Voltage Settings for BMS, Chargers and Loads

Related Resources

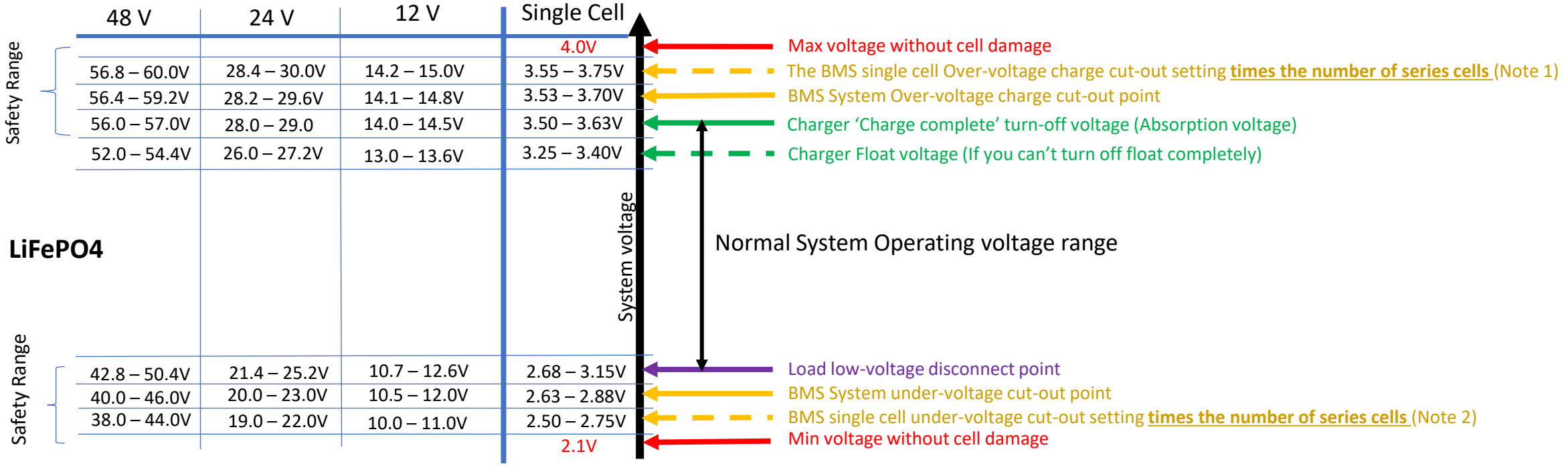
- **Beginners Summary of BMS Types, Functions and Features.**
- **1P and 2P cell configurations for 12V, 24V& 48V LiFePO4 batteries:**
- **Beginners explanation of Top and Bottom Balancing**

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 typical ranges and relative relationships for the various Battery, BMS, Chargers and Loads settings.



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 <u>well</u> 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 the 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 the 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

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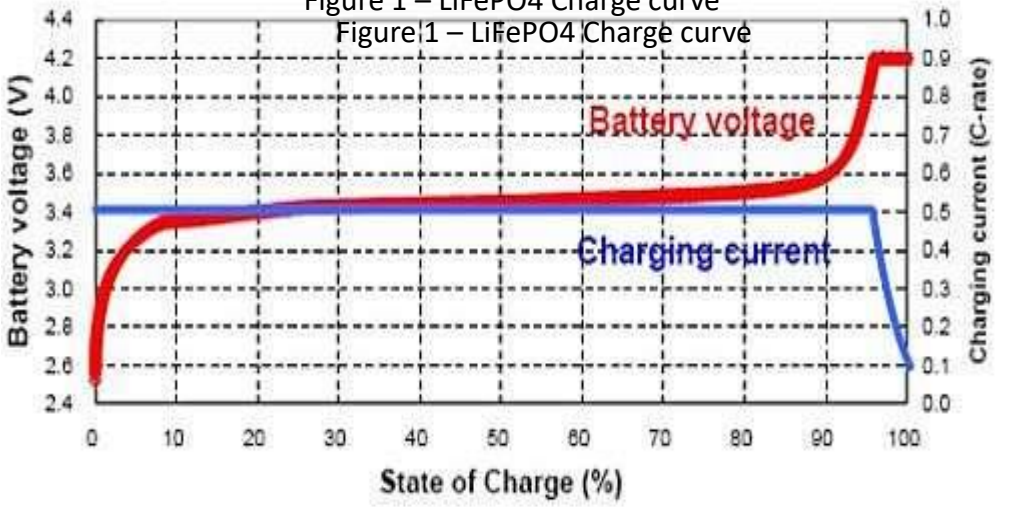
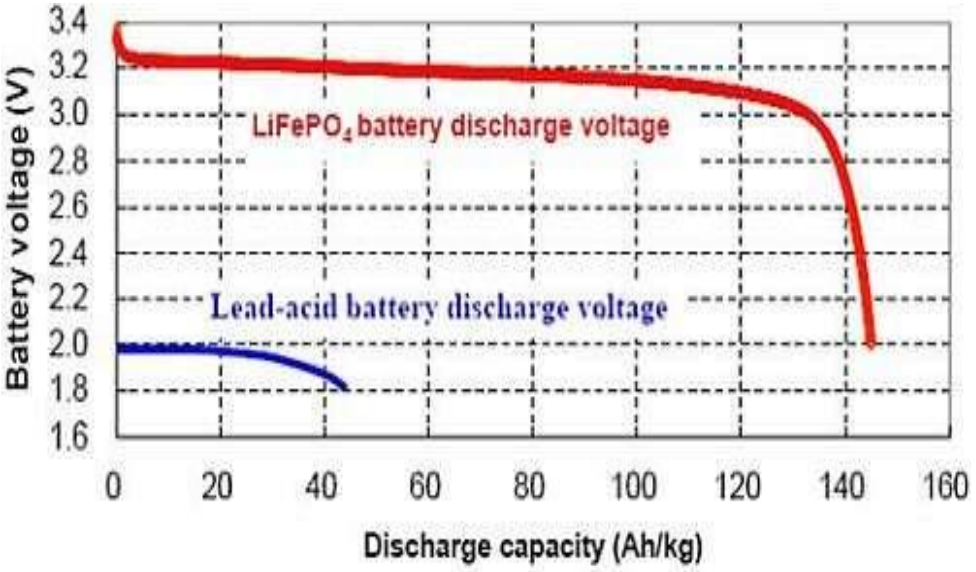
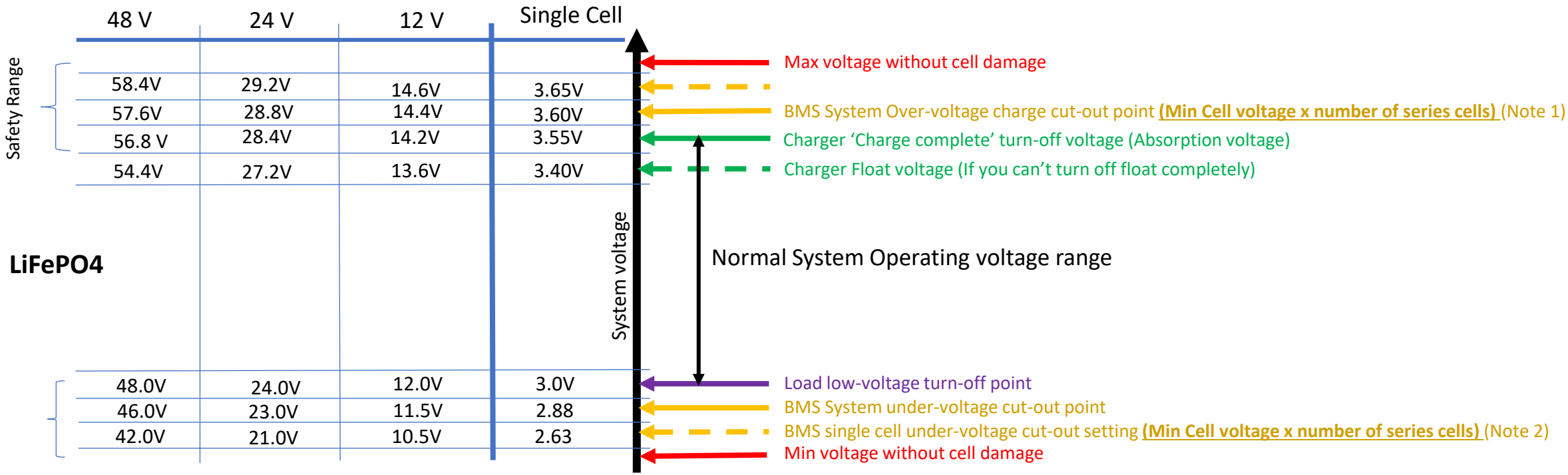


Figure 2 – LiFePO4 Discharge curve



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.



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.

Saturation or Accumulation Cut-off current.

Once a cell reaches the target charge voltage and the charger goes into its Constant-Voltage stage, the current will keep flowing. This is called the saturation or accumulation stage. The cell will not be fully charged for the target voltage till the current stops flowing. Various chargers decide on the duration of the accumulation stage and switch to float mode differently. (Note that this is controlled by the Charger, not the BMS)

1. The most advanced (best) chargers will have a current setting that the charge must get down to before going to float mode. (These chargers will often also have a max-time the battery is allowed to stay in accumulation stage.)

   I tend to set the cut-off current for the end of the accumulation stage quite low. Typically .5%C to 1%C. (EXAMPLE: .5%C on a 200AH battery would be .005 x 200 = 1A) Others are less aggressive and set it to as high as 5C (Example .05 x 200 = 10A)

2. Less advanced chargers will only have a timer on the accumulation stage. I will typically set this to .5-1 hour.

3. The least advanced chargers will switch to float mode as soon as the target voltage is reached.

All 3 algorithms work, and, in my opinion none of them are ‘bad’. However, each gives slightly different level of control of the State of Charge when the charging completes.

Appendix A: Reference Video from the Off-Grid Garage Video Channel

This video is an excellent video that discusses the charge and discharge characteristics of a LiFePO4 cells.

LiFePO4 charging and discharging curve explained. How far to go? (Qishou EVE LF304 capacity test) – YouTube

You will notice that in the video, he uses more conservative than this paper.

3.13V	- Low Voltage discharge
3.45V	- High voltage charge
.05% x C	- Saturation cut-off
3.35 - 3.375	- Float Voltage

These conservative numbers are certainly easier on the cells and there would be nothing wrong with using them for the Charger and Load settings. (I tend to set them more aggressively) You can then use slightly more aggressive numbers for the BMS settings.