Power Quality
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Department of Electrical Engineering
Indian Institute of Technology, Delhi

Lecture - 44
Power Quality Improvement in Diesel Generator Set Based Power Supply System (Contd.)

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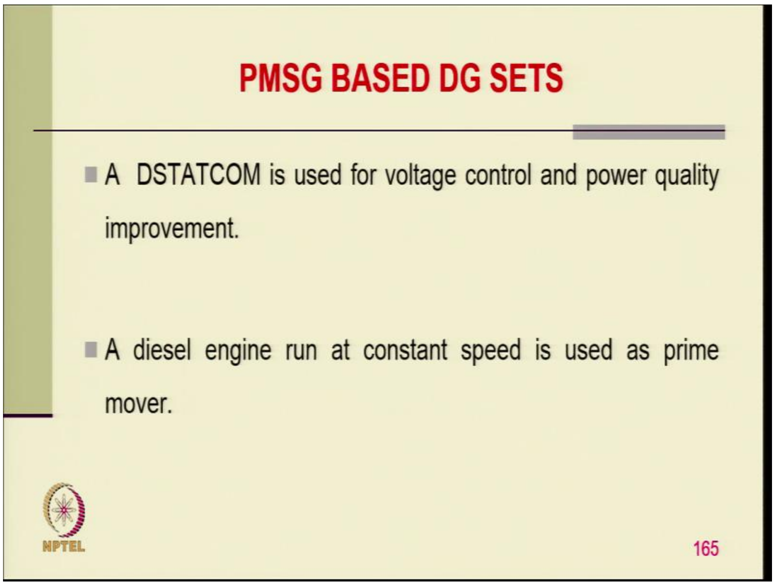

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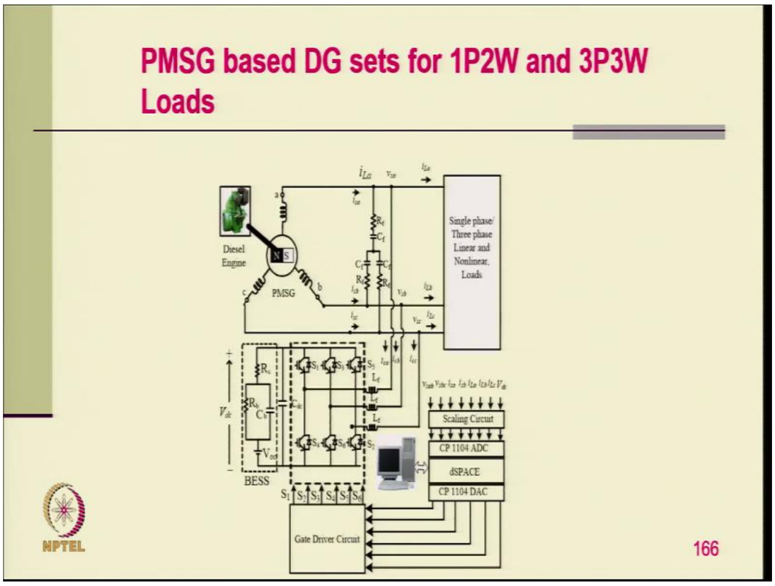

Welcome to the course on Power Quality. We are discussing Power Quality Improvement in Permanent Magnet Synchronous Generator Based Diesel Generator Sets.

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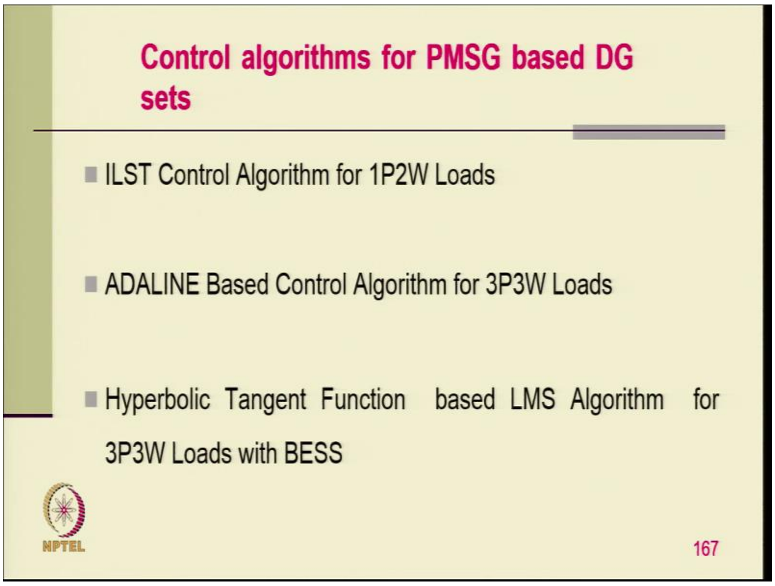

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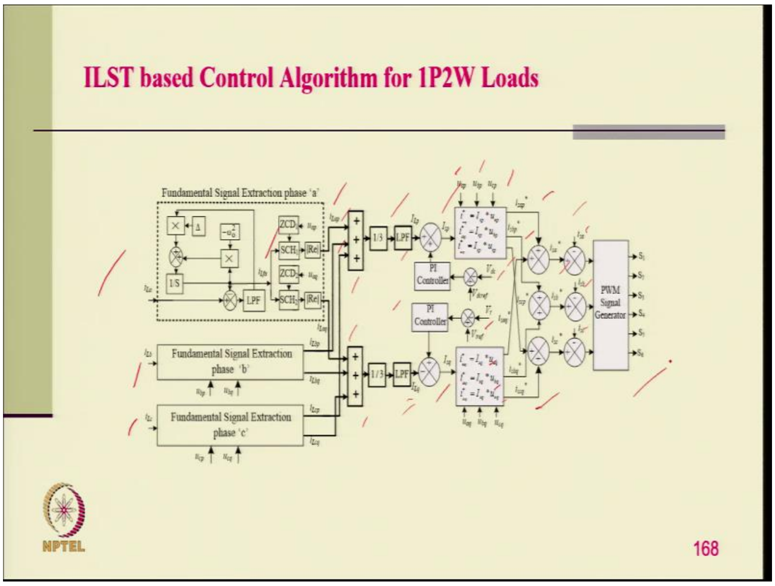

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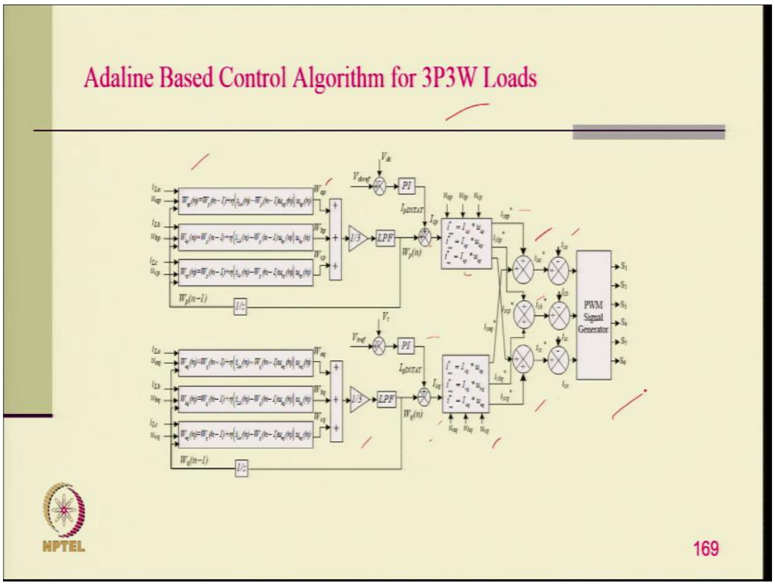

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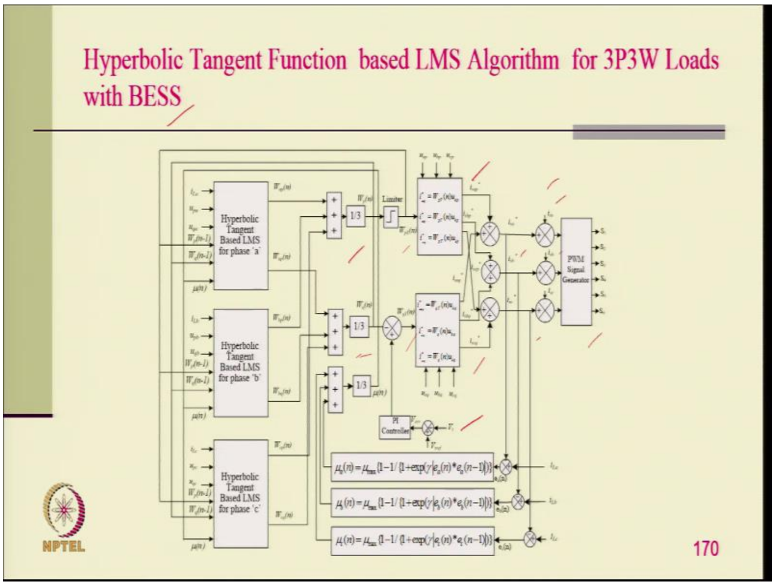

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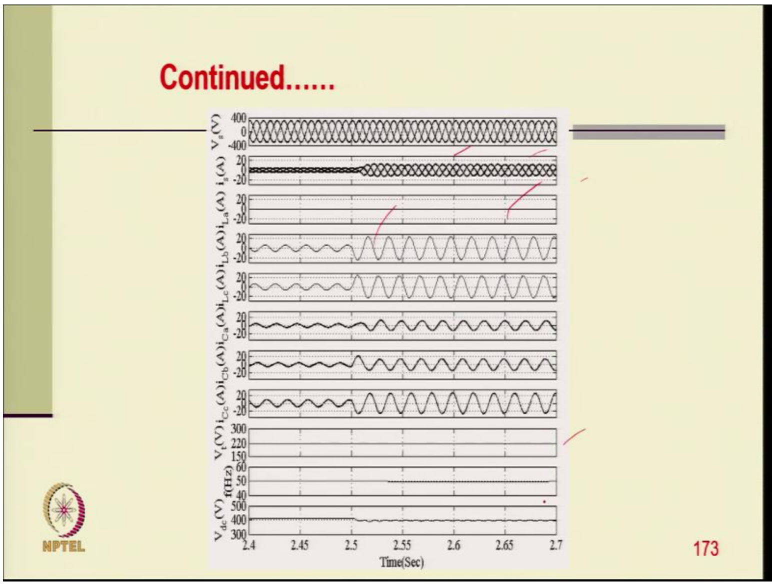

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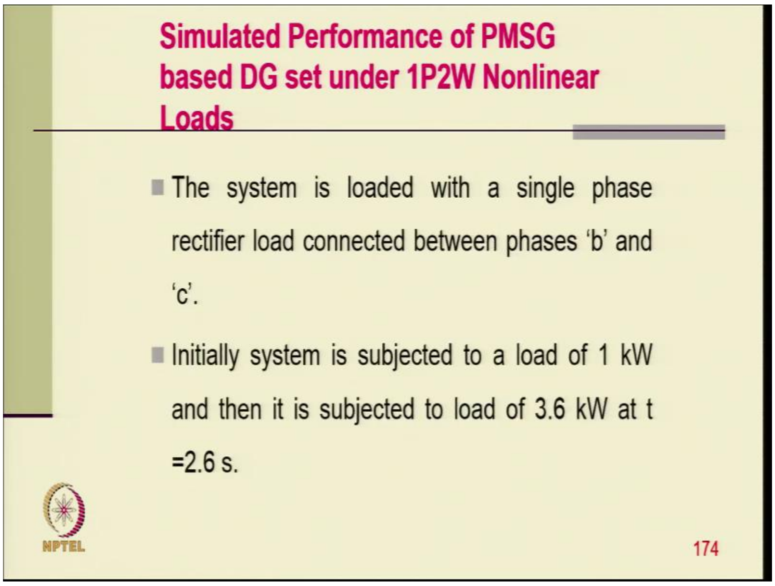

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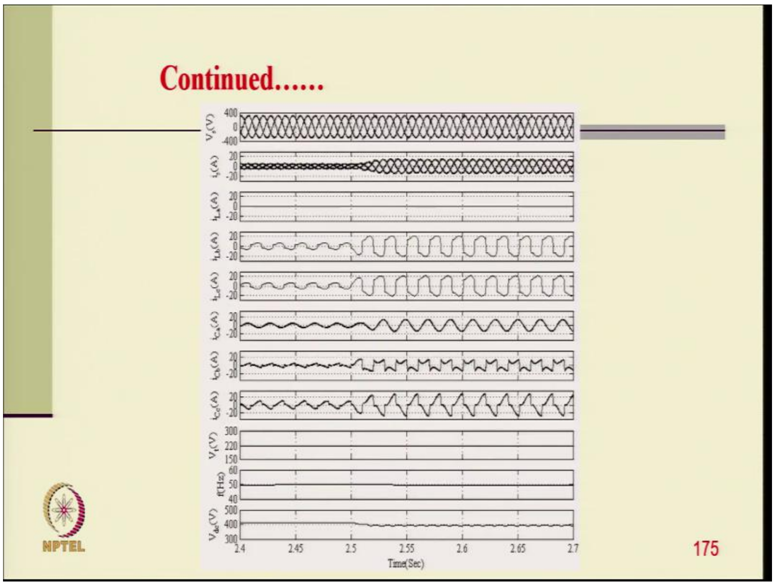

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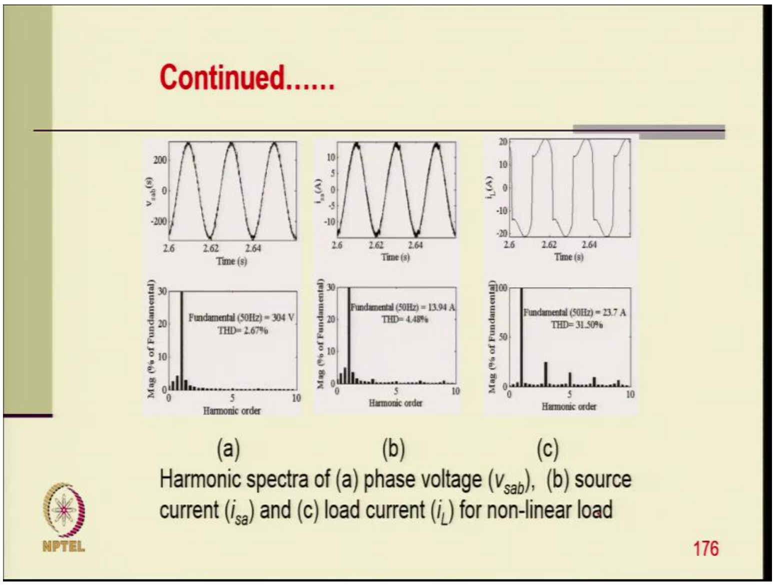

And this is the typically harmonic spectrum of the load current the total harmonic distortion of load current is 31.5 percent, where the generator voltage THD is 2.67 percent and the generator current THD is 4.48 percent like.

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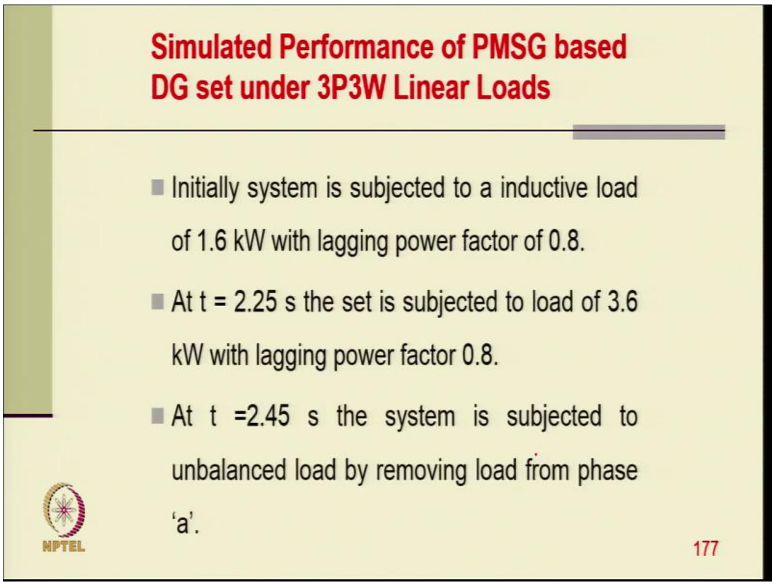

Now, coming to the performance of PMSG DG set with the 3 phase 3 wire lagging power factor load.

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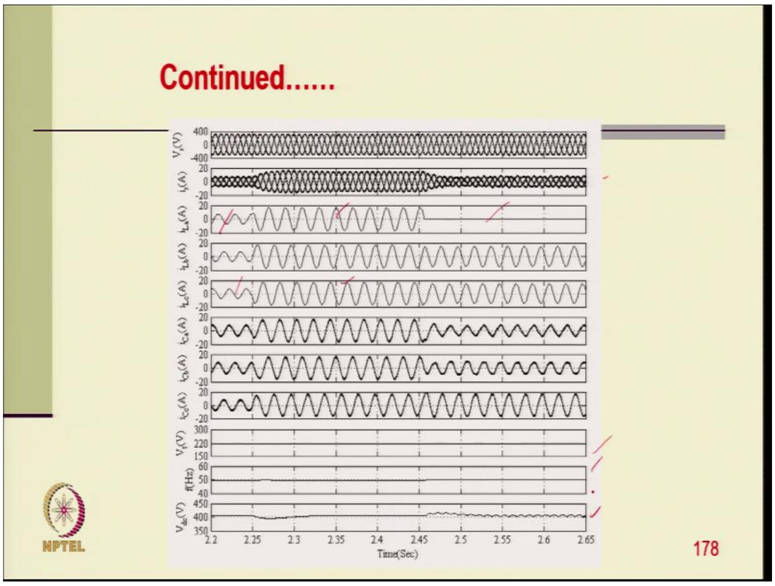

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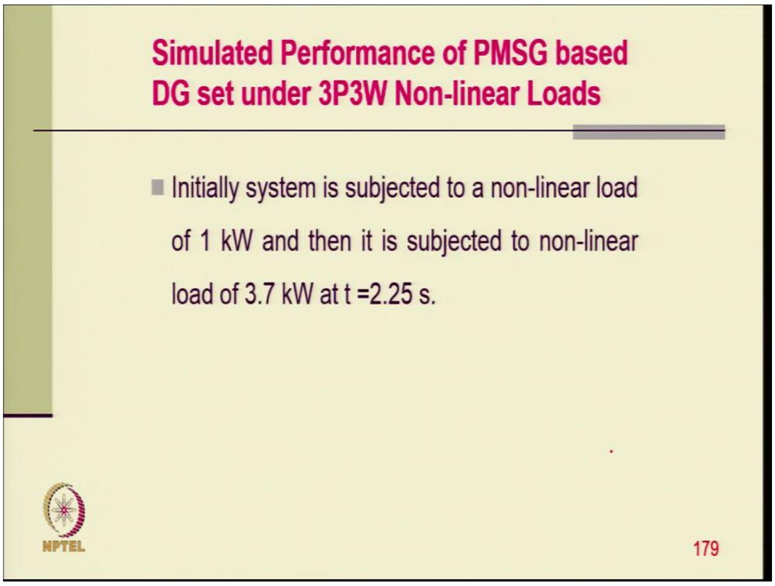

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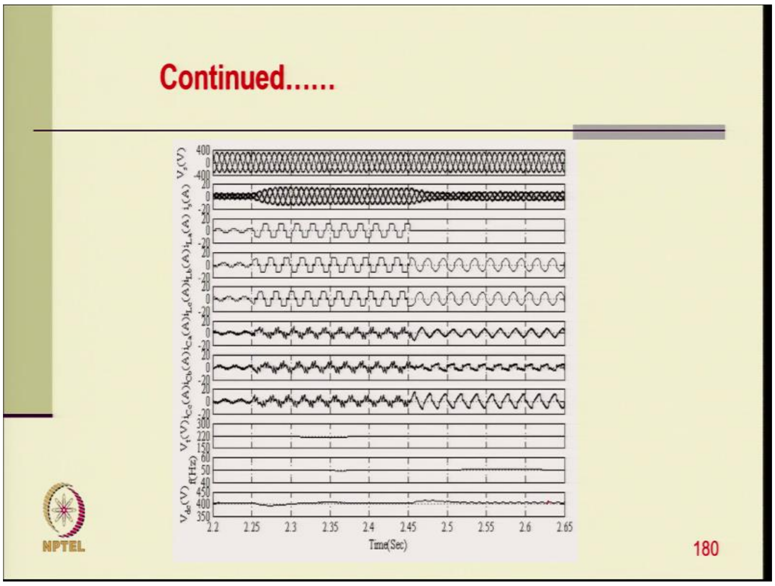

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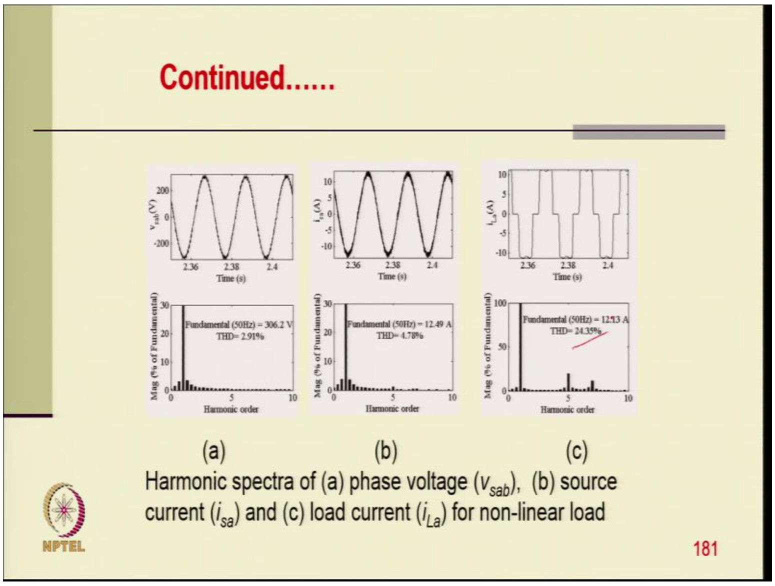

And the THD of load current is 24.33 % and the generator current THD is 4.78% whereas the voltage THD is 2.91 %.

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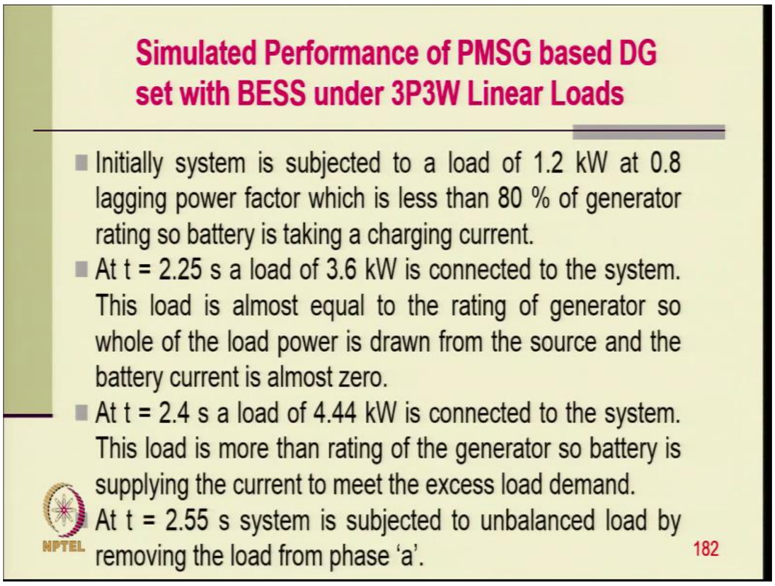

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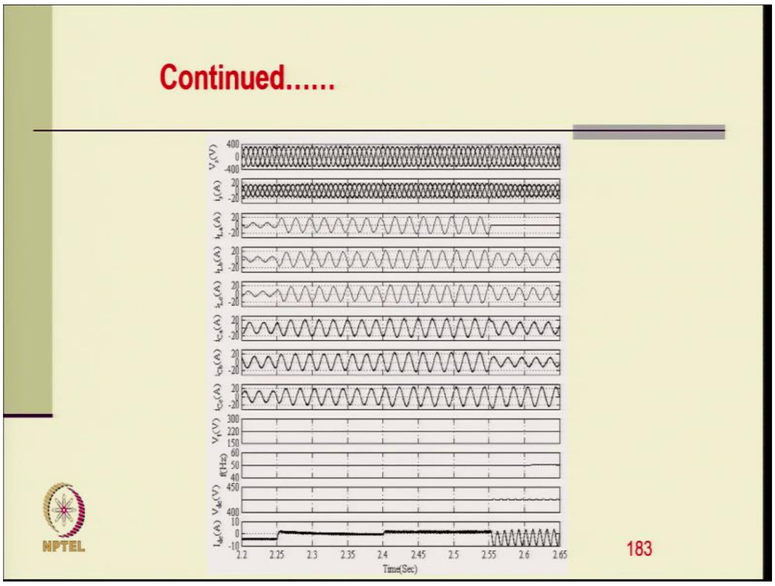

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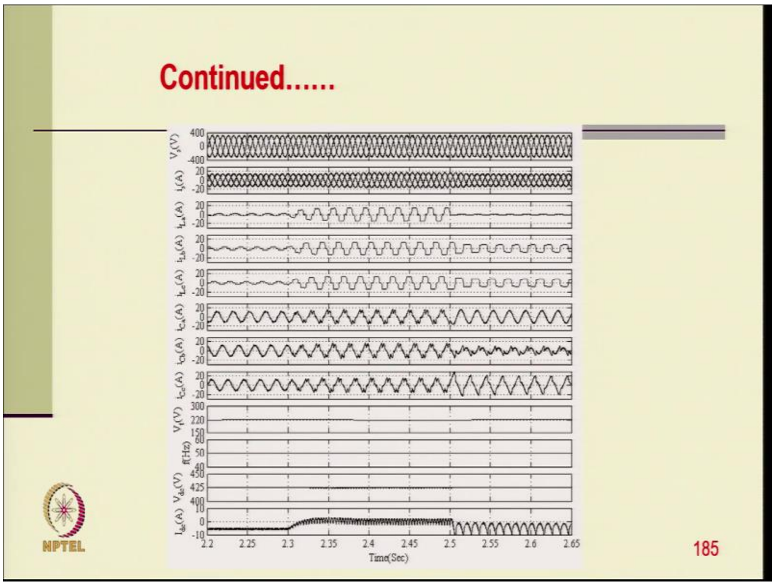

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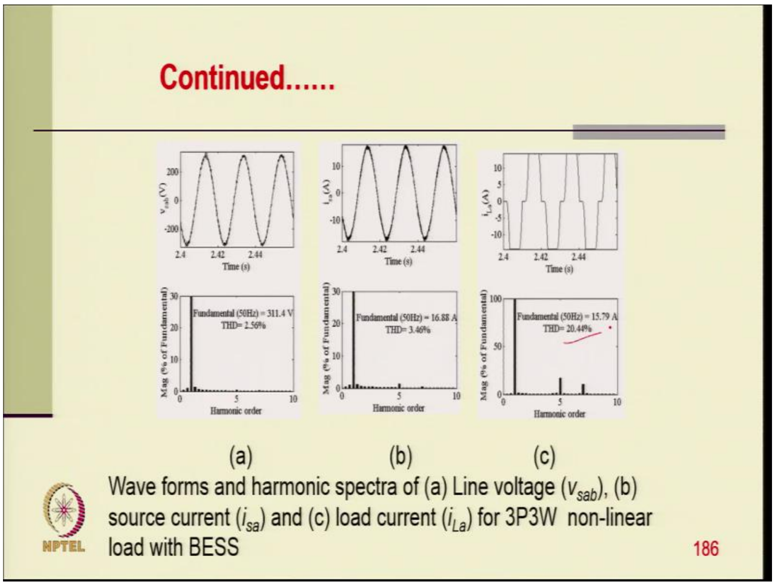

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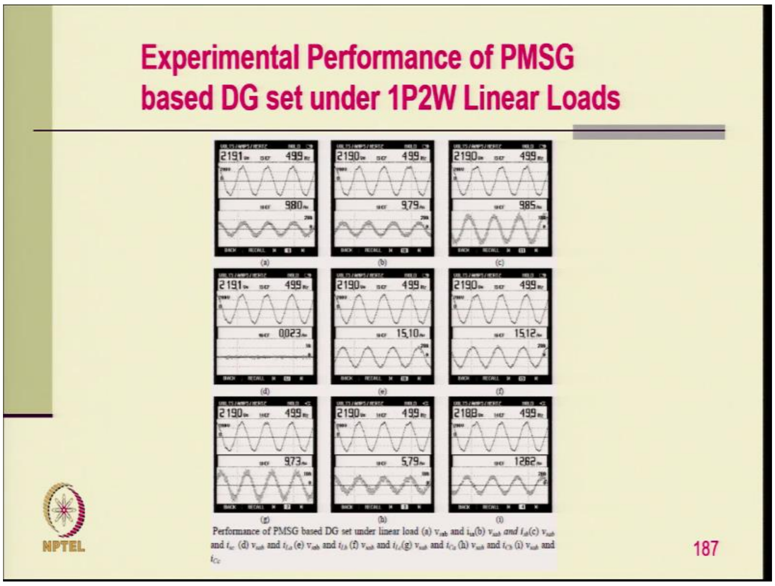

These are the typical experimental results, you can clearly see, that the load generator currents are balanced sinusoidal where the load is unbalanced.

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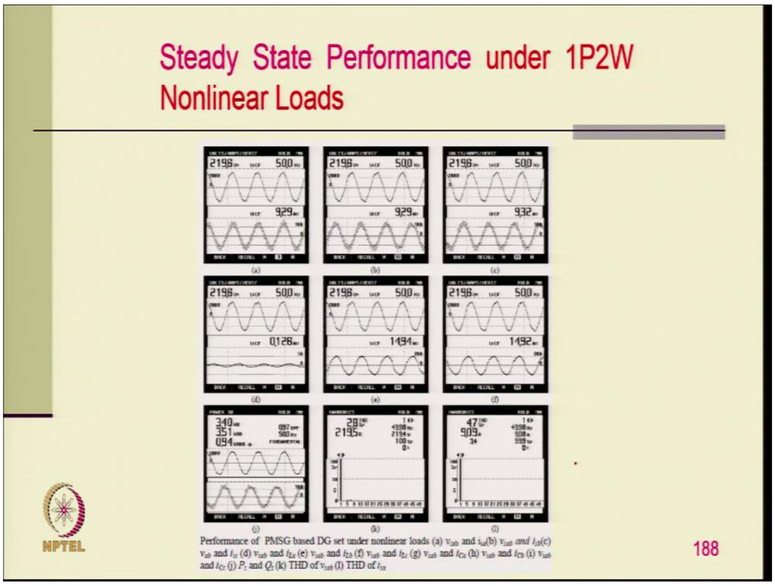

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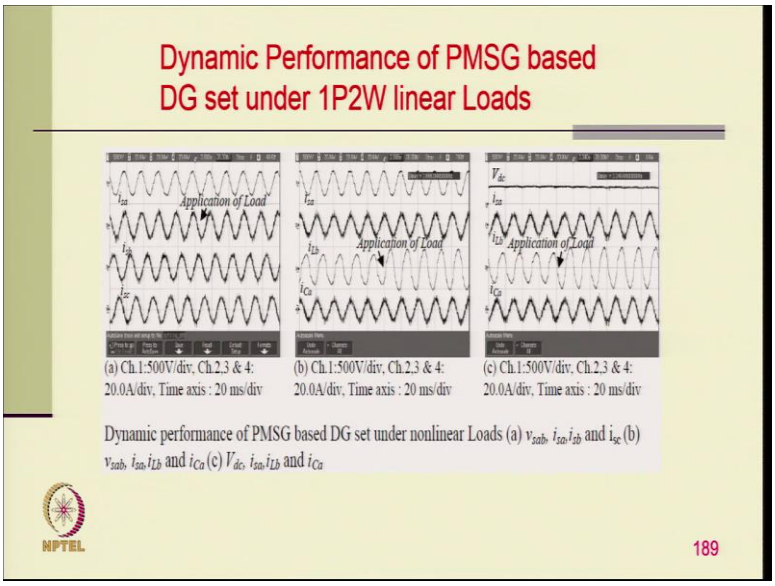

And then during the dynamics, if non-linear load is increased, still you will find the generator currents are not getting disturbed, they remain constant and DC link voltage is also regulated.

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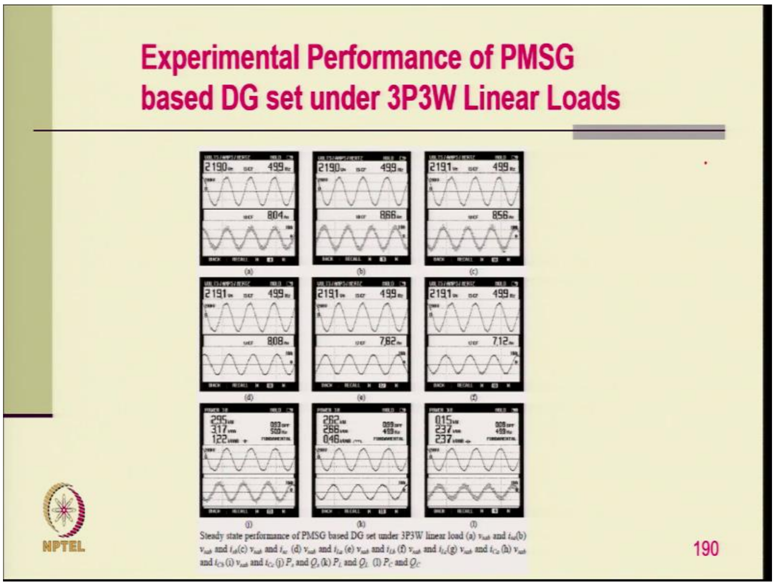

And then with the lagging power factor load, it works very well for correction of typically the power factor of the load and providing compensation.

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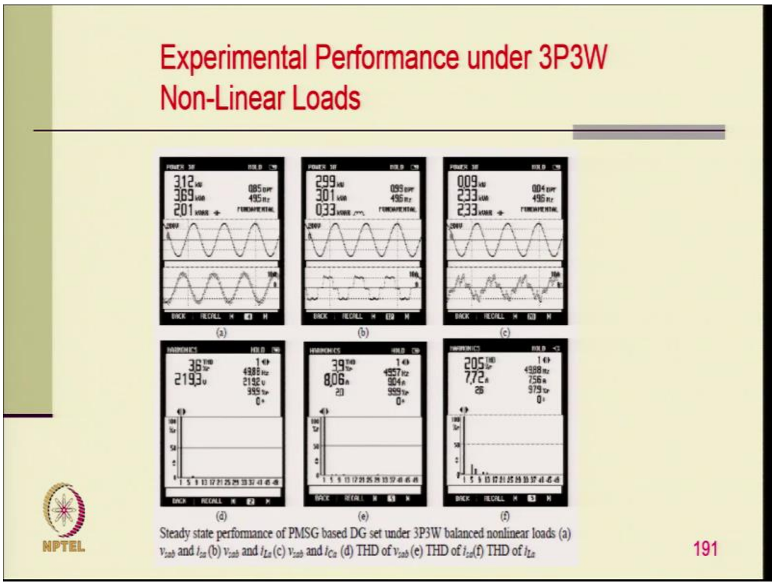

This with the non-linear load, but generator current is balanced and sinusoidal. The voltage THD is 3.6 % where the generator current THD 3.9 % where the load THD is 20.5 %

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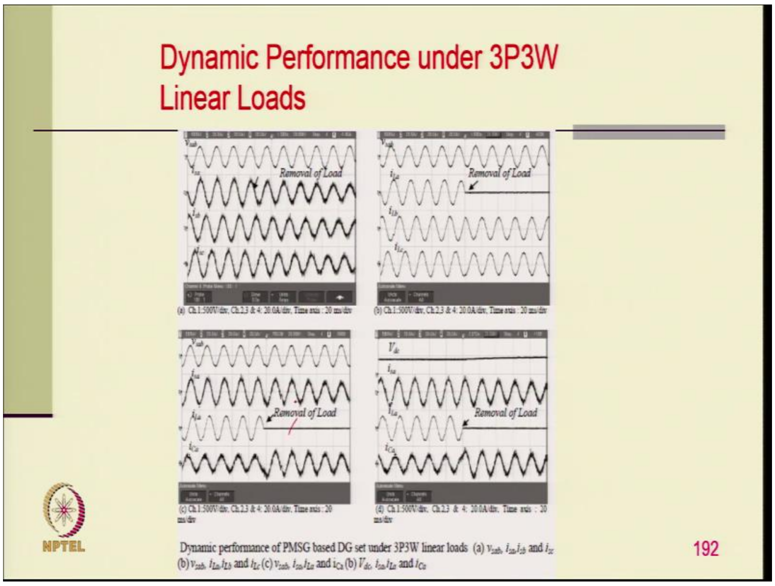

And during dynamics when load is unbalanced, the generator currents are not disturbed as they remain sinusoidal and balanced.

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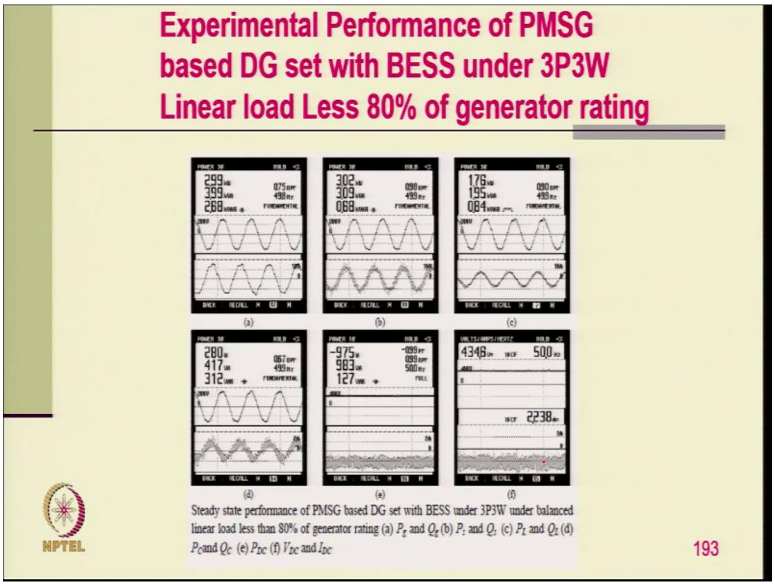

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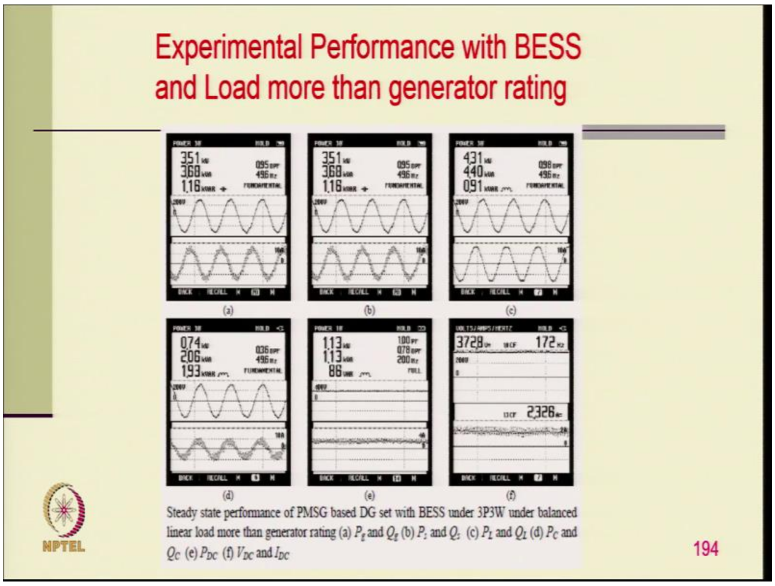

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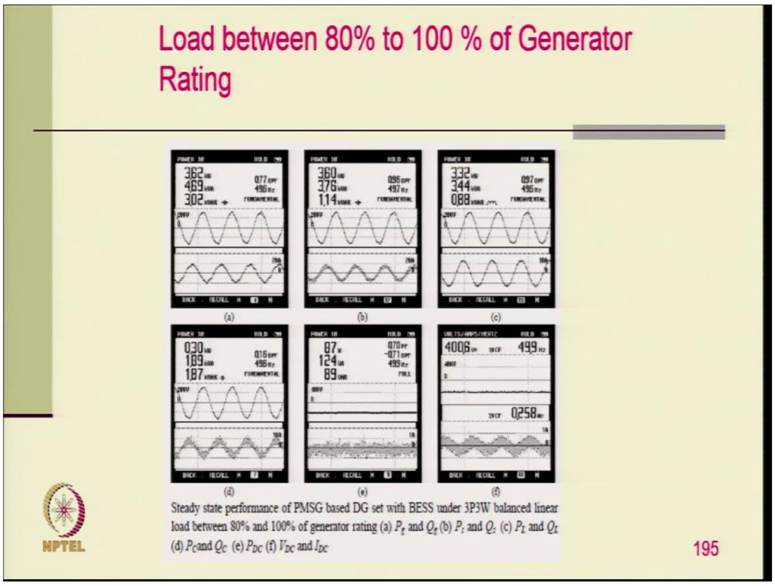

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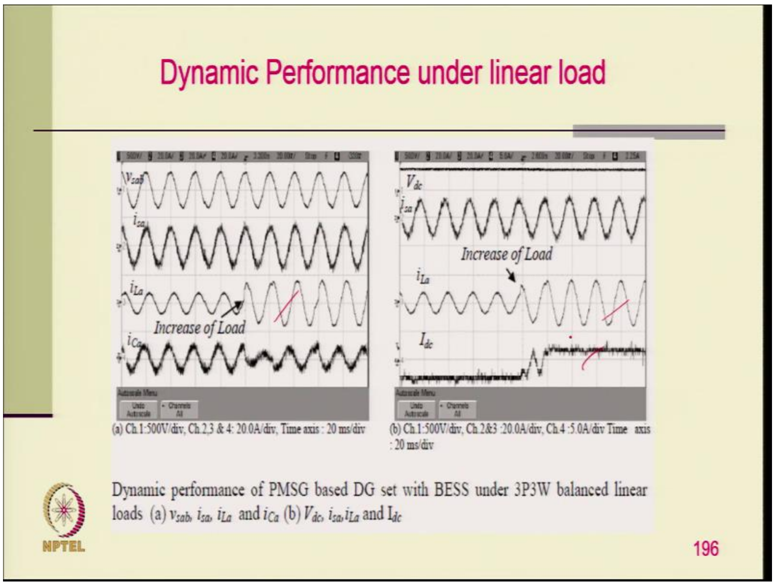

And this is you can say, when load is increased you will not find any change in the generator current. And when the load is off again generator current are not affected. Because the charging and discharging of the battery take place as you can see the battery current here.

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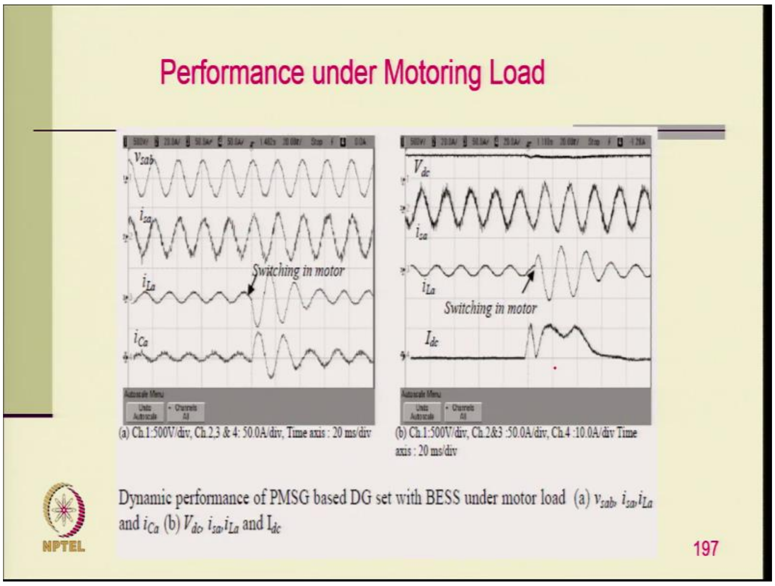

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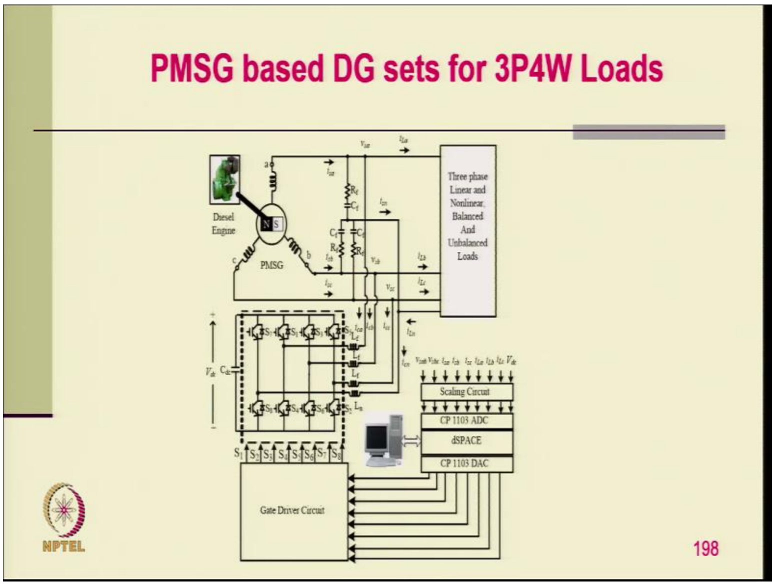

And now we are coming for 3 phase 4 wire system by providing fourth leg. So, that neutral current is also compensated either with the unbalanced load or with your non-linear load neutral current is always there in 3 phase 4 wire system.

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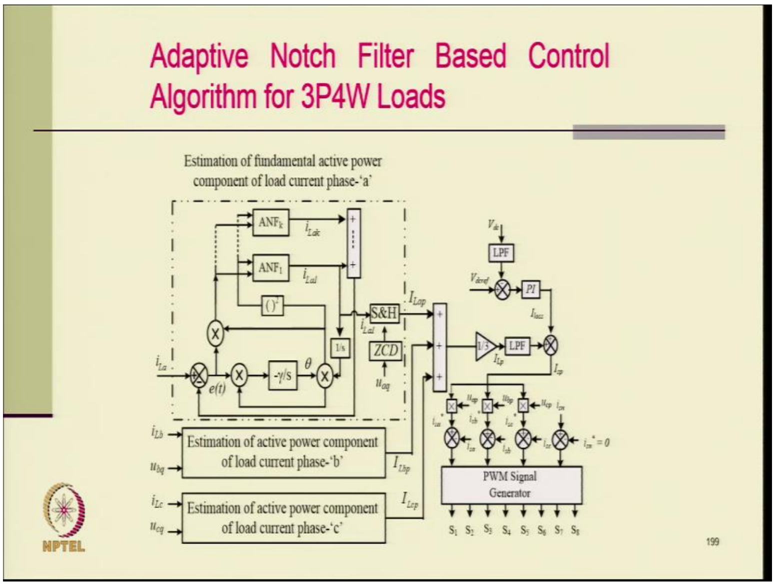

And this is the typical control we are using here notch adapting notch filter.

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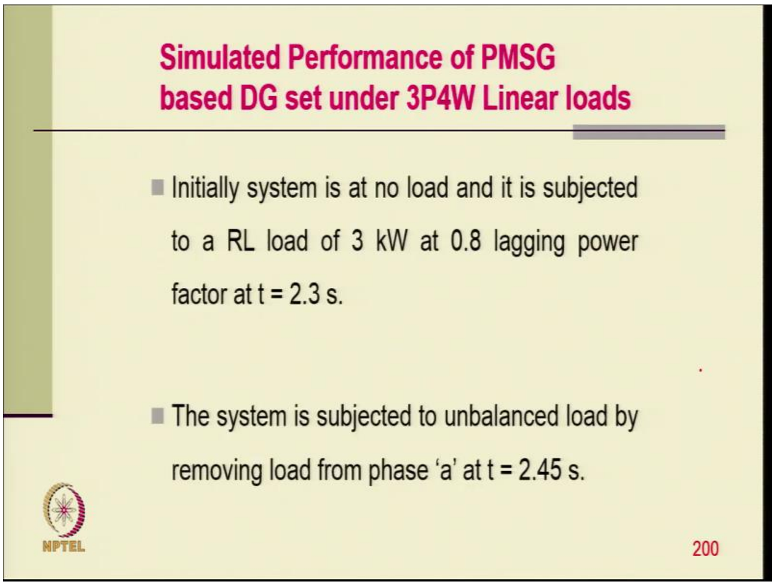

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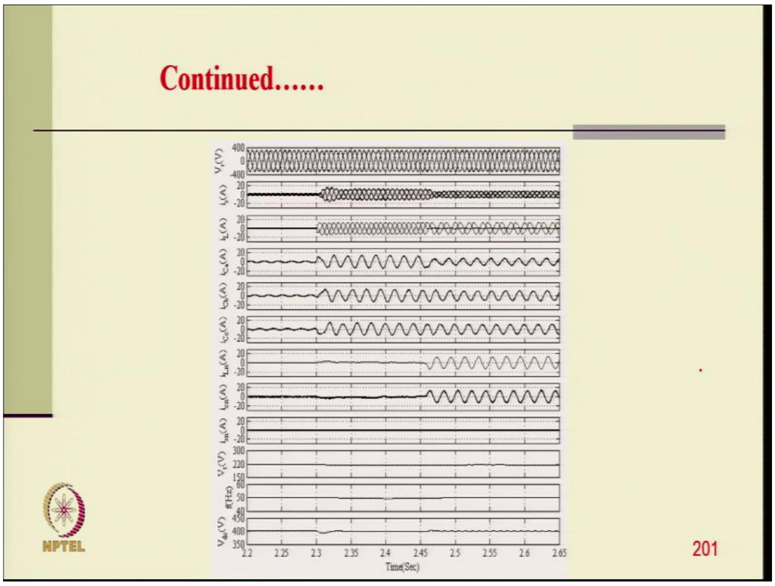

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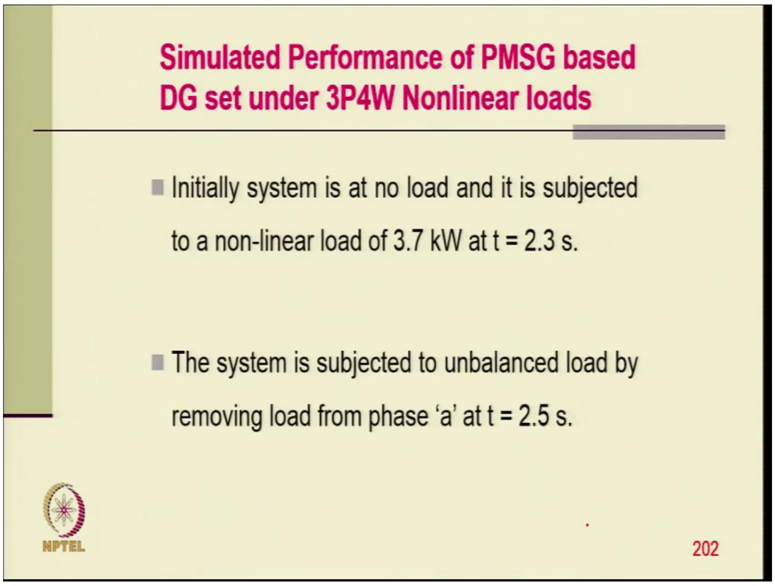

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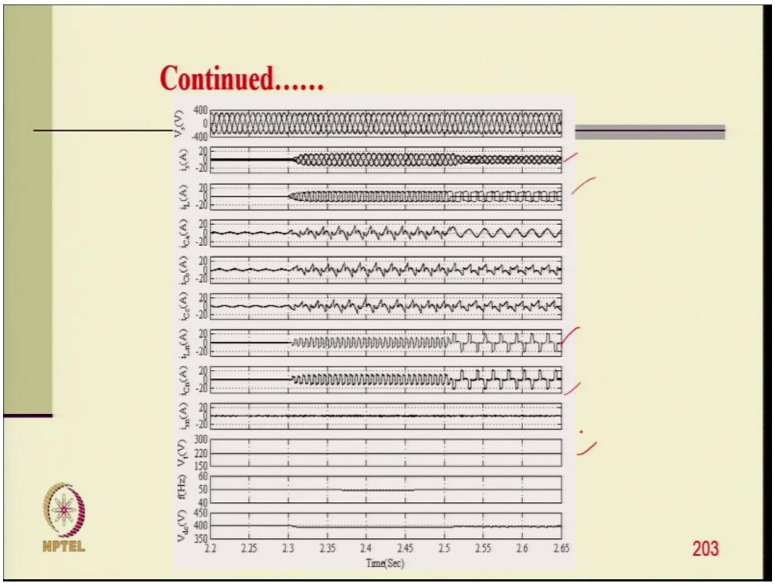

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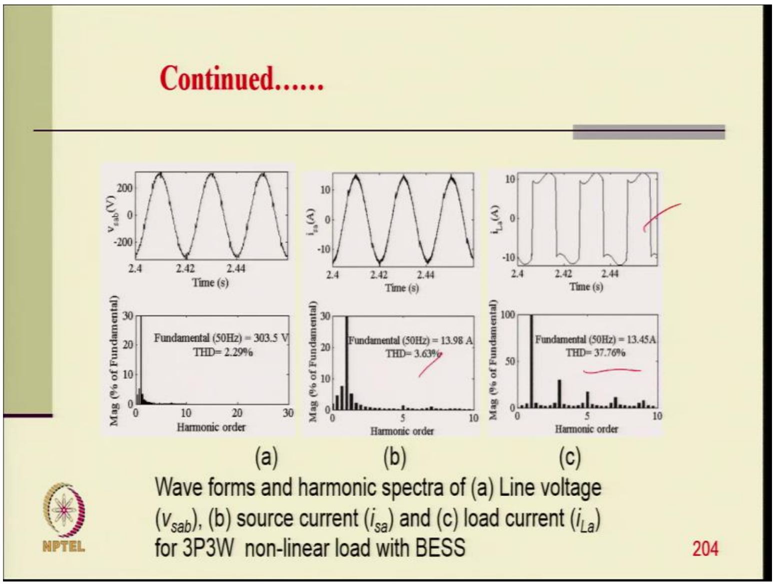

And you have a total harmonic distortion of the load current around 37.76 %, but the generator current THD is 3.63 % and the terminal voltage THD is 2.129 %.

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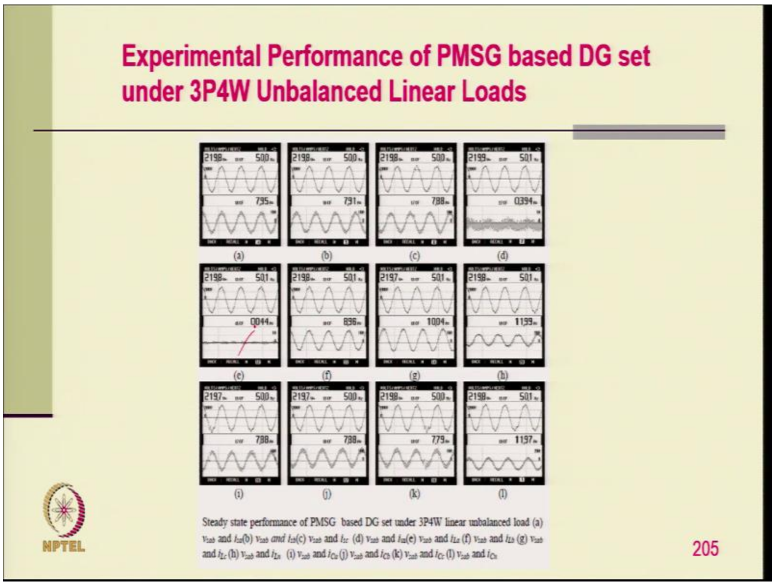

And you can see the here under unbalanced load, you are able to have a balance generator current with the node current almost negligible.

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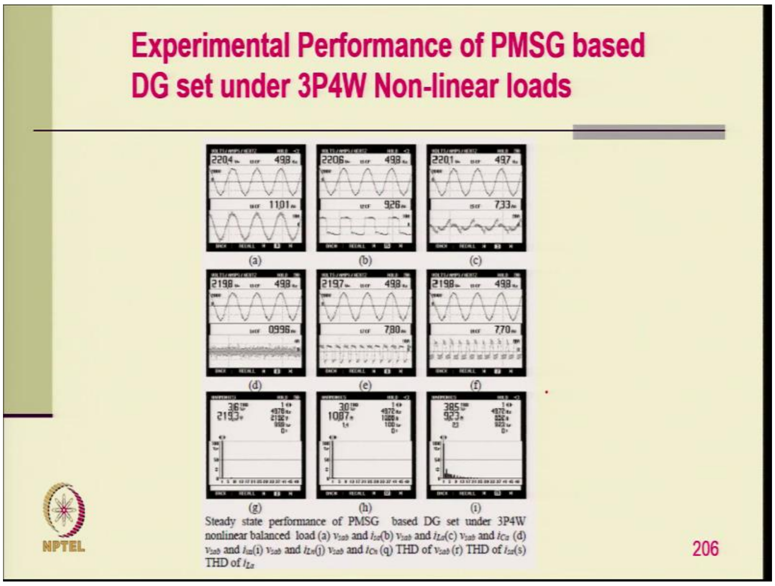

The voltage THD is 3.6 percent and where the generator current THD 3 percent where the load current THD 38.5 percent like.

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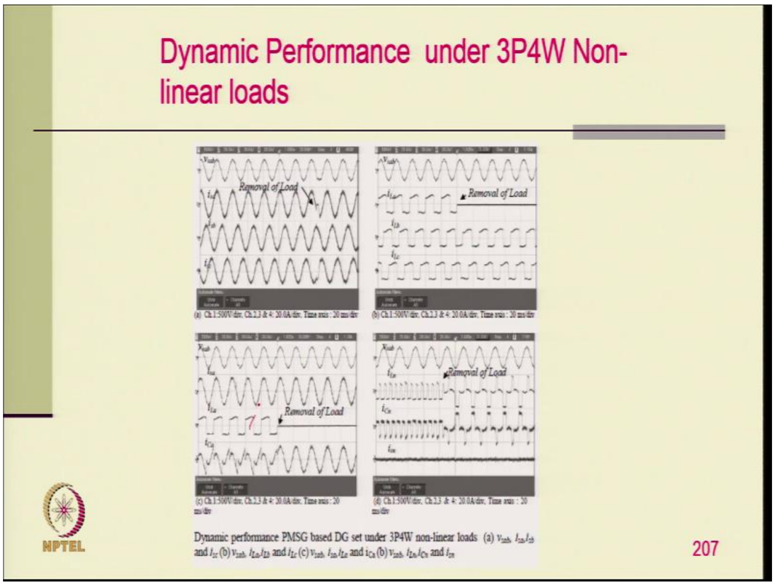

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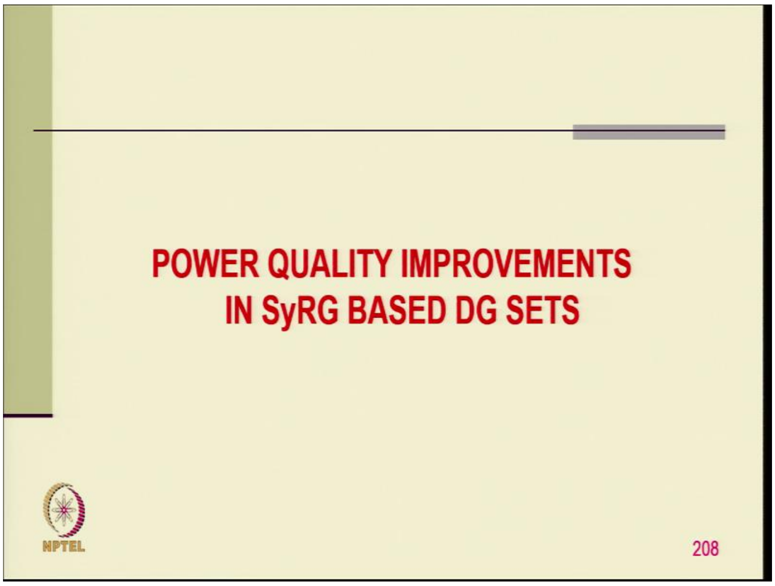

Now, coming to the power quality improvement in synchronous reluctance based DG set.

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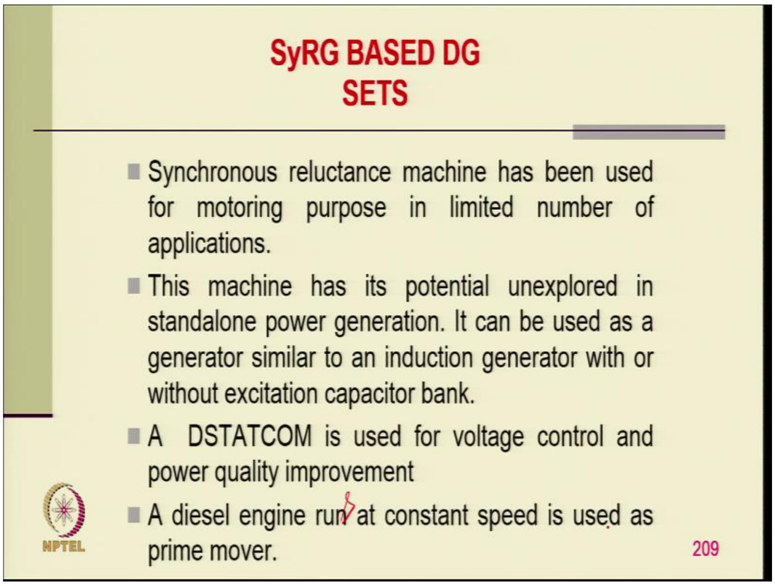

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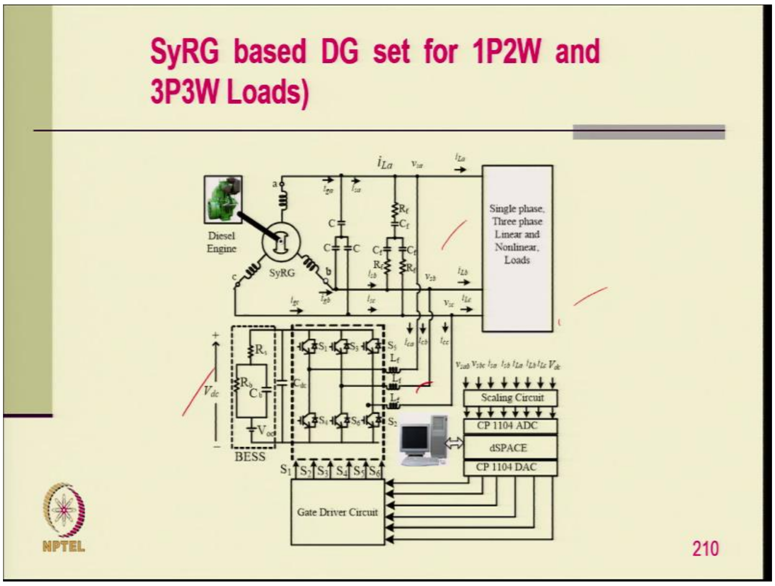

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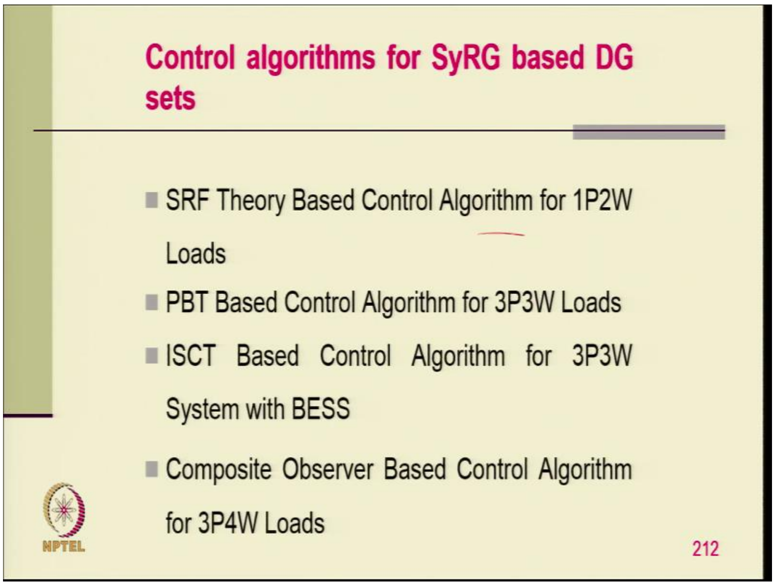

We have used here the synchronous reference frame theory for typical case of single phase load and power balance theory for 3 phase 3 wire load.

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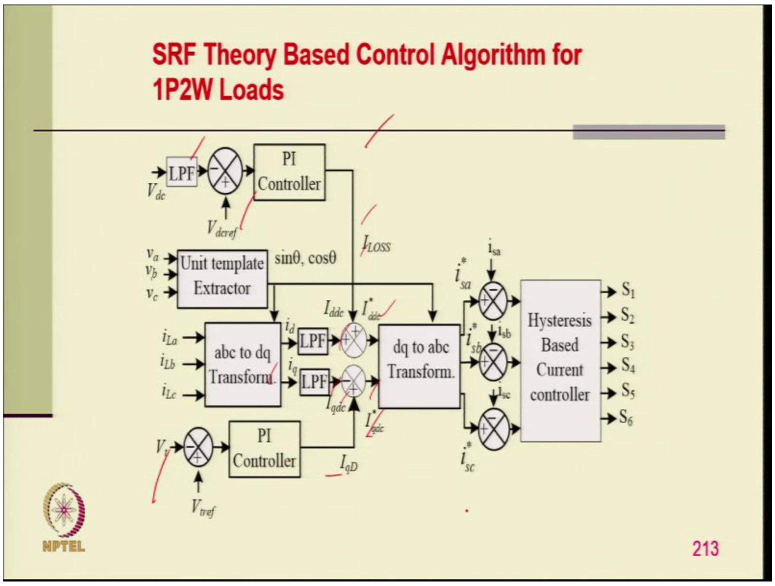

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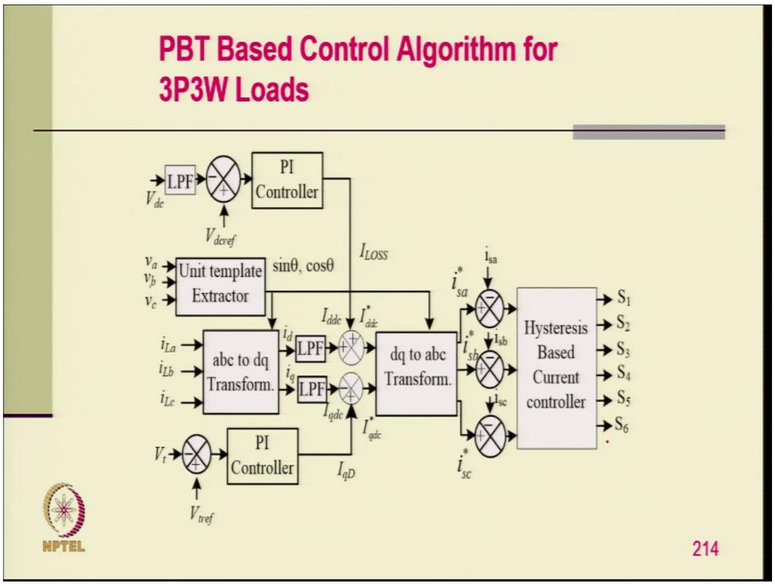

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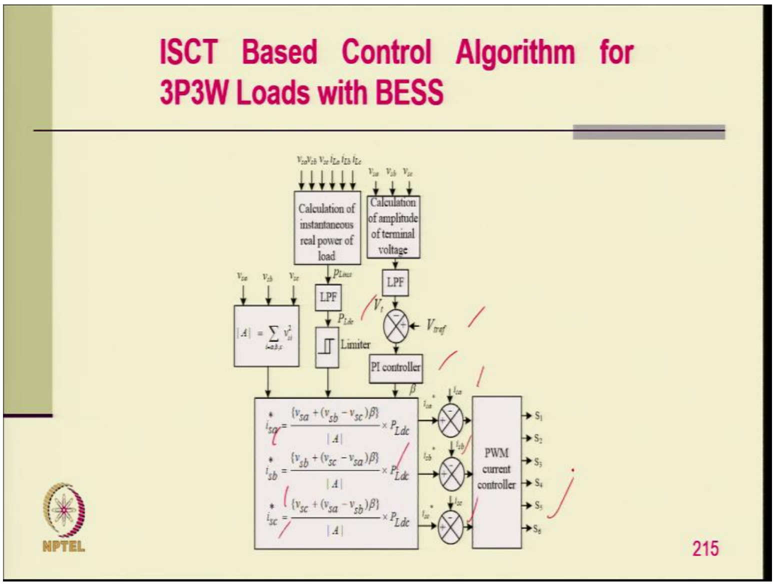

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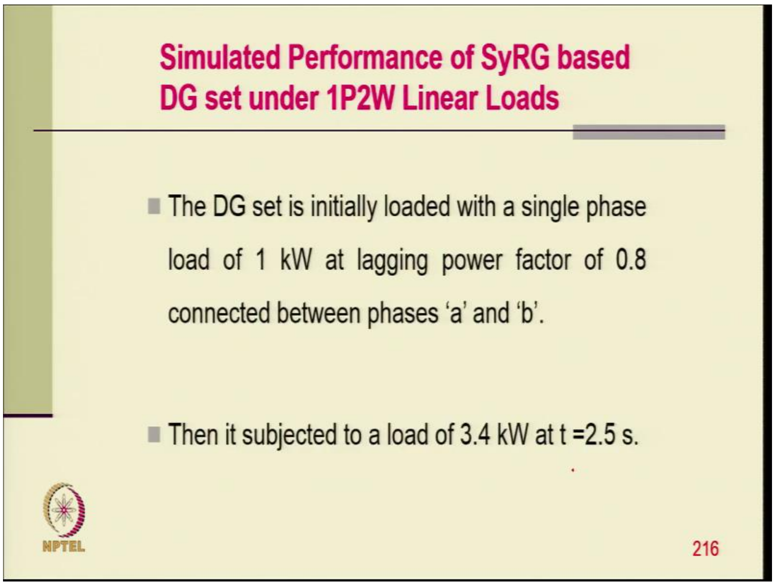

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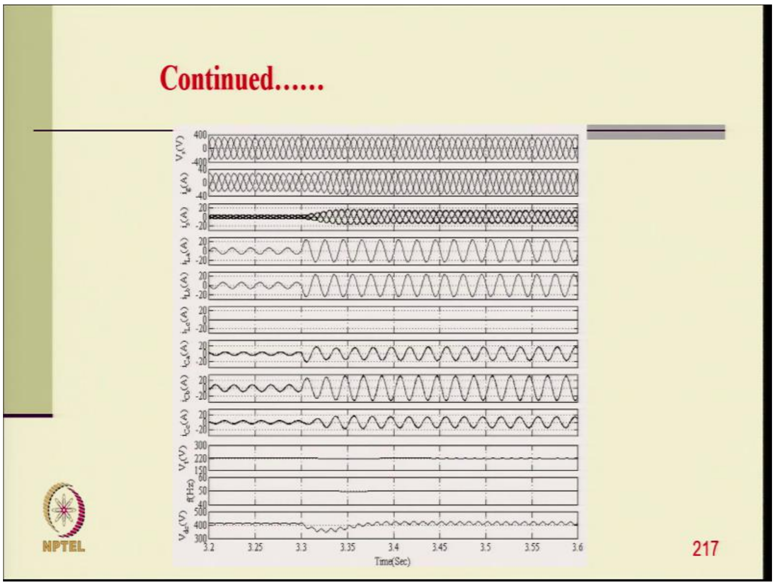

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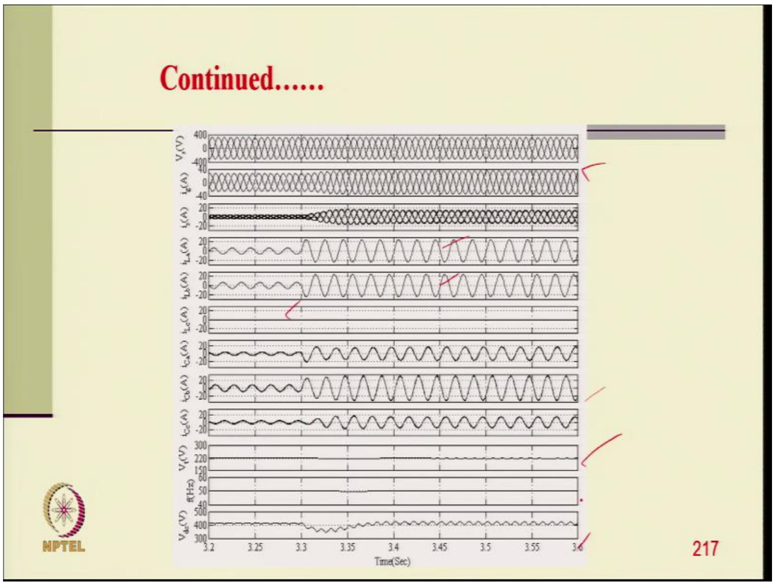

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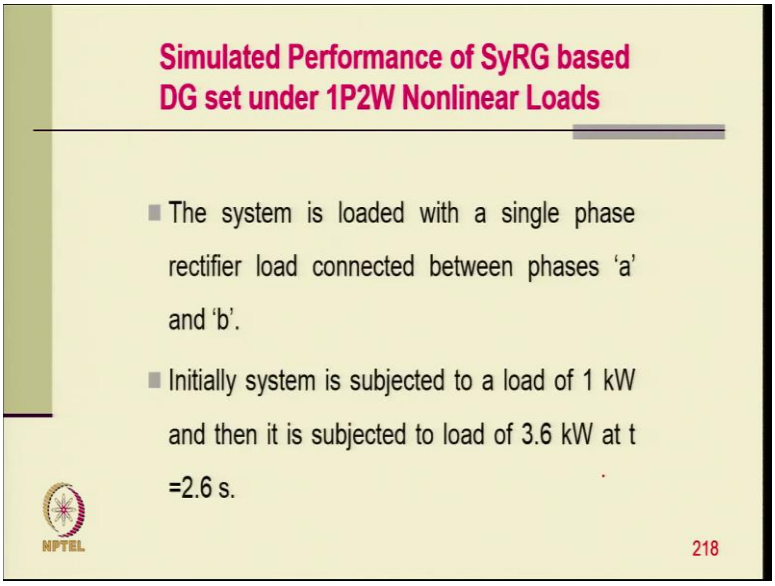

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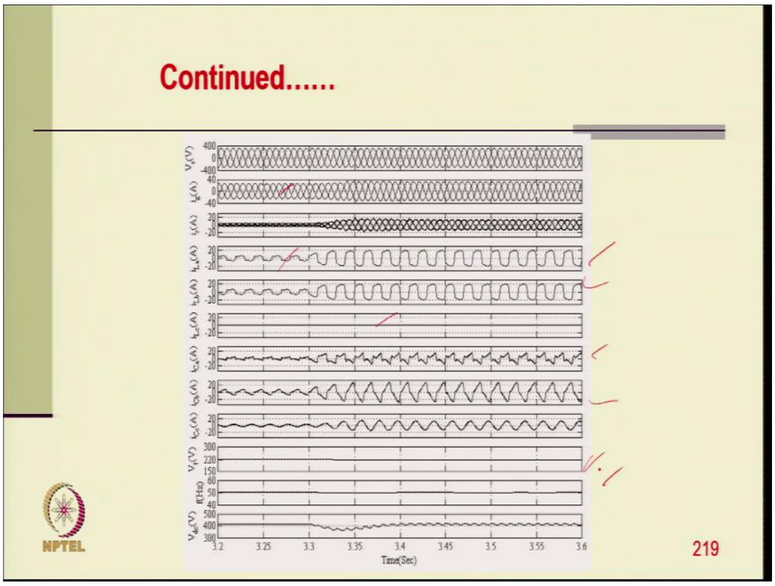

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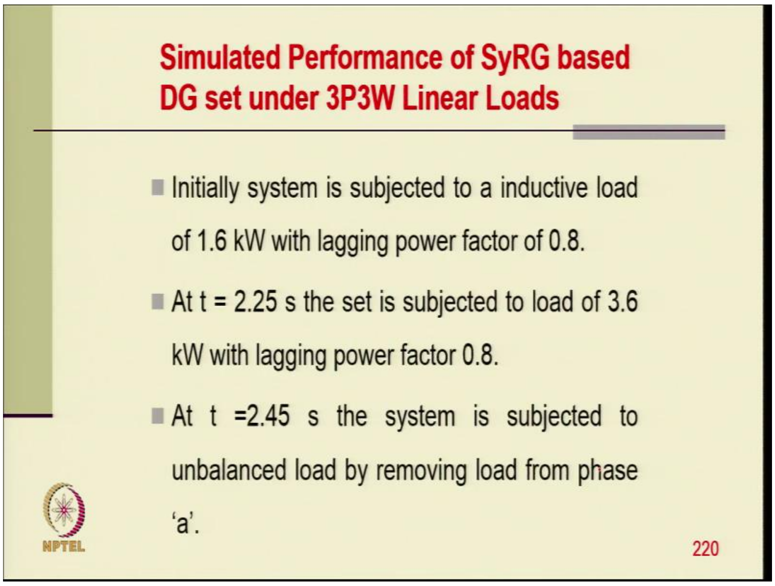

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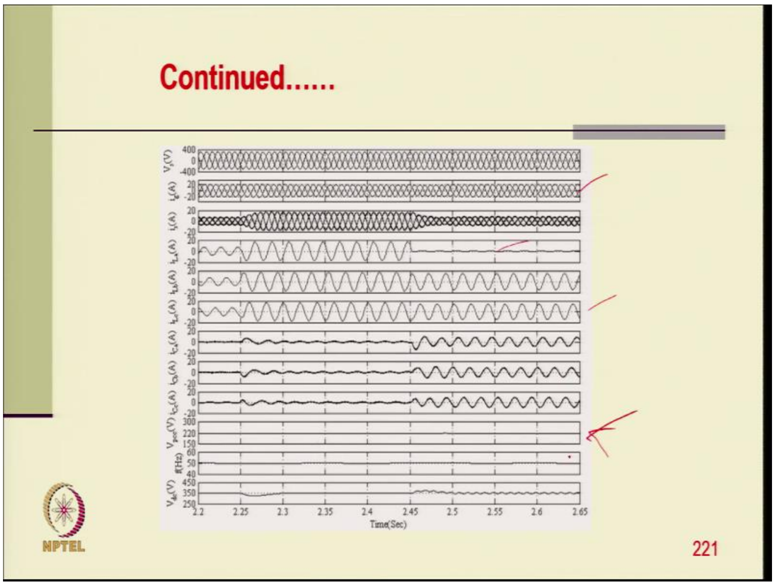

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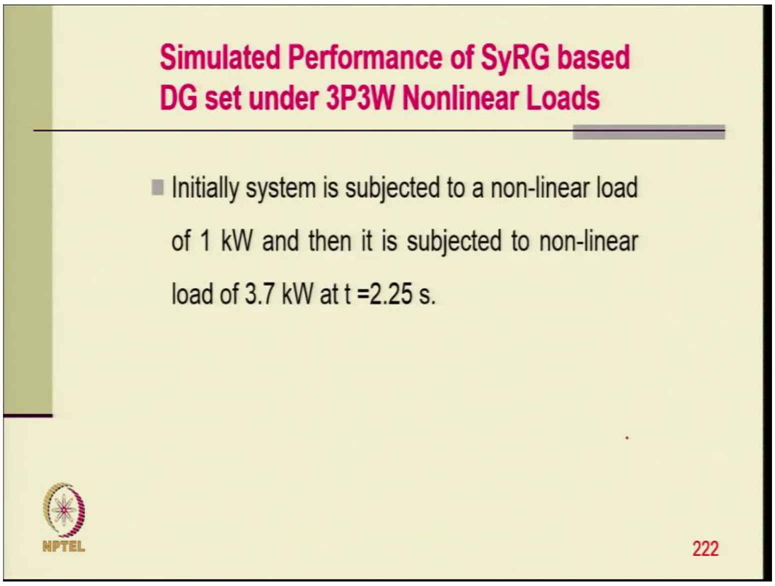

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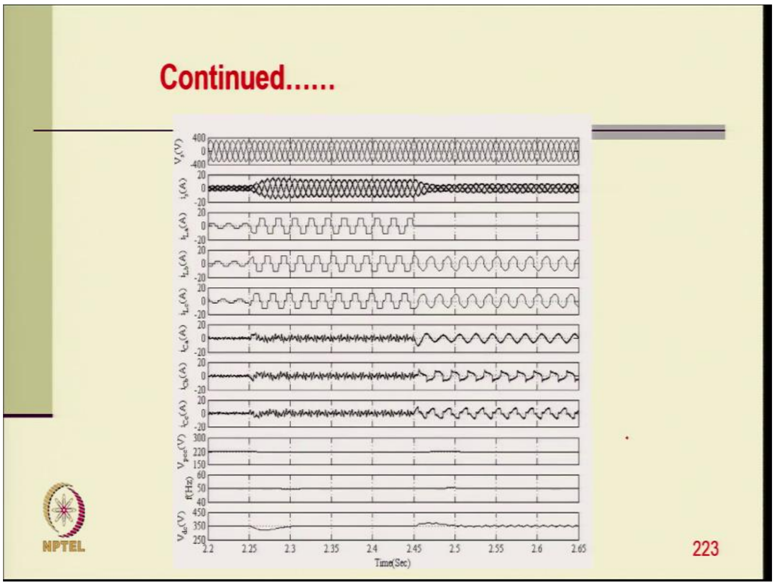

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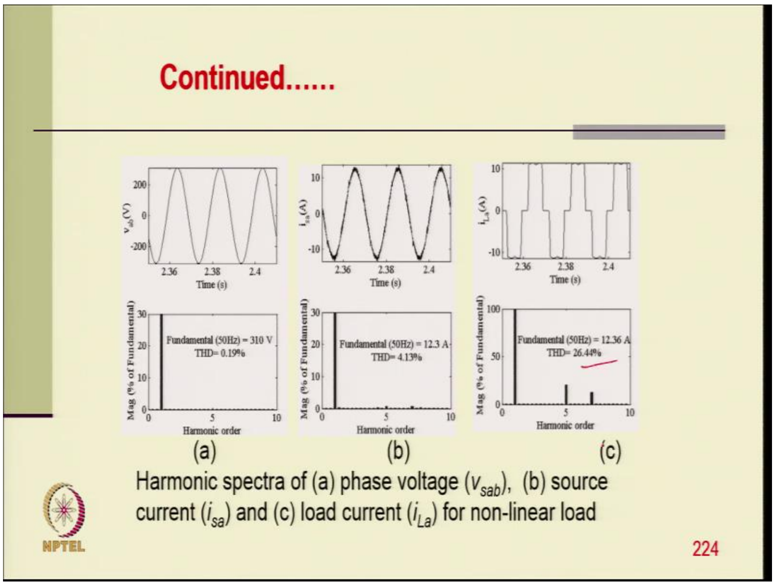

And this is the typically harmonic spectrum of load current is 24.44 percent, total harmonic distortion where generator current is 4.13 percent and the terminal voltage THD is only 0.19 percent.

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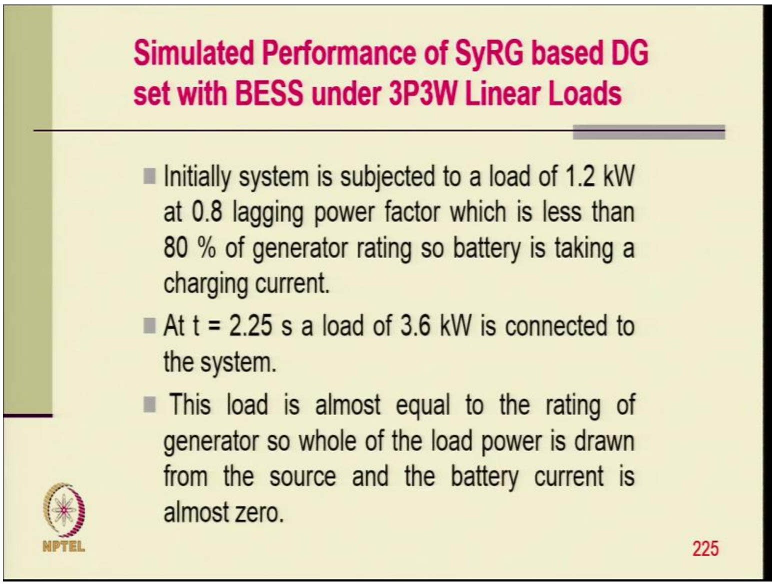

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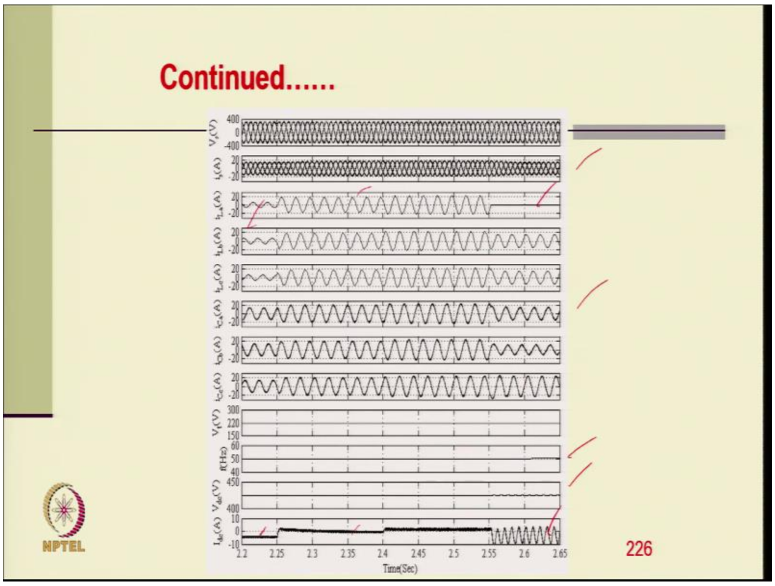

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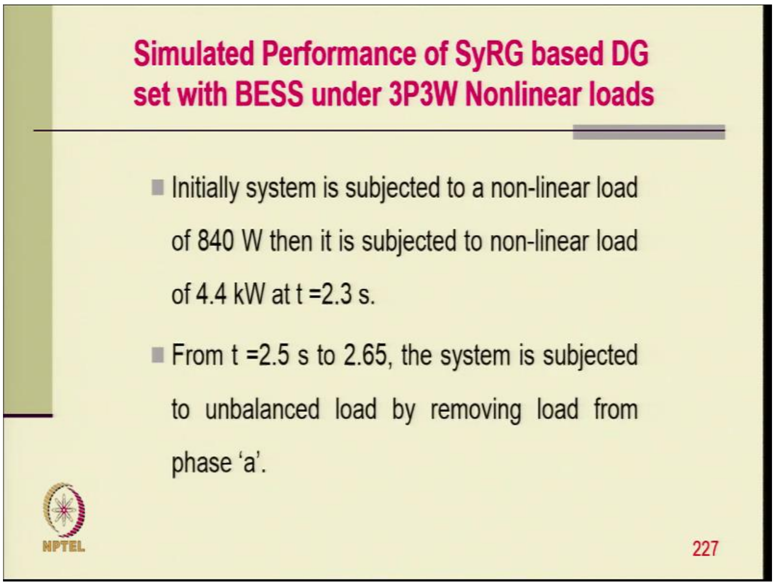

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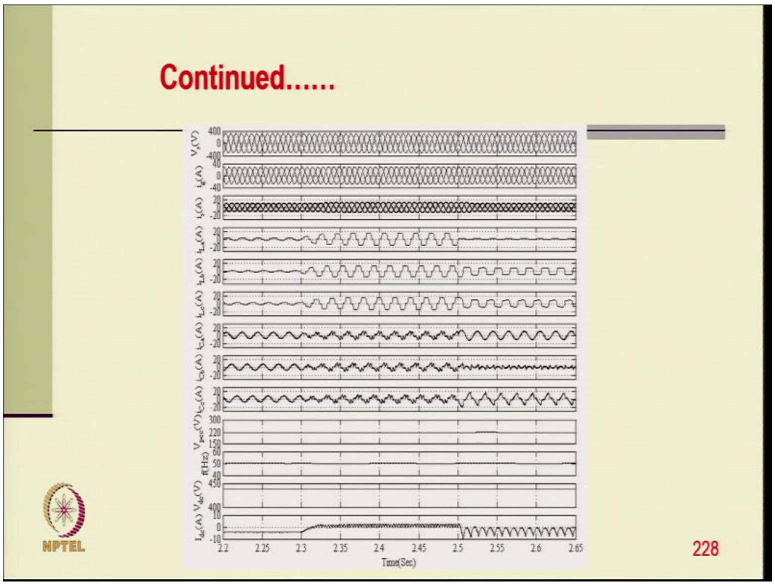

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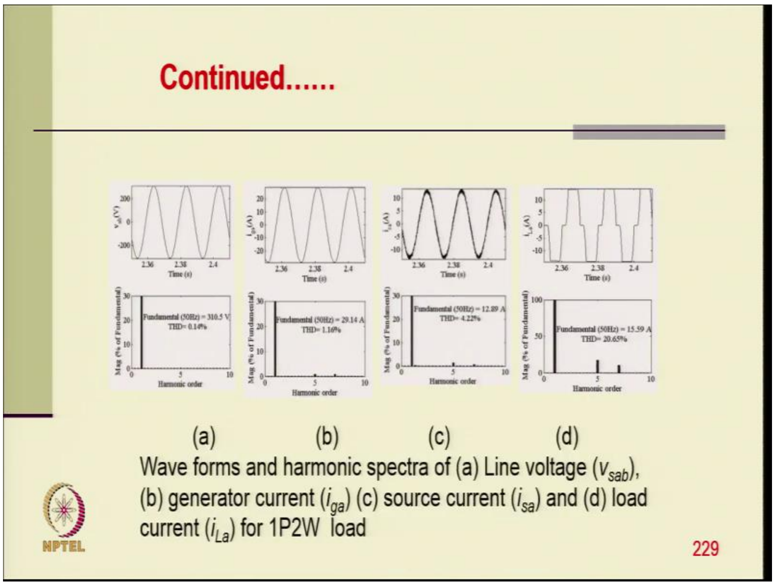

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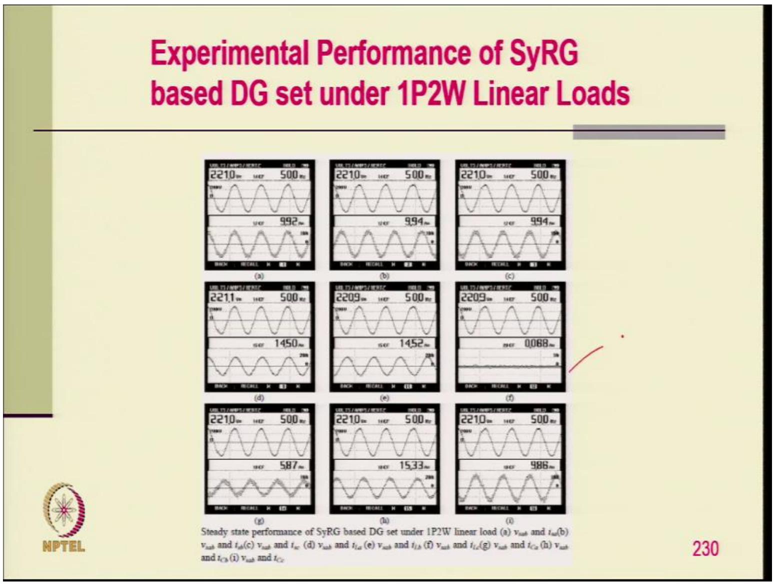

And this is the THD of load current 20.6 percent whereas the source current is 4.22 percent. And where the generator current THD 1.16 and the voltage THD 0.14 percent.

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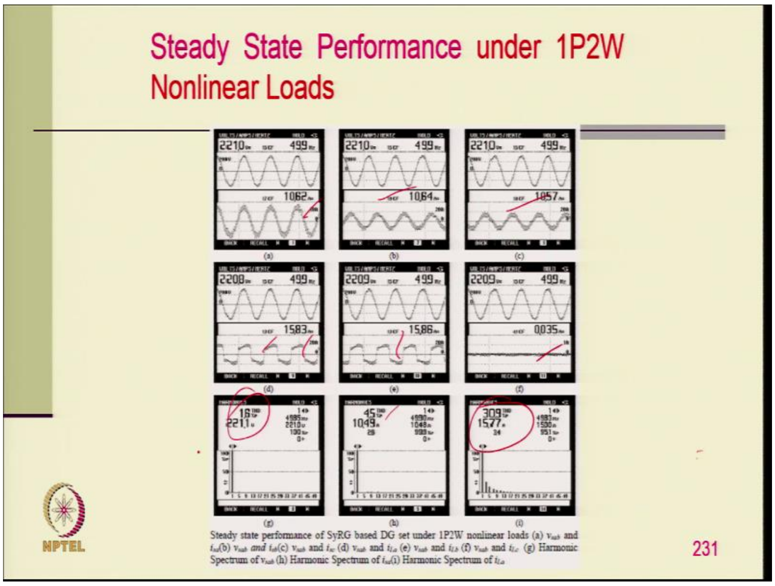

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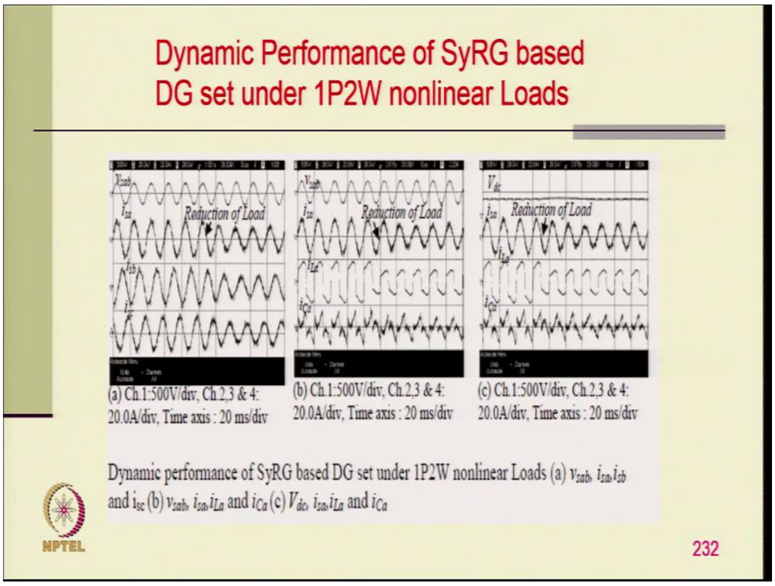

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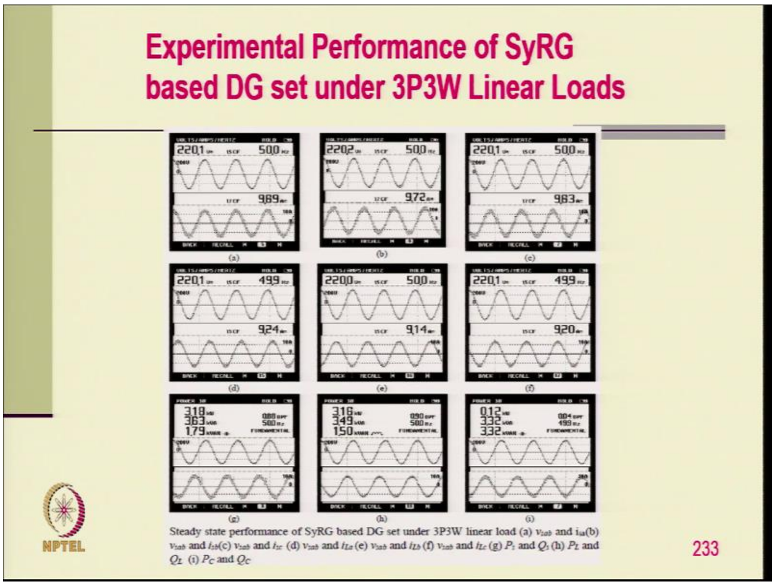

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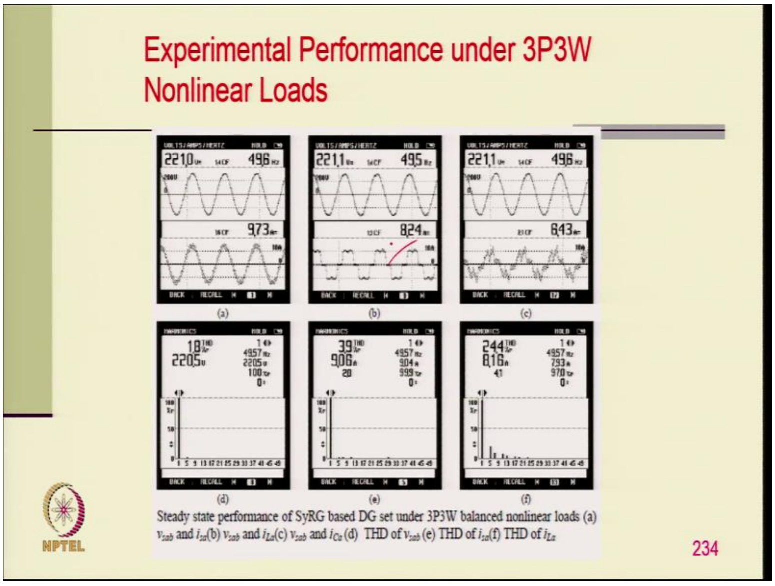

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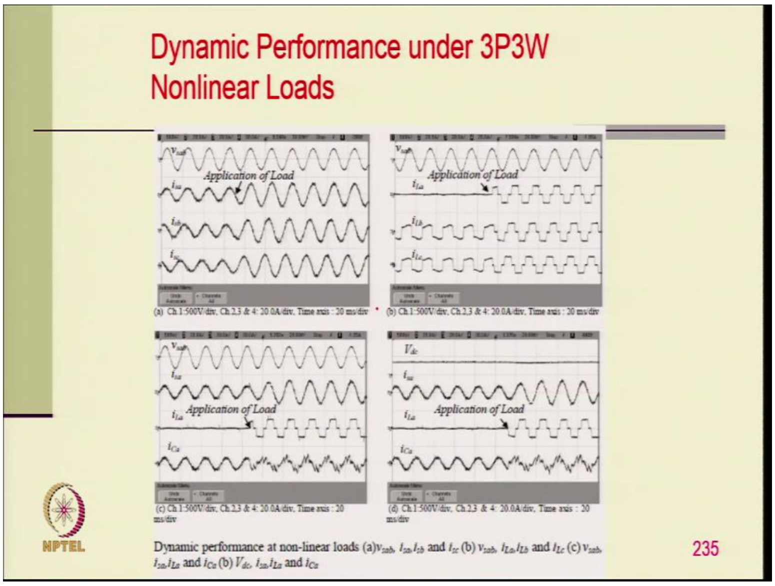

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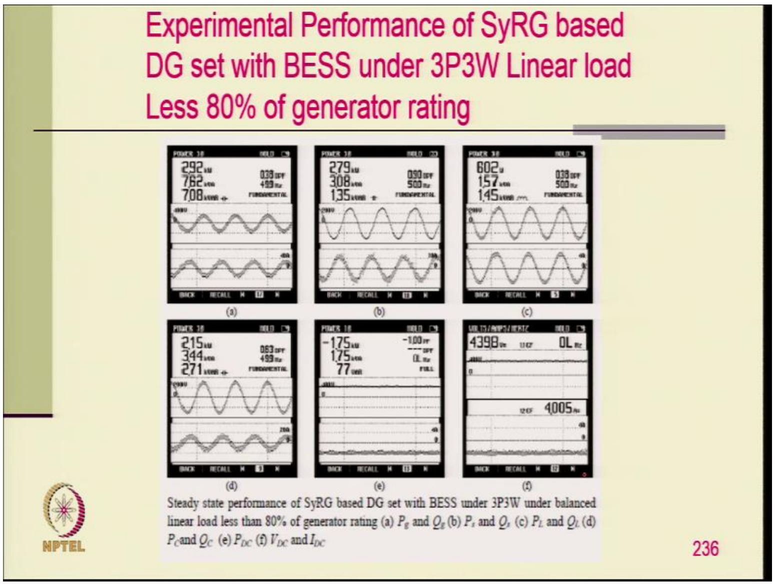

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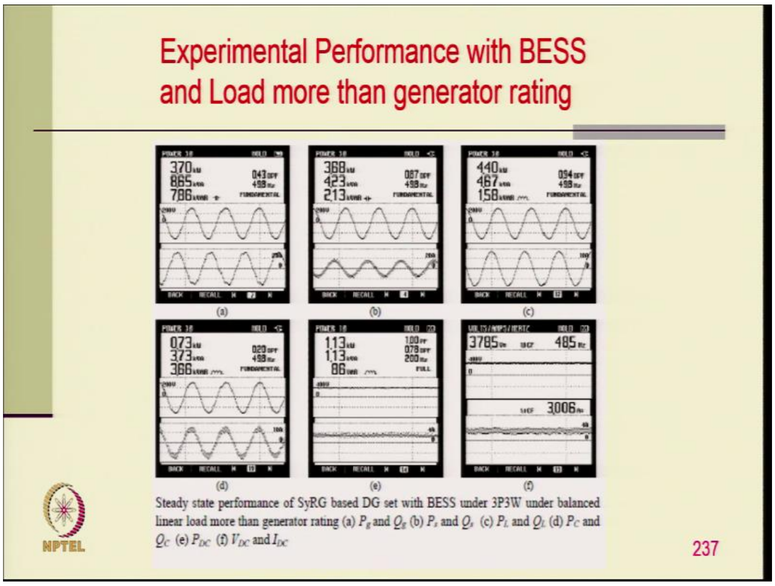

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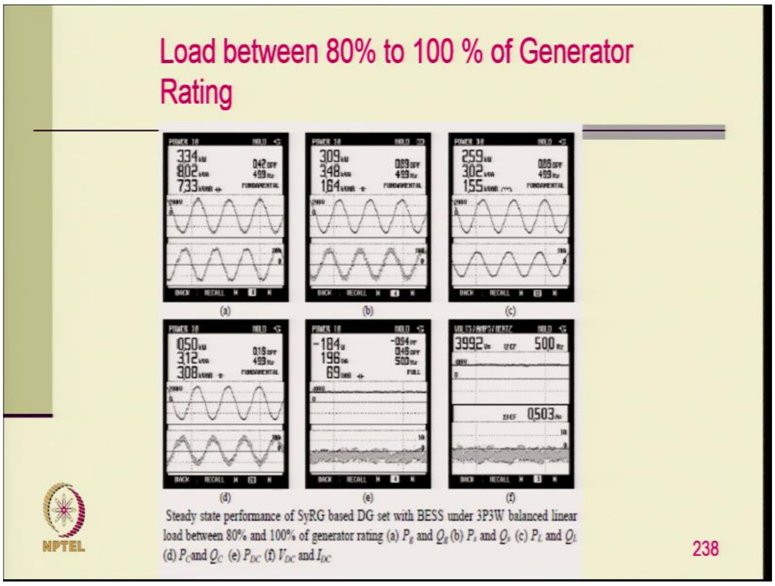

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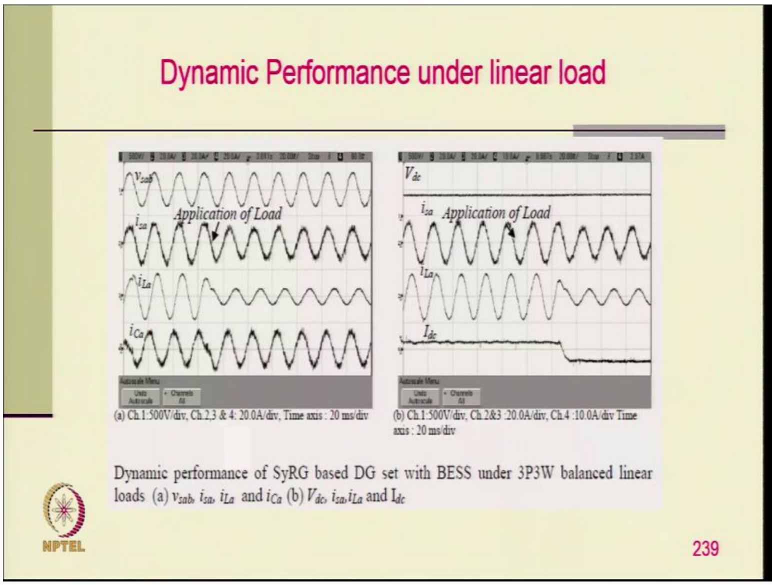

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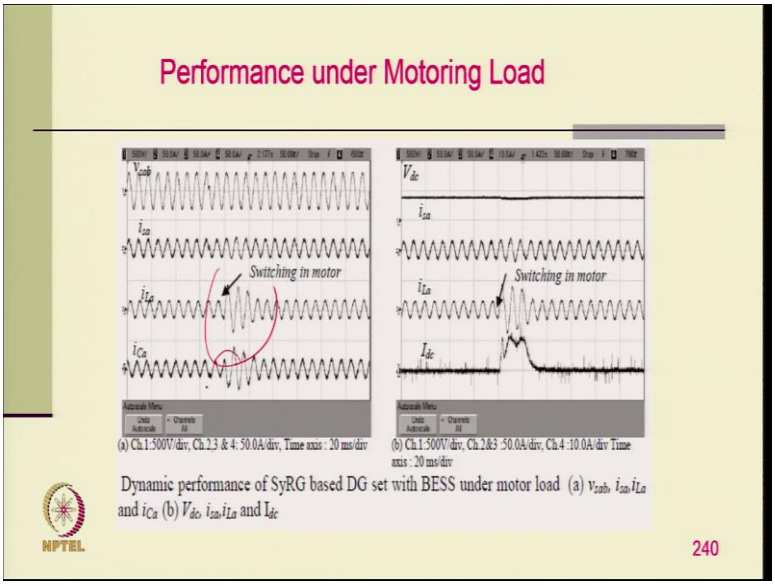

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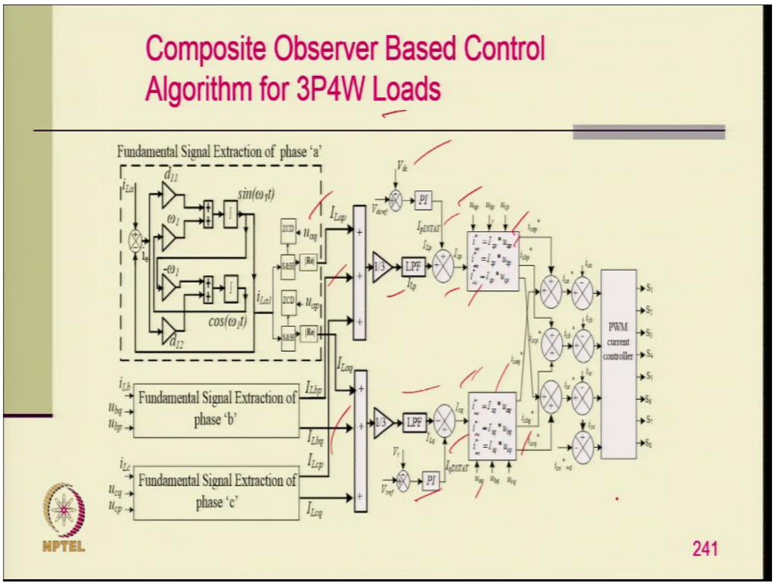

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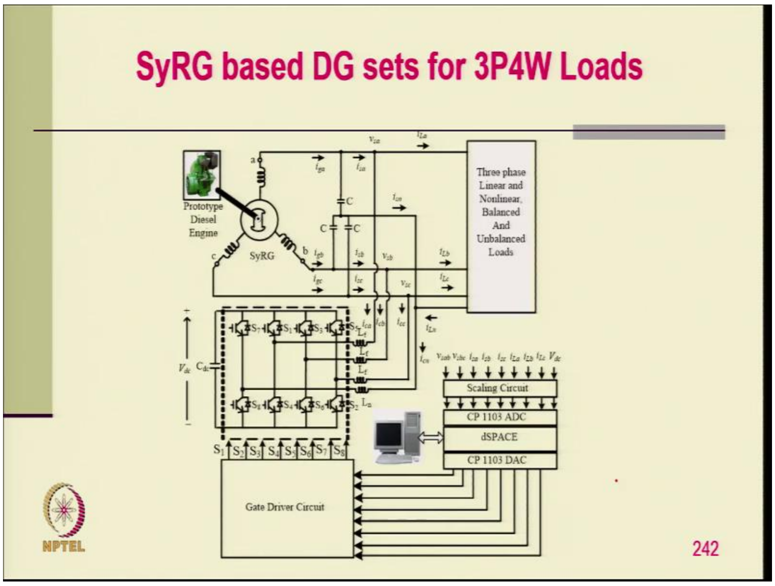

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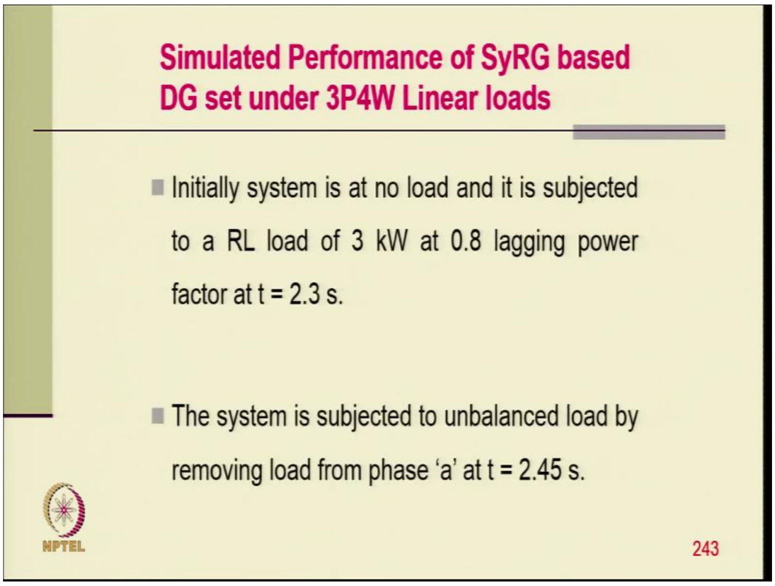

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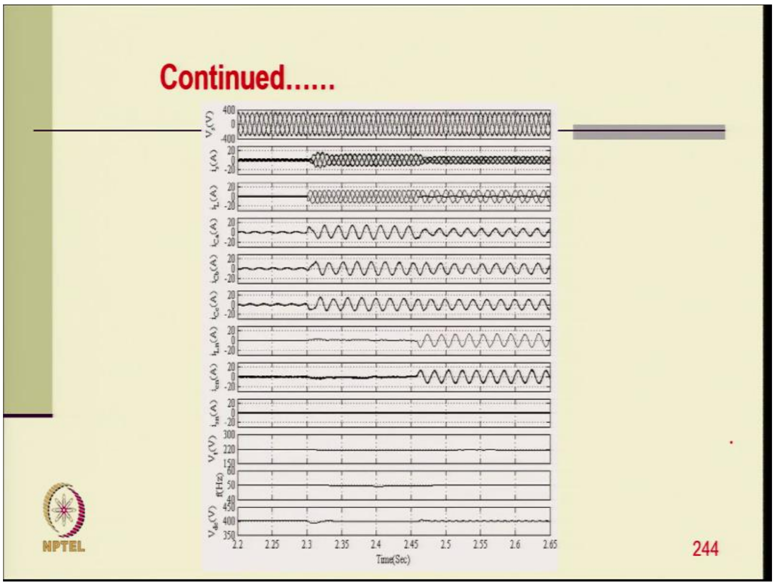

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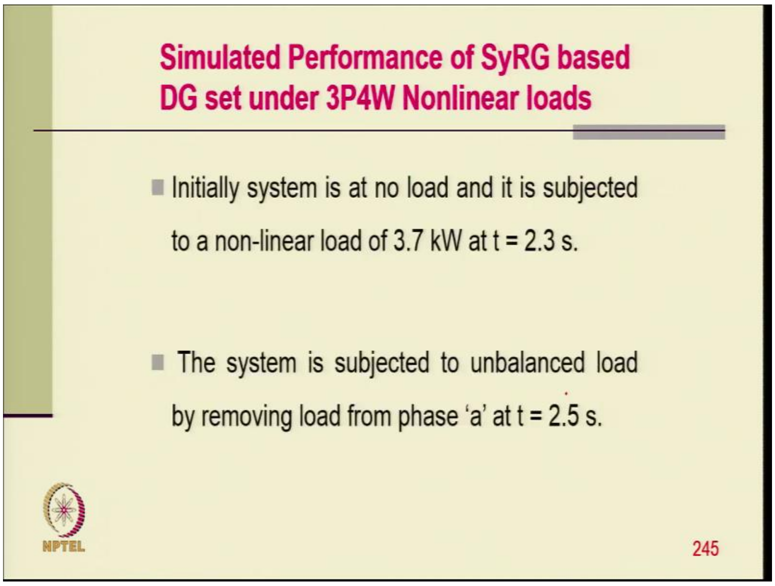

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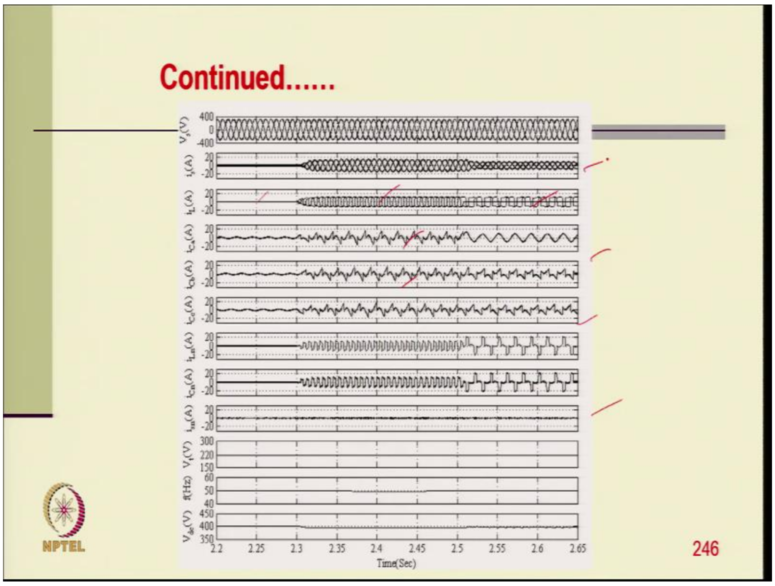

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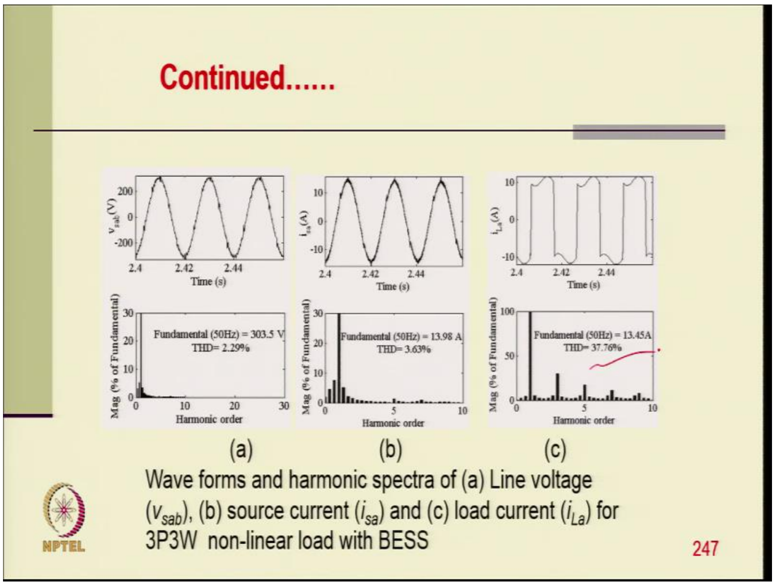

And the THD of the load current is 37.76 percent, where the THD of your generator current is 3.63 percent and terminal voltage THD 2.29 percent.

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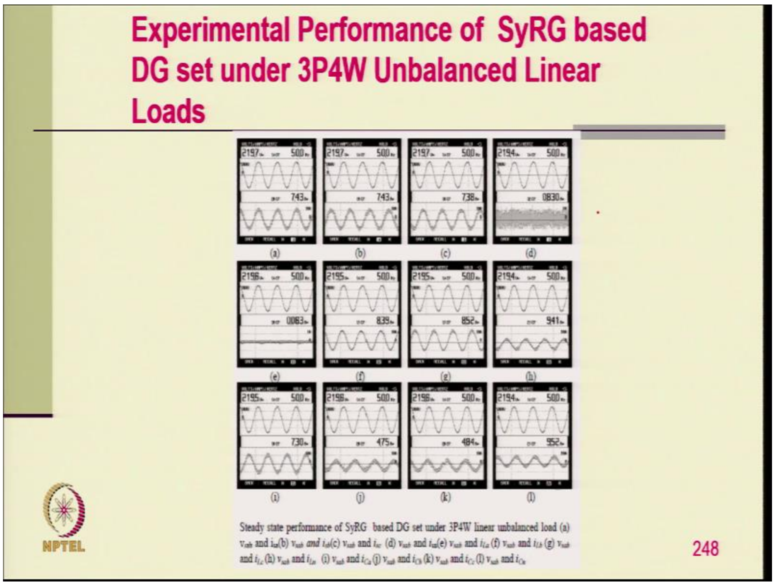

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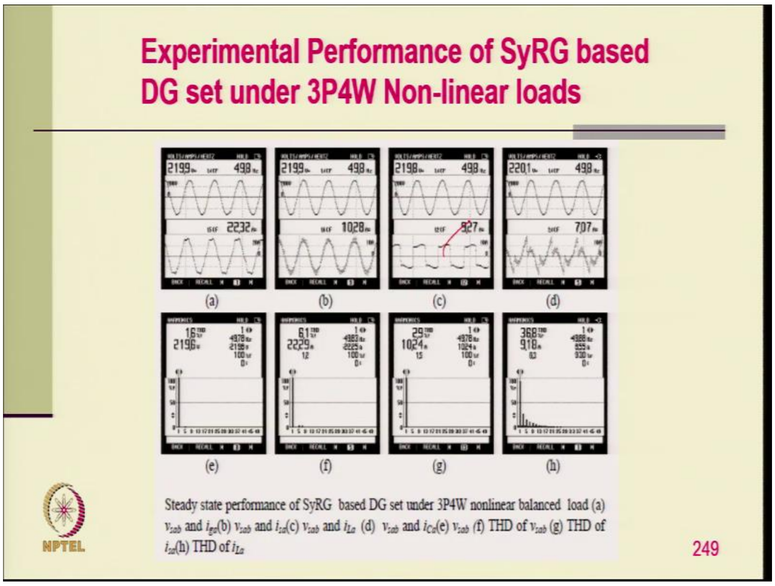

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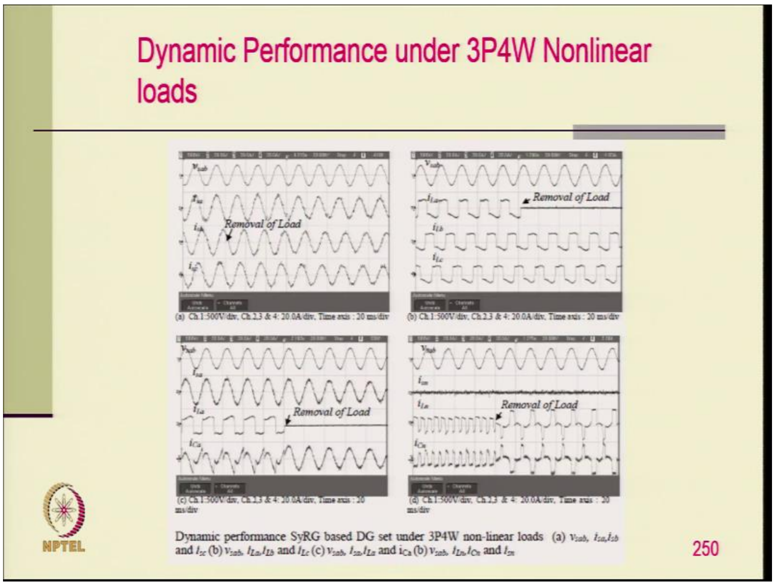

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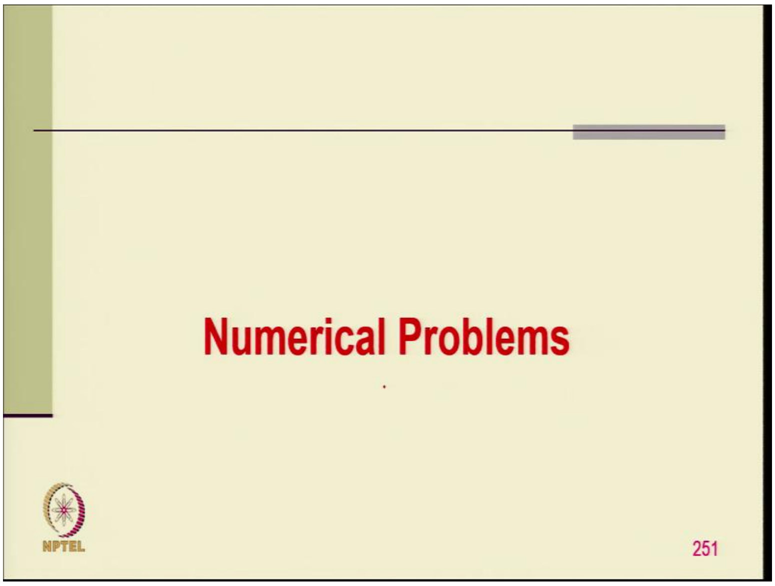

Now, coming to the numerical problems.

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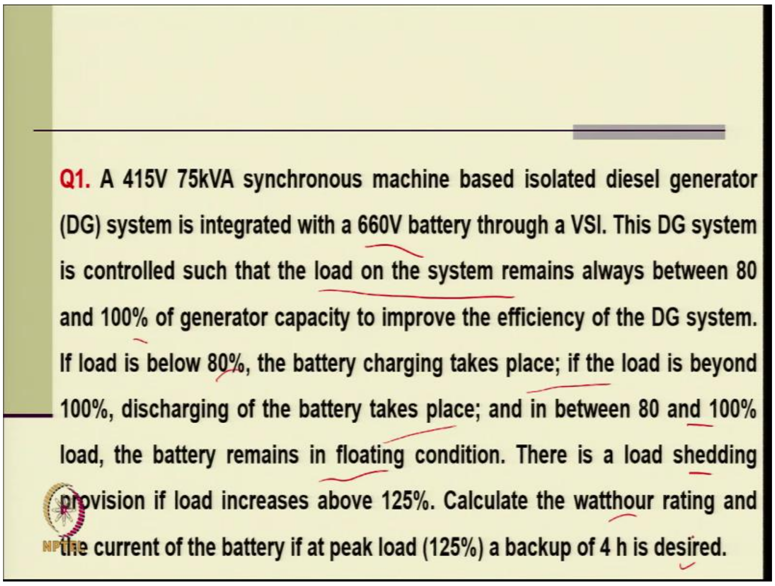

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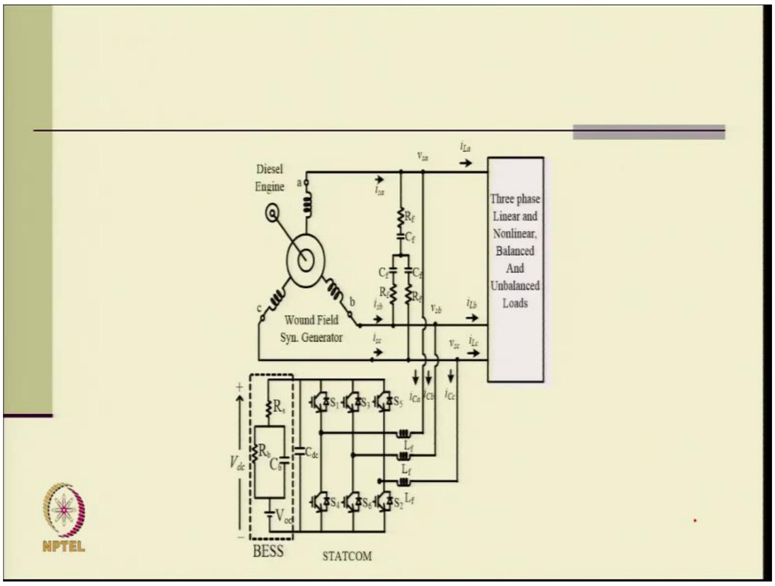

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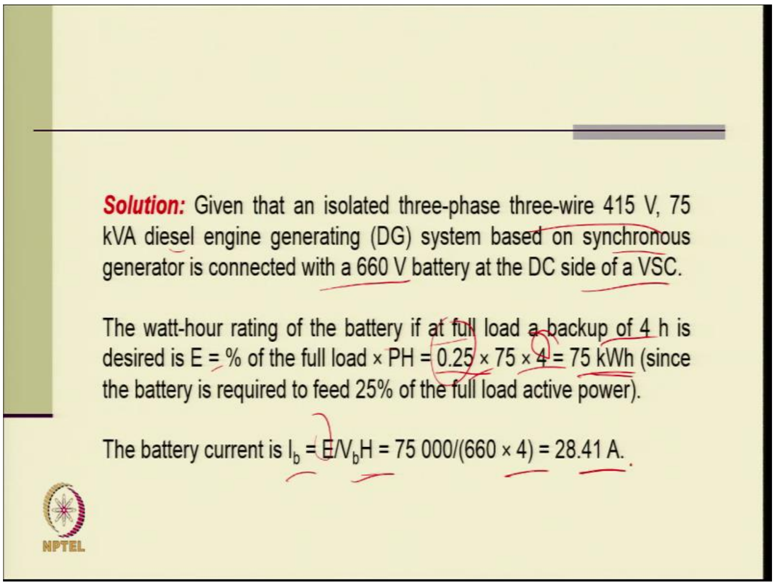

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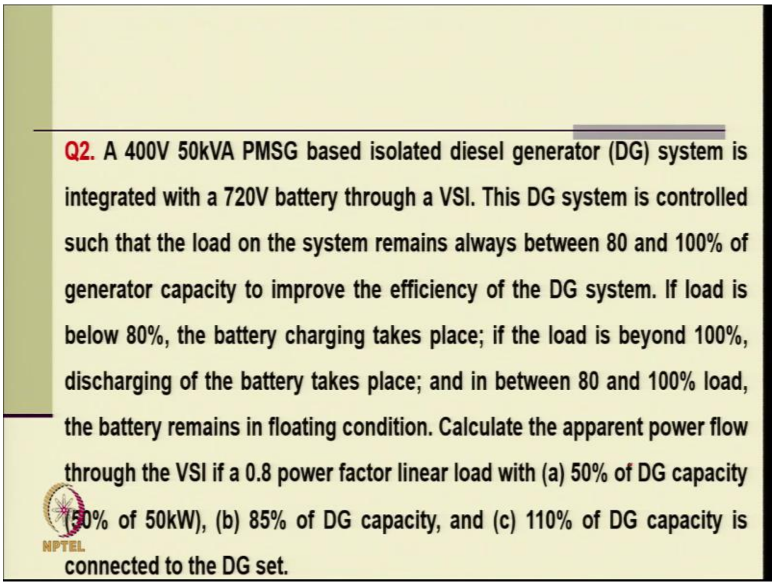

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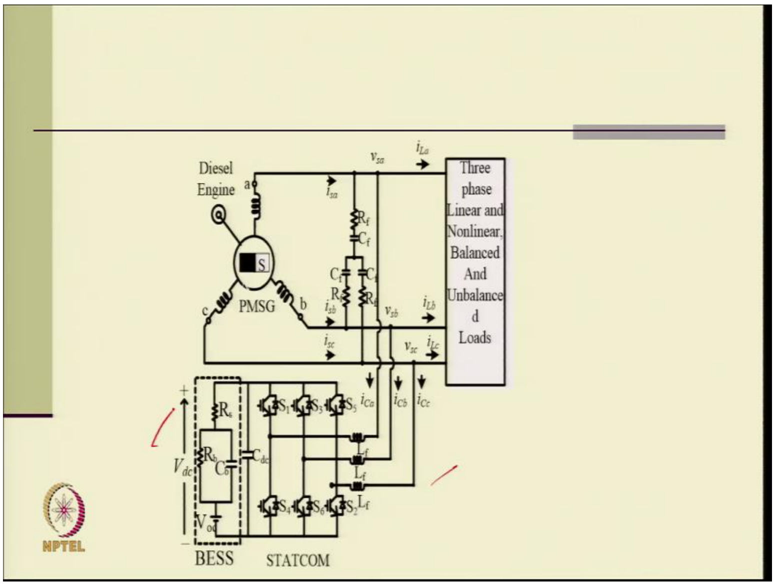

This is the typical system with the battery which provide the power leveling.

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Solution: Given that an isolated three-phase three-wire 415 V, 50 kVA diesel engine generating (DG) system based on PMSg is connected with a 720 V battery at the DC side of a VSC.

(a) The active power of load = 50% of capacity = 50 × 0.5 = 25 kW
Reactive power of load = PtanΦ = 18.75 kVAR

Active power from DG set = 80% of capacity (for optimal fuel consumption) = 50*0.8 = 40kW

Active power through the VSC is $P_{VSI} = P_{dg} - P_l = 40-25 = 15$ kW (battery charging)
Reactive power through the VSC is $Q_{VSI} = 18.75$ kVAR
Apparent Power = $S_{VSI} = \sqrt{(P_{VSI}^2 + Q_{VSI}^2)} = 24.01$ kVA

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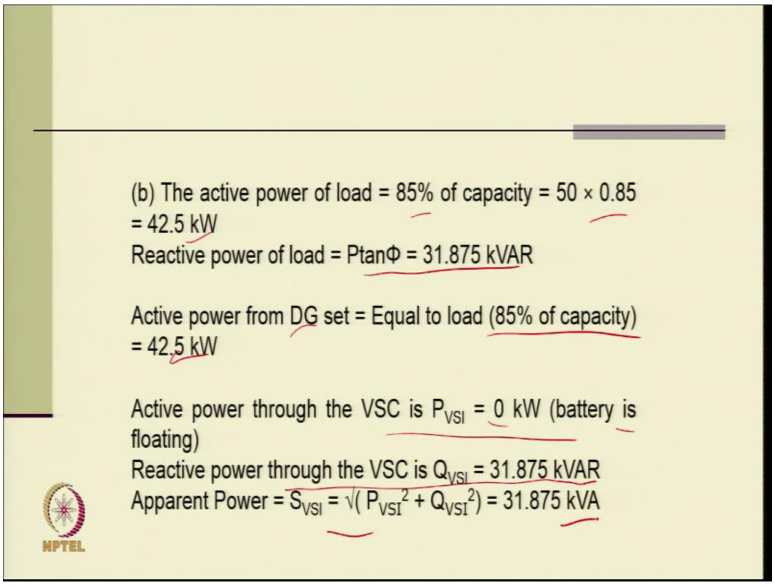

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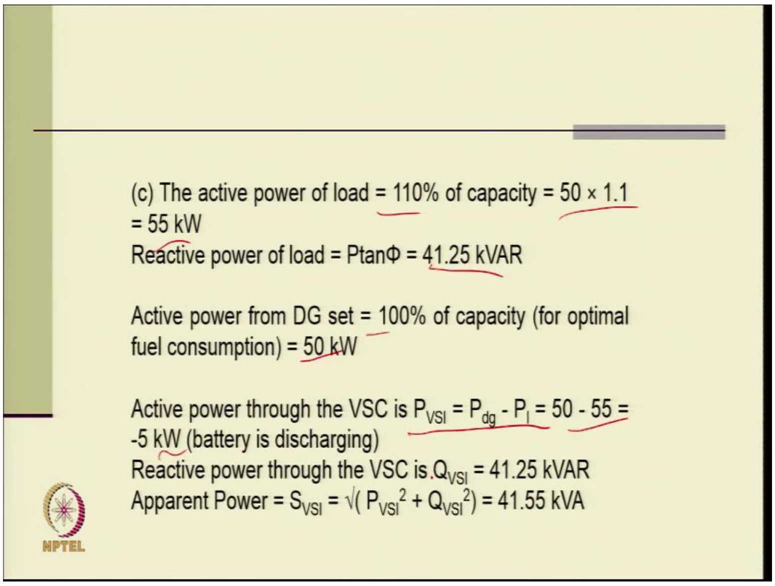

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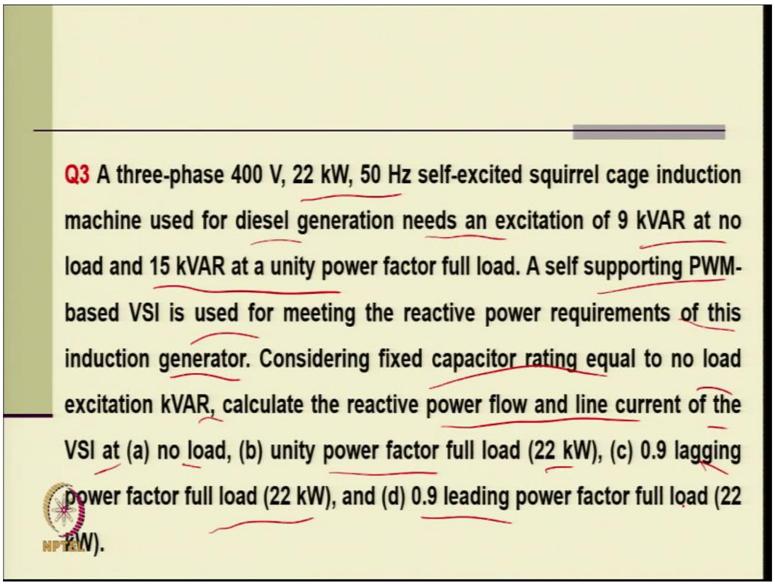

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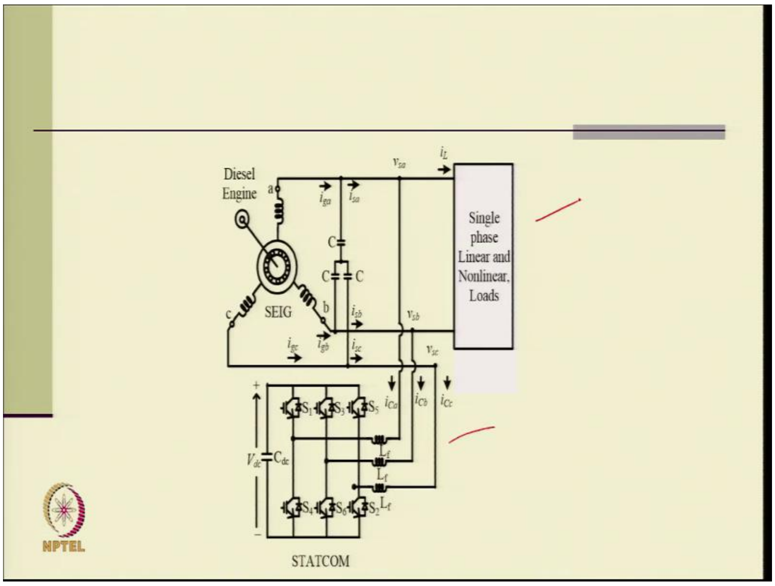

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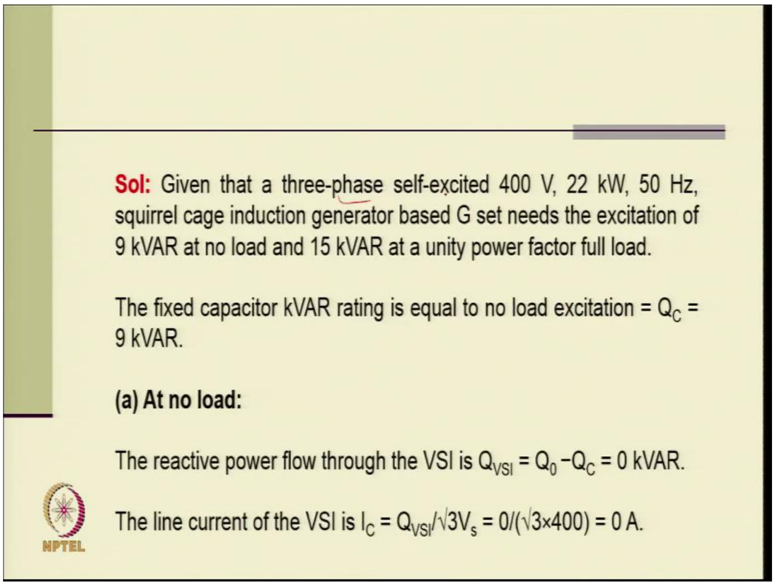

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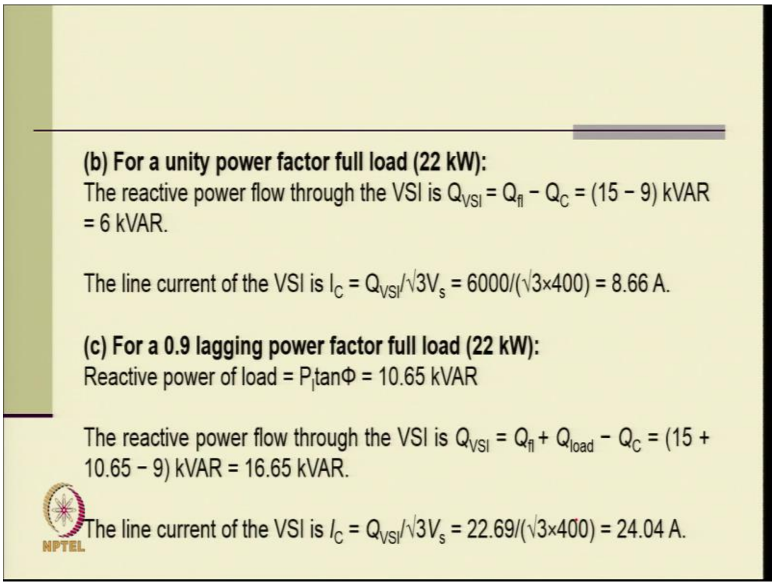

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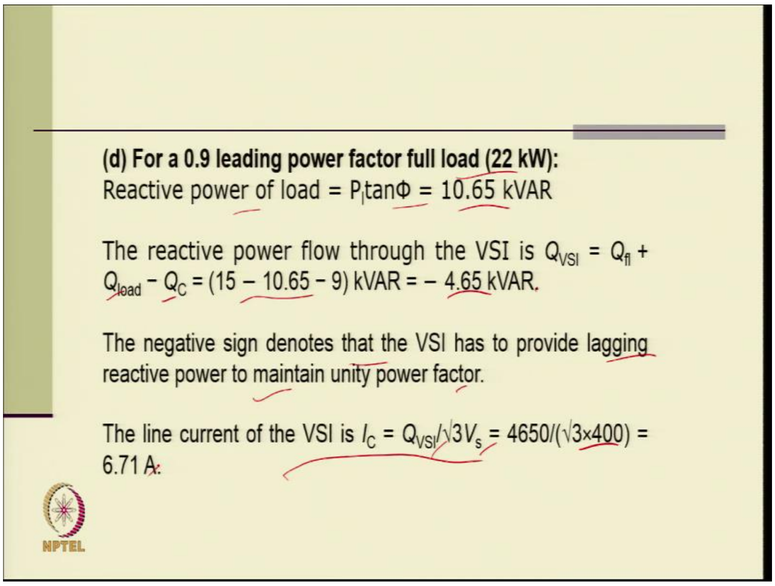

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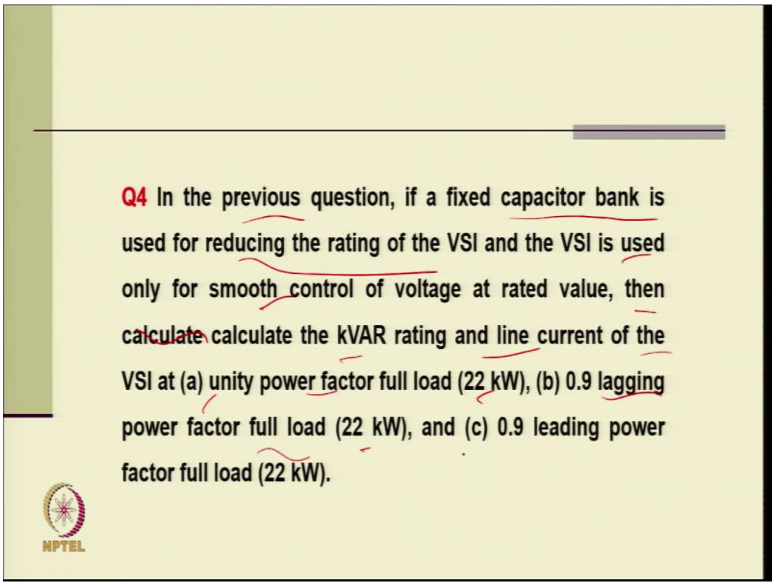

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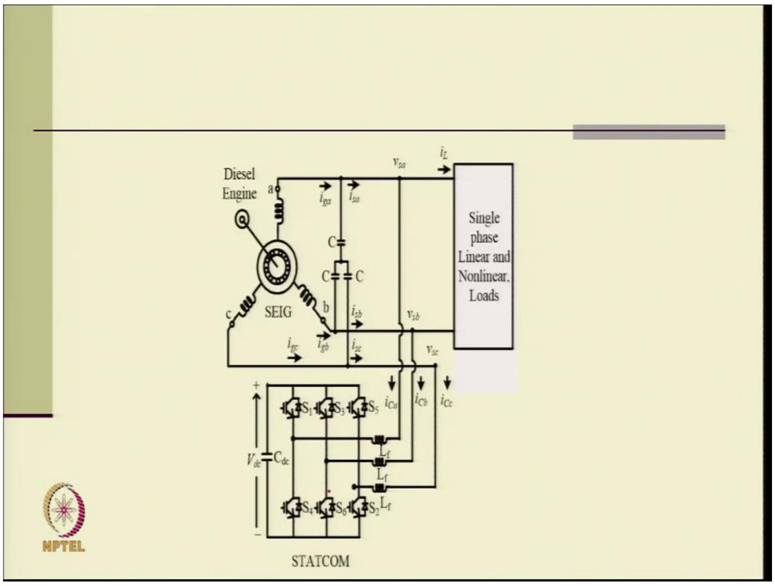

This is the typical system.

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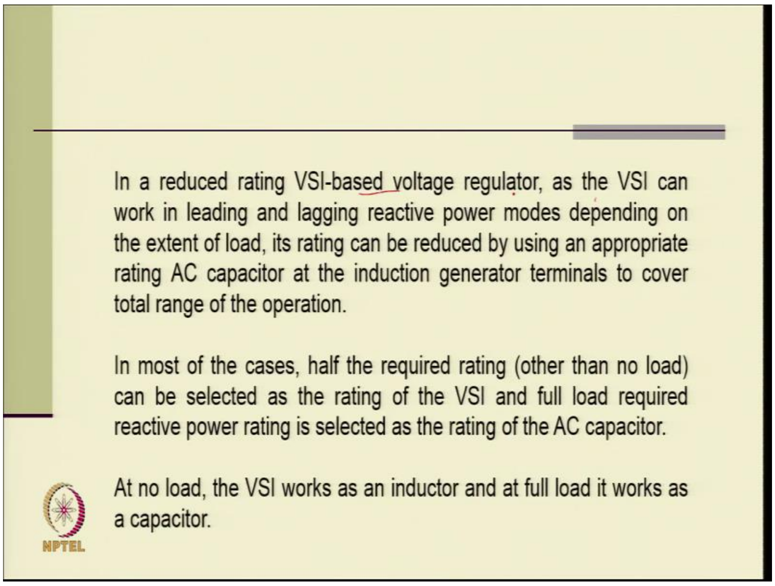

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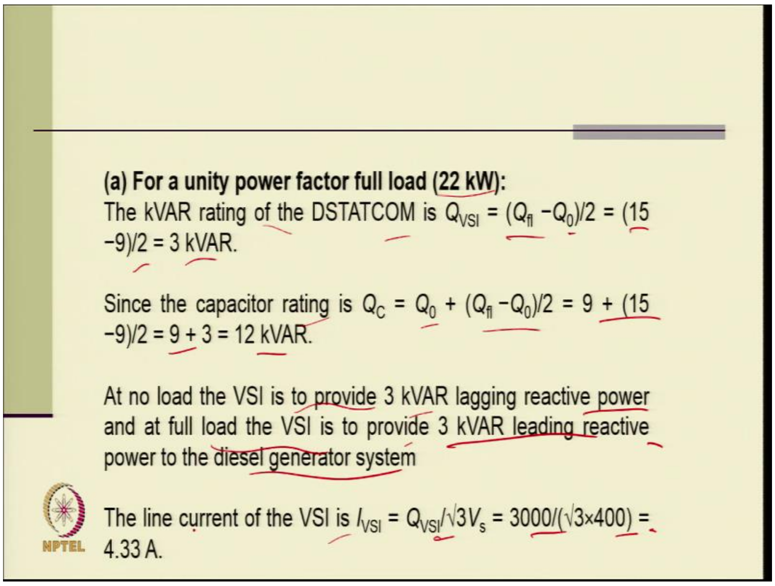

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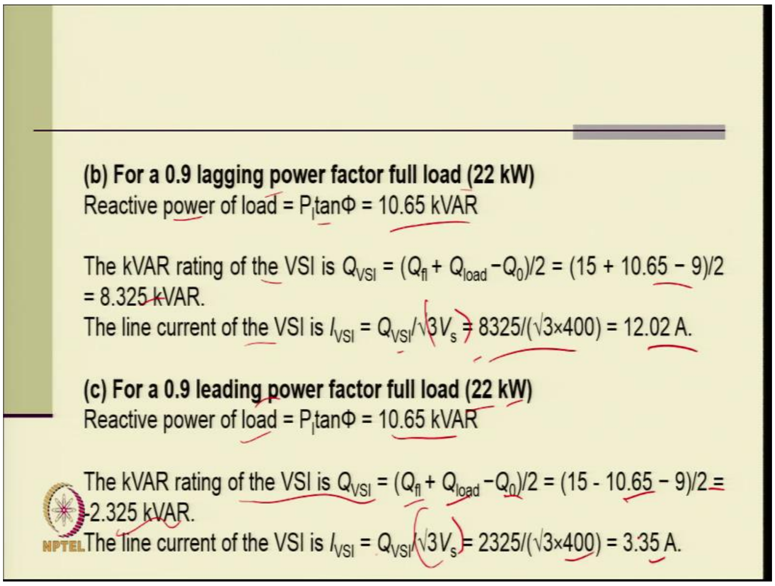

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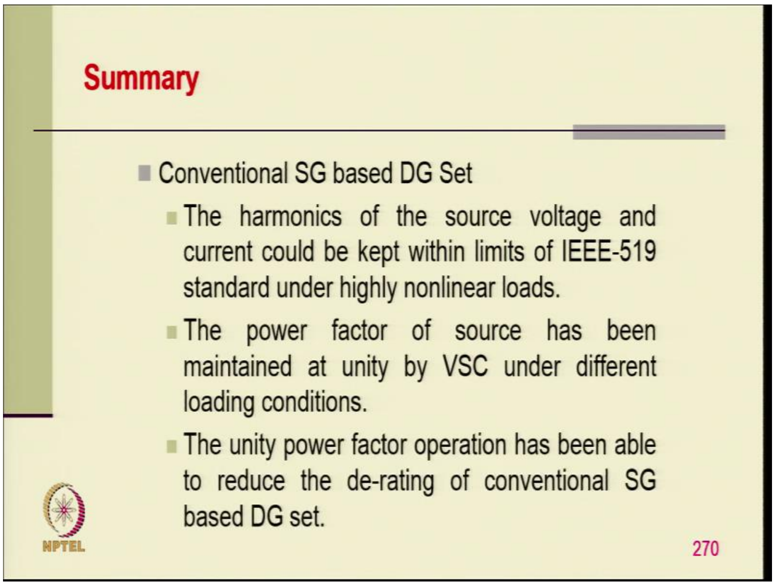

So, with this, we like to summarize, the power quality improvement in DG set. We discussed conventional synchronous generator based DG set. The harmonics of the source voltage or generator voltage and the current are kept within the limit of IEEE 519 standard under highly non-linear load, and, the power factor of the source has been maintained at unity by voltage source converter operating under different conditions.

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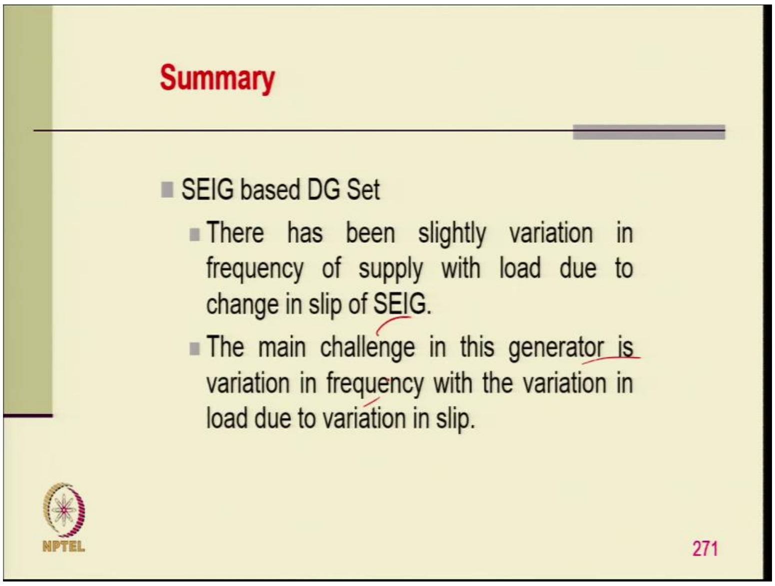

Now, coming to self excited induction generator based DG set. There has been a slightly variation in the frequency of the supply with the load due to changing of the slip in the self excited induction generator. The main challenge in this generator is to variation frequency with variation of load due to variation in slip.

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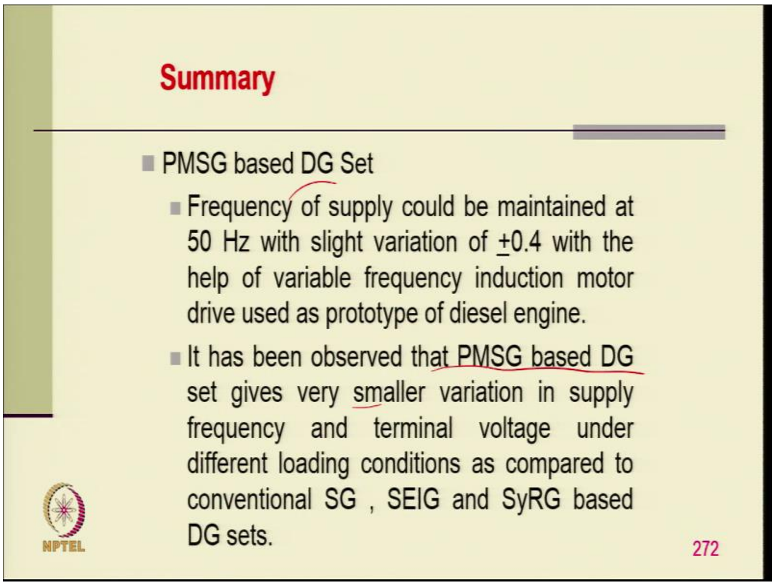

In case of permanent synchronous generator based DG set the frequency of supply could be maintained 50 percent with slight variation of plus minus 0.4 with the help of variable frequency drive used as a prototype. It has been observed that the PMSG based set DG set give the very smaller variation in the supply frequency and the terminal voltage under different loading conditions as compared to conventional synchronous, SEIG and synchronous generator set.

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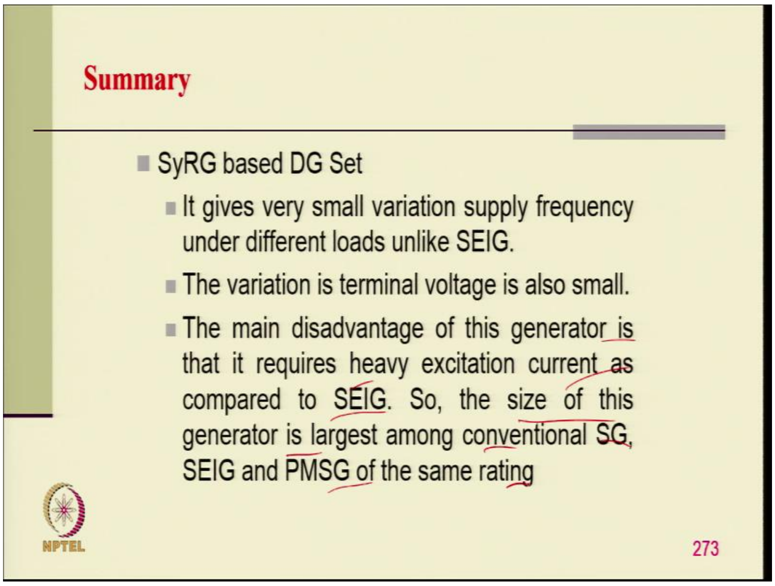

Coming to synchronous reluctance generator set it give the very small variation in supply frequency under different loads unlike SEIG. And the variation is in terminal voltage is also small. And the main disadvantage of this generator is that it requires a heavy excitation current as compared to self excitation. So, the size of the generator is larger among the conventional synchronous generators, self excitation and PMSG of same rating.

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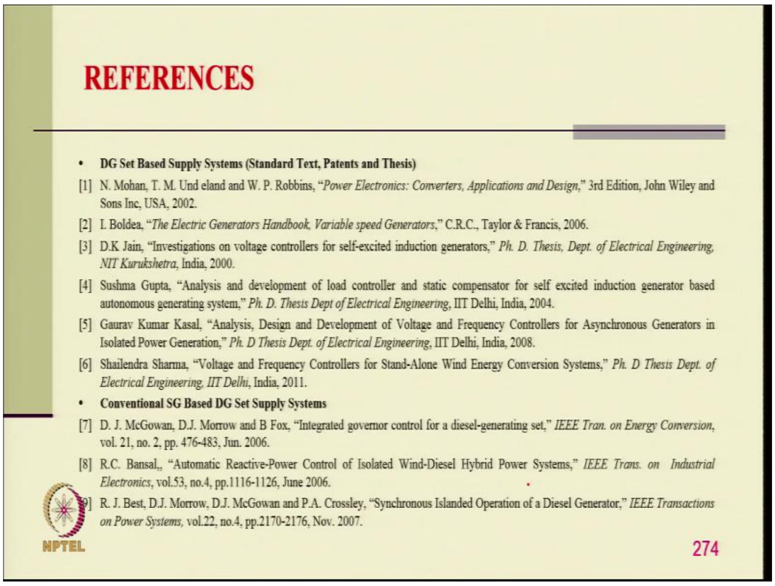

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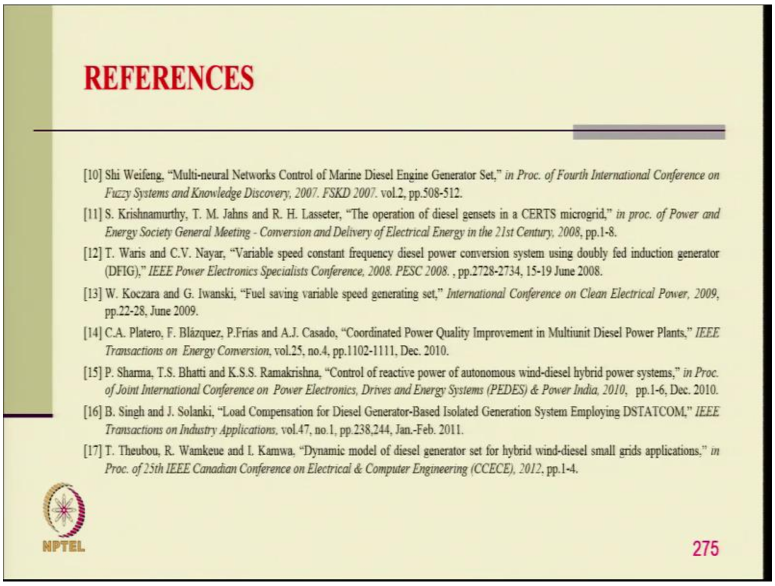

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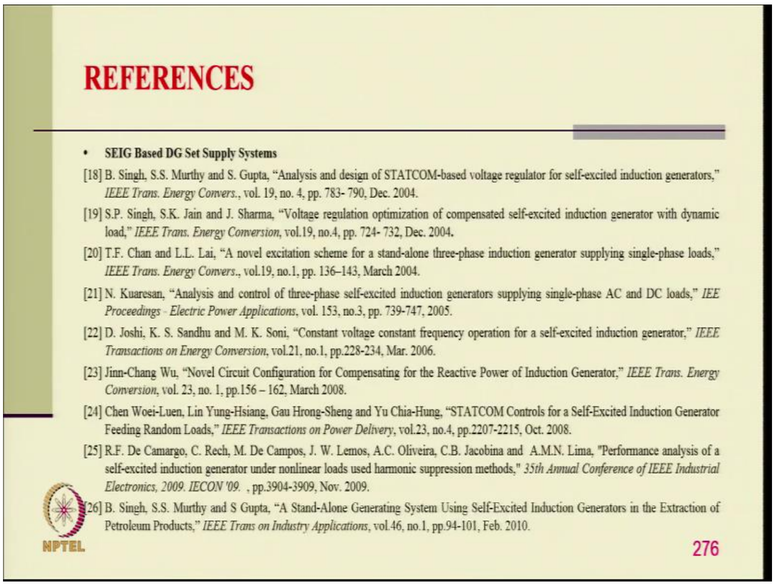

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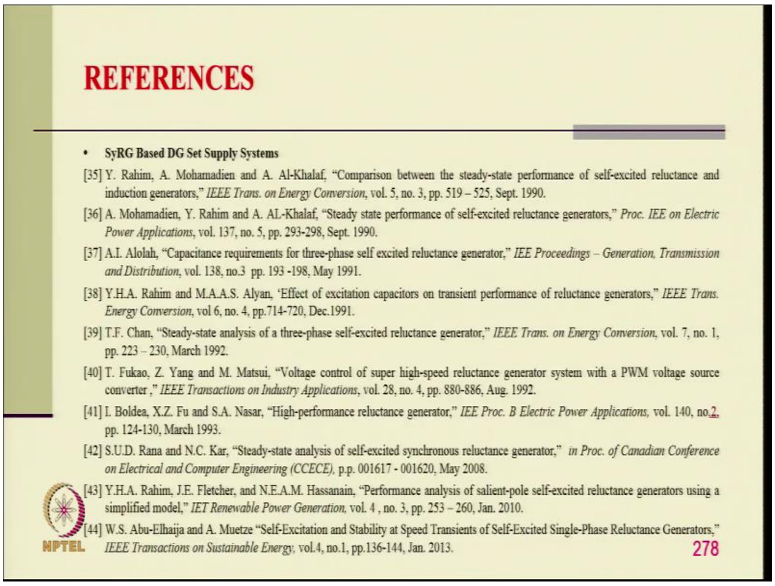

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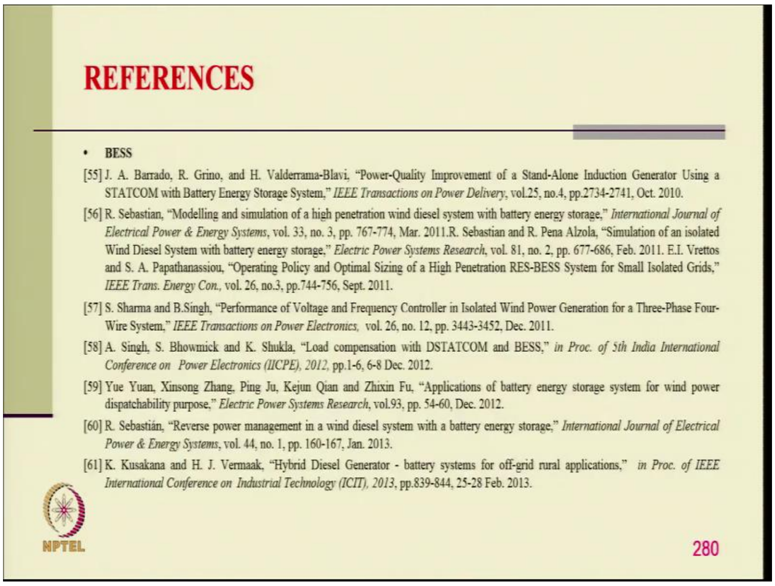

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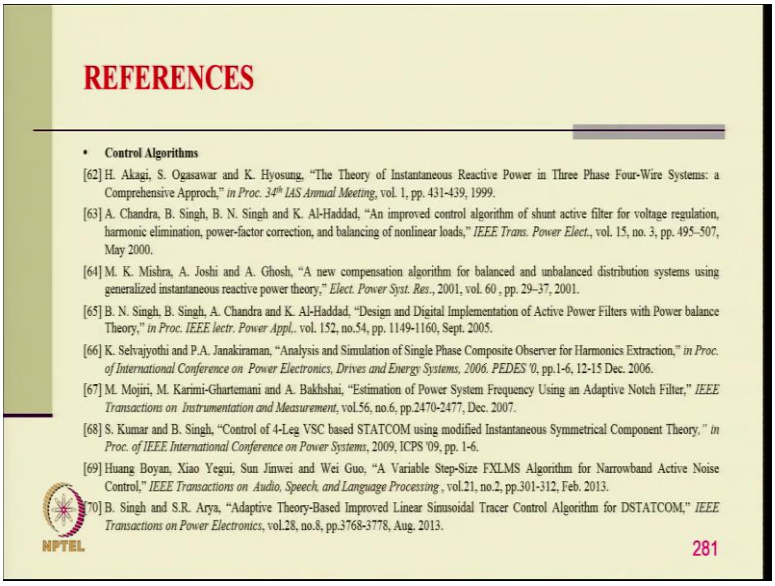

These are the some of the references which we referred for typically for this power quality improvement of DG set and typically for different generators.

Thank you.