Course Name: Power Electronics Applications in Power Systems

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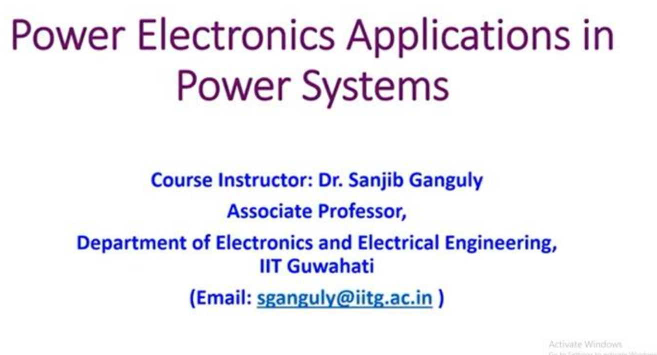


Lec 22: SVC in enhancement of transient stability of power systems

Welcome again to my course Power Electronics Applications in Power Systems. So, in the last lecture, I started a new module for discussion that is the application of static var compensator in power systems. Now, this implies to the fact that SVC can be used, static power compensator can be used in the enhancement of the power system capacity or power system capability in various aspects. For example, in the last lecture I have shown you that how can a SVC be used in enhancing the power transfer capacity of a transmission line. I have mathematically shown you how can it be possible and for doing so what should be the rating requirement of SVC that also I discuss and it I have also shown you that the ideal to enhance the power transfer capacity of a transmission line to twice of the uncompensated line by using an SVC placement at the midpoint of the transmission line. It is possible to have this increase in transfer capacity of twice of the uncompensated line.

So, practically the size of that compensator or size of the SVC which would be required for doing so would be very large. So, therefore, this to limit the capacity of the SVC to a practically feasible value So, we can do one thing that we can use this SVC for increasing the power transmission capacity up to a certain value of this line loading and then beyond that we can use it as a fixed capacitor. Remember, I discussed the same problem when I talk about this midpoint compensation in general. So, if we do so, then I explain that up to a certain line loading, up to a certain amount of line loading, the SPC can provide the required amount of compensation, what is required to increase the power transfer capacity and beyond that it will act as a fixed capacitor. So, therefore, this will make it possible to have a practically feasible size of SVC. Then I also started the discussion on SVC in improving the transient stability of power system. I explained what transient stability is and I also explained how an SVC placement can improve the transient stability of a power system. In this particular lecture I will continue to that. So, let us proceed.

So, if you can remember in my last lecture look at I discussed this equal area criteria for uncompensated line and also for midpoint SVC compensated line. Now, for the uncompensated line, if I repeat the explanation once again very briefly, then you can see that this is what the P delta curve, P means power transfer and delta is the angular difference of this sending n bus and receiving n bus. So, this is V at an angle delta, this is V at an angle 0, this is receiving n bus for example and this is sending n bus. So, depending upon the loading of this line, this amount of this, the value of the delta will get changed. And if we plot this P versus delta characteristics, so this will be plot.

Now, suppose if there is a, so without having any fault. So, suppose this is what the operating condition which is represented by delta 1. So, this is what the operating point at which the system is working. Now, what do you mean by this operating point? At this particular point, this P make that is the mechanical power is equal to the electrical power which is represented by these characteristics. Now, when it is happening, so here P make is basically mechanical power. Now what do you mean by mechanical power? I hope that you understand. Mechanical power is the power available in the shaft of the electrical generator and electrical power is the output of the electrical generator. So at this operating point, this mechanical power and electrical power will be equal. So this is our operating point. Now suppose there is a fault in the line which is represented by this, then what will happen? The electrical power would be 0.

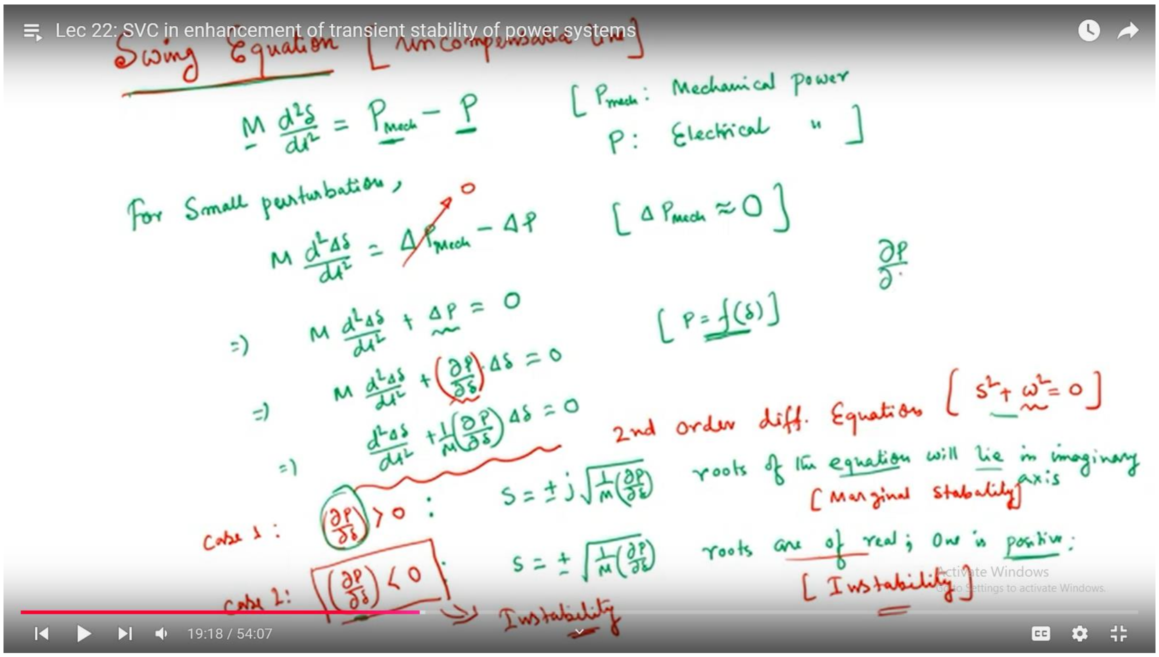
Mechanical power will however continue to the value as it is. Now, this will make the machine increase in its speed, and suppose at this particular point which is represented by delta, the fault is cleared, this fault is of transient type and this fault is cleared. Then, what will happen? At this particular point, again electrical power is that much and mechanical power remains same. So, therefore, electrical power becomes higher than the mechanical power. So, what will happen? Followed by this, the machine will continue to decelerate and it will increase the value of this delta further. And, at this particular value, suppose represented by delta 3, this accelerating area, which is represented by this hash given by this, which is P mechanical multiplied by this difference of this delta 2 to delta 1, this is equated with the deceleration power, which is represented by this hash area. So, this is what the equal area criteria I hope you have gone through this in very well in electrical power system course. Now, again there exists a value of delta which is represented by delta max which represents that if delta 3 is shifted to delta max means that this fault clear is delayed to some value of this delta higher than delta 2 and this delta 3 is exactly superimposed with delta max. Then, it is possible that this equal area criterion would be satisfied. Now, the equal area criterion is the essential condition to have the stable operation of the system.

Now, therefore, the maximum value of this delta 3 would be equal to delta max. And beyond which if delta 3 wants to shift, then it would be not possible to have a stable operation. So, therefore, it is recommended that this delta 3, it should be distant from this delta max as possible. And thus, this area which represents under this particular characteristics represented by red hash is called marginal area. It means that there is a margin of this stability if delta 3 is located at this point and it is far away from the delta max.

Now, this explanation is for the uncompensated line. For the midpoint compensated SVC line, you can see, so suppose this is what the counterpart of delta 1 is, write it delta 1 C to represent it is delta 1 compensated, delta 1 for the compensated line. And, this one is the point where the fault is cleared. Let us represent it by delta 2 C. Here, superscript C is representing this delta 2 for compensated line. And, this is supposed delta 3. So, delta 3 C. And, this is what? This delta max C. So, you can see if you have the same explanation for this compensated line as well, this marginal area which is available to retain the stability of the system is much higher than this. So, this whole explanation gives us that the marginal area of the SVC compensated line is higher than the uncompensated line, because from this eventually you can see that delta this ACmax which represents the marginal area of the compensated line is greater than or much greater than this ACmar which represents the marginal area is higher than this Amar.

So, it means that for the midpoint compensated SVC line, we have a more distant or more available area to keep the system stable. So, that is how the SVC can improve the transient stability or that is how the SVC or rather the presence of SVC can ensure a higher degree of transient stability for the SVC compensated line. Now, we will go further with this and show how SVC further improves the transient stability of a power system. In order to discuss that, let us start with this another important concept of the power system which is called the swing equation. This is again taught in the electrical power system course.

Now, what do we mean by swing equation? So, I will start with initially the swing equation for uncompensated line. Now, what is the swing equation? This swing equation says that this if you ignore the damping, now eventually we consider that the system is lossless. So, therefore, if when a system is having no loss, so there is no damping as well. Why it is so? I will come to that. Even it is taught also in the power system course. Now, if there is no damping in the system basically in synchronous generators which are operating in conventional power plants there are two torques or two power components exist. One is power developed by the turbine that is the power available at the shaft of the generator and another is the power generation by the generator. So, one is called mechanical power, another is called electrical power. Their relation, the relation between this mechanical power and electrical power is represented by the swing equation. So, according to the swing equation, we know m d 2 delta d t 2 is equal to P mechanical minus P electrical.



So, it is basically as you know P mechanical represents mechanical power, mechanical power available at the shaft of the machine and P basically represents the electrical power output of the generator. M is basically, you know, the constant, inertia constant. So, this represents the swing equation. So, if P make, for a stable operating condition, P make is ideally equal to P, so that there is no advancement of this delta, no rate of change of this delta, but delta magnitude will be there. Now, if we take a small perturbation, for around the stable operating point, this equation can be written as m d 2 del delta d t 2 is equal to del p mech minus del p.

Now, this del p mech it is the change of this mechanical power, it is virtually equal to 0, because this mechanical power cannot be instantaneously changed, followed by a small time interval. So, therefore, this we consider that this is equal to 0. So, therefore, this equation can be rewritten as m d 2 del delta d t 2 plus del p is equal to 0. Now, we know that this del p what it is actually it is the change of the active power, and if we consider that the compensated line is symmetrical and at the both ends the voltage magnitudes are regulated and they are kept as fixed and they are kept as constant. So, therefore, this del p is basically function of del delta.

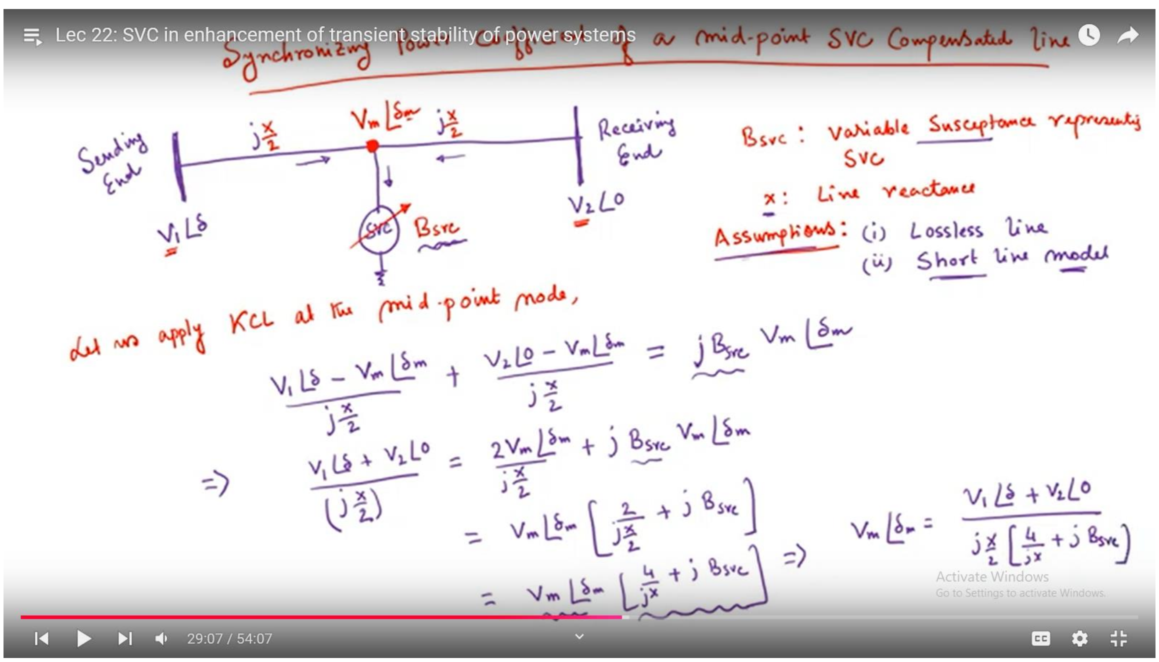
So, we can write this is basically equal to m d 2 del delta dt2 plus del P del delta multiplied by del delta is equal to 0. Because you know this P is basically function of delta only. It is function of other parameters, but they are fixed. P is the function of P is equal to V square by x sin delta for a short line where V is the voltages at both the end, x is the line reactance for a lossless line, ok. So, therefore, p is, since v is square by x, this is constant. So, therefore, this p is a, p will proportionally vary to a sin delta or delta, ok. So, therefore, we can write this. So, now, you can see there is a terminology which is coming out to be del p del delta. Now, we can write this as a, the same equation as d 2 delta d t 2 plus del p del delta upon 1 by m. I am just dividing the whole equation with del delta. So, this is equal to 0. Now, what is that order of this differential equation? This is a second order differential equation, differential equation. And, the solution of this will be, if you convert it to the Laplace domain, will be equal to s square plus omega square equal to 0, where omega is the frequency of the oscillation. So, therefore, you know that, there are two possible cases. So, this will basically follow the second order differential equation that is s square plus omega square is equal to 0, where omega is basically equal to 1 upon m dp d delta. Now, you know there are one case 1, where this dp d delta is greater than 0 and case 2 is del p del delta less than 0.

So, suppose there are two cases if we consider so. Now, what will happen if dp d delta greater than 0? So, then this value of s will be equal to plus minus j root over 1 by m del p del delta. So, this will be so roots of the equation will lie in imaginary axis imaginary axis Whereas, if dp d delta less than equal to 0, then what would be the solution? If it is less than equal to 0, so this will be equal to plus minus root over 1 upon m del p del delta. So, this means here roots are real, one is positive, another is negative. Roots are of real one is positive, another is, in fact, both would be positive rather, but the roots are real, and one of them will be definitely positive.

Now, when we have so, we know that when these roots of the characteristic equation lie in the imaginary axis, so this is a case of marginal stability. this is what the control system knowledge we have. Whereas, when one of the roots is real, can be real, then there is a instability. This implies to the instability in the system. So, therefore, this dp d delta less than 0, it implies to instability. So, this is one of the important criterion even if I do not discuss I think this is known to those who have understood the power system stability part. So, here you can see the importance of this value this del P del delta. In fact, this del P del delta, del P del delta is basically known as synchronizing power coefficient. So, it basically represents the stiffness of the system, how much strip it is towards this disturbance. So, a higher value of means, you know, a positive value of dp d delta is basically the primary condition for the stability.

That is why you know that in here, we consider that. This is the maximum delta corresponding to pi by 2 is the maximum operating point, the maximum theoretical operating point of a transmission line. Because this, up to this you can have this positive dp d delta. Beyond that d delta, del p del delta would be negative. Therefore, we cannot operate it. okay, that will not provide any stable operating point. So that is something already discussed in the power system course, any basic power system course. And I just revisit this idea once again. The idea of this particular lecture would be to see how this del p del delta this particular quantity is getting affected for the midpoint compensated or rather midpoint SVC compensated line. That is what we will try to see in this part of the lecture. So, what we will see is the synchronizing power coefficient of a midpoint HVC compensated line.

So, this is something we need to see over here. So, this is something we need to see. So, in order to understand this, let us consider a transmission line. here this is sending end side, this is receiving end side, the voltage of the sending end site let us consider V1 at an angle delta, the voltage of the receiving end site let us consider V2 at an angle 0. So, this is receiving end, this is sending end. At this midpoint of the line, there is a SVC connected okay. Now how we will represent this SVC, SVC already we have talked this SVC is represented by a variable susceptance that is VSVC. So VSVC is the model or rather the variable susceptance; susceptance representing SVC. Now, suppose this reactance of the line is x by 2 and x by 2.



Let us apply KCL at the mid-point node

$$\frac{V_1\angle\delta - V_m\angle\delta_m}{j\dfrac{X}{2}} + \frac{V_2\angle 0 - V_m\angle\delta_m}{j\dfrac{X}{2}} = V_m\angle\delta_m \left(jB_{SVC} \right)$$

$$\Rightarrow \frac{V_1\angle\delta + V_2\angle 0}{j\frac{X}{2}} = V_m\angle\delta_m\left(jB_{SVC} + \frac{2}{j\frac{X}{2}}\right)$$

$$\Rightarrow V_m\angle\delta_m = \frac{V_1\angle\delta + V_2\angle 0}{j\frac{X}{2}\left[\frac{4}{jX} + jB_{SVC}\right]}$$

$$X_e = j\frac{X}{2}\left[\frac{4}{jX} + jB_{SVC}\right] = 2 - B_{SVC}\frac{X}{2}$$

$$\Rightarrow V_m\angle\delta_m = \frac{V_1\angle\delta + V_2\angle 0}{X_e}$$

Equate real and imaginary parts of L.H.S with R.H.S

$$V_m\cos\delta_m = \frac{V_1\cos\delta + V_2}{X_e}\ ;\ real\ \ part$$

$$V_m\sin\delta_m = \frac{V_1\sin\delta}{X_e}\ ;\ imaginary\ \ part$$

$$\Rightarrow V_m = \frac{1}{X_e}\sqrt{V_1^2 + V_2^2 + 2 * V_1V_2\cos\delta}$$

The power flow of the line due to the mid-point SVC placement is,

$$P_{comp} = \frac{V_1V_m}{\frac{X}{2}}\sin\frac{\delta}{2}\ \ or\ \ \frac{V_2V_m}{\frac{X}{2}}\sin\frac{\delta}{2} \qquad \left[\delta_m = \frac{\delta}{2}\right]$$

$$As\ \ V_m\sin\frac{\delta}{2} = \frac{V_1\sin\delta}{X_e}$$

$$P_{comp} = \frac{V_1^2}{\left(\frac{XX_e}{2}\right)}\sin\delta = \frac{V_2V_m}{\left(\frac{XX_e}{2}\right)}\sin\delta$$

The denominator of the compensated power equation will be

$$\frac{XX_e}{2} = \frac{X}{2}\left[2 - B_{SVC}\frac{X}{2}\right]$$

$$\frac{XX_e}{2} = X\left[1 - B_{SVC}\frac{X}{4}\right]$$

So, basically, x is the line reactance. And most importantly, we have considered again some assumptions here. What are the assumptions we have considered to derive? So, the first assumption is that the line is the lossless, lossless line. And second assumption is that since x is the line reactance I specified, that means automatically we are considering short line model, short line model, which is somewhat different to what we discussed as a long line model. In fact, if you can derive the expression of the synchronizing power coefficient for a midpoint SVC compensated line for a short transmission line model, then automatically you can be able to do the same computation or same derivation for a long line as well.

Those things will come later on. So, this is what the assumption. Now, what we will do again? So, here since it is midpoint of this line, let us consider voltage at this midpoint is Vm and the angle is del m. Now, if this is a symmetrical line that is v1 is equal to v2, then we know that also the value of vm and we know del m is will be equal to del by 2, but we are not doing so here. Let us keep it del m considering that v1, v2 are different. Now, what we can do is that we can apply KCL at this particular node.

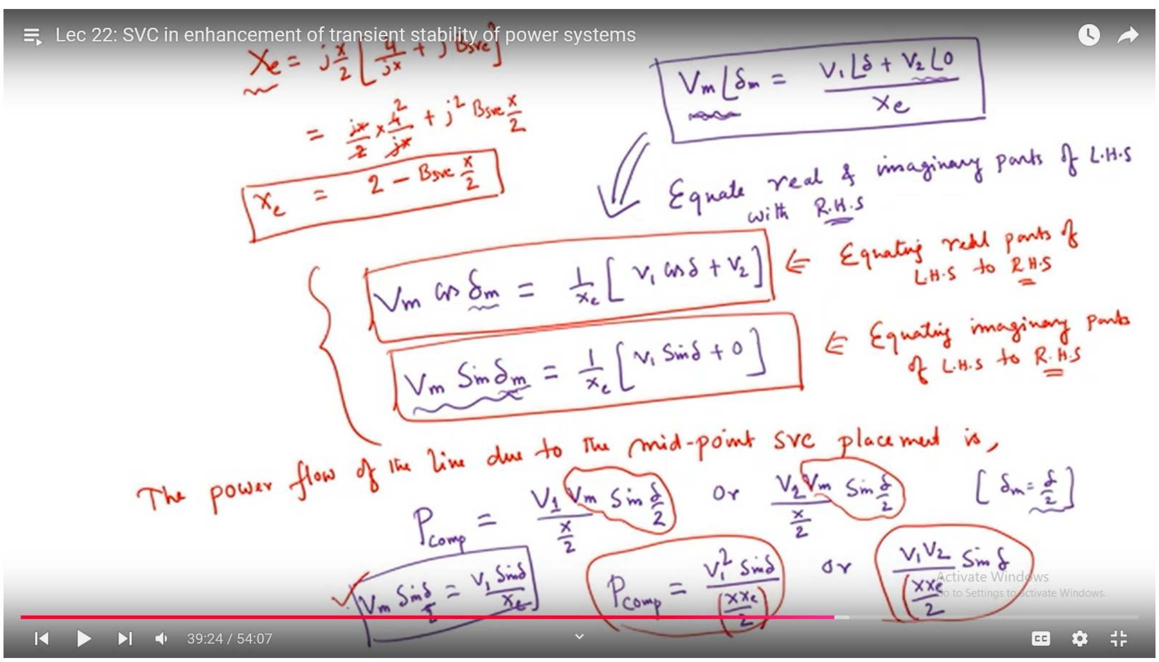
So, let us apply Kirchhoff's current law, KCL at the midpoint node. So, if we apply KCL at this midpoint node, what would be my KCL equation? The KCL equation would be, so current coming in from the sending end to the midpoint will be v1 at an angle delta minus vm at an angle del m divided by x divided by 2. So, this is what the incoming current coming from the sending end to the midpoint. Similarly, current coming from this receiving end to the midpoint would be equal to the v2 at an angle 0 minus vm at an angle del m divided by x by 2. And if you sum up these two, then this would be equal to the outgoing current, which is current flowing through the SVC.

Now, what would be the current flowing through the SVC? We know that this SVC is represented by a variable susceptance that is B SVC. So, that will be equal to the current drawn by this SVC, which is equal to J B SVC multiplied by this voltage that is V m at an angle del m. So, you know that J B SVC is representing the SVC, the susceptance of the SVC. Now we will do the simplification of this equation. So what we will do is that we will bring this all this Vm term to the other side and we will keep the other side here which are non-Vm term that is V1 at an angle delta plus V2 at an angle 0 divided by x by 2.

So, this is equal to, so if we bring this term and that term in that equation, so this will be equal to 2 Vm at an angle del m divided by x by 2 plus j Bs Vc Vm at an angle del m. Now, this we can further simplify, considering this V m del m outside. So, if we consider so, so this will be equal to 2 divided by x by 2, another, this will be equal to plus j B SVC. We can write it as a v m del m so this is nothing but 4 by x plus j B SVC, I have done a mistake over here. Basically, since we have considered j term to represent B SVC so I should term j.

I should use j term here as well so this will be j over here this will be j over here. This will be j over here and this will be j over here. So, there will be j term over here, this will be j term over here as well. So, this is something that you should understand. Now, what we can do is, we can find out what is that v m del m in terms of this.

So, in order to form this equation, what we can write is this v m at an angle del m is equal to v 1 at an angle. So, what I did is this particular component I just multiply with the denominator of the other side that is left hand side equation. So, what I will get that is v n at an angle delta plus v 2 at an angle 0 divided by j x y 2 multiplied by 4 by j x plus j b s v c. Now, what we will do is, we will consider, so this is what we get, first of all, this is what we get, the equation of the midpoint voltage in terms of the sending end voltage, receiving end voltage and the impedances we have. Now what we will do again, we consider the entire denominator that is j x by 2 multiplied by 4 divided by j x plus j BSVC is equal to X e. Let us consider that X e is basically representing the whole denominator of this right-hand side of the equation. Now, what we will get this now? So, we can write if we just copy this over here once again. So, this X e is basically representing if I see what it is, it is equal to j x by 2 multiplied by 4 by j x plus j B SVC. I think I have written this equation correctly j x by 2 multiplied by 4 plus j x plus j B SVC.



So, this is representing X e. Let us consider this X e is something like equivalent reactance or something like that or that will come later on. So, what I can write, I can just multiply this here. So, what I will get? So, this will be equal to this j x divided by 2 multiplied by 4 by j x plus j, j if we multiply this will be j square B SVC multiplied by x by 2. Now, here you can see that j x j x will be canceled out. So, 2 and 4 will have this 2, j square means minus 1. So, this B SVC x by 2. So, this is what xc. It is independent of j term.

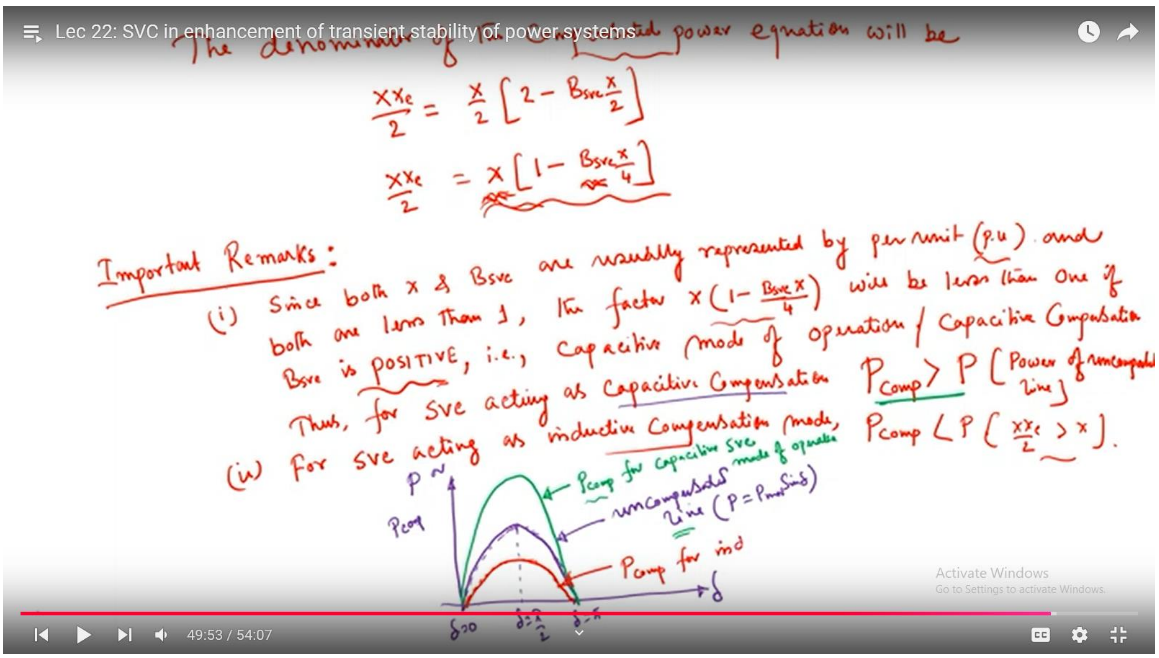
That we can see over here. It is independent of j term. So, what about this other equation? Other equation, we got the main equation, which is this. So, what we can copy from here is vm del m is equal to this v1 at an angle delta plus v2 at an angle 0 divided by x. This is another equation we get, okay. Now, from this particular equation, from this particular equation, if we just, you can see this left-hand side and right-hand side, both you know phasor form or phasor representation and they are in polar form. So, what we can write we can equate this real and imaginary part of this left hand side equation with right hand side equation right hand side expression.

So, what we will get? So, if we just equate with this real part of this left hand side which will be equal to V m cos del m. So, basically this V m at an angle del m is a representation of V m cos del m plus V m J V m sin del m. So, basically real part is V m cos del m. And, this equation is 1 upon xc multiplication of v1 cos delta plus v2. This is what this equating real part. So, this equation we get equating real part, real parts of left hand side to right hand side of this equation. So, this is one equation that we get. Another equation we get by equating the imaginary part, which will be V m sin del m, which is equal to 1 upon x e. So, what will be that imaginary part of V 1 at an angle delta? So, it will be V 1 sine delta and what would be the imaginary part of V 2 at an angle 0? That would be 0; that is 0.

So, this is what another equation we get. This equation we get equating imaginary parts of left hand side to right hand side. So, we get two equations. Now, both the equations will be useful in further derivation because you can see here our goal is to determine the synchronizing power coefficients. So, we have to go long way to find it out. Now, what we can do is that further we need to find out this compensated power flow through the line due to the placement of the SVC at the midpoint. Because you know that when there is a midpoint compensation, the active power flow through a transmission line will also get changed. This I have shown you at the very beginning, okay, when I discussed this power flow due to midpoint compensation. So here also it is natural that this power flow will get changed because of the midpoint SVC. So we need to find out the expression for that. So the power flow of the line due to the midpoint SVC placement is, what would be that? This will be you know, this is will be equal to P compensated power.

This is equal to this, you can look at this particular segment, one is V1 at an angle delta, and another is this Vm at an angle delta. So, the power flow of this would be equal to this V1 multiplied by this V m divided by the angular difference of del m and this delta which will be equal to delta by 2 already we have explained. And so the equation of this will be equal to either this V 1 V m divided by x by 2 sin delta by 2 or this will be equal to v 1, v 2, v m which divided by x by 2 sin delta by 2. Both are equal, both should be equal.

Both should be equal because del m would be equal to delta by 2. This is already I have shown you various times. Now if it is so, now what we can see, if we can consider that del m is equal to del by 2, so you can replace this by sin delta by 2, this one you also can replace it by cos delta by 2. So therefore, this v m sin delta by 2 is equal to this v 1 sin delta divided by x e. So, if we can put over here this is the equation if we consider that del m is equal to del by 2 which is the angular displacement at the midpoint voltage. So, if you put it this expression over here then just means that we are just replacing V m sine delta by 2 with this.



So, here you can see that in both the equations we have V m sine delta by 2 this equation also having V m sine delta by 2. So, if we just replace this with this, then what we will get? We get P comp. is equal to for this particular equation it will be v1 square sin delta divided by x xc divided by 2. If we put this vm sin delta by 2 in this particular equation or it will be equal to this v1 v2 then divided by x e, x x e by 2 multiplied by sin delta. So, either of these equations would be true. And if we consider v 1 is equal to v 2, both equations will be eventually equal. So, both the equations will be true for representation of this active power flow of the line, active power flow of the line, ok. Now, here you can see that the denominator is of the both the equations are same, which is representing x, xb, xc by 2 and we know that xc is equal to this. So, therefore, the denominator of the compensated power the denominator of the compensated power equation will be x xc divided by 2, which can be written as x by 2 multiplied by xc, we know it is equal to 2 minus, you can see over here, it is representation of 2 minus this equation, 2 minus BSVC multiplied by x by 2.

So, it is equal to 2 minus BSVC multiplied by x by 2. So, that is what the representation. It can be written as, x if we just put this 2 inside multiplied by 1 minus Bs Vc x by 4. So, this is the representation of x xc by 2, which is the denominator of the compensated power. Basically, you can see over here is that, although this x xc by 2 is the denominator, but it has some impact in change in power flow, because you can see here v 1 is constant, v 2 is constant and if we consider this delta for a particular loading, so delta will be also same. So, for a particular loading, we can change the compensated power by changing the denominator this.

Now, how can we change this denominator? Denominator is possible to change, because here you see x is constant, x is the line reactance. B SVC is a parameter, which represent the susceptance of the line SVC, which is this. And this is variable, you can see this is variable, by varying the susceptance of the SVC. The denominator of the compensated power flow of the transmission line can be changed or can be regulated. So, that is one thing that you can learn over here. Now, what we can do over here is that important remarks, important remarks. So number 1, so if we consider that this X is in per unit and B SVC is also in per unit, so since both X and B SVC are usually represented by represented by per unit that is p dot u, you know all this power system quantities usually represent in per unit for various reason. So, therefore, what we can write and both are both are less than 1.

So, you know that per-unit quantities can vary from 0 to 1. So, both are less than 1. The factor x multiplied by 1 minus that is this factor I am talking about x multiplied by B SVC multiplied by x divided by 4. This will be less than 1 if BSVC is positive. Now here is one thing that you can remember, when I discuss this SVC, for example, the TSCTCR, you can see that this SVC susceptance can be a positive, can be of negative, as well. Now, when this SVC susceptance is positive, this is something you should understand, when this SVC susceptance is positive, when there is a capacitive mode of operation, that means whole, you know, the SVC will act as a capacitive mode and it, certain amount of reactive part to the system.

So, during that time this SVC, this B SVC would be positive. And when this B SVC will be negative? Ans: It is operated as an inductive compensation mode. So, that means, the whole SVC is used to consume a certain amount of var from the system. So, that is something already I discussed. So, when, so that means, this factor will be less than 1 when the B SVC is positive. So, that is, that is capacitive mode of operation, mode of operation or capacitive compensation. So, therefore, thus for capacitive compensation for SVC acting as capacitive compensation P comp that is compensative power would be higher than this P that is uncompensated power of the uncompensated line power of uncompensated line. So, that is what you should understand. Now for inductive compensation, for SVC acting as inductive compensation, acting as inductive compensation mode P comp will be lower than P. Why it is so? Because when it is acting as inductive compensation, B SVC is negative, meaning that the whole equation would be higher than x, ok. That means this, there will be an additional term of this, in this particular equation above this x.

So therefore, it is basically, this whole x xc by 2, in this case, x xc by will be higher than x and that is what is it is happening and that is why in fact I told you during this drawing of this particular characteristics for midpoint SVC compensated line I told you when this SVC is acting as a fixed capacitance. So, it will act as a, this particular characteristics will be shifted like this. So, I will revisit this idea once again. It means that, suppose this is P-delta characteristics, P delta characteristics, or P comp, P comp is the compensated power.

Suppose this is the P delta characteristic corresponds to uncompensated line. This corresponds to uncompensated line. So, this is what the characteristic, it represents exactly a sin delta and you know this corresponds to delta is equal to 0, this corresponds to delta is equal to pi by 2 and this corresponds to delta is equal to pi. Suppose, this is the characteristics of this uncompensated line, which is representing P is equal to P max sine delta, then for compensated line acting as a capacitive mode of operation will be something like this. So, this will be P comp for the capacitive SVC mode of operation or capacitive mode of operation of SVC. So, this it means that this P comp would be higher than this uncompensated line power. Similarly, when this will be operating in the inductive mode of operation, the characteristics will be something like this.

So, this is what pcomp for inductive mode of operation of SVC. So, this is something is very important, you can see. So, SVC can change, the placement of SVC can change the power flow through a particular transmission line. And how can it change? Ans: By changing simply this magnitude of B SVC. So, BSVC can be positive, BSVC can be negative, as well. So, when BSVC is positive, SVC is operating in a capacitive mode, and when BSVC is negative means that it implies to that the SVC is operating in the inductive mode.

So, therefore, this power flow through the transmission line will accordingly change. So, my goal of this particular lecture is to clarify this gap that we have drawn in the earlier lecture. So, this is basically, this characteristic corresponds to this SVC for this unlimited compensation when SVC can provide an unlimited compensation to hold the midpoint voltage constant. This is what the characteristics, this is what the characteristics, correspond to this characteristics, and corresponds to SVC for fixed capacitor mode of operation. This is SVC for fixed capacitor mode of operation. That is why I told you in this particular lecture that for a practical SVC what it is done is that it follows these characteristics where SVC can provide unlimited compensation up to a certain point when it reaches the rating of that SVC and beyond which it will act as a fixed capacitor.

So fixed capacitor characteristics is something like this. This is what the fixed capacitor characteristic which is, of course, the above the, this uncompensated line, for uncompensated line the characteristics was this, for the uncompensated line this characteristic was this, this is what the characteristics for uncompensated line, this is what the characteristics of a fixed capacitor line and this are what the characteristics of this SVC, when we assume that SVC can provide unlimited compensation for this, for holding this midpoint voltage constant. This is something you should understand and the mathematical aspect of this already is explained in this today's lecture. That means you will come to know by today's lecture how this SVC mode of operation or different modes of operation of SVC can change or can result in the change of the active power flow through the transmission line. This is what the point I want to make here. So, in the next lecture, we will continue this derivation till we arrive at this our goal that is we are interested to determine the synchronous power coefficient of a midpoint SVC compensated line.

This we will continue in the next lecture. So, thank you very much for attending this part of the lecture. Thank you.