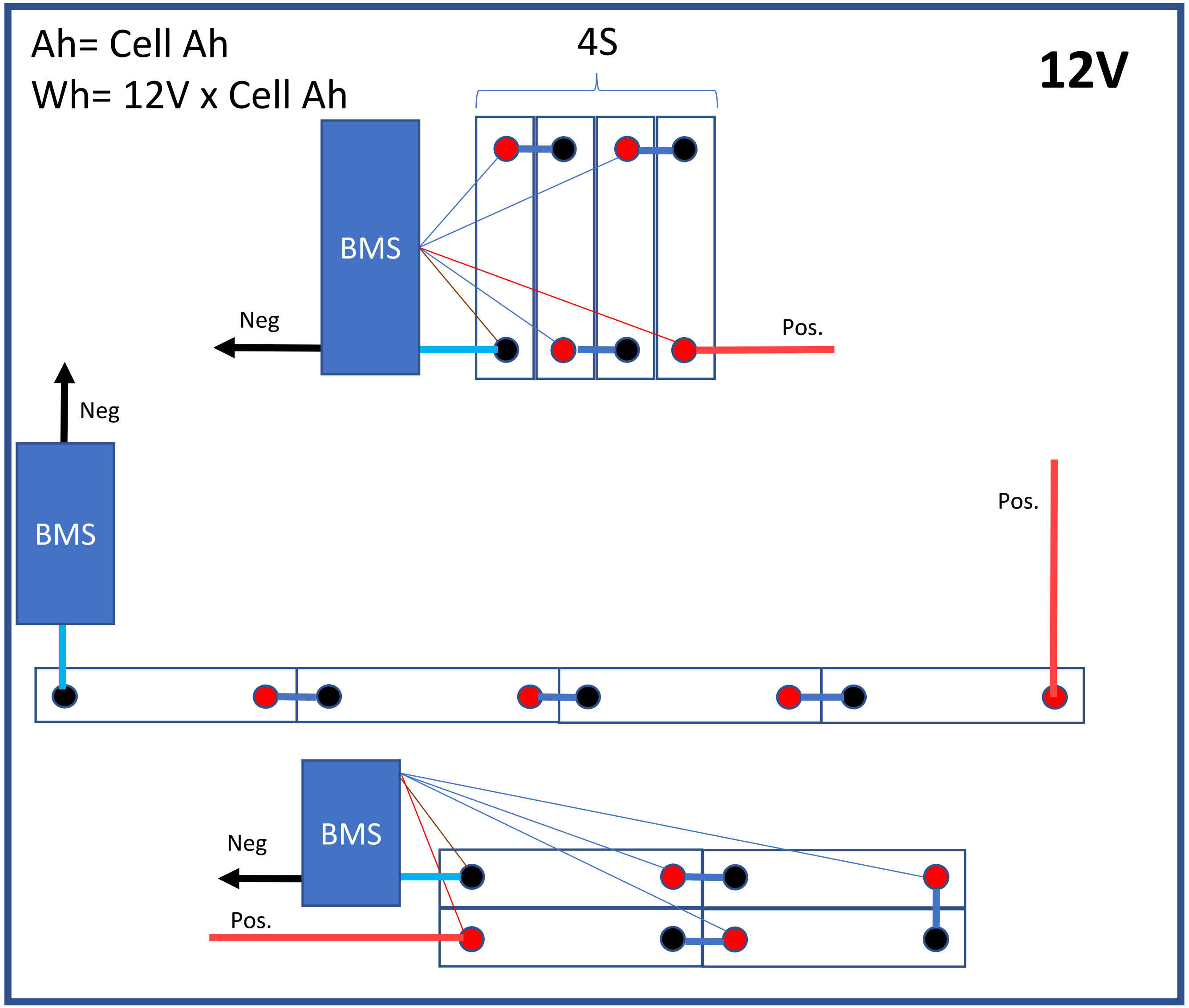
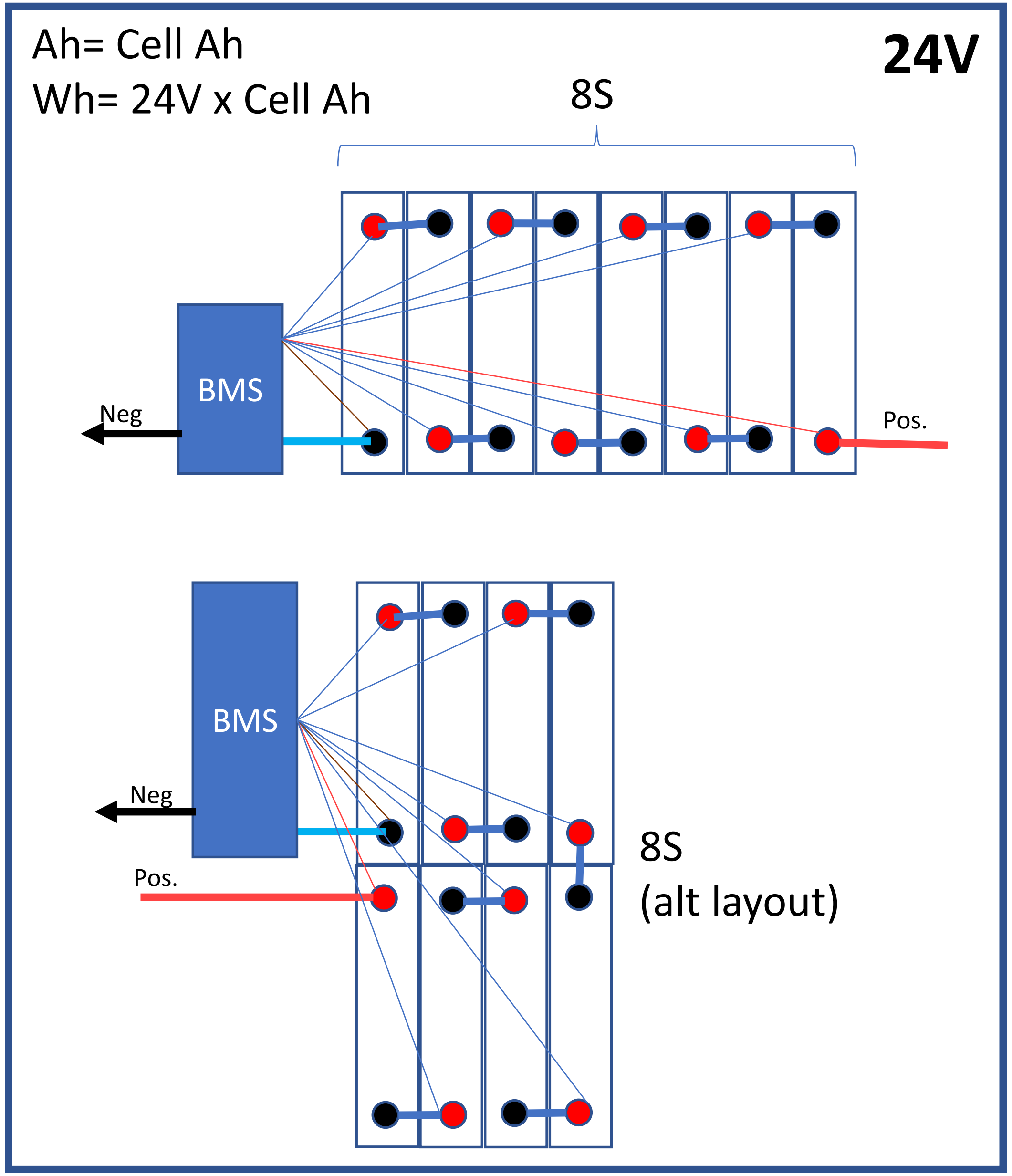
LiFePO4 Cell Configurations 12V, 24V & 48V

This deck shows several common configurations for using LiFePO4 Cells to build 12V, 24V and 48V batteries.

Series-Only (1P) Configurations 12V & 24V



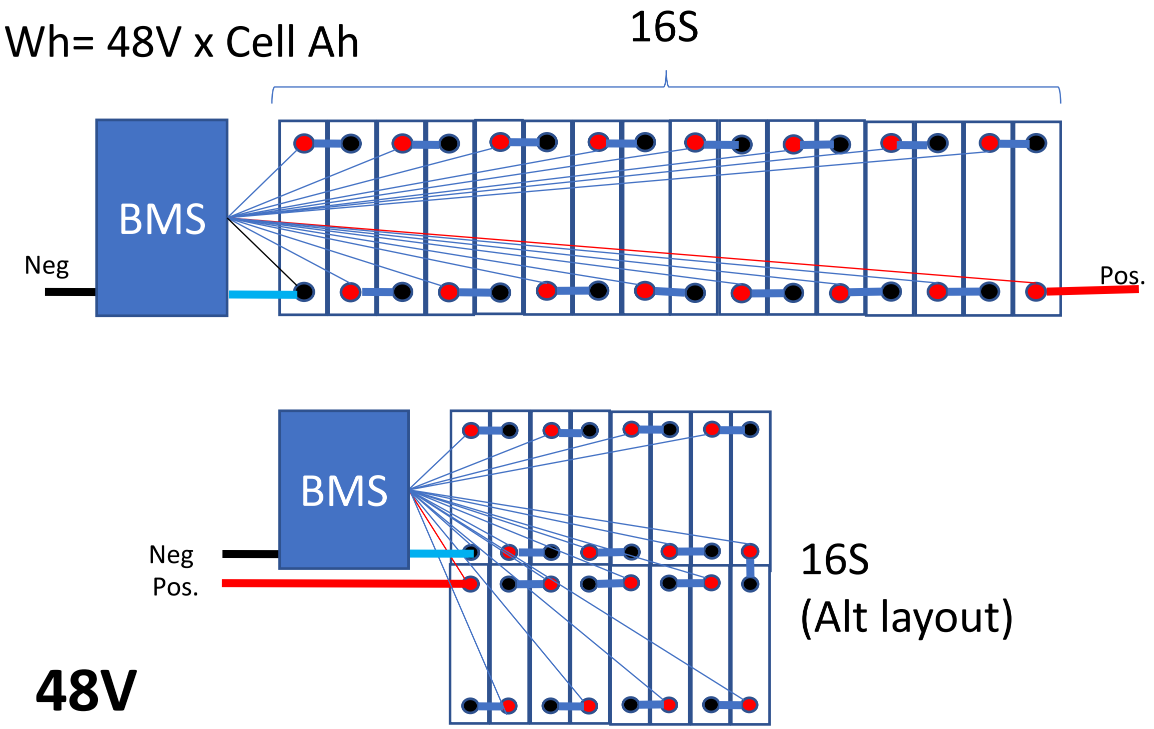


Note: There are other layouts, but they are somewhat uncommon.

Series-Only (1P) Configurations   12V, 24V & 48V

Ah= Cell Ah

Wh= 48V x Cell Ah

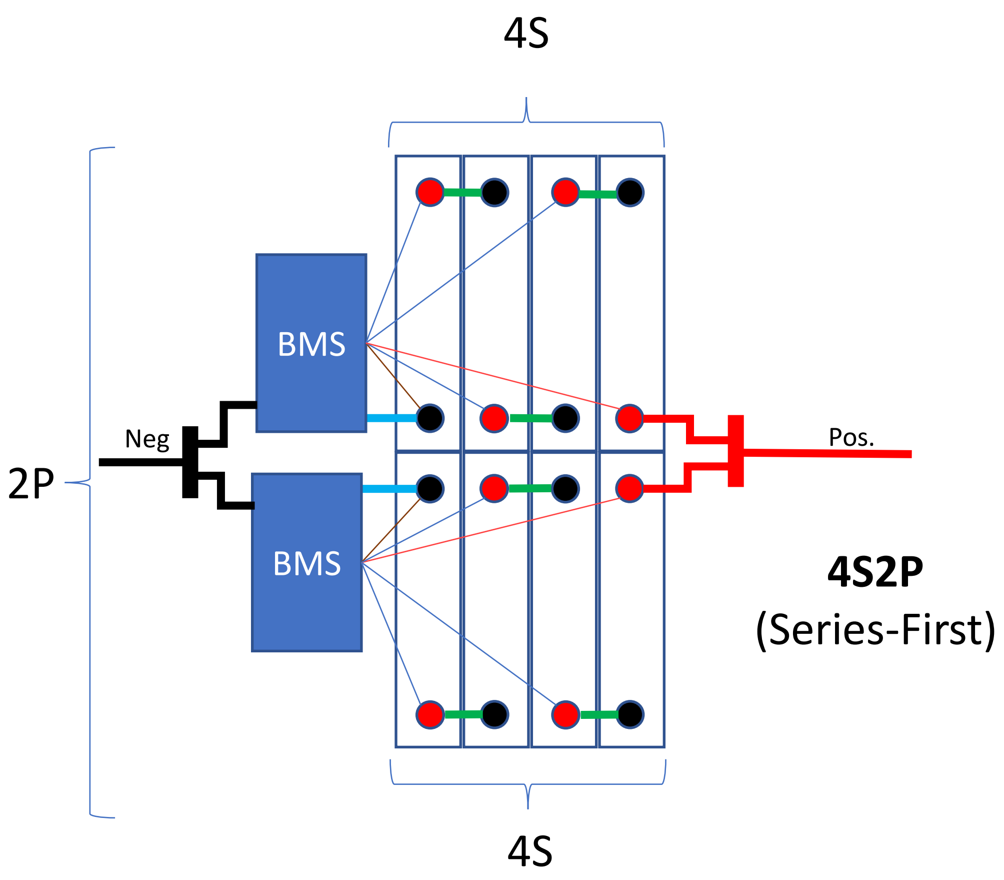


48V

Note: There are other layouts, but they are somewhat uncommon.

4S2P Wiring for 12V batteries (Series First)

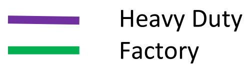
Voltage = 4 times cell voltage = Nominal 12V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= Voltage X Battery Ah = 12V x (2 x Cell Ah) = 24 x Cell Ah

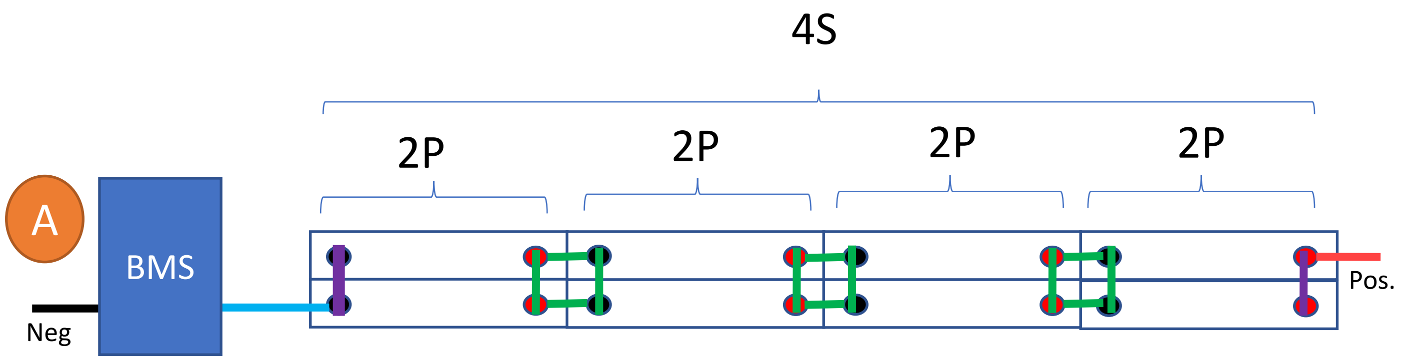


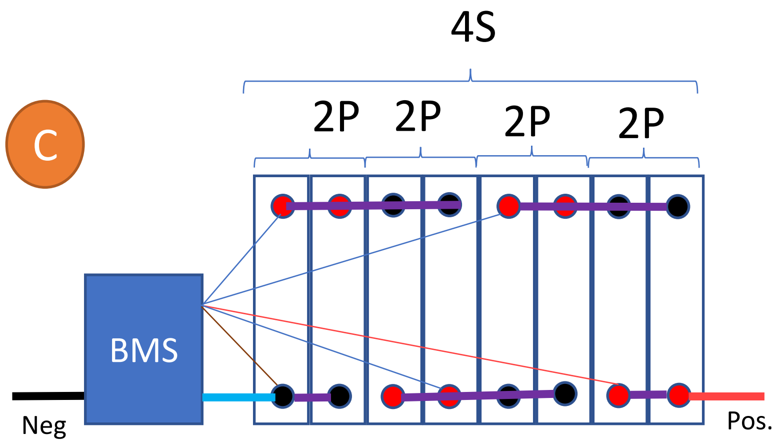
Note: There are other layouts, but they are somewhat uncommon.

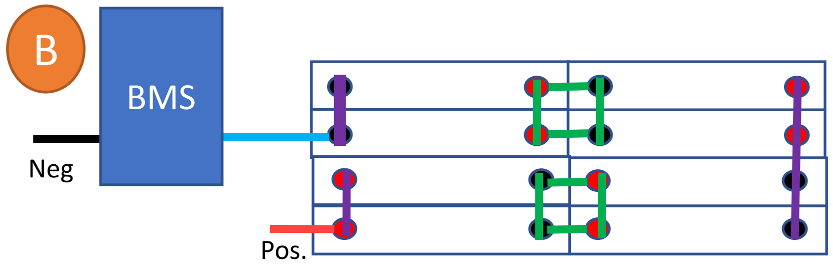
2P4s Wiring for 12V batteries (Parallel first)

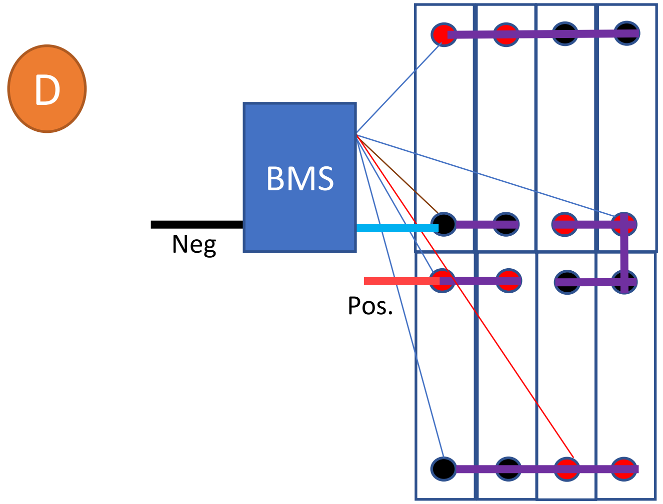
Voltage = 4 times cell voltage = Nominal 12V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= Voltage X Battery Ah = 12V x (2 x Cell Ah) = 24 x Cell Ah





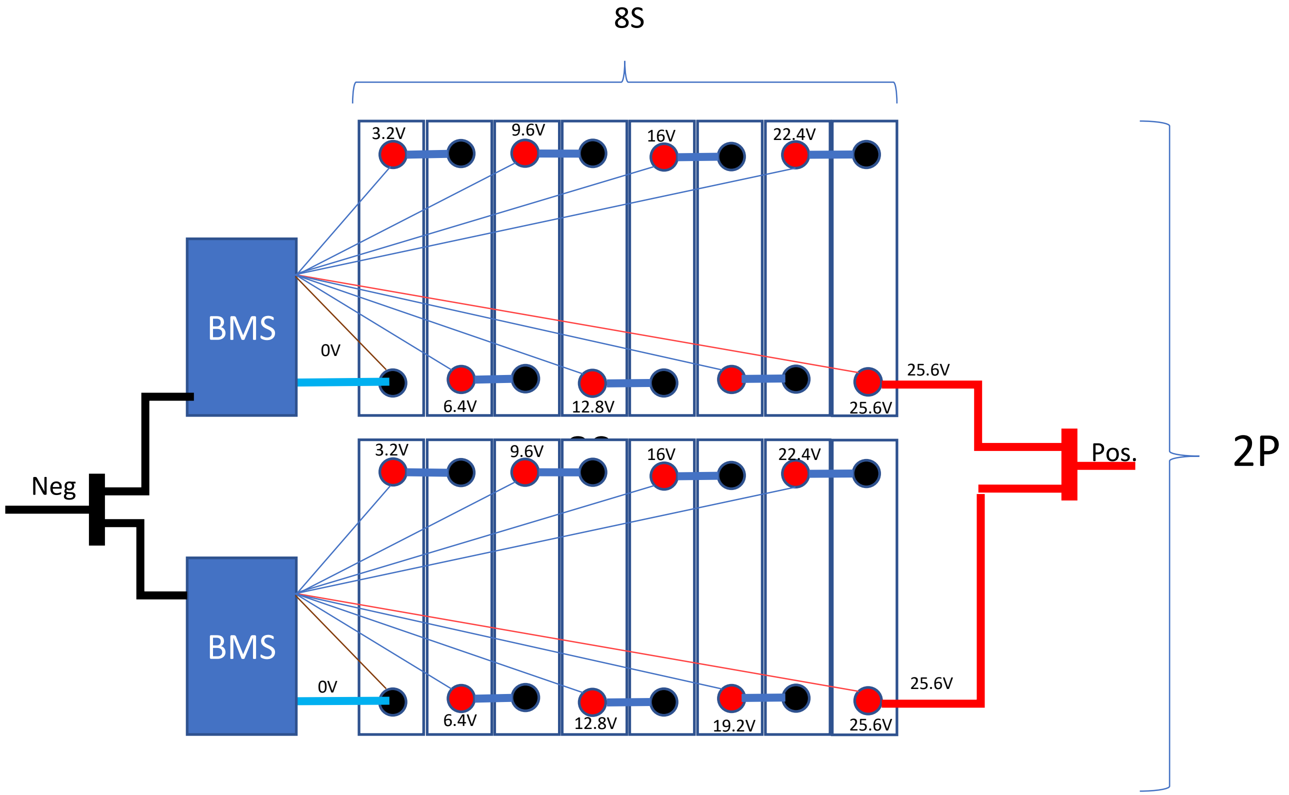






8S2P Wiring for 24V Batteries – Series First

Voltage = 8 times cell voltage = Nominal 24V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= 24V x (2 x Cell Ah) = 48 x Cell Ah



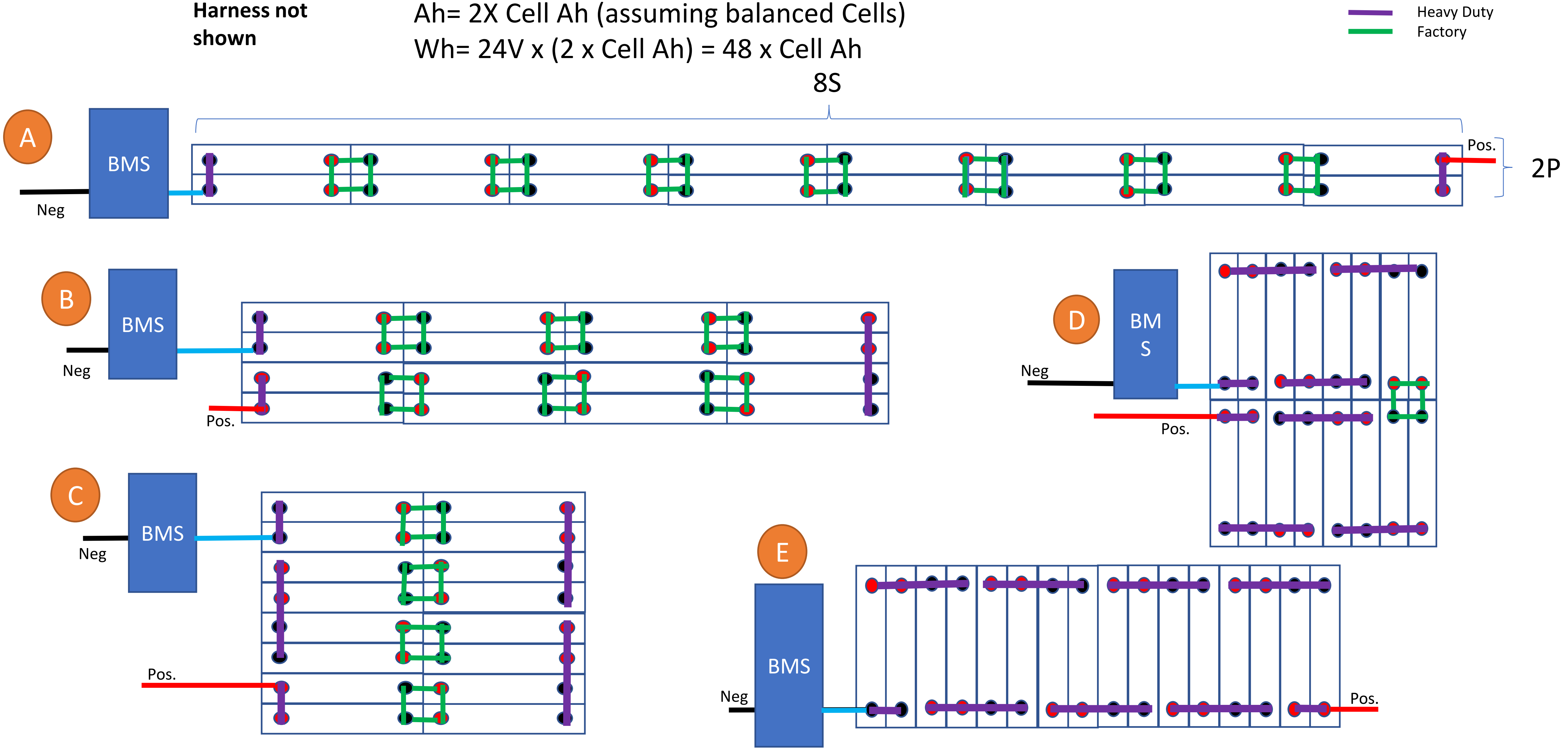
8S2P
(Series-First)

Note: There are other layouts, but they are somewhat uncommon.

Possible 24V 2P8S Fortune Cell Layouts

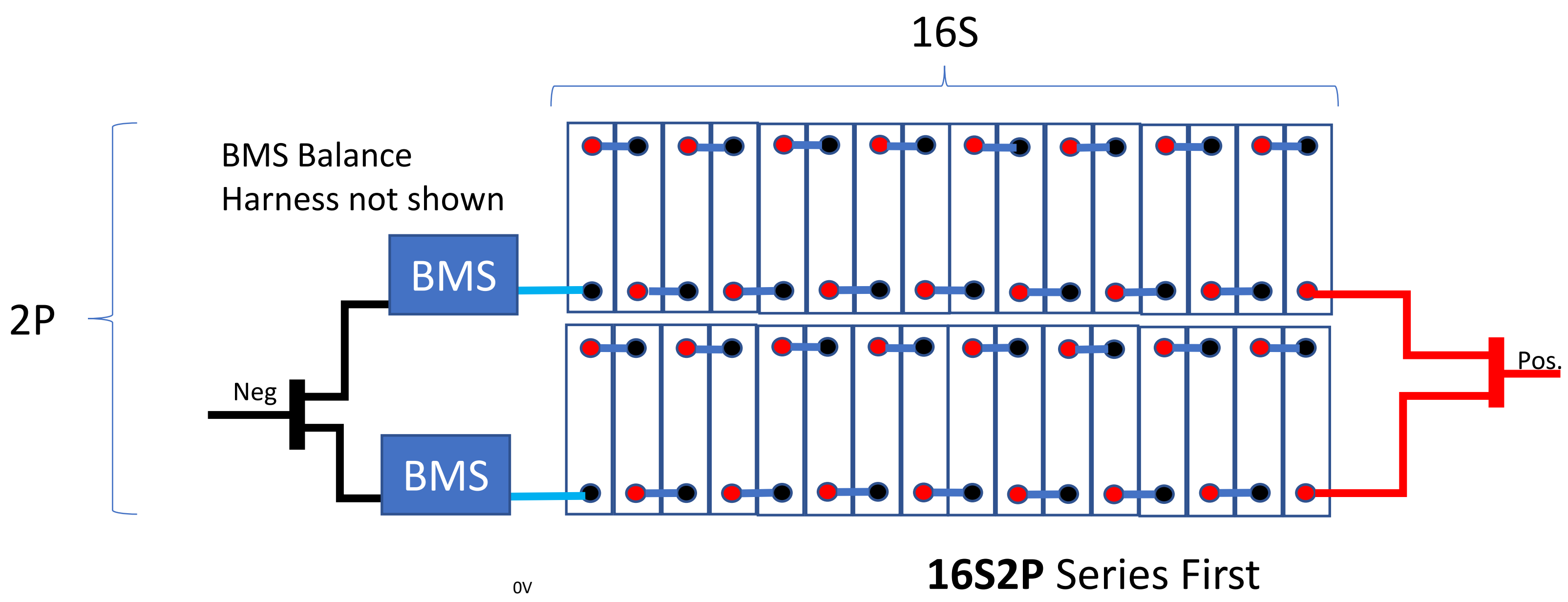
BMS Balance Harness not shown

Voltage = 8 times cell voltage = Nominal 24V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= 24V x (2 x Cell Ah) = 48 x Cell Ah



16S2P Wiring for 48V Batteries – Series First

Voltage = 16 times cell voltage = Nominal 48V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh = 48 X (2 x Cell Ah) = 96 x Cell Ah



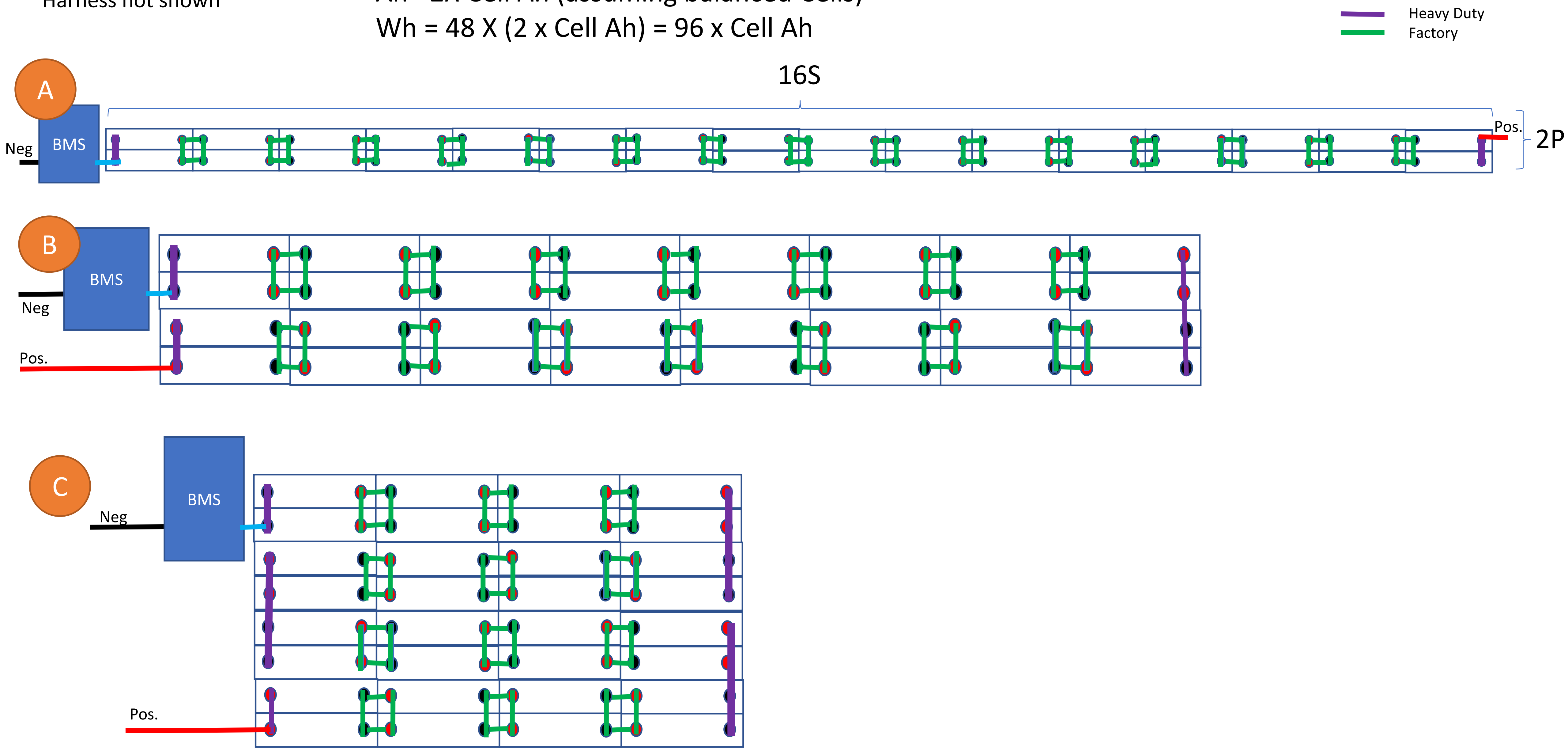
16S2P Series First

Note: There are other layouts, but they are somewhat uncommon.

2P16S Wiring for 48V Batteries – Parallel First

BMS Balance
Harness not shown

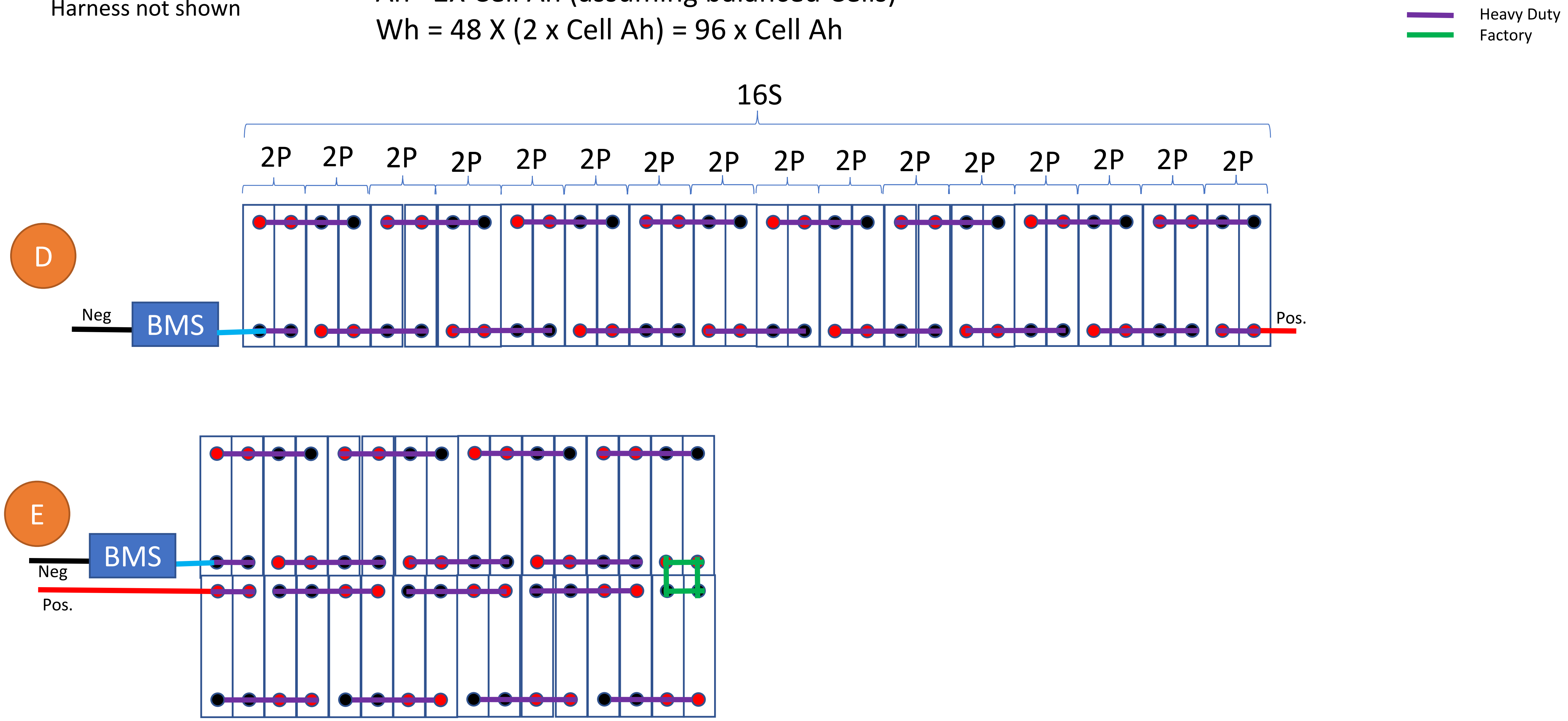
Voltage = 16 times cell voltage = Nominal 48V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh = 48 X (2 x Cell Ah) = 96 x Cell Ah



2P16S Wiring for 48V Batteries – Parallel first (Continued)

BMS Balance
Harness not shown

Voltage = 16 times cell voltage = Nominal 48V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh = 48 X (2 x Cell Ah) = 96 x Cell Ah

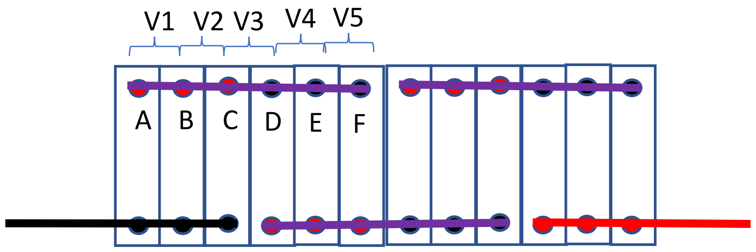


Note: There are other layouts, but they are somewhat uncommon.

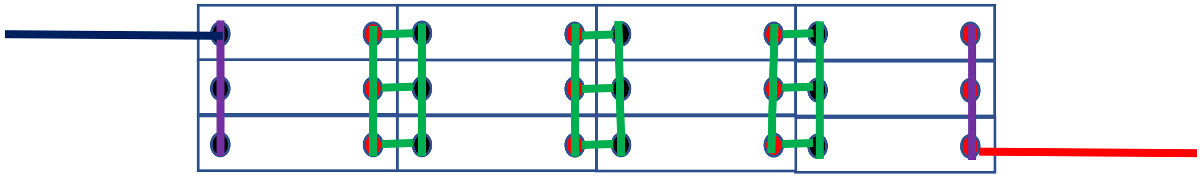
A note about Bus-Bars

Factory bus bars are generally sized to work well in series hook-ups but may be undersized for parallel cell hook-ups. In the Previous pages, when 'heavy duty' bus-bars are indicated, I make Bus-Bars out of stock that is twice as thick as the factory bus bars (or at least double up the factory bus-bars).

For parallel cell configurations it is important to balance voltage drop between cells so the cells wear evenly and long bus bars that span more than two cells pose a greater risk of uneven voltage drops. In the diagram below, posts A, B, C, D, E and F are tied together so we think of them as all being the same voltage. However, due to the resistance in the bus bars, there will be a small voltage drop between A&B, another drop between B&C, C&D and so on.



Since the charge curve for LiFePO4 is so flat the result of these small voltage drops is that the cells with the higher voltages will charge/discharge at a slightly slower rate. For 2P configurations, the voltage drops turn out to 'balance' and not be a problem. However, for 3P or greater, the voltage drops do not balance out. If you have good busbars, this effect will be very small but can add up over time. Consequently, I like to avoid the longer bus bars where I can. That is why I prefer arranging parallel cells like this:



When I do need to span more than two posts, I like to make my own multi-hole bus bars rather than use a series of 2-hole bus-bars. (The connection between busbars will typically be more resistance than the bus bars themselves.)

This may all be overkill, but it is the way I do it.

Series first vs parallel first

There is a lot of debate about whether series-first or parallel-first is best. The fact is, both of them are used successfully by many people. The ‘correct’ choice comes down to the particular situation and the designer's preference.

Parallel-First		Series-First	
Pro	**Con**	**Pro**	**Con**
• Simplicity of a single BMS (Fewer corner cases, less electronics that can go bad) • (possibly) Lower Price of the single BMS • The BMS balances everything	• Must use higher current BMS • Only 'groups' of cells are managed and monitored • With only one bank there is no fall back redundancy	• Each cell is monitored and managed separately. • If one bank goes out, you still have the other bank • You can use lower current BMSs to build up a High current solution.	• Complexity of two BMS and making sure the corner cases are covered. • Doubling the BMSs can increase cost • Doubling the BMSs doubles the circuitry that can go bad. • The multiple BMSs don't balance between the two banks

Series first vs parallel first – Personal Preference

Warning: The following is the authors personal preference. There is no right or wrong

I do builds both ways, but I prefer Parallel first.

- I believe that if you start out with good matched cells, the likelihood of one cell drifting way out from the others is very low so I don't feel a need for monitoring individual cells.
- I am a strong believer in simplicity
- In most of my builds, having half capacity does not help much.

When I do series first it is usually because the BMS available will not handle the current for a parallel-first configuration.

Other folks on the forum *strongly* believe Serial-First is the only way to go.

Each designer must decide based on their situation and priorities

Note About Weight

LiFePO4 cells are considerably lighter than any form of Lead-Acid, but as the cell count goes up the battery can still get very heavy.

Example. the EVE 280AH cells weight in at 5.2 Kg (11.5 LBS) each cell

8 cells = 41.2Kg (93 Lbs)

16 cells = 82.4Kg (184 LBS)

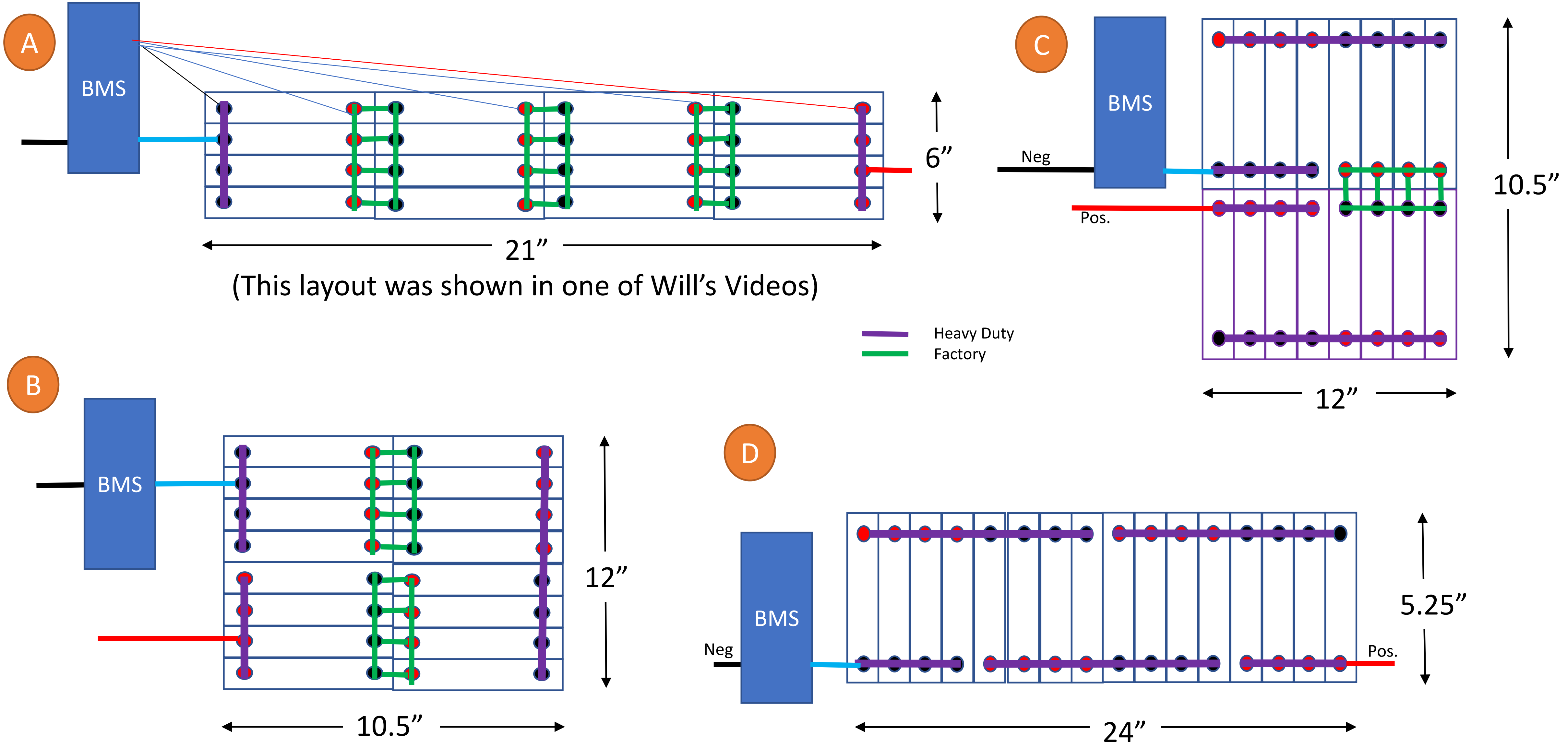
Add the weight of Box and bits it becomes unwieldy quickly.

Bonus Layouts

These are additional layouts I have been asked about on the Forum

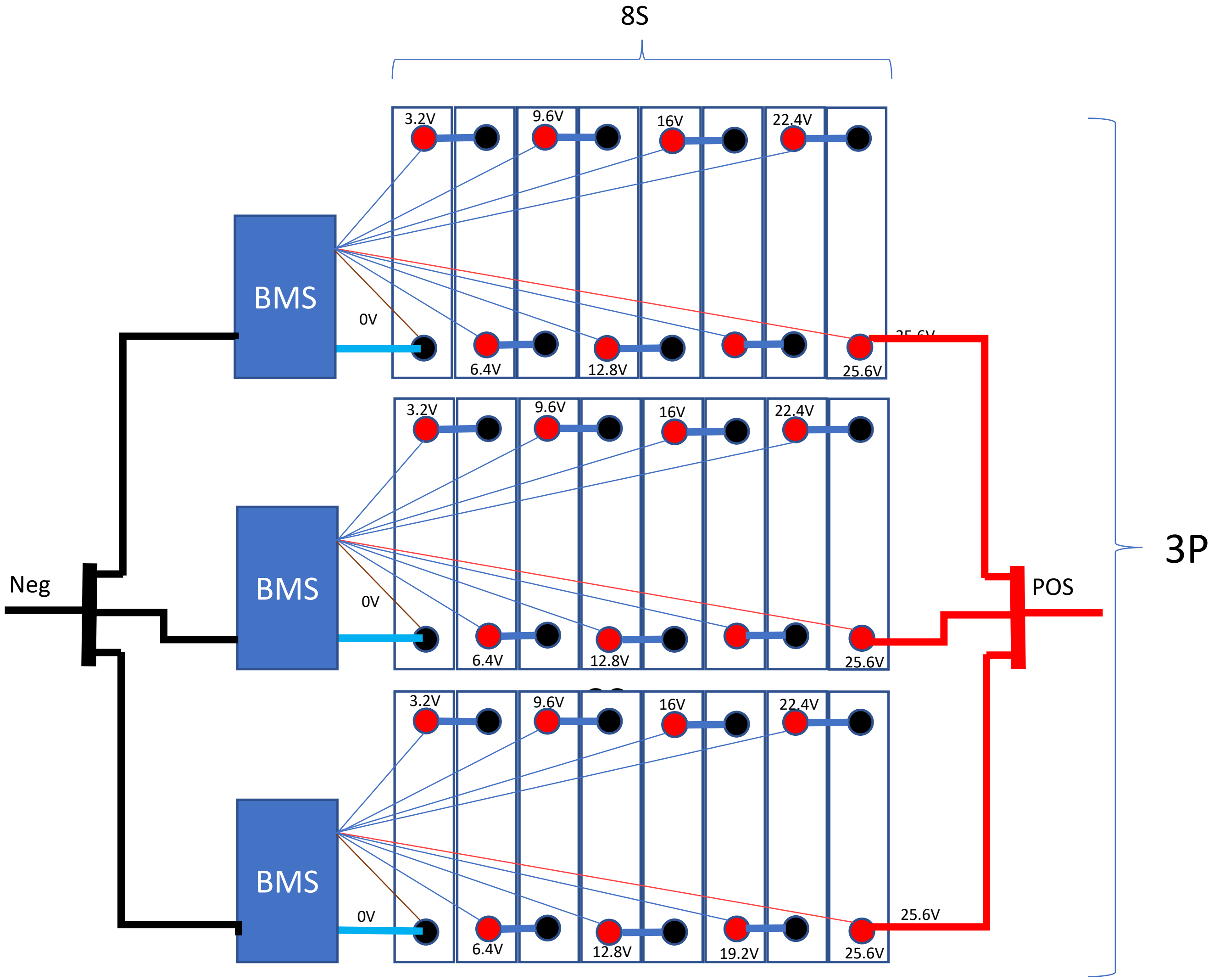
Bonus: A few Possible 12V 4P4S Fortune Cell Layouts

Oversized Bus-bar
Factory Bus-bar



Bonus: 8S3P Wiring for 24V Batteries – Series First

Voltage = 8 times cell voltage = Nominal 24V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= 24V x (3 x Cell Ah) = 60 x Cell Ah



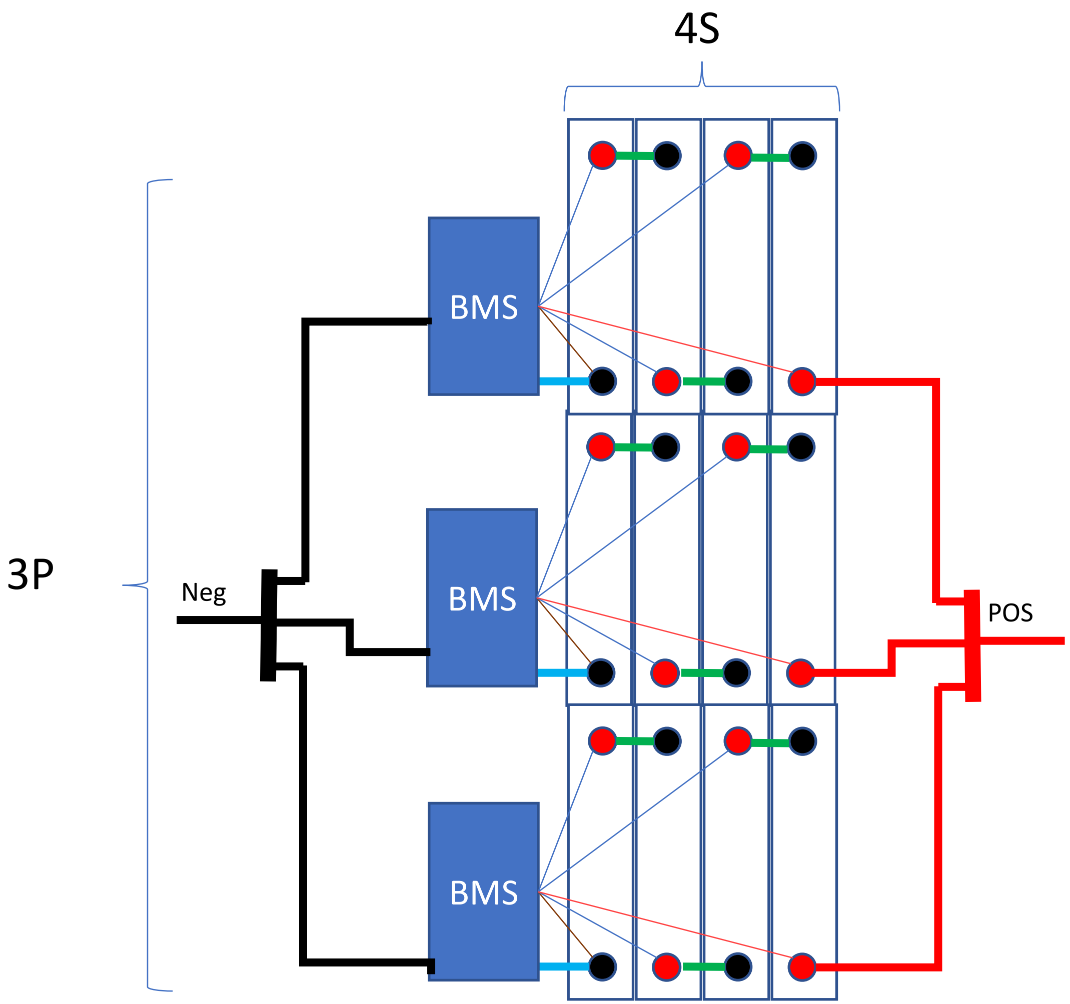
8S3P
(Series-First)

4S3P Wiring for 12V batteries (Series First)

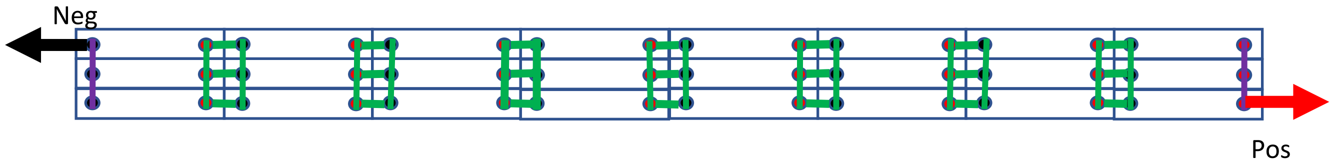
Voltage = 4 times cell voltage = Nominal 12V for LiFePO4

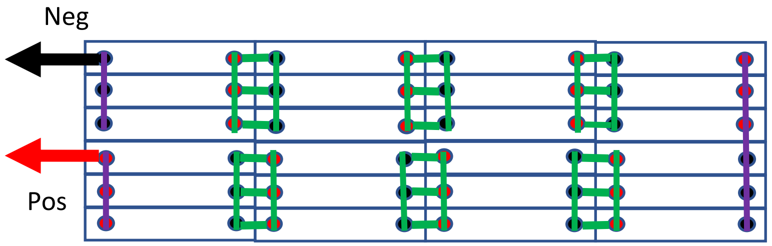
Ah= 3X Cell Ah (assuming balanced Cells)

Wh= Voltage X Battery Ah = 12V x (3 x Cell Ah) = 36 x Cell Ah

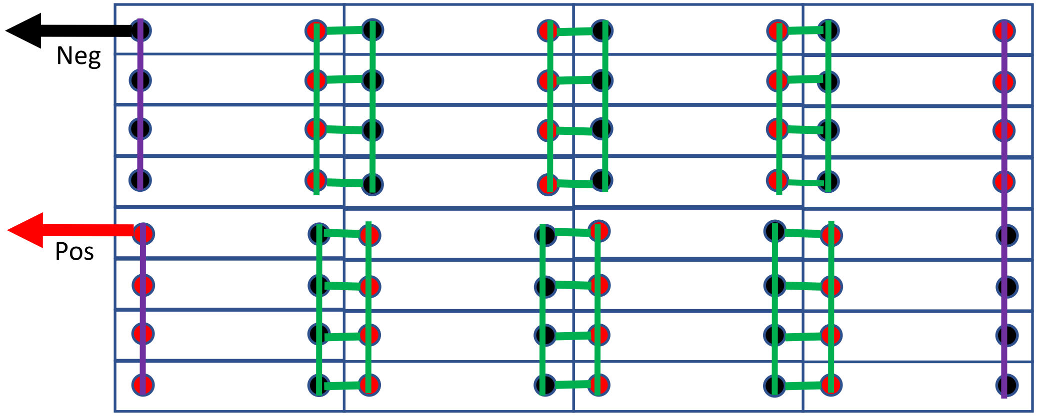


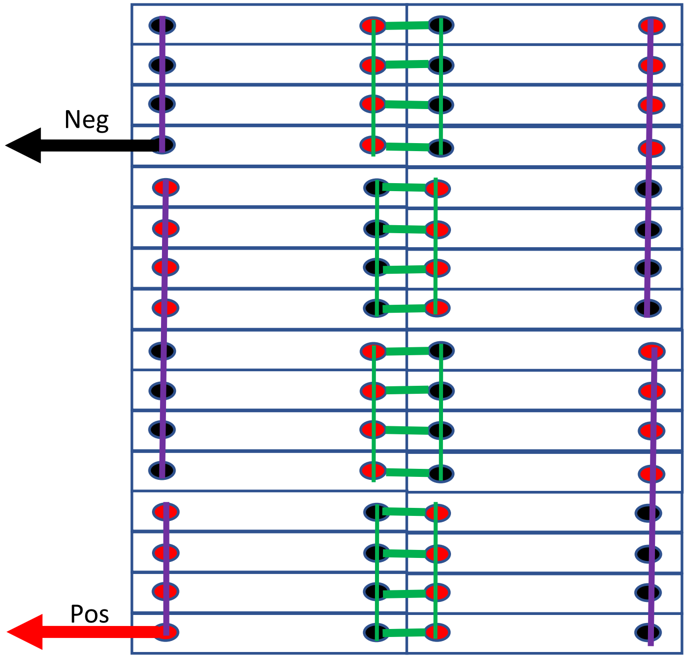
Bonus: A few 3P8S (24V) Layouts

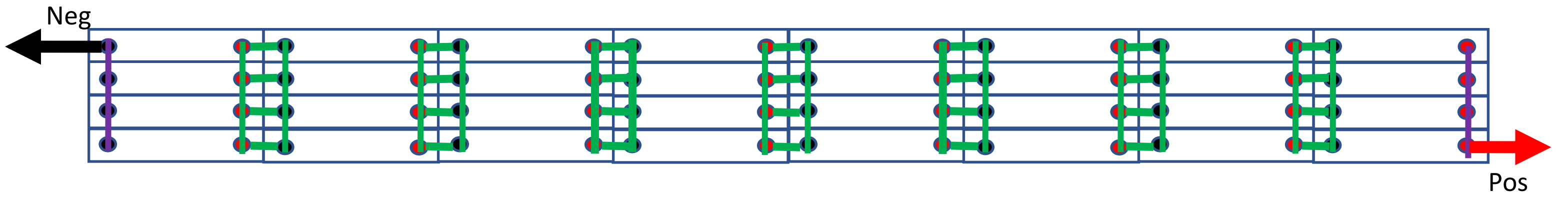




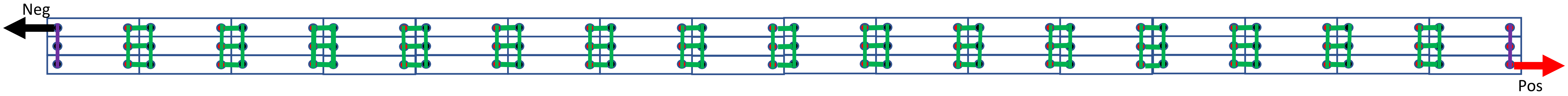
Bonus: A few 4P8S (24V) Layouts

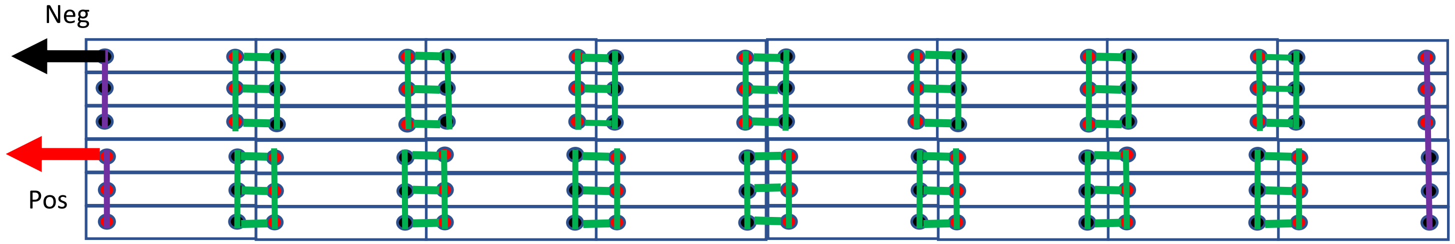


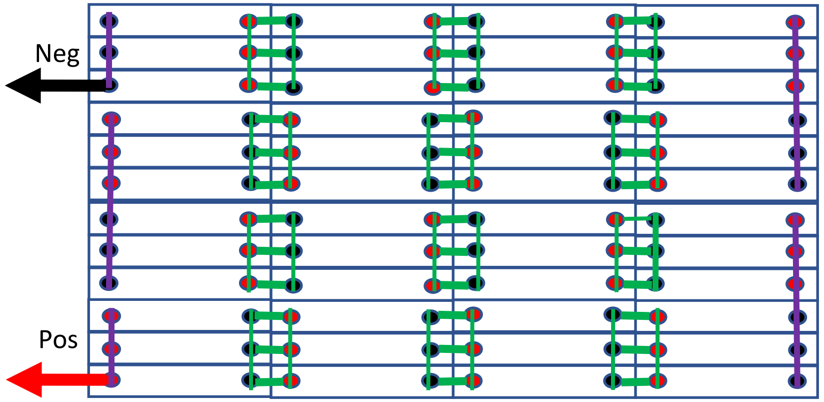




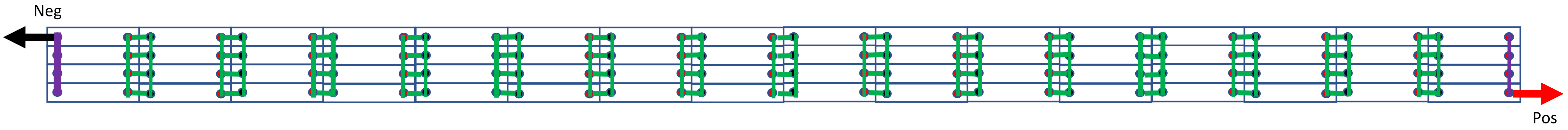
Bonus: A few 3P16S (48V) Layouts

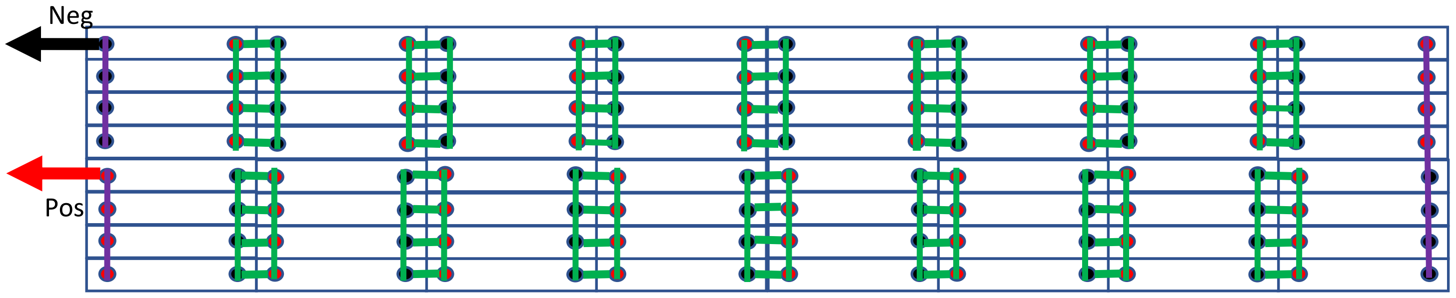


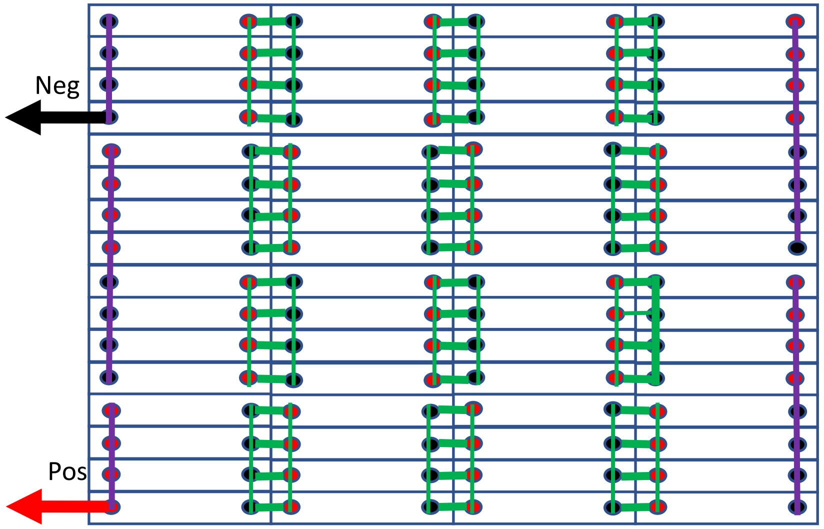




Bonus: A few 4P16S (48V) Layouts







Document Revision History

Revision 2 - Added comments about alternate physical layouts
Revision 3 - Added note about weight of large configurations.
Revision 4 - Added Wh (Watt Hour) Calculations.
Revision 5 - Added parallel-first configurations for each voltage and added a note about bus-bars.
Revision 5 - Added a couple of 'bonus' layouts.
Revision 6 - Updated note about bus-bars.
Revision 7 - Added a page about design considerations for Series-First set ups.
Revision 8 - Corrected a few minor typos/mistakes
Revision 9 - Added a few ‘bonus’ 4P layouts.   Also updated comments on long bus-bars.
Revision 10 - Added 'flat-pack' layouts for 12V.
Revision 11 - Added a few ‘bonus’ 3P16S layouts.
Revision 12 - Corrected color coding on BMS harnesses & added a couple new bonus layouts
Revision 13 – Made it clearer where Battery Positive and Battery Negative is.