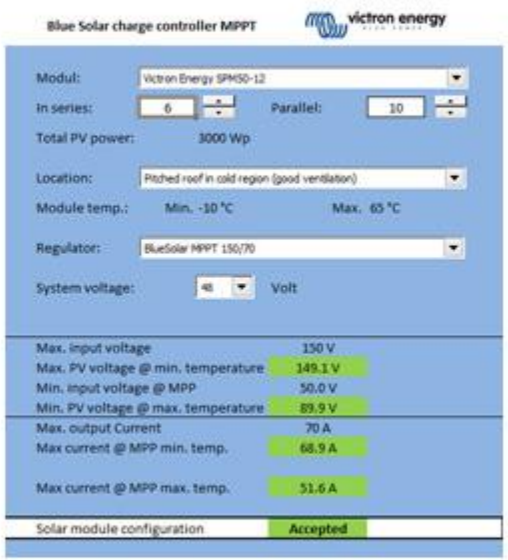
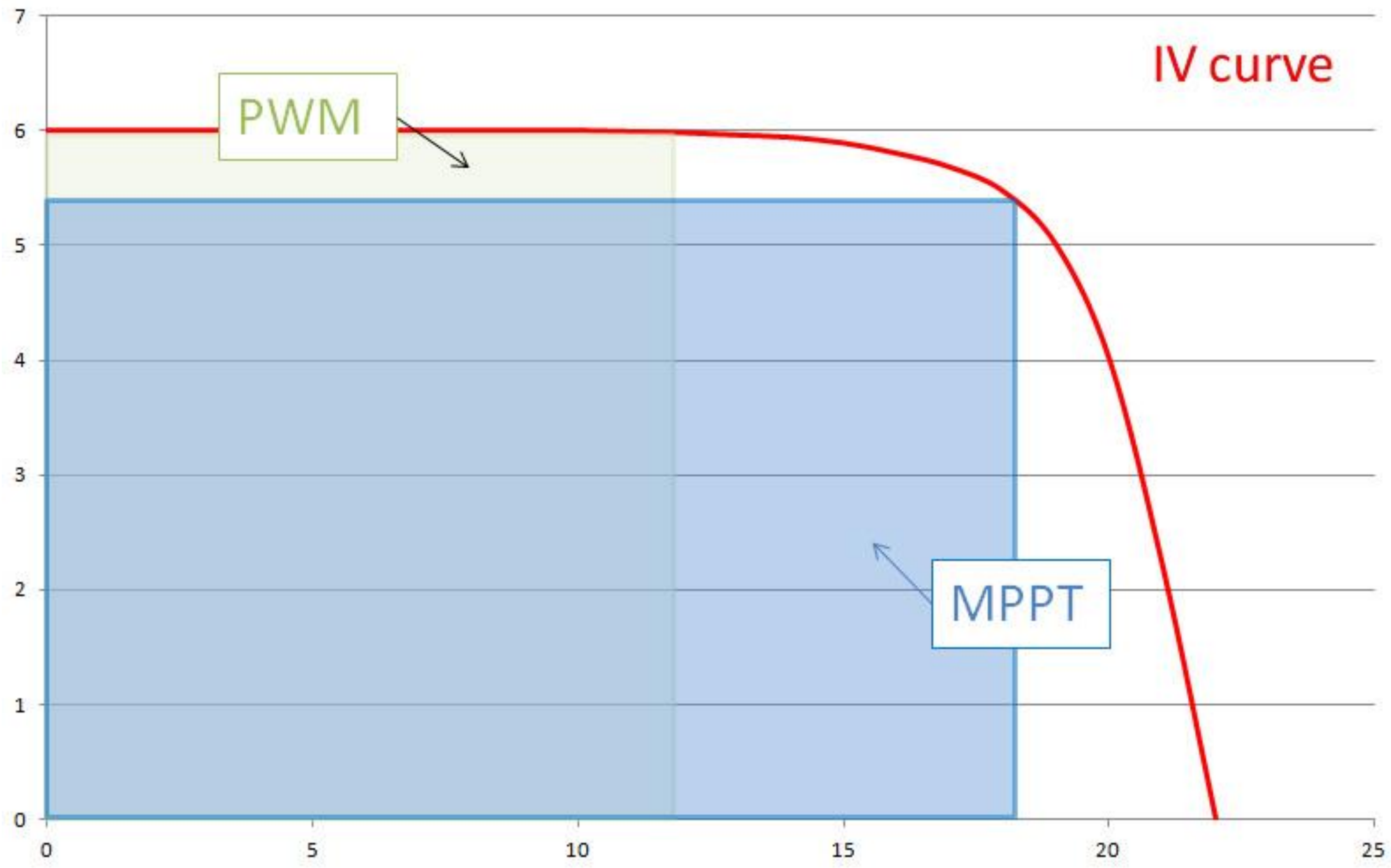
Matching solar modules to MPPT charge controllers

Life used to be so simple; in a 12V battery system you took a ‘12V’ solar module, watched carefully that the maximum PV current would not exceed the charge controller maximum current and the system would work.

Unfortunately due to the fact, that with PWM controllers the PV module is <u>not</u> feeding the battery from its maximum power point (MPP), the system loses a lot of energy. In the following diagram you can see, the area of the MPP in blue (Vmpp * Impp) is up to 30% larger than the PWM area (Vbatt * ~Isc) within the IV curve.





So, with the advent of the newer Victron Energy Blue Solar MPPTs, things changed for the better when compared to PWM solar charge controllers.

- If a specific yield is the goal, the 30% higher efficiency of the MPPT will reduce system costs, because the same energy can now be produced with a smaller PV generator.
- If the size of the solar module was already fixed, the yield is now higher in the same system when using an MPPT.

In both cases the user is a winner!

Sizing the system can be done electrically to see if the system is allowed and will not destroy any components, when looking at the yield to see how much energy it will produce. For now I will look at the first part, to find out what is possible on the electrical side.

By adding a DC/DC converter in the Blue Solar MPPT controller, the system also becomes more flexible when we look at the input voltage of the controller. The challenge now, is to match the PV modules to the controller, because we are not concentrating on only '12V' or '24V' modules anymore. Basically any module can now be used if it is within the input voltage range of the charge controller.

In fact we can now put modules in series as well as parallel, which will also increase the input power and flexibility. Thanks to the output power or current limiter, the output power will never exceed the maximum of the controller. **This Blue Solar MPPT feature is unique and makes the charge controller even more interesting!**

You can now for example add the same type of modules in parallel later without the need to change the MPPT charge controller.
This reduces costs to a minimum, whilst still increasing the yield!

Also, I took the values for all our Blue Solar MPPT charge controllers and Blue Solar modules and combined them into a Spreadsheet. **Now sizing a Blue Solar MPPT charge controller is easy!**

Download: VE-MPPT-Calc.xlsx (744KB) – This configuration spreadsheet is compatible with MS Excel.

victron energy
BLUE POWER

Blue Solar charge controller MPPT

Module:	Victron Energy SPM300-24		
In series:	3	Parallel:	5
Total PV power:	4500 Wp		
Module temperature:	Min. 0 °C	Max.	70 °C
Controller:	BlueSolar MPPT 150/85		
System voltage:	48 Volt		
Cable length, Module to MPPT * * One way length	5 m	Cross-section:	6.0 mm²

Max. input voltage	150 V
Max. PV voltage @ min. temperature	148.1 V
Min. input voltage @ MPP	49.0 V
Min. PV voltage @ max. temperature	84.9 V
Max. output current	85 A
Max. current @ MPP min. temp.	85.0 A * Power limiting @ low temp.
Max. current @ MPP max. temp.	73.0 A
Solar module configuration	**Accepted**

Now for the technical explanation, for those who would like to know some more details:

Exceeding the input voltage range will (as it did with the PWM controllers) damage the controller permanently.

Of course we will also need to take a look at the minimum voltage, where the Blue Solar MPPT controller will start working. If you take a SPM50-12, the Open Circuit Voltage (Voc) is 22.2V and the maximum power voltage (Vmpp) is 18V at Standard Test Conditions (STC) which means 1.000W/m^2 irradiation, 25°C cell temperature and an Airmass of 1.5. If the cell temperature is higher or less than 25°C, this voltage reduces or increases due to the temperature coefficient, in this case -0.34%/°C (see Blue Solar module datasheet).

So if you take 3 modules SPM50-12 on a Blue Solar MPPT 150/70 in a 48V system on cold days say, -10°C (only looking at the voltage), you can start up charging:

*The startup voltage is 48V + 7V (see MPPT 150/70 datasheet) = 55V The modules will produce 3 * (22.2V + (-0.34% of 22.2V * -35°C temperature difference)) = 74.5V 74.5V is higher than 55V -> that's perfect*

Also running in the MPP the system would work:

*The running voltage is 48V + 2V (see MPPT 150/70 datasheet) = 50V The modules will produce 3 * (18V + (-0.34% of 22.2V * -35°C temperature difference)) = 61.9V 61.9V is higher than 50V -> that's perfect*

Doing the same thing, when the modules get warm during the day, in this case 70°C you can see what happens:

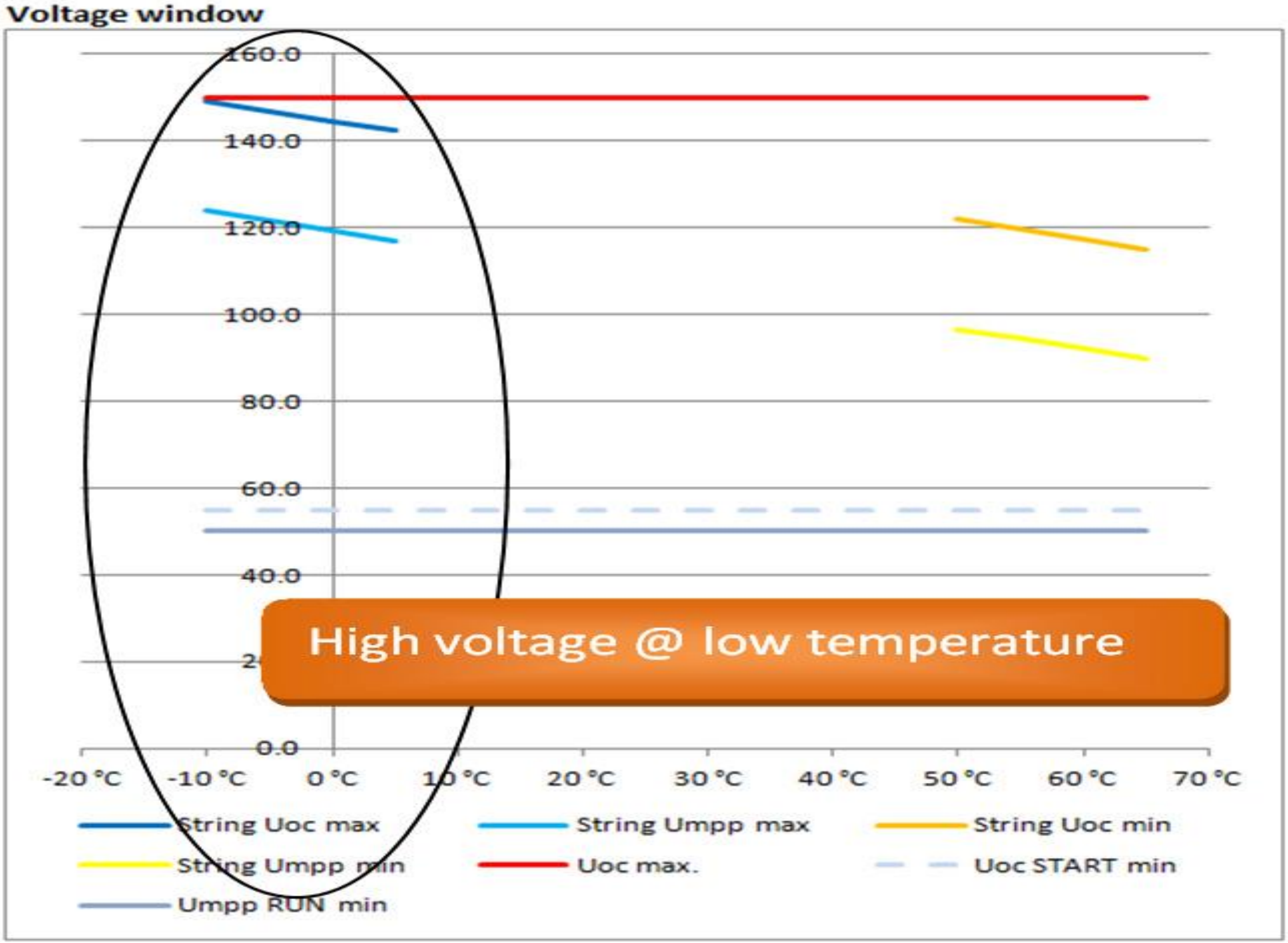
*The startup voltage is still 48V + 7V (see MPPT 150/70 datasheet) = 55V The modules will produce 3 * (22.2V + (-0.34% of 22.2V * 45°C temperature difference)) = 56.4V 56.4V is higher than 55V -> that would work*

But now in the MPP the module voltage is lower than the minimum:

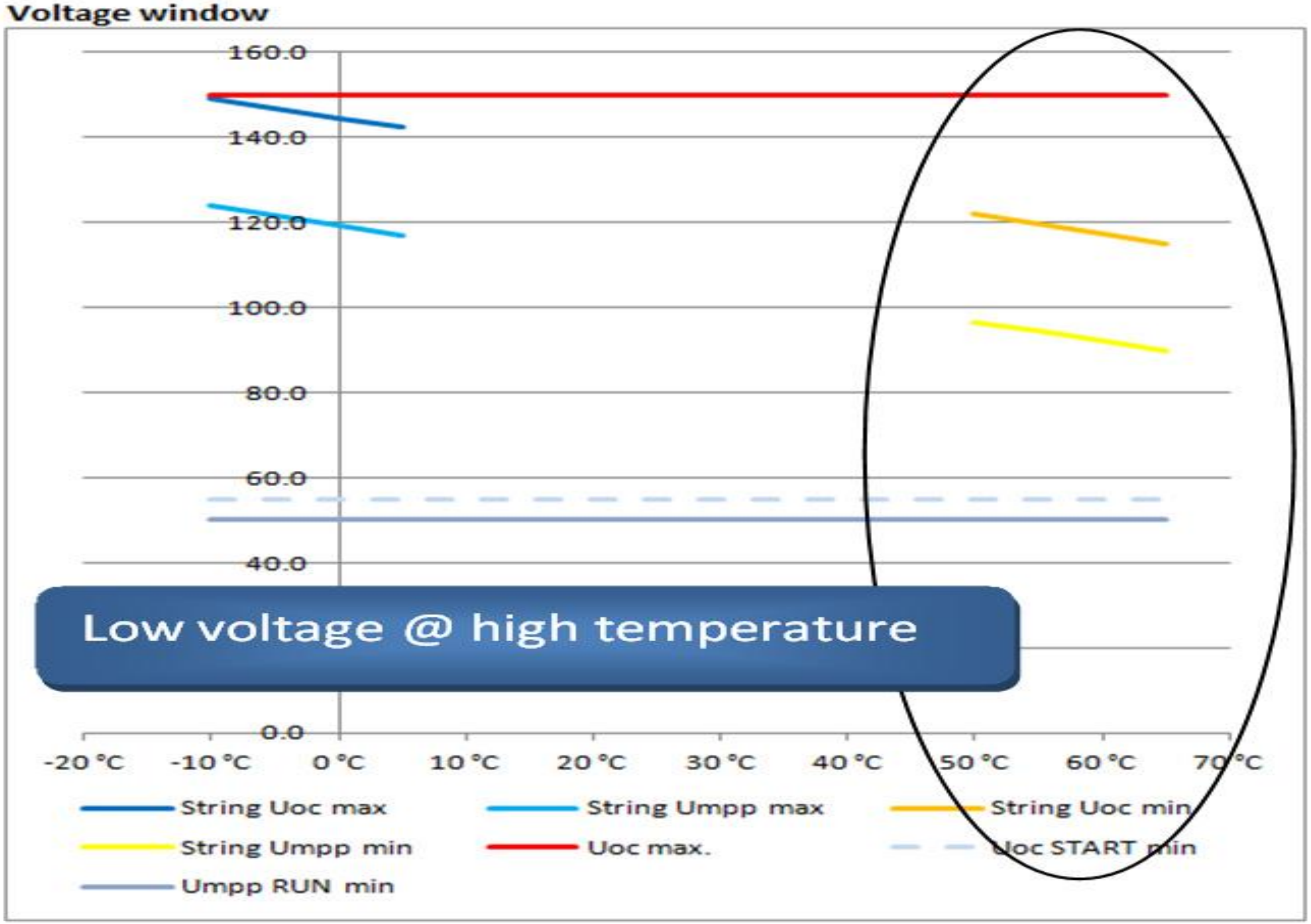
*The running voltage is 48V + 2V (see MPPT 150/70 datasheet) = 50V The modules will produce 3 * (18V + (-0.34% of 22.2V * 45°C temperature difference)) = 43.8V 43.8V is lower than 50V -> this is not enough!*

The high DC/DC conversion efficiency (97.5% at 48V) will result in following output maximum charging current (@ -10°C) of 61.9V Vmpp* 2.74A Impp / 48V Battery voltage * 0.975 Efficiency = 3.45A This is far below the maximum of 70A, so it will be all used to charge the battery.

Increasing the number of modules per string to 6 in series and making 10 strings in parallel gives the following result at -10°C:


Voltage window
160.0
140.0
120.0
100.0
80.0
60.0
40.0
0.0
-20 °C
-10 °C
0 °C
10 °C
20 °C
30 °C
40 °C
50 °C
60 °C
70 °C
String Uoc max
String Umpp max
String Uoc min
String Umpp min
Uoc max.
Uoc START min
Umpp RUN min
High voltage @ low temperature

The Voc will remain under the maximum of 150V at -10°C



Now at high temperatures such as a 70°C cell temperature the system will work just fine! Taking this example in the Spreadsheet you can now increase the number of strings in parallel and you will see, if starting at 11 strings, that the controller will start to reduce power. The big advantage in doing this is that you will now produce the maximum controller output at a lower irradiation. As module prices decrease, this is an effective option.

Please note, that you can use ‘preconfigured’ minimum and maximum temperatures. I’ve also given some installation examples, at the bottom of the spreadsheet, with their anticipated module temperatures for various types of installations.