CHARGING INFRASTRUCTURE

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Week-02

Lecture-11

Lec 11: Single-phase Boost PFC Converter - III

Hello everyone, welcome to this lecture number 11 of NPTEL lecture on charging infrastructure. In this particular lecture, we will further go into detail about a single-phase boost PFC converter. If we see in our previous discussions in our previous lecture, we have seen how this converter works, where we have a full-bridge diode rectifier followed by the boost converter. Here, this particular full-bridge diode rectifier will actually give a vd value, which is actually nothing but the modulus of vs(t), you can say, and which indicates, you know, somewhere around the variation will be the modulus of sine wt.

$$v_d = \left|v_s(t)\right| = \left|v_{s,pk} sin\omega t\right|$$

And it has the voltage with positive polarity. So, and then again, we have understood that the switches S1 and S2 need to be switched at a high frequency as that of the supply or AC input. So, we have also seen that our switching frequency f of the devices has to be greater than fs ($f_{s\omega} \gg f_s$), such that the rectified DC, which is coming across the a and b applied for that switching period, will be like a constant voltage.

Then we have derived the duty ratio, that means the fraction of the time of the switching period when the switch S1 needs to be on. We have seen that since the input to this boost converter is varying in a fashion like this. So, the duty ratio, this is the vd value. So, the duty ratio also has to be varied in such a manner that the constant Vo voltage is achieved across the load resistance. So, if we assume that our output is a constant Vo, then our duty ratio varies from between 1 to going near to 0, then again comes back to the same value one, and then again from here again it goes near to 0 and again comes to 1 and this period is nothing but 1 minus vs,peak /Vo .

$$d(t) = 1 - \frac{v_{s,pk}}{V_0}$$

So, and here we have also seen because of this particular constant we have seen that since the duty ratio need to be varied between 0 and 1 ($0 \ll d(t) < 1$, that indicates that the Vo has to be greater than vs, peak, $V_0 > v_{s,pk}$.

That means you will always get the output voltage greater than the peak value of the input sine wave. So where if we assume the 230 V as input then our peak goes to 325 V that's when the Vo has to be greater than 325 V. Generally, the common practice is to take Vo is equals to 400 V. Now, this is the understanding we got while deriving this duty ratio of time during which this S1 is on within that switching period.

While the remainder of the switching period is for S2, which will be on. So, we can say that for S2 switch, the duty is nothing but (1 minus S1). Or the duty of S2, which is nothing but 1 minus d of t, which is nothing but 1 minus this, which is nothing but the modulus of vs,peak sin wt /Vo.

$$d(t)_{s2} = 1 - d(t) = \frac{|v_{s,pk} sin\omega t|}{V_0}$$

While for S1, the duty ratio will remain the same as d of t. So, these are the understandings we have up till now regarding the duty ratio.

$$d(t)_{s1} = d(t)$$

Then, we move ahead and start sizing the different components because that is also important when designing this kind of AC-to-DC converter, which is nothing but a boost power factor correction converter. When designing it, you need to size your inductance value and appropriately size your capacitance value.

For the S1 and S2 switches, the voltage and current ratings need to be defined. Similarly, the ratings for D1, D2, D3, and D4 also need to be defined so that one can select the appropriate components. So, in that process, we have derived what the required inductance value will be. We have come across this expression, which depends upon the output voltage and the maximum ripple current value. The allowable ripple current is generally taken as 10 percent of is,peak where is,peak is the current drawn from the source. Since this converter is operated in such a manner that it draws unity power factor current, we can write is,peak or is,peak sine w t, where the phase difference between the AC voltage and the current drawn from that voltage source is in the same phase. So, we will take that allowable ripple current, which is generally 10 percent of is,peak This can be easily calculated if you know the power level for which we need to design this converter. Based on that, you can determine the value. You already know the single-phase grid voltage in our system, so using that, we can easily evaluate our is,peak value. We know this could be the maximum current in the circuit, and accordingly, we can define our allowable current. Also, if you see, the inductance value depends upon the switching frequency of S1 and S2. If this switching frequency increases, then the required inductor value will decrease for the same allowable ripple current. So, this is the condition we obtained when we derived this inductance value. Now, let us see how we can size this capacitance value.

Passive component. So, one passive component we have defined. Now, let us see how we can size the capacitance for that. Again, what will be the capacitance value needed to keep the output voltage within a certain allowable ripple? So, let us try to relook our converter. Here we have it now. Let us define this value. Since we are assuming that the converter is operated in such a manner that the unity power factor current is drawn from the AC voltage source or from the single-phase AC grid. So, the assumption is that here we are actually doing the sizing of C or the capacitor which is present. So, one assumption we have taken is that the converter is operated in such a manner that the unity power factor current is drawn from the grid.

That implies my 'is' value is nothing but is,peak times sine w t, and my vs value is nothing but vs,peak times sine w t.

$$i_s = I_{s,pk} \sin sin\ \omega t$$

$$v_s = v_{s,pk} \sin sin\ \omega t$$

Both are in the same phase, and the phase difference is 0 between vs and is. Now, since we have assumed this particular condition, we can calculate the power at the input, or we can see the power at the input.

$$P_{in} = (v_{s,pk} \sin sin\ \omega t\ )(I_{s,pk} \sin sin\ \omega t)$$

$$P_{in} = v_{s,pk} I_{s,pk} \omega t$$

$$P_{in} = v_{s,pk} I_{s,pk} \frac{(1-cos2\omega t)}{2}$$

$$P_{in}(t) = \frac{v_{s,\,pk} I_{s,\,pk}}{2} - \frac{v_{s,\,pk} I_{s,\,pk} cos2\omega t}{2} \quad (1)$$

$$P_d(t) = i_{conv}(t) \cdot V_0 \quad (2)$$

Now, this power at the input, if you do simple mathematics, is nothing but vs, peak sine w t times is,peak sin w t because these are the things, these are basically your input. This is a rectifier circuit, and this is your gross converter. So, our P input, we can calculate the amount of power at the input or the power drawn from the input you can take.

So, which is nothing but we can write this one as vs,peak is,peak sin square 2 w t. Since we have already assumed that this particular converter is operated in such a manner that the unity power factor current is on, we can write the expression in this particular format. Now, that particular thing will give you the relationship as Isp (1 - cos 2wt)/2. Now, that implies we can write Is,pk. vs,peak times is,peak /2 minus vs,peak times is,peak cos 2 w t /2, that is nothing but your input power(Pin). And we can also see if we look here, the current which is coming out of this half-bridge is I converters. Some portion is going into the capacitor, while the average value is coming through the load, and we define that average value as iL, which is actually going through the load. While the ripple portion of this or the ripple present in the I converter will be flowing through the capacitor. So, we can also see one simple thing: whatever the current which we are getting over here and the voltage which is here across at this point, we can simply write the power at the output of the half-bridge. We can write that power at the output of the half-bridge. Let me define this power as.

Now, that is nothing, but we can write my ‘I’ converter current, which is obviously bearing with time, multiplied by the value V naught, which is the voltage appearing across this particular point. Now, if you look very carefully, this particular power is also varying with time. So, we need to write Pin with respect to time. This is varying with time. So, similarly, this power, which is going into the parallel combination of RL and C, is also varying with time, where this I converter is actually varying with time. So, we can write the PD value as this one.

Now, let us define this as equation number 1. This is equation number 2. Now, if you look very carefully at this particular thing, what we see—what we have done—is we have calculated the power which has been drawn from the source and the power at this particular point. And let us take one more assumption. Assume the losses in the rectifier and boost converter are negligible. If this is another assumption we can take, then we can easily write that equation number 1 is equal to equation number 2. That means the power which is coming—which is drawn from this—is nothing but the power which is going into the branch of the parallel branch of C and RL.

So, we can write down that my Pin of t equal to PD of t. This is sometimes also called—or you can also say—by applying, I mean, you can also say that by doing the power balance. Doing the power balance. So, whatever the input coming is going actually into the output, so we can make sure we can write that Pin of t equal to PD of t.

Now, that will imply if we try to write down our equation number one and equation number two, we can write down Iconv of t times Vnaught is nothing but vs,peak is,peak /2 minus vs,peak is,peak 2cos2 w t /2 Iconv of t times Vois nothing but vs,peak is,peak /2 minus vs,peak is,peak 2cos2 w t /2. Let us see—yeah, this is the thing. So now, if we see this particular expression, we can rearrange this where we get is nothing but vs,peak times is,peak /2 (Vo-vs,peak) is,pk cos2 w t /2 Vnaught. Now, if you look very carefully, this particular expression, this is the DC quantity. If you look very carefully, this particular I converter which is at this point is nothing but comprises of this DC quantity and the quantity which is varying at this second harmonics of this line frequency because we have written w so we know w is nothing but 2 pi fs, where fs is nothing but above 50 Hz. If we are operating in India and if it is in US it is 60 Hz. So, if we see here since this particular expression has 2 w variation cos 2 w t. So, we have twice the frequency of what we have given in the input.

$$\varepsilon_q(1) = \varepsilon_q(2)$$

(By doing power balance)

$$P_{in}(t) = P_{d}(t)$$

$$i_{conv}(t) = \frac{v_{S,PK} I_{S,PK}}{2} - \frac{v_{S,PK} I_{S,RK} cos2\omega t}{2}$$

$$i_{conv}(t) = \frac{v_{s,p_k f_{sp}}}{2v_0} - \frac{v_1 p_k I\, spp\, cos2\omega t}{2}$$

So, that is why it has the component this particular current has the component which is having the second line harmonic frequency. so this is nothing but the second line harmonic current where harmonics is in terms of input line frequency that means 50 or 60 Hz so this I converter comprises of the dc quantity and the second line harmonics current, which is also sometimes called as a double line harmonic component. So now if you see very carefully this i converter which is there here is nothing but consist of a ripple and the DC quantity while here since this I converter is going into the parallel branch of capacitance and resistance so this the second harmonic component which is there will be flowing through this capacitor while the DC component which is there will be going through the load so we can write down that this I converter T comprises of ic which is again varying with time plus iL .

$$i_{conv}(t) = i_c(t) + I_L$$

so the dc component is going into the load RL while the second harmonic or the double line frequency component is going through the capacitor bank. So, let us calculate from that the ripple current which is going through this and this particular part if we see this particular component this particular part will be flowing through the capacitor, while this part will be will be flowing to the or to the load RL.

So, the current which we see over here I converter as we have derived comprises of this DC quantity and the second harmonic current which is also sometimes called as a second line harmonic current. What is the second line harmonic current? Because line harmonic means it is second line harmonic of the line frequency which is nothing but 50 Hz second harmonics of that that means 100 Hz if we have 50 Hz if it is 60 Hz it will be 120 Hz. So, since this particular second line harmonic current will be flowing through this capacitor which is responsible for generating this ripple on that capacitor voltage. So, what we have is we have a constant DC voltage over that there is second line harmonic ripple which will be riding and we will see how it looks like.

So, now we can write ic of t nothing but minus of vs,peak is,peak cos2 w t divioded by 2V naught.

$$i_c(t) =- \frac{V_{sipk} I_{s,\,pk}\ cos2\omega t}{2V_0}$$

And we can now, since this current is going through this capacitor, we can write out that the ripple generated due to the flow of ic of t by the current ic or the current going through the capacitor is nothing but we can write Voripple as 1 /C ic of t d of t and that we can take down this particular thing as minus vs,peak is,peak /2Vocos2 w t. Let us define this as equation number 3.

$$V_0,\ ripple\ = \frac{1}{c}\int\ i_c(t)dt.$$

$$V_0,\ ripple\ = \frac{1}{c}\int\ - \frac{v_{s,}p_k I_{s,pk}}{2v_0} cos\cos cos\ 2\omega t\ dt$$

(3)

And if you look very carefully, this, if you look very carefully in the previous slide, this particular thing is the DC quantity of the current, and that particular current will be flowing through this resistance RL. So, we can write this particular value, which is vs,peak is,peak /2V naught, is nothing but equal to iL.

$$\frac{v_{s,pk} I_{s,pk}}{2v_0} = I_L \qquad (4)$$

So, we can also write, we can write. It is nothing but equal to iL, which is the average DC component of current in this I converter or present in this I converter. So, now if we substitute this equation number 4, that will give you the Vo ripple is nothing but minus iL /C integrate cos 2 w t dt, I missed in dt now this we can do the integration we will complete the integration so we will get the 2 w outside and then this will be nothing but sin 2 w t and so we can see that this particular thing which is shown over here we can write this particular thing as Vnaught ripple peak nothing but iL dividede by 2 w c now if we look this particular expression that is given by 5.

$Eq\ (4)\ in\ (3)$

$$V_{0,\,nipple} = \frac{-P_L}{C}\int\ cos2\omega t.\ dt$$

$$V_{0,\,nipple} = -\frac{I_L}{2c\omega}sin2\omega t.$$

$$V_{0,\,nipple,\,ple} = \frac{I_L}{2\omega c} \qquad (5)$$

If we see this particular expression this will have the second line harmonic ripple and this ripple is riding over the average value of voltage which is nothing but the V naught. So, if we see our output voltage so it will be like something like So, if we assume this is my T and this is my vs, which is nothing but vs,peak sine w t. So, I can write I can define the Voas nothing but having the a DC quantity which is maintained at Voand over that you have the second line harmonic current, and depending upon the capacitance value, that amplitude of the ripple will be defined. If we see from equation number 5. Since it is having the sine 2 w t having the negative sign, that means it has the phase which is 180 degrees as that of so our actual voltage will also have this ripple second line harmonic ripple. Now if you look very carefully, this is having the.

The time period is just T by 2, and this is actually T. If we see, this is nothing but the frequency, which is 100 Hz. If we try to define the Voripple peak, this is nothing but our Voripple peak. If we try to see the ripple, it is from this point to this point. From this peak to this peak, and as we already defined, the ripple is nothing but delta V naught. Let us further take equation number 6 and write it in terms of this V naught. We can rearrange this particular thing and write iL /2 w Voripple peak, and 2 times the ripple peak is nothing but. So, we can write C equal to iL /w times delta Voand we can then further write this iL in terms of load power and w times delta Votimes V naught. And that we can write C is nothing but PL /2 pi fs delta Vo times V naught.

$$C = \frac{I_L}{2\omega V_{0'}\,ripple,\,pk} = \frac{I_L}{\omega \Delta V_0}$$

$$C = \frac{P_L}{\omega \Delta V_0 \cdot V_0} = \frac{P_L}{2\pi f_s V_0 \Delta V_0}$$

So, this is what we understood: the output voltage comprises the DC voltage over which there is a voltage ripple. This ripple has a variation due to the second-line harmonic current, and that particular ripple also varies with the second-line harmonic frequency. So, that's why this particular ripple will be defined in this manner.

So, this capacitor C is the second-line harmonic current and has ripple. This ripple is of second-line harmonic frequency. So, this capacitance holds the DC voltage V naught, and along with that, there is a ripple riding over that DC voltage, and that ripple has a second-line harmonic component. If the input is 50 Hz, the ripple will have a 100 Hz component. If the input is 60 Hz, the ripple in the capacitor voltage will be 120 Hz. So, this is a very common phenomenon in single-phase AC-to-DC converters, where the output capacitance has a voltage ripple consisting of a second-line harmonic frequency.

This is why we see that the capacitor size in single-phase AC-to-DC converters is one of the bottlenecks, making these converters very large in size. This capacitor is large because of the second-line harmonics. The frequency component requires us to size our capacitor in such a way that it can withstand or keep the ripple with the second-line harmonic component within the permissible limit. If we see in this particular expression of capacitance, PL is the specification generally given. Vo is again a parameter derived from the specification. So, you can say it is a specification, delta Vo is the allowable voltage ripple, which is again one of the specifications, and this fs is the line frequency, which is also one of the specifications.

So, all these things which is given here will be defined in the specification whenever the specification for this AC to DC power converter is being given to you for designing. So, using those specifications one can easily size or one can easily come to know that what will be the value of capacitance C. So, we have understood or we have seen what is the value of L which is present here we have seen what will be the value of C. Now let us try to see how one can define the rating of those switches and then we will see how one can define the rating of this diodes. So, let us see for the switch ratings how they are defined let us take for S1 switch we know that this particular S1 switch when the S2 turns on this S1 has to block the entire Vovoltage so because you know in this circuit if you take this particular circuit in this particular circuit if this S2 is on then this entire Vois appearing across this S1 switch so the voltage rating of S1 you can say that VS1 is nothing but Vogenerally when you are selecting a particular switch generally used to give a safety margin of 40 to 60 percent so you can select a device having 1.4 times of that V naught. let's say if you have Voselected as 400 volt then generally you will take VS1 which is near to 650 to 700 volt, which is coming roughly to roughly 1.4 times of that V naught. Generally, people keep the safety margin going between 40% to 60%. So, that one can choose the device going between 650 volt to 700 volt. Sometimes people have, I mean the designer have also selected 600 volt devices. That will also work.

Switch ratings for S_2

$$S_1, v_{s_1} = v_0 \; v_{s_1} = 1.4v_0 \, (40\% - 60\%) \; v_0 = 400v. \; v_{s_1} = 650v - 700v.$$

Obviously, one has to make sure that while designing the PCBs for this converter, you must ensure that the voltage across these devices is not going beyond its specified rating. So the voltage rating of the S1 switch we have defined. Now another important thing which is needed is the RMS current. So the RMS current of S1 we need to calculate. Now before that let us understand how we can calculate the RMS current from any power converter if any generalized power converter is given.

So let us take a very simple power converter. Defined by a half-bridge, which is one of the fundamental building blocks of any voltage source power converter, so we have—let's say—we have Vdc applied across this half-bridge, and the output of the half-bridge will be having We will assume we have a constant current which is being drawn from this half-bridge. This is one of the common architectures we find in voltage source converters, where the inductor is kept at the output or pole of the half-bridge. For example, if it is a buck converter, the combination of L and C is kept at the pole of the half-bridge to smoothen the voltage and current which goes into the load.

So, the large inductor at the pole of the half-bridge gives the characteristic of a constant current being drawn from the half-bridge. There will be ripple, but it is minimal. So, it can be assumed that we are having a constant current which is being drawn from the half-bridge. So, we assume that we have the constant current I naught coming out of this half-bridge, and let's define this as the Sa switch and Sb switch. When Sa is on, and at that particular time—let's say, DTs period—that means D is the duty ratio, which defines the fraction of the time of the switching period Ts. This is, you know, defined as the switching period or one by the switching frequency, you can say, 1 /f switching frequency for this generalized voltage source converter, and this is nothing but the duty ratio—the fraction of time during which the Sa switch is on. So, when the Sa switch is on, the current through Sa is nothing but I naught because that current is going through the load. You can say that it is coming out of that particular half-bridge. Similarly, when Sa is off, we can write that the current through Sa is nothing but 0. So, let us try to find what will be my RMS current or what will be my RMS current rating of this Sa switch. So, we can write Irms of Sa is nothing but—we can write—so it is nothing but a root mean square.

So, root we have to take mean. So, since the Sa is on for DTs period and this particular this Sa is off when during this 1 minus DTs period, I mean the remaining portion of the period Sa is off so some portion of the period Sa is on and the remaining portion of the period Sa is off during that time my Sb is on, so the current which is coming out of the hub bridge is going through the Sb but here we are bothered about how we can calculate the RMS current of Sa switch. So, we have to take a mean.

So, what we have understood that for DTs period Sa is on. For 1 minus DTs period Sa is off. Then again in the next cycle again for DTs period Sa is on so we have to take the mean that means we have to take the average that means we have to take the average in one switching cycle so we can write 1 /Ts, 0 to Ts and the current through Sa or i,Sa. So, let me write this as isa square times dt now we can write this particular expression as 1 by Ts so from 0 to DTs the Sa cat takes I naught current so this is I naught square plus DTs to 1 minus DTs or you can say the remaining portion you can just write Ts.

It is nothing but 0 because during 1 minus DTs period, it is 0 it is carrying 0, i mean it is having 0 current. So, it will be this one and dt now this will nothing but 1 /Ts and that will I naught will come out and that will be dt integration of dt going from 0 to DTs and that will nothing but gives you is Sa 1 by Ts I naught square. Since it is going to 0 to Dts, we will have DT which is going to 0 to Dts. I think we have 1 by TS and not square Dts. This TST has got cancelled.

That will come out to be i rms of sa is nothing but I naught coming out and the root of D. That means if you have to calculate in any generic power converter what is the rms current flowing through the switches one need to know what is the fraction of time during which the particular device is on in a switching period So, here we have assumed that for D fraction of the switching period this device S1 is on. So, we get the IRMS current going through the switch Sa is nothing but I0 which is the current which will be flowing through the switch Sa when switch Sa is on during Dts period. So, that particular RMS current is nothing but I naught times under root D.

RMS corrent of S_1

$$I_{ras,S_a} = \sqrt{\frac{1}{T_s}\int_0^{T_s}\left(i_{isa}\right)^2 dt} = \sqrt{\frac{1}{T_s}\int_0^{DT_s} I_0^2 + \int_{DT_s}^{T_s} 0]dt} = \sqrt{\frac{1}{T_s}I_0^2 dt}\, I_{mrs,S_a} = \sqrt{\frac{1}{T_s}\cdot I_0^2 t]_0^{DT_s}} = \sqrt{\frac{1}{T_s}I_0^2\cdot DT$$

So, similarly the same concept we will use and calculate the RMS current of switch S1. So, for that we have already assumed that our current at the input which is there which will be flowing through this diode bridge rectifier and this id is nearly equal to is in positive half cycle in the negative half cycle the id is nothing but equal to minus of is which is there and we have already assumed that because of the operation of this converter my is of t, 'is' nothing but is peak sine wt. So, we can say that in the positive half cycle my id or which is nothing but the iL is nothing but is,peak sin w t. Obviously, I am neglecting the high frequency ripple which will be there over this average value of this iL current.

So, that particular thing has been neglected here. So, we have assumed that this or we have assumed or we have taken the approximation that my current which is flowing through this one is nothing but this in positive half cycles. And that current is the one which will be flowing through the S1 switch when it is on during DTs period. So we can very easily write that IS1 RMS is nothing but I mean the current which is going through this switch S1 the RMS value of that we can write that 1 by T T by 2. Why we have taken 1 by T by 2?

Because only in the positive half cycle have we taken it, as in the negative half cycle, this ID is nothing but minus of ISP sine wt, and this S1 will be seeing the same variation after the T by 2 period. So we have taken the average, or we have to take the mean from 0 to T by 2 period, which is nothing but 1 by T by 2 we can take, and we can write this one as going from 0 to T by 2 is of T square, we can do times d of T. Now, what is d of T? We already know because during d of t Ts period, only my S1 is on, so that's why, as during T period, S1 is on. So, by using the same analogy as we have derived sometime before, we are using the same thing, and we can write in this particular manner. We can then put values 2 by T, 0 to T, and write is,peak square sine square w t dt was nothing but d of t is nothing but 1 minus modulus of vs,peak sine w t /Votimes, or this particular thing is integrated over 0 to T by 2. Now, using this expression, one can put this particular expression in high-end mathematical software, and you can easily evaluate what will be your iS1 RMS.

$$i_s(t) = I_{s,pk} sin\omega t. \quad i_s(t) = I_{s,pk} sin\omega t \quad I_{s1,mm} = \sqrt{\frac{1}{T/2}\int_0^{T/2}\left(i_s(t)\right)^2 dt \cdot dt} \quad I_{s_{1,mm}} = \sqrt{2/T\int_0^{T/2} I_{sp_k}^2 sin^2\omega t}$$

Because if we see in this particular expression, vs,peak generally, once you know what is the RMS input voltage, you know your vs,peak, which is nothing but root 2 times the RMS value. Once the converter is defined, the specification is defined, that means you already know what is your Vo value, so these particular two variables you know. Similarly, using the power imbalance method, you can easily calculate what is your is peak, which you expect it to be from the input set. So, for example, if someone says that you need to design the power converter of 3.3 kilowatt, so let's say my PL value someone has given is 3.3 kilowatt, that implies if we assume the efficiency to be 100%, we can say that our P input is nothing but 3.3 kilowatt. Or you can take an efficiency of 95% or 97%, which is a good estimate to calculate the Pin, which is nothing but 3.3 kilowatt /the efficiency number. So here, let us take efficiency equal to 100%, so our Pin will also be 3.3 kilowatt. That implies I can easily calculate this Pin is nothing but vs,peak is,peak, /2 equal to nothing but 3.3 kilowatt, and that will give you is,peak,. Since mostly we know what will be my AC peak input voltage, so I can easily calculate using this formula. I can easily calculate my is,peak, which is again, if we generalize this formula, it is is,peak, is nothing but PL times 2 /vs,peak.

$$P_L = 3.3kw$$

$$P_{in} = 3.3kw$$

$$\frac{V_{s,pk} I_{s,pk}}{2} = 3.3kw$$

$$I_{s,pk} = \frac{3.3kw*2}{V_{s,pk}}$$

$$I_{s,pk} = \frac{P_{in}*2}{V_{s,pk}}$$

Now, using this formula, one can also know what will be my is,peak, and thus one can easily calculate what will be the rating or what will be the RMS current rating of this S1 switch.

So, in this particular lecture, we have seen how we can calculate the capacitance value, how one can easily size the capacitance value once they know what will be my load power, as well as what will be my output voltage to be kept, as well as what is the allowable voltage ripple, and your line frequency one already knows. Because this particular converter is going for certain AC voltage, I mean, it has input which is nothing but AC voltage, so one must know what is the line frequency. So, using that three or four quantities, one can easily calculate the capacitance value. And if we see that capacitance value has the second line harmonic frequency component, and because of that, the size of capacitance is enormously high in case of any single-phase AC to DC converter. Here, we have explained the same concept using boost PFC converter, but it's the same. This concept will remain the same for different single-phase AC to DC power converters. Obviously, single-phase AC to DC power converters having unity power factor current are wrong, so that is also one important condition. Then, we have seen how we can size this switch S1. We have understood the voltage rating of S1 is nothing but equal to the V naught, which is the output voltage, and then we have understood how one can obtain the expressions of RMS current flowing through the switch in any generic power converter. Using that concept, we have also obtained the expression of RMS current for switch S1. Using this expression, one can evaluate the RMS current ratings of the devices and select the appropriate device. If one has to select the MOSFET, they can use the RMS ratings. If one has to select the IGBT, then one must also evaluate the average current flowing through switch S1, and that depends upon vs,peak, Vovalue, and vs,peak, which we already know. This is because we know to what AC voltage the converter will be connected, what the output DC voltage is, and what the peak current will be. The peak current, which will be drawn from the AC voltage source, can be expected from the power converter if it is designed for a certain power level. So, using that particular scenario, one can easily calculate what the value of is,peak will be. Thus, one can input this particular expression into any high-end computing software and calculate the RMS current that will flow through iS1.

In the next lecture, we will see how to calculate the RMS current going through the iS2 switch. We will also examine the ratings of these diodes and then proceed further to explore how we can implement closed-loop control of this power converter. Thank you for patiently listening to this lecture. Thank you.