

FRC Battery Upgrade

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A Zebicorn Labs Paper

1 Introduction to the Battery and Connectors

The legal FRC battery is a sealed lead acid battery with a nominal voltage of 12 volts. It has two terminals on the top, connected with battery cables attached to an SB50 Anderson Powerpole connector (typically it is an SB50 but some teams have opted for even larger gauge wire and larger Anderson Powerpole Connectors).

The battery cables themselves are generally 10-12 inches in length. This extra length takes into account flexibility of battery orientation inside the robot. There are two cables per battery: one red and one black. On each cable, there is a ring terminal crimped on one end. This terminal is secured to the battery itself. On the other end, the cable connects to an Anderson Powerpole contact which goes into the Anderson SB50 connector housing. These cables deliver power to the robot.

This paper will discuss the process that our team went through to upgrade our battery cables and connectors in an attempt to improve robot performance.



Figure 1.1: Batteries arranged in a conspicuous pattern.

2 Problem

Like most FRC teams, we have been bitten by loose battery connections from bolts, nuts, and even poor insulation. We've also researched the marginal improvement gains to be had from switching from 6 AWG cables to 4 AWG cables on our batteries. While 6-gauge wire has .3951 Ohm per 1000 ft of resistance, 4-gauge wire has .2485 Ohm per 1000 ft¹ of resistance.



Figure 2.1: Note how the electrical tape peels away, leaving metal exposed.



Figure 2.2: The wire underneath contorts over time as well.

3 Our Solution

To work towards resolution we decided to fortify the connections from the wires to the batteries as well as upgrade to 4-gauge copper wire. The larger wire will have the effect of decreasing resistance. Team 358's research and analysis² shows that the decreased gauge size also decreases the power lost to the wire.

For the fastening system we used number 10 bolts with Nord-Lock washers³, nylock nuts, and heatshrink as much as possible to reduce the chance of the leads rattling loose. The

¹<http://www.tfcbooks.com/referenc/wiresize.htm>

²<http://www.team358.org/files/electrical/>

³<http://www.nord-lock.com/nord-lock/wedge-locking/washers/introduction/>

Nord-Lock washers use [tension](#) instead of relying on friction to keep contact and maintain a solid connection.

The total cost for each cable we made was less than \$10.00 though it is worth noting that we spent closer to \$400 in parts for this project.

4 Materials Required Per Battery

Part Name	Quantity	Type
4-gauge Copper Wire	11" of black and red	4-gauge copper wire
button head socket cap screws	2	10-32 x 5/8"
Nord-Lock Wedge lock washer	4	#10, found here
Nylock nut	2	10-32
Copper Lug	2	Thomas Betts 54906BE; 1/4" Bolt hole
Ring Terminal	2	
Anderson SB50 Connector	1	

5 Tools Required

- Crimper (we used [this](#) pneumatic one)
- Wire cutters ([This](#) is what we used)
- Wire strippers for large gauge (Found [here](#))
- Heat gun
- Scissors
- Allen keys
- Box wrenches

6 Changing the Battery Cable



Figure 6.1: Battery without cables. Nut and bolt orientation is shown as they were before upgrade.

1. To begin the battery upgrade we cleaned the battery terminals of any old parts [Figure 6-1]
2. Now we need to prepare the new leads.
 - (a) Cut lengths of 4-gauge wire to 11 inches. One black and one red wire for each battery.
 - (b) Strip one end of each wire 3/4 inches.
 - (c) Insert the 3/4" stripped ends into the copper lugs.
 - (d) Make sure to get all of the individual copper fibers into the lug.

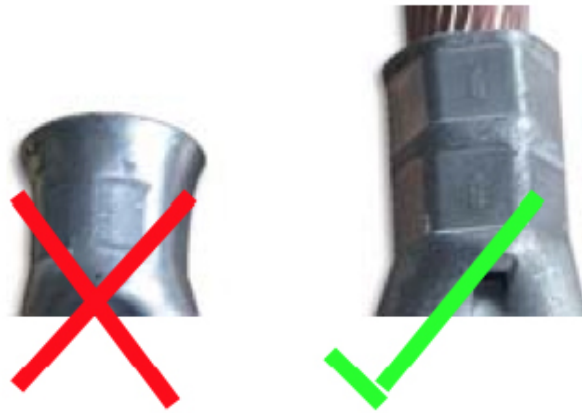


Figure 6.2: An improper crimp on the left next to a proper crimp on the right

- (e) Crimp the lugs onto the wires. You may have to use multiple crimps in different places on the lug to get the entire lug crimped. We used a pneumatic crimper. Do a pull test on the wires to make sure they are secure [Figure 6-2]. Tug wires to test if you can pull them out by hand. Tug the wires hard because if you can pull them out by hand then they won't stand up to the rigors of FRC.
- (f) Strip the other end 3/8" in and repeat the crimping procedure on the Anderson Powerpole contact lug. The Anderson lug can be a tighter fit and you will need to be patient when putting the 4 AWG wire into the contact lug. Other teams have reported success using methods of expanding the lug before inserting 4-gauge wire. [Figure 6-3]



Figure 6.3: 4-gauge cables with lugs on both ends

- (g) Next install the Anderson Powerpole connector into the SB50 housing while making sure that the lug will hook over the tongue. The black wire will go on the side marked "-" and the red wire will go on the side marked "+". There will be an audible click when it successfully goes together. Pull test the wires; you should not be able to pull the lugs out by hand. [Figure 6-4]



Figure 6.4: The internal workings of an Anderson Powerpole connector

3. Before you attach the wires to the battery be sure that there is a 3 inch length of heatshrink on each wire. The heatshrink may be cut with scissors. Simply slide heatshrink over the wire before attaching it to the battery.
4. Now install the cables on the battery. The lug should line up on the outside of the

corresponding color terminal facing so that the wire is directly above the battery terminal.

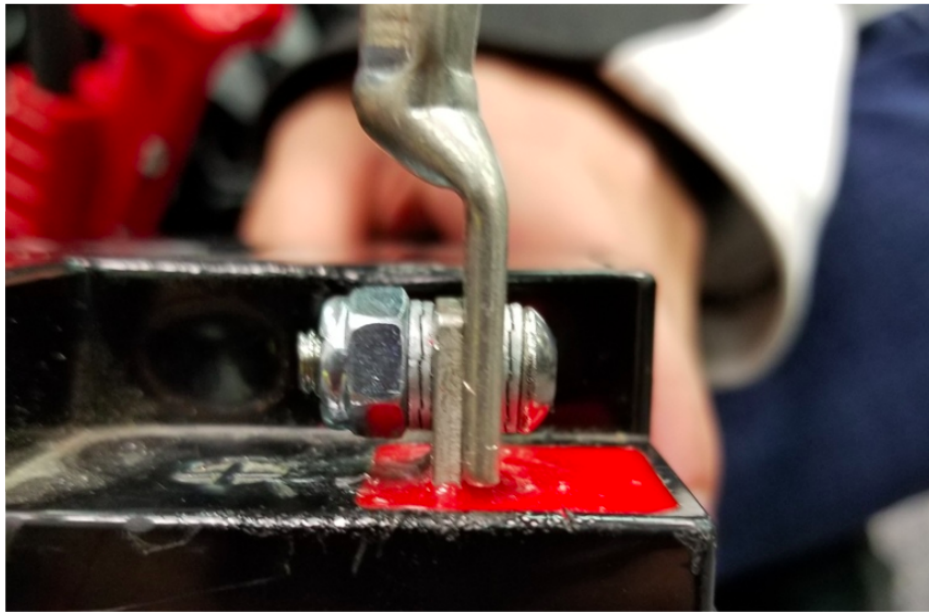


Figure 6.5: Order of bolts, washers, and nuts on the battery terminal

5. Then the number 10 bolt goes, from the outside, through a Nord-Lock washer (each Nord-Lock has 2 parts, do not separate them or you risk ruining their magic power), the copper lug, the battery terminal, another Nord-Lock washer and the into the nylock nut. This arrangement is correct for through hole applications of Nord-Locks⁴ [Figure 6.5]
6. Tighten the nut until the copper lug does not easily rotate on the battery terminal. NOTE: It was not necessary for us to orient the terminal in a specific direction as the wires we chose were flexible enough for us to deal with any orientation issues, your mileage may vary.

⁴<http://www.nord-lock.com/nord-lock/wedge-locking/washers/joint-guide/>



Figure 6.6: A very beautifully done heatshrink battery terminal

7. Slide the heat-shrink over the the battery terminal as low as it will go and apply heat to it with the heat gun. Start on the bottom and use one slow, steady movement upwards, and then move to another side of the heatshrink. [Figure 6.6] **Be very careful not to melt the soft plastic of the battery case!** [Figure 6.7] No metal should be visible if this step is done correctly.



Figure 6.7: This is what happens when the heat gun melts the battery case plastic. Salvador Dali batteries are not desirable.

8. The finished battery should look similar to the one below. [Figure 6.8]



Figure 6.8: A completed battery. Yay!

Appendix A Battery Specs

According to R37 of [FRC 2017 Steamworks Game Manual](#), Section 8.7, only the batteries listed below are allowed on the robot during competition. Specifications for these batteries are linked below. If PDF specs could not be found, either specs from or a direct link to the website is listed. If not using any of the batteries listed, teams will be asked to provide documentation of the specifications of their battery.

- [Energys \(P/N: NP18-12, NP18-12B, NP18-12BFR\)](#)
- [MK Battery \(P/N: ES17-12\)](#)
- [Battery Mart \(P/N: SLA-12V18\)](#)

Product Specifications for 12 Volt 18 Ah Sealed Lead Acid Rechargeable Battery with Nut & Bolt Terminals	
SPECIFICATIONS:	
BM Part #:	SLA-12V18
Voltage:	12 Volt
Capacity:	18 Ah
Type:	Sealed Lead Acid Battery
Length:	7.13"
Width:	3.01"
Height:	6.59"
Cold Cranking Amps:	200 CCA
Shipping Weight:	15.00Lbs
Warranty:	1 Year
Rechargeable:	Yes
FEATURES:	
<ul style="list-style-type: none">• Nut and Bolt Style Terminals: 6mm diameter.• Recyclable, rechargeable battery and no memory effect.• AGM Sealed, maintenance free with a long service life. Built to last in the roughest situations.• Operating temperature of -40°C to +60°C (-40°F to +140°F).• Wide-range of charging temperatures: -20°C to +50°C (4°F to +122°F).• Shock, vibration, and heat resistant battery case.• Made of either non-conductive ABS plastic, styrene, or polypropylene.	

- [Sigma \(P/N: SP12-18\)](#)
- [Universal Battery \(P/N: UB12180\)](#)
- [Power Patrol \(P/N: SLA1116\)](#)

Item Number: SLAA12-18NB
Brand: Duracell Ultra
Voltage: 12
Lead Acid Type: General Purpose
Capacity: 18AH
Chemistry: Lead Acid
Lead Acid Design: AGM
Product Category: Sealed Lead Acid
Terminal Type: M6 Nut and Bolt, NB, Nut and Bolt, J
Torque: 3.9 - 5.4Nm / 34.5 - 47.8 in-lbs
Weight: 11.9 lbs
Length: 7.13 in
Width: 3.03 in
Height: 6.57 in

- [Werker Battery \(P/N: WKA12-18NB\)](#)
- [Power Sonic \(P/N: PS-12180NB\)](#)
- [Yuasa \(P/N: NP18-12B\)](#)
- [Panasonic \(P/N: LC-RD-1217\)](#)
- [Interstate Batteries \(P/N: BSL1116\)](#)
- [Duracell Ultra Battery \(P/N: DURA12-18NB\)](#)