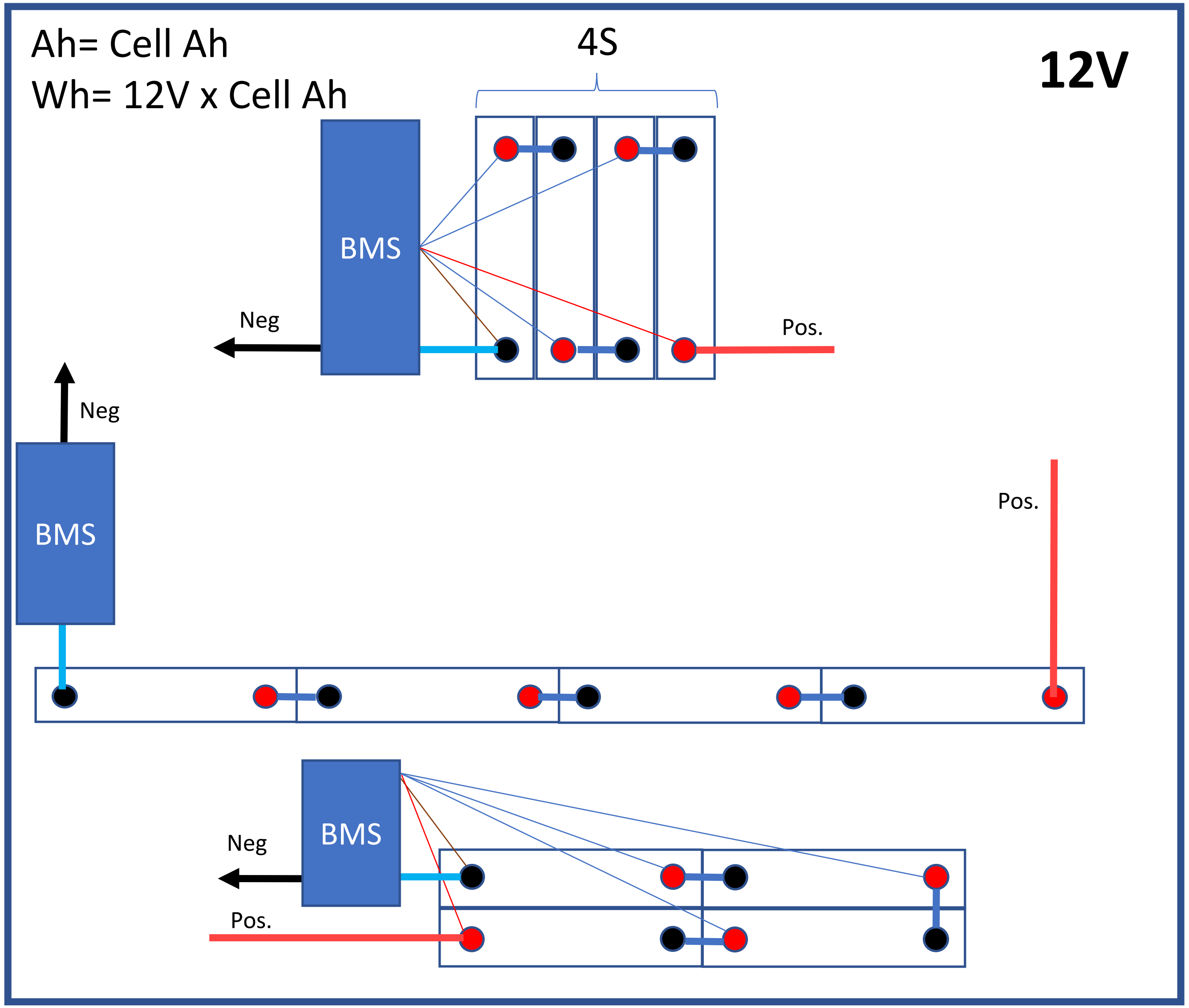
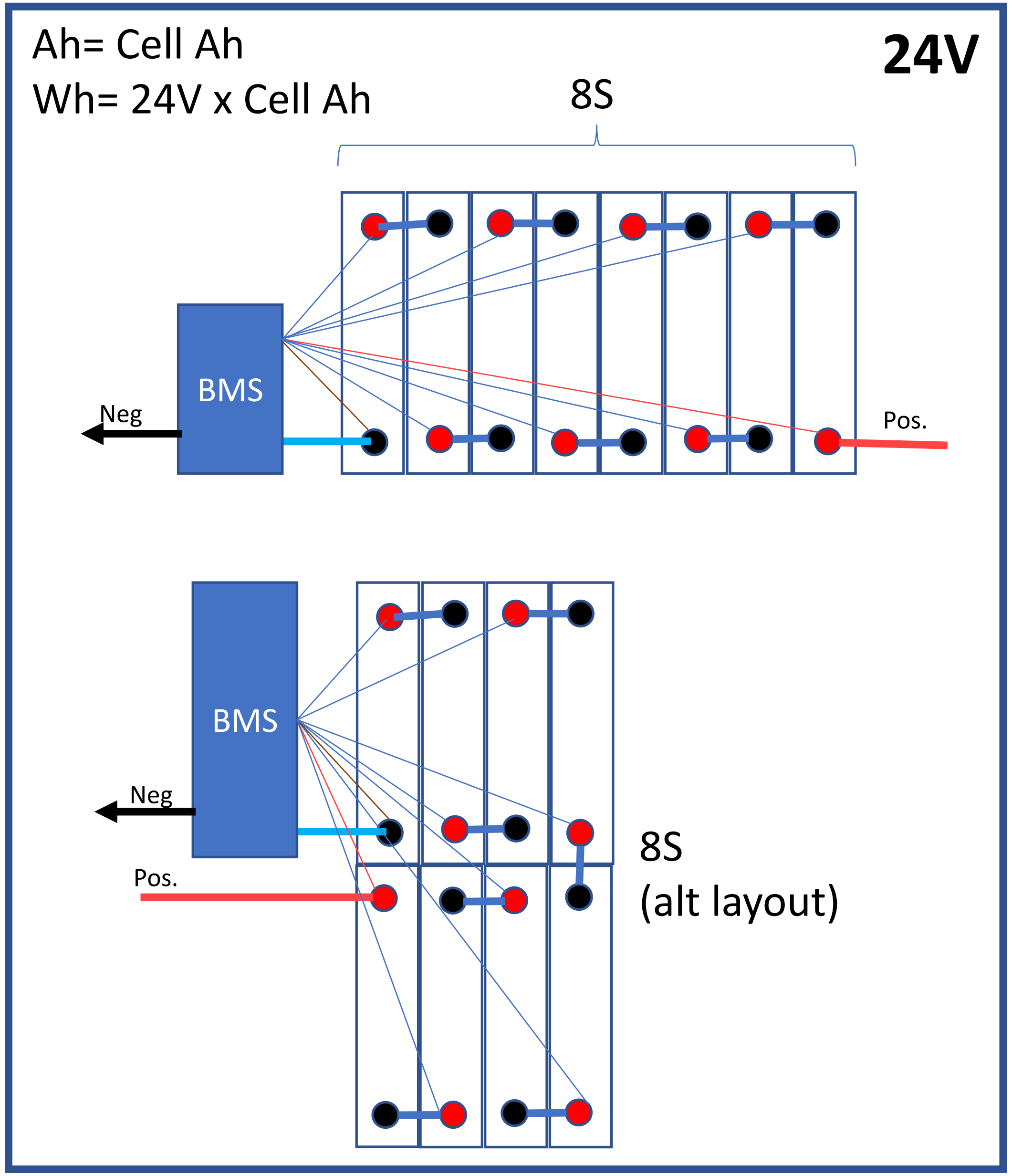
LiFePO4 Cell Configurations 12V, 24V & 48V

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

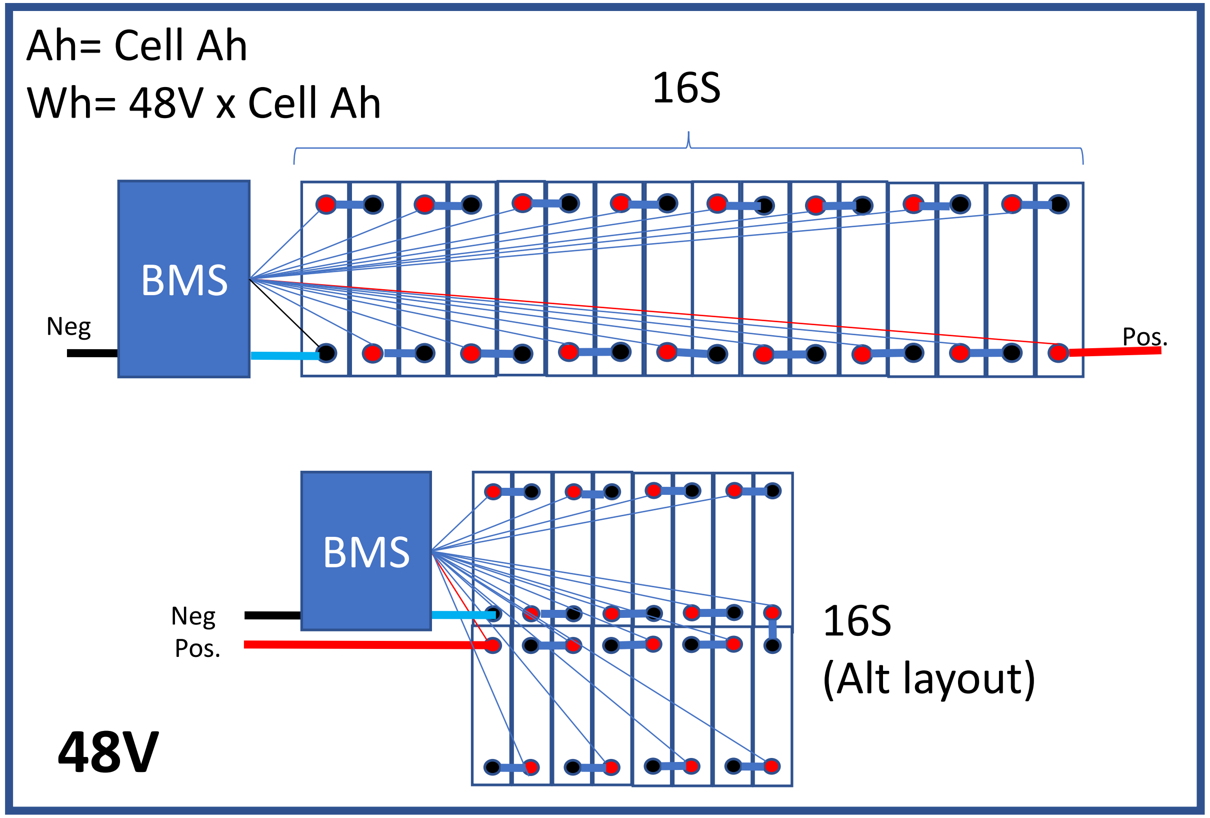
Series-Only (1P) Configurations 12V & 24V





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

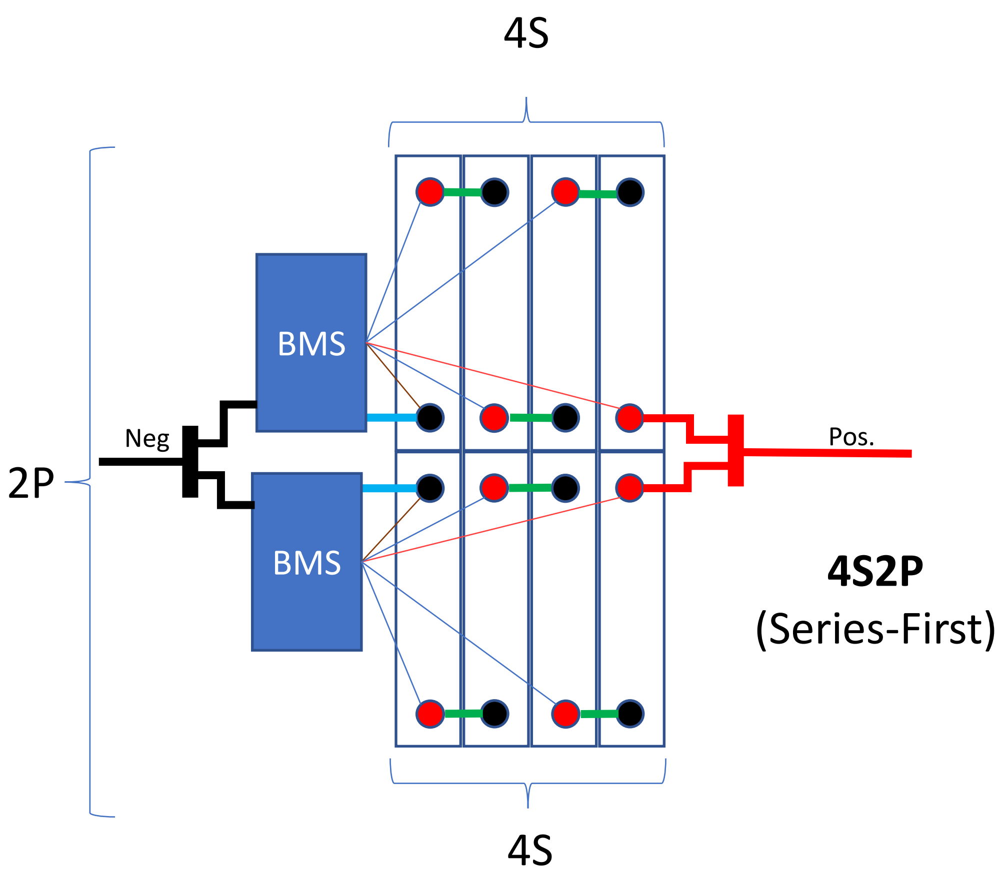
Series-Only (1P) Configurations   12V, 24V & 48V



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

4S2P Wiring for 12V batteries (Series First)

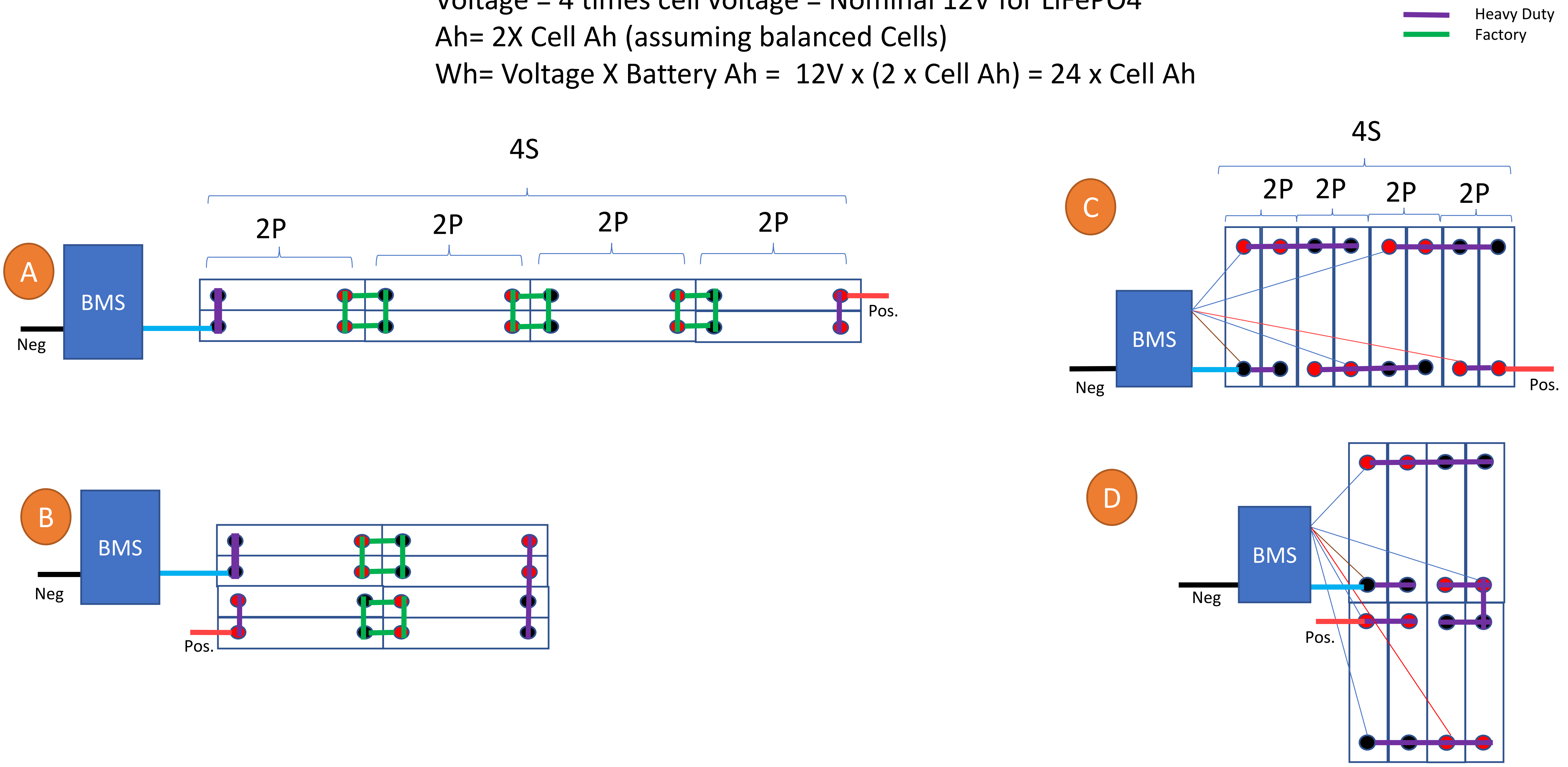
Voltage = 4 times cell voltage = Nominal 12V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh= Voltage X Battery Ah = 12V x (2 x Cell Ah) = 24 x Cell Ah



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

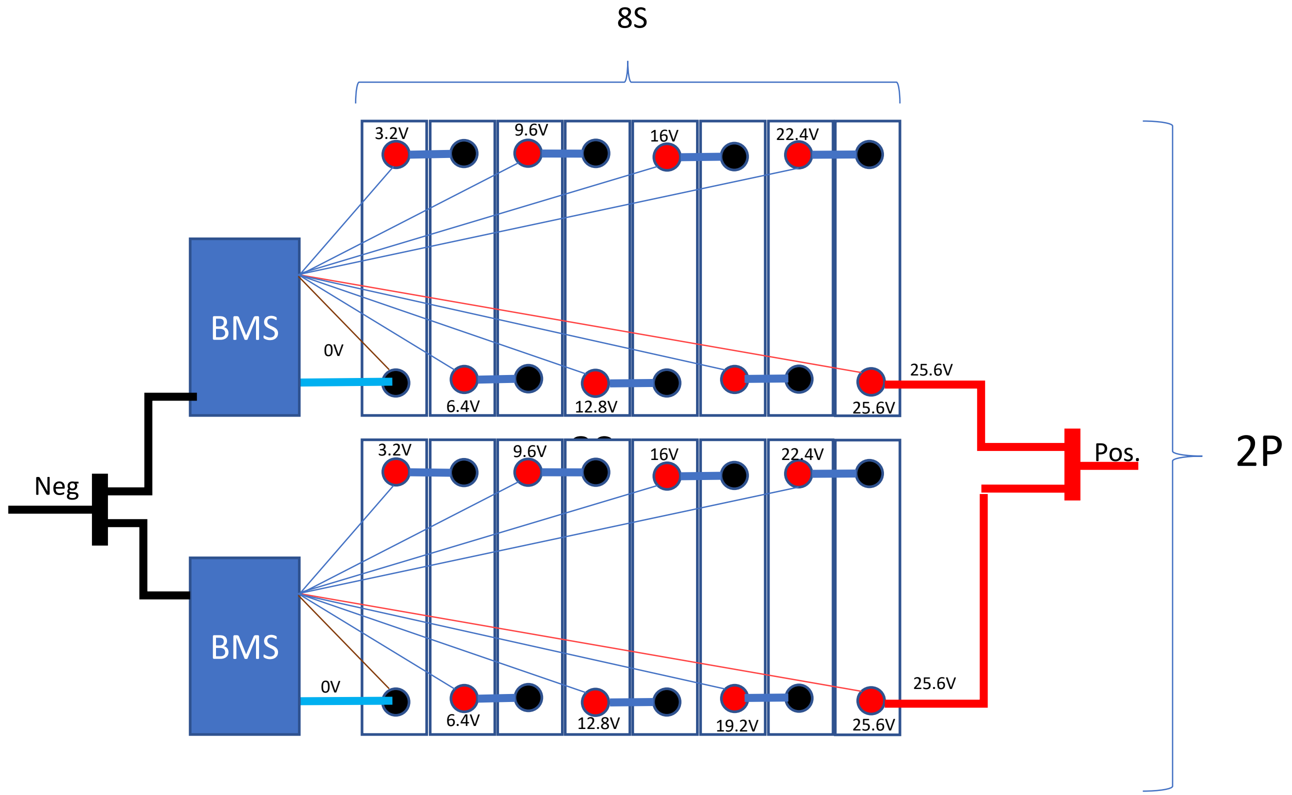
2P4s Wiring for 12V batteries (Parallel first)

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)

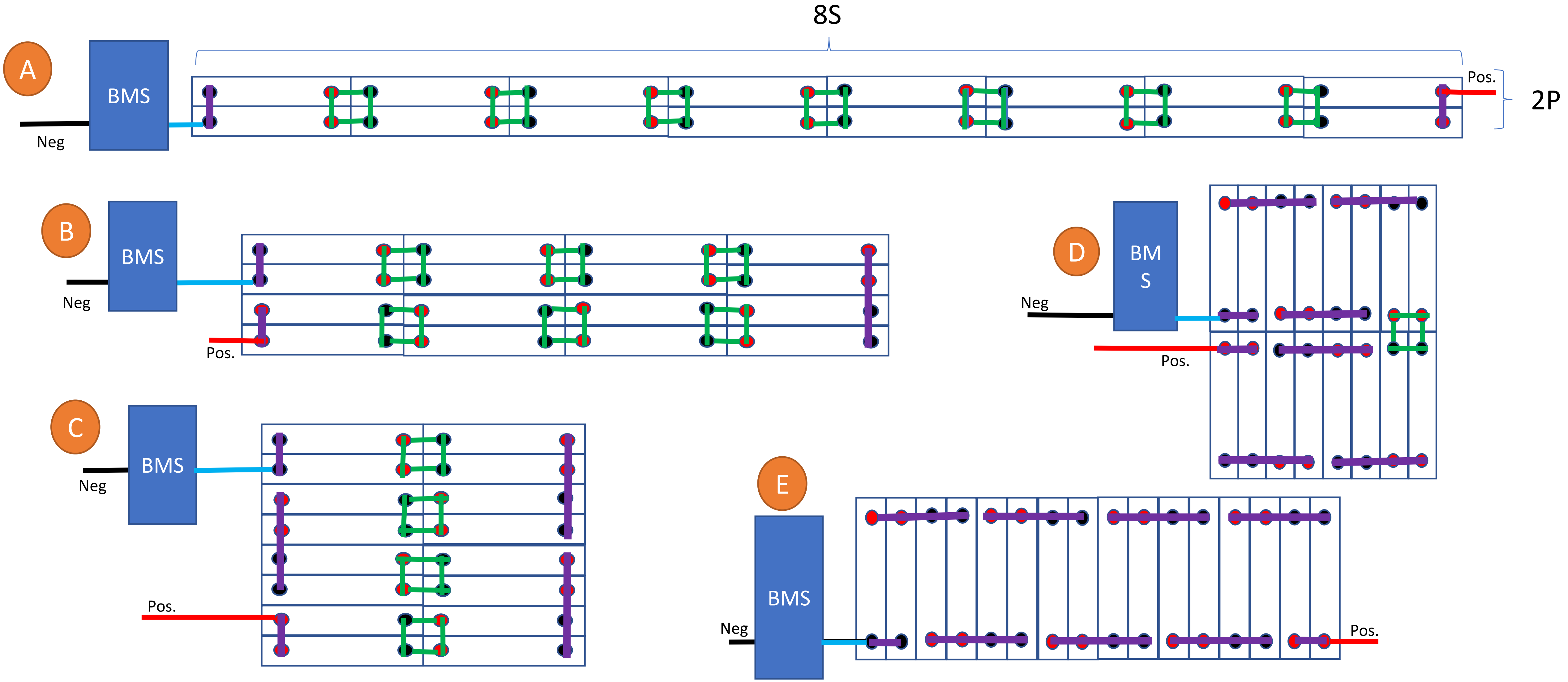
Note: There are other layouts, but they are somewhat uncommon.

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

Heavy Duty
Factory

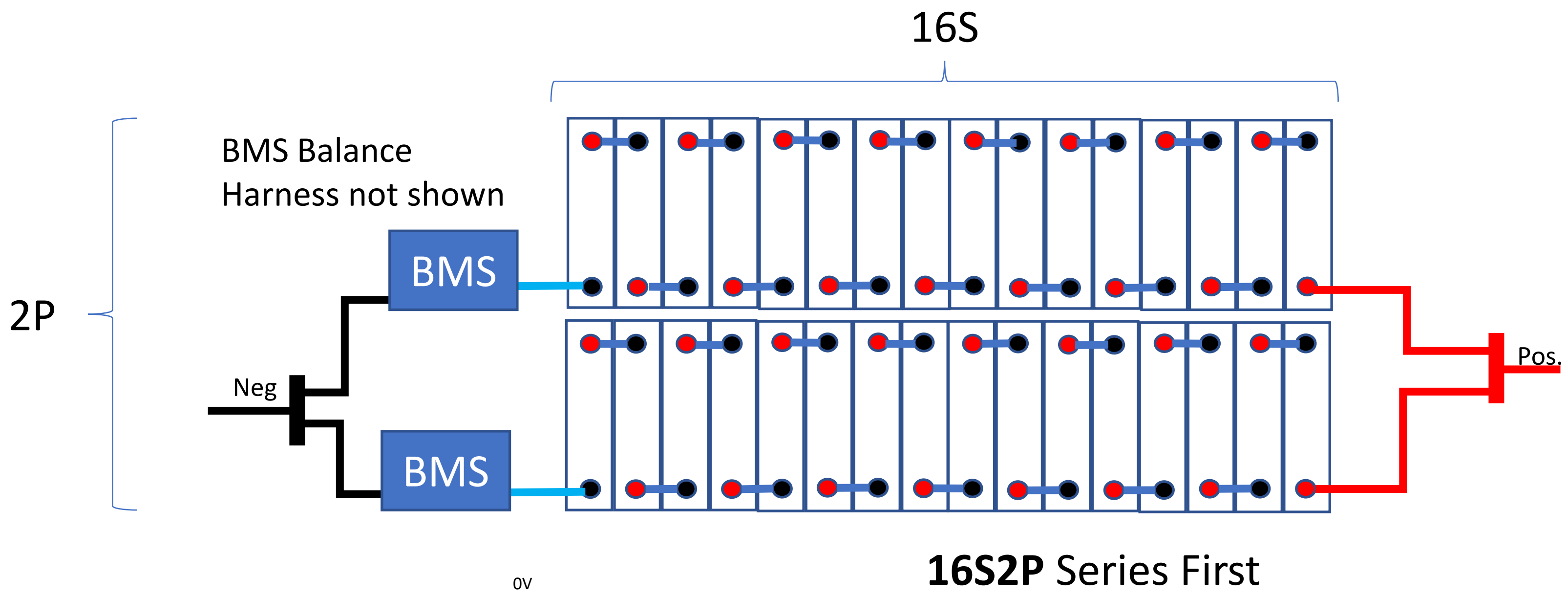


16S2P Wiring for 48V Batteries – Series First

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



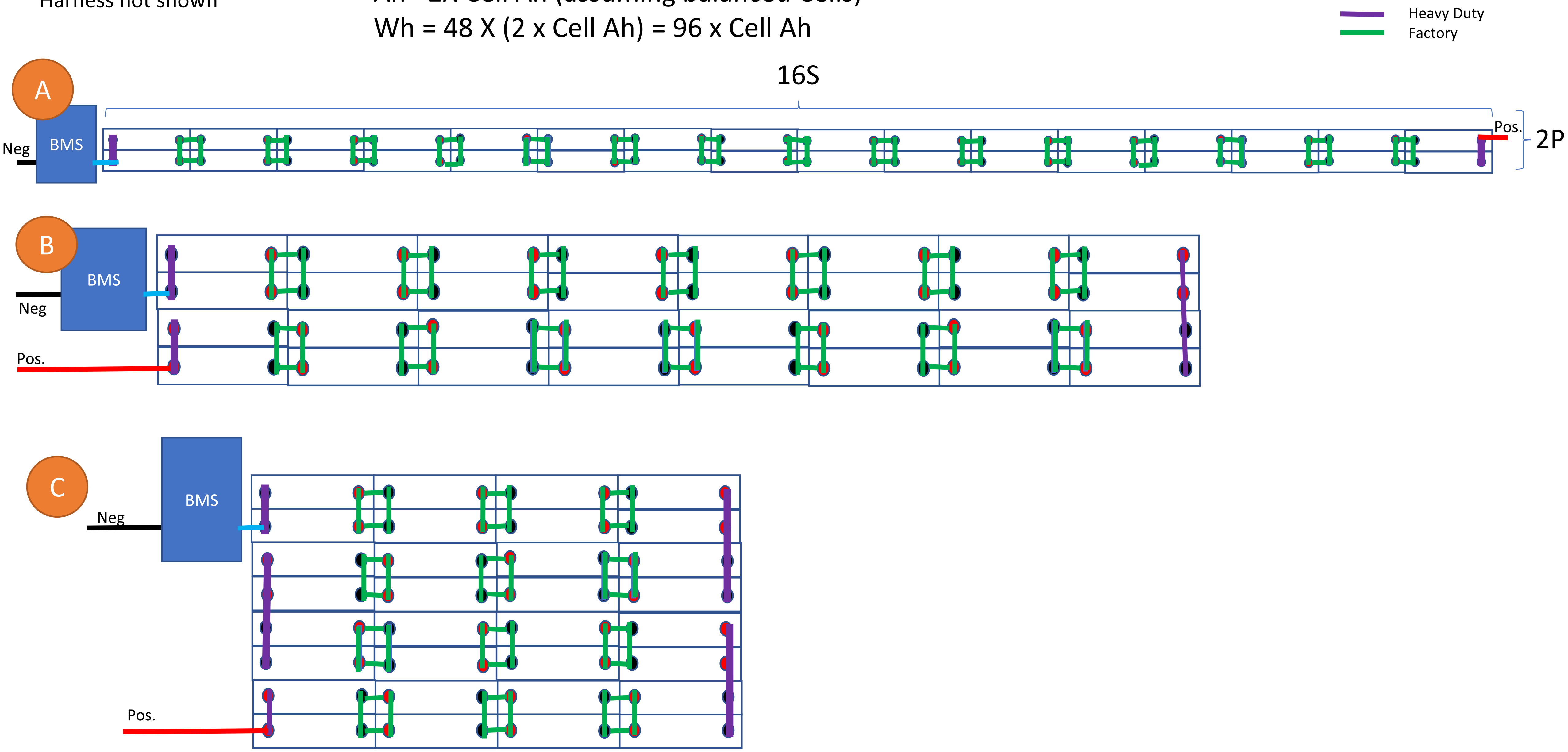
16S2P Series First

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

2P16S Wiring for 48V Batteries – Parallel First

BMS Balance
Harness not shown

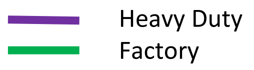
Voltage = 16 times cell voltage = Nominal 48V for LiFePO4
Ah= 2X Cell Ah (assuming balanced Cells)
Wh = 48 X (2 x Cell Ah) = 96 x Cell Ah

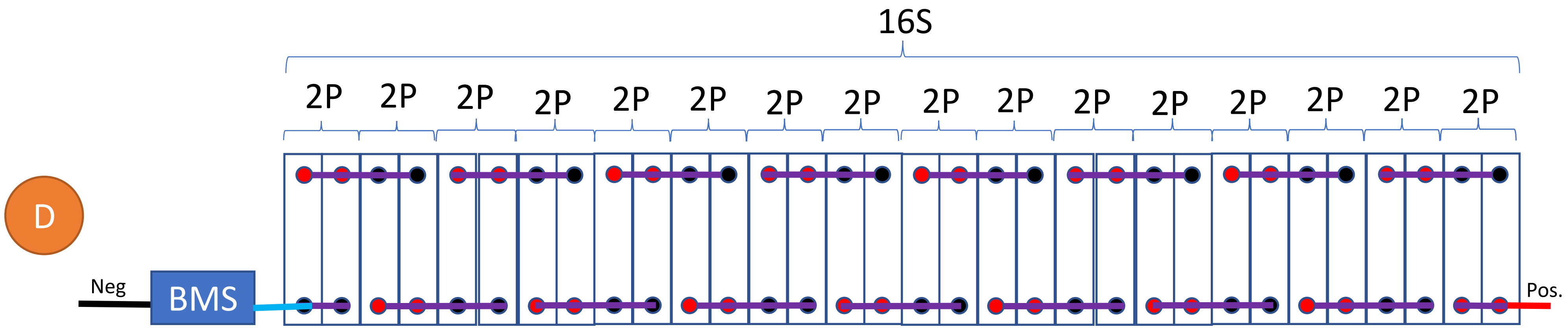


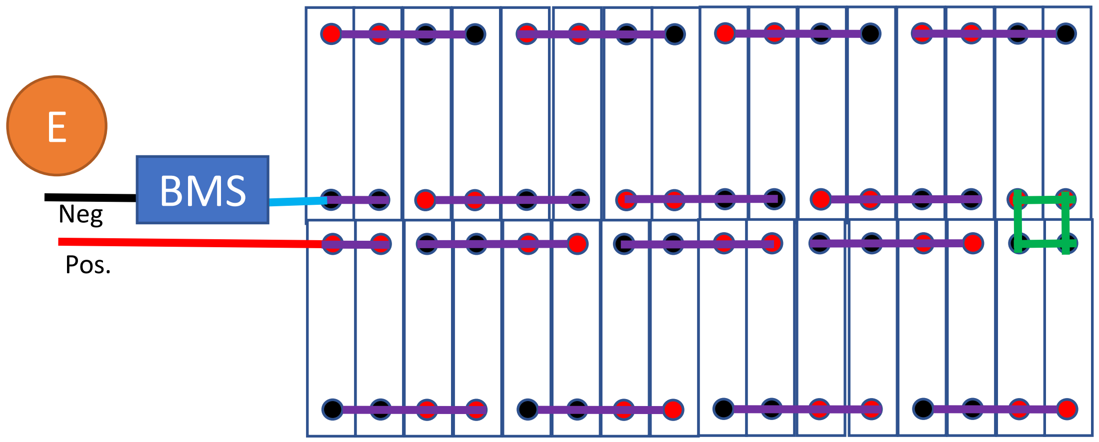
2P16S Wiring for 48V Batteries – Parallel first (Continued)

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





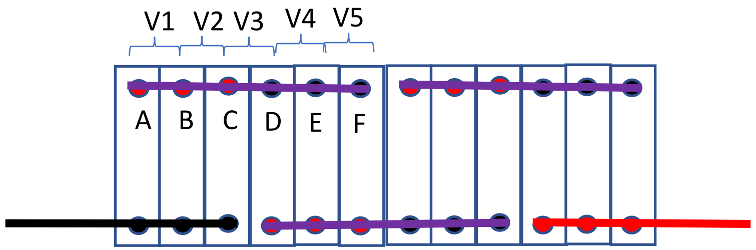


Note: There are other layouts, but they are somewhat uncommon.

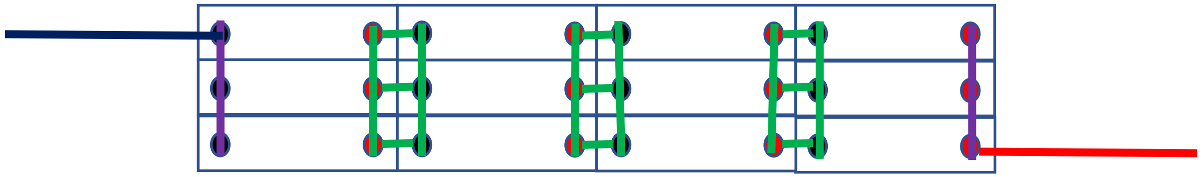
A note about Bus-Bars

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. • The BMS balancing has fewer cells to balance and will be better able to keep up. (This is more important on miss-matched cells and BMSs with low balance current)	• 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

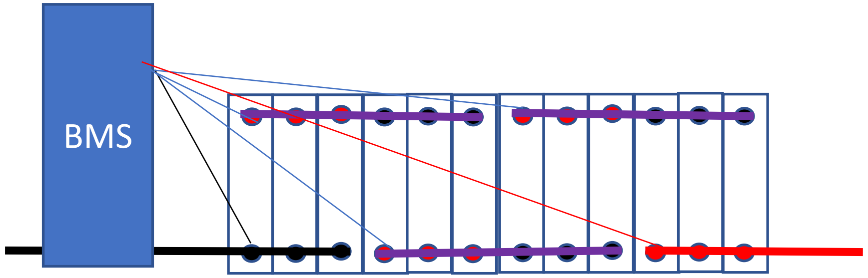
    8 cells = 41.2Kg (93 Lbs)
    16 cells = 82.4Kg (184 LBS)

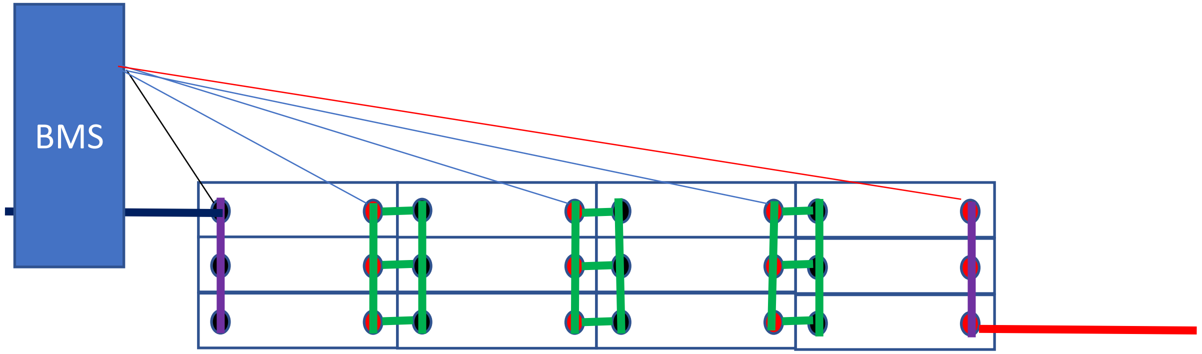
Add the weight of Box and bits it becomes unwieldy quickly.

Bonus Layouts

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

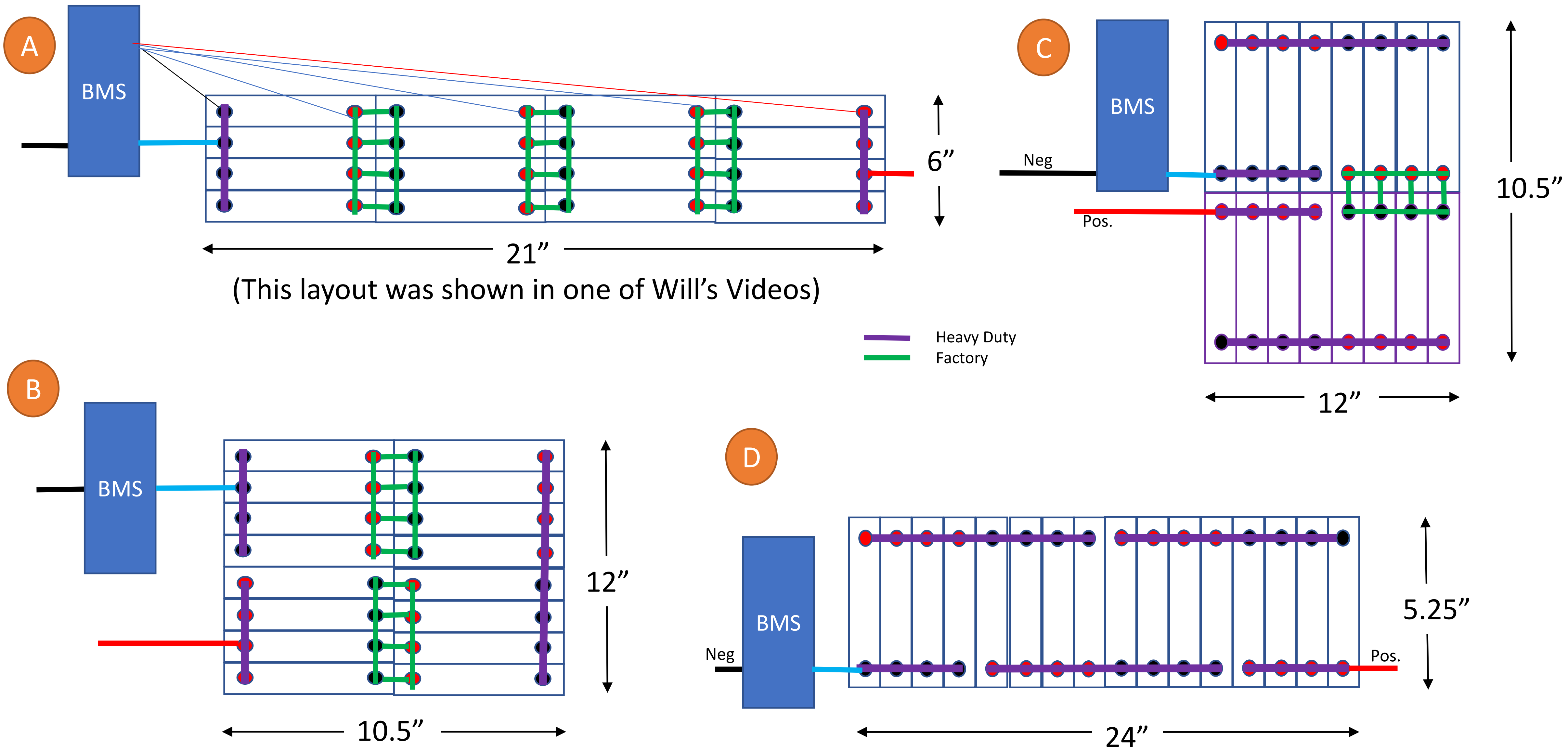
Bonus: A Couple Possible 12V 3P4S Fortune Cell Layouts





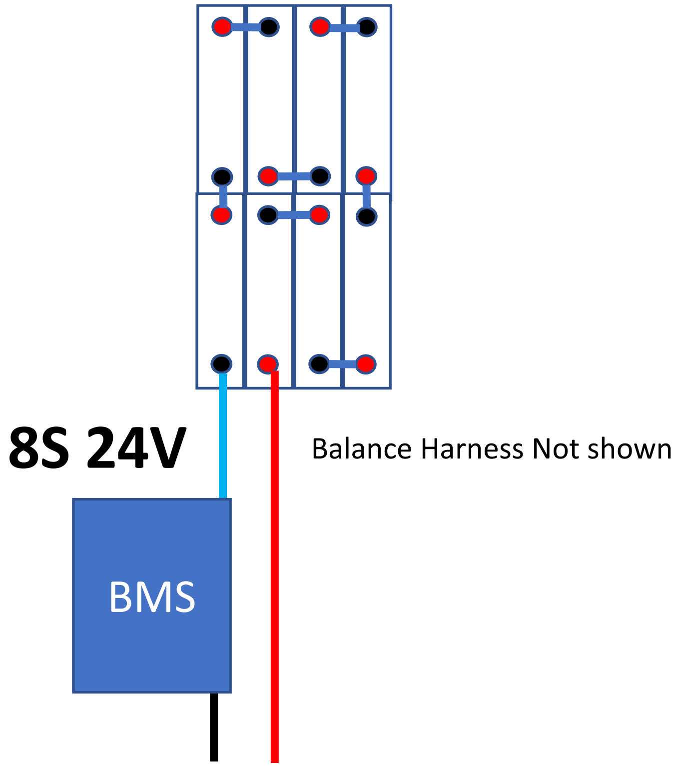
Bonus: A few Possible 12V 4P4S Fortune Cell Layouts

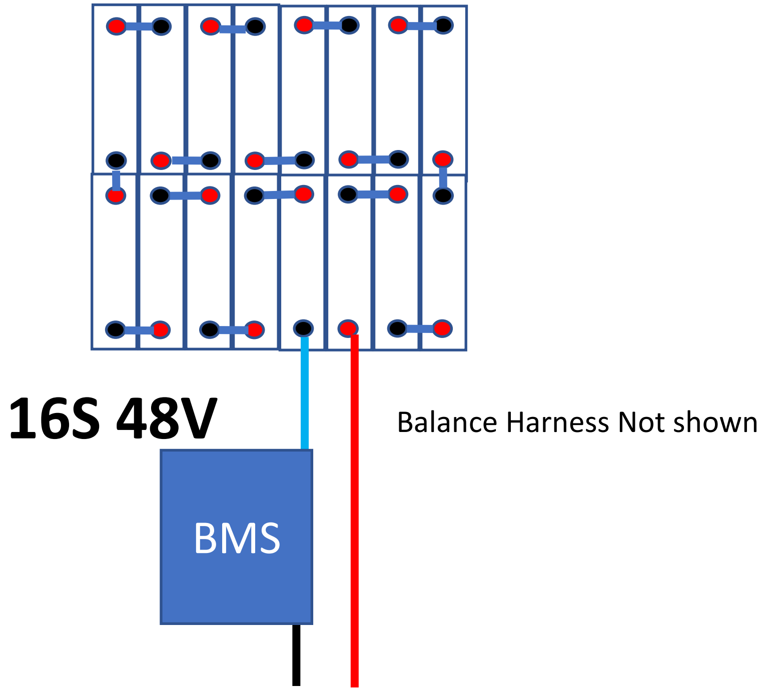
Oversized Bus-bar
Factory Bus-bar



Bonus: “Side Tap of main positive and negative”

In most of the layouts shown in this paper, the Main Positive and Main Negative is at the ‘end’ of the pack. However, there may be cases where the most convenient place for the main positive and negative is on the side of the pack as shown below

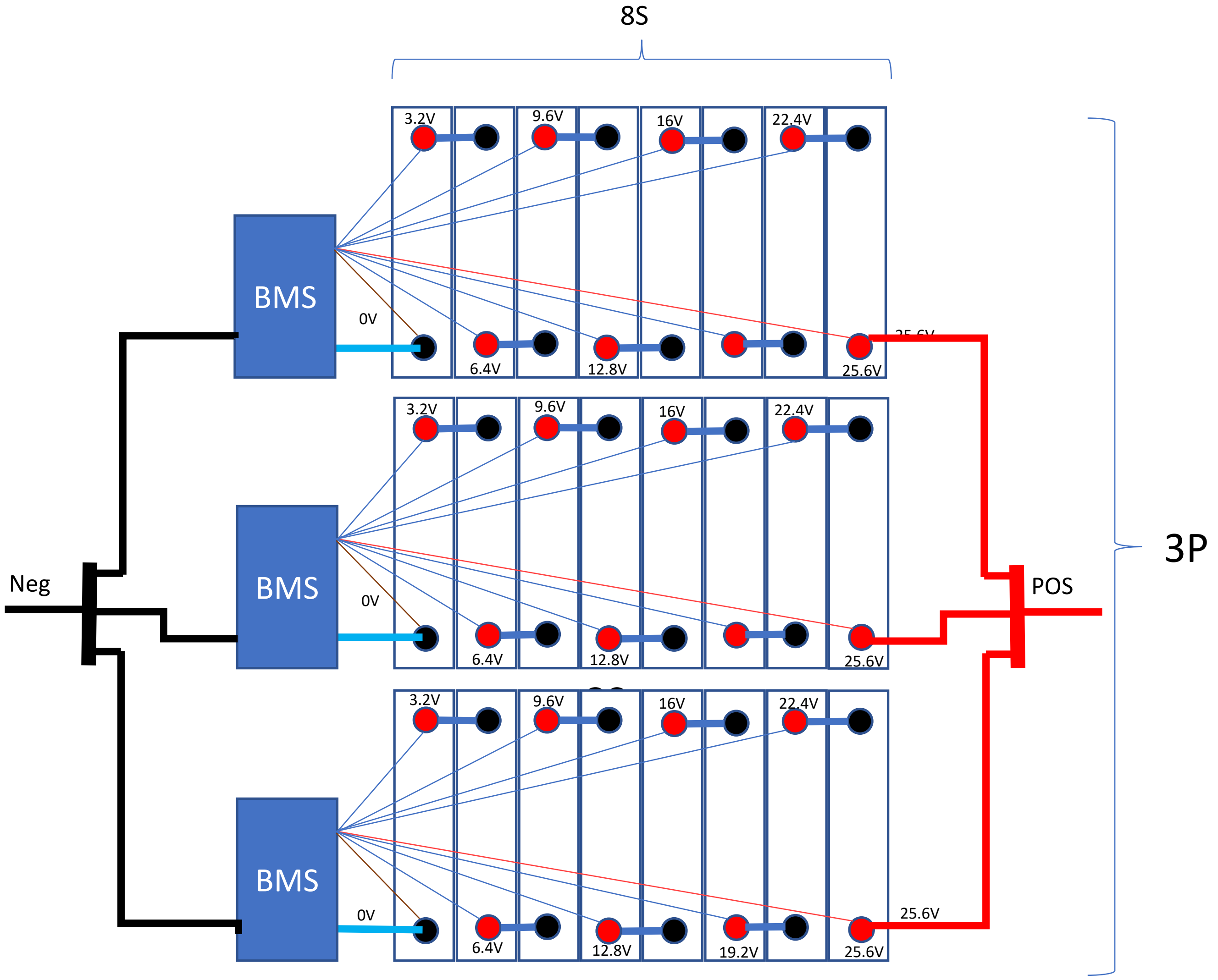




Notes:
* These are two examples. However, there are several points along either side that could be main positive and main negative
* There can be similar side-tap arrangement with the Parallel-first arrangements

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



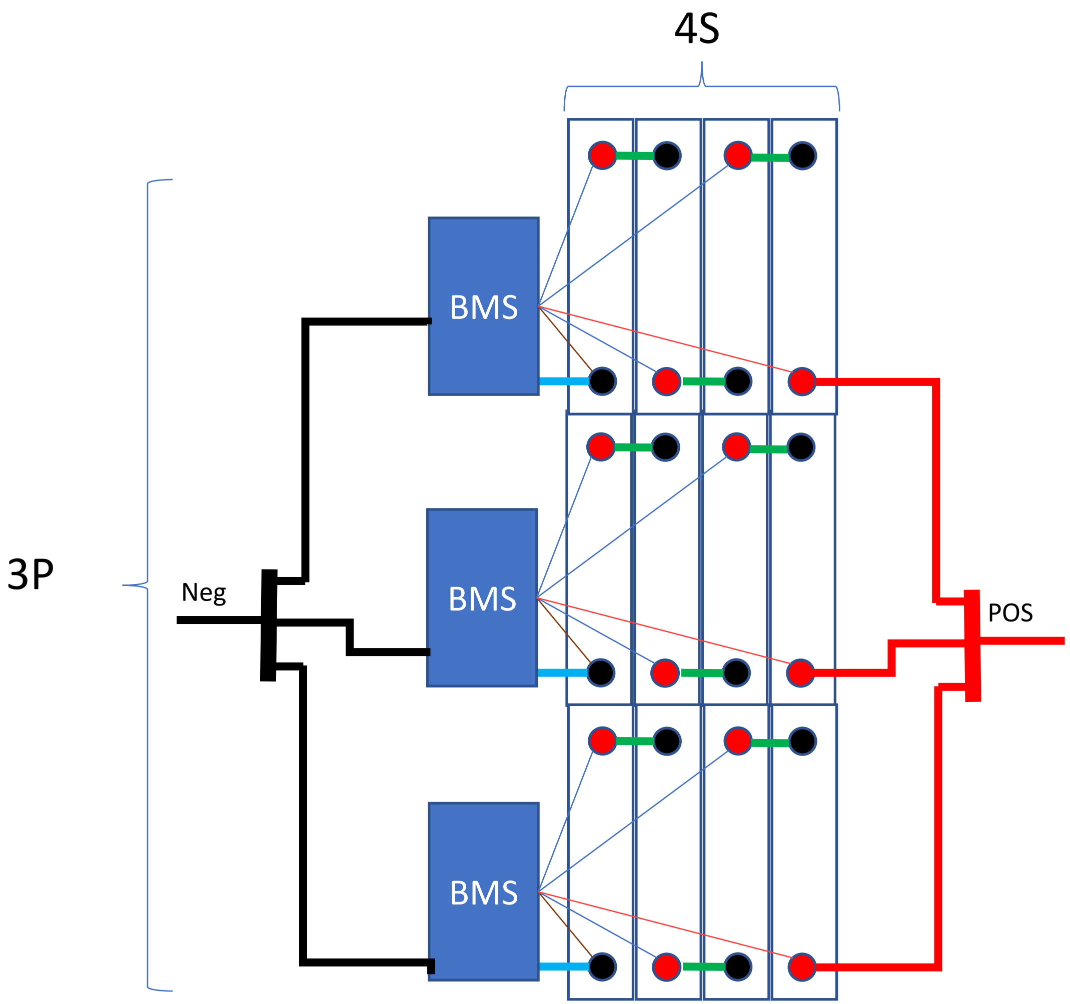
8S3P
(Series-First)

4S3P Wiring for 12V batteries (Series First)

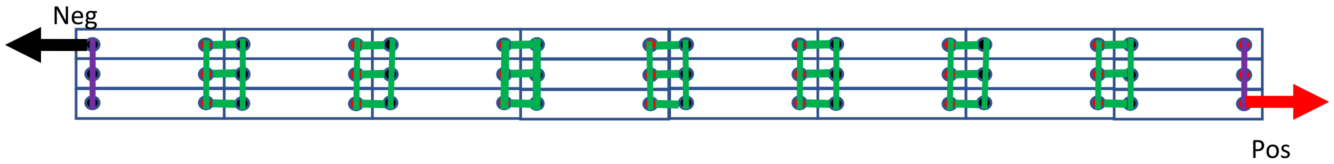
Voltage = 4 times cell voltage = Nominal 12V for LiFePO4

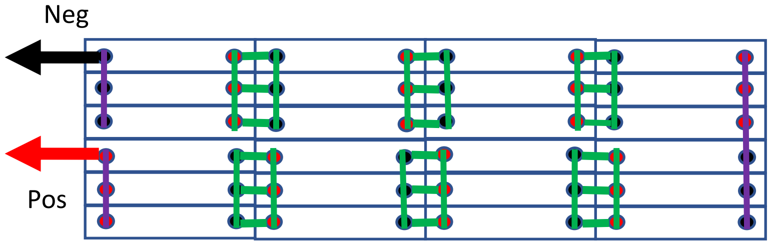
Ah= 3X Cell Ah (assuming balanced Cells)

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

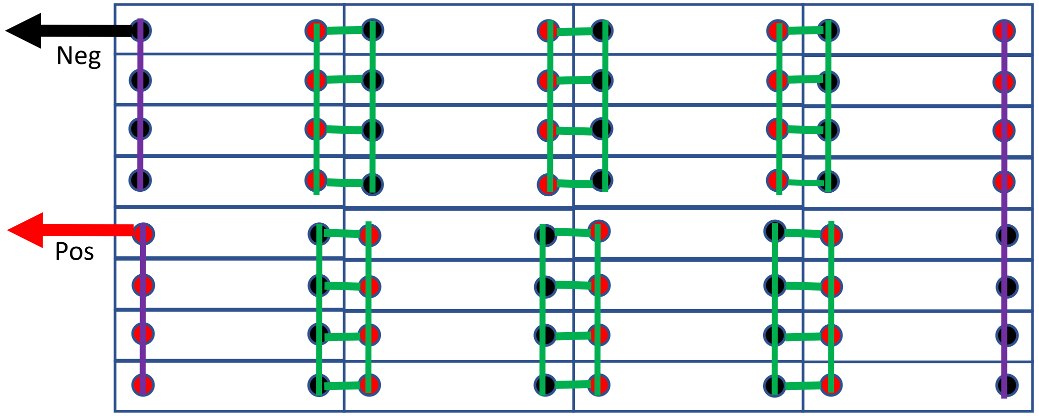


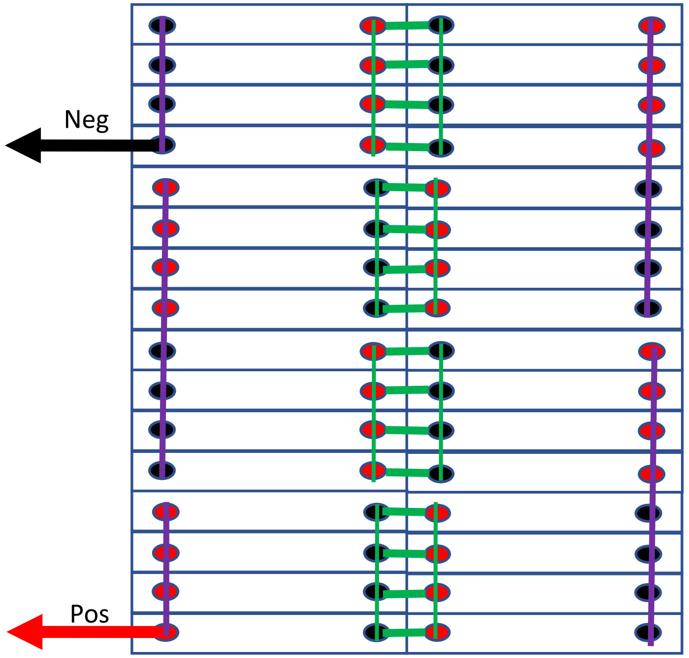
Bonus: A few 3P8S (24V) Layouts

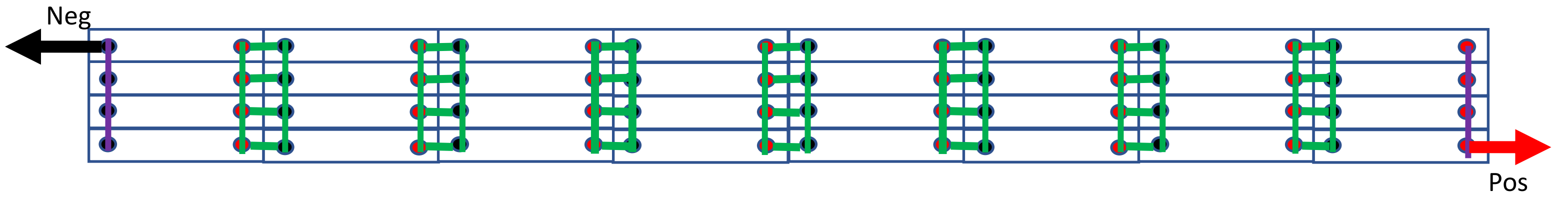




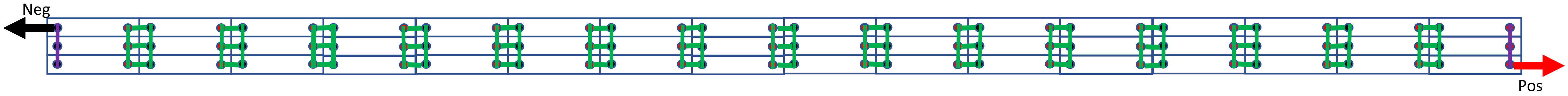
Bonus: A few 4P8S (24V) Layouts

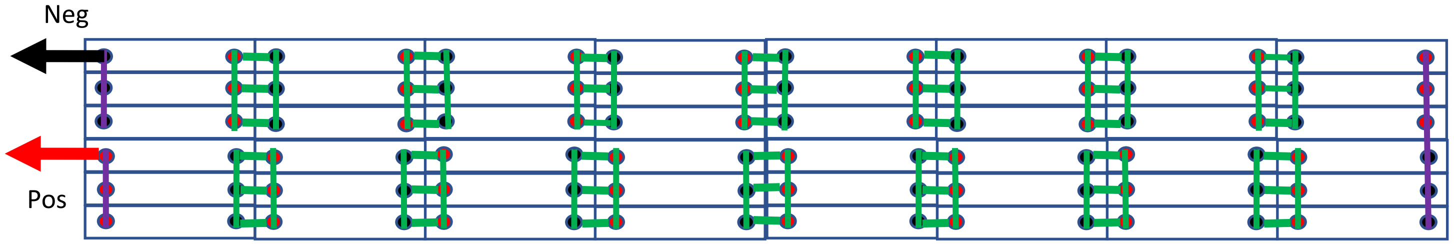


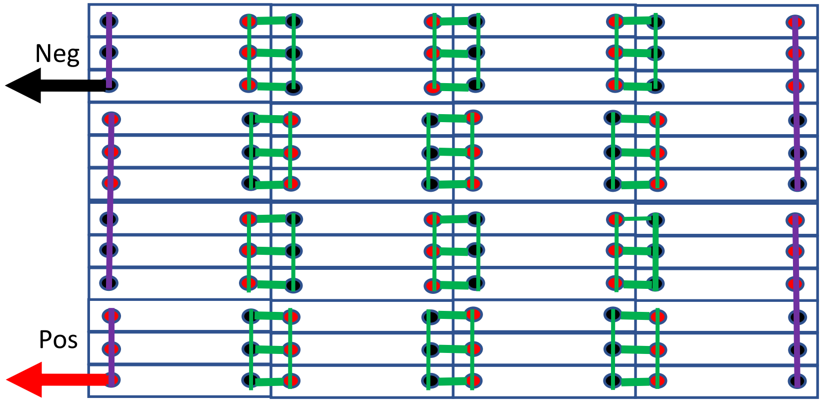




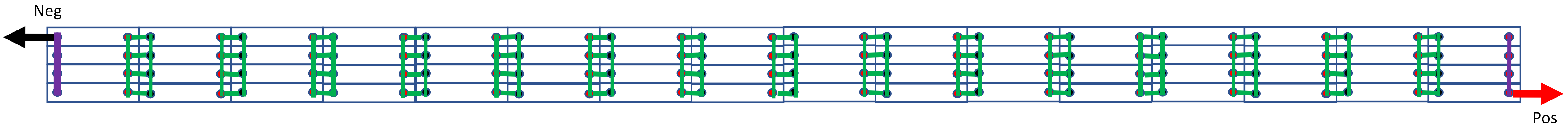
Bonus: A few 3P16S (48V) Layouts

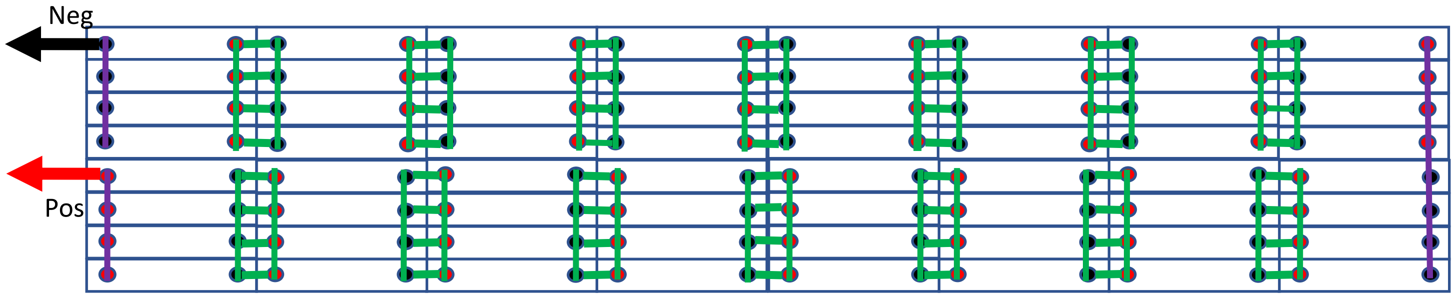


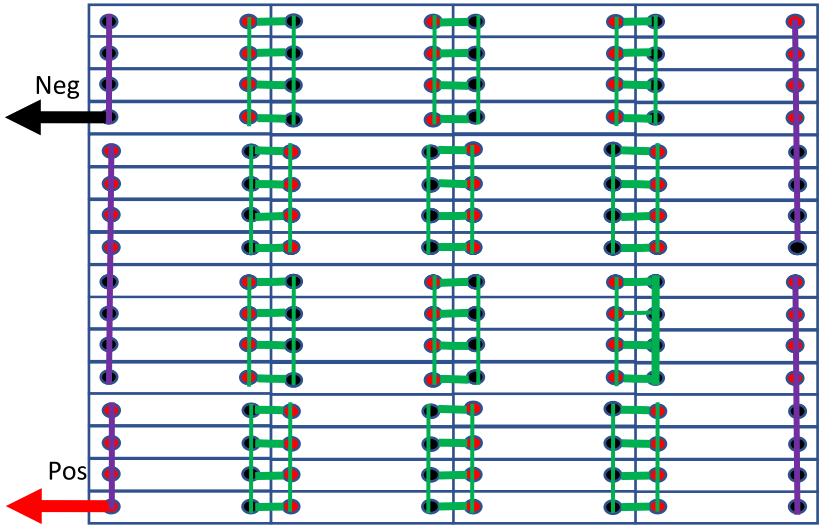




Bonus: A few 4P16S (48V) Layouts







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.