ET3034TUx - 7.5.3 - Batteries 3 - Charge controllers

Welcome back.

Now we come to an important power electronic device that makes the battery storage in the modern PV system widely applicable.

I am talking about the charge controller.

What is a charge controller, and why do we need it?

Note that the use of charge controllers is found in PV systems with battery usage.

In most cases, this would mean a stand-alone PV system.

In the previous video about the battery parameters, you have learnt the importance of having the right amount of current and voltage being provided to the battery.

You know that the battery is an electrochemical device which requires a small over-potential when it needs to charge.

However, battery technologies have strict voltage limits required for their optimal functioning.

Also, the amount of current sent to the battery by the PV array and the current being discharged away by the load have to be within required limits for proper functioning of the battery.

You have also seen previously, how a lead-acid battery responds poorly to overcharge and overdischarge.

You also know how the PV array responds dynamically to ambient conditions like irradiance, temperature and other factors like shading.

Under such circumstances, a direct coupling between a PV array, battery and load is far from healthy for the battery.

This means that we need a device that can interface 3 way - between the PV system, the battery and the load, and ensure that the electrical parameters around the battery are maintained within the battery manufacturer's specifications.

This is where the charge controller comes in.

The modern charge controller performs a multitude of functions.

These functions can further be enhanced depending on the set of technologies the manufacturer wishes to integrate within the device.

I will discuss the most basic functions here.

When the sun is shining in peak summer, there is enough PV energy meeting the load.

The excess energy is sent to the battery.

But when the battery is fully charged, and the PV array is still connected to the battery, the battery tends to overcharge.

This brings about its own set of problems like gas formation in the lead-acid battery, capacity loss and overheating, to name a few.

The charge controller here plays a vital role by cutting off the PV power from overcharging the battery.

Similarly, in severe winters when low irradiance causes the load demand to be more than the supply power, the battery is heavily drawn.

The battery under such conditions tends to be overdischarged, which weighs strongly on the battery life, as discussed in the previous block.

The charge controller under such a case prevents overdischarge by disconnecting the battery from the load.

For optimal performance, the battery voltage has to be within specified limits.

The charge controller can help in maintaining an allowed voltage range so as to ensure a healthy operation.

Also, the PV array could have its Vmpp at different levels, based on the temperature and irradiance conditions.

Therefore the charge controller needs to do an appropriate voltage regulation to ensure the battery operates in the specified voltage range, while the PV array functions at MPP.

This means that the modern charge controller can, and often does, integrate an MPP tracker within its design.

We have seen before how the battery has certain C-rates defined.

Higher the charge/discharge rates, the lower the coulombic efficiency of the battery will be.

The optimal charge rates indicated by the manufacturer could be adhered to by manipulating the current flowing into the battery.

With proper current regulation, the charge controller is also able to control the C-rates.

At the very least, the charge controller can impose the limits on the maximum allowable currents flowing into and from the battery.

Without blocking diodes, it is even possible that when the PV array is producing a very low voltage, the battery can load the PV array, or in other words, the battery can try to forward bias the PV modules and make them consume the battery power.

Traditionally, blocking diodes are used at the PV panel or string level to prevent the supposed "back discharge" of the battery through the PV array.

This function is also easily integrated these days via the charge controller.

I won't go into too much of the hardware details but most charge controllers usually have either a shunt or a series kind of controller.

In a series controller, the overcharging is prevented by cutting out the PV array until a particular voltage drop is detected, at which point the circuit is completed again.

On the other hand, in a parallel or shunt controller, the overcharging is prevented by shorting the PV array.

This means that the PV modules work under short-circuit mode, and that no current flows into the battery.

These topologies also ensure over-discharge protection using power switches for the load connection, appropriately controlled by the charge controller's algorithm.

We have seen in the previous block how the temperature plays a crucial role in the functioning of the battery.

Not only does temperature affect the lifespan of the battery, but it also changes its electrical parameters significantly.

How does the charge controller handle this situation?

A good charge controller these days comes with an in-built temperature sensor.

Therefore, it compensates for temperature fluctuations and dynamically decides how the electrical specifications like operating voltage change with temperature.

It successfully keeps the battery operating in the desired range of voltages, depending on the temperature.

For this reason the charge controller is usually kept in close proximity to the battery, so that the battery's operating temperature is close to that of the charge controller.

In extreme cases, if the battery is heavily loaded, sustained high currents might heat up the battery, and the charge controller would expect a different battery operating temperature than the actual value.

However, high-end charge controllers are being designed to also take into account the temperature effects due to high currents.

This space of developing application specific power electronics for PV systems is evolving at a very high pace.

Thus, the charge controller can go a long way in increasing the lifespan of the battery by ensuring a healthy battery operation under most conditions.

The modern charge controller has become an indispensable part of the stand-alone PV system.

Like any other component of the PV system it is expected to have a very high efficiency.

I have given you an overview of this very important power electronic device in this block.

This week has been about knowing the various components of your PV system.

In the next and the last week of the course, I would show you how these components come together and create different types of PV systems, and what are the basic things to be kept in mind before designing your PV system.

So, see you in the last week!