Voltage Settings for BMS, Chargers and Loads

Related Resources
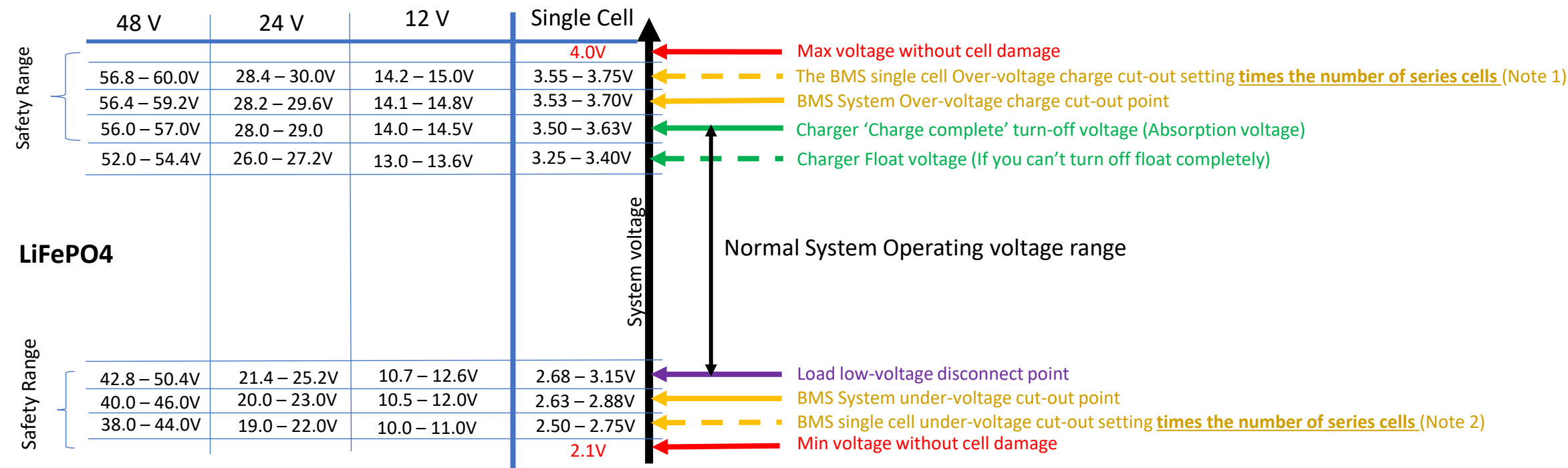- **Beginners Summary of BMS Types, Functions and Features.**
- **1P and 2P cell configurations for 12V, 24V& 48V LiFePO4 batteries:**
- **Beginners explanation of Top and Bottom Balancing**

BMS, Load and Charger voltage settings.

When setting up your system, the various voltage settings on the BMS, Loads and Chargers are critical for a hassle free but safe system operation.   The decision on each setting is driven by several, sometimes conflicting factors.

- Protect the cells from under-voltage or over-voltage conditions.
- Maximizing the available storage
- Being gentle on the cells to prolong their life
- Ensuring the Loads or Chargers turn on/off before the BMS does.
- Ensuring there is a sufficient gap between the various setting to ensure there are no unintended 'nuisance' triggers of the BMS. (*Note:* Having well matched and balanced cells allows for narrower gaps between the various settings)
- Available settings ranges on the system devices
- Manufactures specs on the cells.

The diagram below shows <u>typical</u> ranges and relative relationships for the various Battery, BMS, Chargers and Loads settings.

LiFePO4

Safety Range	48 V	24 V	12 V	Single Cell	
				4.0V	Max voltage without cell damage
	56.8 – 60.0V	28.4 – 30.0V	14.2 – 15.0V	3.55 – 3.75V	The BMS single cell Over-voltage charge cut-out setting **times the number of series cells** (Note 1)
	56.4 – 59.2V	28.2 – 29.6V	14.1 – 14.8V	3.53 – 3.70V	BMS System Over-voltage charge cut-out point
	56.0 – 57.0V	28.0 – 29.0	14.0 – 14.5V	3.50 – 3.63V	Charger 'Charge complete' turn-off voltage (Absorption voltage)
	52.0 – 54.4V	26.0 – 27.2V	13.0 – 13.6V	3.25 – 3.40V	Charger Float voltage (If you can't turn off float completely)

Normal System Operating voltage range

System voltage

Safety Range	48 V	24 V	12 V	Single Cell	
	42.8 – 50.4V	21.4 – 25.2V	10.7 – 12.6V	2.68 – 3.15V	Load low-voltage disconnect point
	40.0 – 46.0V	20.0 – 23.0V	10.5 – 12.0V	2.63 – 2.88V	BMS System under-voltage cut-out point
	38.0 – 44.0V	19.0 – 22.0V	10.0 – 11.0V	2.50 – 2.75V	BMS single cell under-voltage cut-out setting **times the number of series cells** (Note 2)
				2.1V	Min voltage without cell damage

Note 1: The BMS cell Over-voltage setting is typically the same or slightly less than the voltage used for top balancing the cells

Note 2: The BMS cell Under-voltage setting is typically the same or slightly more than the voltage used for bottom balancing the cells

Picking voltages that are right for you.

A. Pick your normal system operating voltage range. This will be what you set your load and chargers too. (The loads and Chargers control the normal operational 'bandwidth' of the battery capacity.)

As can be seen in figure 1, After ~ 3.6V, there is little gain in increasing the charge voltage. Likewise, Figure 2 shows that there is little gain in capacity from discharging below ~3.0 V. Consequently, the operating range for most systems is set up to be within the 3.0V - 3.6V range.

There is a school of thought that keeping the voltages well inside the 3.0 – 3.6V range will extend the battery life.   However, this reduces the available capacity and there is some debate about how much good it really does.

B. Pick your BMS voltages. (Your BMS is a safety layer that kicks in if the Loads and Chargers misbehave. Within the BMS there are two layers: Battery voltage monitoring and Cell voltage monitoring.)
   1. Pick a BMS Battery over-voltage above the top end of your operating range.
   2. Pick a BMS Cell over-voltage (The Cell Overvoltage times number of series cells should be more than the BMS Battery over-voltage
   3. Pick a BMS Battery Under-voltage below the bottom end of your operating range.
   4. Pick a BMS Cell Under-voltage. (The Cell Under voltage times number of series cells should be less than the BMS Battery under-voltage)
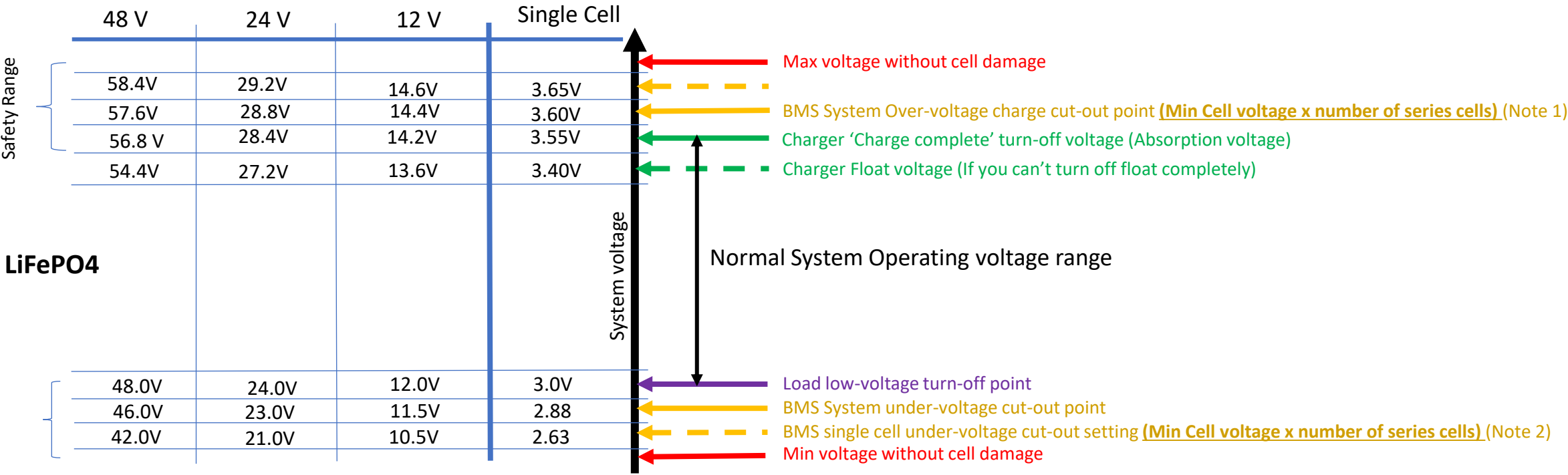
Note 1: The gap between voltages needs to be large enough to ensure you don't inadvertently get Under or Over voltage BMS events during normal operation. Where possible I like to have at least .1V/cell gap...and that is not always enough. The better matched and balanced the cells are, the narrower that gap can be.

You may have to play with the settings some once you see how your cells behave.

Figure 1 – LiFePO4 Charge curve

Figure 2 – LiFePO4 Discharge curve
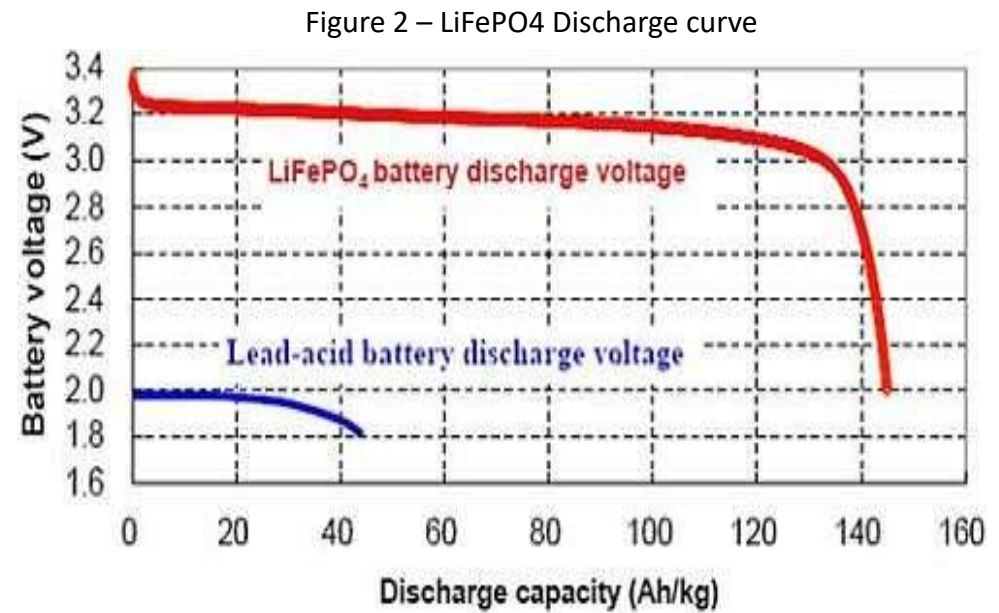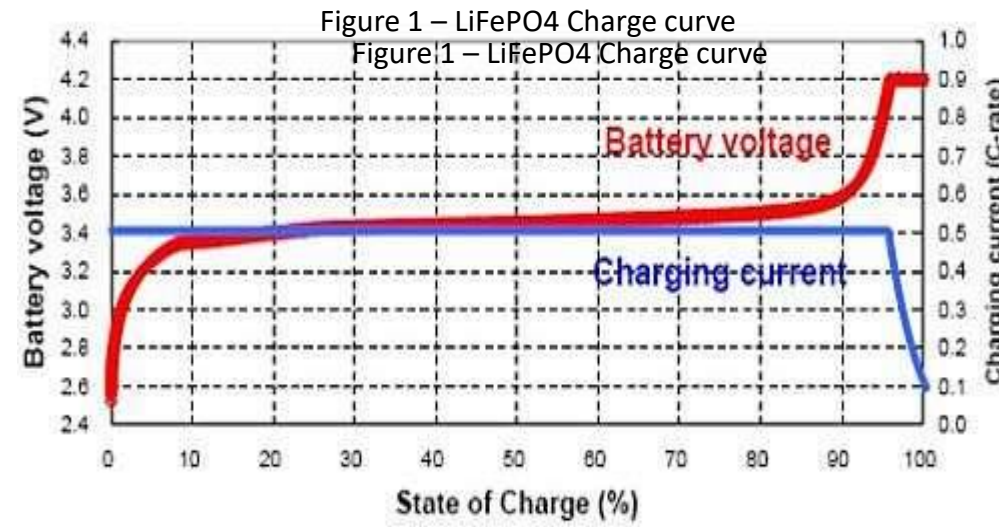
Example BMS, Load and Charger voltage settings.

The following diagram shows a set of typical settings for a system.   It is more conservative than some people use and more aggressive than others.   Also, keep in mind that once you see how your system behaves, you might find you need to adjust your initial settings to avoid nuisance triggers of the BMS.

48 V	24 V	12 V	Single Cell	
				Max voltage without cell damage
58.4V	29.2V	14.6V	3.65V	
57.6V	28.8V	14.4V	3.60V	BMS System Over-voltage charge cut-out point **(Min Cell voltage x number of series cells)** (Note 1)
56.8 V	28.4V	14.2V	3.55V	Charger 'Charge complete' turn-off voltage (Absorption voltage)
54.4V	27.2V	13.6V	3.40V	Charger Float voltage (If you can't turn off float completely)

LiFePO4

Normal System Operating voltage range

48 V	24 V	12 V	Single Cell	
48.0V	24.0V	12.0V	3.0V	Load low-voltage turn-off point
46.0V	23.0V	11.5V	2.88	BMS System under-voltage cut-out point
42.0V	21.0V	10.5V	2.63	BMS single cell under-voltage cut-out setting **(Min Cell voltage x number of series cells)** (Note 2)
				Min voltage without cell damage

Safety Range (left bracket), *System voltage* (vertical axis label)

Note 1: The BMS cell Over-voltage setting is typically the same or slightly less than the voltage used for top balancing the cells
Note 2: The BMS cell Under-voltage setting is typically the same or slightly more than the voltage used for bottom balancing the cells
Note 3: The above voltages are a good starting point for LiFePO4 systems and are more conservative than some people use.
Note 4: After the system is set up and running, you might need to tune the voltages to prevent unintended trips of the BMS.