Indian Institute of Science

Design of Photovoltaic Systems

Prof. L. Umanand
Department of Electronic Systems Engineering
Indian Institute of Science, Bangalore

NPTEL Online Certification Course

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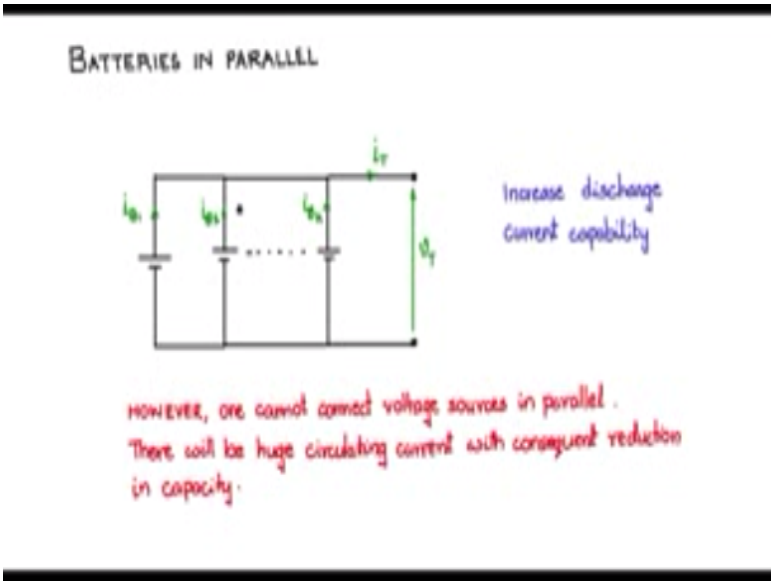

We discussed connecting batteries and series to enhance terminal voltage. If we want to enhance the terminal current, then we can connect batteries in parallel. But can we connect batteries in parallel is the question. Now let us say that we have few batteries connected like this in parallel, we have the terminal voltage Vt and you have the Ib1, Ib2, Ibn currents from each of the battery and the terminal current It is somehow Ib1+Ib2+Ibn so on.

So this will increase the discharge current capability of the whole set of the whole system. However, you should know that one cannot connect voltage sources in parallel, we have seen that earlier connecting voltage sources in parallel will cause huge circulating current to flow among them. Even if there is a small difference in the voltage, even the nano holes or micro holes, there can be a huge circulating current, because their impedances, the series impedances, resources are almost 0, and then there can be a huge circulating current.

And this will lead to reduction, huge reduction in the capacity of the whole battery set. So in general you do not directly connect to a voltage sources in parallel like this, this is not on.

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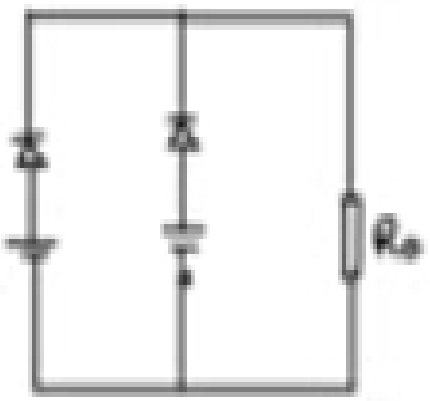

In order to avoid the circulating current problem, I could connect diode in series in each of the battery and or them and then connect it to the load like this. So in this case there will not be a circulating current between these two batteries, because of these two diodes and the oring effect will try to see that current from here and here through the load. But there is no guarantee that there will be sharing of current between the two batteries.

It depends again upon the internal impedances of the two batteries, let us say the internal impedance of this battery is less, so this will try to drive a large current. And if this has a impedance, internal impedance which is larger then there will be a drop across the internal impedance, and then this diode may reverse biased. So only this will be delivering power to R0.

So these problems may occur and you cannot grantee or ensure the sharing of current between the parallel connection then this defeats the purpose of having enhanced terminal current so what do we do we need to have some electronics come into the picture let us have a look at that.

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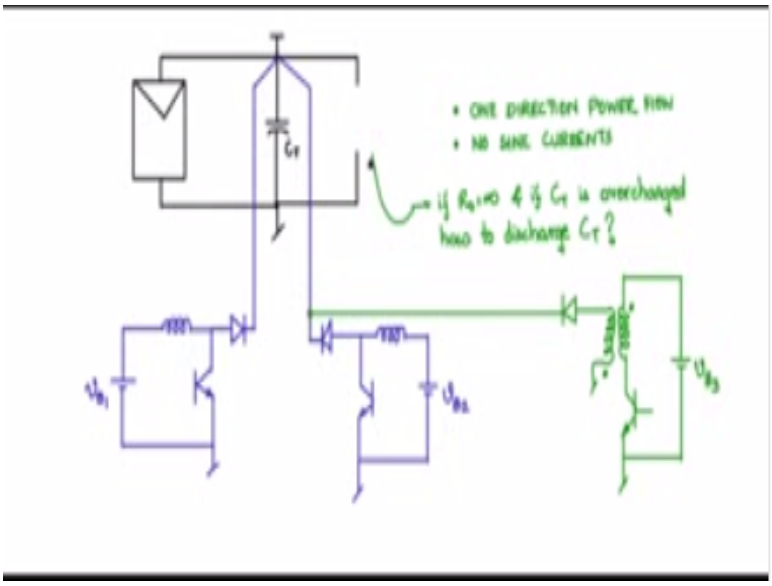

Let us now discuss how we will go about connecting a batteries in parallel to a PV application the typical PV application is like this the PV module is connected to a buffer capacitance CT like this and then we just connected to R0 when you have battery you normally connecting the battery here across this terminal but you can connect only one battery a single battery if you are having many batteries and you want to parallel them such that the terminal current is enhanced then we will have to take the aide of DC-DC converter.

So let us say that I have a battery here now this battery I want to interface it to this point how will I do that so this battery let me pass it through DC- DC converter I will take a boost converter has an example but you can take any other converter to that will suit match this battery potential with terminal potential of the PV panel where you can appropriately take the duties cycle which we have discussed earlier.

It need to be just a boost converter or a buck converter or a buck boost converter it can also be an isolated converter like a fly back converter probably I will show you an example later now let us say that this is the first part of the boost converter we have the induct and the switch and I should have a diode here let me make this to grounds combine so let us say this is the same circuit ground and here we will put the diode the boost converter circuit now becomes complete and the diode output should go to a capacitance and that capacitance will be the capacitance CT.

So the boost converter will pump the voltage from here boost it and then puts it into the capacitance CT so and the transistors switch is on the energy the power is flowing through in this

fashion current is flowing through and the energy stored in the inductor and when the switch is of the current of the inductor will flow through this diode into the CT and the back again.

So this will be how it flows now that will be one battery connected in this fashion now let us say you have another battery and let me include one more convertor and I will put the boost convertors similarly and battery will pumped when the switch is on the battery will charge up the inductor and the switches all it will flow through and diode like this, and to the capacitor here so in this way this battery let me say it is V_{B2} will pump the powers from the battery into the capacitors CD, now these two are operating independently and therefore will be having power and therefore the current will be enhanced now the point here.

To be noted is that these two batteries need not necessarily b of the same voltage this could be a 6 hold battery this could be a 12 hold battery and this could be 20 volt DC bass at the terminals so accordingly depending upon the duty cycle you can still pump energy into the CD in parallel so that with the advantage of using a PC DC convertor, you could also as I said use an isolated convertor now let us say I have a battery connected in this fashion is the same ground, now I have this battery now this battery is V_{B3}.

Now that is connected to an inductor and the switch so on the switches on energy stored in the inductor now I will pass it on to the secondary side to the inductor in this fashion so when the switch is off so when the switch is on dot is positive when the switch is off the dot becomes negative non dot becomes positive this becomes positive this will start pumping the current to this node into the CT and then it will come back here secondary of the capacity secondary of the transformer.

So you will see that you can pump energy from this battery into this buffer capacitor CT even from a non isolated the convertor so it is not necessary that you should have seen convertor same battery you can in different batteries u-tech combinational batteries we can have different convertors different types of convertors isolated non isolated.

And still pumped power into the bass capacitor in parallel one short coming of this what I have just shown is that power can flow only in one direction, on direction power flow what it means is that power can flow only from battery to CT vb1 to Ct, vb2 to CT power cannot go from CT to back vb1, vb2 because when you normally connect a battery here if there is any charge that has

to be removed that can sink into the battery, battery can act as a sink but here with this, because of this presence of these diodes they can only source and they cannot sink.

And let us say even the PV panel is having a internal diode protection diode and therefore this also cannot sink so what will happen if you need to discharge the capacitance CT, so you have no sink current capability now let us say that, this r0 is removed that it is open circuited r0 is infinite. So if r0 is infinite and let us say CT is over charged if Ct is over charged the voltage is more and needed, even it would discharge the CT.

How do you discharge the CT, the CT has no discharge power it cannot discharge through this, it cannot discharge through this, it cannot discharge through this, it cannot discharge through this, it cannot discharge through the PV because PV is having a protection series protect diode. So therefore, Ct cannot be discharged at all and it does not have a discharge path this is the one single drawback of this particular topology that I have drawn.

But we will try to elevate this problem we will see how we can remove this problem and we will try to answer the question how to discharge the CT, if it is over charge under the condition of r0 infinity or even during any other conditions where you need to remove charge from the CT.

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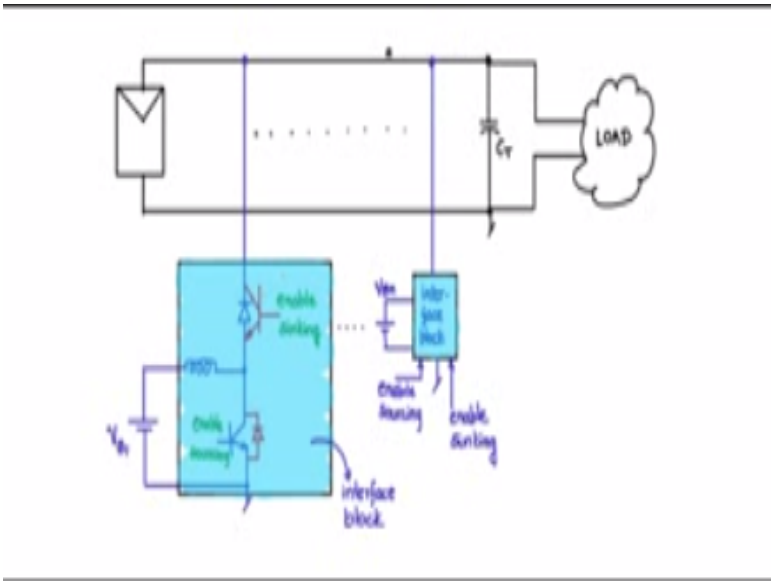

Let us now see how we can solve the problem or UT directional power flow we will make the power convertors bidirectional so first let me connect the PV source to the buffer capacitance

which is connected to the load this is CT. Now to this CT we need to set up the interface for connecting the battery, now consider a battery and like as before we will have a boost converter and I will common this ground and I will make this ground also same, same points from here diode of straight of so let me connect the time so now this portion is the convertor and switch is on energy stored into the inductor and the switch is off and energy stored in the inductor is dumped into the capacitor ct and back.

Now how do we pump power backed into the battery in case there is excess charge on ct wither due to regeneration or into regeneration beck from the load so what we shall do is make a connection like this now I am connecting a BJT here like this and across this transit or at diode I am connecting a BJT across this diode and I am connecting diode across this transistor.

Now you see now assume at this is the input source and power as to flow in this passion to the battery so if you look at that you look at only the red components BJT diode inductor battery so this forms a back convertor in this direction it forms the boost conductor in this direction battery to ct when the power is flowing in that direction then it goes operation.

It is a blue components ct to the battery they use the red components and it will be buck operations so it will become buck convertor so in this way if we use this technique then you can have power flow in both direction to and flow and you will not have this sourcing sinking problem so we will call this as enable sourcing so when you enable this and allow the pulse to come into this drive of the BJT.

This transistor is switching enable and the batteries is able to source you will have this pin also and we will call that once has enable sinking so this two accumulates exclusives and you enable sinking than this transistor is switching on or high frequency and the buck operation comes into the picture and the power is delivered into the battery from the C_T into the battery, so this way you can pump power in both the directions.

So now let us mark of this portion, so this is our main interface block between the battery and the PV terminal and this is called the interface block or parallel connection. Now this interface black you can duplicate let us say I have one more interface block like that, and I connect the battery I make this ground connection here and then I bring out this enable sourcing in out.

Then I bring out this enable sinking pin out and then after that I will connect this interface block, I will connect that, so in this way one more battery is interfaced to the C_T parallel. Now if I call this Vb1 and I will call this as V_{bn} and in-between there can be any number of blocks any number of batteries and there can be any number of such interface connections in parallel to this terminal voltage point when enhance the terminal current.

V_{b1} to V_{bn} maybe same batteries or they may be the different batteries or different types of batteries one could be lead acid battery, lithium polymer battery, one could have power high density one could high energy density, so you can have a combinations of batteries trying to get connected to parallel delivering appropriate power. These interface blocks which are basically DC convertor which could be boost fly back convertors enable this interface to happen. And by using these kinds of bi directional switches you will be able to make power flow from this direction to C_T and to this direction.

So now let us say that you are going to source you will be enabling this you will make this 0 you will not allow this transistor to switch only the diode will be used, so this is switching power is put into the C_T. Now once the C_T voltage goes high beyond a particular set specified limit and then we would like to put it into the battery. So you can enable the sinking mode this can be enable this can be disable.

So only the diode of this red component diode and this BJT will be used and bucking operation will happen and then the power will be put into the battery in this fashion we shall now see how we will get the signals consider the voltage across CT let me draw that as VT is the terminal voltage now using this terminal voltage let us decide whether we can give the signal for enabling sourcing or enabling sinking now let me draw a comparator and the output of the comparator I will comparator output to give a GATE signal and I will end with an ant iGATE.

And the other input of the AND gate I will give to clock and that clock will have duty cycle pulse like this which will actually give pass on the pulses to the switch based diagram likewise I will have one more set one more comparator and the output of that comparator goes to another AND gate it grates another AND gate input and the clock is given there so here you will get gated clock pulses in these two places now I will connect in the inputs like this okay now the first input here I will call it as VT max.

This is something that we need to set we will say that the voltage across this capacitor cannot exceed VT max that is upper limit and the other one is the sensed value of VT we will give to this and also there is pulse minus pulse and minus so let us complete the naming of the parts call this one as enable sourcing call this enable sinking other supply yeah the operation is pretty simple VT is sensitive signal VT max is constant so whenever VT is less than VT max this is high and here VT max given to the minus terminal minus pin.

So this is low so this is high when VT is less than VT max and this AND gate is enabled this AND gate is not enabled so clock pulses pass on to enable sourcing so this will be pulsing and this will act as a boost convertor so that is why power will flow from here to CT now when VT crosses VT max VT becomes higher than VT max VT is connected to minus here this will go low VT is connected to pulse here this will go high moment this goes high this AND gate is enabled this is disabled.

So enable sinking clock also goes into enable sinking it will go here and this will start switching this will not switch and therefore this will now act as buck convertor and power flows from VT side into VB1 so in this way you can have power flowing both back and forth and just by seeing sensing VT you can have a measure of regulation of the voltage across CT and the batteries as many batteries as you wish can be paralleled in this fashion.