal). By connecting to the first positive terminal the Xantrex battery monitor can correctly measure the voltage left between the two batteries within each bank.

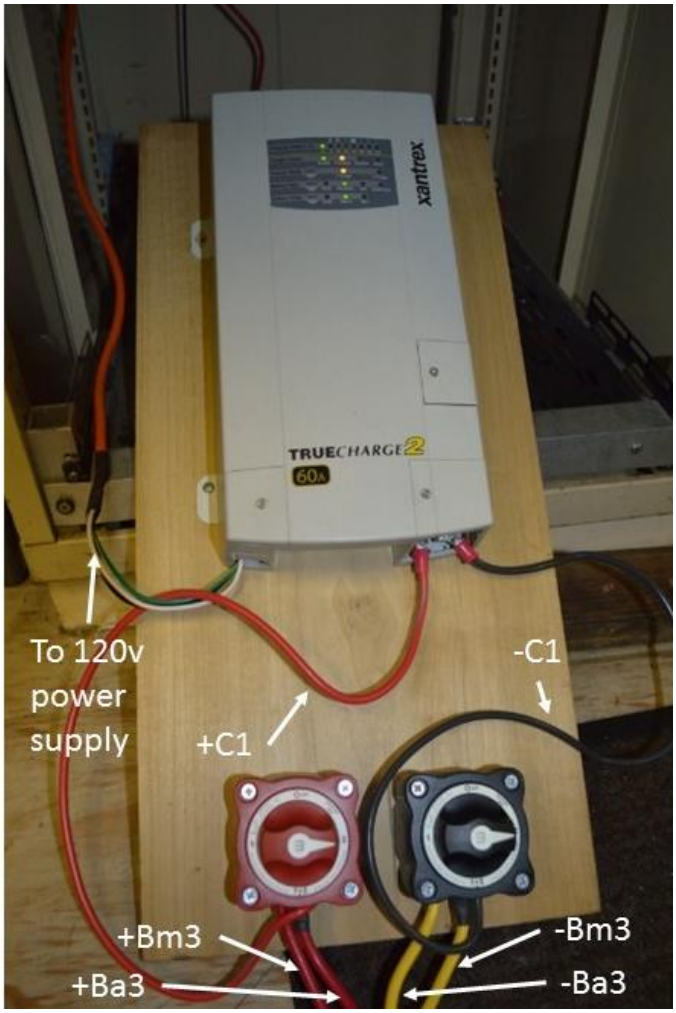

Figure 9. The Xantrex TrueCharge2 60A Charger is mounted to a board with both negative and positive 1-2-all switches. Wires +Bm3, +Ba3, -Bm3 and -Ba3 were cut to be 5 meters long because the charging switch board rests on top one of the battery banks, or very close by. These wires can be longer depending on your set up. Wires +C1 and –C1, the only two wires isolated in the C section, connect the positive and negative switches to the TrueCharge2. The TrueCharge2 60 charges the battery bank system through a 120v power supply.

APPENDIX

Appendix A. List of supplies needed for multi-battery bank design.

Description	qty	Section
Xantrex LinkPRO battery monitor (includes shunt)	1	A
Blue Sea PowerPost Plus (positive splitter)	1	A
fuse box	1	A
Terminals, stud size US6 for AWG 12/14 (for fuse box)	2	A
Terminals stud size US10 for AGW12/14 for internal ARS hook up.	4	A
Terminals stud size 5/16" for AGW12/14 for internal ARS hook up.	4	A
Dual 8 AWG wire, 15m	2	A and B
Red 12/14 AWG wire, 40m	1	A and B
Black 12/14 AWG wire, 10m	1	A and B
Blue Sea Red battery switch, 1-2-all-off	2	A and C
Blue Sea Black battery switch, 1-2-all-off	2	A and C
Terminals, stud size 3/8" for AWG 8 (for 1-2-all switches to terminals)	8	A and C
Terminals, stud size 3/8" for AWG 12/14 (for 1-2-all switches to monitor)	4	A and C
Optima blue top D31M batteries, 75 Ah	4	B
18'-by-36' bins	2	B
Terminals, stud size 5/16" for AWG 8 (for battery terminals to other terminals and switches)	16	B
Terminals, stud size 5/16" for AWG 12/14 (for battery terminals to monitor)	2	B
Dual 8 AWG wire, 5m	2	B and C
Red 8 AWG wire, 2m	1	C
Black 8 AWG wire, 2m	1	C
Xantrex TrueCharge2 battery charger, 60A	1	C
Heat shrink, for AWG 8		A, B and C
Heat shrink, for AWG 12/14		A, B and C

Appendix B. Wire purposes and lengths.

Cable	Length	Charge	Gauge	Purpose
+A1	60cm	Positive	12/14	Connects the fuse box to the splitter.
+A2	60cm	Positive	12/14	Connects the splitter to the positive A-area 1-2-all switch.
-A1	60cm	Negative	12/14	Connects the fuse box to the large terminal on the battery side of the shunt.
-A2	60cm	Negative	12/14	Connects the large terminal on the system side of the shunt to the A-area 1-2-all switch.
+ power supply	60cm	Positive	12/14	Connects the splitter to the monitor, plugs into the “+” port in the back.
- power supply	60cm	Negative	12/14	Connects the small terminal on the battery side of the shunt to the monitor, plugs into the “-” port in the back.
Current sense (I+)	60cm	Negative	12/14	Connects the small terminal on the battery side of the shunt to the monitor, plugs into the “I+” port in the back.
Current sense (I-)	60cm	Negative	12/14	Connects the small terminal on the system side of the shunt to the monitor, plugs into the “I-” port in the back.
Vm (main)	15m	Positive	12/14	Connects the monitor to the first terminal on battery bank 1, plugs into the “Vm” port in back of monitor.
Va (aux)	15m	Positive	12/14	Connects the monitor to the first terminal on battery bank 2, plugs into the “Va” port in back of monitor.
+Bm1	15m	Positive	8	Connects from the “1” terminal on the A-area 1-2-all positive switch to the first positive terminal in bank 1.
+Bm2	30cm	Positive	8	Connects the first and second positive battery terminals in battery bank 1.
+Bm3	5m	Positive	8	Connects the second positive battery terminal in battery bank 1 with the “1” terminal on the C-area 1-2-all switch.
+Ba1	15m	Positive	8	Connects from the “2” terminal on the A-area 1-2-all positive switch to the first positive terminal in bank 2.
+Ba2	30cm	Positive	8	Connects the first and second positive battery terminals in battery bank 2.
+Ba3	5m	Positive	8	Connects the second positive battery terminal in battery bank 2 with the “2” terminal on the C-area 1-2-all switch.
-Bm1	15m	Negative	8	Connects from the “1” terminal on the A-area 1-2-all negative switch to the first negative terminal in bank 1.
-Bm2	30cm	Negative	8	Connects the first and second negative battery terminals in battery bank 1.
-Bm3	5m	Negative	8	Connects the second negative battery terminal in battery bank 1 with the “1” terminal on the C-area 1-2-all switch.
-Ba1	15m	Negative	8	Connects from the “2” terminal on the A-area 1-2-all negative switch to the first negative terminal in bank 2.
-Ba2	30cm	Negative	8	Connects the first and second negative battery terminals in battery bank 2.
-Ba3	5m	Negative	8	Connects the second negative battery terminal in battery bank 2 with the “2” terminal on the C-area 1-2-all switch.
+C1	30cm	Positive	8	Connects the C-area 1-2-all switch to the Xantrex Charger.
-C1	30cm	Negative	8	Connects the C-area 1-2-all switch to the Xantrex Charger.