Power Quality
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Modeling, Simulation and Performance of on DVR
Lecture - 11
Active Series Compensation (contd.)

Welcome to the this course on Power Quality. Today we like to discuss this Modeling, Simulation and Performance of Dynamic Voltage Restorer.

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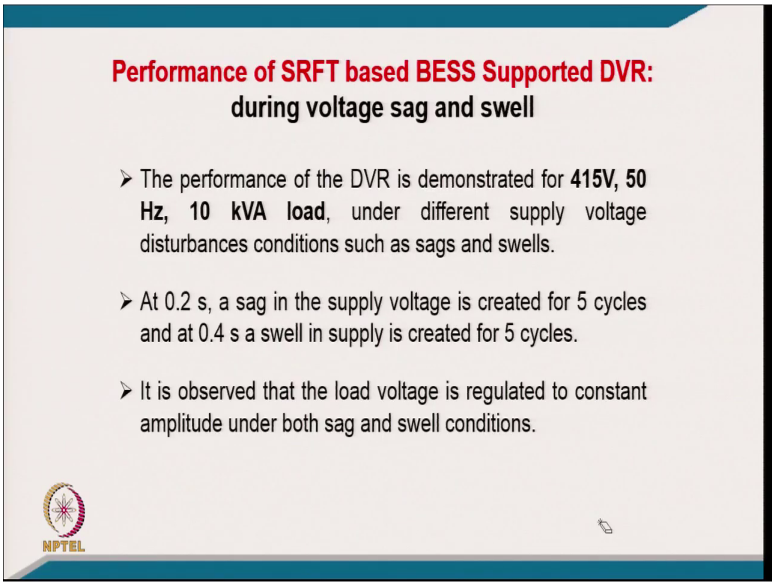

Ah The performance of synchronous loading reference frame BESS supported DVR we like to discuss first with that during voltage sag and swell. And the performance of the DVR is demonstrated here for 415 volt, 50 hertz, 10 kVA load under different supply voltage disturbances conditions such as voltage sag and voltage swell. At of course, we will discussed with the time domain a sag in the voltage is applied.

First for (Refer Time: 00:58) 5 cycles and then swell for 5 cycle and it is observed that load voltage is regulated to a constant amplitude under both voltage sag and voltage swell condition.

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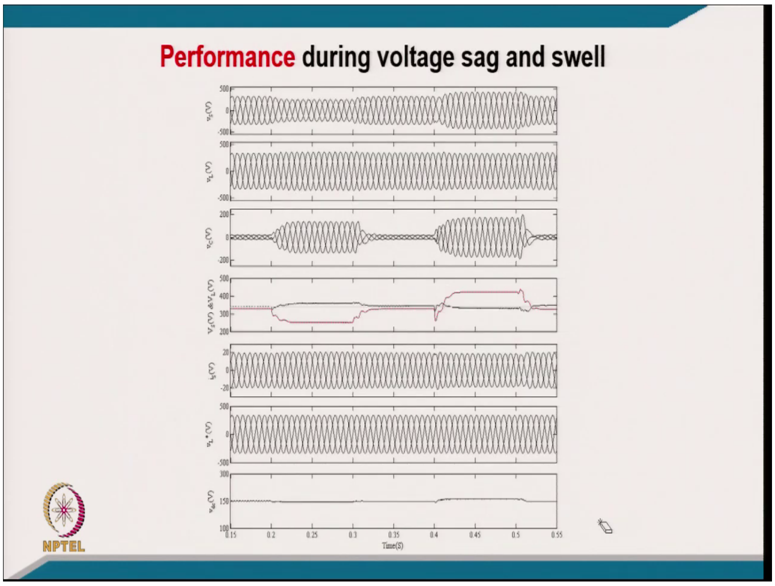

This is the typical result. I mean you can just see the first waveform. I mean like here it is the supply voltage or the voltage at the point of common coupling and there is a typically a voltage sag here 415 cycles. And then it was nominal voltage then sag 415 cycle then the nominal voltage then again swell for voltage 5 cycles in the PCC voltage.

But you can see I mean after putting the series compensator or DVR the load voltage is regulated to a constant value. I mean throughout the typically of the operation of the system and this is the injected voltage. [FL] you can see the injected voltage even under voltage swell condition which is injected in phase and the swell condition the voltage of course, injected out of the phase.

So, that the voltage should reduce to nominal value or rated value and these are the typical RMS value of the voltage how it is red represents the PCC voltage and the black represents virtually the voltage after the compensation the RMS voltage. And of course, since the load voltage is regulated that is why the typically your load current is not affected and even the reference load voltage is also maintained.

And because of reference load voltage this yours typically the actual voltage across the load is regulated. And the DC link of course, what is the regulated at typically order of constant value of 150 volt like I mean.

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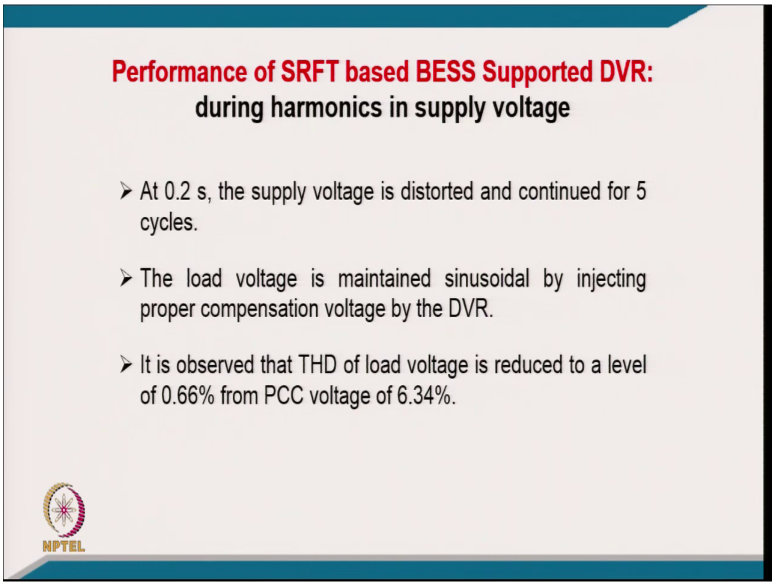

[FL] now, coming to performance sorry performance of synchronous reference frame theory with, but BESS supported during the harmonics in supply voltage. [FL] for the 3 cycle there is a supply voltage distorted, for 5 cycle and the load voltage maintained sinusoidal by sorry proper compensation of voltage by DVR and is observed that the total harmonic distortion in load voltage sorry is reduced to a level of 66 percent from PCC voltage of 6.34 percent.

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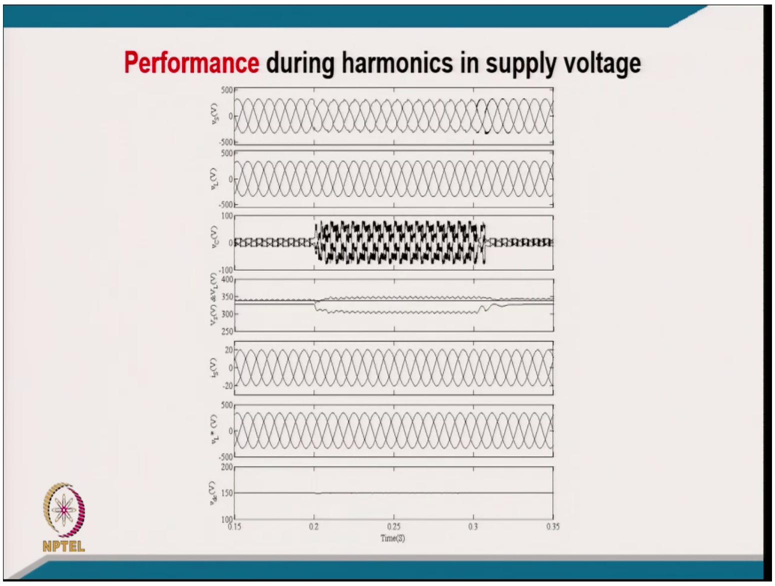

[FL] you can see here I mean here it is the nominal voltage and here it the voltage harmonics are injected at the point of common coupling and then nominally and, but you can see the load voltage is I mean sinusoidal and it is not I mean polluted from the harmonics.

And these are of course, the injected voltage I mean the harmonics are injected to cancel out the harmonics at the point of common coupling voltage. So, that the load voltage are sinusoidal balance across the load and you can clearly see here also accordingly the load voltage is regulated now it is not affected.

However, the source voltage because of little sag in harmonics it is reduced. Hence, because of this you can see the load current is also not affected because load voltage across the load is constant that is why the load current is not affected and even the load reference voltage is also sinusoidal balance that is the reason the actual voltage is also balanced and sinusoidally across the load. And of course, DC link voltage is regulated constant of 150 volt.

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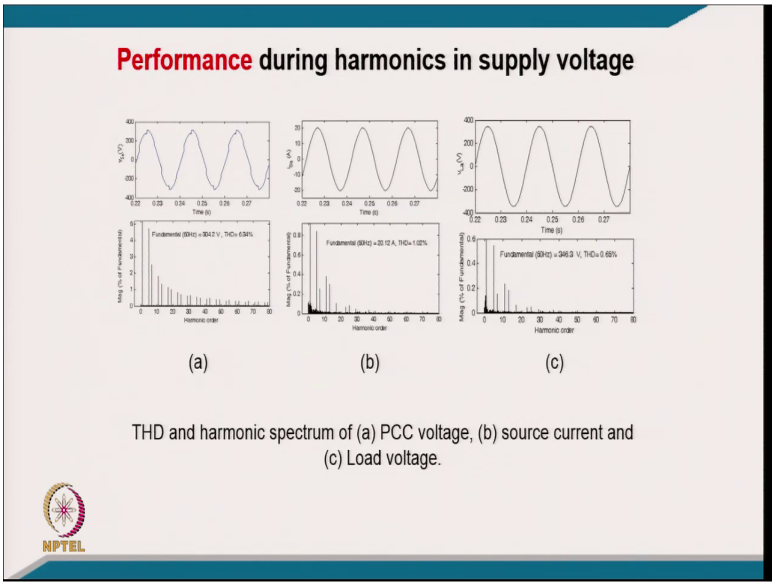

This is the typically harmonic spectrum. I mean of this typically of different quantity. I mean this is the here the supply voltage which have a total harmonic distortion of voltage is distorted 6.34. Now, this is the typically the load you can call it load current harmonics only 1 percent. Here it is the voltage load voltage which have a THD even less than 1 percent point 0.68.

[FL] you can see clearly the harmonics are injected and at the point of common coupling you are getting sinusoidal voltage lag.

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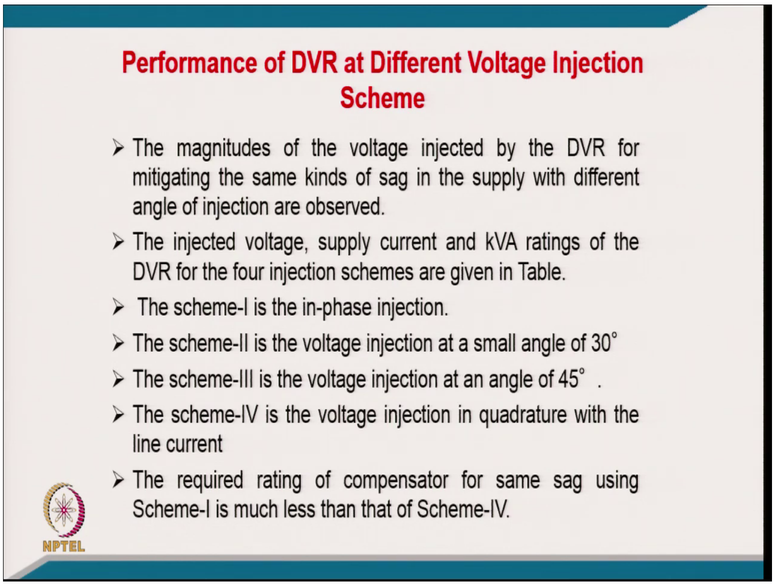

[FL] coming to now the performance of DVR at different voltage injection scheme, I mean [FL] we can call it the magnitude of voltage injected by the DVR for mitigating the same kinds of sag voltage sag in the supply with different angles of injection. The observed which we discussed last time in the different cases and the injected voltage supply current and kVA rating of the DVR for the 4 injection are given in the table like I mean.

Well the scheme 1 is the when the voltage is injected in the phase of the PCC voltage and scheme 2 is the voltage injected with this angle of 30 degree and scheme 3 is the voltage injected 45 degree and scheme 4 is the voltage injected at the quadrature which you can call it like normally with the self supporting. Thus because in order to put any active power in the injection only reactive power.

But other cases you can see maybe there is may be a some injection of active power also depends on the current phase with respect to the point of common coupling voltage or injected voltage like or so. And the required rating of compensator for the same sag voltage sag for scheme 1 is much less than that of a scheme 4.

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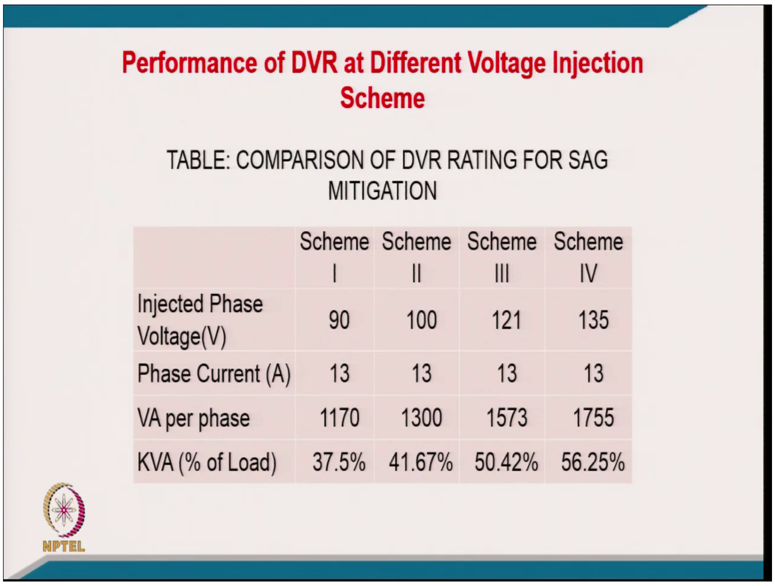

	Scheme I	Scheme II	Scheme III	Scheme IV
Injected Phase Voltage(V)	90	100	121	135
Phase Current (A)	13	13	13	13
VA per phase	1170	1300	1573	1755
KVA (% of Load)	37.5%	41.67%	50.42%	56.25%

[FL] these are different schemes. So, you can call it which we discussed in previous one in phase then 30 degree 45 degree and then typically 90 degree or quadrature and these are the injected voltage these are the typically the current all same current and these are the VA rating.

[FL] you can clearly see the VA rating here it is minimum in case of when you inject the voltage and typically and this is the typically the kVA rating of the percentage of the load that how much kVA comes. [FL] its comes with the minimum of this rating, but of course, maybe in this case maybe not only the reactive power, but you have to probably you I mean provide the active power also for the injection from the DVR like.

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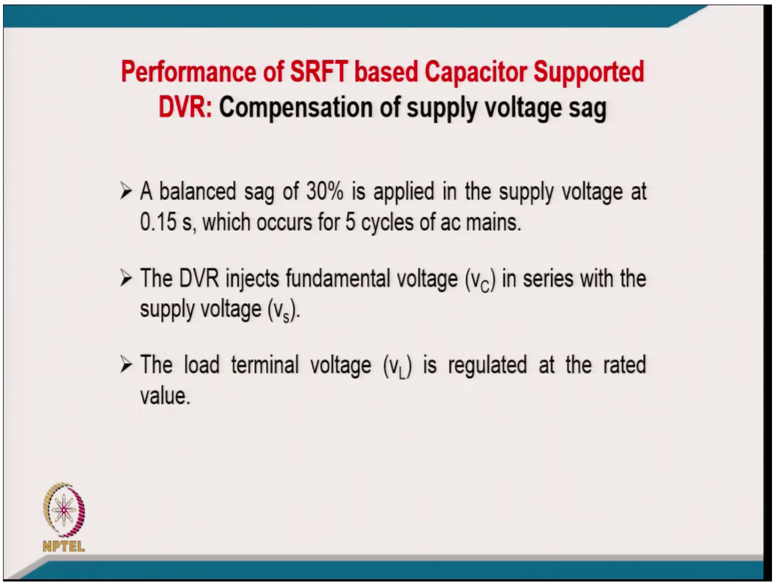

[FL] typically coming performance of the synchronous reference frame theory based capacitors supported DVR and here let us say for considering the consistent compensation of supply voltage sag, a balance sag of 30 percent is applied in the supply voltage at a time of point 0.15 second and which occurs for 5 cycles in of AC mains. And DVR inject the fundamental voltage in series with the supply voltage and load terminal voltage is regulated at the rated value.

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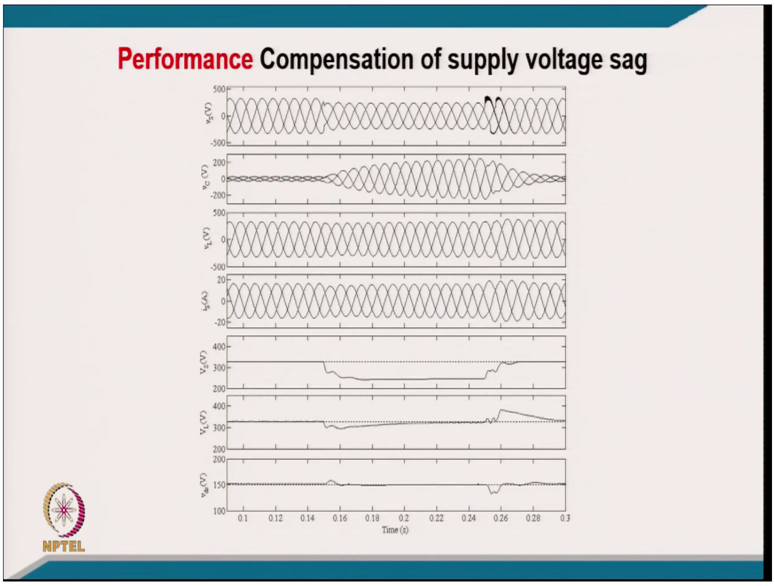

And in the typical case you can see here it is the sag is applied for 5 cycles and you have injected voltage here. So, that the load voltage is maintained sinusoidal balance and constant across the load. [FL] load is not getting affected by the sag and because of that your load current is also typically balanced and sinusoidal and you can see the how the source voltage is reduced. PCC voltage reviewed but load voltage is regulated and DC link voltage is regulated.

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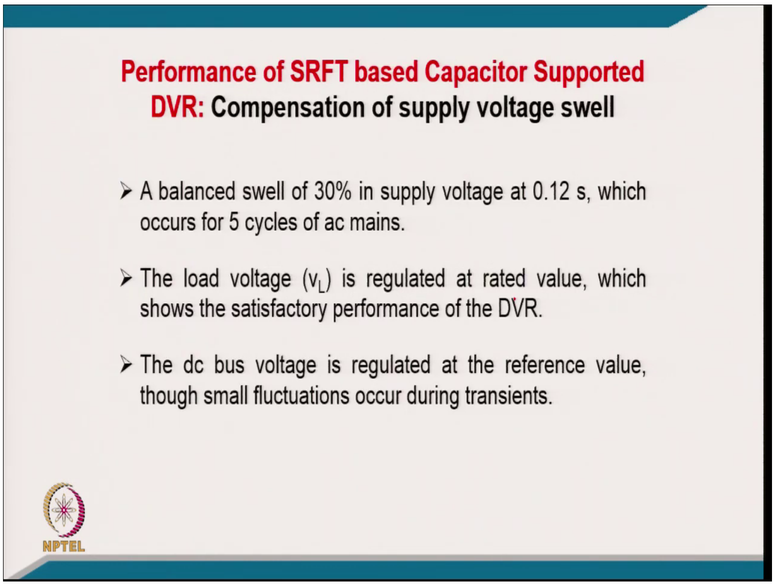

Coming to that typically the on another condition of performance of synchronous reference frame theory based capacitor supported DVR for the compensation of voltage swell. [FL] a balanced again swell of 30 percent in supply voltage is applied which occurs for 5 cycles of AC mains frequency.

And the load voltage is regulated at rated value which shows the satisfactory performance of the dynamic voltage restorer. And DC bus is regulated the reference value through small fluctuations occur during the transient line.

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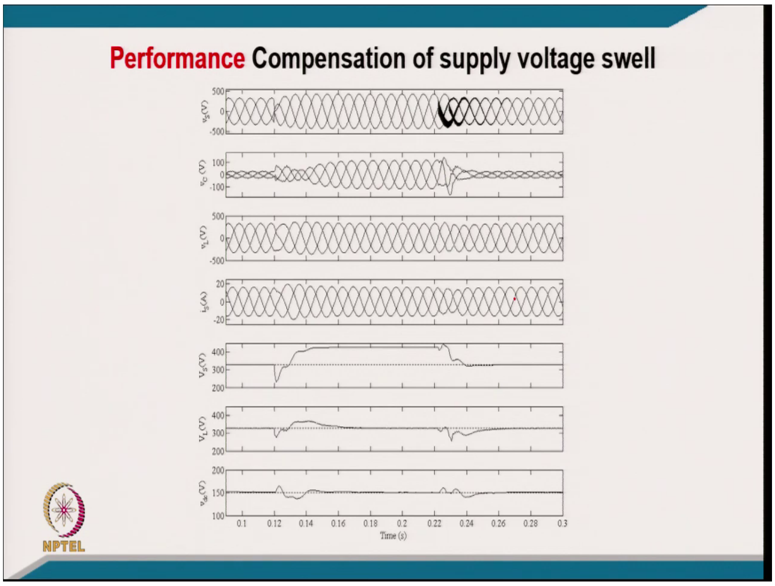

[FL] you can clearly see here in the PCC voltage there is a swell for 5 cycles and this is the typical injected voltage. And after injected this voltage I mean the load voltage is regulated sinusoidal balance across the load and thus the region the load is not affected I mean by this particular sag also.

And this is how I mean after the sag how the voltage is, during the sag how the voltage RMS voltage is there and how the load voltage and DC link voltage is regulated like I mean or so.

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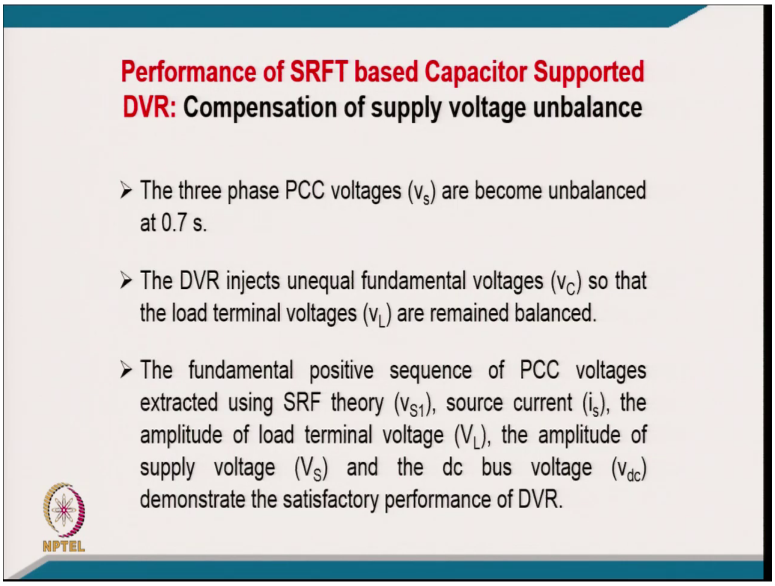

[FL] coming to the performance of this synchronous reference frame theory based capacitor supported DVR for the compensation of supply voltage unbalance and the three phase PCC voltages are have become unbalanced at typically 0.7 second. And DVR inject unequal fundamental voltage so that the load terminal voltage are remain balanced.

And the fundamental positive sequence volt of PCC voltage extracted using SRF theory and typically source current and the amplitude of voltage and the voltage amplitude of the PCC voltage and the DC link voltage demonstrate the satisfactory performance of the DVR.

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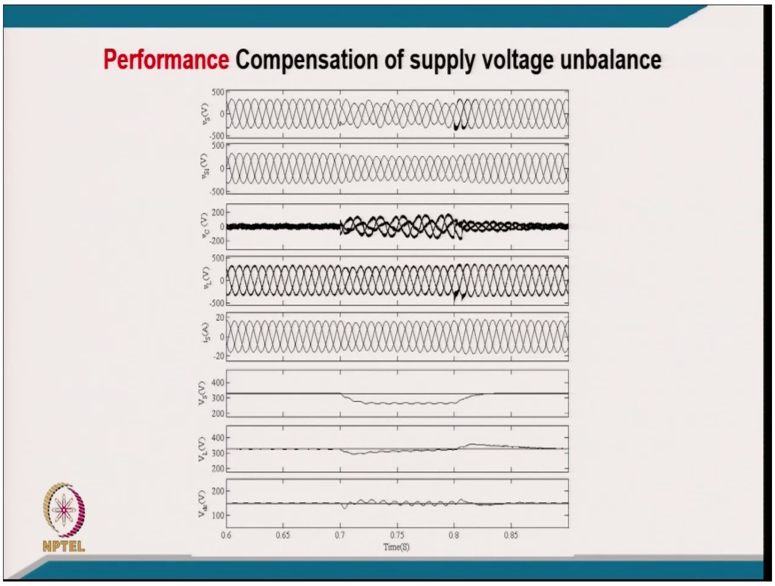

[FL] you can see here it is we have a unbalanced voltage I mean in the PCC, but the load voltage is regulated and this is the injected voltage. [FL] unbalanced voltage only to be injected there and typically the I mean like that is positive then this is load voltage and then the load current is not affected.

You can clearly see how this unbalance with the sag is getting affected here and the load voltage not affected and DC link voltage. Of course, because of the unbalance second harmonics appearing which we discussed many time second harmonics appear on the DC link of this voltage source converter operating as a DVR like I mean.

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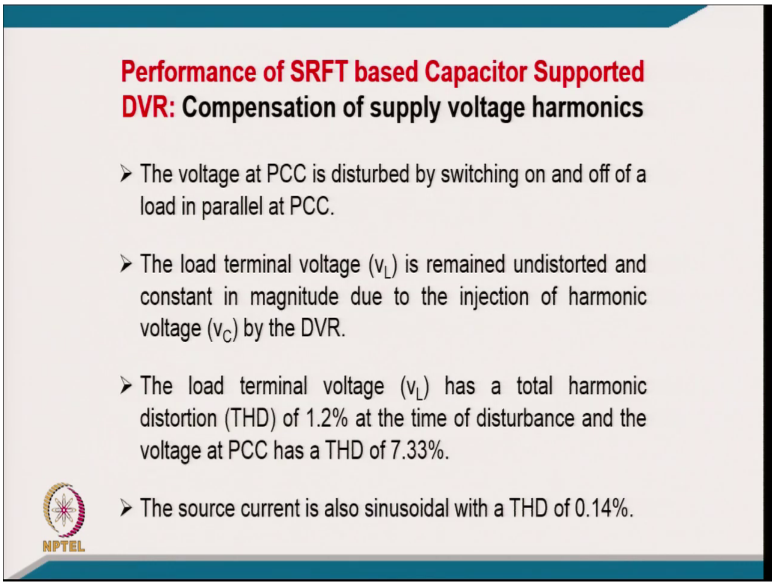

[FL] coming to like a performance of this SRFT based capacitor supported DVR with a compensation of supply voltage harmonic. [FL] voltage at PCC is disturbed by switching on and off the load in parallel to PCC. And the load terminal voltage will remain undistorted and constant in magnitude due to injection of harmonic voltage by DVR.

And the load terminal voltage has a total harmonic distortion of 1.2 percent at the time of disturbance and the voltage at PCC has a THD of 7.22 percent and source current is also sinusoidal with the THD of 0.19 percent.

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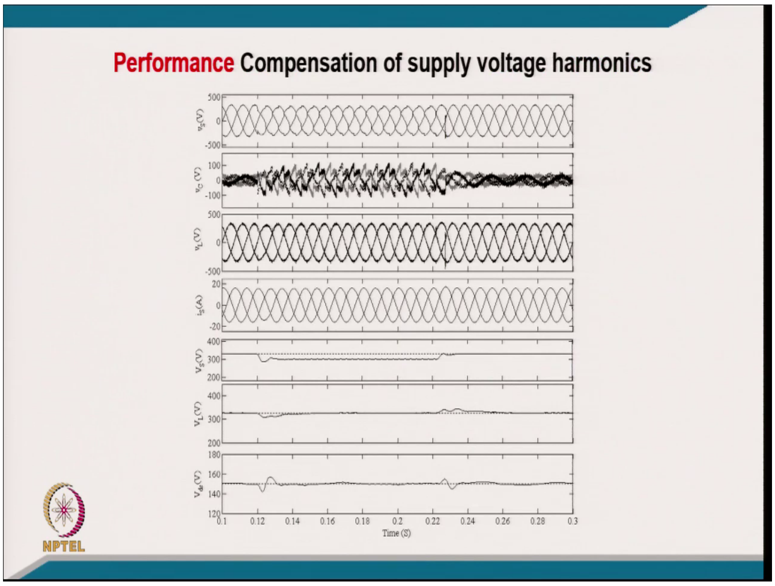

[FL] you can clearly see here you have a typically little sag with the harmonics in the voltage. These are the injected voltage and you will say in load voltage are balanced sinusoidal that is the reason the load current is also balanced and sinusoidal. And you can clearly see during this typically of injected harmonic the fundamental slightly reduced here, but the load voltage is not affected and the DC link is also not affected.

I mean you will have a harmonics here corresponding to double harmonics which are there. [FL], that is not too much reflected here in DC link like I mean or so.

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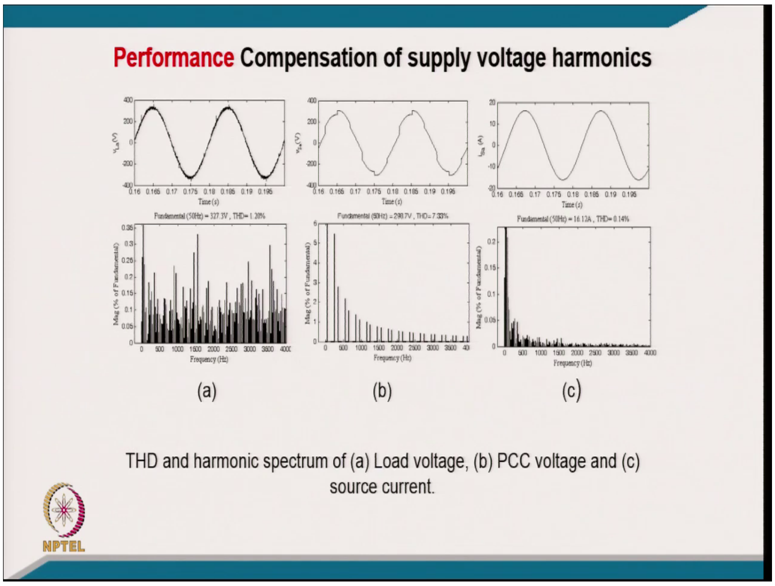

And this is the harmonic spectrum typically of your load voltage which have a THD of only 1.2 percent where the PCC voltage have a THD of 7 type 0.22 percent and the typically the load current or have only the THD of 0.14 percent like I mean. These are typical [FL] you can call it harmonic performance of this typically of DVR compensation system.

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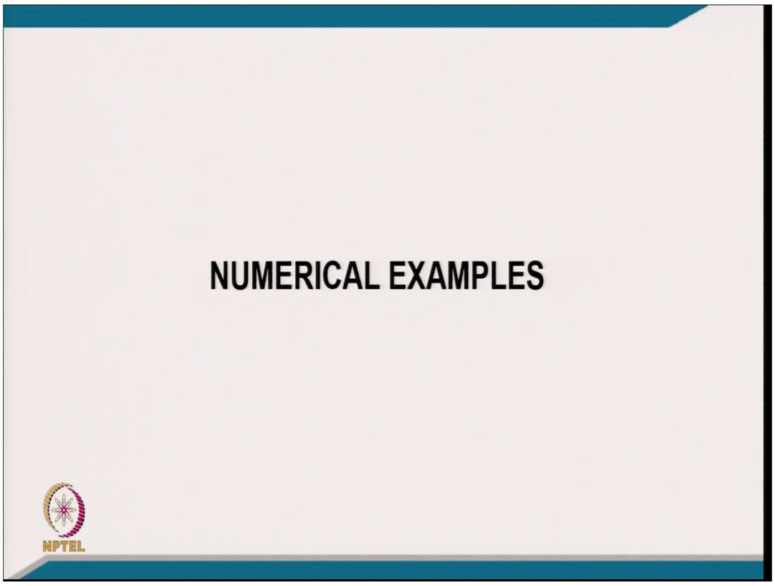

Now, coming to the numerical examples on the series compensator or active series compensator typically at the moment we are considering the DVR.

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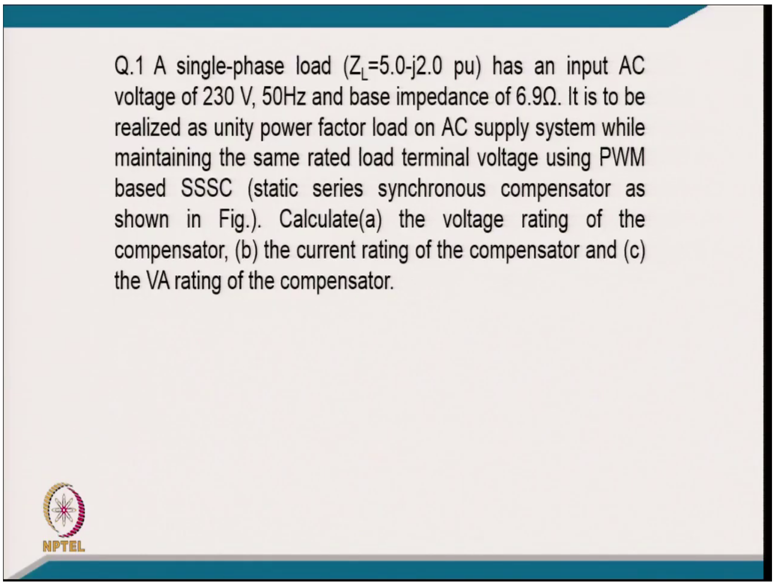

[FL] starting first numerical a single phase load of 5.0 minus 2.0 per unit has a input AC voltage up to 30 volt, 50 Hertz and a base impedance of 6.9 ohm and it is to be realized as a unity power factor load on AC supply system while maintaining the same rated terminal voltage using the PWM static series synchronous compensator as shown in figure.

Calculate the voltage rating of the compensator, current rating of the compensator and VA rating of the compensator.

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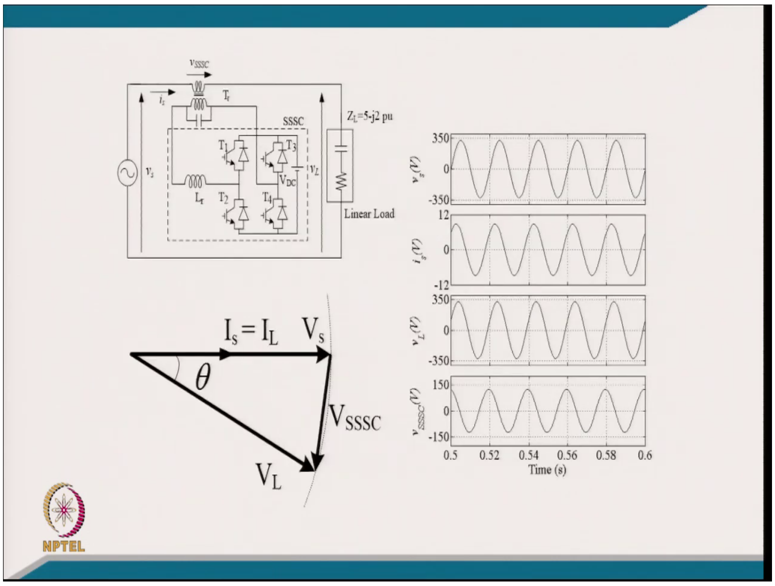

[FL] if you look into typically, I mean we have here the load and series compensator. I mean typically here and you can clearly see the I mean the we can say the source voltage is this much and load voltage also we want same. [FL] typically we have to inject the voltage typically of this nature so that it is on the same arc like. [FL] we modify the control in that manner.

[FL] you can clearly supply voltage then typically the supply current or load current and load voltage and the this typically the compensation voltage, which is typically injected in series to regulate the voltage across the load like I mean.

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Solution: : Given that, supply voltage, V_s = 230 V rms, frequency of the supply, f=50 Hz, a critical load of (Z_L=5.0−j2.0 pu), and base impedance of 6.9Ω/ phase.

The load resistance is as, R_L= 5×6.9 Ω = 34.5 Ω. The load reactance, X_C = 2×6.9Ω = 13.8 Ω.

The total load impedance is as, $Z_L = R_L - jX_C = |Z_L|\angle\theta$
$= 34.5 - j13.8 = 37.15\angle{-21.8^\circ}\Omega$.

The load current before compensation is as, $|I_L| = |V_L|/|Z_L|$ = 230/37.15 = 6.19 A.

The magnitude of supply current under compensation is equal to load current and hence, $I_s = I_L$ = 6.19 A.

As under compensation an extra active power is pumped from the single phase supply, a battery energy storage system is required at the DC link of SSSC to maintain active power balance.

[FL] coming to the numerical part solution of this, [FL] given a supply voltage of 230 volt and frequency of supply 50 Hertz, a critical load of 5.0 minus 2.0 per unit with the base impedance of 6.9 ohm is there and the load. Now, resistance will be I mean per unit multiplied the base impedance that comes 34.5 ohm and the load reactance comes X equal to into 6.9 that is 13.8 and the total load impedance comes R L minus j X c.

And if you put the value then it comes 37.15 at the angle of 21.8 and the load current before the compensation will be your V divided by this impedance and that is 6.19 ohm and the magnitude of supply current under the compensation equal is typical compensation is equal to the load current. And under the compensation extra active power is pumped from the single phase supply a battery energy storage system is required on the DC link of this to maintain the active power balance.

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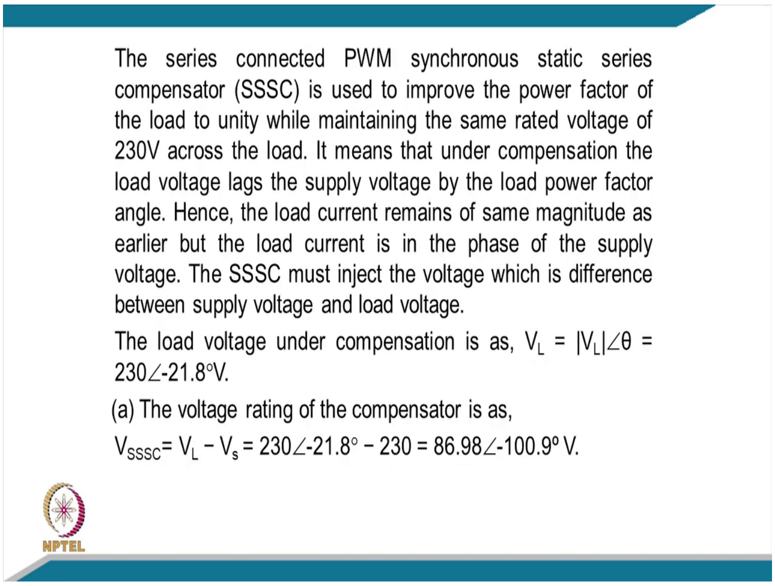

And the series compensated connected PWM synchronous compensator is used to improve the power factor of the load to unity while maintaining the same rated voltage of 230 volt across the load. It means that under the compensation load voltage lags the supply voltage by a load power factor angle.

Hence, the load current remains the same magnitude as earlier, but the load current is in phase with the typically supply voltage. [FL] the SSC must inject a voltage which is difference between supply voltage and load voltage and that the voltage under the compensation load voltage under the compensation is we get equal to 230 point at the angle of 21.8 and the voltage rating of the compensator will be V L minus V s I mean.

[FL] this is typically the V s and this is the V L. [FL] you will get this injected voltage eighty 6.98 at the angle of 100 degree 0.9 degree like.

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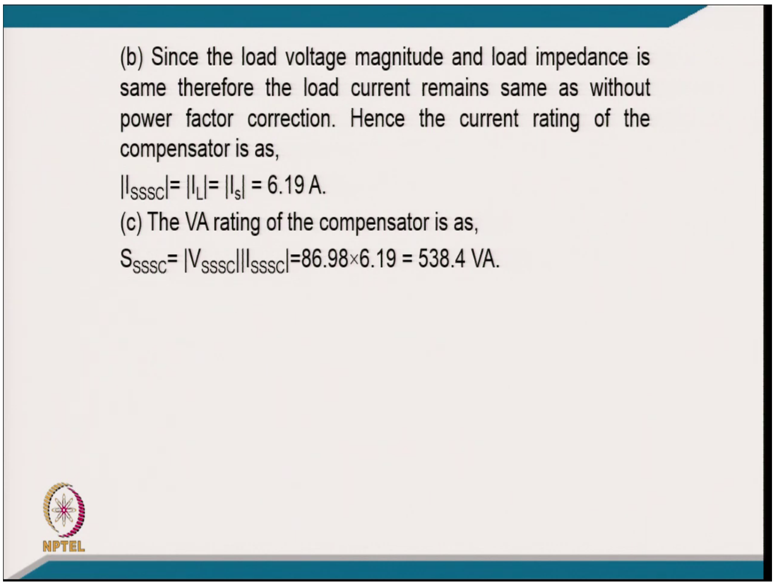

[FL], since the load voltage magnitude and load impedance are the therefore, the load current remains the same as without the power factor correction. Hence, the current rating of the compensator is your current or same, but voltage rating of compensator is we calculated. [FL] multiply this will be 538.4 VA rating like I mean.

[FL], this typically a typically non power unity power factor load is realized as a unity power factor load at the supply by injecting a appropriate voltage and even still maintaining the load voltage same like I mean or so.

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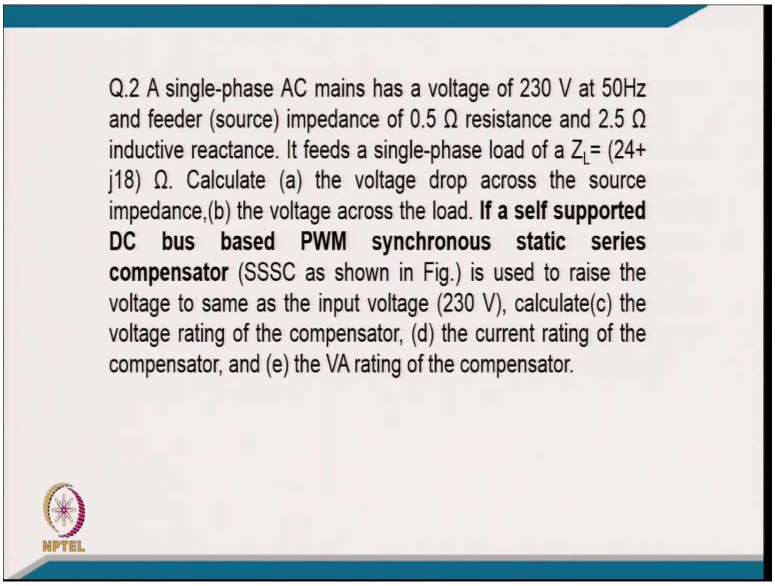

[FL] coming to the second example, a single phase AC mains has a voltage of 230 volt at 50 Hertz and the feeders impedance of 0.5 ohm and 2 point resistance and 2.5 ohm inductive reactance. It feeds a single phase load of Z L equal to 24 plus j 18 ohm and calculate the voltage drop across the source impedance, voltage across the load.

If self supported DC bus based PWM synchronous static compensator is used to raise the voltage same as the input voltage calculate the voltage rating of the compensator current rating of the compensator and VA rating of the compensator.

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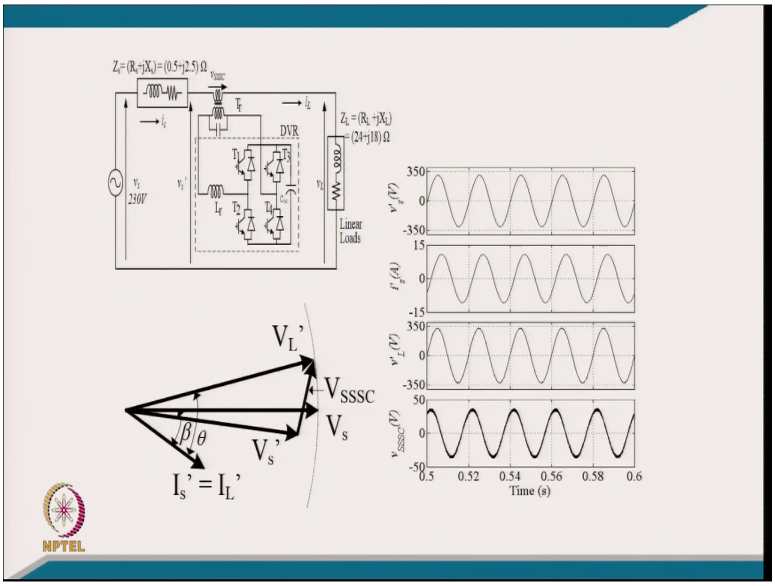

[FL] is there a typically we have a source impedance we are injecting the voltage in series with the line so that the load voltage is the same as the typically the voltage at the typically on supply side. And you can clearly see here I mean the point of common coupling if series compensator is not there. The voltage at the point of one common coupling will reduce little less compared to the source voltage because of the drop of this, but we have to bring back if this voltage equal to the source voltage load voltage.

[FL] we have to inject the typically voltage, but at the quadrature so that it needs only the reactive power like. [FL] that is the typical phasor diagram and after making a model and this is the typically the injection of the this is typically the you can call it the voltage at the point of common coupling.

This is the of course, load current which is common in all because it is all connected in series and this is the typically you can call it the load voltage after the compensation which is equal to the supply voltage and this is the series compensated voltage.

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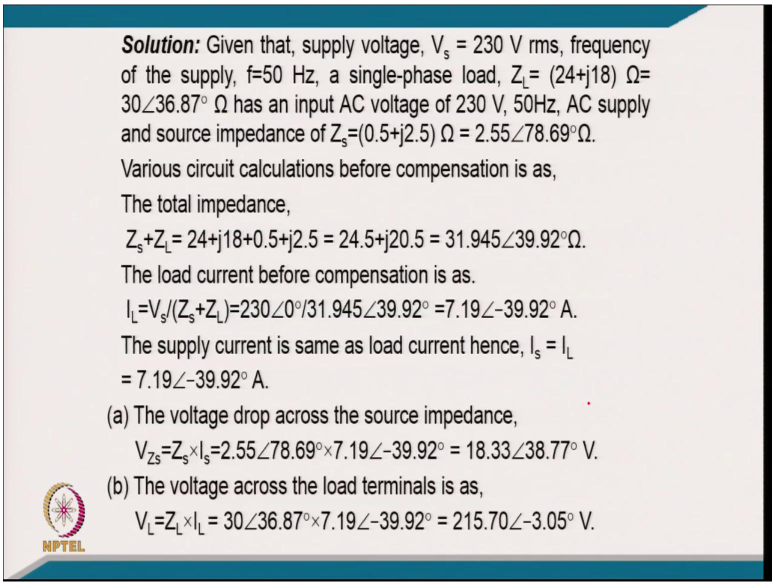

[FL] coming to the numerical part of it. Given that supply voltage is V s 230 volt RMS and frequency of supply of 50 Hertz, a single phase load of Z L equal to 24 point j 18 ohm, 30 at the angle of 36.87 has a input voltage of 230 volt 50 Hertz AC supply and source impedance of your Z s is equal to 0.5 plus j 2.5 at the value of 2.55 at the angle of 7 8.69 degree ohm and various circuit calculation before compensation.

I mean total impedance is Z s plus Z L and that comes around typically 39.9945 at the angle of 39.92 and the load current will be before the compensation I s equal to V s V s upon Z s plus Z L and putting the value it come 7.19 at the angle of minus 39.92 and supply current same as the load current has both of will be equal and the voltage drop across the source impedance will be Z s into I s the value.

[FL] it becomes 18.33 at the angle of 38.77 volt and voltage across the load will be or typically the load impedance and load current and it comes 215.70 minus at the 3.05. I mean before the compensation, [FL] it reduces compared to 230 volt like.

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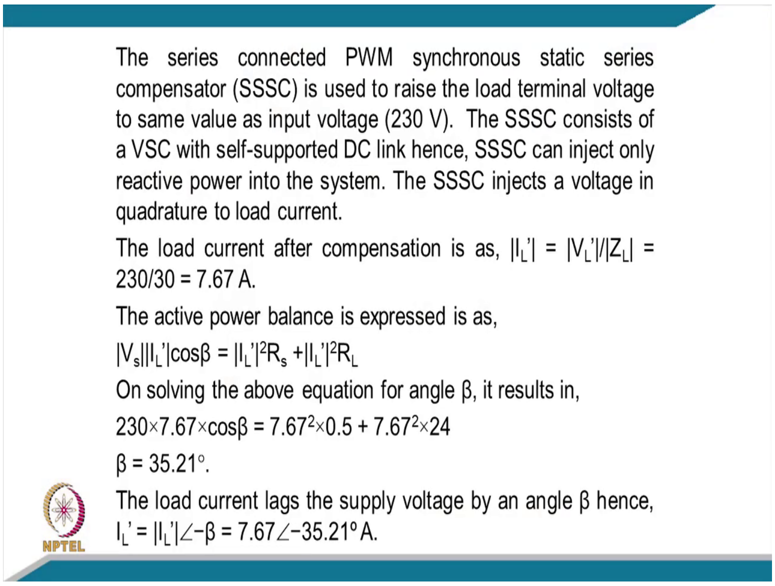

[FL] we want to have a series connected, PWM synchronous static compensator to used to raise the voltage load volt terminal voltage is same as the input voltage of 230 and triple SC consists of VSC with self supporting DC link has the SSC can inject only reactive power into the system. And SSC inject the voltage in quadrature with the load current. [FL] we have a load current after compensation I mean typically because voltage is it maintain rated and this is the typically you can call it the load impedance.

[FL] it comes 7.67 and we can find out the active power now. I mean here that is V s I L cos beta [FL] that is the source law source impedance loss and this is the load active power. And solving this equation we get the beta from this relation. [FL] beta becomes 35.27 and that load current lags the supply voltage by angle beta. [FL] I L equal to I L at minus beta it comes 7.67 at the angle of minus 30.21 degree ampere.

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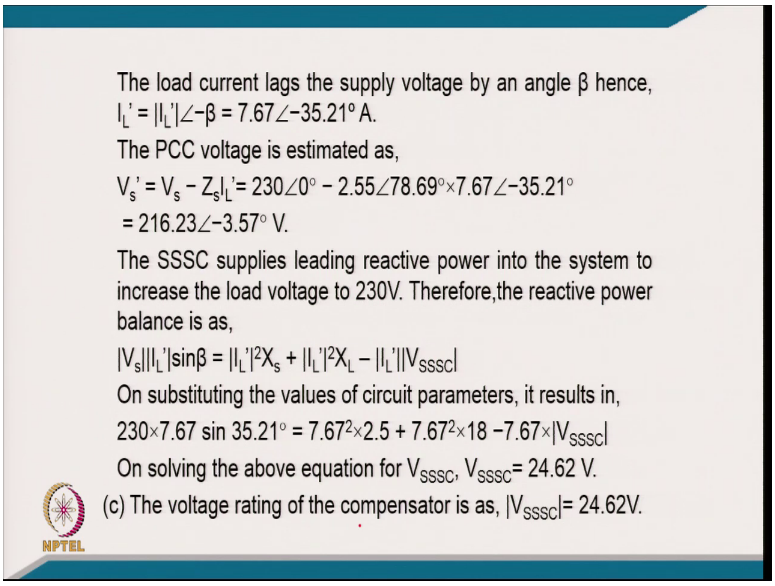

[FL] load current lags the supply voltage by an angle beta and that is the L delta c equal to 7.67 that minus 35.21 and PCC voltage is estimated that is V s dash equal to V s into Z s into I l. [FL] putting the value we get this is typically now the point of common coupling voltage 216.23 minus 3.57 degree volt and SSC applied during reactive power into the system to increase the load voltage to 230. Therefore, the reactive power balance is achieved.

[FL] V L I L sin beta equal to I L X square plus I L X L minus the injected voltage I L V SSSC go on substituting the value of circuit parameter and solving this we get the VSSSC equal to 24.62 volt and voltage rating will be this typically the same of 44.62 volt.

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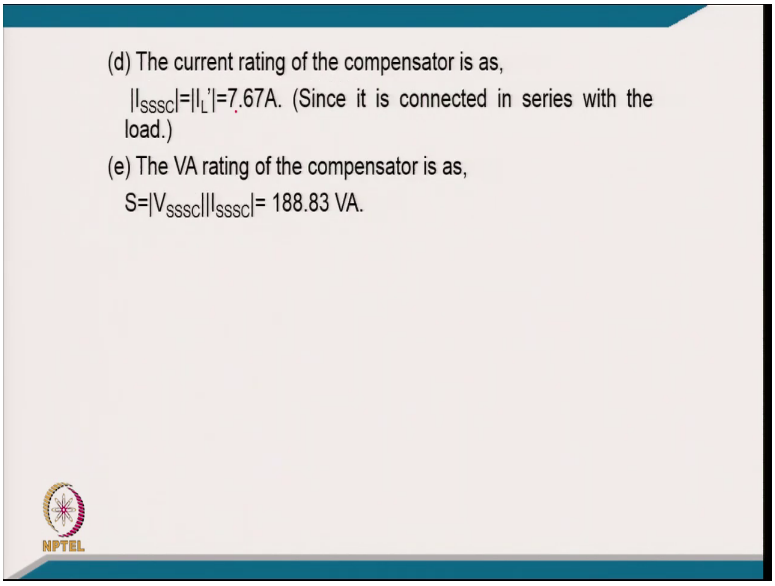

And current rating of this compensator is same as the load current that is 7.67 and the VA rating will be that voltage rating and current rating that comes one 88.83 volt ampere.

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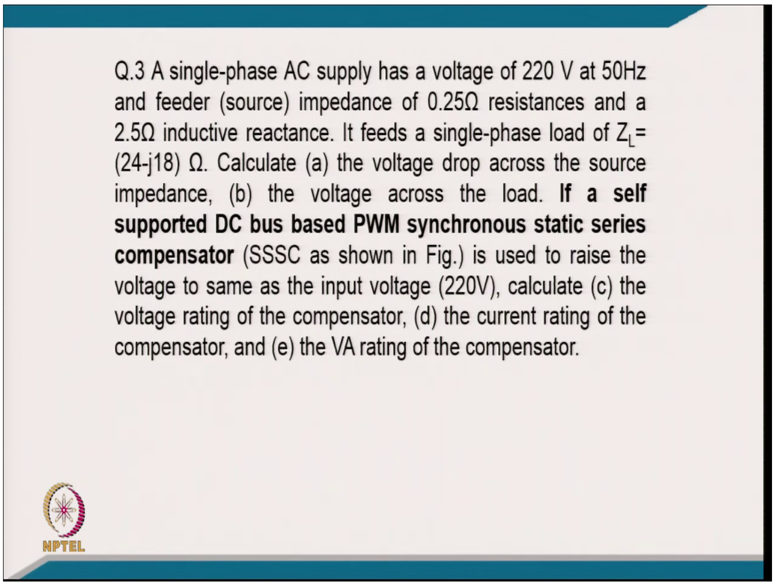

[FL] coming to third example of this series compensator. A single phase AC supply have a 220 volt 50 Hertz and feeder impedance of 0.25 ohm and resistance of resistance and the 2.45 ohm inductive reactance. It feeds a single phase load of Z L equal to 24 minus j 18 ohm.

Calculate the voltage drop across the source impedance the voltage across the load if see if a series supported DC bus based PWM synchronous static compensator is used to raise the voltage at the same as the input voltage of 220. Calculate the voltage rating of the compensator, current rating of the compensator and VA rating of the compensator.

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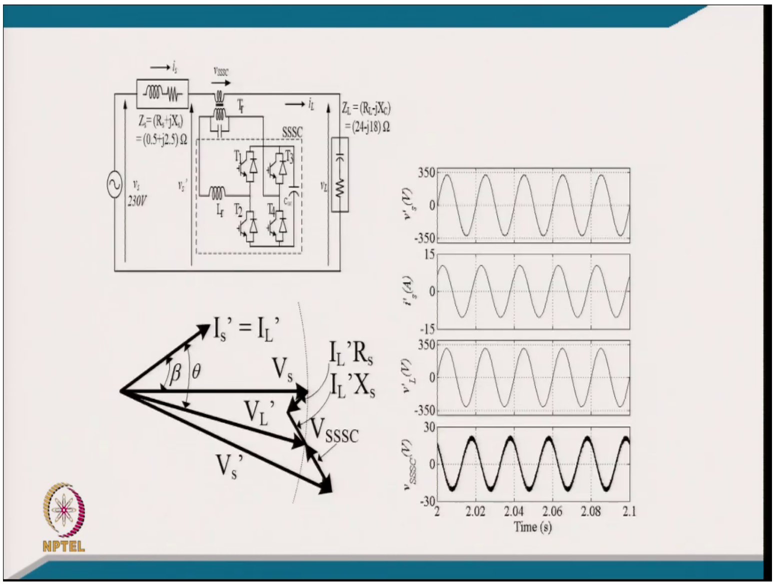

[FL] these are typical circuit you can call it like we have a solid impedance we have a load in between we are putting the compensator. And you can call it like a typically because it is a kind of a capacitive load [FL] or leading power factor load that is the region the voltage I mean before the compensation will increase more and that voltage we have to certainly reduce it to bring it to the same as the source voltage.

I mean here as you can see I mean the because the current have to be little leading at the beta angle from the supply voltage. [FL] it would be in this the phasor diagram and these are after designing and putting the value these are the result like you have a like a V s here the point of common coupling voltage then the your current common current that this is a load current and this is a load voltage which is regulated to the rated voltage of 220 and this is the injected voltage by series compensator.

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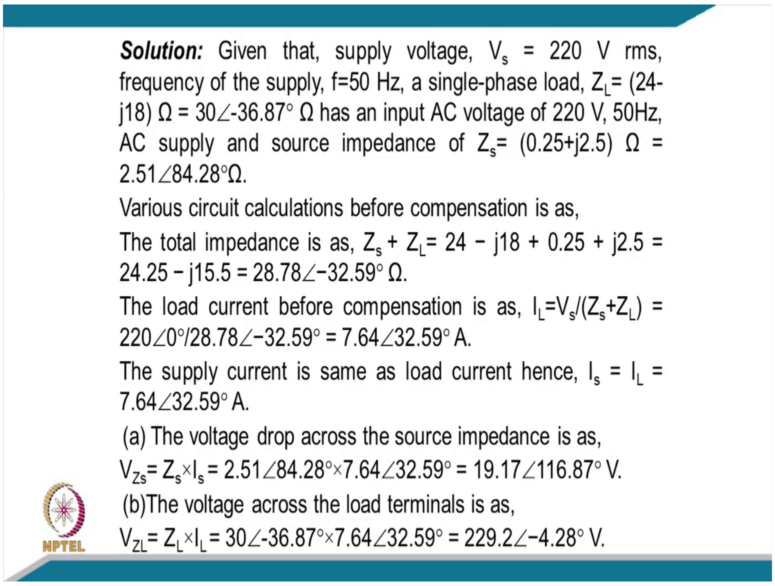

These are numerical part of the problems that given that supply voltage of 220 volt RMS frequency 50 Hertz and single phase load of 24 ohm minus j 18 and that comes 30 ohm at the angle of 36.87 ohm has a input voltage of 220 volt and a source impedance of 0.25 plus j 2.5 ohm which comes 2.51 at the angle of 84.28 ohm.

And various circuit calculation before the compensation, the total impedance Z s plus Z L typically before the compensation is typically order of 28.78 at the angle of your minus 32.59 and total current before the compensation is I s V s upon Z s plus Z L. [FL] it comes 7.64 at the angle of 302.59 ampere. The supply current is same as the load current and I s equal to I L and that is 7.64 at the angle of 32.59 and voltage drop across the source impedance is Z s I s.

[FL] that is keeping the value it comes 19.17 at the angle of 116.87 volt and the voltage across the load will be your current multiplied the load impedance. [FL] it comes 229.2 at the angle of 4.28.

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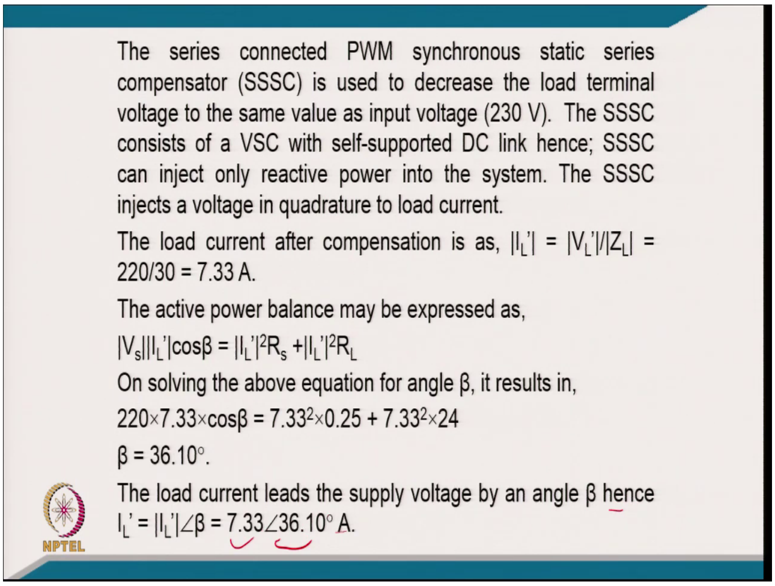

[FL] series compensator connected PWM synchronous static compensator is used to decrease the load terminal voltage to the same as.

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[FL] the series connected PWM synchronous static compensator is used to decrease the load terminal voltage to the same value as the input voltage and the this triple SC consists of a

VSC with self supported DC link. Hence, the SSC can inject only reactive power into the system and SSC inject the voltage in quadrature to the load current.

And the load current after compensation is equal to typically I L dash V L upon V L dash upon Z L. [FL] it comes 220 by 7.33 and the active power balance is expressed V s I L cos beta into I L s R s plus I square R L. On solving the above equation for beta it results 220 that putting the value beta becomes 36.16. And load current leads to the voltage by angle of typically 7.33 at the angle of 36.10.

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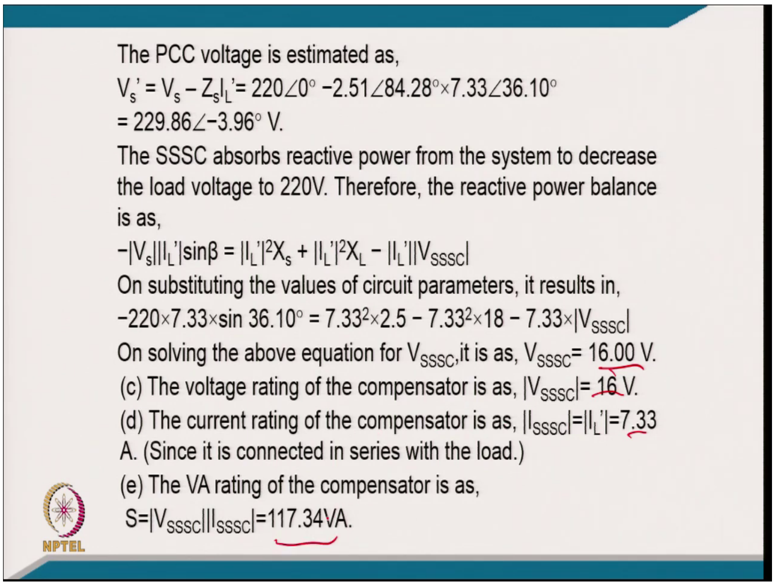

And the PCC voltage can be estimated from this relation V s minus I s Z L. [FL] it is a 220 at the 0 and putting the value of this it comes 229.86 at the angle of minus 3.96 degree volt and SSC absorb the reactive power from the system to decrease the load voltage to 220. Therefore

I mean the reactive power balance is at typically from this formula we can calculate it and it comes the VSC typically 16.00 volt.

And that is the voltage rating and current rating the same as the series compensator and the VA rating of the compensator is at 117.34 volt.

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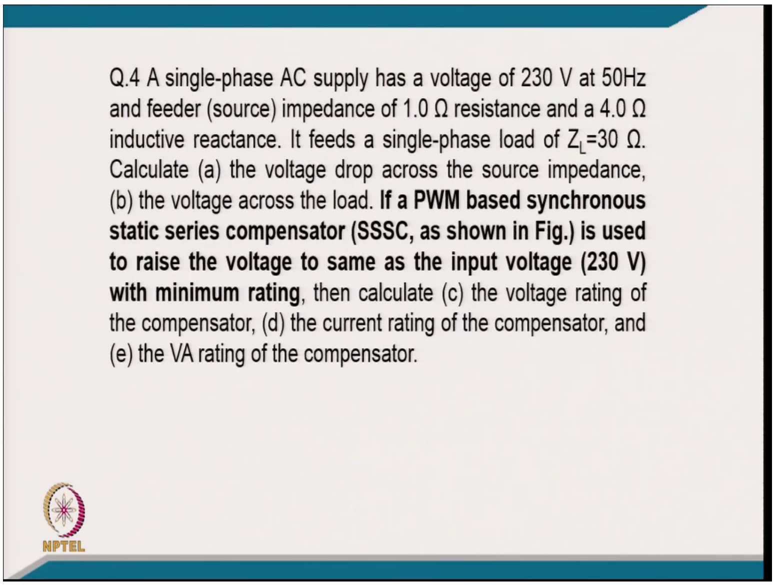

Coming to 4th example a single phase AC supply has a voltage of 230 volt at a 50 Hertz and feeder source impedance of one of 1 ohm resistance and 4 ohm the inductive reactance and you feed the single phase load of 30 ohm. And calculate the voltage rating across the source impedance, voltage rating across the load, a PWM based synchronous static series compensator is used shown this used to raise the voltage to the same as the input voltage with the minimum rating.

Then the calculate the voltage rating of the compensator, current rating of the compensator and the VA rating of the compensator.

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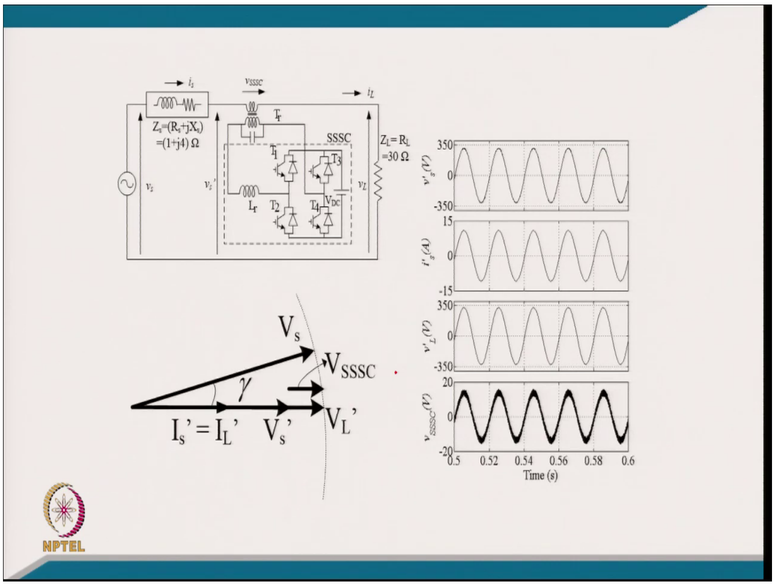

[FL] these are typically you can just see clearly here that we have a source impedance, we have a load resistive load, but voltage will drop because of the source impedance. [FL] we have to inject the voltage. So, that this voltage is the same as the supply voltage and that is clearly you can just see here you have to inject the typically the voltage I mean in this manner

[FL] these are typically you can call it like a the voltage at the PCC. This is the load current, this is the load voltage after the compensation that is the injected voltage.

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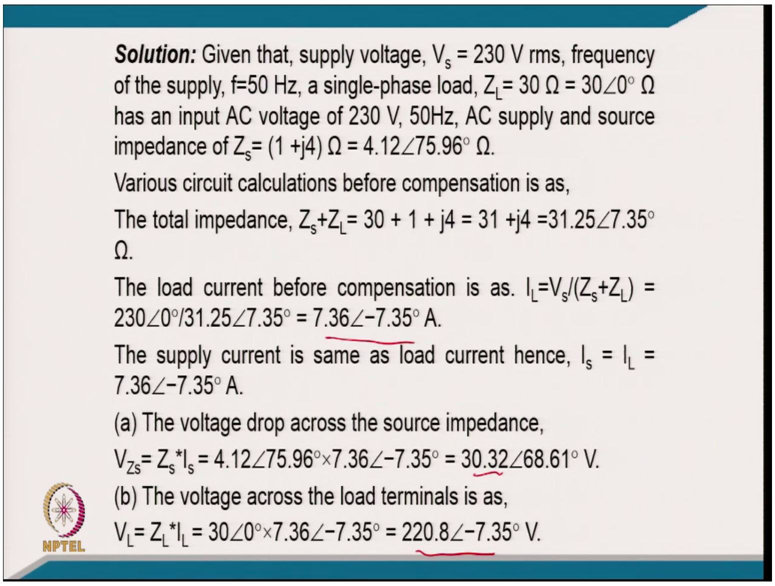

[FL] coming to numerical part of this given that the supply voltage V s equal to 230 RMS and frequency of 50 Hertz and single phase load up to 30 ohm and it has a AC voltage of 230 volt 50 Hertz and supply impedance of typically 1.1 plus j 4 ohm and that comes at 4.12 at the angle of 75.96 degree ohms and various circuit calculation before the compensation.

[FL] total impedance of the circuit source impedance plus load impedance it comes 30 1.25 ohms at the angle of 7.35 degree ohm and the load current will I mean before the compensation will be this V s upon Z s plus Z L. It comes typically of 7.36 at the angle of minus 7.35 degree ampere and supply current is same as load current. [FL] that is same as 7 7.36 at the angle of minus 7.36 degree ampere.

[FL] voltage drop across the source impedance will be the source impedance multiplied the current and it comes 30.32 at the angle of 68.61 degree volt and the voltage across the load terminal will be I mean Z L I L putting the value it comes 220.8 at the angle of minus 7 typically 35 degree volt.

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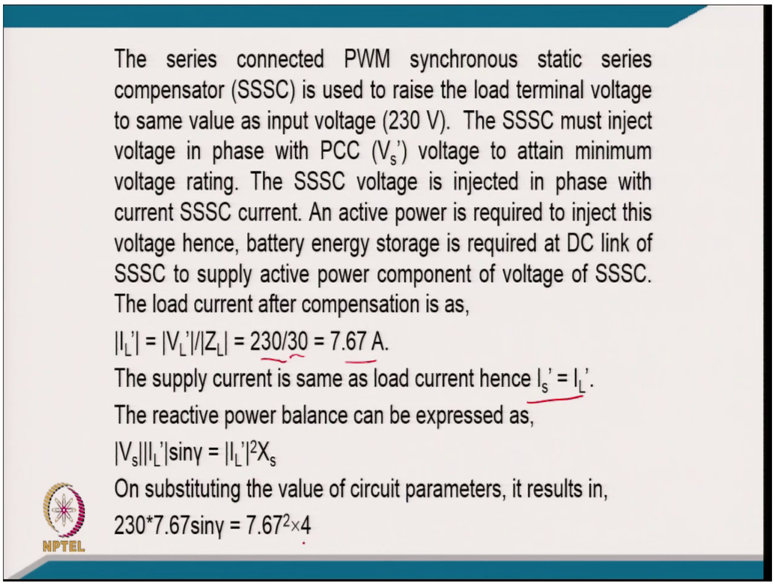

[FL] series compensate series connected PWM synchronous static compensator is used to raise the load terminal voltage to the same as the input voltage of 230 volt. And the SSC must inject the voltage at PCC to attain the minimum voltage rating and SSC voltage injected in phase with the current of SSC and active power is required to inject the voltage.

Hence, the battery and it is just required the DC link of triple SC to supply the active power component of voltage of SSC and the load current after the compensation because voltage regulator 230 volt and 30 the load ohm is the load impedance. [FL] it comes 7.6 7 ampere and the current load current and source current are same and the reactive power balance can be expressed from this and we can find out typically the angle corresponding to from this.

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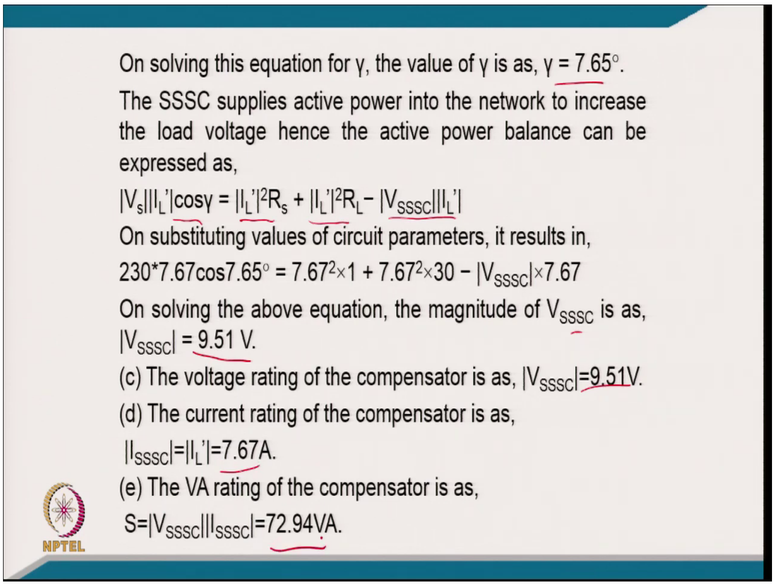

[FL] this angle at which at it to be injected 7.65 degree and thus triple SC supply the active power into the network to increase the load voltage hence the active power balance can be expressed. [FL] from this relation of active power on the typically grid side we put the loss in source impedance than loss in load.

And then the active power injected to the minus the active power injected into the your series compensation. [FL] putting the value we get here typically the value of typically VSC is equal to 9.51 volt and the voltage rating of compensator is same as 9.51 and current rating is 7. 6. [FL] the VA rating of the compensator will be 72.94 VA.

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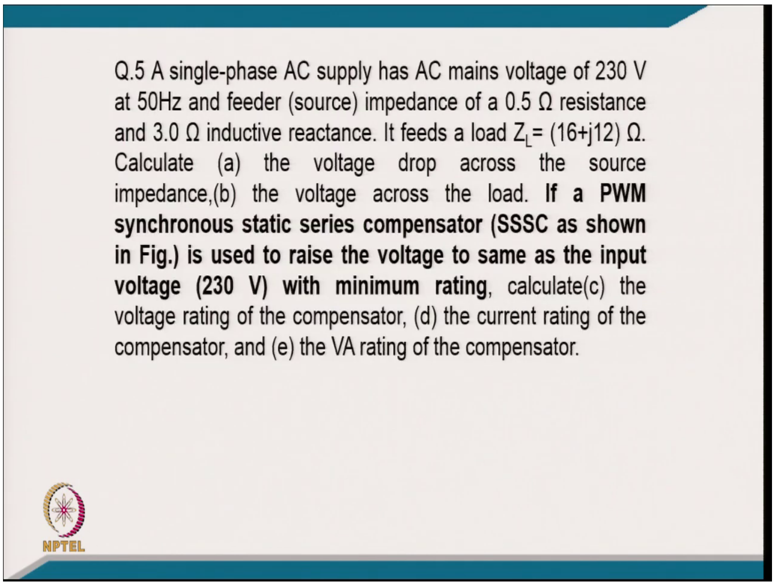

Coming to 5th example: A single phase AC supply has a AC mains voltage of 230 volt at 50 Hertz and feeder impedance of 0.45 ohm resistance and 3 ohm inductive reactance, it feeds a load of 16 point j 12 ohm. Calculate the voltage drop across the source impedance voltage across the load and if PWM a synchronous static series compensator is used to raise the voltage same as the typically the source voltage of 230 volt with the minimum rating.

Calculate the voltage rating of the compensator, current rating of the compensator and VA rating of the compensator.

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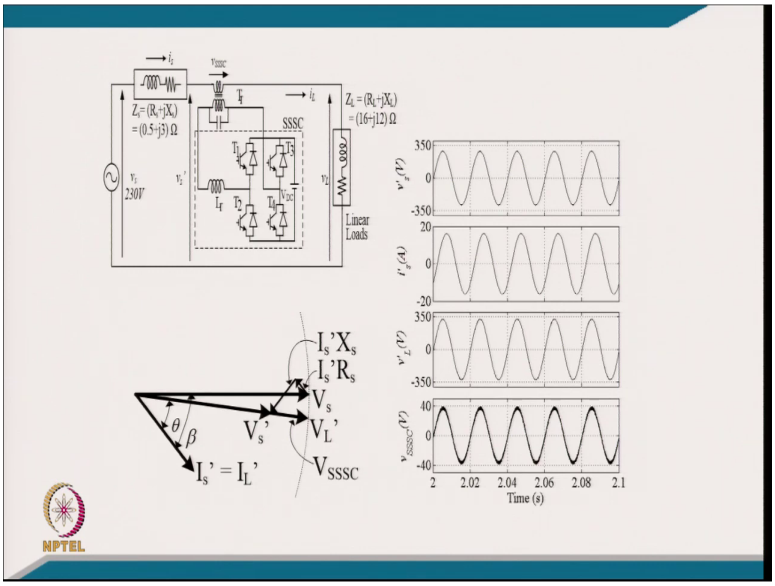

[FL] this is the typical case. I mean we have a load impedance. We have a source impedance if compensator is not put certainly load voltage will reduce because of lagging power factor and drop of source impedance. [FL] it is a worst voltage regulation, but we are injecting the voltage with the minimum radiating in the sense minimum voltage injection. [FL] that is corresponding to the phasor of this typically how it comes and we inject the voltage just to take care of the drop of this.

[FL] that is one we have a source impedance. [FL] a injection of the typically in opposite to the IR then I X and then it comes to equal to this. [FL] after design I am making the control and these are the voltage I mean at the point of common coupling this is the typically same common load current and source current and this is the voltage across the load which is regulated to 230 volt and this is the series compensated voltage of the compensator like.

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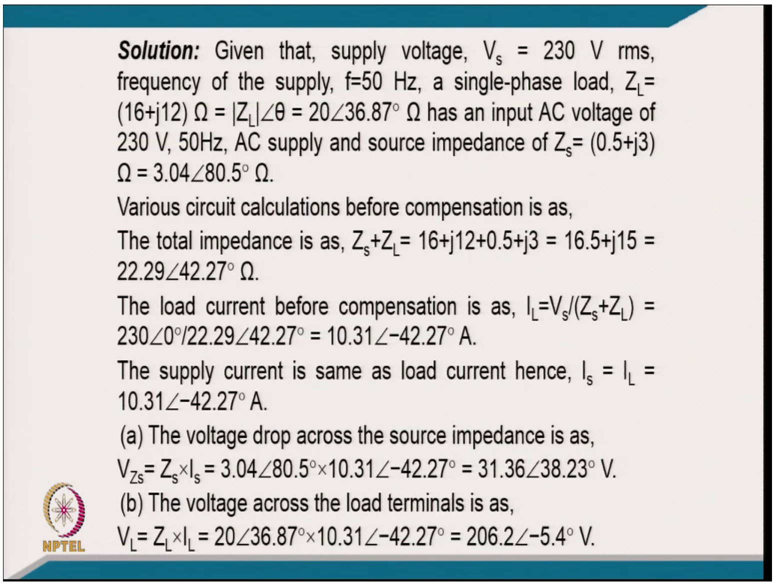

Coming to the typically numerical part of this, given that supply voltage V s equal to 230 volt RMS you can say of supply 50 Hertz and a single phase load of Z L equal to 16 point j 12 ohm Z L at the angle of 0 that comes 20 ohm at the angle of 36.87 ohm has an input AC voltage of 230 volt 50 Hertz, AC supply and source impedance of 0.5 ohm plus j 3 that comes 3.04 at the angle 80.5 degree ohm.

And various circuit calculation before the compensation is you can call it the total impedance Z s plus Z L and that comes 22.29 at the angle of 42.27 degree ohm and the load current before the compensation will be V s upon total impedance, it comes 10.31 at the angle of 42.27 degree ampere and the supply current is the same as that the load current and voltage drop across the source impedance will be I V Z s I s.

And it comes 31.36 at the angle of 38.23 degree volt and voltage rating across the load terminal would be Z L multiplied the I L and come 206.2 at the angle of point minus point 5.4 degree volt like.

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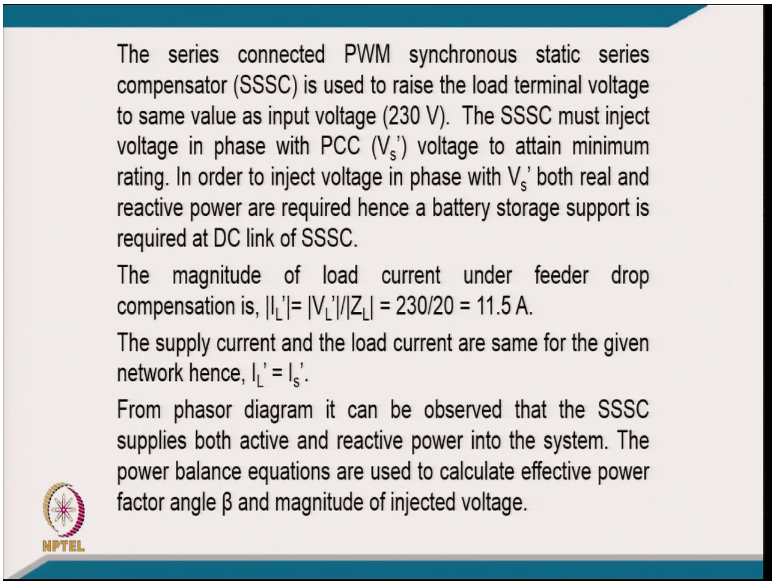

[FL] is then the series connected PWM synchronous static series compensator is used to raise the load terminal voltage to the same as the input voltage of 230 volt and SSSC must inject the voltage in phase with the PCC voltage to attain the minimum rating and in order to inject voltage in phase with the V s dash both real and reactive power are required. Hence, the battery supported storage support is required at the DC link of the SSC.

[FL] the magnitude I mean we can find out load terminal because load voltage is which is regulate 230 divided by the load impedance. [FL], this is the current 11.5 ampere. And the load current at the source current is the same that is 11.5 ampere and from the phase diagram it can be observed that the SSC. Supply both active and reactive power into the system and the power balance equation are used to calculate the effective power factor angle and beta and magnitude of inductance voltage.

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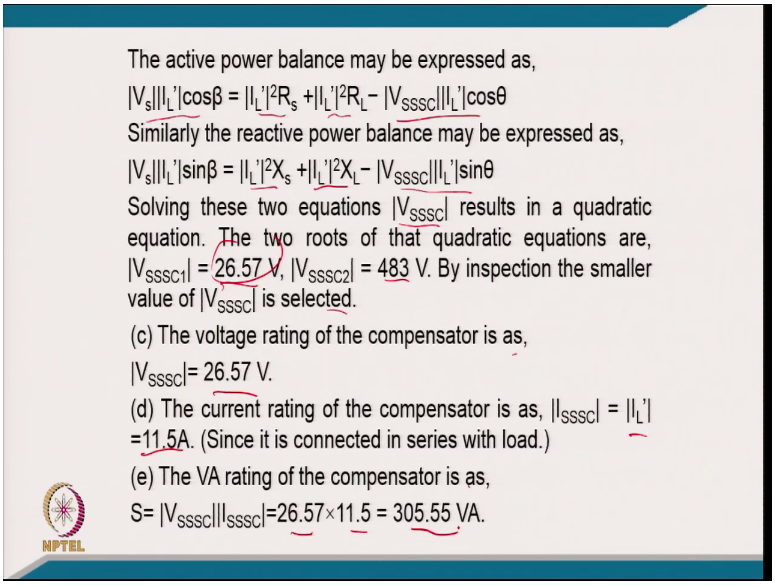

[FL] the active power balance may be expressed as typically the active power on the supply side then comes equal to the source loss in source impedance, loss in load and then the typically the active power injected minus the active power injected by the series compensator.

And similarly for reactive power I mean this is the reactive power consumed by source impedance and reactive power consumed by the load and the reactive power injected by the typically the by the compensator. [FL] solving these equation I mean we can get the VSC result in quadratic equation. There are 2 roots for this. [FL] we get the minimum value of 26 point for 57. Another value it comes 483 which is not practical value.

So, we select typically the this value of this and by inspection a smaller value is selected and voltage rating of the compensator is then 26.57 and current rating of the compensator is then same as the load current rating 11.5 ampere and VA rating be now, injected voltage multiplied the current and that comes 305.55 volt ampere.

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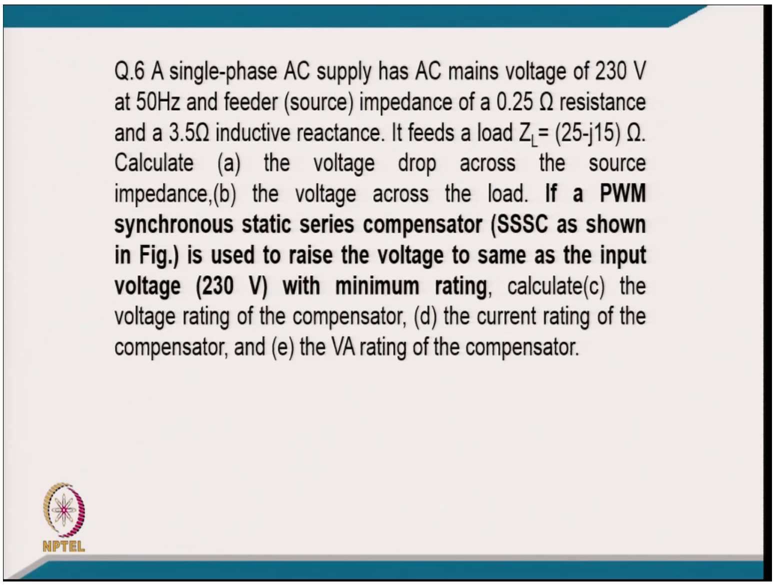

Now, coming to the sixth numerical a single phase AC supply has a AC mains voltage of 230 at 50 Hertz and feeder source impedance of 0.25 ohms resistance and 3.5 ohm inductive reactance. It feeds a load of Z L equal to 25 ohm minus j 15 ohm. And calculate the voltage drop across the source impedance, voltage drop across the load.

If PWM the synchronous static compensator as triple SC used to raise the voltage same as the input voltage of 230 volt typically with the minimum rating, calculate the voltage rating of the compensator, current rating of the compensator and VA rating of the compensator.

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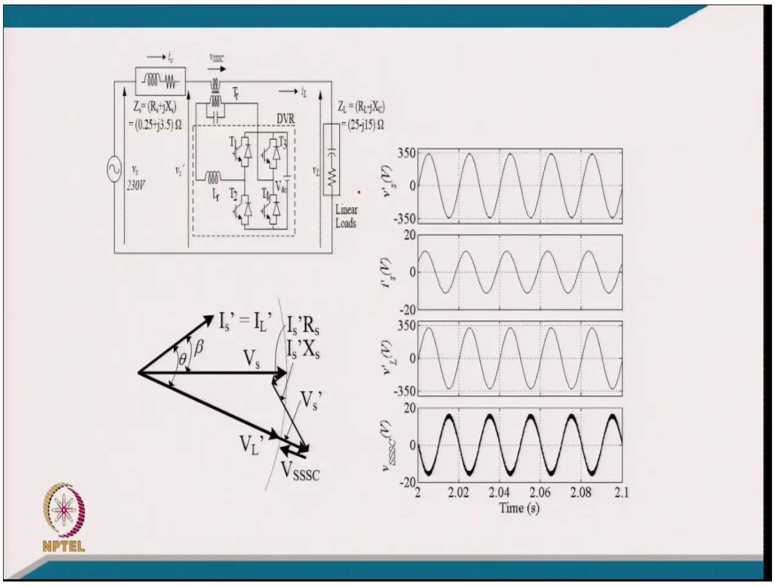

[FL] this is typically now we have a leading power factor load and which leading power factor load may increase the voltage if compensator is not used. Now, we have to bring the voltage equal to the same as the source voltage by putting series compensator. And clearly you can just see here and before this the voltage was more because of capacitive load and now it is to be reduced with minimum rating corresponding to same voltage rating by injecting this voltage typically.

[FL] here it is you can say it is the PCC voltage it is the load and source current which is same and this because of series circuit and this is the load voltage which is regulated to 230 volt RMS. And this is the compensate typically the compensator voltage to be injected by this here series compensator.

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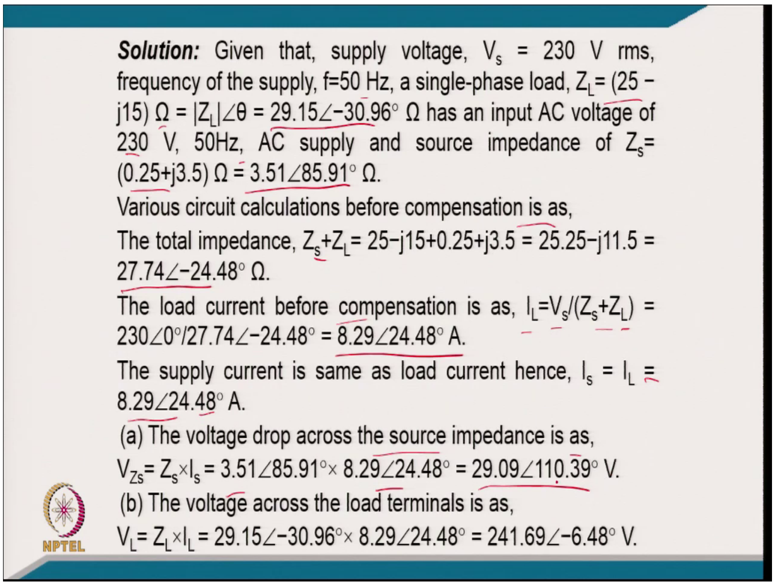

Coming to the solution part of this given that the supply voltage V s equal to 230 volt RMS, frequency of supply 50 Hertz and single phase load of Z L equal to 25 minus j 15 ohm and putting the value it comes 29.15 ohm at the angle of minus 30.96 degree. And has AC input voltage of 230 volt, 50 Hertz, AC supply and source impedance equal to that is equal to 0.25 plus j 3.5 ohm that comes 3.51 ohm at the angle of 85.91 degree and various circuit calculation before the compensation.

[FL], total impedance Z s plus Z L is equal to now 27.74 at the ohm at the angle of minus 24.88 degree. And the load current before the compensation will be I s equal to V s upon Z s plus Z L and it comes like a after putting value 8.29 ohm at the angle of 24.48 degree.

And supply current is same as the load current. [FL] it comes like 8.29 at the ampere at the angle of 24.48 degree and voltage across the source impedance is equal to the current multiplied the impedance its come 29.09 volt at the angle of 110.39 degree and the voltage across the load is your Z L into I L. [FL] it comes down 241.69 volt at the angle of minus 6.48 degree.

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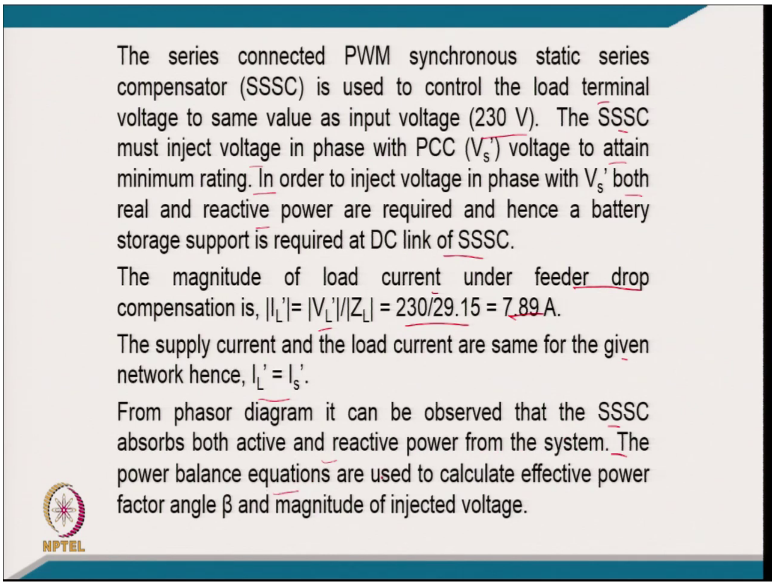

The series connected PWM synchronous static compensator is used to control the load terminal voltage to the same as the input voltage of 230 volt. [FL], SS triple SC must inject the voltage in phase with the PCC voltage to attain the minimum rating in order to inject the voltage in phase with the V s both real and reactive power required.

Hence, the V R the battery storage support is required at the DC link of triple SC and the magnitude of load current under the feeder drop compensation, I mean it comes V L dash upon Z L. [FL], putting the value of 230 divided by 2 point 29.15. It comes 7.89 ampere and supply current after the load same as this. [FL], this will be the same 7.89 ampere and from the phasor it can be observed that the triple SC absorb both active and reactive power from the system.

[FL] power balance equation are used to calculate the effective power factor angle and magnitude of the injected voltage.

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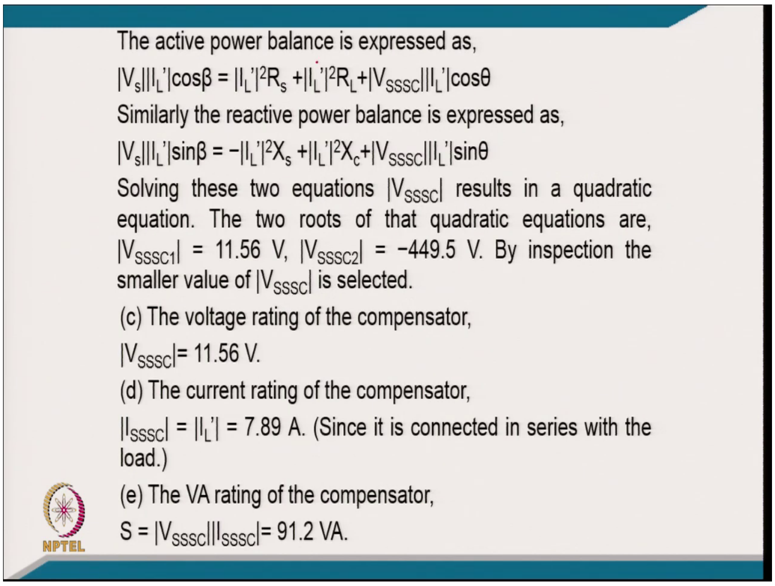

And the active power balance I mean from V s into I L dash into cos beta [FL] equal to typically I L square R s that is for active power equation for the system. And for reactive power balance I mean similarly we wrote the equation for reactive power and solving these two equation for V SS results in a quadratic equation.

[FL], these two roots of quadratic equation are V SSS is equal to 11.56 volt and VSC 2 minus 44.95 by inspecting a smaller value VSC, is selected. [FL] the voltage rating of the compensator is your 11.56 volt and the current rating is the same as the load current 7.89. [FL] VA rating will be VA rating will be your V SSC into I SC, it comes 90 1.2 VA.

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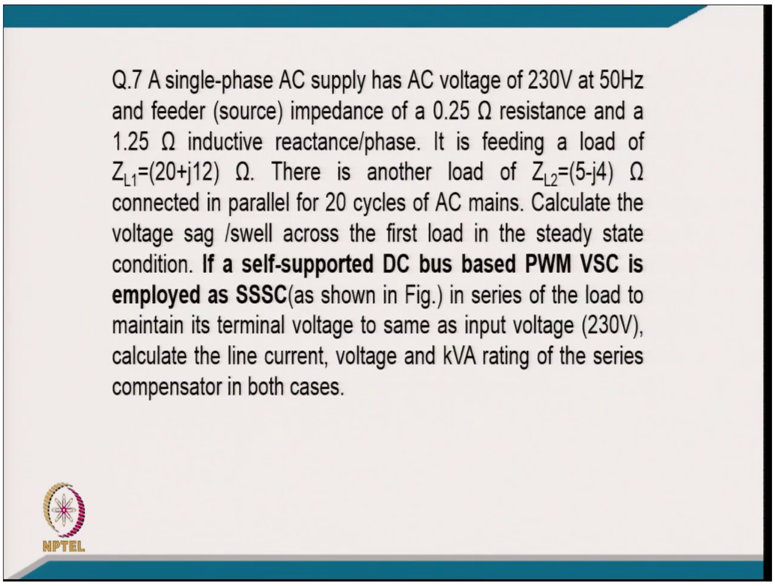

[FL] coming to another example number 7: A single phase AC supply has AC voltage of 230 volt, 50 Hertz and a feeder impedance of 0.25 ohm resistance and 1.25 ohm inductive reactance per. And if it is feeding a load of Z L equal to 220 plus j 12 ohm there is a another load of Z L2 5 minus j 4 ohm connected in parallel for 20 cycle of AC mains.

Calculate the voltage sag swell across the first load in the steady state condition if the self supported DC bus based PWM VSC is employed as a series compensator in series with the load to maintain its terminal voltage to same as the input of 230. Calculate the line current voltage and the kVA rating of series compensator in both the cases like.

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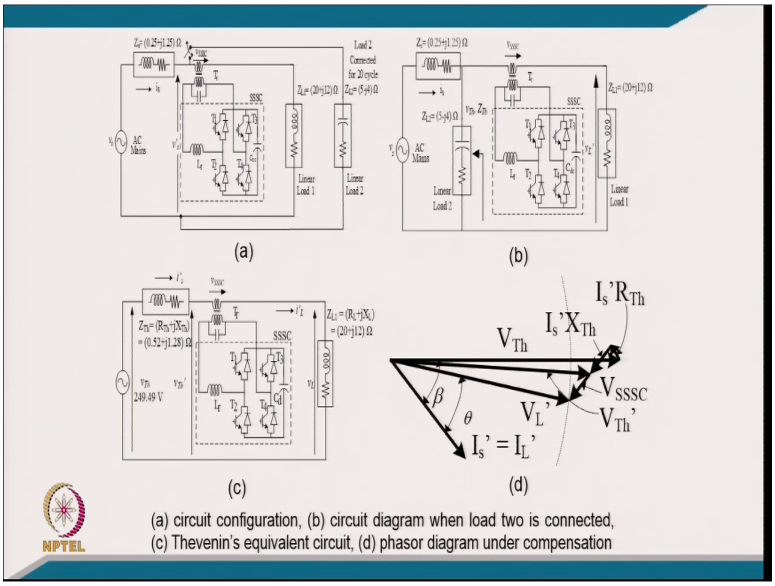

[FL] there are typically the two case. The one case is here we can call it like a we have a only load and we have a for short period another load which is highly capacitive load which certainly we call the voltage swell. I mean typically here. [FL] this is a kind of a load here and we are connecting of course, we are maintaining the voltage of course, here across the second case and this is the typically the first normal case.

[FL] this is the normal case you can call it phasor diagram under compensation because you are putting compensation this is the first diagram with the two loads connected I mean for short period and that is Thevenin equivalent like.

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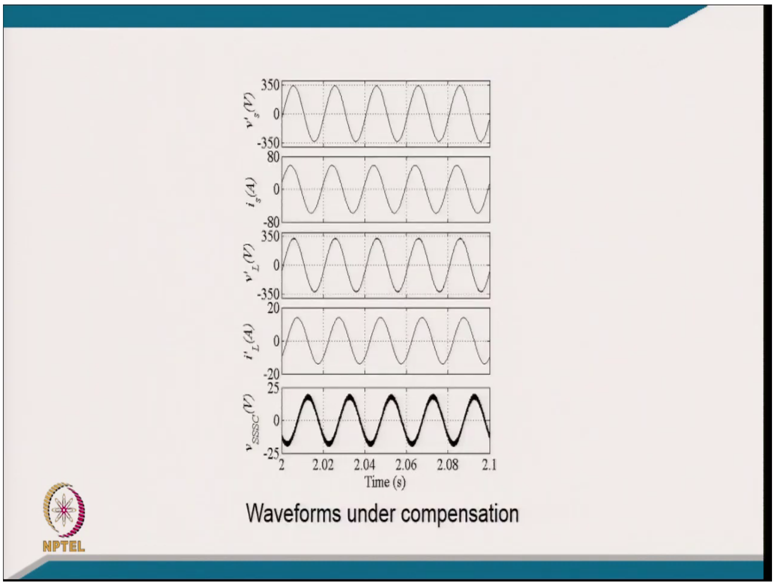

[FL] this is the phase diagram of the total like. And these are of course, the voltage you can call it the PCC voltage and the grid and load current and source current the load voltage and load current unlike and typically the your compensator voltage.

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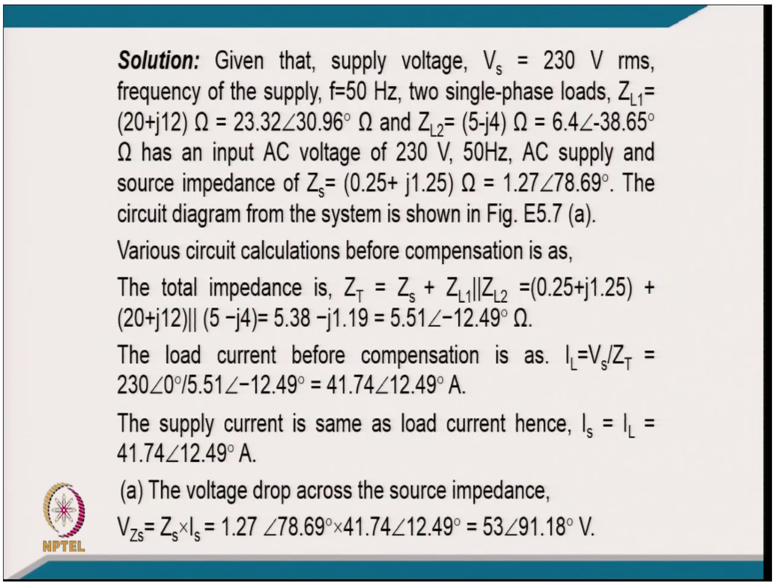

[FL] coming to numerical part of this given that the supply voltage V s 230 volt RMS, so, and frequency of supply 50 Hertz. And two single phase loads Z L1 equal to 20 plus j 12 that is 23.32 at the angle of 30.96 degree ohm and Z L2 5 minus 4 j 4 ohm which comes to like a 6.4 at the angle of minus 38.65 degree ohm. And has a input AC voltage of 230 volt AC supply impedance of 0.25 plus j 1 point ohm and the circuit diagram shown in figure.

[FL] various calculation before the compensation comes like we put the value of Z T equal to Z s plus parallel impedance of both the impedances because both are connected in parallel and that impedance total comes like a your 5.51 at the angle of minus 12.49 degree ohms. [FL] load current before the compensation comes I L equal to V s upon Z T and this comes 41.74 at the angle of volt sorry ampere at the angle of 12.49 degree and supply current is the same as the load current.

[FL] that comes 41.74 ampere at the angle of 12.49 degree. [FL] voltage across the source impedance will be that typically source impedance multiplied the current. [FL] that come 53 53 volt like I mean.

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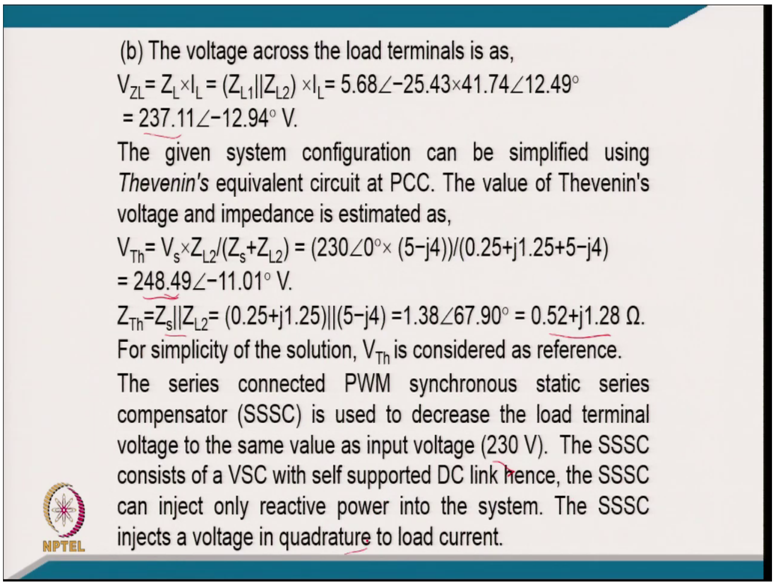

[FL] the voltage across the load terminal will be your Z L I L. [FL], keeping the value of this it comes typically 237.11 volt and the given system configuration can be simplified using Thevenin equivalent circuit at PCC. The value of Thevenin equivalent the voltage and impedance can be calculated

So, Thevenin voltage from this comes like a 248.49 volt at the angle of minus 11.01 degree and the Thevenin impedance is Z s multiplied to the Z L2. [FL], you calculating, so, it comes out 0.52 plus j 1.2 ohm. For simplicity the solution we Thevenin consider as the reference.

[FL] series connected PWM synchronous static series compensator is used to decrease the voltage of load to the same at 230 volt because it has increased 248.

[FL], it had to bring back 230 and series compensator consists of volt VSC with self supported DC link. Hence, the SSC can inject reactive power into the system [FL] SSC in that the voltage in quadrature with the current.

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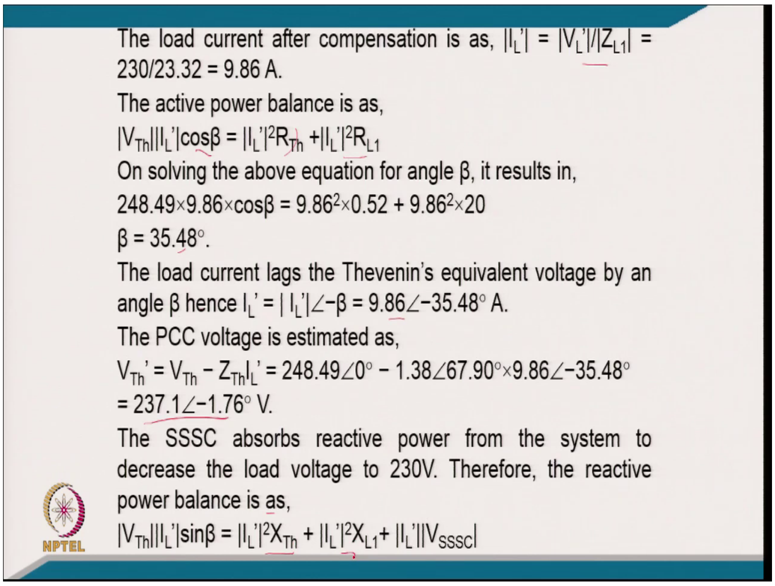

[FL] the typically calculating the current from this rated voltage divided by impedance it comes 9.86 and then putting a power balance I mean the power on the typically you can call it on grid side. I mean corresponding to voltage current and the angle between voltage and current and the loss in resistance of Thevenin and that is the load resistance.

So, solving this beta comes 35.48 degree and the load current lags the terminal voltage by angle beta. Hence, it comes typically 9.86 ampere at the angle of minus 35.48 degree and PCC voltage is estimated from this Thevenin voltage minus the Thevenin impendence drop multiplied the current.

[FL] it comes typically 237.1 at the angle of typically 1.76 degree. [FL] series compensator absorbs the reactive power from the system to decrease the load voltage 230. Therefore, the reactive power balance, I mean we can get from this is the reactive power of course, on the good side. That is the reactive power consumed by Thevenin impedance reactive power consumed by the load and the reactive power I mean like injected by the series compensator.

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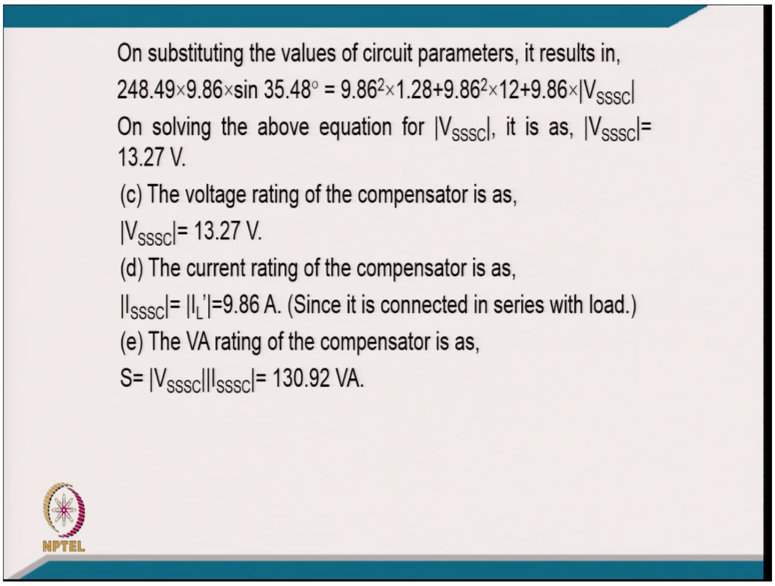

[FL] substituting the value we get here the series compensator value of 13.27 volt and the typically this is the same as the voltage rating of the compensator and current rating same as the load current and the VA rating comes here typically this multiplied this. [FL] it come [FL] 130.92 VA.

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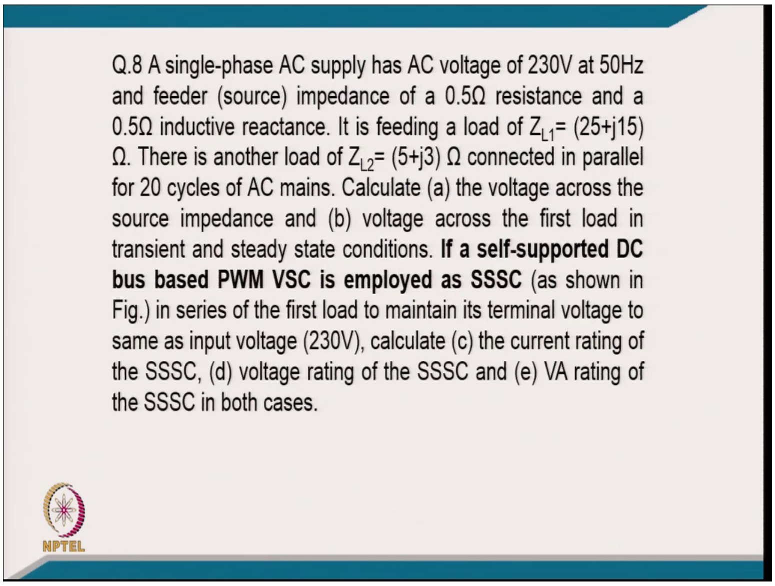

Coming to the 8th numerical a single phase AC supply has a AC voltage of 230 volt 50 Hertz and a feeder impedance of 0.5 ohm and a resistance inductive reactance of 0.5 ohm induction it feeding load of 25 point j of 15 ohm. And there is another load Z L2 5 plus j 3 ohm connected in parallel to 20 cycle of AC mains.

Calculate the voltage across the source impedance, voltage across the first load transient in transient and steady state condition if self supported DC bus based PWM voltage source converter is used as SC in series with the first load to maintain the terminal voltage as the input voltage of 230 volt. Calculate the current rating of SSC, voltage rating of the SSC and VA rating of the SSC in both the cases.

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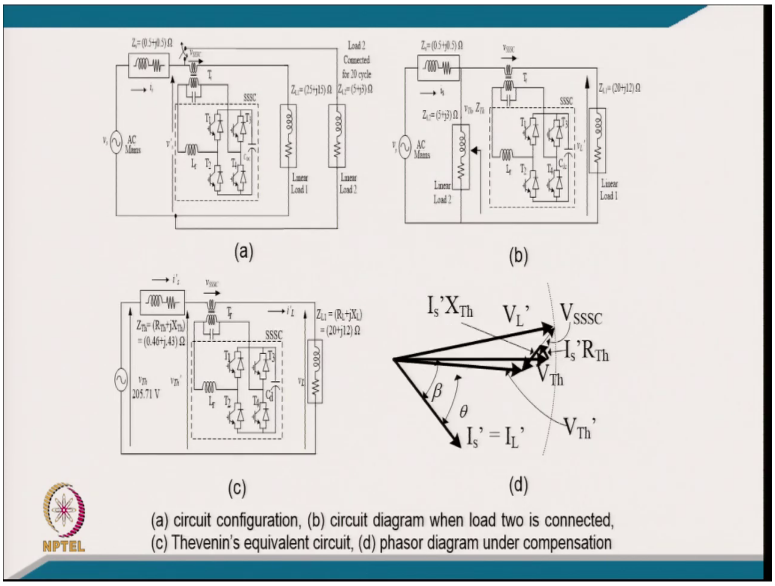

[FL], these are the typically you can call it the circuit diagram of typically of the configuration where I mean that is the original load this is series compensator and in for short period another load is connected that is Thevenin equivalent of this. And this is the typically the final along with the Thevenin equivalent the circuit diagram for from which calculation are to be made.

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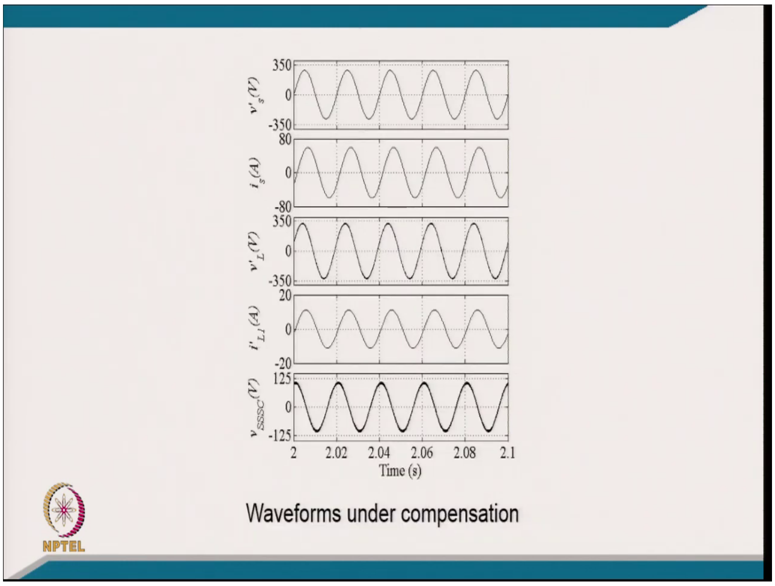

And after doing the all this I mean this is the typical waveform of the PCC voltage then the load current source current, load voltage modified load voltage, load current and series injected voltage which are in 90 degree from the current load current.

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Solution: Given that, supply voltage, V_s = 230 V rms, frequency of the supply, f=50 Hz, two single-phase loads, Z_{L1}= (25+j15) Ω = 29.15∠30.96° Ω and Z_{L2}= (5+j3) Ω = 5.83∠30.96° Ω has an input AC voltage of 230 V, 50Hz, AC supply and source impedance of Z_s= (0.5+ j0.5) Ω = 0.707∠45° Ω. The circuit diagram from the system is shown in Fig.

Various circuit calculations before compensation is as,

The total impedance is as, $Z_T = Z_s + Z_{L1}||Z_{L2}$ = (0.5 + j0.5)+ (25+j15)|| (5+j3)= 4.66+j3 = 5.54∠32.77° Ω.

The load current before compensation is as, I_L= V_s/Z_T = 230∠0°/5.54∠32.77° = 41.51∠−32.77° A.

The supply current is same as load current hence, $I_s = I_L$ = 41.51∠−32.77° A.

(a) The voltage drop across the source impedance is as,

V_{Zs}= Z_s×I_s = 0.707∠45°×41.51∠−32.77° = 29.31∠12.27° V.

[FL] coming to the solution numerical part of it given that the supply voltage V s of 230 volt RMS frequency of supply 50 Hertz and two single phase load Z L1 equal to 25 plus j 15 ohm and Z L2 5 plus j 3 ohm and AC voltage of 230 volt and we can find out typically the Z s given here.

And we can find out the total impedance typically Z s plus Z L1 parallel with the Z L2. [FL], it comes 5.55 ohm at the angle of 32.77 degree and the load current will be your I L equal to V s upon total Z T. It comes 41.51 ampere at the angle of minus 32.77 and supply current is same their load current. And the voltage across the source impedance will be that load source impedance and the current. It comes 79.31 volt at the angle of 12.27 degree.

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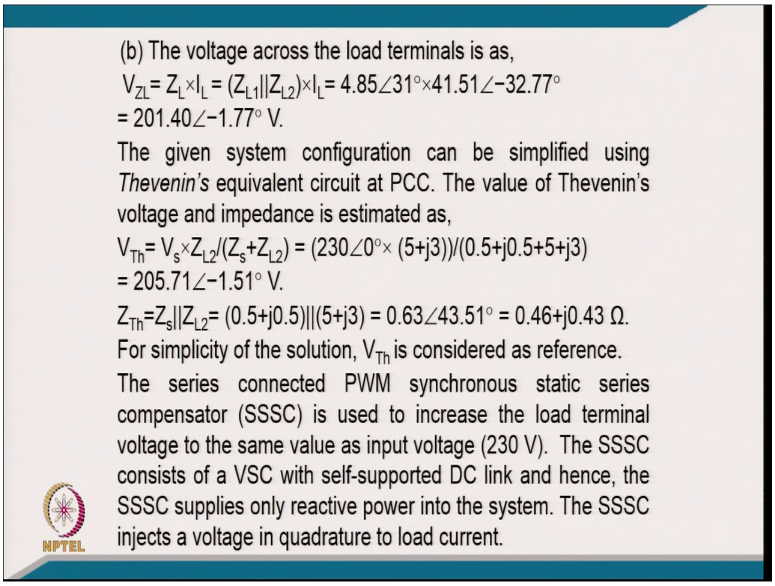

[FL] voltage across the load terminal is now Z L into I L and load is the parallel impedance of the both load multiplied I L. [FL] you can find out the load voltage now 201.4440 volt at the angle of minus 1.77. This voltage reduces I mean because both are the lagging power factor load and there is a kind of voltage sag is created here because of another heavy load connected at the point of common coupling.

[FL] given system configuration can be simplified using a Thevenin equivalent circuit at PCC and value of Thevenin voltage and impedance is calculated here and that is the Thevenin voltage comes 205.71 volt at the angle of minus 1.51 degree and Z Thevenin is a parallel impedance of the source with Z L2. [FL] it comes like a typically 0.63 ohm at the angle of typically 43.51 degree, for simplicity the solution with having considered as a reference.

And the series connected to PWM synchronous static compensator is used to increase the load terminal voltage to the same as the input voltage of 230 volt. So, SSC consists of VSC with self supporting DC link and hence the SSC supply only reactive power into the system and SSC inject the voltage in quadrature with the load current.

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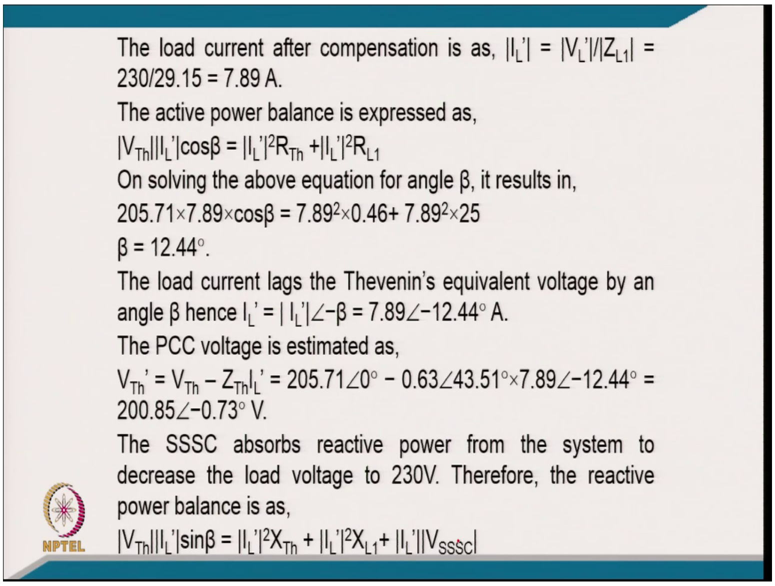

Coming to after compensation the typically the current, [FL] voltage is regulated to the source voltage of 230 volt divided by the impedance of load. [FL] it comes 7.889 ampere. And now we can have active power balance, the active power on the typically at the point of common coupling. It comes the power consumed in the Thevenin resistance plus the load power consuming the load.

[FL] solving this we get the beta equal to angle of power factor. We get the 12.44 degree and the load current lags by Thevenin voltage. [FL] it comes like a current comes like 7.89 at the angle of minus beta 12.44 ampere and with Thevenin volt new Thevenin voltage V Th and Th I L.

[FL] it comes typically of 200.89 volt at the angle of minus 0.73 degree and series compensator absorb the reactive power from the system to decrease the load voltage to 230 and therefore, the reactive power I mean calculated from here.

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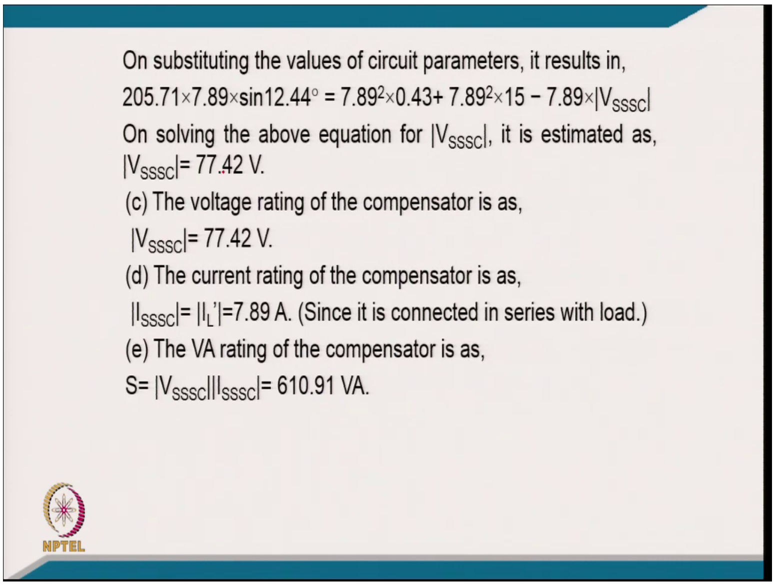

[FL] putting the value we get the typically the series compensator value of 77.42 volt and that is the same rating of the compensator. And current rating of compensator is says that load rate current rating that is 7.8 and multiplying these two with the VA rating of the compensator that is 610.91 VA like.

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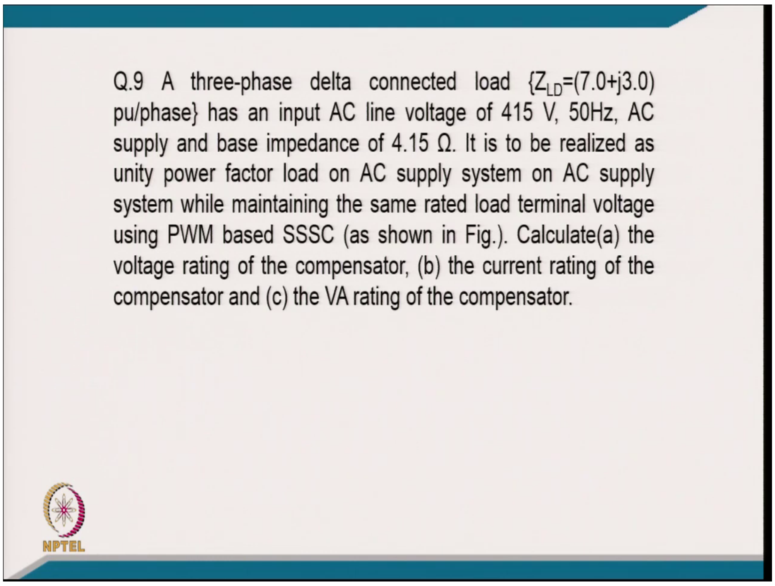

[FL] coming to 9th example: A three phase delta connected load of Z LD equal to 7.0 plus j 3 0 per phase has a input line voltage of 415 volt 50 Hertz AC supply and base impedance of 4.15 ohm. And it to be realized as a unity power factor load on the AC supply system on the while maintaining the same rated terminal voltage using a PWM series compensator. Calculate the voltage rating of the compensator, current rating of the compensator and VA rating of the compensator.

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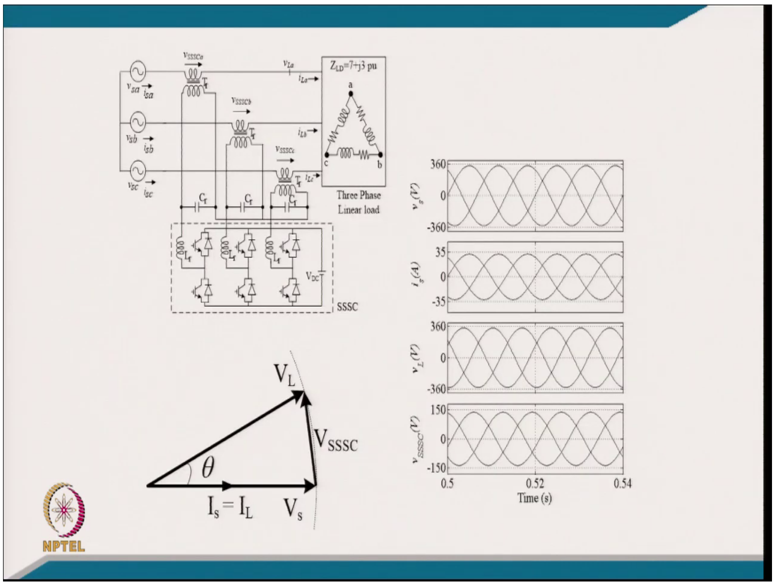

Typically you can call it here I mean we are keeping a here typically the compensator in series to regulate the voltage across this lagging power factor load and these are the typical waveform. [FL] what we have to do? By putting here by injecting the voltage we are maintaining same as the load voltage this is the same as source voltage. Even under the typically kind of voltage.

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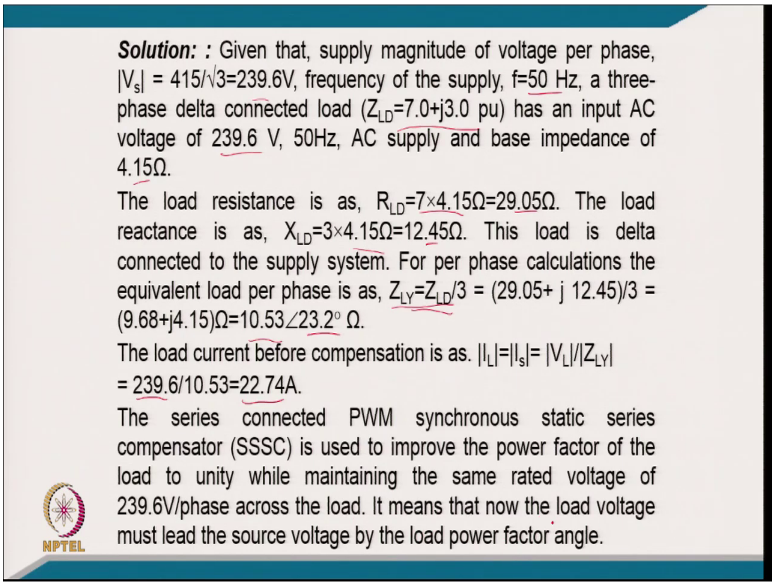

[FL], given supply voltage per phase is a 415 by root 3 239.6 and frequency of supply 50 Hertz and three phase delta connected load of Z LD equal to 7.0 plus 3 per unit has an input voltage of 239.6 and the base impedance of 4.15 ohm. [FL] the load resistance multiplying the per unit and this it comes 29.05 ohm and the load reactance comes same 12.45 ohm.

The load is delta connected to the system. [FL] per phase calculation we can calculate. The equivalent star comes Z LD by 3 that comes like a 10.53 at the angle of 23.2 degree and the load current I mean like which you can call it before compensation will be typically I mean here V L upon Z Y.

[FL] it will be your phase voltage 239.6 divided by the impedance 10.53. [FL] it comes 22.74 ampere. And the series connected PWM synchronous static compensator used to improve the power factor of the load to unity while maintaining the same rated voltage of 239.6 volt per phase across the load. It means that now the load voltage must lead the source voltage by the compensator by the load power factor angle.

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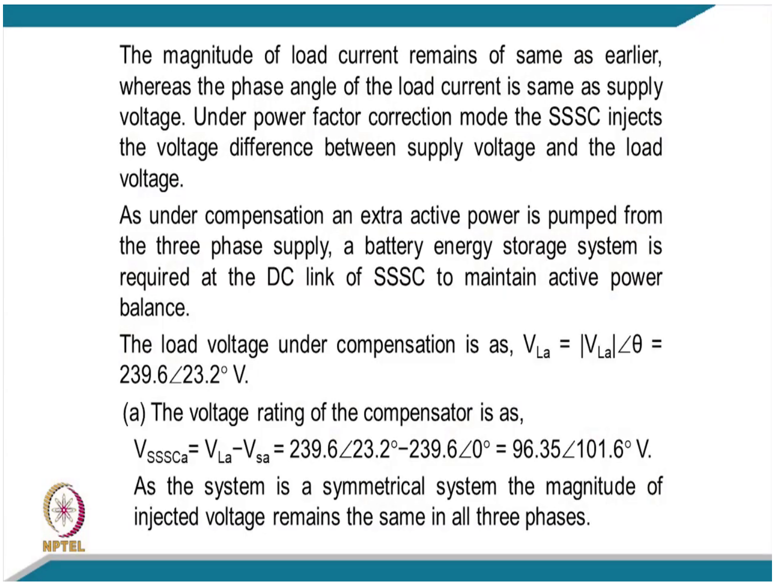

[FL] the magnitude of the load current remains the same as the earlier whereas, the phase angle of the load current is same as the supply voltage. [FL] under power factor correction mode the SSC inject the voltage difference between supply voltage and the load voltage as under compensation extra active power is pumped from the single phase supply.

[FL] a battery energy storage system is required the DC link of the SSC to maintain the active power balance and the load voltage after the compensation is same as the source voltage of 239.6 and the voltage rating of the compensator will be your V La minus V Sa. [FL] keeping this. [FL] it comes 96.35 degree at the angle volt at the angle of 101.6 degree. The as the system is symmetrical system the magnitude of injector voltage remain the same for all the three phases.

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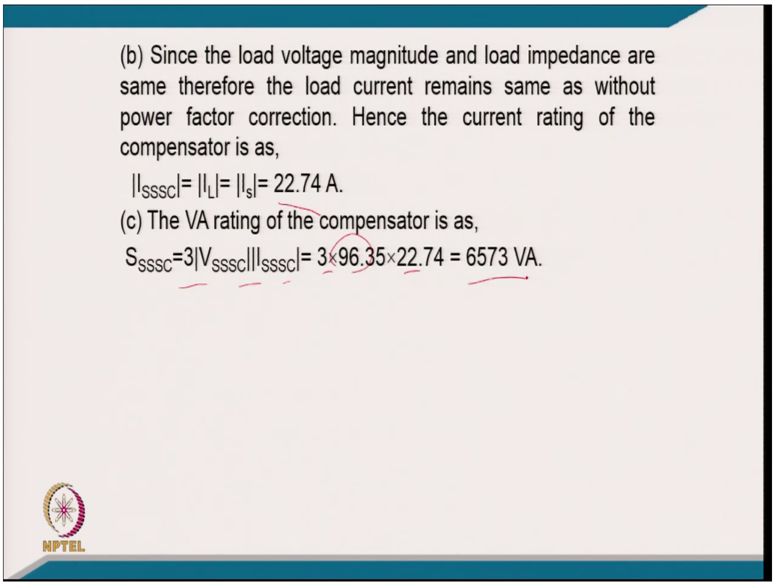

[FL], since the load voltage magnitude and source and load impedance are same, therefore, the load current remains the same without power factor correction hence the current rating of the compensator will be same 22.74 ampere. And VA rating will be 3 time V SC and I SC. [FL] this is 3 into the voltage 96.35 and current of its rating of 22.74 that comes 6573 volt ampere.

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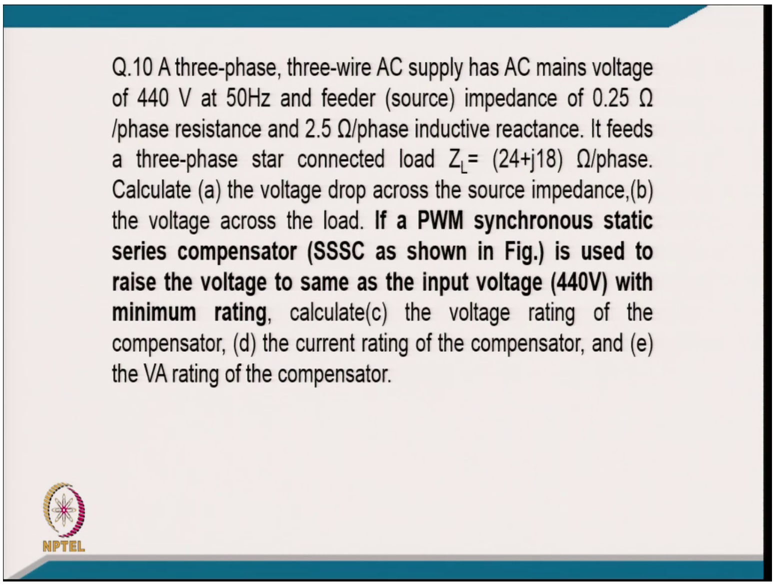

Coming to typically the 10th example: A three phase three wire AC supply has a AC mains voltage of 440 volt 50 Hertz and a feeder impedance of point 0.25 ohm per phase resistance and 2.5 ohm per phase inductive reactance. It feeds a three phase star connected load of Z L equal to 24 point j 18 ohms per phase.

[FL] calculate the voltage drop across the source impedance, voltage drop across the load and if PWM synchronous static series compensator is used to raise the voltage typically for to the same as the input voltage of 440 volt with the minimum rating. Calculate the voltage rating of compensator, current rating of the compensator and VA rating of the compensator.

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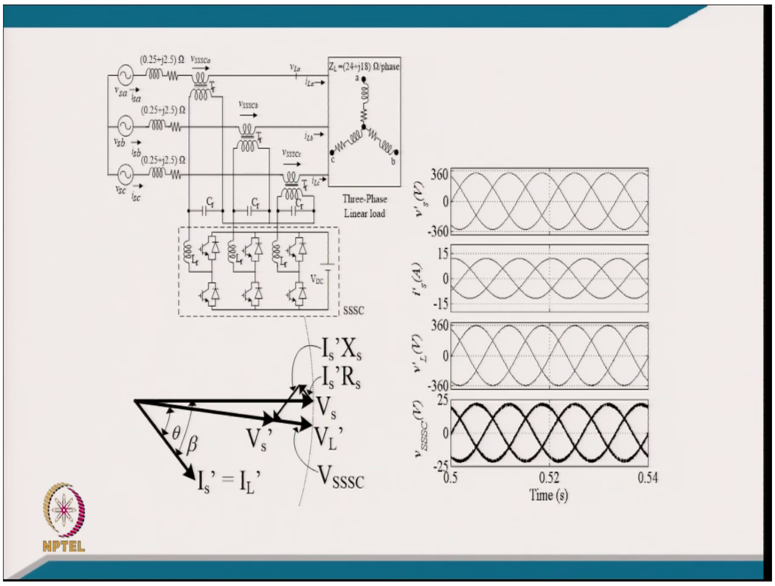

[FL] this is a typical circuit diagram. I mean we have a load here typically the balanced load. We have a source impedance. If compensator is not used this voltage will certainly go down because a lagging power factor load. And there is a source impedance which have a highly inductive part like.

[FL] that I mean will cause the voltage, but we have to regulate. [FL] we inject the voltage here. So, that the load voltage is thus same as the source voltage and these are the typical waveform.

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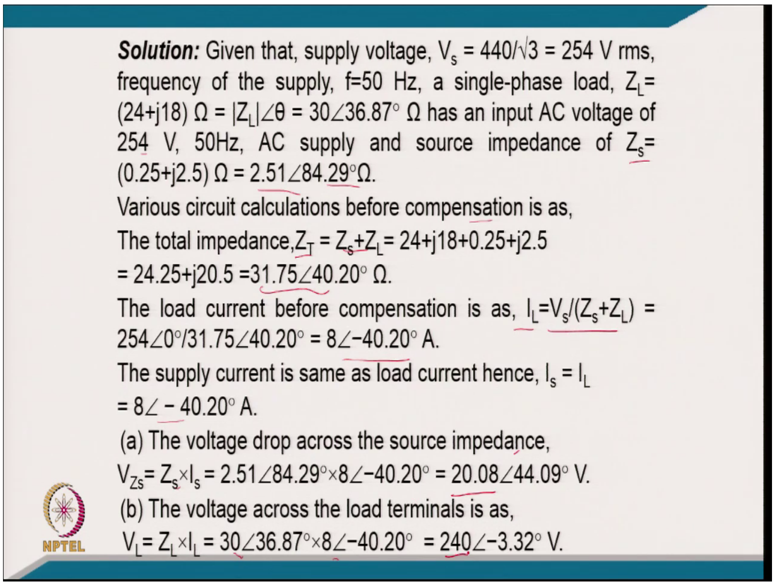

[FL] coming to numerical part of it given that the supply voltage V s equal to 440 by root 3 250 volt RMS, frequency of supply 50 Hertz and a single phase load Z L equal to 24 point plus j 18 that is typically 30 ohm at the angle of 36.87 with the input voltage of 254 that is 415 by root 3 50 Hertz so, AC supply and source impedance is typically 2.51 ohm at the angle of 84.29 degree.

[FL] various circuit calculation, I mean before the compensation we can find out Z T total impedance source impedance plus load impedance that is come 31.75 ohm at the angle of 40.20 degree and load current before the compensation will be I L equal to V s upon total impedance Z s plus Z L.

It comes 8 ampere at the angle of 40 point minus 40.20 degree and supply current same as the load current. [FL] it will be same as 8 ampere at the angle of 8 ampere at the angle of minus

40.20 degree. [FL] the voltage across the source impedance will be Z s I S. [FL] that will be 20.08 volt and the voltage across the load will be your load impedance multiplied the load current that comes 240 volt across the load.

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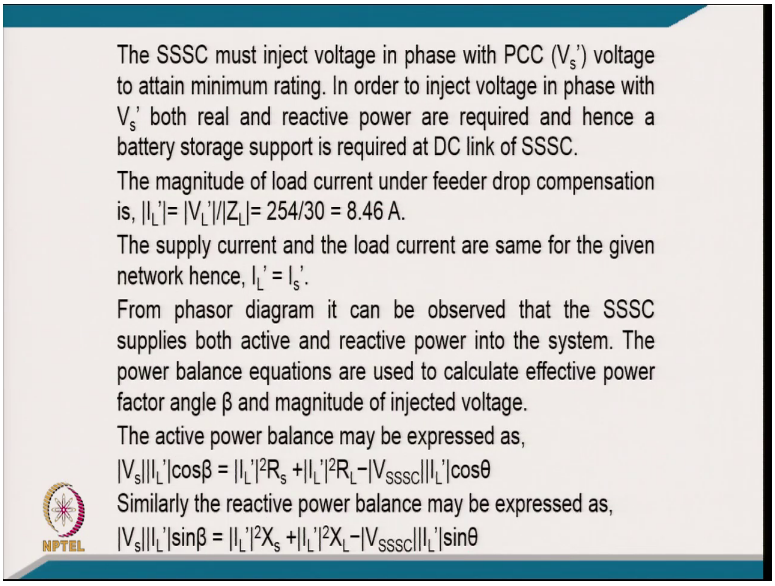

[FL] now series triple SC must inject the voltage in phase with the PCC voltage to attain minimum rating and in order to inject the voltage in phase with V s dash both real and reactive power are required and hence the battery energy storage support is required at the DC link of triple SC.

And the magnitude of load current or feeder drop compensation that is I L dash is equal to rated voltage of 440 by root 3 that is 254 by 30. It comes 840 8.46 ampere and supply current and load current are the same. [FL] that is 8.46 ampere. [FL] from the phasor diagram it can be observed that SSC supply both at active and reactive power to the system.

[FL] power balance equation are used to calculate effective power factor angle beta and magnitude of the injected voltage. Per phase active power balance we can have here V s I L cos beta that is power on the PCC sorry, grid side and this is the power consumed by the source impedance load impedance and injected power by the compensator.

And similarly for reactive power balance the power reactive power at the grid side, the reactive power consumed by the source impedance, reactive power consumed by load and the reactive power injected by the compensator.

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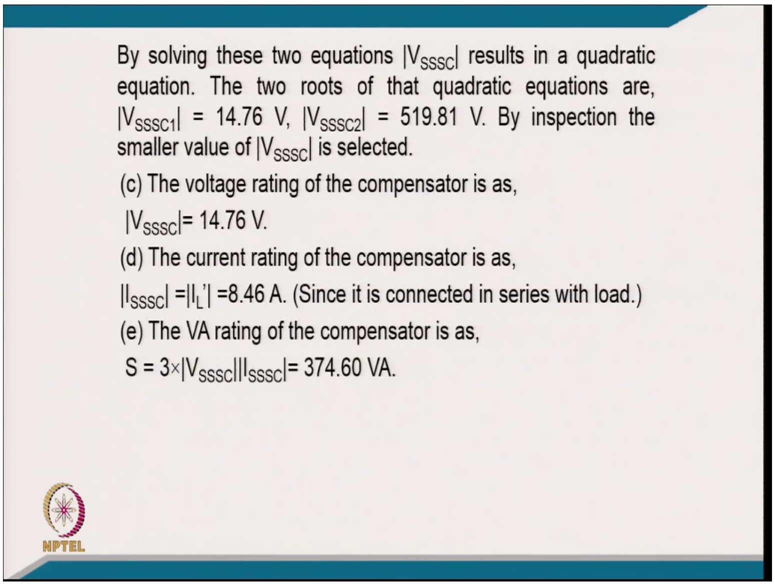

[FL] by solving this of course, I mean we will get the two value of the series injected voltage 14.76 another is typically 519.81 volt, but of course, we have to select lowest rating. [FL] the lowest rating is 14.76 we select that and the current rating is already for series load current.

[FL] that is 8.46 and now the compensator rating 3 times the injected voltage, multiply the current, [FL] it comes 374.6 volt ampere.

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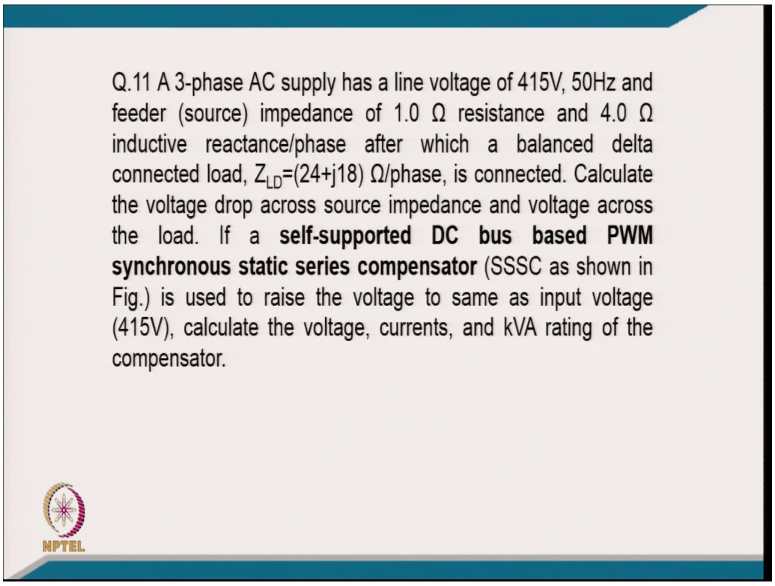

Coming to the numerical number 11: A three phase AC supply has a line voltage of 415 volt, 50 Hertz and a feeder impedance of 1 ohm resistance and 4 ohm resistance inductive reactance per phase after which a balanced delta connected load of Z LD equal to 24 point j 18 ohm per phase is connected.

Calculate the voltage drop across the source impedance and voltage drop across the load. [FL] if self supported DC bus is based synchronous static series compensator is used to raise the voltage same as the input voltage, calculate the VA rating current calculate the voltage current and kVA rating of the compensator.

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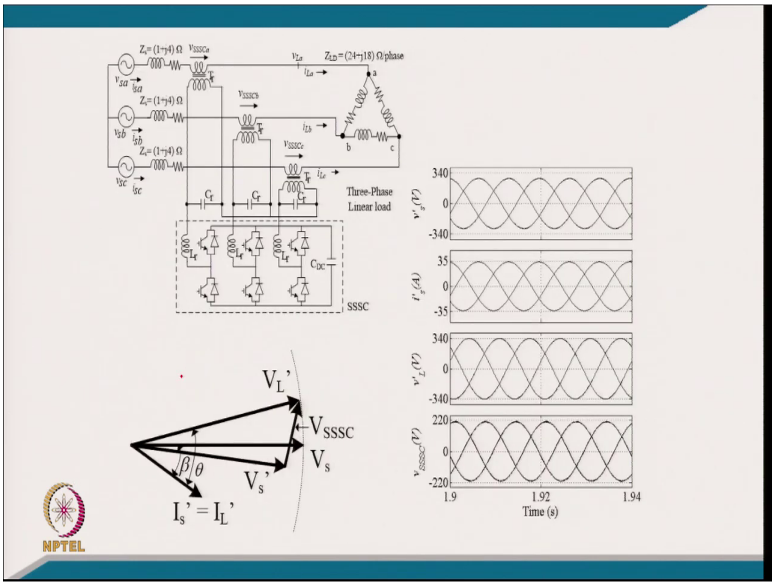

This is the typical circuit. [FL] we have a I mean source impedance has a in inductive and load is also lagging power factor load. [FL] the compensator is not used. Certainly voltage will drop across the load because of poorest voltage regulation. [FL] we connect the series compensator and we inject the voltage so that the load voltage here is the same as the source voltage. And these are point of common coupling voltage source current, load current and compensated voltage and with the phasor diagram.

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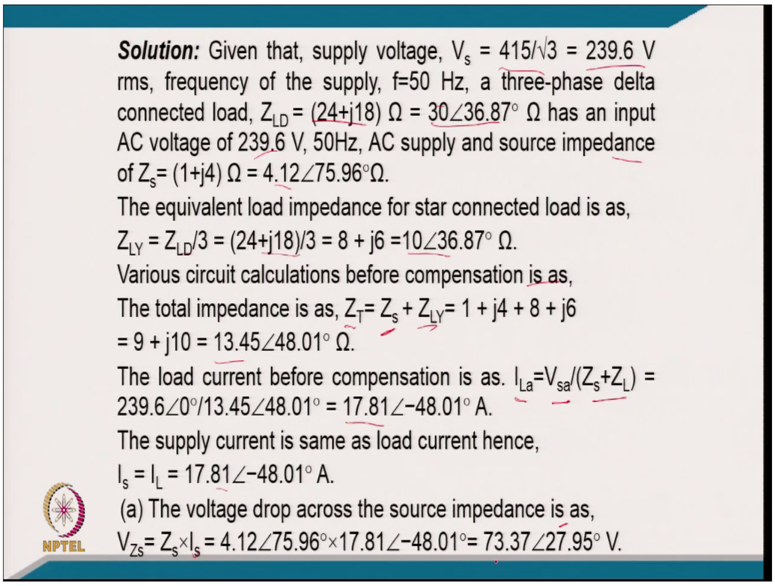

[FL] coming to the solution that given that supply voltage of phase voltage is 415 by root 3 that is 239.6 volt and frequency of 50 Hertz and we have a load impedance Z LD equal to 24 point j 18 that is 30 ohm at the angle of 36.87 has a input voltage of 239.6 volt at 50 Hertz and AC supply and source impedance is Z s equal to 1 plus j 4 ohm. It comes 4.1 2 ohm at the angle of 75.96 degree and the equivalent impedance of into the equivalent star is typically Z by Z L y equal to z ld by 3.

[FL] dividing by 3 it comes 10 at the angle of 10 ohm at the angle of 36.87 degree and calculating the various circuit calculation before the compensation, [FL] we get the total impedance that is the source impedance plus the impedance of equivalent star per phase. [FL] this comes the impedance 13.45 ohm at the angle of 48.01 degree.

And the load current before the compensation will be I L equal to V sa divided by Z L plus Z s and that is comes typically 17.81 ampere at the angle of minus 48.01 ampere and supply current is the same as the load current [FL] that will be the same as the 17.81 ampere and voltage drop across the source impedance will be the source impedance multiplied this typically source current and it comes 73.37 volt like.

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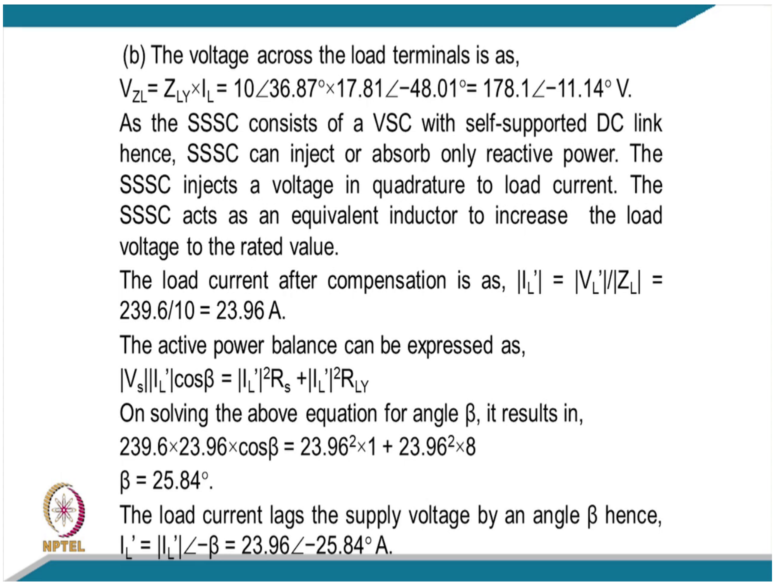

The voltage across the load terminal is now the load impedance multiplied the load current. [FL] we are putting the value it comes one 178.1 volt at the angle of minus 11.14. This is certainly much much lesser than typically through 229, the rated voltage because of lagging power factor and the source impedance is also of inductive nature.

[FL] as the triple SC consists of VSC with self supporting this supported DC link and the SSC can inject or absorb reactive power. SSC inject the voltage in quadrature to the load current. [FL] SSC acts as is equivalent inductor to decrease the voltage to increase the voltage of typically the load voltage to the rated voltage. The load current after the compensation is equal to the rated voltage 239.6 divided by 10.

[FL] it comes 23.96 ampere and active power balance for this circuit will be of typically active power consumed by the source impedance and active power consumed by the equivalent star connected load on the per phase basis. And solving this we get the beta equal to that is the angle between V s and I L is 25.84 degree and the load current lag by this angle. [FL] we know the now load current with this angle.

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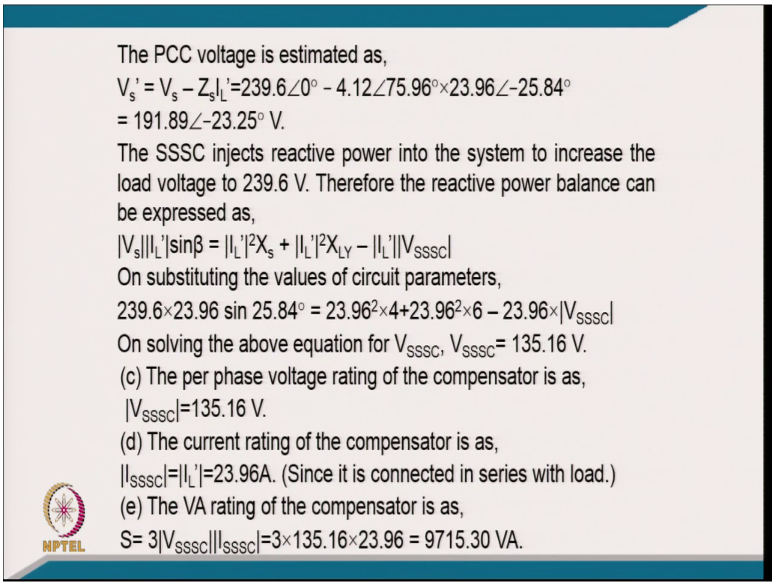

And now PCC voltage can be calculated V s minus the source impedance drop and it comes like a typically 191.89 volt that is the voltage at the point of common coupling. Now, the SSC inject the reactive part to the system to increase the voltage to 239.6 volt. Therefore, the reactive power balance can be expressed as reactive power at the source side, reactive equal to reactive power consumed by the source impedance, reactive power consumed by the load and reactive power injected by typically by the series compensator [FL] that is typically only the reactive power.

[FL] on substituting this value I mean we get the value of series compensator voltage 139.16 volt and this is the per phase voltage injected into this and current is already equal to load current 23.96 ampere. [FL] getting the rating 3 times for three phase then the voltage injected and then the current of series [FL] it comes 9715.30 volt ampere.

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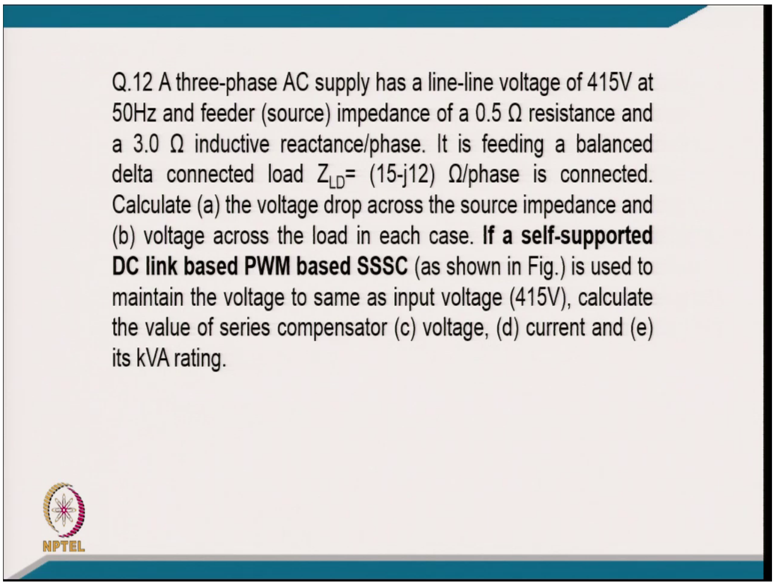

Coming to the 12th numerical problem: A three phase AC supply has a line voltage of 415 volt at 50 Hertz and feeder impedance of 0.5 ohm and resistance and 3 ohm reactant inductive reactance and it is feeding the balance delta connected load of 15 minus j 12 ohm per phase connected and calculate the voltage drop across the source impedance and voltage across the load.

If self supported DC link PWM VSC triple SC is used to maintain the voltage across the load same as the input voltage, calculate the voltage value of the voltage rating of the compensator, current rating of the compensator and kVA rating of the compensator.

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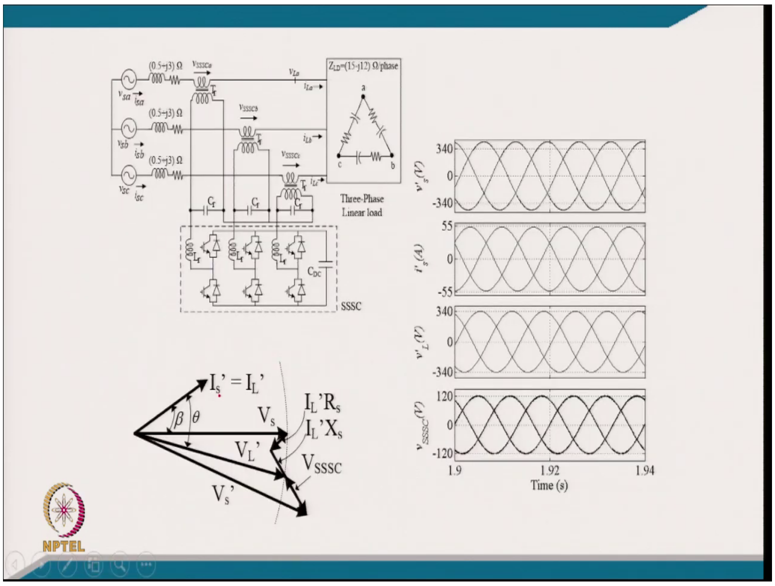

The typical circuit we have a here source impedance, we have a leading the power factor load which have a can have a lead typically the voltage more than the rated voltage. [FL] we have to bring the voltage equal to the rated by putting a series compensate consistent of the voltage. [FL] here you can see the source voltage is a load voltage which is regulated and this is the current and this is the series injected volt.

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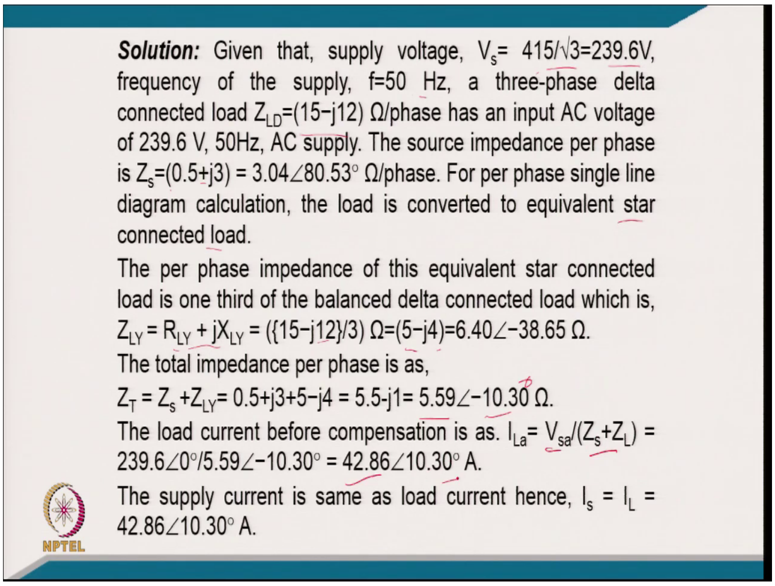

[FL] coming to the numerical part of this given that supply voltage equal to 415 by root 3 per phase that is 239.6 and we can say frequency supply 50 Hertz and 3 phase delta connected load of 15 minus j 12 ohm. Per phase have a AC voltage of 239 and the feeder source impedance is 0.5 plus j 3 ohm that comes 3.04 ohm at the angle of 80.53 degree.

[FL] for per phase single line diagram calculation, the load is converted equivalent to star connected from the delta connection and that per phase impedance of the equivalent star connected load is the one-third of the balance because of star delta conversion. [FL] it comes like typically 5 minus j 4 which comes 6.4 ohm at the angle of minus 38.65 degree.

And now the total impedance per phase will be Z s plus Z LY, [FL] it comes 5.59 ohm at the angle of minus 10.30 degree and the load current before the compensation will be your V sa divided by total impedance. It comes 42.86 at the ampere at the angle of 10.30 and this current will be the same as the your load current.

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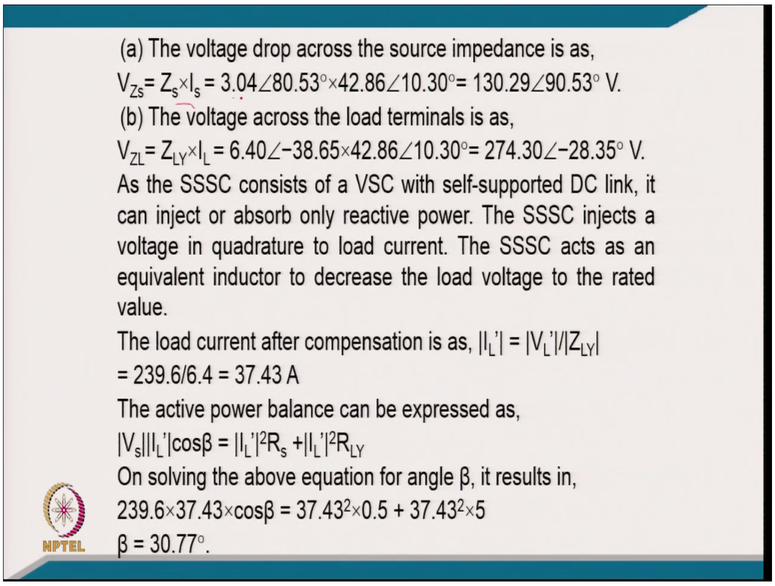

[FL] now the voltage drop across the source impedance will be impedance multiplied the current and it comes 30 130.29 volt at the angle of 90.53 degree and voltage drop across the load will be now load impedance multiplied the load current. It comes like a 274.30 volt and this voltage is much higher than the rated voltage because the load is inductive. [FL] we have negative voltage regulation.

[FL] as the SSC is consists of the VSC with self supporting DC link. It can inject the or absorb the only reactive power. So, SSC inject the voltage in quadrature to the load current. SSC act as a equivalent inductor to decrease the load voltage and the load current after the compensation is rated voltage divided by your impedance of the load. [FL] it will come 37.43 on per phase basis.

And from active power balance we can say active power at the point of common coupling equal to the sorry at the source equal to the power consumed by the source impedance and power consumed by the load and solving this we get the beta this angle power factor angle 30.77 degree at typically.

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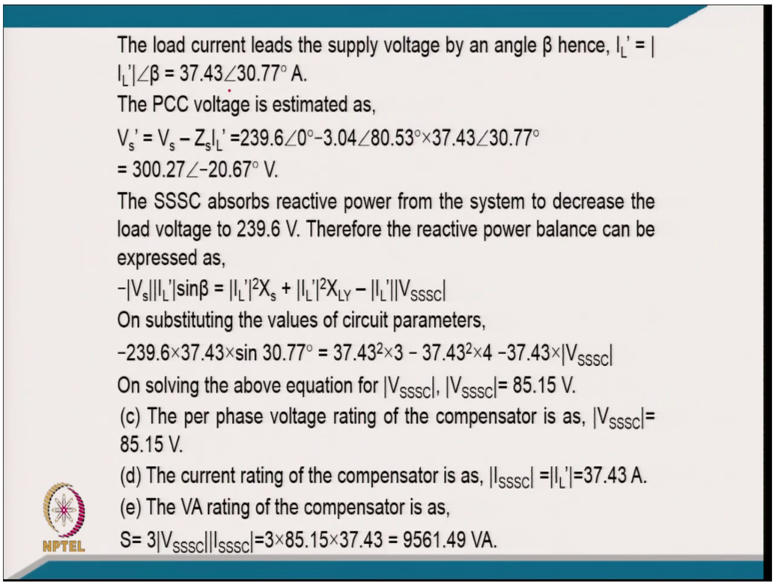

And the current will be there now at this angle of 37.43 ampere at the angle of typically of 30.77 and PCC voltage we can calculate. From here it comes like typically 300.27. [FL] this is much higher voltage and SSC absorb the reactive power to decrease the voltage to 239.6 from 300 and there therefore, reactive power can be expressed from reactive power balance.

[FL] this is reactive power at the source side reactive power consumed by the source impedance reactive power consumed by load and minus the reactive power injected by the compensator. [FL] substituting the value we get the series compensator voltage equal to 85.15 volt and per phase voltage rating of the compensator is equal to same as 85.15.

And the current rating is same as the load current rating that is we calculated earlier, it comes 37.43 and the VA rating will be 3 times the compensator injected voltage multiplied the current and it comes 9561.49 volt ampere.

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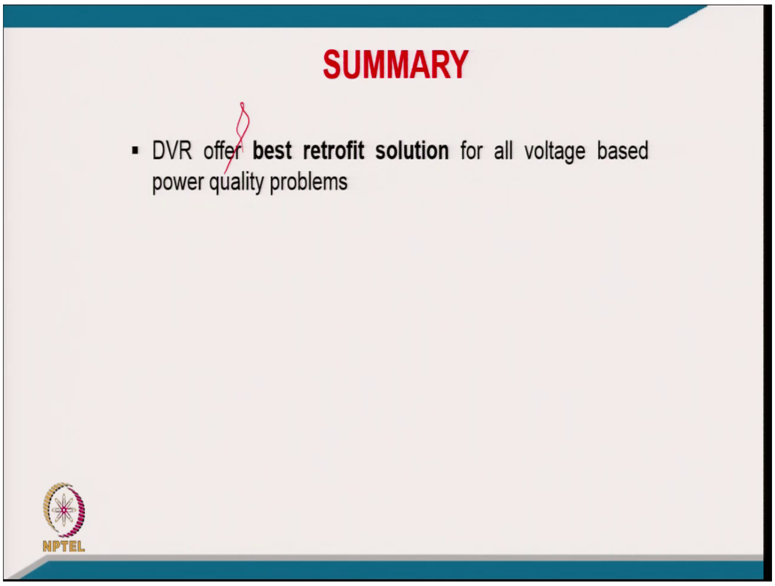

[FL] now we would like to summarize this series compensator or DVR. [FL], DVR offers best retrofit solution for all voltage based power quality problem. We discussed already the many problems of voltage compensation like a voltage sag swell, voltage fluctuation of balance and voltage harmonics. So, all we have considered here for to be considered here.

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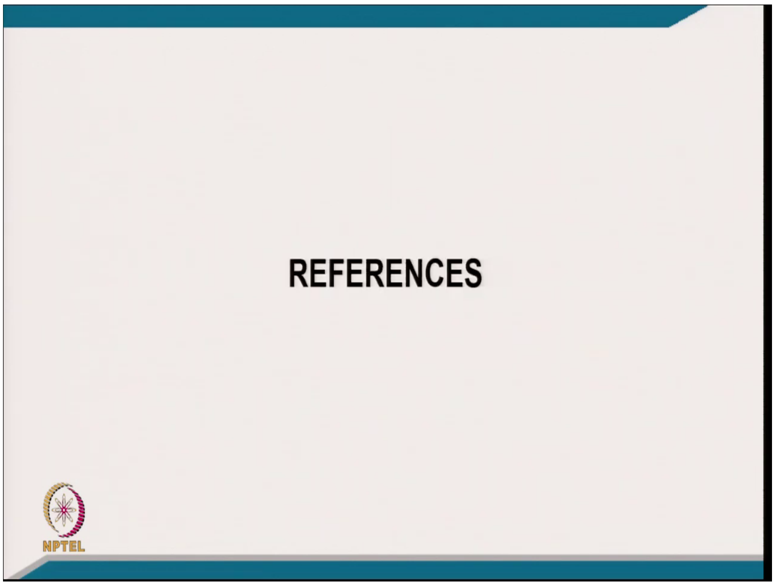

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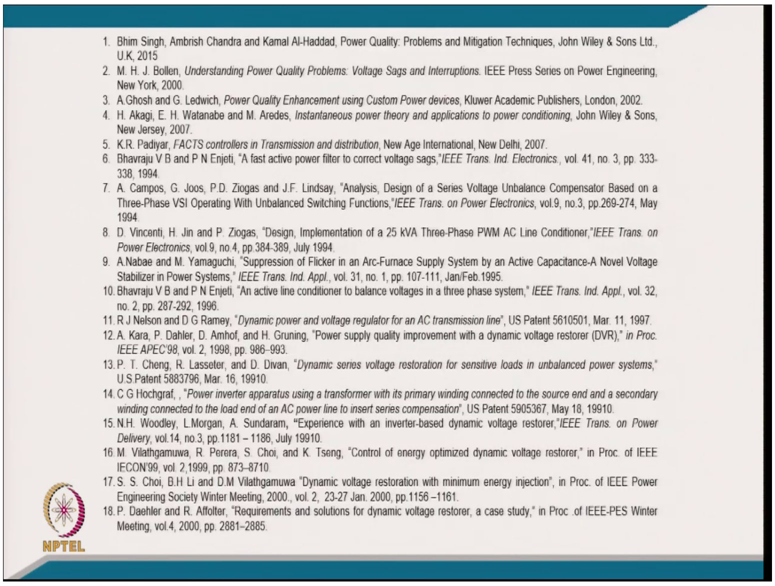

And these are of course, the references which we have considered of course, in this and.

Thank you very much, (Refer Time: 62:54).