Course Name: Power Electronics Applications in Power Systems

Course Instructor: Dr. Sanjib Ganguly

Department of Electronics and Electrical Engineering,
Indian Institute of Technology Guwahati

Week: 07

Lecture: 03

Lec 23: SVC in enhancement of synchronizing power coefficient

Welcome again in my course Power Electronics Applications in Power Systems. In the last few lectures, I am discussing the application of static var compensator in power systems. And in the last lecture, I discuss or I started discussion on how a SVC placement at the midpoint of a lossless short transmission line can improve the synchronizing power coefficient of the system. I explained in the last lecture what is synchronizing power coefficient and why it is so important and what is its role in power system stability. So therefore, we will continue to this derivation in this lecture as well. We will come up with an expression for the synchronizing power coefficient for a lossless short transmission line.

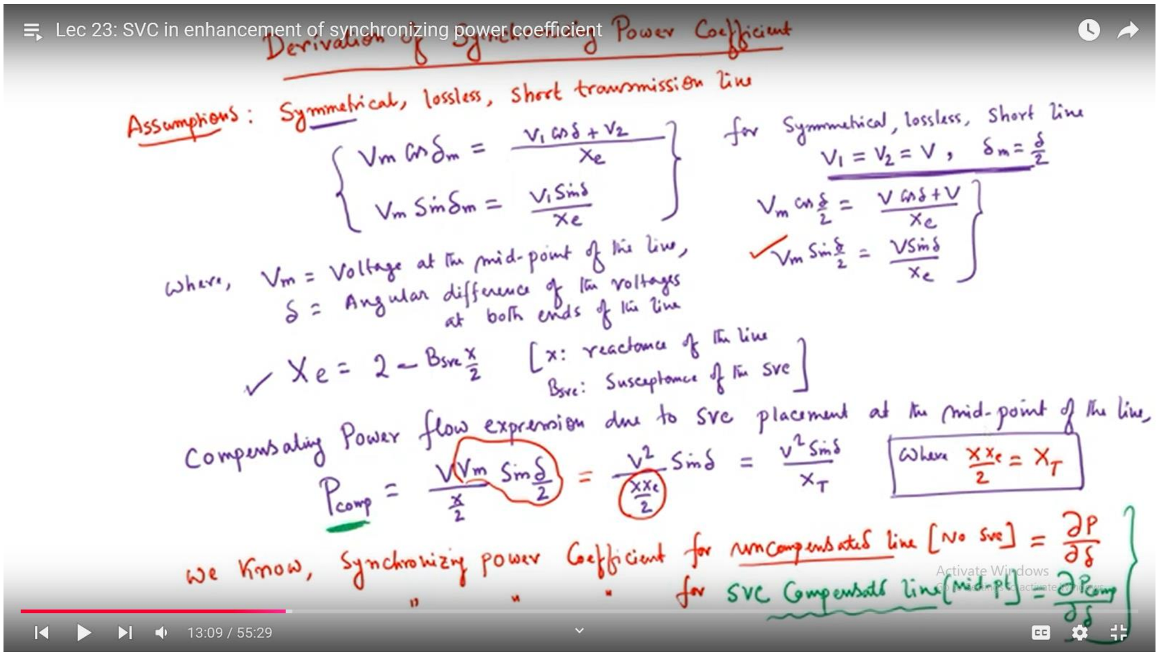
So, let us move forward and see what we were discussing in the last class. So, we are here actually, we are deriving the expression of synchronizing power coefficient, synchronizing power coefficient of a midpoint SVC compensated line. Now, we considered at the midpoint of this transmission line, we have a SVC and SVC is modeled as a variable susceptance. So, here is our assumption is that we consider lossless line, we consider short line.

Now, in addition to that, we will consider also another assumption that the line is symmetrical in nature. As of now, we have seen all the derivation for this particular course. I consider this assumption as well, that is the line is symmetrical. Now, what do we mean by symmetrical transmission line? Symmetrical transmission line implies to the fact that the voltage at the both end of the line would be regulated and they would be made constant. They would be equal and they would be made constant irrespective of the loading. So, for this particular system, here we arrive at this expression. So, we will move forward with this expression. We will let us find out this expression for synchronizing power coefficient. So, I will write again. Derivation of synchronizing power coefficient coefficient for symmetrical lossless short transmission line: Here our assumptions are we have symmetrical lossless short transmission line short transmission line.

Now with this assumption we will proceed further and we will rewrite the expression that we received or that we derived in the last lecture that is these two expressions. This voltage representing this V m is basically representing the voltage at the midpoint as you can see. So it is the voltage at the midpoint and del m is basically representing the angle of the voltage at the midpoint of the transmission line. So, therefore, we will rewrite this expression once again, V m cos del m is equal to 1 upon x c or let us write x in the denominator and numerator it is v 1 cos delta plus v 2 and v m sin del m is equal to v 1 sin delta divided by x e. These are the two expressions we derived in the last lecture.

These are the two expressions we derived at the last lecture, but this does not consider that we have a symmetrical line. So, for symmetrical line, for symmetrical lossless short line this expression would be as we know that for symmetrical line v1 is equal to v2, let us consider this is equal to v. So, this expressions will be vm and we also know that for symmetrical line del m is equal to delta by 2. So, this is we already derived in previous lecture when I discussed midpoint compensation of a transmission line. So, therefore, this equations will be 1 is V m cos delta by 2 will be equal to V cos delta plus V by X c and V m sine delta by 2 will be equal to V sine delta divided by X c.

So, just I replaced this V 1 and V 2 equal to V and I also replaced del m is equal to del by 2. Now, you know that here, so V m is what? V m is the voltage at the midpoint of the line. Delta is the angular difference of the voltages at both ends of the line. Already if you can recall this circuit single-line diagram that I had drawn, that V1, sending end voltage was V1 at an angle delta, receiving end voltage on V1, V2 at an angle 0. So angular difference between sending end voltage and receiving end voltage is delta, which is easy to understand. And, we also have derived the expression for X c, which is equal to, if we can go back and see, X c is equal to what? X c is equal to this, 2 minus B SVC X by 2. So, 2 minus B SVC multiplied by X by 2, where X is the reactance of the line or line reactance and BSVC is susceptance of the SVC which is connected at the midpoint of the transmission line. So, this is already known to us. Now, what we will be interested from this? We will be interested to find out the compensating power or compensating power flow expression due to SVC placement at the midpoint of the line what would be that? That we already derived that P comp is equal to V, V m divided by x by 2 multiplied by sin del m. Now, we will put these values of this v m del m.



❖ Derivation of synchronising power coefficient

Assumptions: Symmetrical, lossless, Short transmission line

$$V_1 = V_2 = V,\ \delta_m = \frac{\delta}{2}$$

Compensating power flow expression due to SVC placement at the mid-point of the line,

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

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

Where, $V_m =$ Voltage at the mid-point of the line.

$\delta =$ Angular difference of the voltages at both ends of the line.

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

$X =$ Reactance of the line.

$B_{SVC} =$ Susceptance of the SVC.

Compensating power flow expression due to SVC placement at the mid-point of the line,

$$P_{comp} = \frac{VV_m}{\frac{X}{2}} \sin\frac{\delta}{2} = \frac{V^2}{\frac{XX_e}{2}} \sin\delta = \frac{V^2 \sin\delta}{X_T}$$

Where, $X_T = \frac{XX_e}{2}$

We know, synchronizing power coefficient for uncompensated line = $\frac{\partial P}{\partial \delta}$

Synchronizing power coefficient for SVC compensated line [mid-point] = $\frac{\partial P_{comp}}{\partial \delta}$

For SVC compensated line, $P_{comp} = \frac{V^2 \sin\delta}{X_T}$

$$V_m = \sqrt{\left(V_m \cos\frac{\delta}{2}\right)^2 + \left(V_m \sin\frac{\delta}{2}\right)^2}$$

$$= \sqrt{\left(\frac{V(1+\cos\delta)}{X_e}\right)^2 + \left(\frac{V\sin\delta}{X_e}\right)^2}$$

$$= \frac{V}{X_e}\sqrt{(1+\cos\delta)^2 + \sin\delta^2}$$

$$= \frac{V}{X_e}\sqrt{1+(\cos\delta)^2 + 2\cos\delta + (\sin\delta)^2}$$

$$= \frac{V}{X_e}\sqrt{2+2\cos\delta} \qquad ($$

$$V_m^2 X_e^2 = 2V^2(1+\cos\delta)$$

Let us differentiate both side with $\frac{\partial}{\partial \delta}$

$$2V_m^2\left(\frac{\partial X_e}{\partial \delta}\right)X_e = -2V^2\sin\delta \Rightarrow \frac{\partial X_e}{\partial \delta} = -\frac{V^2 \sin\delta}{V_m^2 X_e}$$

$V_m =$ Constant irrespective of loading (δ)

$$P_{comp} = \frac{VV_m}{\frac{X}{2}} \sin\frac{\delta}{2} = \frac{V^2}{\frac{XX_e}{2}} \sin\delta = \frac{V^2 \sin\delta}{X_T}$$

Synchronizing power coefficient of mid-point SVC compensated symmetrical, lossless, short transmission line.

$$P_{comp} = \frac{V_1 V_2 \sin\delta}{\frac{X}{2} X_e} = f\left(\delta, X_e\right)$$

$$k_s^{'} = \frac{\partial P_{comp}}{\partial \delta} = \frac{2V^2 \cos\delta}{XX_e} - \left[\frac{2V^2 \sin\delta}{XX_e^2}\right] \frac{\partial X_e}{\partial \delta}$$

$$= \frac{V^2 \cos\delta}{X_T} + \left[\frac{V^2 \sin\delta}{\frac{XX_e^2}{2}}\right] \left(\frac{V^2 \sin\delta}{X_e V_m{}^2}\right)$$

$$= \frac{V^2 \cos\delta}{X_T} + \left[\frac{1}{X_T}\right] \left(\frac{V^2 \sin\delta}{X_e V_m}\right)^2$$

$$= \frac{V^2 \cos\delta}{X_T} + \left(\frac{P_{comp}}{V_m}\right)^2 \cdot \frac{X^2}{4X_T}$$

For uncompensated line

$$\frac{\partial P}{\partial \delta} = \frac{V^2 \cos\delta}{X}$$

The net increase of synchronising power coefficient for SVC compensated line

$$\Delta k_s = \frac{V^2 \cos\delta}{X_T} - \frac{V^2 \cos\delta}{X} + \left(\frac{P_{comp}}{V_m}\right)^2 \cdot \frac{X^2}{4X_T}$$

$$= V^2 \cos\delta \left[\frac{X - X_T}{X_T X}\right] + \left(\frac{P_{comp}}{V_m}\right)^2 \cdot \frac{X^2}{4X_T}$$

$$\therefore k'_s = \left(k_s\right) + \Delta k_s$$

$k'_s > k_s$

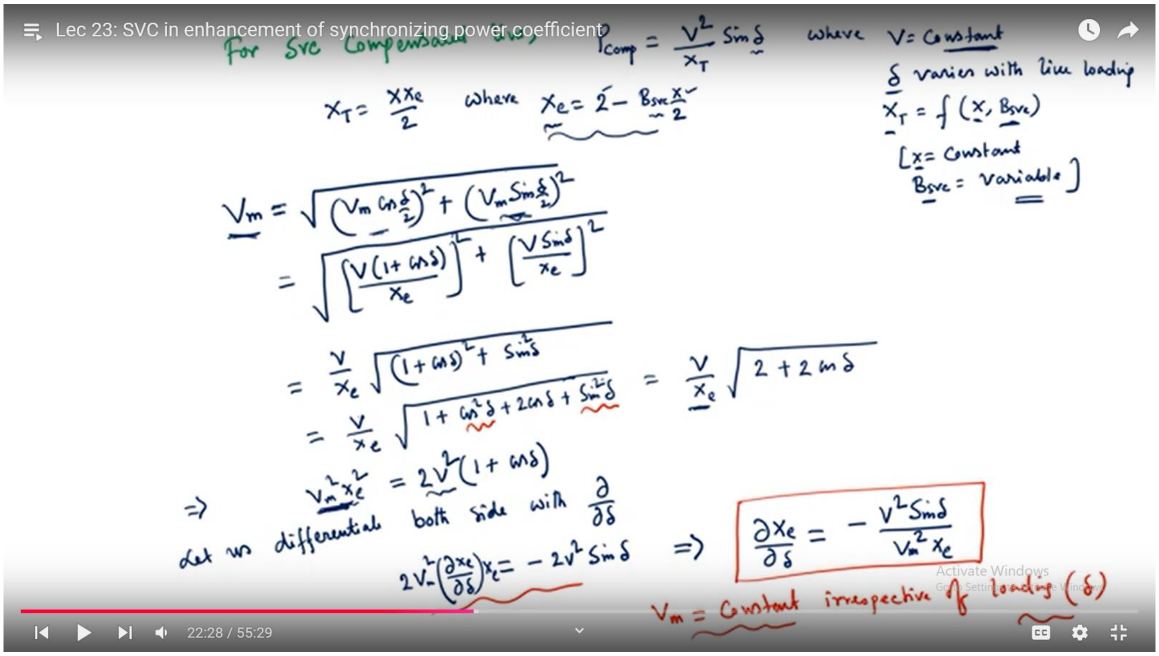
So, del m is here delta by 2. I just simply replace this del m by delta by 2 and we know that this v m sin delta by 2 is this. So, let us replace this. So, what we get is if we replace this, then this will be v square divided by, here x c would be there, here denominator, here x by 2 will be denominator, so this will be x x c by 2, then sine delta. Now, if we consider that this x x c by 2, the denominator, that is this x x c by 2, let us consider as X t. So, this expression would be then V square sin delta divided by So, this is whereas, where we consider X t is equal to X X c by 2, X c is already we determine X we know that it is line reactance. Now, what we will do is that we know the synchronizing power coefficient. So, we know what is synchronizing power coefficient, synchronizing power coefficient expression is basically for uncompensated line, let us start with uncompensated line. Let us assume that there is no SVC over here, so that means no SVC, then this will be equal del P del delta. You can see already we have explained this in the lecture before.

So, this d P d delta is basically representing the synchronizing power coefficient. So, synchronizing power coefficient is d P d delta, del P del delta to be more correct. Similarly, for synchronizing power coefficient for SVC compensated line S-V-C compensated line, where we have S-V-C at the midpoint is equal to this del P comp del delta. And we have to show that there is a difference between these two expressions. And let us see what is that difference. If one is dp d delta, another is dp com del delta. Now dp d delta can be easily determined. I am coming to that. So let us first determine that SVC compensated line del synchronizing power coefficient. So, to do so, so what we need to do? We need to differentiate this P comp with respect to delta. Now, here you can see this P comp is a function of v which is regulated at the both end. So, v is constant over here. It is also function of this delta. It is also function of xt. Now, we have to see that this delta as you know, delta depends upon the line loading. X t basically depends upon X t is a function of this X plus B SVC. So, let us write this. So, for SVC compensated line, compensated line, what is actually we get? P comp is equal to v square divided by xt sin delta where v is constant and regulated at the both end. This is what the property of symmetrical transmission line we consider and delta varies with line loading. So, it is a variable and X t is a basically function of again that X and B SVC.

Now, you know that X is constant because it is line reactance it cannot be changed, but B SVC can vary, it is a variable according to the control strategy of the SVC. I already explained that we can finally model the SVC by a simple variable susceptance. Now, the susceptance of that particular SVC can be controlled according to the our requirement. So, BSVC is variable, BSVC can be variable with respect to delta as well, but X is remain constant, so as this V. So, therefore, what we have to see is, we know that Xt is function of X and BSVC.

In fact, Xt is equal to X Xc by 2 where Xc we know that it is equal to 2 minus Vs Vc multiplied by X by 2. So, that is already determined in the last lecture that is this expression. And, so what we will do is that, we know that x c will get changed because v s v c will get changed. Other than that x is constant, 2 is constant, so it would have been constant. But here we are interested to change the B SVC according to the loading, so that we can improve the synchronizing power coefficient. So, first thing that we have to develop is, in this particular expression, we have two variables, one is delta, another is x e. So, I have to find out the dependency or differential equation of this d x e or del x e with del delta. In order to find out this, let us find out the magnitude of this Vm, rather this Vm, because we already consider symmetrical lossless transmission line. So, we can write that Vm is equal to root of Vm cos del by 2 whole square plus Vm sin del by 2 whole square. I think this is you understood because cos square del y 2 plus sin square del y 2 will be equal to 1.

So, I can write this. Now, I will put the expression of V m cos delta y 2 from here, V m cos delta y 2 from here. So, what I will get? Let us see. So, this will be equal to V 1 plus cos delta divided by x c whole square plus this will be, I can put this expression of Vm sine delta by 2 from this expression as well. So, what I will get here? This is V sine delta divided by xc whole square and then square root of this will be equal to Vm. I just simply replace this Vm cos delta and Vm sine delta from the previous expressions. Then what we will get, this is equal to 1 upon Xc root of, so we know that this is, if we just bring V even outside, so then what we will see is, or rather, so I can put this V so that this becomes equal to 1 plus cos delta square plus sin delta square or sin square Now what is this actually? You know that 1 plus cos delta square is basically can be splitted to V divided by X c root of 1 plus cos square delta plus 2 cos delta plus sin square delta. Now, again this summation of cos square delta plus sin square delta will be equal to 1. So, therefore, this can be written as v by x e square root 2 plus 2 cos delta. Now, from this expression, I can write that v m square x c, I just put this x in the left hand side equation, v m square x c square is equal to v multiplied by, or rather if we take 2 outside, so 2 v 1 plus cos delta. So, is it correct? So, it is correct.



So, this is what the correct expression. Now what we will do is, one thing I did not do over here is that, if we just take this square of this v m, so x u will be square, so as the square of the v, so this will be the correct expression. Now what we will do is that, let us differentiate both side with del del delta. So, what we will get in this side, we will be having this expression as 2 V m square, V m square will be differentiated. So, you know that V m square, V m can be considered to be independent of this del, but V m will also vary with del. So, therefore, if we just differentiate with this. So, this side will be 2 v m square del x e del delta and this side v is constant. So, therefore, 2 v square plus 2 v square plus cos delta 2 v square is a constant if we just differentiate with respect to delta. So, this will be minus 2 v square sin delta. So, therefore, from this we can find out del X e del delta is equal to minus V square sin v m square, here since we are differentiate with respect to this x e, so another x e term would be there, so that x e square is differentiated with respect to delta that is 2 x e d x e d delta, so one x e term would be here as well.

Now remember, here this is done considering that v m will be kept constant irrespective of loading or irrespective of the change of the delta. So, this differentiation is based upon the assumption that Vm is kept constant irrespective of the line loading, okay. So, which is one of the, you know, goal for SVC placement at the midpoint of the transmission line to keep the midpoint voltage constant irrespective of the line loading. So, this derivation is based upon this assumption as well, that we consider Vm constant irrespective of the line loading. So, this is one expression we get. Now, we know that this P comp is this and X t is basically function of X c as well. So, if we write it in the next page, so what we can write as, so from the previous page, I can just copy this P comp is equal to P comp is equal to v square divided by xt sin delta. So, what is the expression? This expression gives you the expression for power flow of the midpoint SVC compensated short symmetrical lossless transmission line. So, where we can, we know that X t is equal to X x e by 2. So, this can be written as V square sine delta divided by X x e divided by 2.

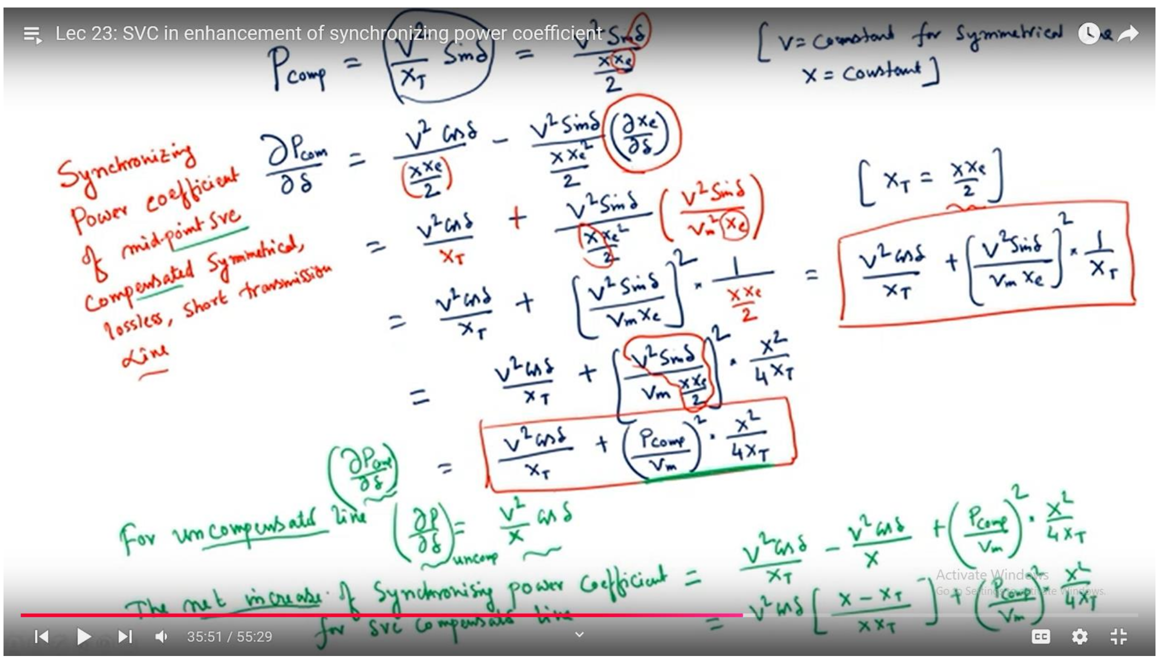
So, as we said that here V is constant. V is constant because we consider symmetrical line for symmetrical line and x is also constant. Line reactance cannot be changed. It depends upon the line design and as long as there is no change in the design, the line reactance will be constant, not change, unchanged. So, only parameter that will vary with respect to this delta is this x c and this delta itself. So, therefore, if we take differentiation, let us say del p comp delta, so what we can write is, it is equal to, so here are two variables, one is this delta itself, another is x c, which can vary with the line loading. So therefore, we can write it as a, if we assume that first x c is constant, so we can write this is equal to V square divided by x x c by 2 cos delta plus this v square. Let us consider delta constant now, sin delta multiplied by x x c. Now, here you know that if we differentiate with respect to delta, that is 1 upon x c, so this will be equal to minus, this will be equal to square, this will be equal to 2. So, this multiplied by del x c del delta. So, this is the differentiation of x c with respect to del delta.

Now, what we can write? This, let us write v square cos delta divided by x c, x x c by 2, which let us consider that this is x t. So, this is x t. Then this part is v square sin delta divided by x x square by 2 multiplied by this del x del delta. Now what we will do? We will put this del x del delta expression what we got in the last page. So that is this. So, if I copy and this expression there, so since there is a negative, so this will be positive multiplied by, let us see what it was, v square sin delta, it was v square sin delta divided by v m square x c, v m square x c. I just simply put this del Xc del delta at this particular expression. Now we will keep on simplifying this. How we can keep on simplifying? So this will be as it is, this will be V square cos delta divided by Xt, where you know Xt is equal to what? It is equal to X Xc by 2 and plus this v square sin delta and v square sin delta are already there. So, we can write v square sin delta square and v m and x c square are there.

So, just I am just keeping v m and x c and v square sin delta within a square that I can write right. Then what we will get? This multiplied by 1 upon this x would be there, this x by 2 would be there, this xc would be there. So, this multiplied by x xc divided by 2. Now, what is that x xc divided by 2? That can be written as xt. So, we can write it again this is equal to v square cos delta divided by xt plus v square sin delta divided by vm xc whole square multiplied by 1 upon xt.

So, that is what the synchronous power coefficient that is what the synchronous power coefficient of the symmetrical lossless short transmission line. That is what the, this is what the synchronous power coefficient, synchronizing power coefficient of midpoint HVC compensated symmetrical lossless short transmission line. So, this is what the expression of synchronizing power coefficient of symmetrical lossless transmission line. Now, we can do further derivation of this. How can we do further derivation? So, let us consider because you know that we already know that this v square sin delta divided by xt basically equal to p comp.

So, we can write this as a v square cos delta divided by xt plus this v square sin delta v square sin delta divided by V m, I am just multiplying x by 2 inside this square. So, what I have to do is, I have to, since I have divided this x by 2 here, so I have to multiply x square by 4 here divided by x d. Now, what we know that this V square sine delta divided by this, this is nothing but X t which is this, so this can be written as P comp, so this is equal to, this is equal to V square cos delta divided by X t plus, so this is basically P comp. So P comp divided by V m whole square multiplied by x square divided by 4 x t. So, this expressions we got from for the synchronizing power coefficient of the midpoint SVC compensated line.



So, this is what our expression final expression is. What was the expression for uncompensated line? This del P del delta was how much? We know that here for uncompensated line, what would be the expression of P? Look at this single-line diagram. So, for uncompensated line, for uncompensated line, what would be the expression for P? P will be equal to this v1 v2 divided by x sin delta. And since we consider v1 and v2 are equal for symmetrical line, so this will be expression of the power flow for uncompensated line, since v1 is equal to v2. That we are, since v1 is equal to v2 for a symmetrical line. So, if we just differentiate with respect to del delta, so what we will get v square x is here constant because v is the voltage of both end which is regulated by the consideration of symmetrical line x is constant.

So, therefore, del p del delta will be equal to v square x cos delta. So, we can write this is equal to v square by x cos delta. So, this is synchronizing coefficient for uncompensated line, uncompensated line. And this is what the synchronous power coefficient for compensated line. So, what is the difference of these two? So, you can see if we just compare this with this, this is having an additional term, which means that the synchronizing power coefficient when we have midpoint SVC compensated line will be higher than the uncompensated line.

So, therefore, the net increase of synchronizing power coefficient for SVC compensated line would be equal to this minus this. So, this will be equal to V square cos delta divided by X t minus V square cos delta divided by X plus this plus P comp divided by V m square multiplied by X square 4 X t. So, this can be written as if we take v square cos delta common. So, this can be written as x 60 x minus x t plus p com v m whole square multiplied by x square So, this is what the net increase of synchronizing power coefficient.

So, this is something is very important to understand. So, when we have a SVC at the midpoint of a transmission line, irrespective of whether it is a short line or long line, it will increase the synchronizing power coefficient. Here we consider the short line, but this can be shown that this is the same thing will happen to be true for the long line as well. So, important remark over here is that, remark is that the above exercise or above derivation shows the presence of SVC in a transmission line, in a lossless transmission line improves or increases the synchronizing power coefficient, which is an important parameter in transient stability. And already I discussed the significance of synchronizing power coefficient is that it measures the stiffness of the line. How steep it is due to the fault and similar kinds of large disturbances.

So that is eventually improved with this SVC compensated line that we can mathematically show here. Now, here one thing that you can see, I discuss that here our assumption in whole discussion was that the role of the SVC will be to keep the midpoint voltage constant irrespective of the loading, in fact. And our all the previous studies are also based upon this consideration only that the role of the SVC is to keep the midpoint voltage constant irrespective of the loading. But, this has some practical deficiencies which I already discussed. First of all that to do so whatever the size of SVC we require that will be very large and that would be practically infeasible.

That is one of the bottleneck of that. But apart from that, it is also not advisable that always you need to maintain the midpoint voltage constant. There are some occasions SVC can also be useful in modulating the midpoint voltage and these are very dynamic changes and these are very short-duration changes. So, therefore, we will also see the role of the SVC in the modulation of midpoint voltage and thereby its impact on this power system stability. So, so far from my discussion, I considered the role of the SVC in improving this or enhancing the transient stability in terms of increasing the stability margin, in terms of the increase in what we call synchronizing power coefficient. But apart from that, it can also be useful for creating damping of the system.

So, those things we will be discussing mostly in the next lecture. I want to give some of the feel or some of the core idea of this right now. So, this is the first remark. This is one of the remarks and a second remark was SVC can also increase the stability margin. So, those things I already established with mathematical analysis and the conceptual idea. Now, what we will see over here is that the role of SVC in power system damping.

If you can remember at the very first lecture of when I started this module that is application of SVC, I said that SVC can increase the steady state power transfer capacity which I have already shown. Now, I have shown that how can SVC impact on this transient stability of the power system. Then, what I am going to show right now, which I will continue in the next lecture is how it is useful in damping the power system oscillations. Now to do so, we have to come out from the idea that SVC would always maintain this midpoint voltage constant. Rather, we need to understand that, to dampen the power system oscillations, SVC can be useful in particular by providing or by enhancing appropriate damping.

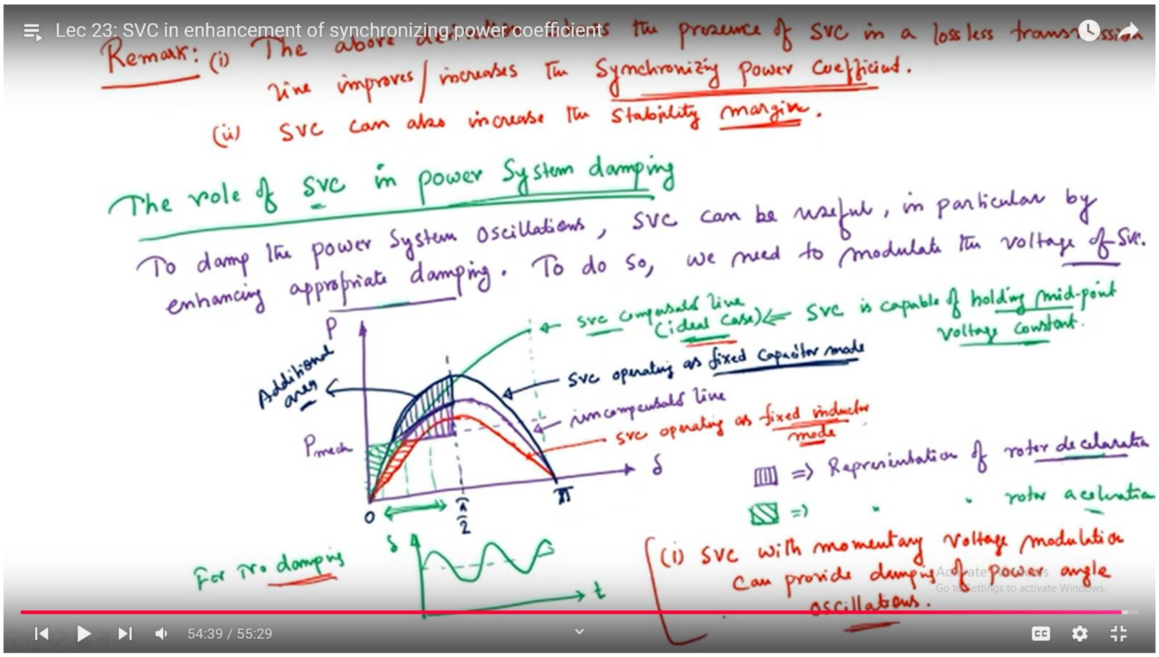
So, this is something very important and to do so, we need to modulate the voltage. So far our discussion was limited to the fact that we always planned that SVC should be capable to hold the midpoint voltage constant. But this will hold true for steady-state analysis, but for dynamic cases in particular to enhance the damping we need this SVC to modulate the voltage at the midpoint and thereby it can improve the damping. How it can improve? Let us see pictorially.

So, let us again revisit this idea with this P delta characteristics. Suppose this is the P-delta characteristic for the uncompensated line. So, this is supposed P-delta characteristic for the uncompensated line. Now, suppose this is what the mechanical power, this is what P mechanical and this is what the operating point. Now also I have seen that this, if we consider that SVC is designed to hold the midpoint voltage constant, then it will revise this P delta characteristic, something like this. So this is for the SVC compensated line providing the ideal case, providing that SVC is capable of holding.

So, the ideal case in the meaning that SVC is capable of holding the midpoint voltage constant. So, when we will design the SVC to hold the midpoint voltage constant, this will be the characteristic. However, that SVC can be also modeled as a fixed capacitor or a fixed inductor mode. So, this is the characteristic corresponds to SVC operation at the fixed capacitor fixed inductor mode.

So, here SVC operating at operating as fixed inductor mode. Why it is so? Already I explained in the, I already mathematically derived this expression and I explained over here. In the inductive mode of operation, the characteristic will be something like that.

Now, so for the inductive mode of operation, it will be something like that. Now, this is the fixed inductor mode of operation and when the SVC will be operating as a fixed capacitor mode, the characteristic will be something like this. So, this is for SVC operating as fixed capacitor mode or fixed capacitor mode of operation.



Now one thing that you can see over here is, that already I explained that the theoretical maximum limit of the stability is this, which corresponds to delta is equal to pi by 2. This is delta is equal to pi. So this is what the theoretical maximum stability limit. Now you can see that this hatch area, this hatch area beyond this operating point represents the deceleration area. This hatch area is basically representation of deceleration area. Now, what is that stands for? So, this hatch area is the representation of rotor deceleration, where the rotor decelerates. Now, why it decelerates? because in this particular region, the electrical power is above the mechanical power. So, that is why rotor will decelerate. However, this particular area This particular area is representing rotor acceleration. In fact, this was hatched in a different way in order to avoid the confusion I hatched the way it is shown in the figure.

So, this is the representation of rotor acceleration. Now, higher and higher this area would be better. You know actually without damping if we consider the whole line to be lossless, the rotor will keep on accelerating and decelerating and it will change from the point of this, from the operating point to the fault clearing or maximum value of delta. It will keep on increasing the value of delta and it will keep on reducing. Now we need some sort of damping of this. So basically if we, for no damping, for no damping what it would be, if we plot this delta with respect to time, then it would be something like that.

So, it will accelerate and decelerate and it will like that. We need some sort of damping to this, so that it will quickly settle to some point and that is what is called power system damping, that is what called power system damping. Now, what is the role of SVC is, it can momentarily change or modulate the voltage, so that you can increase this deceleration area and also this acceleration area. How it is possible you can see, instead of operating it a ideal case when it will be responsible to hold the midpoint voltage constant, If we use it as a fixed capacitor mode, now what is the role of the fixed capacitor? Fixed capacitor mode means it will momentarily increase the voltage at which the SVC is placed, then it will get some additional deceleration area like this, this is what the additional deceleration area. This is what the additional area, additional area by momentarily increase the voltage at which this SVC is placed by operating as a fixed capacitor mode. Similarly, here also when we need damping to descent, so instead of using it for the ideal case, if we use for fixed inductor mode, what a fixed inductor mode does, it momentarily reduces the voltage.

And, to do so, you will get this is the additional area, if we operate at fixed inductor mode. So, instead of keeping this SVC voltage constant, if we can modulate it, we can improve the system damping. And, that is exactly done by this SVC. In fact, that is done by STATCOM as well. When I will discuss this, I will again revisit and show you that the same discussion will be hold for the STATCOM, Static Synchronous Compensator as well.

So, therefore, two important comments that you can note down, one is number 1, SVC with voltage modulation or rather I should say that momentary voltage modulation can provide damping of power angle oscillations. So we will revisit this idea in the next class once again and show you how can you model this SVC and you can effectively provide damping of the oscillations or damping of the oscillations of the power angle in more detail. So thank you for your attention. Thank you.