HDARC Presentation

LiFePO4 Battery Assembly

Instruction Materials

August 28, 20245

INTRODUCTION

- Welcome to another HDARC build activity.
- The following will step you through an assembly process for constructing an 8-cell LiFePO4 portable battery.
- This battery will support SOTA/POTA radio operations and provide long-life operation.
- Please understand this build will likely take 6-8 hours of your time.
- This is a really fun activity that will hopefully provide you with some additional insight into HAM radio skills and operation.

PREREQUISTES

- Please read and be familiar with the instruction manual, available on the HDARC website.
- We expect that you purchased or have in your possession the required materials defined in the instruction manual for this build.
- You possess the basic electrical soldering skills and an understanding of electrical components and circuitry.
- You are familiar with and will adhere to personal safety guidelines, such as:
  - Wearing of eye protection and
  - Safeguarding against electrical shock.

PREREQUISTES

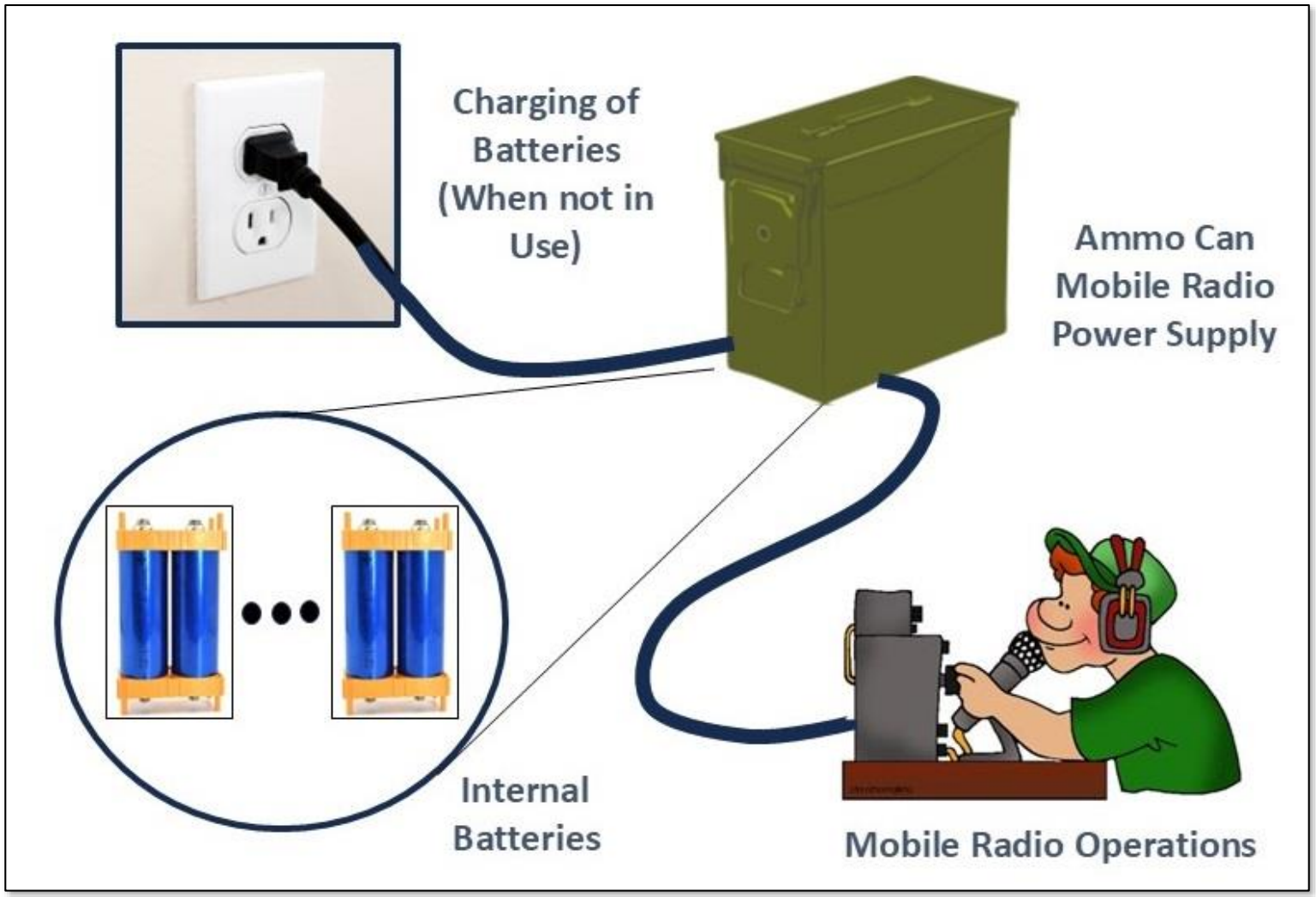
- **You possess electrical and mechanical tools needed for the build, to include:**
    a. **Multi-meter,**
    b. **Wire strippers,**
    c. **Solder, soldering iron and heat gun,**
    d. **Crimpers,**
    e. **Plyers, screwdrivers,**
    f. **Indelible markers, and so on.**

- ***But most of all - Have Fun!***

CAUTIONARY

- HDARC assumes no liability for any personal injury to builders who undertake this project.
- Any deviation from the instruction manual undertaken by the builder will remain the consequential responsibility of the builder.
- In other words, please understand that we can only fix what we told you to do.

In a Nutshell, This is What We are Building



THE BUILD PROCESS

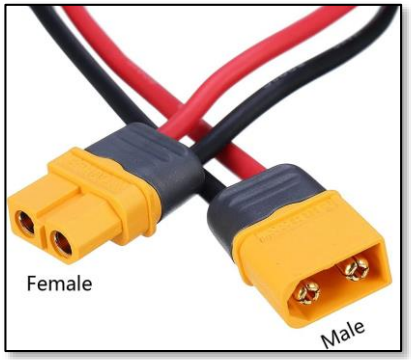
This build consists of 7 major assemblies:

1. **The Battery Charger System (BCS) Power supply with connector,**
2. **The Basic 4-cell LiFe Battery unit,**
3. **The Battery Charger System (BCS),**
4. **Battery Management System (BMS),**
5. **Integration of the 4-cell LiFe Battery unit**
6. **Integration of two 4-cell units into an 8-cell unit configuration, and**
7. **Package the 8-cell battery unit into a portable configuration.**

BCS Power Supply

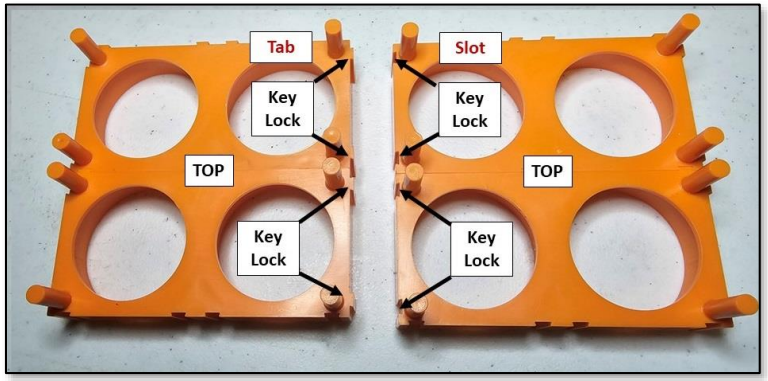
- *You may need a gender bender for the 60-Aamp connector*

- We are using an iSDT Air8 BCS.
- The Air8 BCS requires an external power source.
- Obtain a 19-19.5v power supply for an old laptop computer, either:
  - Purchase a female 60-Amp adapter and connect it to the power supply output pin, or
  - Splice a 60-Amp adapter to the power supplies output.
- Note, if splicing, most old power supplies have three wires (blue, white, black):
  - Cut the blue wire short.
  - Test the remaining wires with a multimeter to determine which is power and common.
  - Connect power to the square 60-amp side.



Assemble the Basic 4-Cell Battery Unit

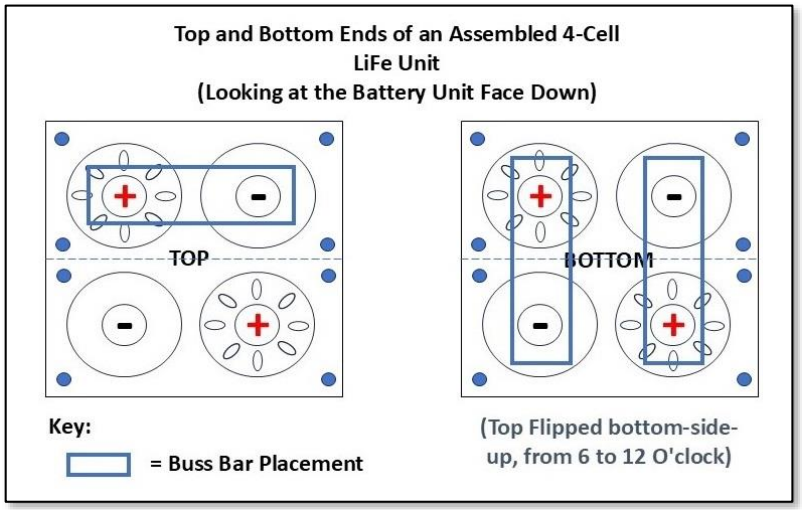
- Test all the individual batteries first to make sure they provide ~3.3v power.
- Assemble the batteries into two separate 4-cell units.
- Use plastic sleds to hold the battery units together, as shown below:



- The sleds are individual 2-hole modules.
- They connect with molded key locks.
- Slide one sled down on top of another to lock in place.

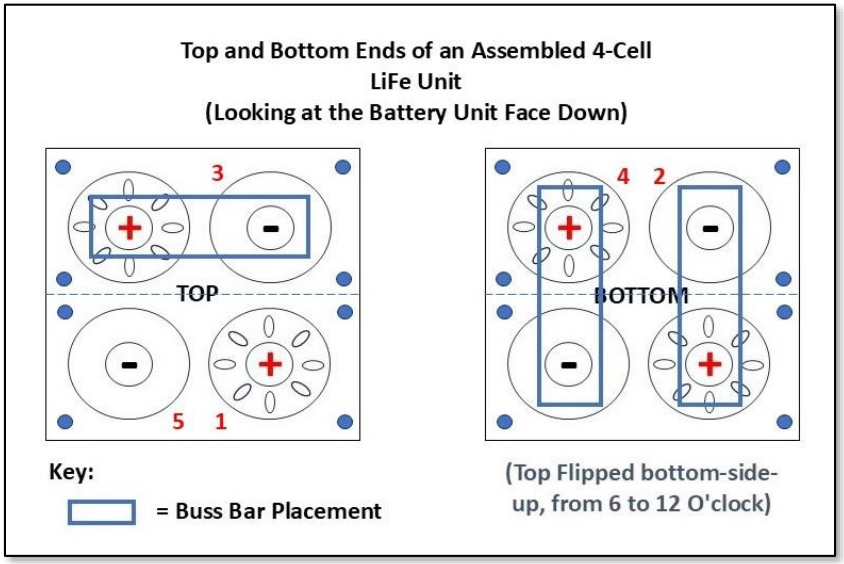
- Do this 4x to make 4 sleds.
- Make sure the seams are horizonal on each 4-hole assembly
- Ensure that the left sled assembly has key locks on TOP and BOTTOM that will connect with a right-hand unit.

Construct the Battery Assembly



- **Sled assemblies with batteries should look like this.**
- **Alternate the insertion of the batteries to expose positive and negative ends for TOP and BOTTOM**
- **The positive end of a battery is the multi-holed silver end; the black end is negative.**

- **Connect buss bars between the battery terminals with lock washers and screws.**
- **Label the TOP and BOTTOM sleds, and terminals, as shown (using an indelible marker).**
- **Test terminals 5 (negative) with terminal 1 (positive) to verify ~13.2 volts total power.**



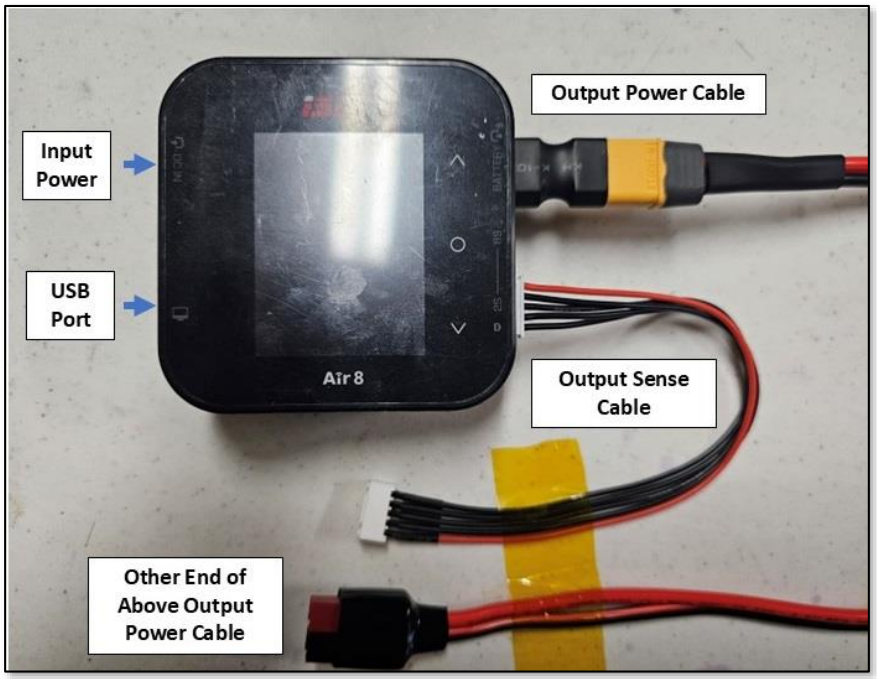
Construct the Battery Assemblies

- **Each of your finished 4-cell battery assemblies should look like this, with labeling.**
- **These two units are now the basic building blocks to connect the Battery Charging System (BCS), the Battery Management Systems (BMS), and the final harness assembly into an Ammo battery container.**

This is what a BCS looks like:

Assemble the Battery Charging System (BCS)

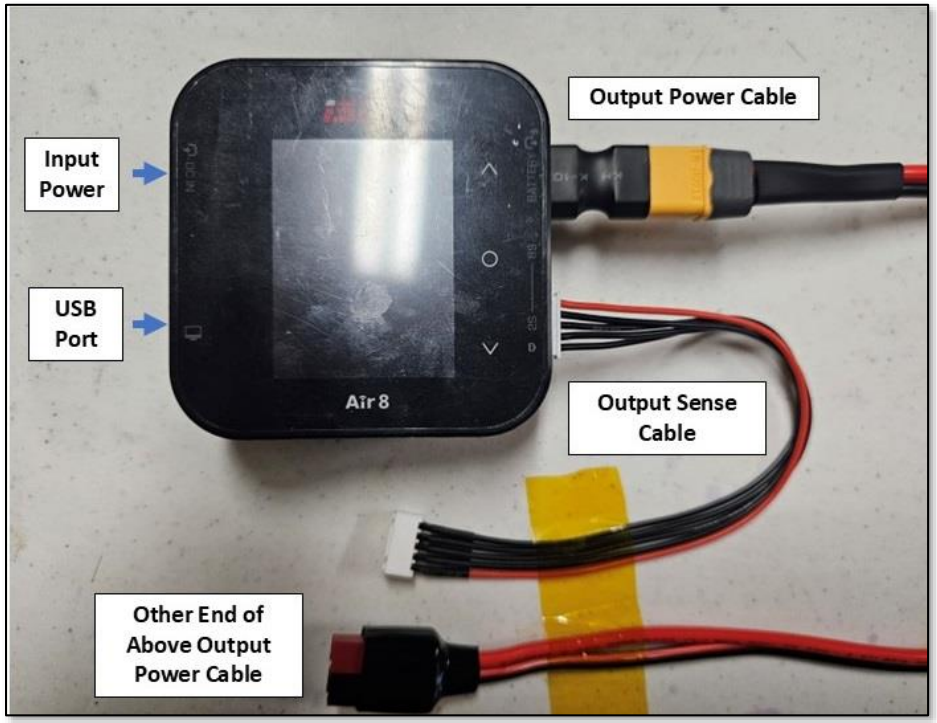
- The iSDT Air8 has an input side (left) and an output side (right).
- The left side accepts the adapted laptop power input previously described.
- There is also a mini-USB for just powering the unit to program it, but it is not sufficient for charging batteries, so, ignore it, unless you want to program the BCS per the Appendix in the instruction manual.
- The output side provides the power input to an individual 4-cell battery unit.



- The output sides consists of a power cable (that will connect to the battery unit harness cable).
- The other BCS output is a 4-cell sense cable.
- The sense cable has 5-wires which will connect to battery terminals.

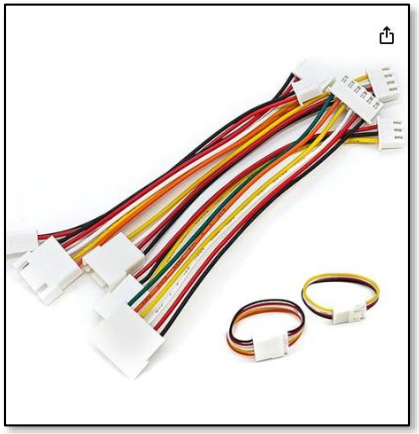
Assemble the Battery Charging System (BCS)

- **Build two sense cable (twice) with ring connectors as shown in the next couple of slides.**
- **The sense cables connect to pre-purchased extension cables, as shown below.**
- **More on the extension cables, the sense cables, and the output power cable in the next couple of slides.**



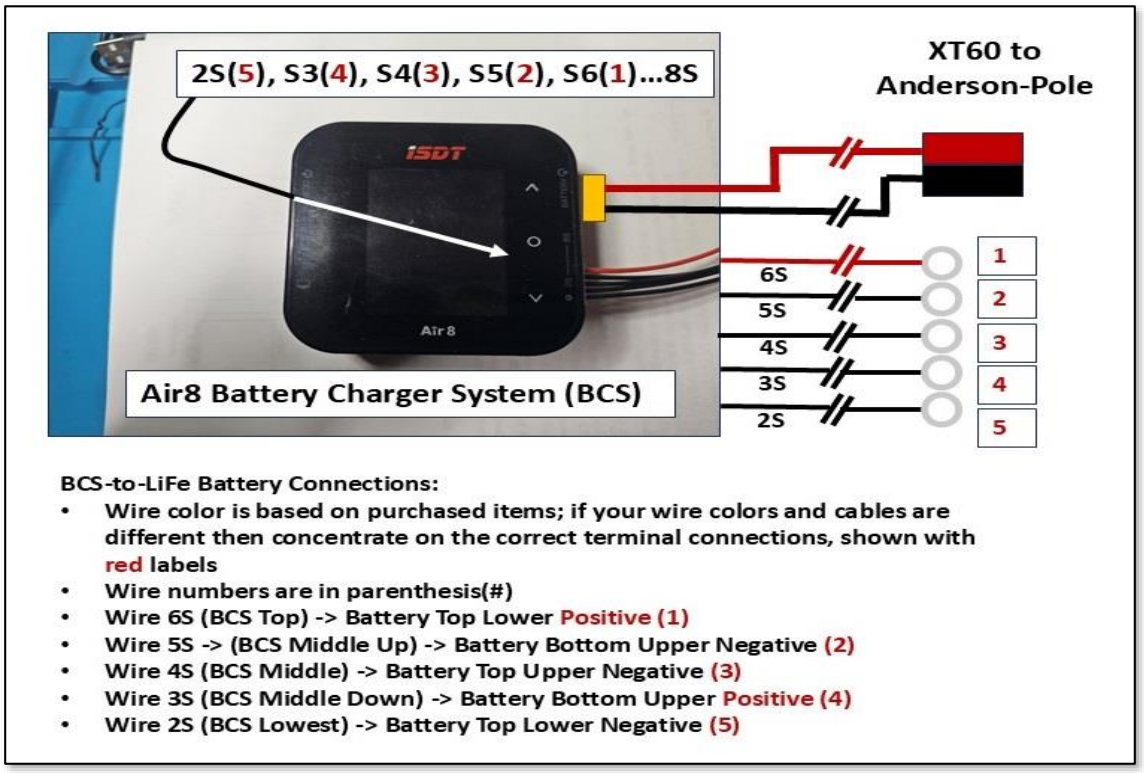
Assemble the Battery Charging System (BCS)

- This is what the BCS output cables look like:
  - The 5-wire sense cable with extension, and
  - The output power cable.
- The output power cable is another 60-amp female connector from the BCS to an Anderson-Power-Pole connector. These can be purchased or you can build it.
- To build the sense cable with ring connectors::
  - Strip the 5 wire ends and attach ring connectors.
  - Depending on your chosen connectors you will need to tin, solder, crimp, and/or heat the connectors.
  - Label the ring connectors to correspond to battery terminals, as in the next figure.
- If you decide to build a power output cable, then please do it now.



Assemble the Battery Charging System (BCS)

- This is the notional assembly diagram for your BCS output sense cable.
- Please label the output rings according to the 1-5 nomenclature provided below.
- Ensure that the output sense cable connects to the extension cable, and that the extension cable connects to the BCS.



- Note, the extension cable can connect to the BCS only one way, via the keyed tab in the BCS output sense port.
- The next slide provides an example of labeled ring connectors.

Example of Ring Labeling and Shrink Wrap

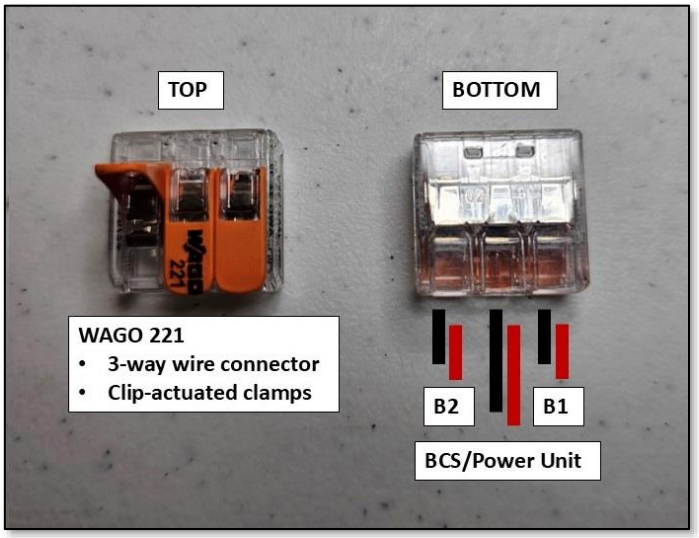
Assemble the Battery Management System (BMS)

- The BMS has two sets of cables:
  - A 5-wire sense cable with ring connectors, and
  - A set of heavier 14-gauge power wires.
- The sense cable is a linked group of 5 wires with a JCT-XH connector end that fits into its mate on the BMS:
  - The sense cable plugs into the BMS (only one way).
  - Like the BCS this sense cable consists of 22 AWG wires.
- Attach ring connectors to the stripped ends of the BMS sense cable, similar to the activity followed for building the BCS sense cable.
- Build and label two BMS sense cables - one for each BMS.
- Unlike the BCS, there is no BMS extension cable.
- The next page provides a notional picture of the BMS, along with:
  - Sense cable connection,
  - Sense cable ring numbering, and
  - The remaining power control wires that we will build next.
- OK now for something completely unexpected:

INTERMISSION!

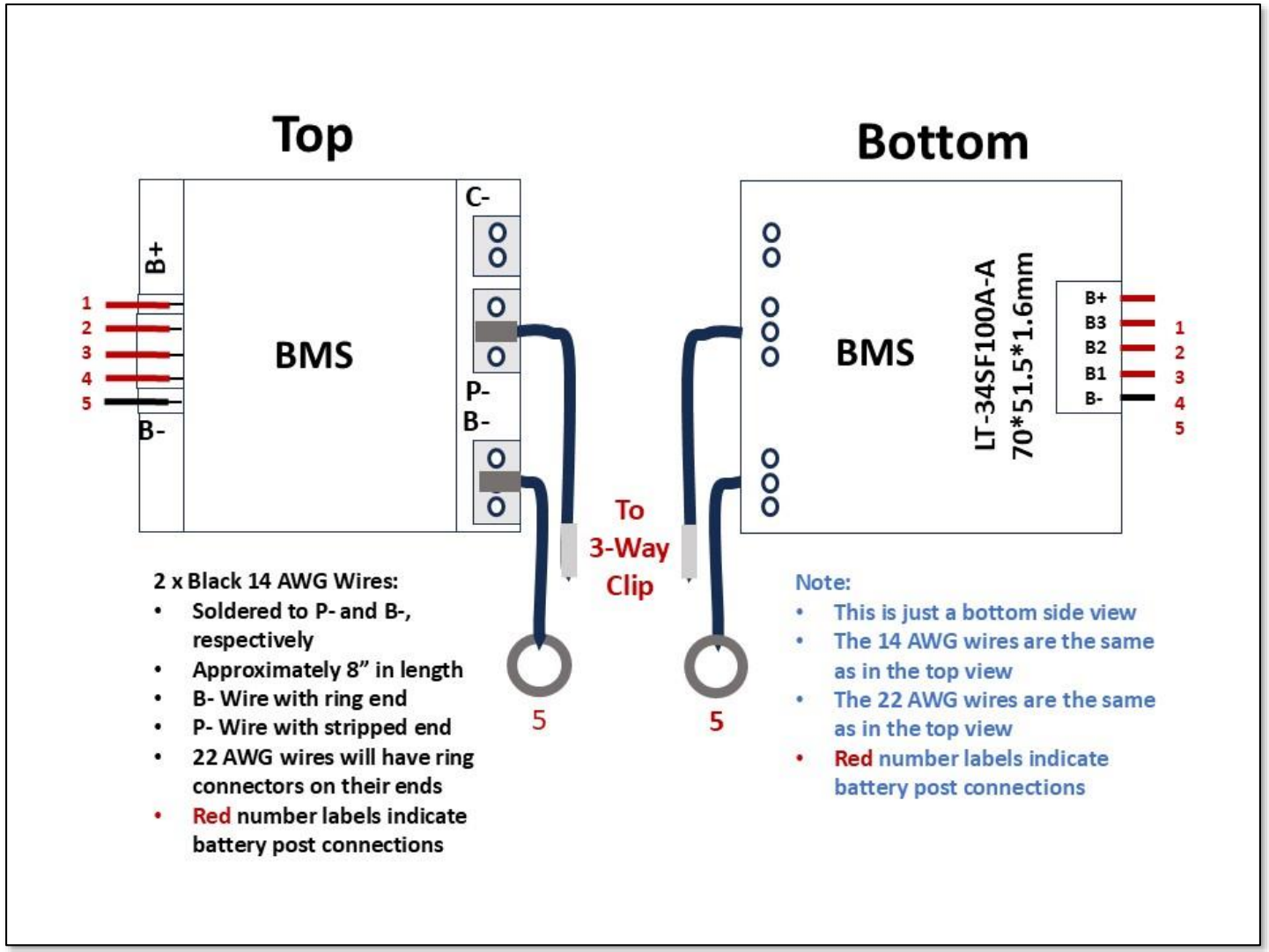
Assemble the Battery Management System (BMS)

INTERMISSION OVER!



- First, let's take a look at the 3-way wire-splice clip, a WAGO 221 connector
- We use this WAGO clip to:
  - Adapt the BMS to the harness, and
  - To prevent accidental arching in the meantime.
- You can likely come up with an alternative splice mechanism, but these are so practical and will give you four, since they only seem to be available in lots of 50.
- Moving on, the BMS requires a set of two heavier 14-gauge wires that connect to the B- and P- joints on the BMS board.
- Note, the BMS controls the battery unit through the negative side of the harness cable (which you will build in a little bit).
- To assemble the BMS negative control connection:
  - Cut 4 lengths of black 14-gauge wire into 8" lengths.
  - Strip and tin the ends.

Assemble the Battery Management System (BMS)

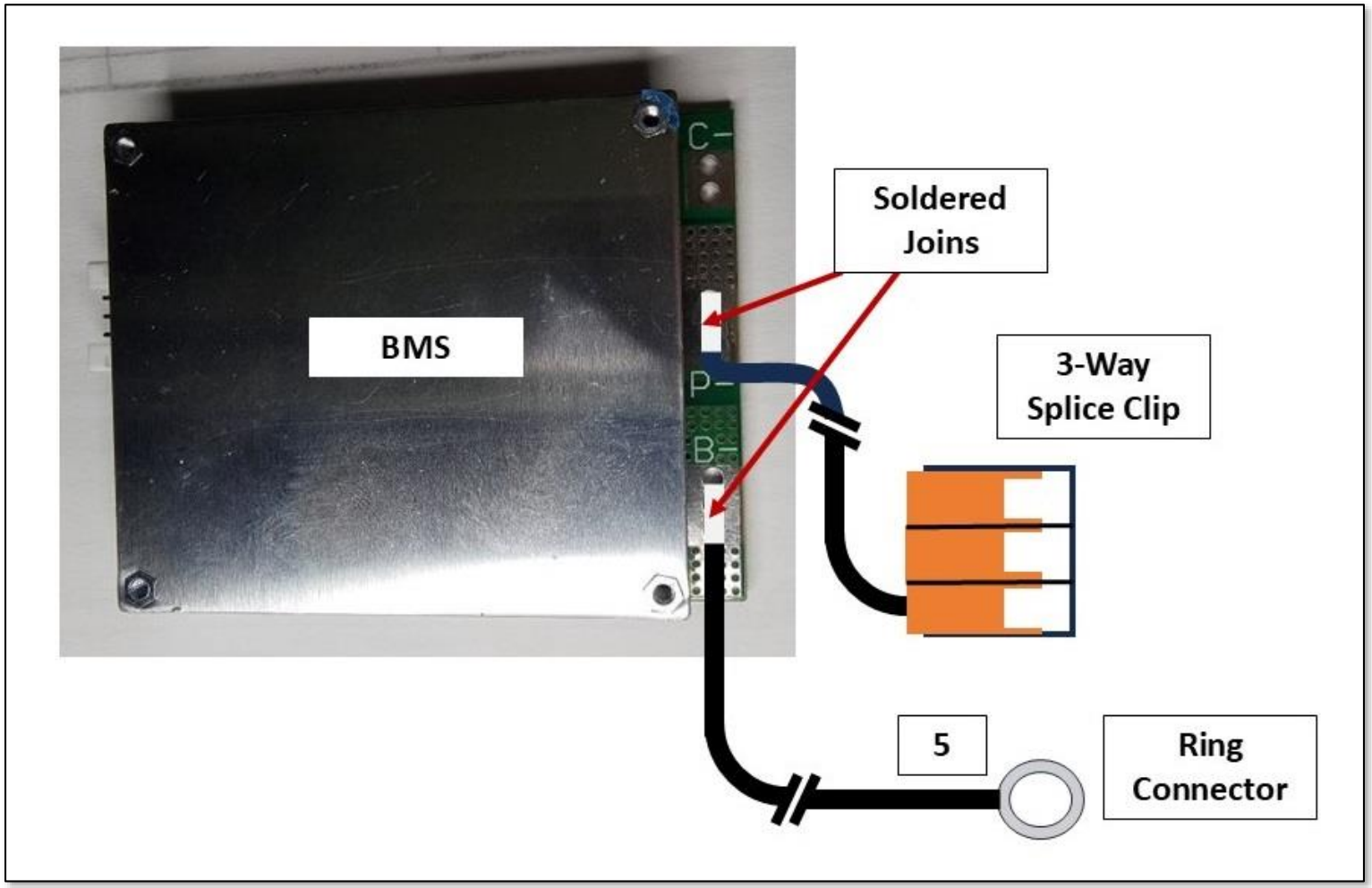


Assemble the Battery Management System (BMS)

- To assemble the BMS negative control connection (Continued…):
  - Connect a ring connector to two separate black 8” wires.
  - Attach a 3-way wire-splice clip to one end of the other two black wires with ring connectors.
  - If you don’t have splice clips then cover one end each with tape to prevent inadvertent contact with another metal or conductive source.
  - Solder a set of two black wires to each BMS:
    - Solder one wire with a ring connector to the B- terminal pad.
    - Solder the other black wire with the attached 3-way clip to the P- terminal pad.
    - Very important: make sure your wires when soldered orient downward away from the C- terminal pad, as previously shown in the BMS notional wiring diagram.
    - You may need to use helping hands (clips, weights, etc. to keep the soldered leads on the BMS terminal pads.
    - It may be helpful for you to first apply flux to the terminal pads and then add more solder to accept a join with the tinned wire leads.
    - See the next Figure for another depiction of these soldered joins.

Assemble the Battery Management System (BCS)

- **BMS with 2 negative wires attached – Note, the Splice Clip Protection!**

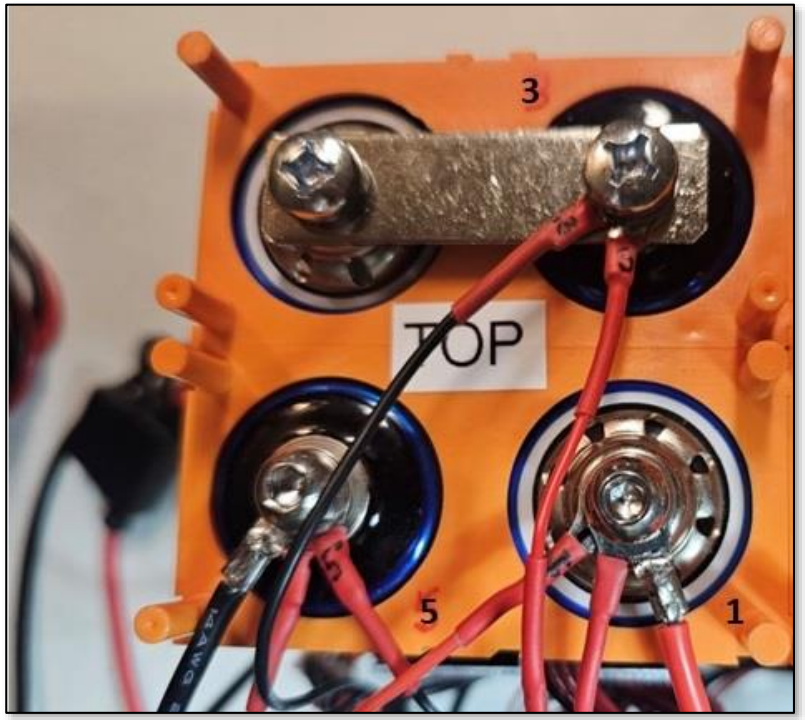


Integration of 4-Cell Battery Unit

- We've reached a major construction milestone
- Time to assemble a full 4-cell battery unit with BCS and BMS functions.
- First attach the BCS sense cable with 5 ring connectors to their labeled 4-cell battery terminals on the TOP and BOTTOM of the battery unit:
  - Connect labeled rings to battery terminals 5, 1, 3 (TOP).
  - Connect labeled rings to battery terminals 4 and 2 (BOTTOM).
  - Make sure the terminal screws with lock washers are lightly secure – not loose and rattling around but form firm connections.
  - Repeat this connection for the second 4-cell battery unit.
  - Ensure the ring connectors face toward the front of the battery unit.
- With a multi-meter measure the voltage of the BCS sense cable to ensure proper connection:
  - Place the positive probe on the JCT-XH terminal exposed connector wire 1.
  - Place the negative probe on the JCT-XH terminal exposed connector for wire 5.
  - Verify a reading of ~13.2 volts.

Integration of 4-Cell Battery Unit

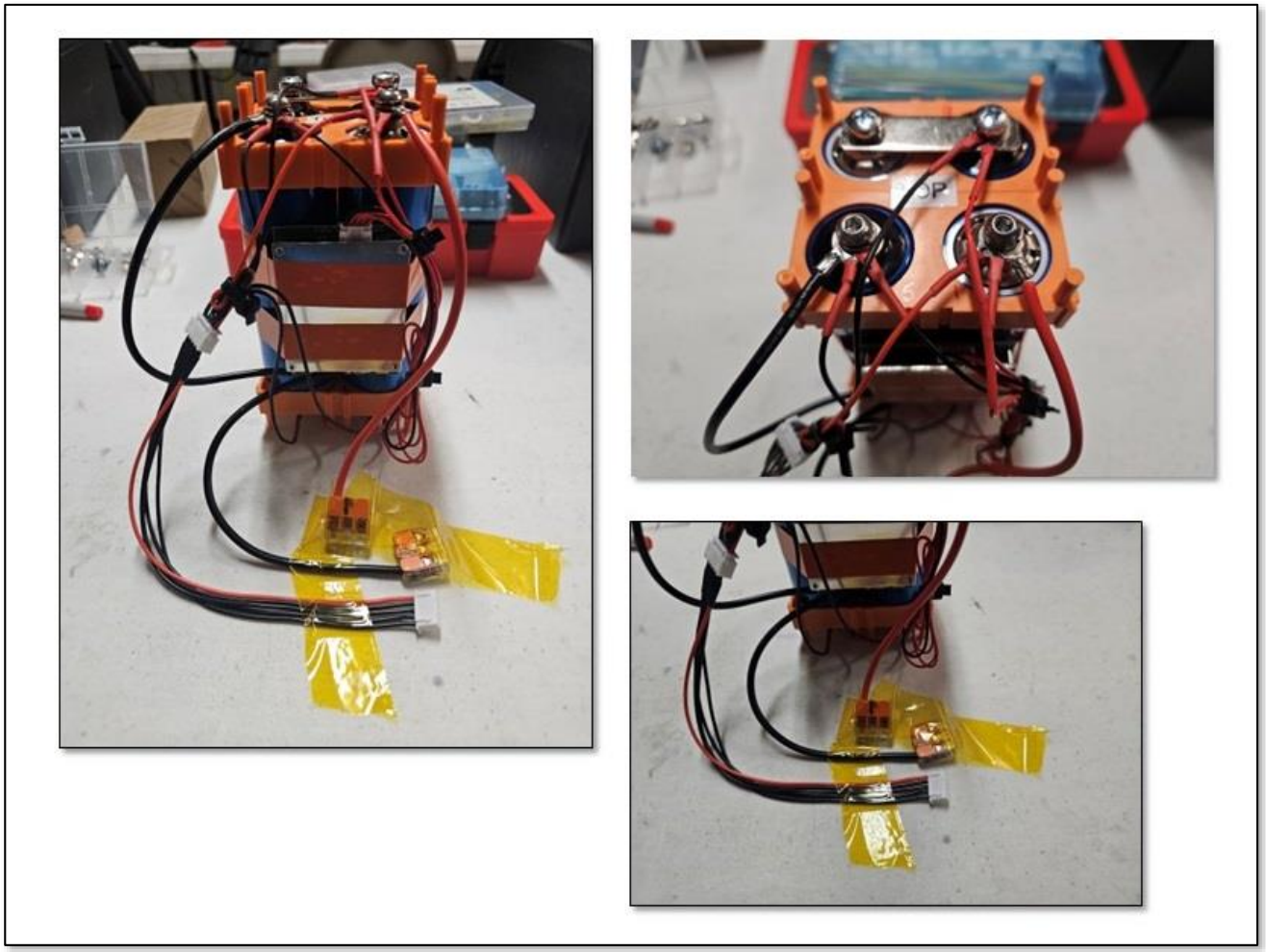
- With a multi-meter measure (Continued…):
  - Moving the negative probe sequentially verify readings of ~9.9, 6.6, and 3.3 volts across sense cable connectors 4, 3, and 2 respectively.
- We are progressively moving toward a connection of all sense and power wires to the 4-cell battery unit as shown in the following figure.



- The TOP terminal connections shown in the Figure highlight the attachment of ring connectors that face forward to the front of the battery.
- Each time you connect a new set of rings, as for the BMS to follow, ensure they all face forward.
- Ensure the same alignment for the BOTTOM side of the battery unit.

Integration of 4-Cell Battery Unit

- **The final assembly that integrates BCS and BMS will look like the following Figure:**



Integration of 4-Cell Battery Unit

- Now it is time to connect the BMS to the 4-cell battery units.
- Attach the BMS to the front face of the 4-cell battery unit:
  - Note, you will do this twice, one for each 4-cell battery unit.
  - Attach the BMS with electrical tape, tie-wraps, and/or both
    - The sense cable connection of the BMS needs to face upwards.
    - Leave enough vertical space to be able to connect and disconnect the sense cable to the BMS.
  - Connect the BMS sense cable with the 5-ring connectors to the BMS unit.
- Connect the BMS cables to the battery unit:
  - Following the sense cable number of the BMS:
    - Attach and tighten the ring connectors of sense cable wires 5, 1, and 3 to the TOP of the 4-cell battery unit.
    - Flip the battery unit over.
    - Attach and tighten the ring connectors of sense cable wires 4 and 2 to the BOTTOM of the 4-cell battery unit
    - Make sure the ring connectors of all terminal connections face to the front of the battery unit..

Integration of 4-Cell Battery Unit

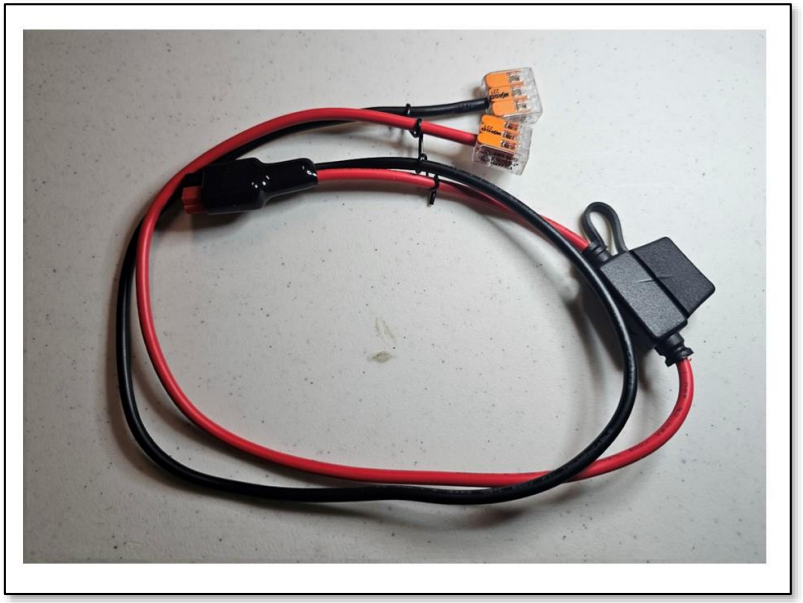
- **With your finger feel the area around the BMC JCT-XH connection:**
  - **If it feels hot you got a problem.**
  - **Disconnect the BMS sense wire immediately.**
  - **Re-verify your sense ring-wire battery terminal connection.**
- **With a multi-meter measure the voltage of the BMS sense cable to ensure proper connection:**
  - **Place the positive probe on the JCT-XH terminal exposed connector wire 1.**
  - **Place the negative probe on the JCT-XH terminal exposed connector for wire 5.**
  - **Verify a reading of ~13.2 volts.**
  - **Moving the negative probe sequentially verify readings of ~9.9, 6.6, and 3.3 volts across connectors 4, 3, and 2 respectively.**

Integration of 4-Cell Battery Unit

- Now connect the BMS power wire B- to battery unit terminal 5:
  - This connection is from the 14-gauge B- wire of the BMS that was soldered to the board and has a ring connector.
  - Again, please ensure there is a 3-way spice connector or piece of tape on the soldered black wire extending from the 14-gauge P- wire connection on the BMS.
- At this point, pay attention to the fact that there are multiple wires connected to the 5, 1, 3, 4, and 2 battery terminals:
  - There may be an entanglement of wires do to the 3 sets of connections made.
  - You may need to re-sort some of the wiring connections to group the sense wires by disconnecting wires from battery terminals and rethreading around each other.
  - At a future point, you will use tie wraps or some other binding method to clean-up and shorten these groupings in order to fit the entire 8-cell battery assembly into the ammo box.

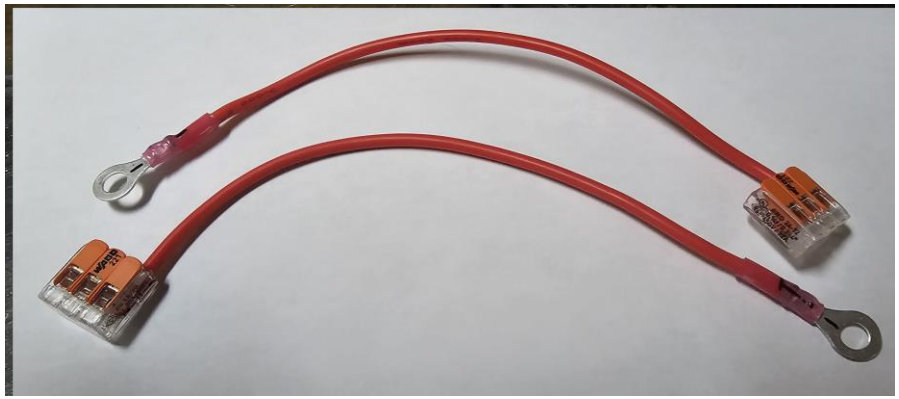
Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

- Now we're in the home stretch; the tasks remaining are:
  - Build two positive 14-gauge battery terminal wires.
  - Build a harness cable.
  - Test that everything works with BCS charging and providing power to a radio.
  - The adjacent picture depicts a harness cable.
  - This cable is a 12-gauge dual-stranded wire set that connects the battery assembly to the external power activity, either
    - BCS charging or
    - Radio unit operation.
  - But first, let's build the 2 positive terminal wires.



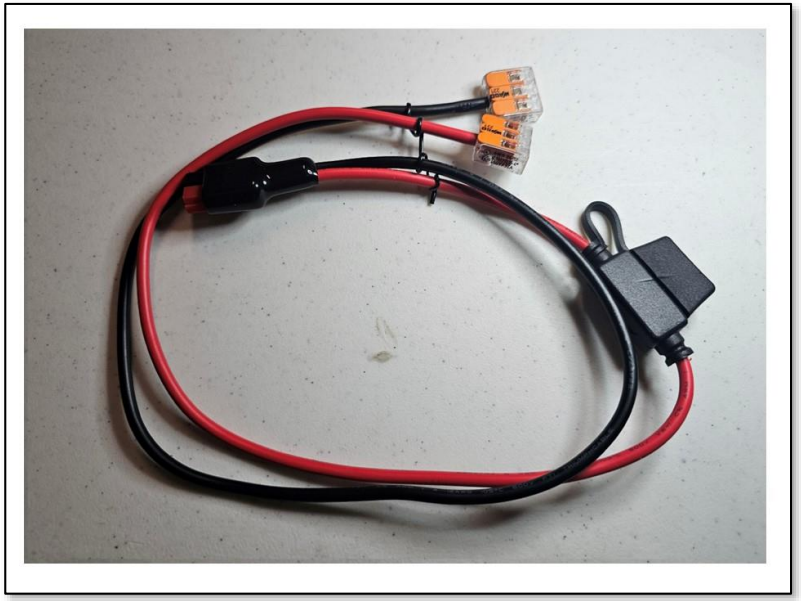
Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

- Build the positive wire connectors for the battery leads, as follows:
  - Cut 2 lengths of red 14-gauge wire into 8” lengths.
  - Strip and tin the ends.
  - Connect a ring connector to two separate red 8” wires by crimping heat-sink-shielded ring connectors or separate rings with added heat shrink.
  - Label the ring connectors with a “1” for attachment to terminal 1.
  - Attach a WAGO 3-way wire-splice clip to the open ends of the two red wires, per the adjacent figure.
  - If you don’t have splice clips then cover the ends with tape to prevent accidental sparking.
  - Attach a positive wires to each battery TOP terminal 1.



Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

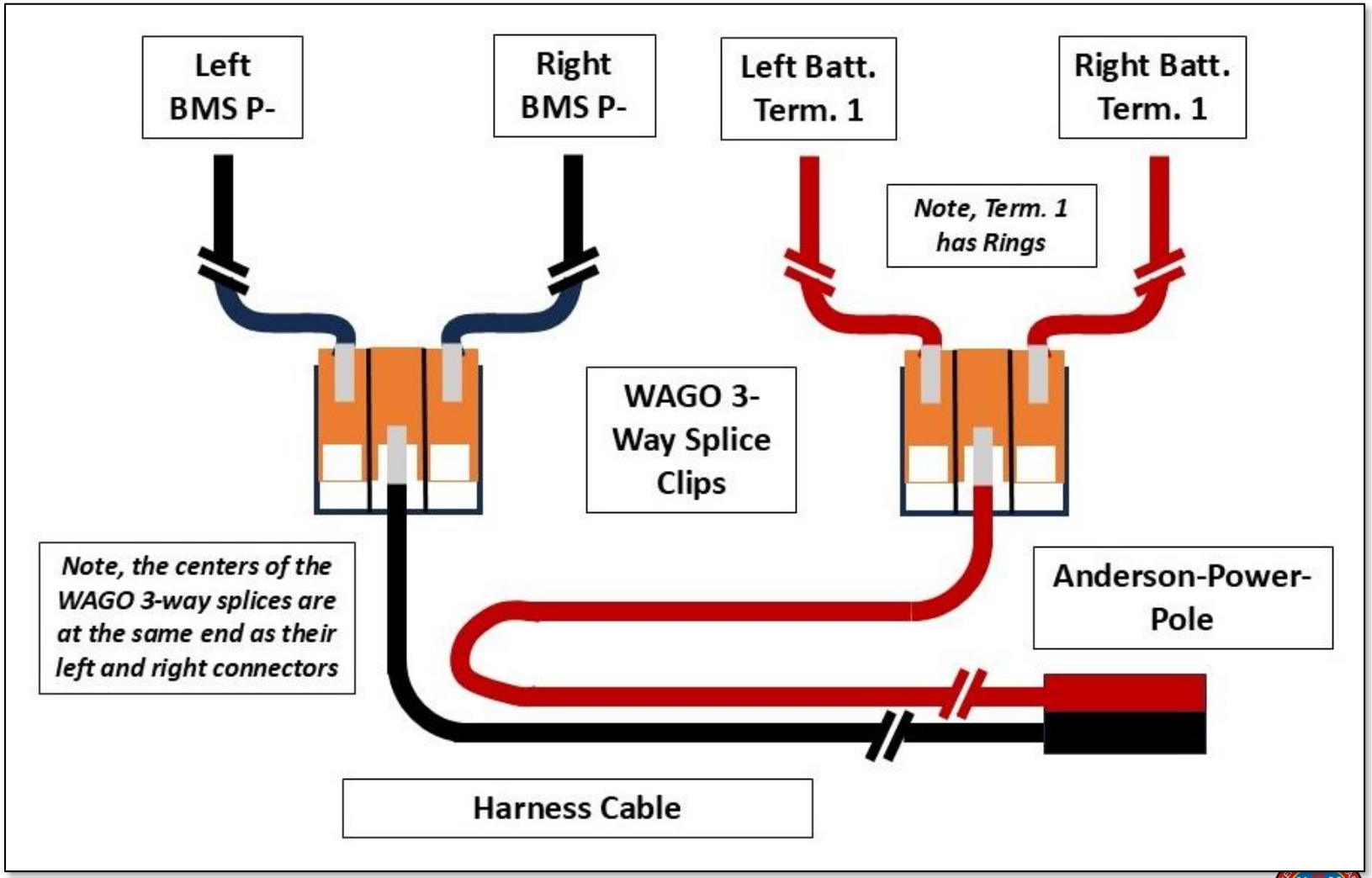
- The harness cable has a fused positive side:
  - 30-amp fuse is sufficient,
  - 40-amp fuse can also be used, and a
  - Double-fused wire connector will also work – just more fuses and safeguards.
- The harness terminates in an Anders Power-Poll connector that joins:
  - The BCS output power connector, or
  - The Anderson-Power-Poll connector to your radio unit.
  - (But never both)
- The input side to the harness is a spliced wire connection from the center of a WAGO 3-way splice.



Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

- Building the harness cable (continued…)
- Recall, we previously added WAGO connectors to P- terminal pads on 2 BMS's and the positive terminal 1 of two 4-cell battery unit.
- To connect the harness, we will remove the WAGO connectors from the right-hand or second battery unit and insert it in the right side of the remaining WAGO connectors.
- This will splice two battery units into a single harness and output connector, as shown in the next Figure.
- The actual harness is a pre-made 12-gauge Anderson-Power-Pole connector with fuse and pigtail.
- Depending on what you purchased, the end of the pigtail will need to be cut and inserted into the center of the WAGO (now only 2) connectors:
- To prepare the harness:
  - Cut off any ring or connector ends, leaving the Anderson-Power-Pole connector and fuse.
  - Strip the cut ends to about ¼" exposed wire and tin them.
  - Insert in the center of the 2 WAGO negative and positive connectors, respectively.

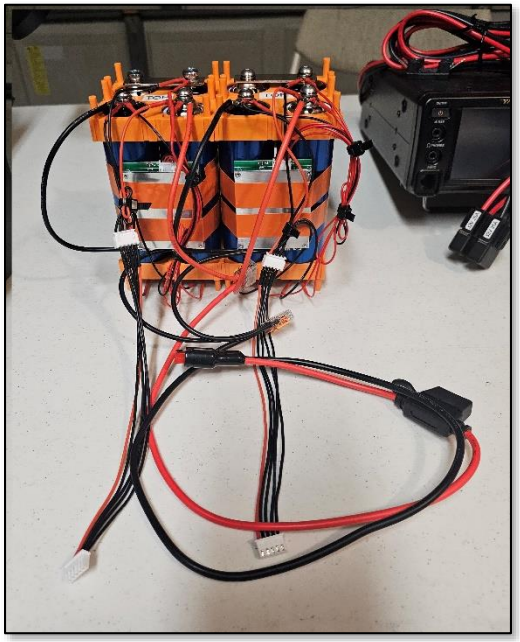
Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit



Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

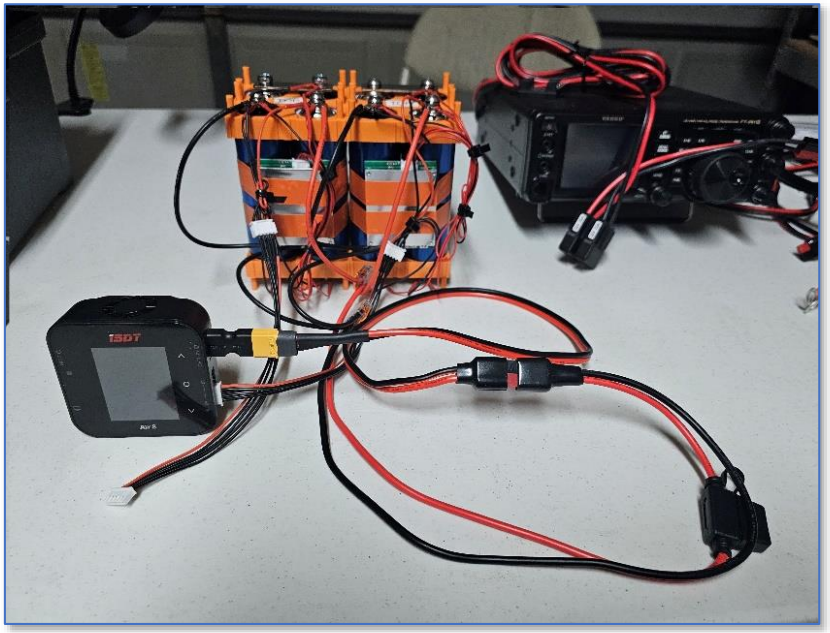
- Building the harness cable (continued…)
- The 8-cell battery unit with attached harness should look like the following figure.
- Note, If you elected to build only a 4-cell battery unit then the harness connection will not have a right-hand wire inserted in either of the 2 WAGO 3-way connectors.

- The 8-cell battery unit is now ready for final testing.
- At this time, take one last opportunity to straighten the grouping of wires and cable from the battery unit(s) in order to facilitate subsequent tie-wrapping.
- To test the BCS, connect the BCS to the right-hand battery:
  - Attach the right BCS sense cable, and
  - The BCS output power connector to the battery unit harness.



Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

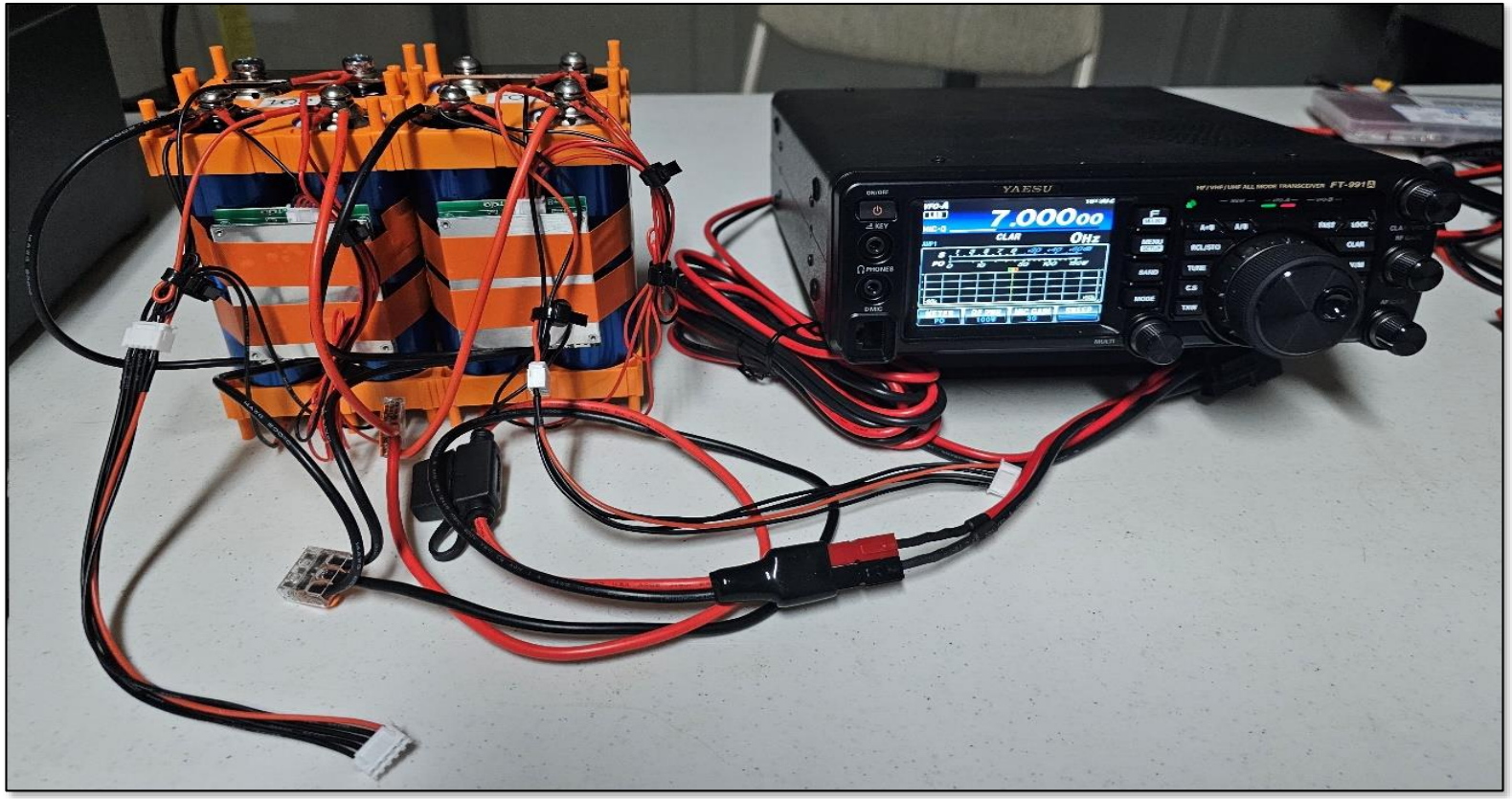
- Testing the battery unit with the BCS (continued…)
- Connect the BCS input power cable from the adapted laptop power supply.
- The BCS will power on and is now available for charging:
- Following the Appendix procedure in the instruction manual start a charge session:
  - Note, the BCS screen will change to an orange color indicating that charging is in progress.
  - The BS will display a set of 4 batteries in various charge states.
  - The BCS screen will increment added amperage as the charge proceeds.



Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit

- BCS test and charging (continued…):
- At the End of charging, the BCS screen will turn a green color with final charge totals.
- Repeat the same charging process for the left hand 4-cell battery unit.
- Remember to power off the BCS before disconnecting or switching any cabling.
- After charging the 8-cell battery unit, disconnect any BCS and connect the battery unit harness to a radio unit.
- Power on the radio, and verify operation.
- With testing completed, tidy up the wiring into tie-wrap bundles.
- Now, slide the two loose 4-cell battery units into a bound 8-cell unit by aligning the locking sled keys previously discussed.
    - Mating of the two 4-cell units may be best performed by laying the two units on their backs and nudging their respective sleds together.
    - This technique allows gravity to work for you.
    - Be patient, you will get there.
- Your completed battery unit should look like the following Figure.

Integration of 2 x 4-Cell Battery Units into an 8-Cell Single Battery Unit



Package the 8-Cell Battery Unit into a Portable Configuration – The Ammo Can

- The ammo-can package is actually a plastic storage bin that is approximately the size of a 30-cal. Ammunition container, as shown in the Figure.
- Actually, any container will work that is:
  - Waterproof,
  - Rugged,
  - Provides secure restraint for the battery, and
  - Allows easy access to the cabling.

- The ammo-can configuration also provides for easy drilling of holes, which should be protected with rubber grommets for cable feeds

– an exercise left for the builder -

Package the 8-Cell Battery Unit into a Portable Configuration – The Ammo Can

And without Further Ado

CONGRADULATIONS!

You're Done.