BATTERY CHARGER CART

by Team 571: Paragon

rev 0.3

Features

- Holds up to 6 FIRST Robotics batteries and chargers.
- Large wheels easily roll over obstructions and up or down stairs.
- Carpet covered cabinet travels well without showing wear.
- Voltmeters display the open circuit voltage of all 6 batteries simultaneously.
- Load tester gives accurate assessment of battery life.
- Tray on top of cabinet for temporary tool storage or battery testing.
- All outlets ground fault (GFCI) protected.
- Two additional outlets provided for tools or other accessories.

Tools Required

- Basic hand tools
- Staple gun
- Electric drill
- Tablesaw (not required if you get wood cut to size at lumberyard).
- Drill press (optional)
- Thickness planer (optional)
- Pnuematic brad nailer (optional)
- Metal lathe (optional)

Notes

1. The following instructions are written to follow the construction techniques of the original team 571 battery cart. For teams who want to build a cart, but do not have access to a well equipped shop (with pneumatic nail gun, thickness planer, machine lathe), an alternate build is also documented.
2. Teams may choose to omit or substitute some portions of the electronics package (type of charger, voltmeters, load tester, etc).
3. The original charger cart was built from a good grade of ½ inch thick, 7 ply (layer), birch plywood. It is not recommended to substitute a lesser grade plywood such as CDX or underlayment as these grades of plywood have a greater tendency to twist, which will make construction more difficult.
4. The cart was designed to fit two 6-1/2 in wide, 4 in deep, 7 in tall battery chargers on each shelf. If your chargers are bigger, you will need to alter the cabinet size.
5. The back rub strips on the cabinet serve two purposes. It holds the carpet in place without using staples that might be visible; and is prevents the carpet from being torn or pulled loose if the cart is dragged on its back. As these are the only two parts that require a (varnish) coating, it is recommended that you varnish them before beginning the cart so it is ready to be installed as the cart is built.
6. Battery cart instructions brought to you courtesy of Team 571: Paragon (Loomis Chaffee and Windsor High, located in Windsor, CT).
7. Good luck with your battery cart.

1. Cabinet Assembly

1. Cut back panel (D) to size.
2. Bevel cut the corner braces (M) from solid wood at a 45 degree angle as shown in figure 1. Cut six pieces to 11 inches long (see appendix A). Cut two additional scraps to the same length to serve as guides for assembling the shelves. Alternative: Cut the corner braces (and extras) from 2x2 stock (1-1/4 or 1-1/2 in square). The square corner braces are recommended if you plan to hand nail or screw the cabinet together.

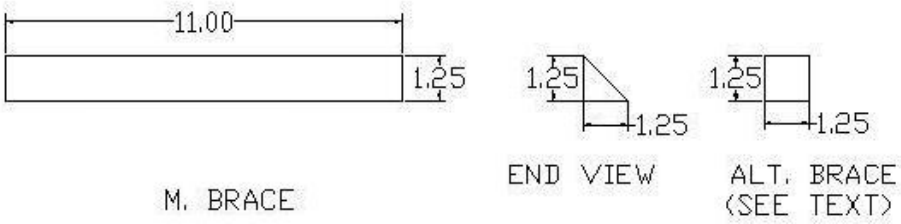


Figure 1: Corner Brace Part (M)

3. Cut the two side pieces (A) to size. Cut the lower part of each side away to form the front foot, which will support the cart as shown in figure 2.

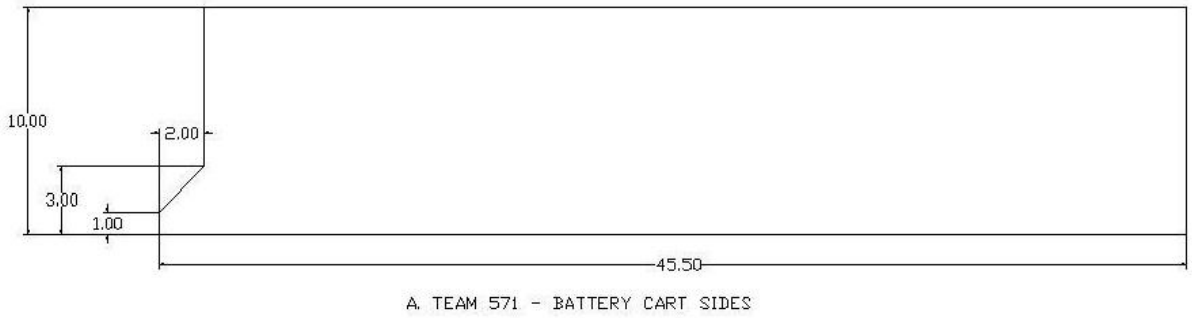


Figure 2: Cabinet Side Part (A)

4. Lay the back panel (D) on a bench or sawhorse. Glue and nail the right side panel (A) to the back panel such that the side panel is sitting next to the back. See figure 3. Repeat with the left side panel. The outside width of the case should now be approximately 24 inches (23in back panel plus two ½in side panels).

Figure 3: Back and Side Assembly Detail

5. Cut the four middle shelves (C) and one top shelf (B) to size. Drill the required holes in the shelves. See Appendix A for notes on drilling the holes.
6. Install the lowest shelf (C) flush with the back panel (D) and 2in up from the bottom of the front feet. Verify this shelf is square to the cabinet in both directions (left/right and front/back)! Any error here will affect all the other shelves. Nail (or screw) the shelf in place.
7. Glue and nail (or screw) two corner supports (M) into the back corners above the lowest shelf. When installing the nails (or screws) be sure to keep the area where the axle will pass through the cabinet free of nails or screws.

8. Install the next lowest shelf (C). The shelf should rest on top of the corner supports (M) in the back and the two temporary supports in the front. Glue and nail (or screw) the shelf in place.
9. Repeat step 8 for the two remaining shelves (C).
10. Glue and nail (or screw) the top shelf (B) 2in below the top of the cabinet.
11. Pre-assemble the six battery corrals by gluing and nailing pieces (E), (F), and (G) in a horseshoe or "C" shape.
12. Glue and nail (or screw) two battery corrals to each of the three battery shelves. Each corral should be open in the front to allow the battery to be installed and removed form the front.
13. Glue and nail the side trim (J) to the sides (A) of the battery cart. The trim should be flush with the outside of the cart and hangs inside the cart by 1/2in. The side trim is to be flush with the bottom and have the 45 degree cut at the top as shown in detail X.
14. Glue and nail the shelf front (K) to the front of each shelf. The trim should be flush with the bottom of the shelf and forma 1/2in tall lip on the front of each shelf.
15. Glue and nail the top shelf front wall (I) to the cart. The wall should be flush with the top of each side and match the 45 degree cut of the side trim pieces (J). See detail X.

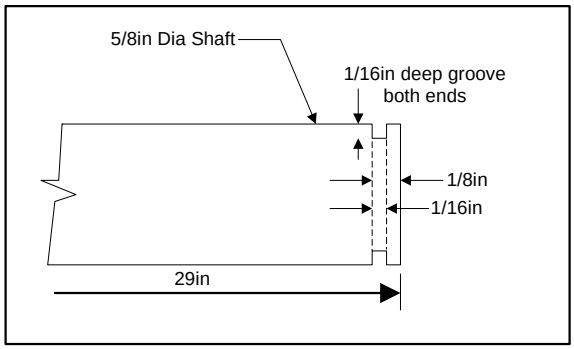
2. Carpeting the Cabinet

1. Lay the carpet face down on a table. Lay the cabinet face up on the carpet.
2. Line the carpet up with one edge (right) of the cabinet. Make sure there is enough carpet at the top of the cabinet to wrap around the inside of the tray at the top of the cabinet.
3. Staple the carpet to the side of the cabinet along the (right) side.
4. Pull the carpet tight around the cabinet and staple it to the other side (left) of the cabinet.
5. Cut the carpet flush with the (left) side of the cabinet.
6. Fold the carpet around the bottom of the cabinet. At the back corner, you will need to make a pair of 45 degree cuts to prevent overlap of the carpet at the corner. Staple the carpet to the bottom. Cut off any excess.
7. Fold the carpet around the top of the cabinet down the sides of the top tray. Cut the carpet flush with the bottom of the tray's side walls (even with the bottom).
8. Cut two pieces of 1x1 aluminum angle (item H19) to 45-1/2in. Drill eight 0.0116 in dia (#19 drill) holes as shown in detail K. Countersink the holes to match the head of the #8 x 3/4in wood screws.
9. Screw an angle (H19) to each side of the cart at the front. The screws should go through the carpet and into the side(s) of the cart.
10. Paint the back rub strips with varnish or other clear finish. When dry, fasten the back rub strips (O) to the cart about 3in in from the sides and 5in up from the bottom. The rub strips are fastened by driving drywall screws through the cart from the inside, through the carpet, and into the rub strips.

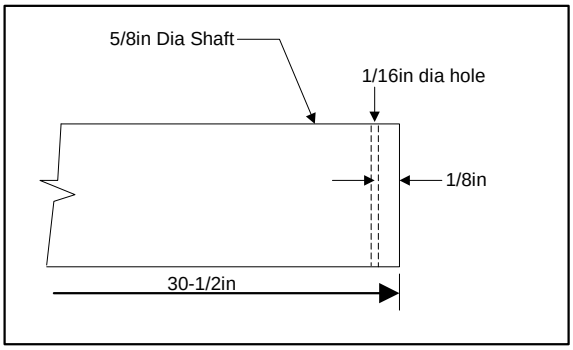
3. Wheel Assembly

1. Measure 5-7/8 in up from the bottom of the cabinet and 1 inch in on each side. Drill a 5/8in diameter hole through the carpet, the side (A) and corner support (M). Be careful to drill straight into the cabinet.

2. Cut the 5/8” diameter axle rod (item H11) to 29in long. Alternate: if you plan to use cotter pins to retain the wheels, cut the axle to 30-1/2 in.
3. Machine a 1/16in wide, 1/16in deep slot in the axle 1/8in back from each end. See detail L. Alternate: drill a 1/8in diameter hole through the axle 1/8in from each edge. See detail C.

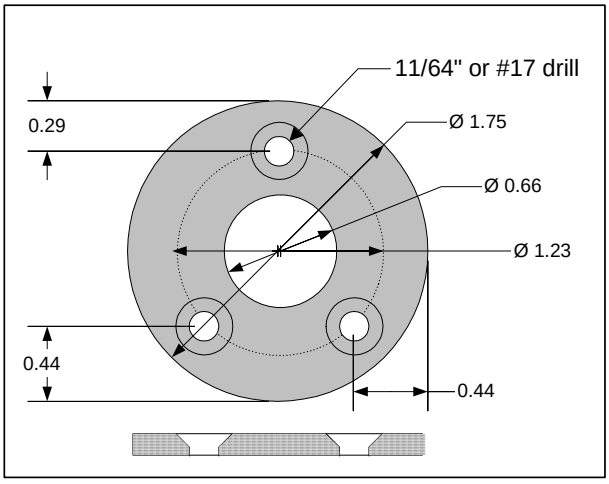


Detail L: Axle Option 1



Detail C: Axle Option 2

4. Drill three 11/64” dia holes in each 5/8in fender washer (item H17) 120deg apart from each other as shown in detail W. Countersink the holes to match the head of the #8 x 3/4in wood screws.
5. Install a washer (item H17) around each hole for the axle. Fasten with 3 #8 x ¾ wood screws.



Detail W: Modified Washer

6. Slide the axle (item H11) through the holes in the cart. Install the wheels (item H10) on each axle. The wheels should be installed with the flat side facing the cart and the hollow on the outside. Install a 5/8” flat washer on each side.
7. Install the spring clip or cotter pin (item H22) on each axle to retain the wheel. If you are using the spring clip. The clip will sit in the hollow in the hub such that the end of the axle will not protrude past the hub of the wheel.

4. Handle Installation

1. Cut a piece of ½" EMT conduit to 48in long.
2. Bend the conduit according to detail H.
3. Using a vise, crimp the ends of the EMT conduit closed. See detail H.
4. Drill a 0.191in (#11 drill) hole in the EMT conduit in four places as shown in detail H.
5. Slide the handle over the sides of the cart. Position the handle 6" below the top of the cart and with the end of the handle about 4" from the front of the cart.
6. Use the holes in the handle as a guide to drill holes through the carpet and the side of the cart.
7. Secure than handle with four #10-32 x 2" machine screws and nuts.

5. Door Construction and Assembly

1. Cut the doors (H) to size.
2. Lay a door on a table.
3. Lay the carpet face up on top of the door with the edge aligned with the hinge side of the door. Make sure there is 2" to 3" of carpet overhanging on the top. The carpet can be flush with the bottom of the door.
4. Staple the carpet to the door on the hinge side only.
5. Wrap the carpet around the latch side of the door and staple to carpet to the other face of the door on the hinge side only.
6. Cut the carpet flush with the bottom of the door (if necessary). Staple the carpet to the front and back sides of the door.

7. Cut the carpet at the top of the door as shown in detail C. The carpet on the front/outside of the door is cut taller than the height of the door.
8. Fold the carpet over the top of the door onto the back of the door. Using a straight edge (such as a 2" wide framing square) cut through the front and back carpet which is now overlapping on the back side of the door.
9. Remove the cut portion of carpet on the back of the door.
10. Stable the carpet on each side of the cut line. The carpet should now blend together with minimal exposed joint.
11. Repeat steps 1-10 for the second door.
12. Cut the aluminum channel
13. Attach the channel to the door. The channel should cover the cut ends of the carpet as shown in photo H.
14. Construct a double acting hinge (item H16) as shown in Appendix B. See photo H. Alternate: Use a standard butt hinge.

Photo H: Hinges

15. Lay the hinges on the door 3in up from the bottom and 3 in down from the top. Mark the centers of the holes closest to the hinge pin on the aluminum channel. Drill and tap for a 6-32 screw.
16. Fasten the hinges to the door using two 6-32 x 1/2in screws and two #6 x ½" wood screws per hinge.
17. With the battery cart laying on its back, lay the doors on the cart. Fasten each hinge to the side of the cabinet with #6 x 1/2in wood screws.

6. Standard Electronics Package

1. The installation of the wiring package is best done with the battery cart laying on its back on a bench or sawhorses.
2. Cut two pieces of ½" EMT conduit to 11" long, and one piece to 6" long.

3. Remove the knockout from one end of one of the handy boxes as shown in figure E. Install an EMT connector in the hole. Install one piece of 11" conduit in the adapter and tighten the set screw.

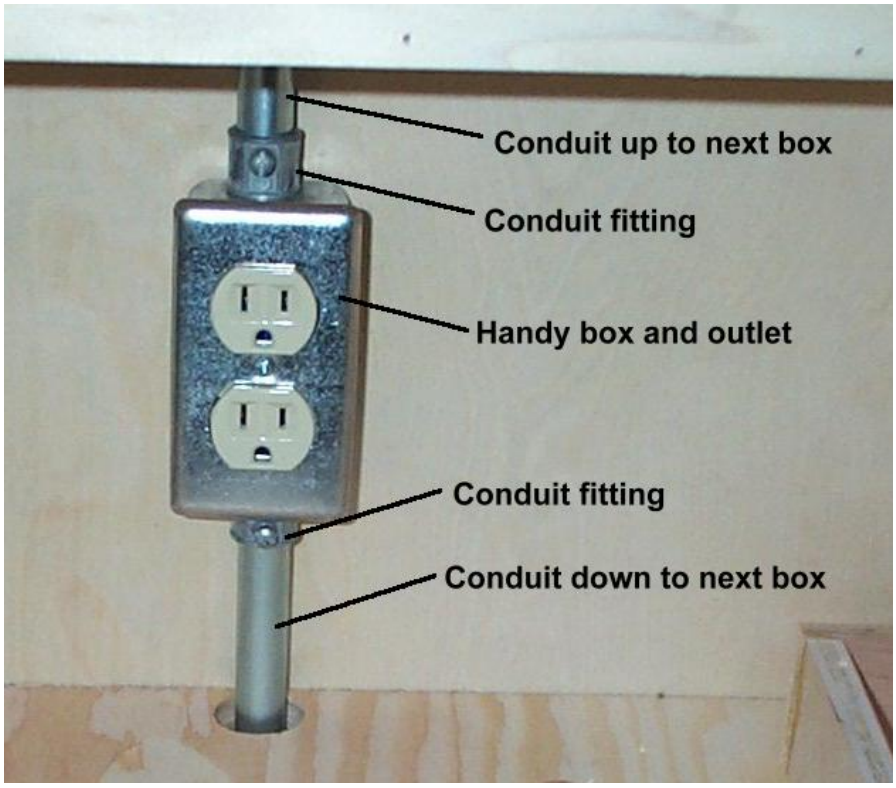


Figure E: Conduit and Handy Box Installation

4. Slide the assembly of box and conduit through the hole in the second shelf from the bottom. See figure F. Do not screw to box to the cart yet.
5. Remove the knockout from both ends of the next handy box. Install EMT connectors in both ends. Install one piece of 11" conduit in one of the adapters and tighten the set screw.
6. Slide the second box/conduit assembly through the hole in the third shelf from the bottom.
7. Install the conduit from the lowest handy box into the fitting in the second handy box and tighten the set screw on the fitting. Do not screw the boxes to the cart yet.
8. Remove the knockout from both ends of the third handy box. Install EMT connectors in both ends. Install one piece of 6" conduit in one of the adapters and tighten the set screw.
9. Slide the second box/conduit assembly through the hole in the fourth shelf from the bottom. This shelf forms the bottom of the electronics bay.
10. Install the conduit from the middle handy box into the fitting in the third handy box and tighten the set screw on the fitting. Do not screw the boxes to the cart yet.
11. With all three handy boxes rigidly connected together via the conduit, slide the assembly up or down until the boxes are centered in each battery bay. Install two #8 x ½" pan head wood screws to hold each handy box to the cart.
12. Cut a red, black and bare #14AWG solid copper wire to about 18" long. Cut a second bare copper wire to 4" long. Connect the white wire to the silver colored terminal on one of the

outlets. Connect the black wire to the brass colored terminal on the other side of the outlet. Connect the 4" bare copper wire to the green ground terminal on the outlet.
13. Wrap the outlet with two wraps of electrical tape, covering the exposed screw terminals.
14. Slide the two insulated wires (black and white) and the 18" base copper wire through the lowest handy box and into the conduit leading up to the next box until the outlet is within a few inches of the handy box.
15. Wrap the 18" bare copper wire around a green bonding screw (H25) in the back of the handy box leaving about 3-4" free. See figure G.
16. Use a wire nut to connect the ground wire connected to the box bonding screw with the wire leading off of the outlet.
17. Push the outlet into the handy box. You may need to pull some of the wire through the upper conduit and/or fold the wires to make them fit inside the box.
18. Screw the outlet to the box. You will need to cut the screw at the upper end of the box as it will hit the conduit fitting before the screw is tight. Alternatively, substitute a 6-32 x ½" flat head screw (H26).
19. Install the cover plate on the handy box.
20. Repeat step 12 at the second handy box.
21. Slide the two insulated wires (black and white) and the 18" base copper wire through the second handy box and into the conduit leading up to the next box until the outlet is within a few inches of the handy box.
22. Cut the black and white wires which are coming up from the first hand box to a convenient length. Connect the white wire to the second silver colored terminal on outlet #2. Connect the black wire to the second brass colored terminal on outlet #2.
23. Wrap the outlet with two wraps of electrical tape, covering the exposed screw terminals.
24. Twist the three bare copper wires in box #2 together and cap with a wire nut.
25. Push the outlet into the handy box. You may need to pull some of the wire through the upper conduit and/or fold the wires to make them fit inside the box.
26. Screw the outlet to the box. You will need to cut both screws as they will hit the conduit fittings before the screws are tight. Alternatively, substitute two 6-32 x ½" flat head screws (H26).
27. Install the cover plate on the second handy box.
28. Cut a red, black and bare #14AWG solid copper wire to about 24" long. Cut a second bare copper wire to 4" long. Connect the white wire to the silver colored terminal on one of the outlets. Connect the black wire to the brass colored terminal on the other side of the outlet. Connect the 4" bare copper wire to the green ground terminal on the outlet.
29. Repeat steps 21 through 27 for the third handy box.
30.

7. Optional Electronics Package #1 (Voltmeters)

The following instructions apply to the panel meters used in the Team Paragon battery cart. If you choose to use a different brand or style panel meter, you will need to modify the instructions accordingly.

1. Build three mounting brackets for the six panel meters. See figure M.
2. Set the jumpers on the back of the panel meters to match the application (short "20V" and "P2" connections.
3. Solder 15" lengths of #22AWG wire to each panel meter at the "VIN" and "GND". Connect ¼" quick disconnect lugs to the ends of the wires.
4. Connect mating ¼" quick disconnect terminals to the battery charger side of the Anderson plugs (or charger side of the battery charger terminals).
5. Solder 48" lengths of #22AWG wire to the VP and VN terminals on each panel meter.
6. Install the panel meters in the mounting brackets. Use a tag (numbers 1 through 6) to identify both the panel meter and the battery leads to prevent swapping left/right battery connections when using the charger cabinet.
7. Fasten the mounting brackets to the inside face of the battery charger trim as shown in figure F.
8. Pull the six sets of input voltage leads up to the test panel area of the power supply. The wires can be wire tied to the outside of the electrical conduit used for the outlets and run through the same holes in the shelves.
9. Connect the (+) leads to the 5VDC output of the power supply.
10. Connect the (-) leads to the GND/Return output of the power supply.
11. Mount the power supply to the inside of the test compartment. We chose to mount it to the back of the sheet metal panel in the power supply.
12. Connect the 120VAC input for the power supply to the "Accessories" switch on the test panel as shown in figure W.
13. Connect the 120Vrtn input for the power supply to the neutral (white) incoming power.

Figure M: Panel Meter Mounting Bracket

Instructions for use:

When the "Accessories" switch on the cart is turned on, the panel meter will show the voltage for each battery. To get an accurate reading (open circuit) you must turn off the battery chargers ("Chargers" switch). The battery chargers will force a higher voltage on the battery during the charging process and thus gives an incorrect reading on the panel meters. By shutting off power to the chargers, the true open circuit battery voltage is displayed on each panel meter.

8. Optional Electronics Package #2 (Load Tester)

Background: The batteries used in the FIRST robot can be tested in two ways: open circuit, or under load. The open circuit voltage test (which is performed by the six voltmeters in the cart) is useful to determine if the battery has been changed, but does not give an indication of how well the battery will perform when under real life conditions (in the robot). A battery with a higher open circuit voltage has better potential to operate the robot, but the load test is a better check on how the battery will operate when the battery is loaded down by the robot. As the load tester partly discharges the battery to perform the test, you should leave time (15 min) to recharge the battery after load testing it before you need to use the battery.

As an alternate to the load tester integrated in the battery cart, you may choose to purchase a commercially available load tester. Harbor Freight offers a low cost battery load tester (P/N 90636) for about $20.00. Note that this tester does not include a timer to regulate how long the test will be performed. If you leave the tester turned on for a longer time, you will get a lower battery voltage, which may lead to inaccurate comparisons of batteries.

Theory of operation: The battery load tester is connected to the battery via the Anderson type plug (which matches the plug on the battery changer). When the start button is pressed, the K1 relay is energized, which puts a 2ohm load across the battery terminals. Another contact of the K1 relay forms a “self holding” circuit around the start button and keeps the K1 relay energized and the test running even if the user releases the start button. A fully charged battery should deliver about 14V/2ohm = 7A to the tester. Relays K1 and K2 also connect a panel meter and capacitor to the battery and load. The panel meter is used to monitor the output voltage during the test. After 15 seconds, timer 2 energizes relay K2

which interrupts the current to the load tester and capacitor. The voltmeter is now connected to only the capacitor, which stores a sample of the battery voltage at the instant just before the load was removed. A capacitor is used to sample the battery voltage as the battery voltage will drop under load, but will rise once the load is removed. This rise in voltage will give a misleading measurement. Thus the capacitor sample gives a more accurate reading of the battery voltage after 15 seconds of load test. Note: The 1000uF capacitor shown is too small to maintain the final test voltage due to the load of the panel meter. Add a larger (maybe 5000uf) panel mounted capacitor to the circuit.

After an additional 12 sec delay (27sec total time), timer 2 will energize the K3 relay. This relay has a single NC contact in series with all three relays. The relay will energize for a brief instant, which interrupts power to all three relays, which then turn off. With all three relays off, the panel meter shuts off and the load tester is ready for the next battery.

When using the load tester, connect only the battery under test to the load tester. Never connect the load tester to the output of a battery charger as the load tester could damage the battery charger. To track the performance of the battery over a time, a simple table to record the battery health (as shown in figure C) can be taped to the side of the battery. Each time the battery is tested (after being fully charged), you can record the test results on the battery. When load tester shows the battery capacity is diminishing, its time to change the battery's status from "Competition Ready" to "Practice Only", and eventually to "Dead".

Battery Load Test Chart

Date	Voltage		Date	Voltage

Battery Status:
- ☐ Competition Ready
- ☐ Practice Only
- ☐ Dead- Recycle

Figure C: Battery Load Test Label

1. Cut the 6 position terminal block (item E15) down to 5 positions. This was necessary to fit the terminal block on the 2-3/4" wide circuit board. If you are using a smaller terminal block, this may not be necessary. Although only 3 unique positions are required on the PCB, we chose to use a 5 position terminal block to make wiring in and out of the PCB easier as some terminals would have 2 wires per terminal.
2. Drill the PCB (item E13) to match the wire terminals and mounting screws on the terminal block.

3. Assemble the terminal block to the PCB. The screws for the terminal block can be used to fasten the standoffs on the front of the circuit board as shown in photo S and figure J.
4. Install two more standoff in the back of the circuit board as shown in figure S and figure J.
5. Install the four power resistors (item E12) and capacitor (item E14) into the holes in the PCB as shown in photo S. The resistors should be spaced to leave a small air gap between the resistors (there is just enough room).

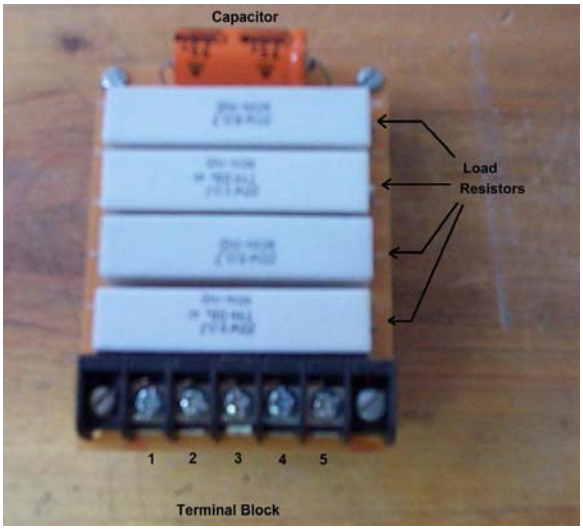


Photo S: Front of Load PCB

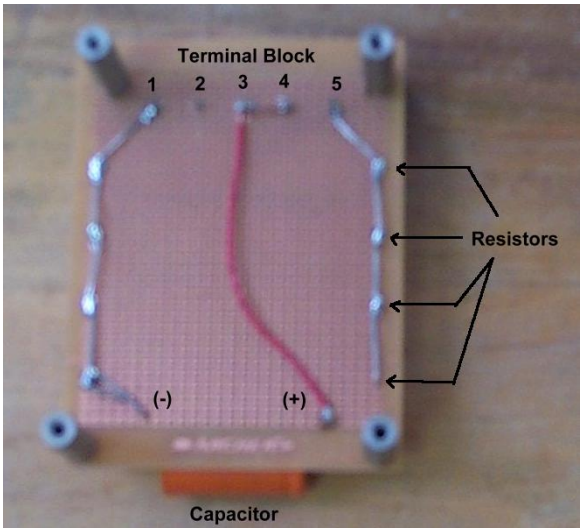


Photo B: Back of Load Test PCB

6. Solder the (-) lead on the capacitor to the resistor lead on the same side. Then solder all the resistor leads on the side together and to terminals 1 and 2 on the terminal block. See photo B.
7. Solder the (+) lead on the capacitor to terminals 3 and 4 on the terminal block. You will need to extend the capacitor's lead with a piece of #22 AWG wire as shown in photo B.
8. Solder the four resistor leads on the second side together and solder those connections to terminal 1 on the terminal block.
9. Verify with an ohm meter that the resistance between terminals 1 and 5 is about 2 ohms.

10. To make the PCB easier to mount in the battery charger case, the PCB was fastened to a 3” x 6” piece of bent sheet metal as shown in figure J. The sheet metal base can be fastened to the inside of the cabinet with wood screws rather than trying to accurately drill holes for the 6-32 machine screws through the plywood shelf to exactly match the layout of the standoffs in the PCB. You may need to modify your mounting plate to suit the standoffs on your PCB.

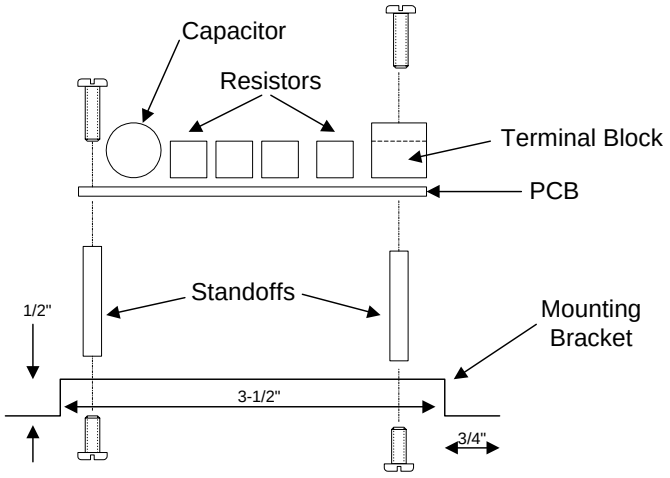


Figure J: Load PCB Mounting

11. Although several methods for mounting the relays and timers could be used, we chose to use relays which plug into sockets which can mount on standard 35mm DIN rail as shown in photo R. The timers are fastened to the relay bases with double stick tape.
12. Assemble the relays and timers onto the DIN rail.
13. Wire the relays, timers, and PCB as shown in figure W.
14. Timer 1 should have a 150Kohm resistor installed to set the time delay at 15sec.

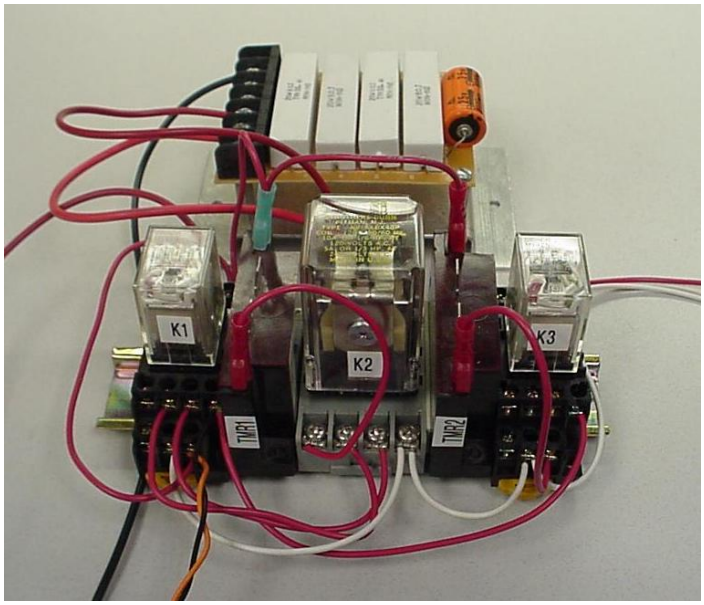


Photo R: Load Tester Assembly

15. Timer 2 should have a 270Kohm resistor installed to set the time delay at 27 sec.
16. The power (120VAC) for the load tester should be subject to the “Accessories” switch on the control panel as shown in the schematic.
17. There is space on the front panel of the battery cart to mount the panel meter and the “Start Test” button. See photo S. You may need to adjust the size of the panel if you use a different panel meter.

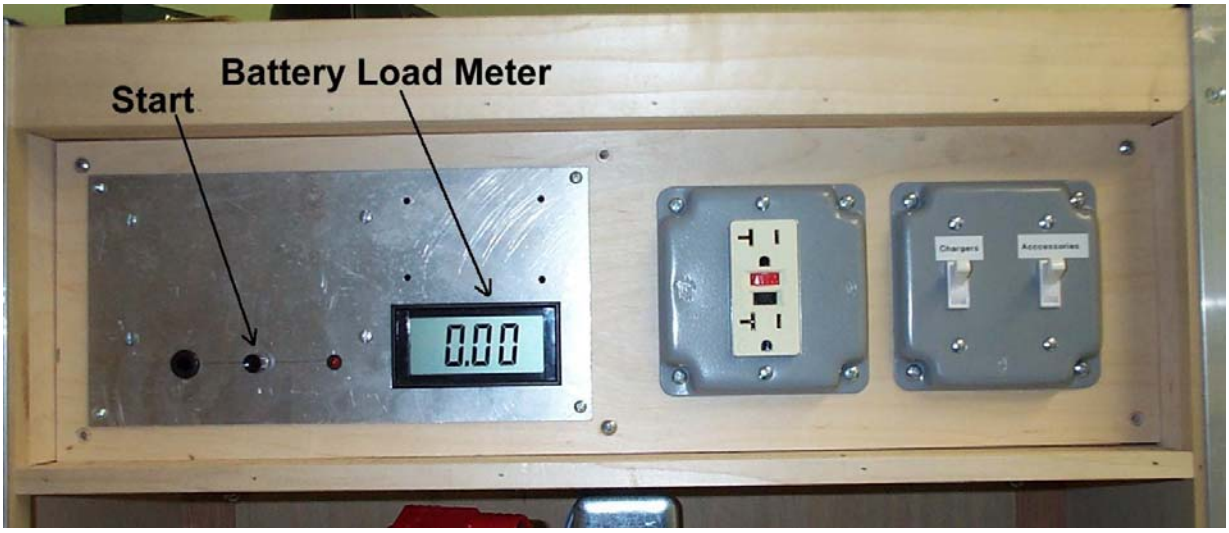


Photo S: Load Test Panel

1. Appendix A: Shelf Construction

The shelves in the original battery cart were made from ½in plywood and nailed through the sides with a pneumatic nailer. If you are hand nailing or screwing the shelves into the cabinet, you may find it helpful to substitute ¾in thick stock as it will give you more room to nail or screw into. If you use ¾ in thick stock, reduce the height of the corner braces (M) and two extra scraps to 10-¾in.

All shelves can be drilled with identical holes except for the top shelf (which forms the bottom of the top tray. See figure Y. Each self has four ¾" dia holes used to tie down the battery chargers (use a Velcro strap) and 13 ¾" dia holes which are used to enhance the air flow through the battery chargers. If your chargers are a different size, you may need to put the holes under the chargers in a different location. One additional 1-1/4" dia hole is provided to run the 120VAC power and 5VDC power for the panel meters.

When drilling the holes in the shelves, it is recommended that you stack and clamp all the shelves together and drill them all at once. By drilling them at once, the splintering of the plywood where the drill bit exits can be minimized. If possible, use a piece of scrap under the lowest shelf in the pile while drilling to eliminate splintering of those holes as well. See detail K.

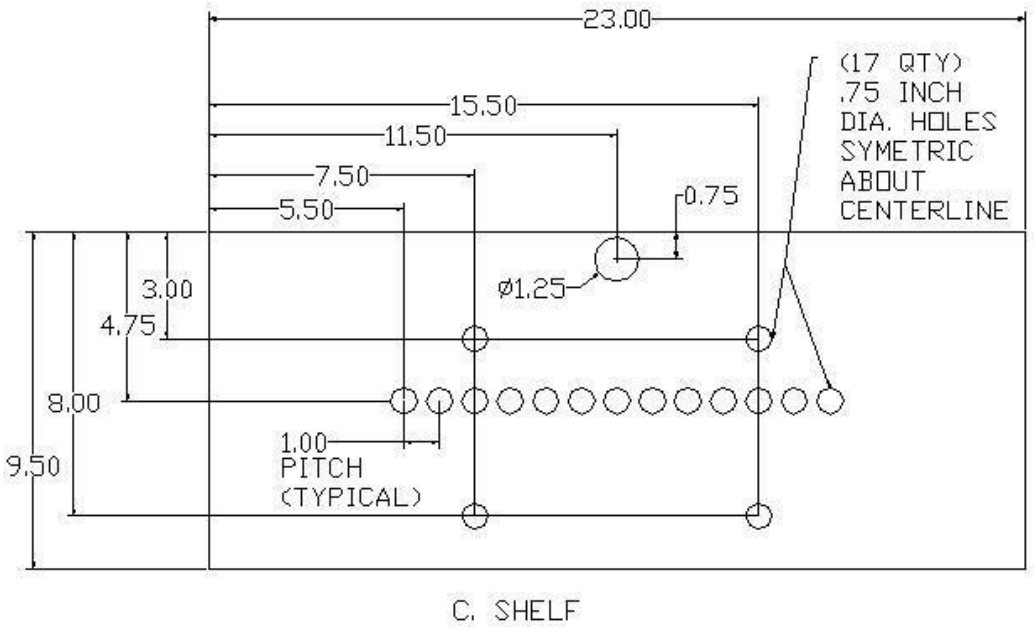


Figure Y: Shelf Cutting and Drilling Pattern part (A)

Appendix B: Double Acting Hinge

In order to provide better clearance for the door to swing flat against the side of the cabinet, a double acting hinge was used. The hinge allows the hinged side of the door to stand farther out from the side of the cabinet when the door is open. This allows the door to hang a little more parallel to the side of the cabinet and not flare out when the door hits the wheels on the sides of the cabinet.

As we could not find a suitable double acting hinge, we chose to make one from a double acting hasp, which was available from Lowes home center. The package was not marked with a manufacturer's name, but the manufacturer's part number is 64307.

1. Original Hinge (model 64307)
2. Cut hasp even with slot. Discard cut end.
3. Drill four holes 5/32" dia. Holes are 3/8" in from the edges. Ease corners with a file.
4. Countersink holes for #6 screw. Note that the holes are countersunk on the opposite side of the original holes.

Appendix C: Material Lists

Wood Cutting List

Ref	Description	Dimensions	Material	Qty
A	Side *	45-1/2" x 10"	1/2" 7ply plywood	2
B	Top Shelf	23" x 9-1/2"		1
C	Mid Shelf *	23" x 9-1/2"		4
D	Back Panel	23" x 43-1/2"		1
E	Battery Side Wall	2" x 7-1/4"		6
F	Battery Back Wall	2 x 4-3/8"		6
G	Battery Side/Spacer	2" x 7-1/4"		6
H	Door	11-3/4" X 43-1/4"		2
I	Top Tray-Front Wall	24" x 2" x 1/2"	Poplar or Maple	1
J	Side Trim	1/2" x 1" x 44-1/2"		2
K	Shelf Trim	1/2" x 1" x 22"		3
L	Top Shelf Trim	1/2" x 1/2" x 22"		1
M	Corner Brace*	1-1/4" x 1-1/4" x 11"	Pine or Poplar	6
N	Panel Front	6-3/8" X 22"	1/4" plywood or aluminum	1
O	Back Rub Strip	3/4" x 2" x 30"	Oak or Maple	2

* special cut instruction- see drawings

Hardware List

Ref	Description	Part Number	Manufacturer	Qty
H1	Handy Box			3
H2	Outlet Cover			3
H3	Duplex Receptacle			3
H4	GFCI			1
H5	GFCI Cover for 4x4 box			1
H6	Light switch			2
H7	Double light switch cover for 4x4 box			1
H8	1/2" x 10' EMT			1
H9	1/2" EMT fitting			5
H10	12" dia pneumatic wheel w/ 5/8" hub			2
H11	5/8" x 30" steel rod			1
H12	3 conductor #14AWG type SOJ cord			15ft
H13	15A plug			1
H14	#8 x 3/4" Flat Head Wood Screws			50
H15	#8 x 1-1/4" Drywall screws			50
H16	2" x 3" butt hinge or double pivot hasp*	64307	?	4
H17	5/8" Fender washer *			2
H18	6' x 6' carpet			
H19	1" x 1" x 1/16" Aluminum Angle			8ft
H20	Aluminum "C" channel for 3/4" plywood			8ft
H21	5/8” Flat washer			2
H22	E-clip			2
or	1/16” x 1” cotter pin			
H23	4” x 9” x 22GA Aluminum Bracket *		Custom Made	6
H24	House/Mailbox Numbers			2 pair
H25	10-32 x ½” green bonding screws			3
H26	6-32 x ½” flat head machine screws (opt)			5
H27	15” long Velcro strap			6

* requires customization

Electronics Package

Ref	Description	Part Number	Manufacturer	Qty
E1	6A Battery Charger	7032206	Exide	6
E2	5VDC, 2.6A power supply	11408-PS	Marlin P Jones	1
E3	0-20VDC 3-1/2 Digit Panel Meter	12306-ME	Marlin P Jones	6
E4	50Amp “Anderson” type power plugs			7 pr
	(The following parts are for optional battery load tester)			
E5	0-20VDC Panel Meter	12306-ME	Marlin P Jones	1
E6	7” long DIN rail			1
E7	Delay Timer	438U	Artisan	2
E8	Relay, 115VAC coil, 4 form C contacts (K1, K3)	MY4-AC110/120	Omron	2
		Z185-ND	Digi-Key	
E9	Relay, 115VAC coil, 2 from C contacts (K2)	MK2P-S-AC120	Omron	1
		Z797-ND	Digi-Key	
E10	Relay Socket	PYF14A-E	Omron	2
		Z811-ND	Digi-Key	
E11	Relay Socket	PF083A-E	Omron	1
		Z805-ND	Digi-Key	
E12	Resistor, 8ohm, 20 Watt	Radio Shack	271-120	4
E13	Printed Circuit Board	Radio Shack	276-158A	1
E14	1000uF, 35V Capacitor	Radio Shack		1
E15	Terminal block (5pos cut down from 6pos)			1
E16	6-32 x 1” hex standoff			4
E17	Resistor 150Kohm, 1/4W	Radio Shack		1
E18	Resistor 270Kohm, 1/4W	Radio Shack		1