Power Quality
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Lecture - 28
Hybrid Power Filters (contd.)

Welcome to the course on Power Quality. We are discussing the Hybrid Power Filters.

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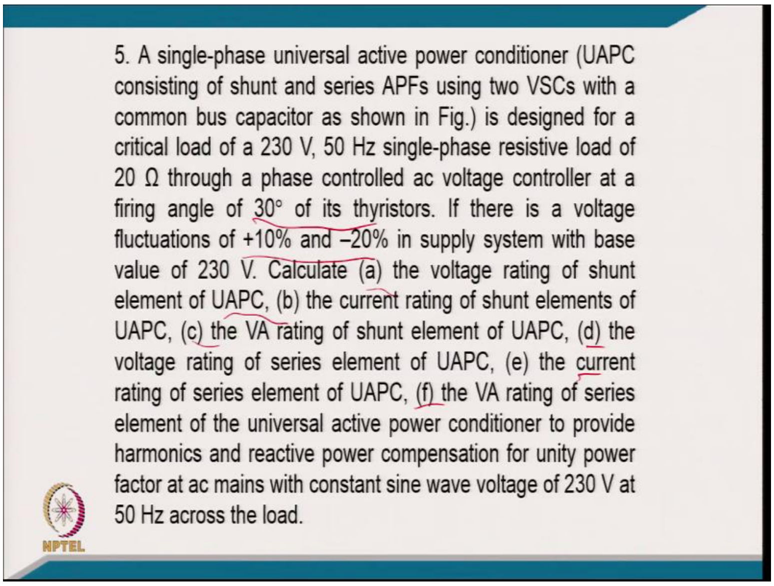

Coming to the 5th numerical, A single phase universal active power conditioner consisting of shunt and series active power filters using two voltage source converter with common dc bus as shown in figure is design for critical load of 230 volt 50 hertz single phase the resistive load of 20 ohm, through a phase control ac voltage controller at fire angle of 30 degree of its thyristor.

And if there is any if there is a flow voltage fluctuations of plus 10 percent minus 20 percent in the supply voltage, this way with the base value of 230 volt calculate a the voltage rating of shunt element b current rating of shunt element, c VA rating of shunt element, d voltage rating of the series element, e current rating of series element, f VA rating of series element of the universal active power conditioner to provide harmonics and reactive power compensation for unity power factor at ac mains with constant sine wave voltage of 230 volt across the load.

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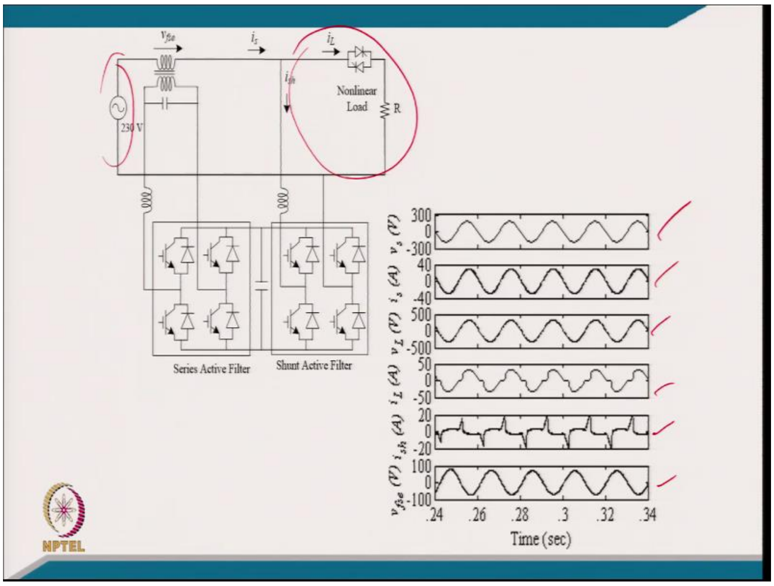

The explanation of the numerical problem is described in the screenshots herein.

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Solution: Given that, supply voltage, V_s =230 V rms, frequency of supply, f = 50 Hz, a nonlinear load of a phase controlled ac voltage controller consisting of 230 V, 50 Hz, R = 20 Ω, α = 30° (π/6 rads). There is a voltage fluctuation of +10% and –20% in supply system with base value of 230 V. A single-phase universal active power conditioner (UAPC) is to provide unity power factor at the ac mains with constant sine wave voltage of 230 V at 50 Hz across the load. Let X be the pu voltage variation and V_s' be the PCC voltage under voltage variation.

In this system, load current harmonics and reactive power compensation are to be provided by the shunt active filter of UAPC. The voltage sag/swell compensation is provided by series filter of UAPC. However, while compensating for sag/swell, an active power is circulated between series and shunt active filters as explained earlier in chapter of UPQC. Under maximum voltage dip, the maximum rating for both the VSCs are realized. The various rating calculations are as follows,

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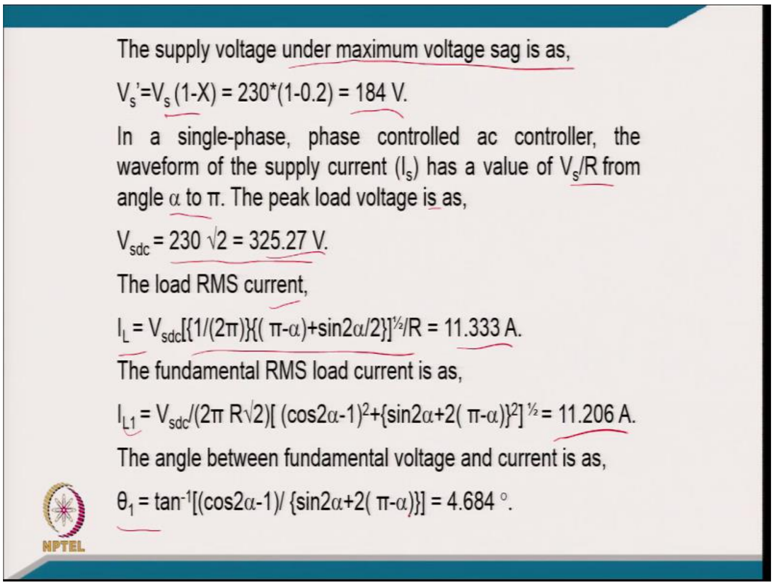

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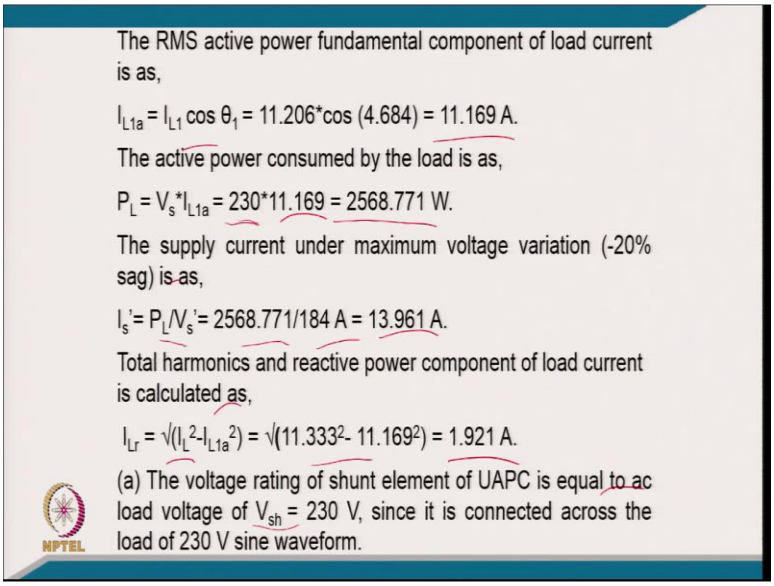

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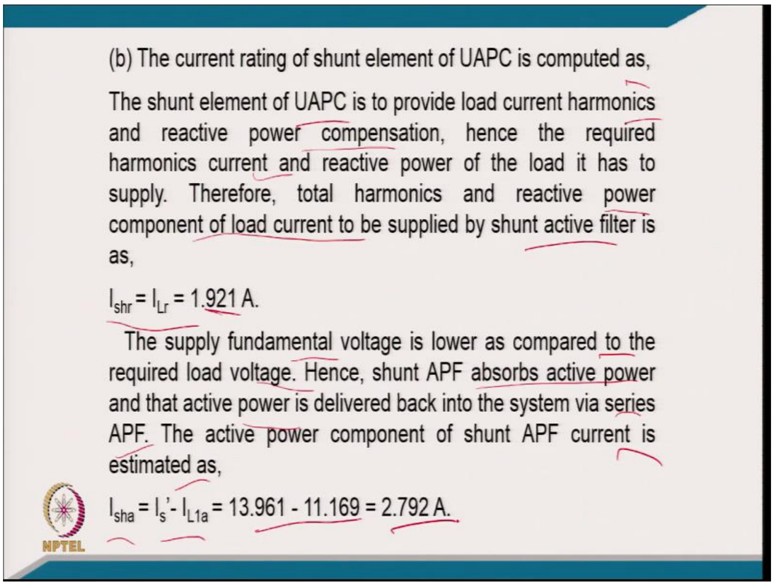

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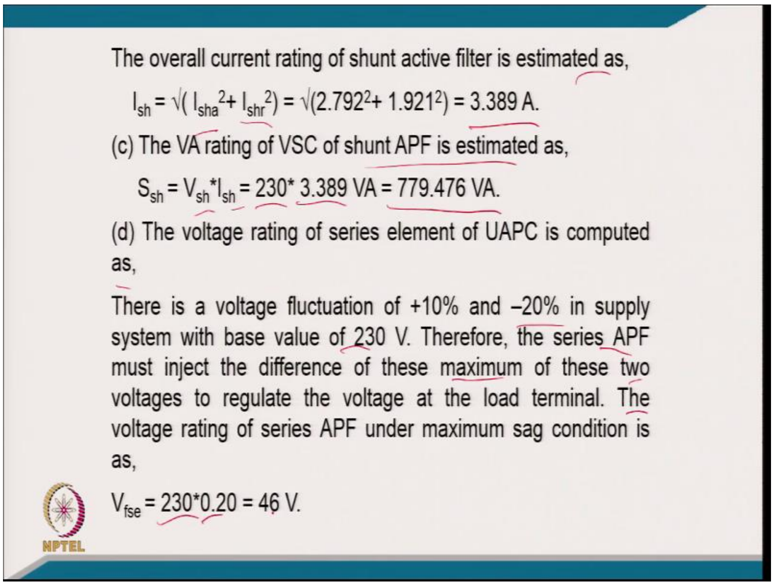

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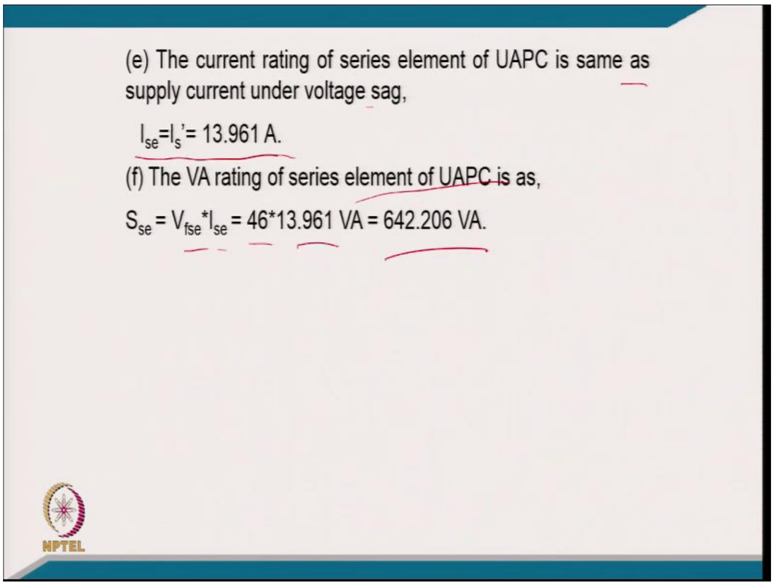

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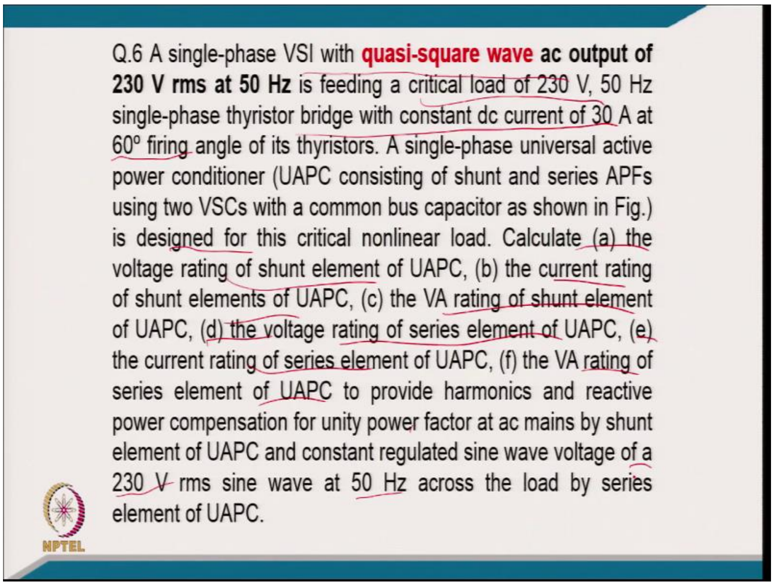

Coming to the 6th numerical problem a single phase voltage source inverter with a quasi square wave form ac output of 230 volt 50 hertz is feeding the critical load of 230 volt 50 hertz single phase thyristor bridge. With a constant dc current of 30 ampere, at the 60 degree fire angle of thyristor and single phase universal active power conditioner is design for this critical non-linear load calculate a the voltage rating of shunt element current rating of shunt element.

VA rating of shunt element and the voltage rating of series element and the current rating of series element and a VA rating of series element of universal active power conditioner to provide harmonics and reactive power compensation. For unity power factor at ac mains by shunt element of universal active power filter and constant regulated sine wave voltage of the 230 volt rms sine wave at 50 hertz across the load by series element of universal active power filter.

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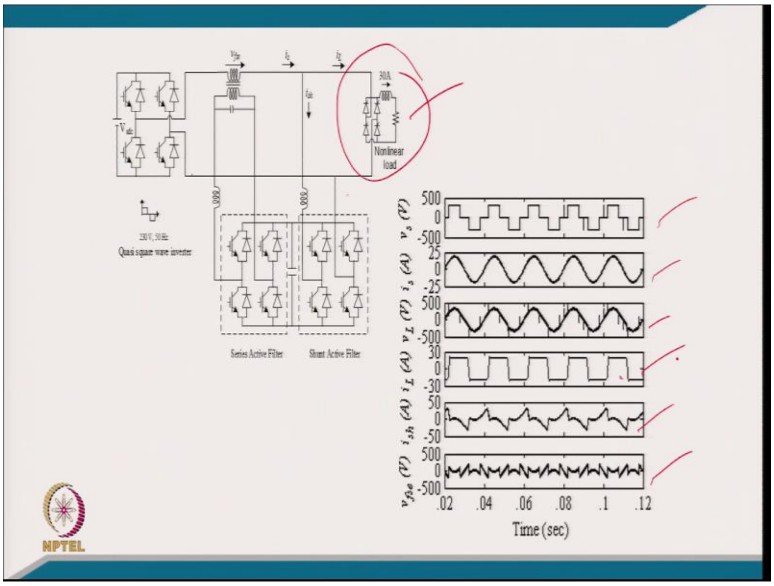

The explanation of the numerical problem is described in the screenshots herein.

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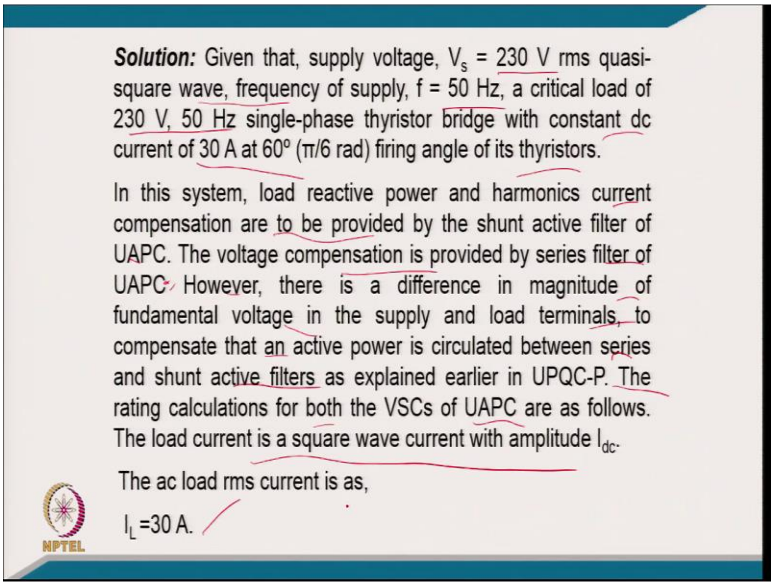

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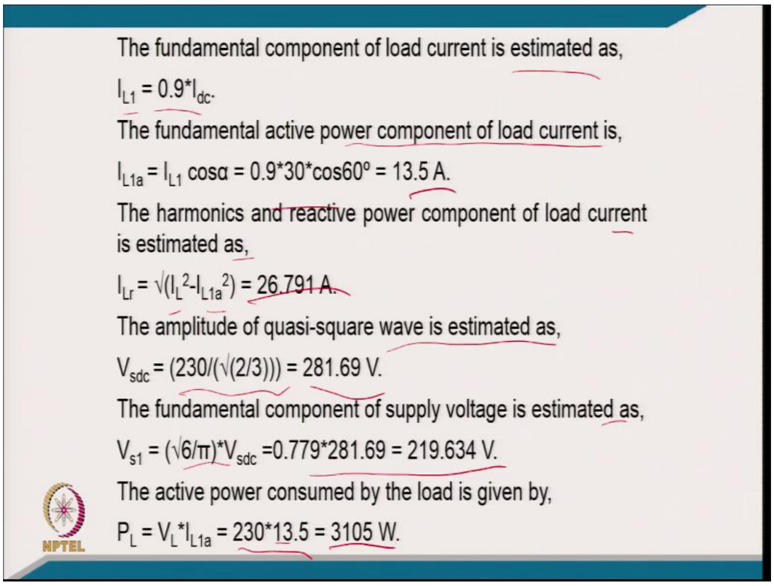

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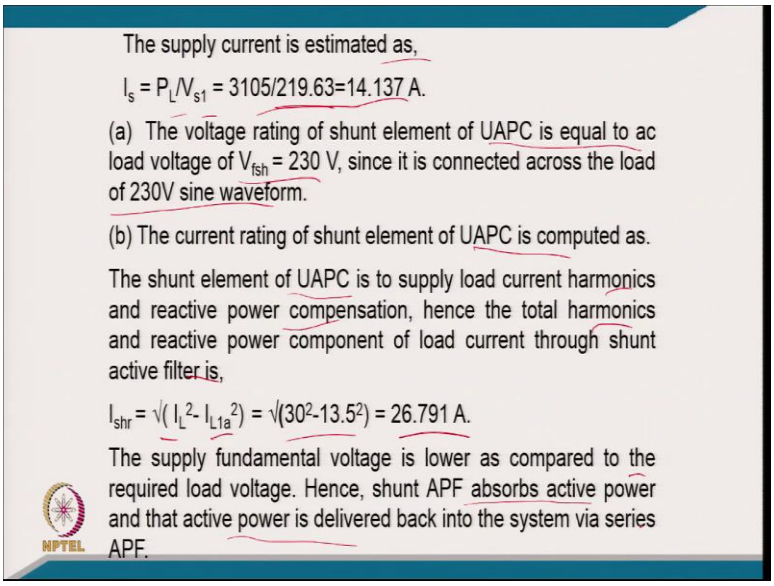

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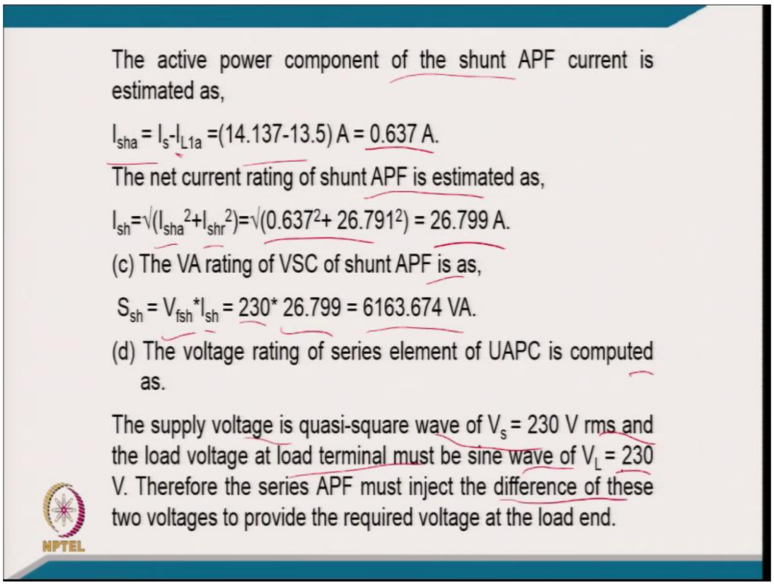

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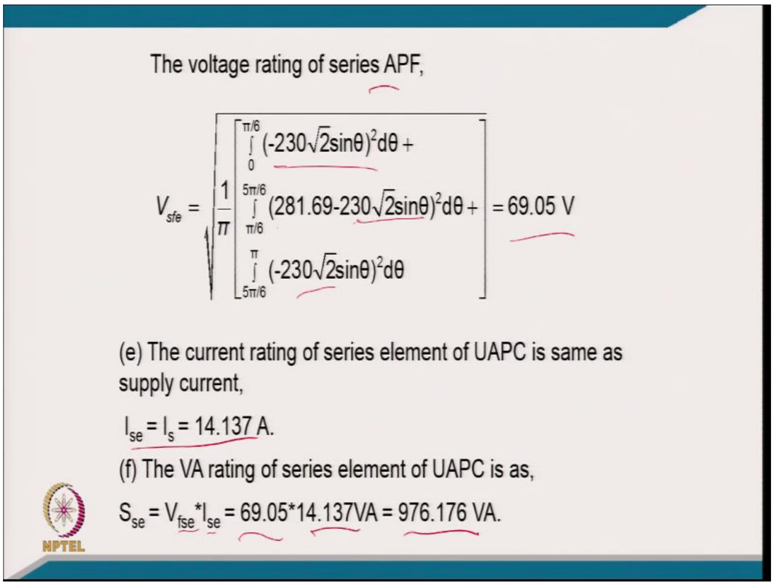

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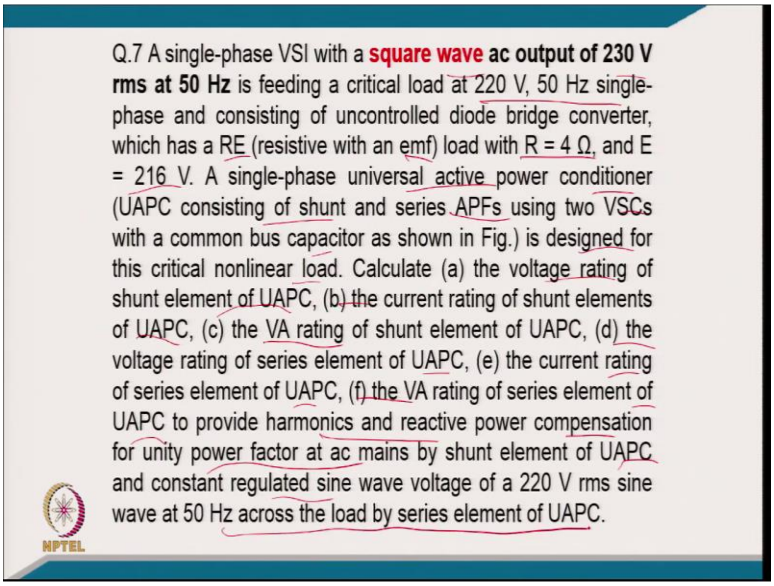

Coming to 7th numerical problem a single phase voltage source inverter with a square wave ac output of 230 volt at 50 hertz is feeding the critical load of 220 volt, 50 hertz a single phase. And consisting of un controlled diode bridge converter having a RE resistive and bend emf load with resistance equal to 4 ohm and E equal to 216 volt, a single phase universal active power conditioner consisting shunt and series active power filter using a 2 voltage source converter with common dc bus capacitor is use.

And which is design for critical non-linear load, calculate the a voltage rating of the shunt element of universal active power filter. b current rating of the shunt act element of universal active power conditioner, the c the VA rating of the shunt element of universal active power filter, d the voltage rating of series element of universal active power filter and e the current rating of series element of universal active power conditioner.

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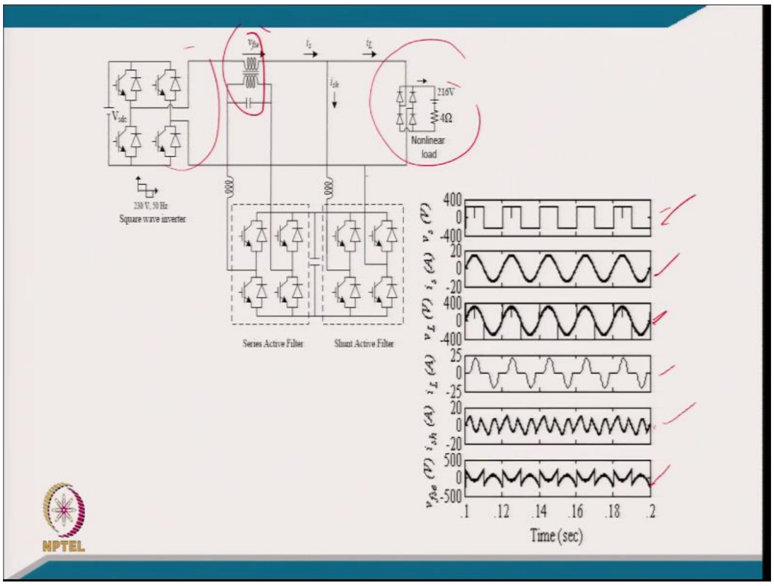

The explanation of the numerical problem is described in the screenshots herein.

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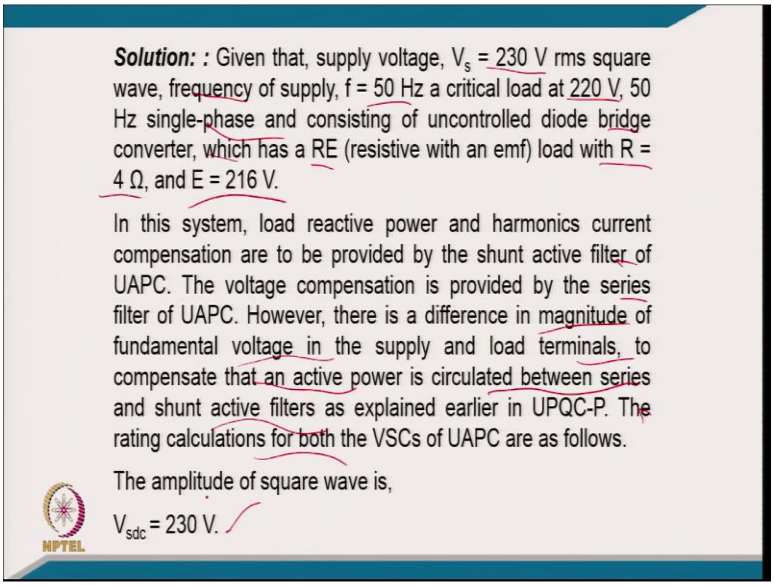

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The fundamental component of supply voltage is estimated as, $V_{s1} = 0.9*V_{sdc} = 0.9*230 = 207$ V. However, the load terminal voltage is need to be regulated at, $V_L = 220$ V.

Under this reduced fundamental voltage, the rating calculations for both the conditioners are as follows,

In single-phase diode bridge converter with RE load, the current flows from angle (α) when ac voltage is equal to E and to the angle (β) at which ac voltage reduces to E.

The peak load voltage is,

$V_{Lm} = 220*\sqrt{2}\ V = 311.13$ V.

$\alpha = \sin^{-1}(E/V_{Lm}) = \sin^{-1}(216/311.13) = 43.96^\circ$,

$\beta = \pi - \alpha = 136.03^\circ$,

The conduction angle = $\beta - \alpha = 92.06^\circ$.

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The RMS load current (I_L) is rms of discontinuous current in the ac mains which is estimated as,

$I_L = [\{1/(\pi R^2)\}\{(0.5V_{Lm}^2+E^2)(\pi-2\alpha)+0.5V_{Lm}^2\sin 2\alpha-4V_{Lm}E\cos\alpha\}]^{1/2}$

$I_L = 12.32$ A.

An average current (I_{dc}) flowing into the battery is as,

$I_{dc} = \{1/(\pi R)\}(2V_{Lm}\cos\alpha+2E\alpha-\pi E) = 8.02$ A.

Active power drawn from the ac mains is as,

$P_L = I_L^2R+EI_{dc} = 12.32^2*4+216*8.02 = 2339.8$ W.

The active power component of fundamental load current from ac mains is,

$I_{L1a} = P_L/V_L = 2339.8/220 = 10.63$ A.

The supply current is estimated as,

$I_s = P_L/V_{s1} = 2339.8/207 = 11.30$ A.

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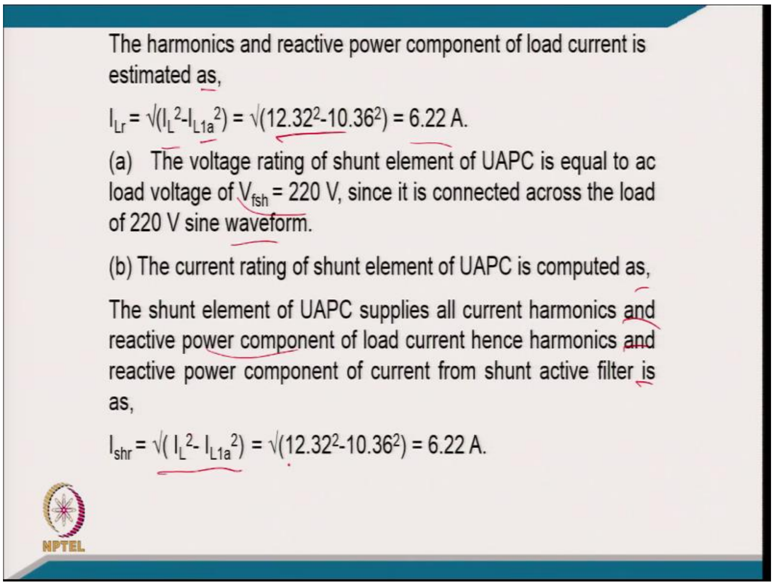

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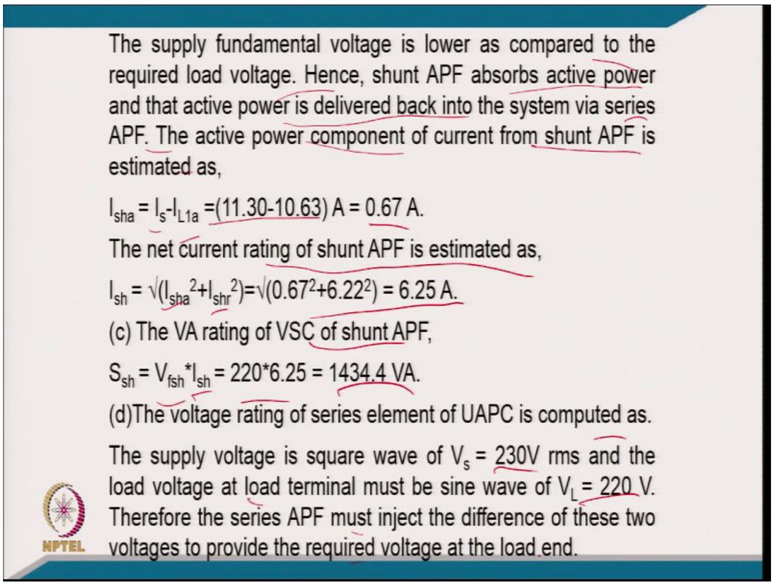

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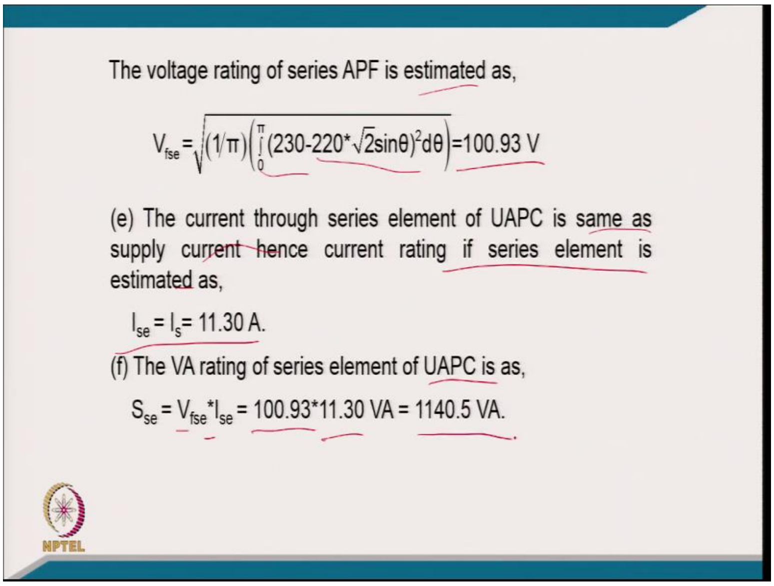

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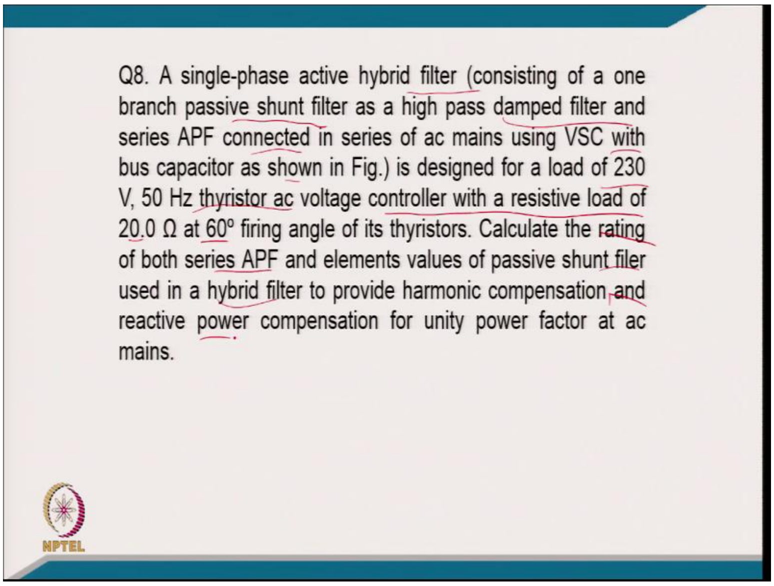

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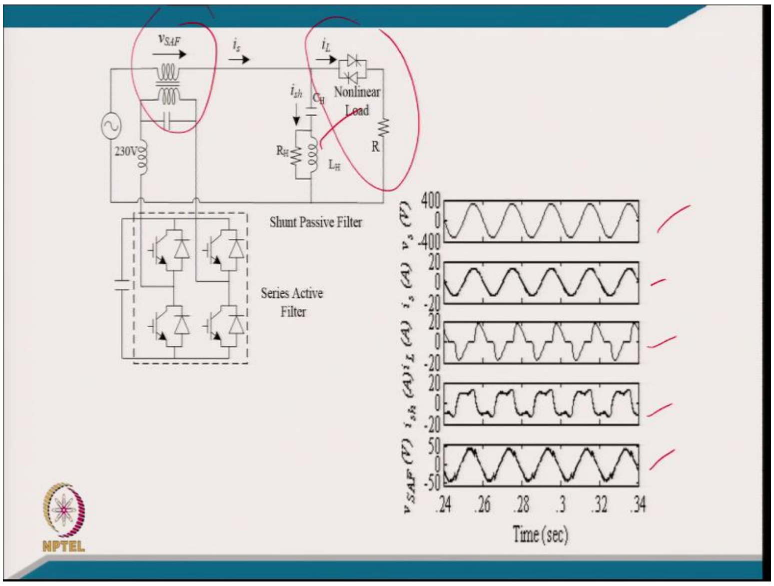

The explanation of the numerical problem is described in the screenshots herein.

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Solution: Given that, supply rms voltage, V_s = 230 V, frequency of the supply f = 50 Hz, R = 20 Ω, $\alpha = 60^0$. A single-phase active hybrid filter (consisting of a shunt passive filter and series APF using VSC with dc bus capacitor) connected in series with ac mains is designed for this load compensation.

In a single-phase, phase controlled ac controller, the waveform of the supply current (I_s) has a value of V_s/R from angle α to π. The peak load voltage is as,

$V_{sdc} = 230\sqrt{2} = 325.27$ V.

An ac load rms current is as,

$I_L = V_{sdc}[\{1/(2\pi)\}\{(\pi-\alpha)+\sin2\alpha/2\}]^{1/2}/R = 10.315$ A.

Fundamental RMS load current

$I_{L1} = V_{sdc}/(2\pi R\sqrt{2})[(\cos2\alpha-1)^2+\{\sin2\alpha+2(\pi-\alpha)\}^2]^{1/2} = 9.65$ A.

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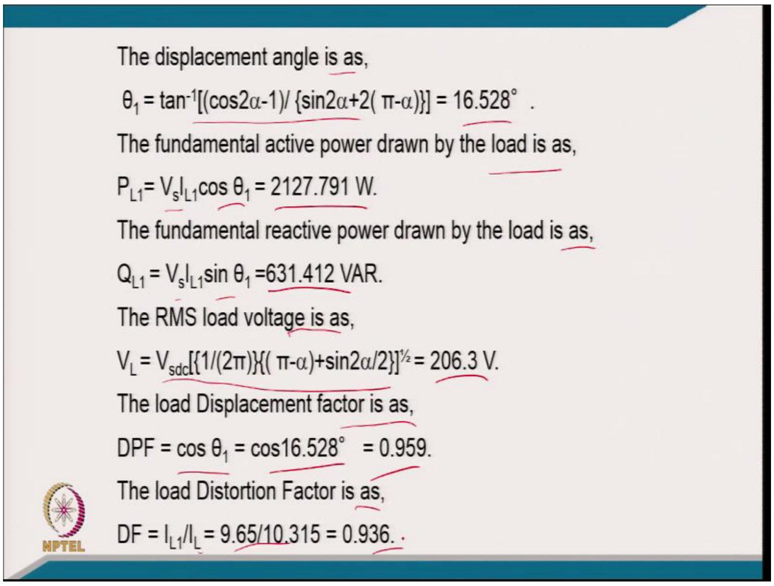

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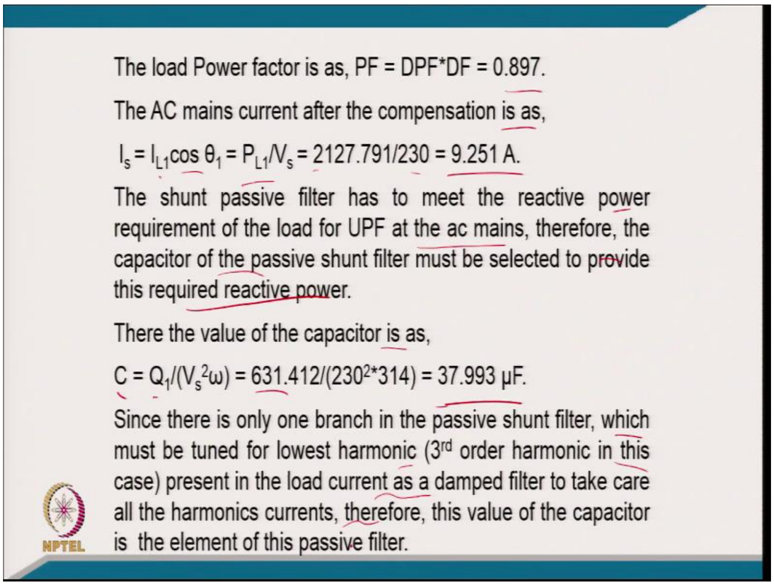

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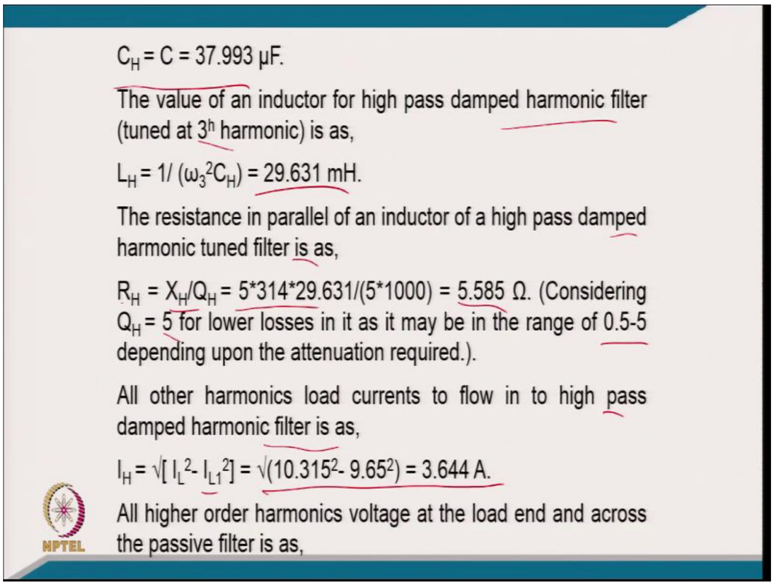

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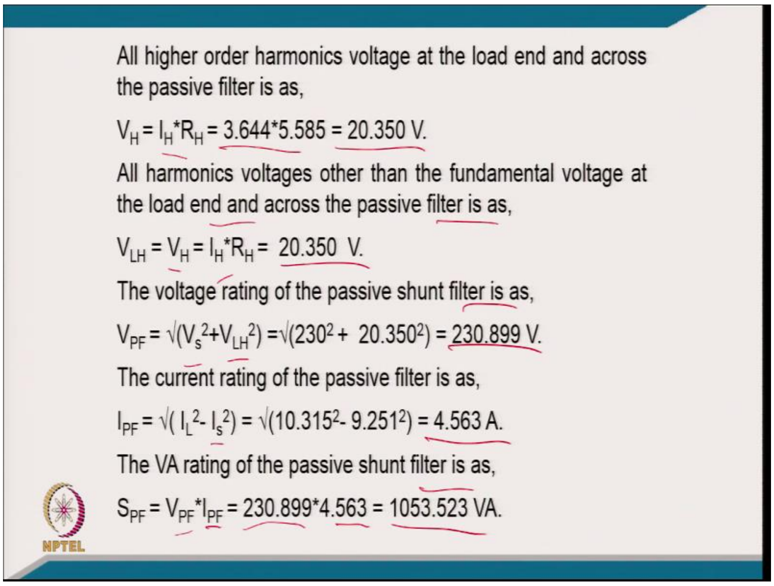

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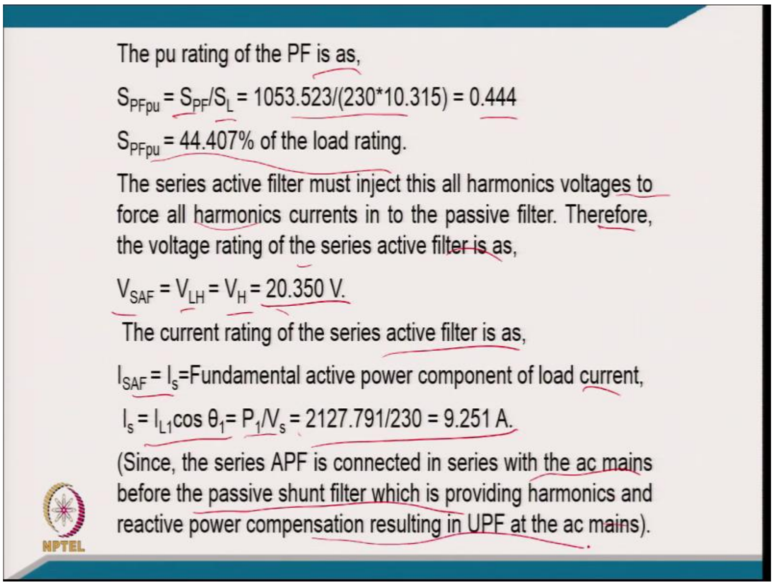

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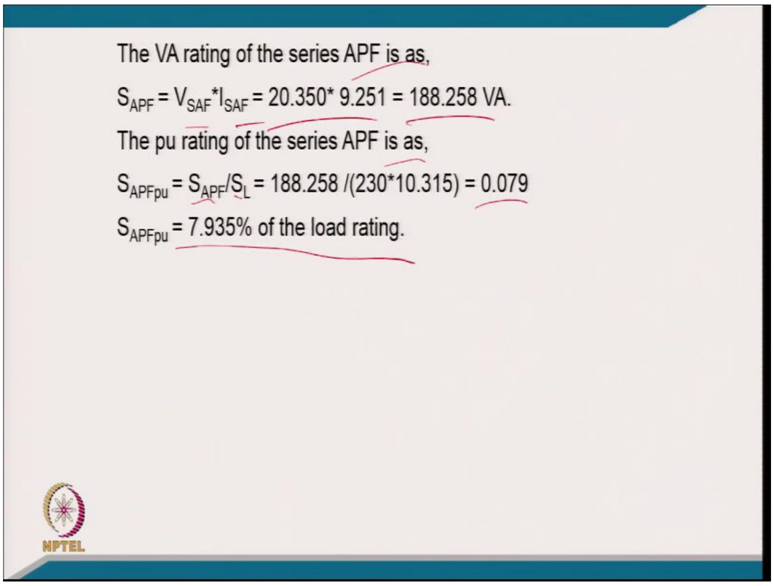

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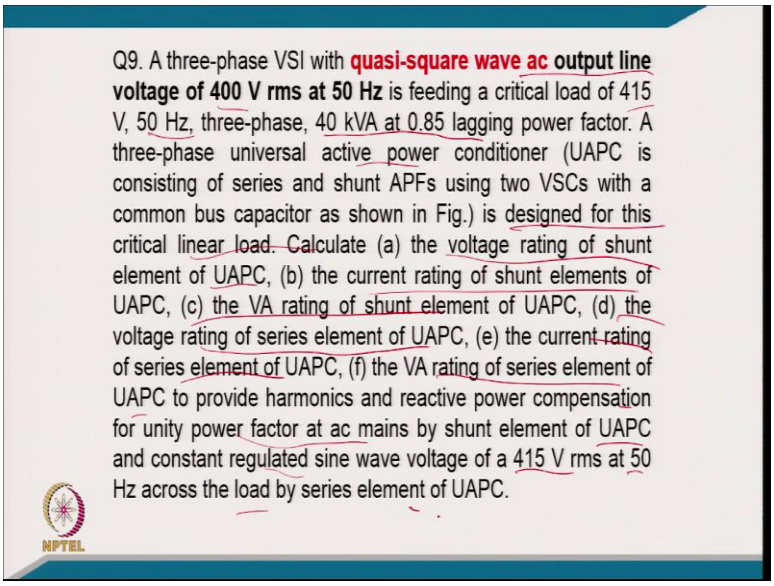

Coming to the 9th numerical problem, a three phase voltage source inverter with quasi square wave ac output line voltage of 400 volt rms at 50 hertz is feeding a critical load of 415 volt 50 hertz three phase 40 k VA 0.85 lagging power factor load. A three phase universal active power conditioner I mean is design for this critical non-linear load calculate the a voltage rating of the shunt element, current rating of shunt element, VA rating of shunt element and the voltage rating of series element, current rating of series element.

And the VA rating of series element of universal active power conditioner to provide harmonics and reactive power compensation for unity power factor at ac main by shunt element of the universal active power conditioner. And constant regulated sine wave voltage of 415-volt rms at 50 hertz across the load by series element of universal active power conditioner.

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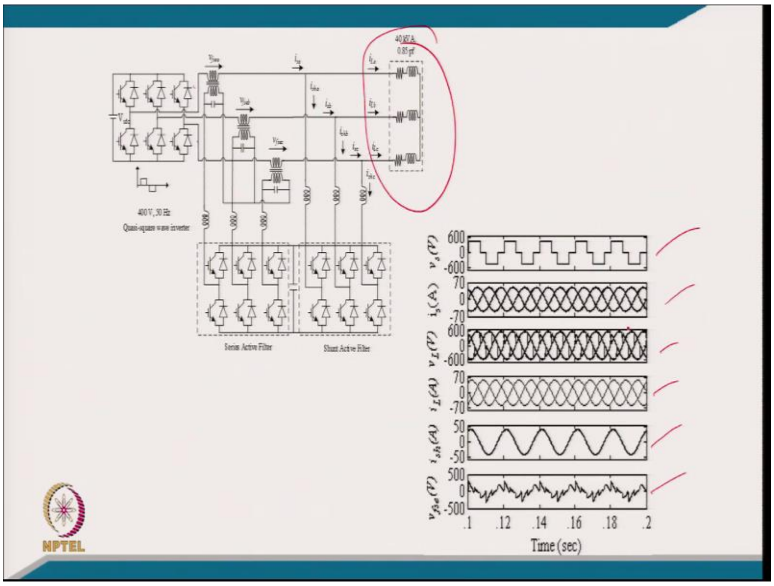

The explanation of the numerical problem is described in the screenshots herein.

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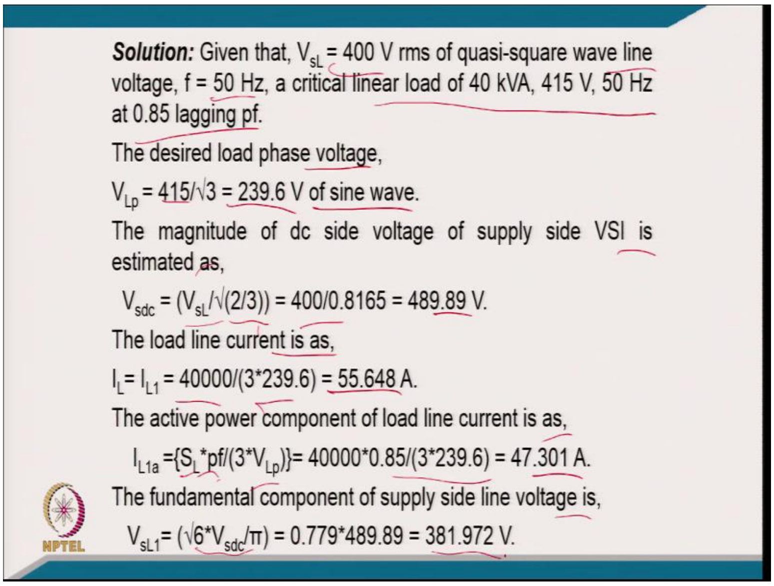

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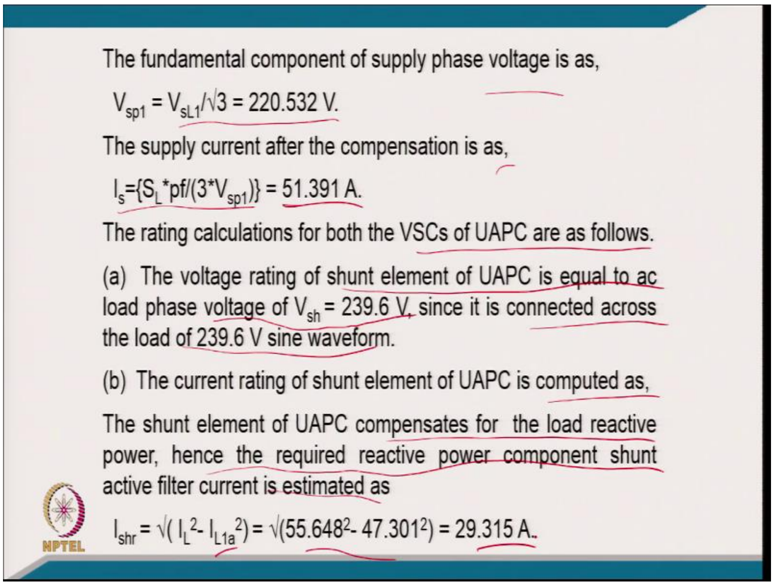

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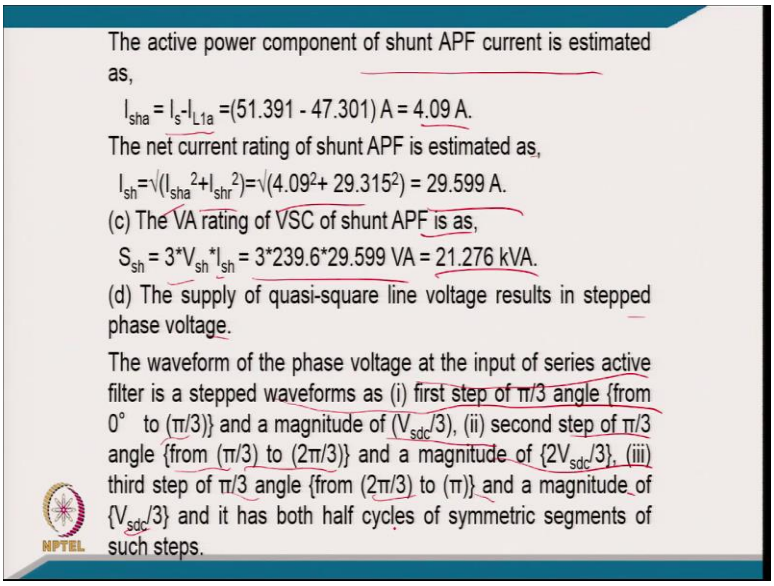

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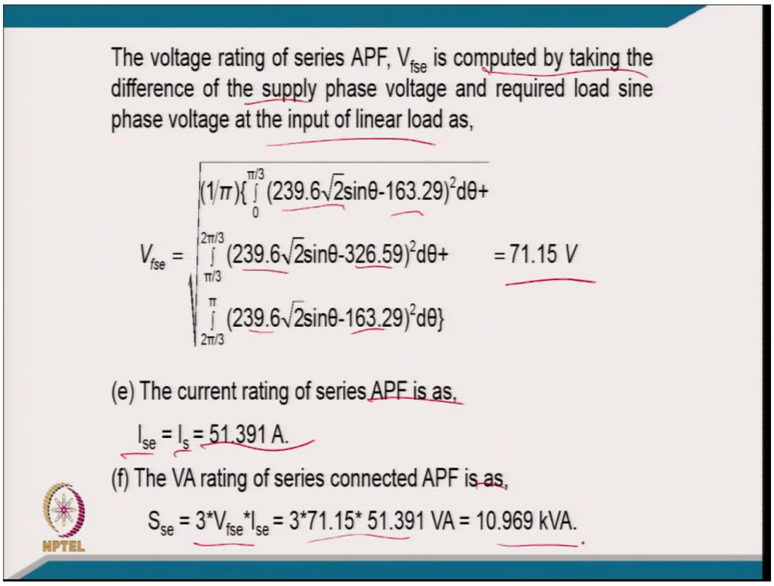

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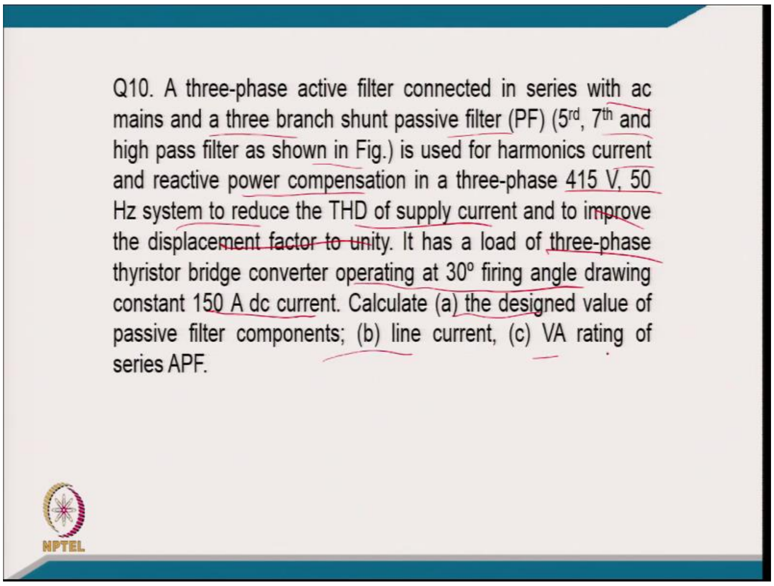

Coming to the 10th problem, a three phase active power filter connected in series with the ac mains and three phase and 3 branch passive shunt passive filter tune for 5th 7th and high pass is use for harmonics current and reactive power compensation in three phase 415 volt 50 hertz system to reduce the THD of supply current and to improve the displacement factory unity. It has a load of three phase thyristor bridge converter operating a 30-degree angle drawing a constant current of 150 ampere dc current, calculate the a desired value of passive filter element b line current c VA rating of series active filter.

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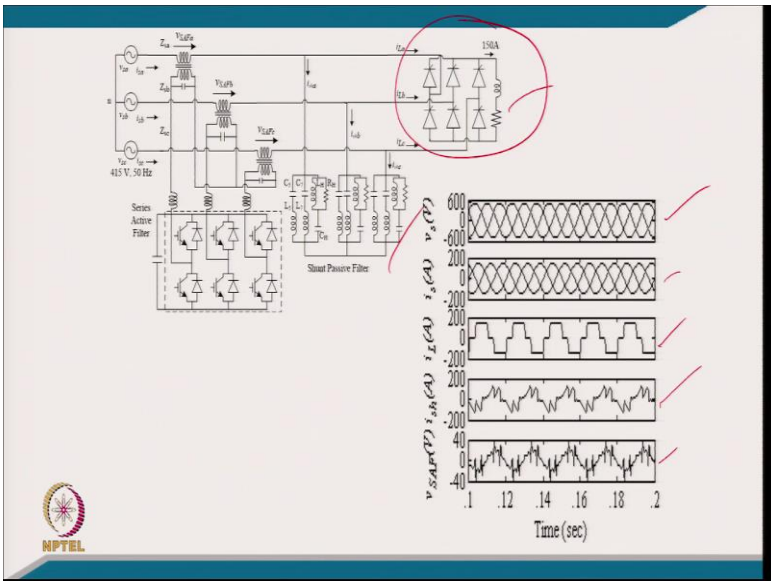

The explanation of the numerical problem is described in the screenshots herein.

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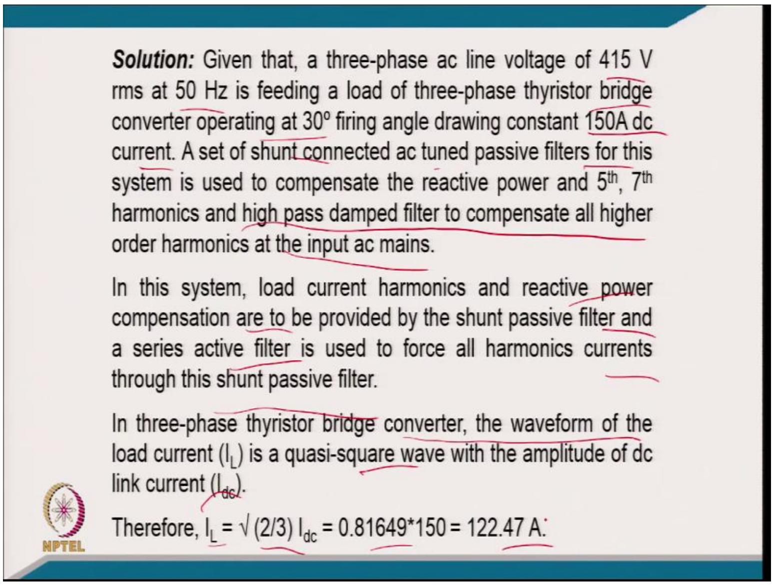

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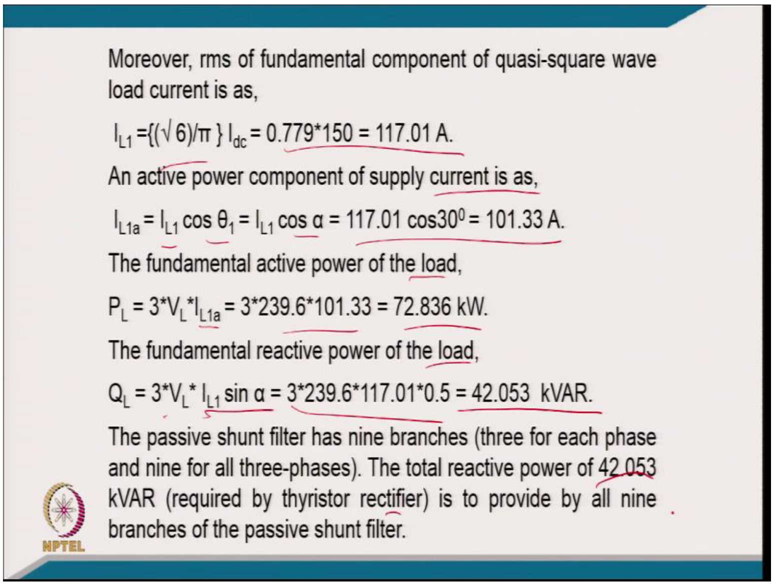

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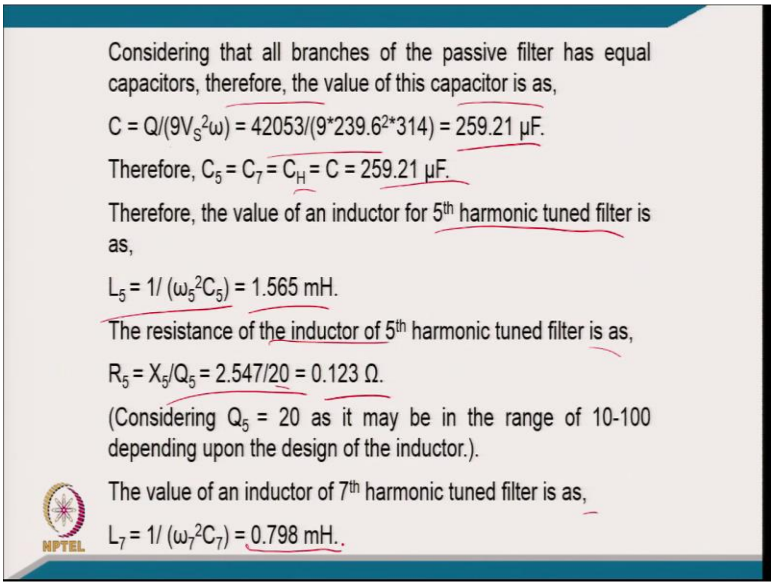

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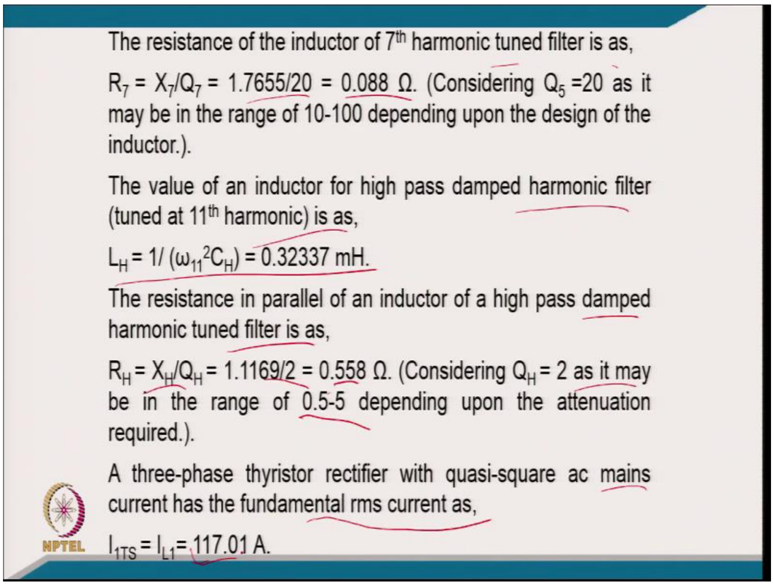

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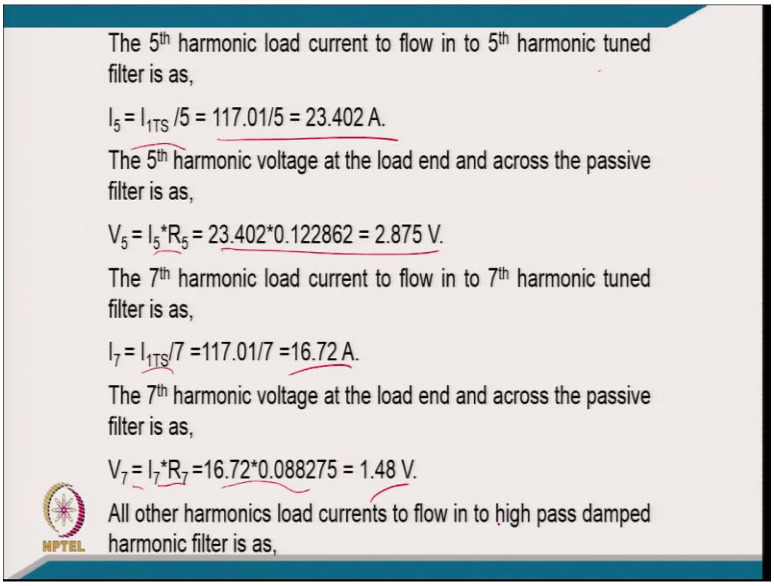

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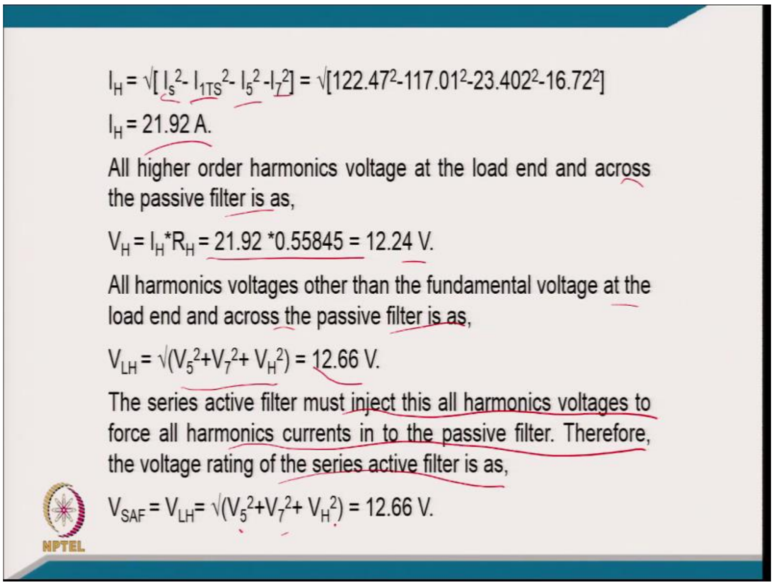

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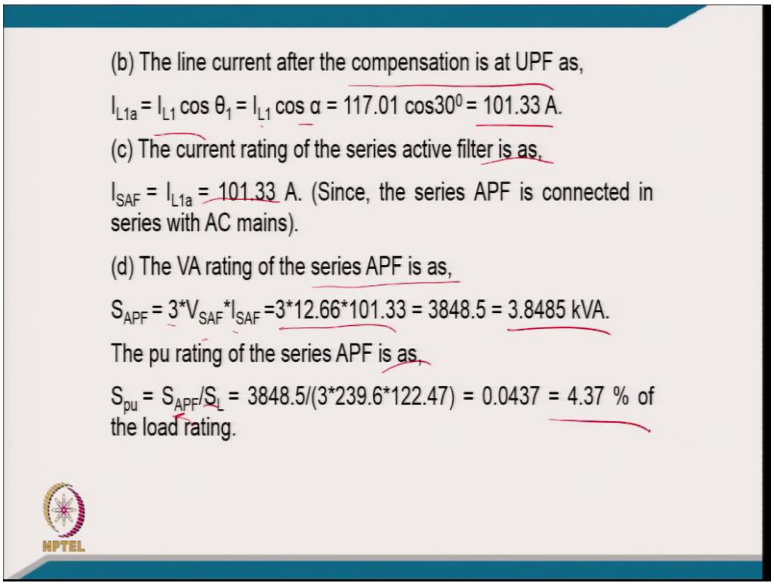

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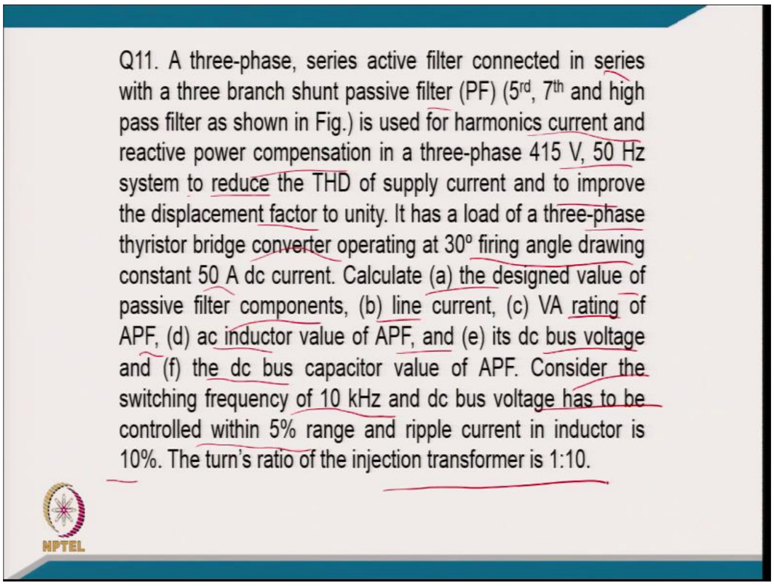

Coming to the problem number 11. A three phase series active power filter connected in series with a three branch shunt passive filter 5th 7th and high pass filter is used for harmonic current and reactive power compensation in three phase 415 volt 50 hertz system to reduce the THD of supply current and to improve the displacement factor to unity it has a load of the three phase thyristor bridge converter operating at fire 30 degree fire angle drawing a current of constant current of 50 ampere.

Calculate a, the design value of the passive shunt filter component, b line current, c VA rating of series active filter, d ac inductor value of active power filter and e the dc link voltage of series active filter and the f the dc bus capacitor value of APF consider the switching frequency of 10 kilo hertz and dc link voltage have to be controlled within 5 percent of the range and ripple current of in the inductor 10 percent and turns ratio of injection transformer is 1 to 10.

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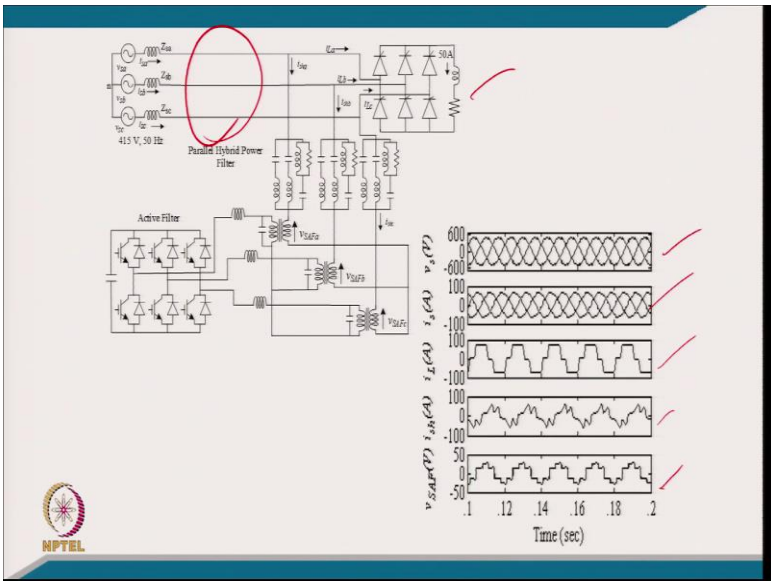

The explanation of the numerical problem is described in the screenshots herein.

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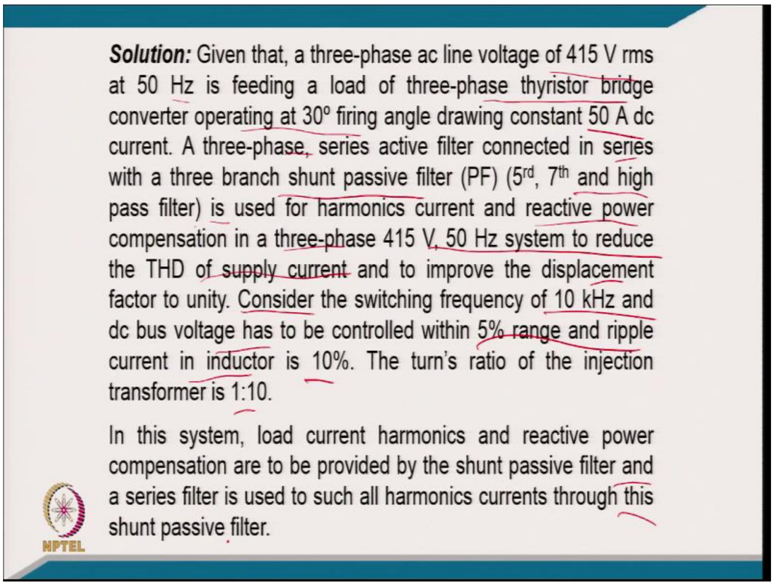

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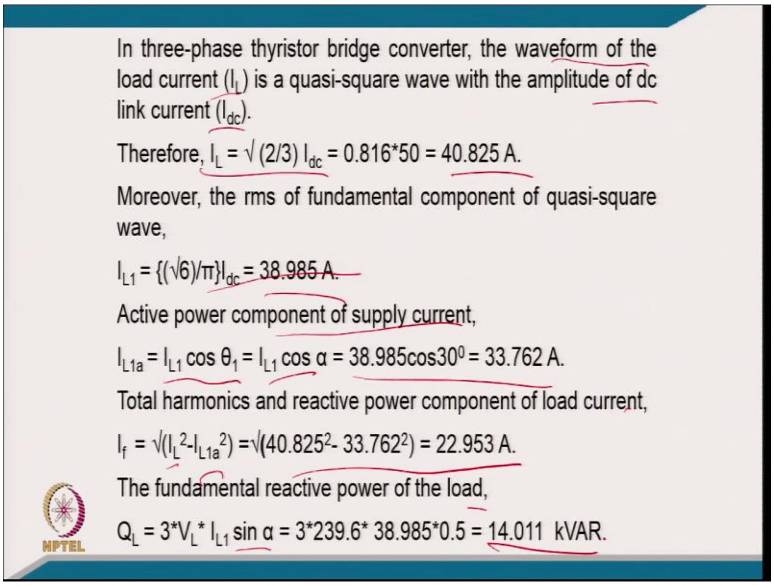

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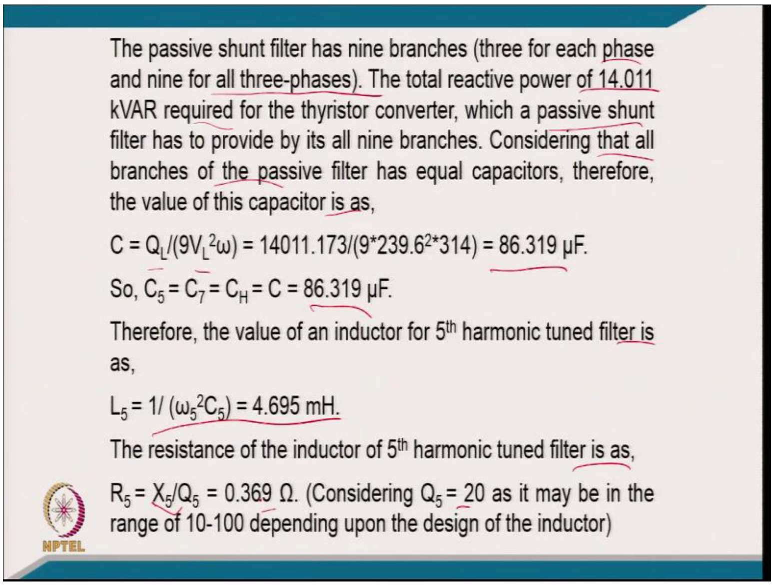

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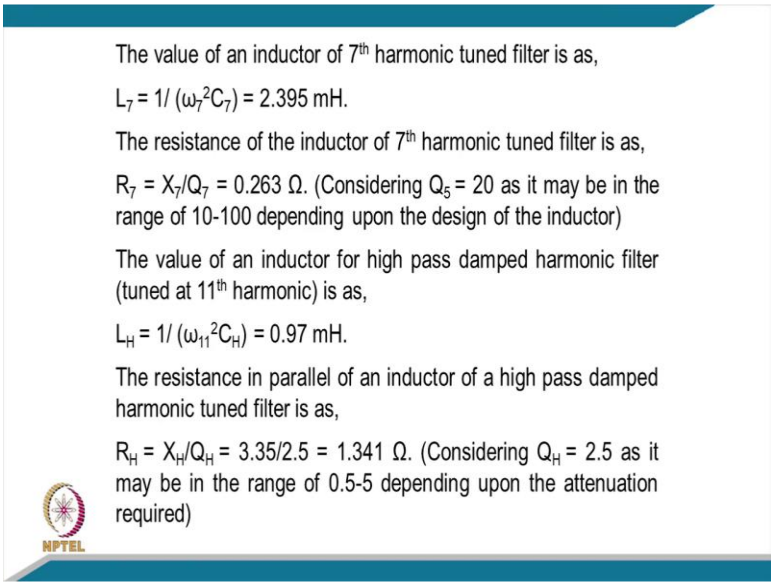

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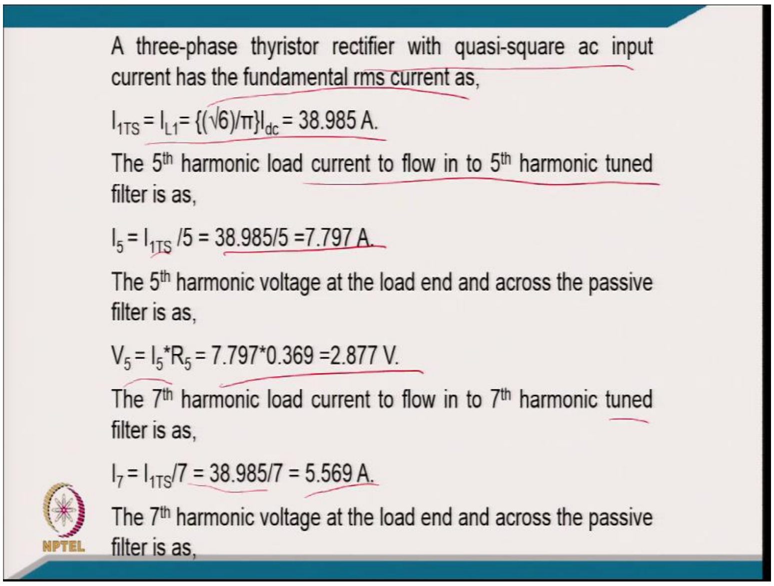

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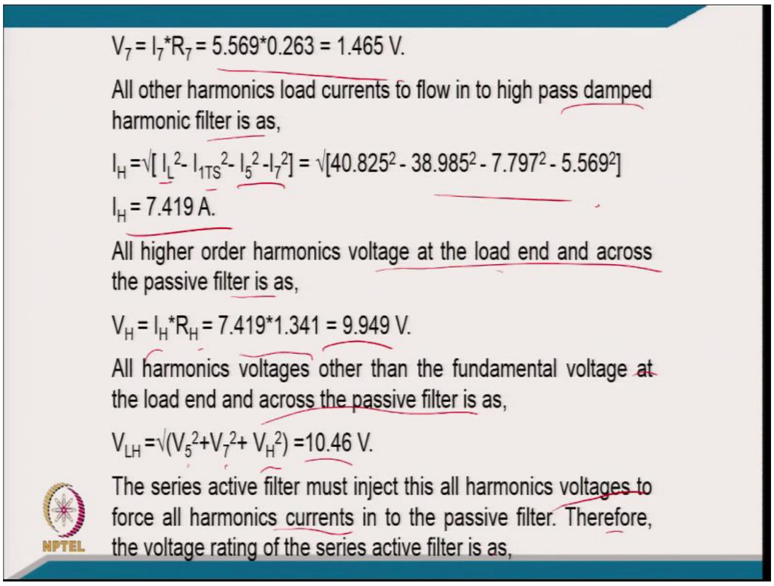

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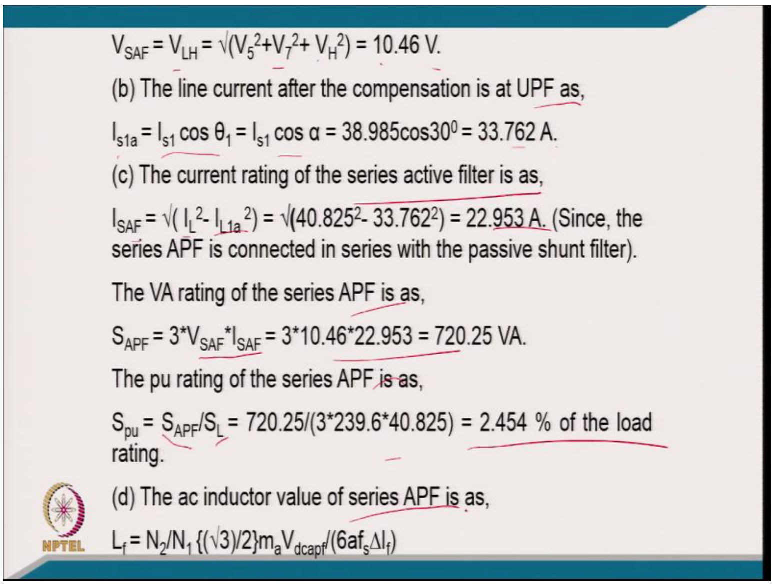

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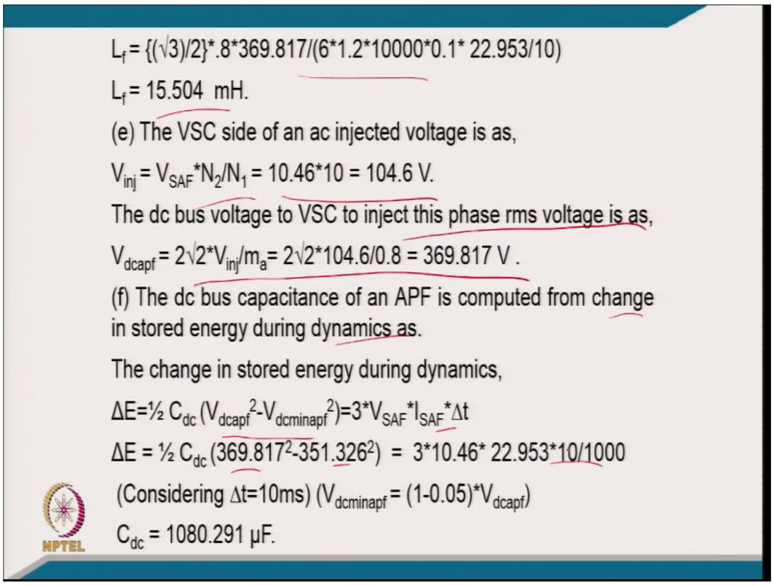

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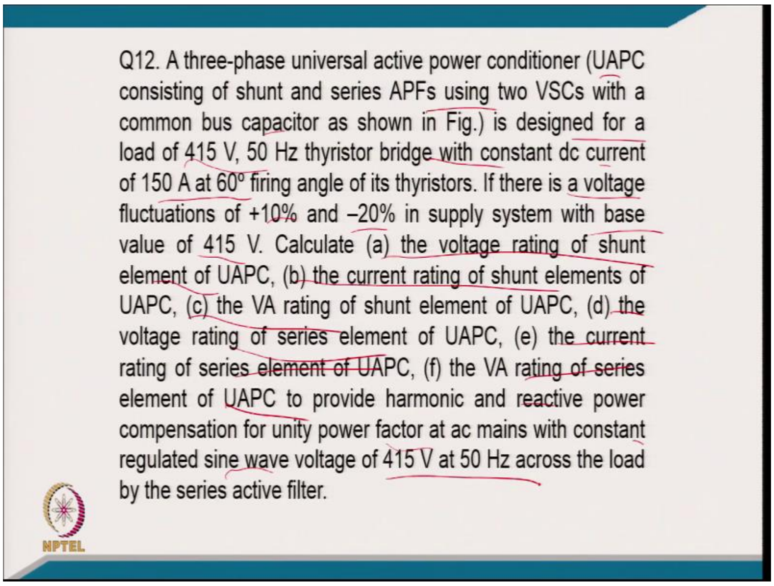

Coming to the 12th numerical problem a three phase universal active power conditioner consisting of shunt and series active filter using two voltage source converter with common dc bus capacitor is design for a load of 415 volt 50 hertz thyristor converter. Thyristor bridge with a constant dc current of 150 ampere, 60 degree fire angle of the thyristor. If there is any voltage fluctuation of 10 percent minus 20 percent in the supply system with the base value of 415 volt.

Calculate a the voltage rating of the shunt value shunt filter, current rating of shunt filter, VA rating of shunt filter, then the voltage rating of series filter current rating of series filter and the VA rating of series filter to provide the harmonics and reactive power compensation for unity power factor at ac mains with the constant regulator sine wave voltage of 415 volt 50 hertz across the load by the series active filter.

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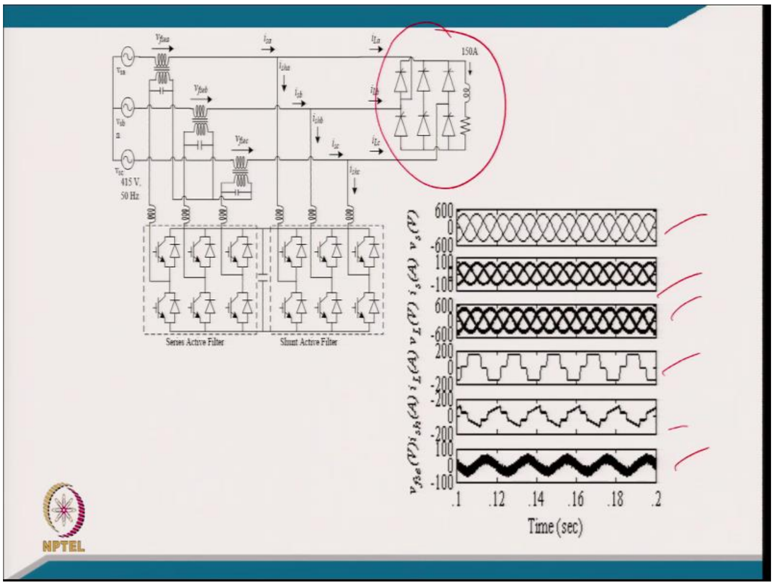

The explanation of the numerical problem is described in the screenshots herein.

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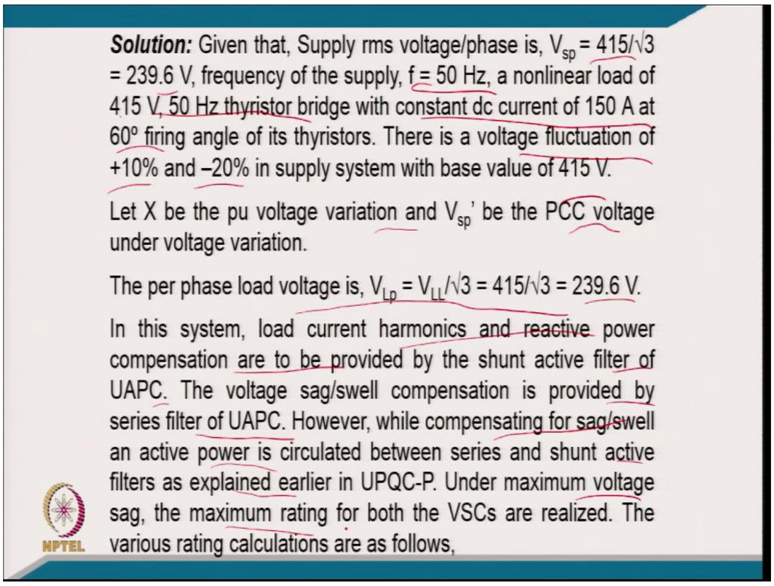

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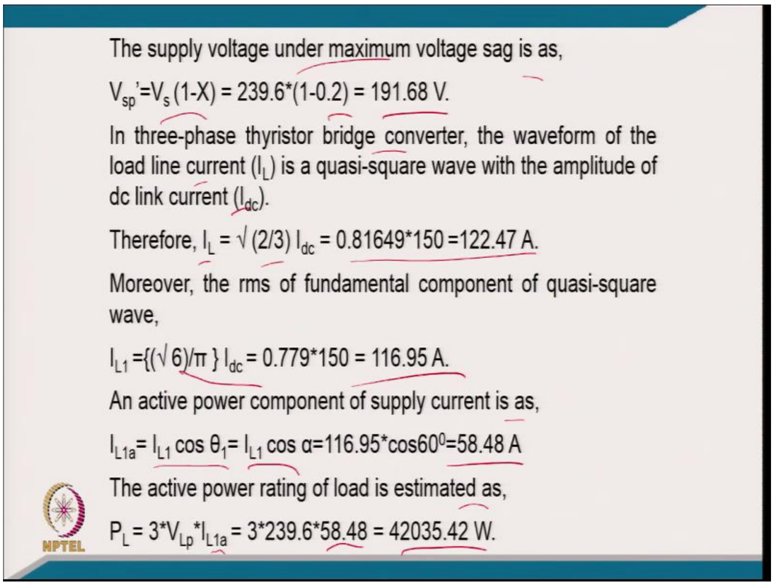

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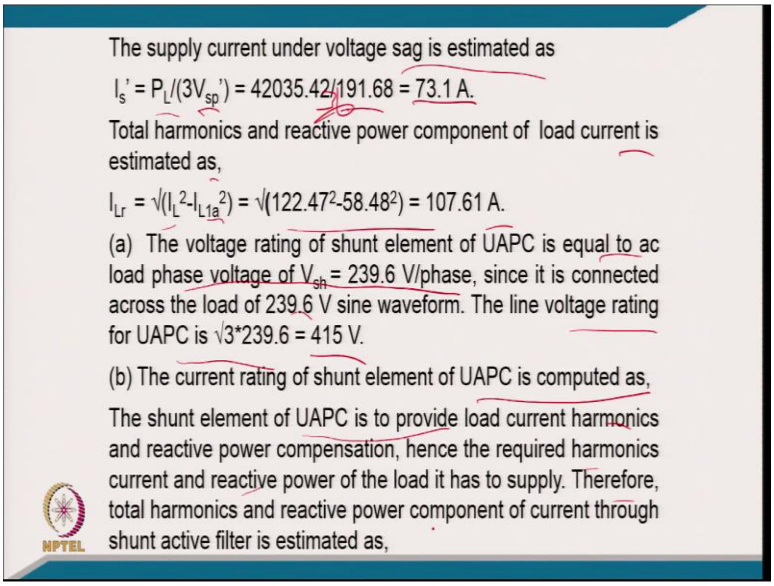

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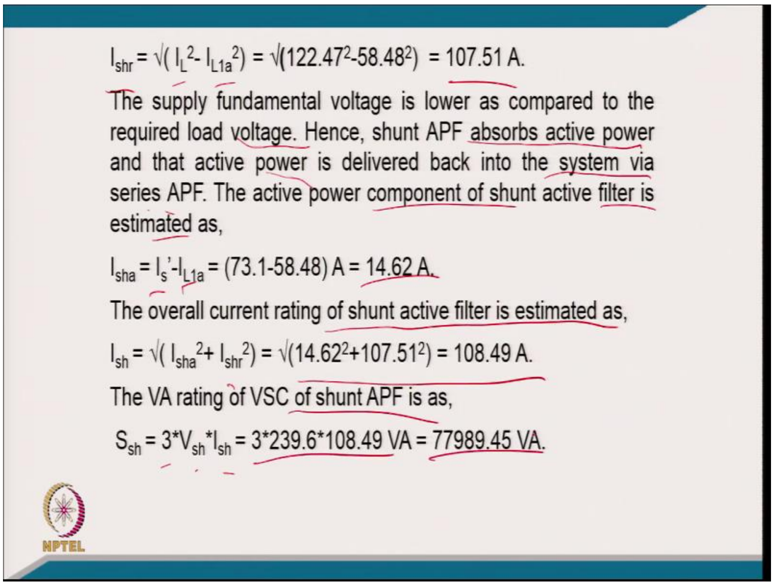

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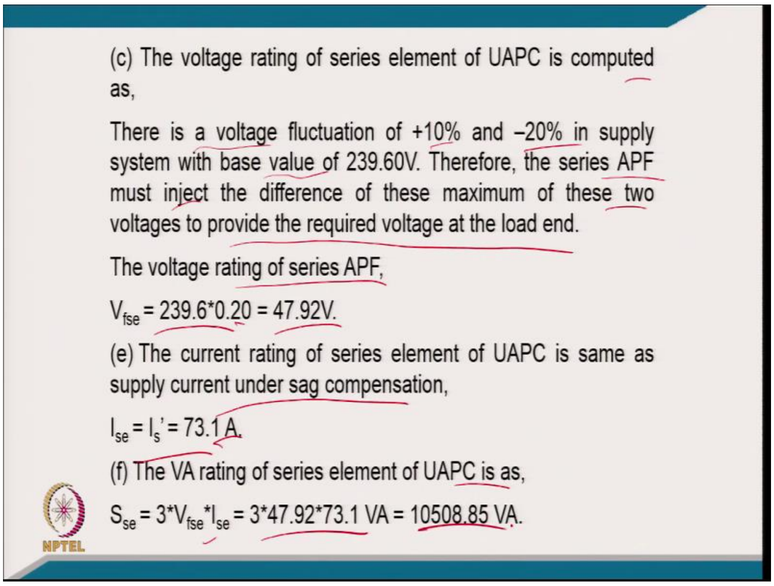

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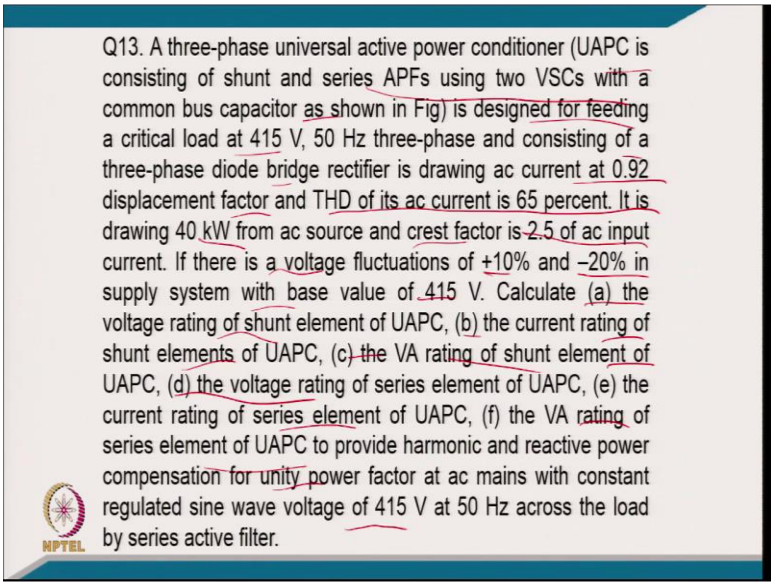

Coming to 13th problem, a three phase universal active power conditioner consisting of shunt and series active filter using two voltage source converter, the common dc bus capacitor is design for feeding the critical load of 415 volt 50 hertz. Three phase and consisting of three phase diode rectifier is drawing ac current at 0.9 to displacement factor and THD of its current is 65 percent, it is drawing 40 kilowatt from the ac source and crest factor is 2.5 of ac mains current. If there is a voltage fluctuations of plus 10 percent and minus 20 percent in the supply system with base value of 415 volt.

Calculate a voltage rating of shunt element of universal active power filter b, current rating of the shunt element of universal active power filter c, the VA rating of shunt active filter and voltage rating of series active filter current rating of series active filter VA rating of series active filter to provide harmonics and reactive power compensation for unity power factor at ac main and constant regulated sine wave 415 voltage 50 hertz across the load by the series active filter.

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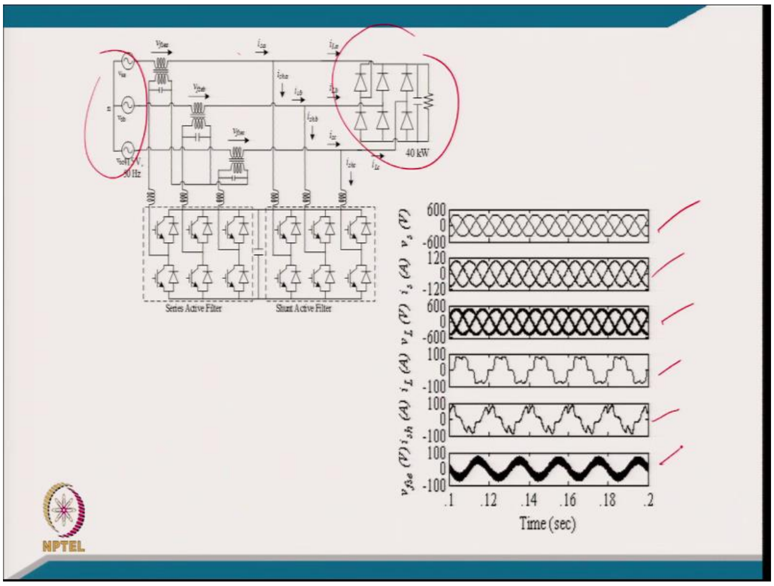

The explanation of the numerical problem is described in the screenshots herein.

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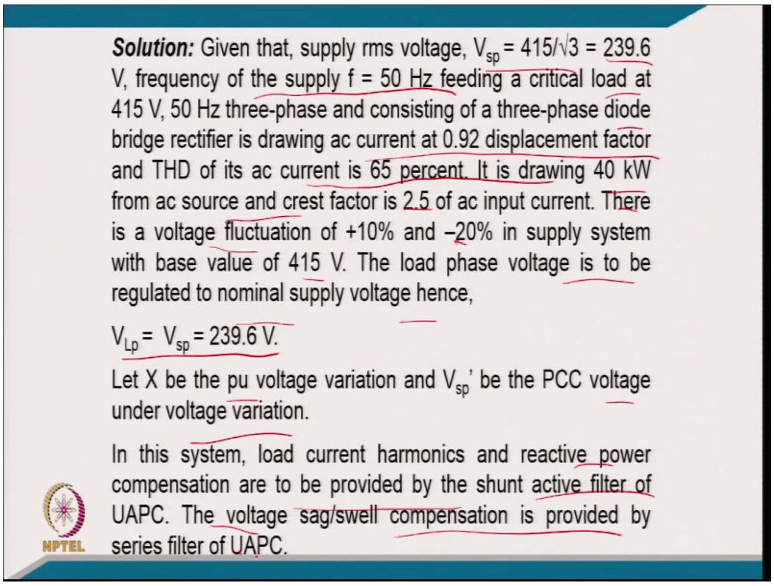

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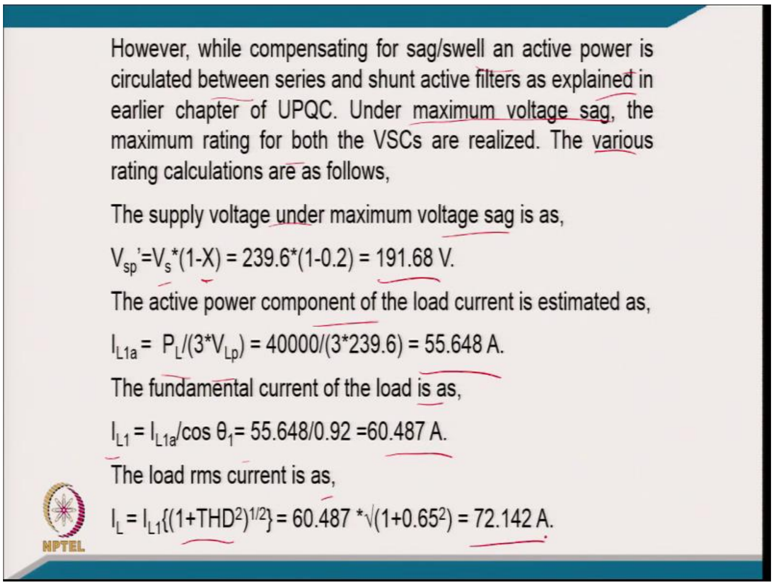

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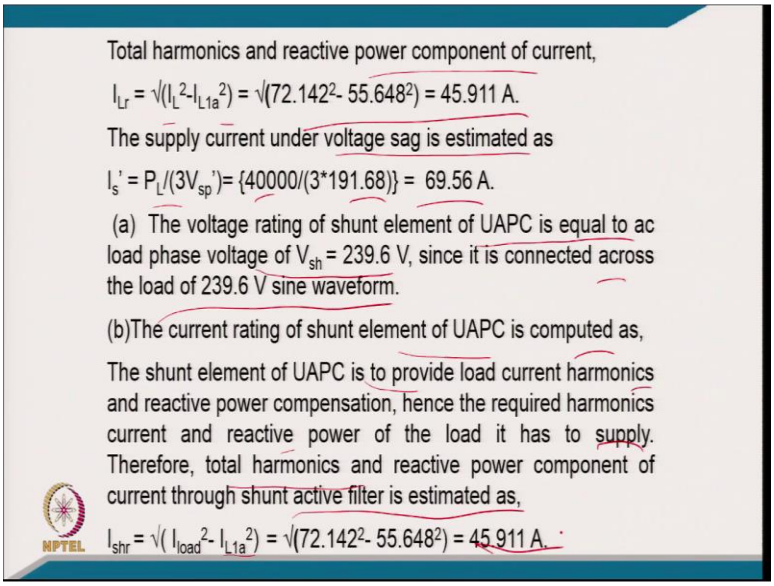

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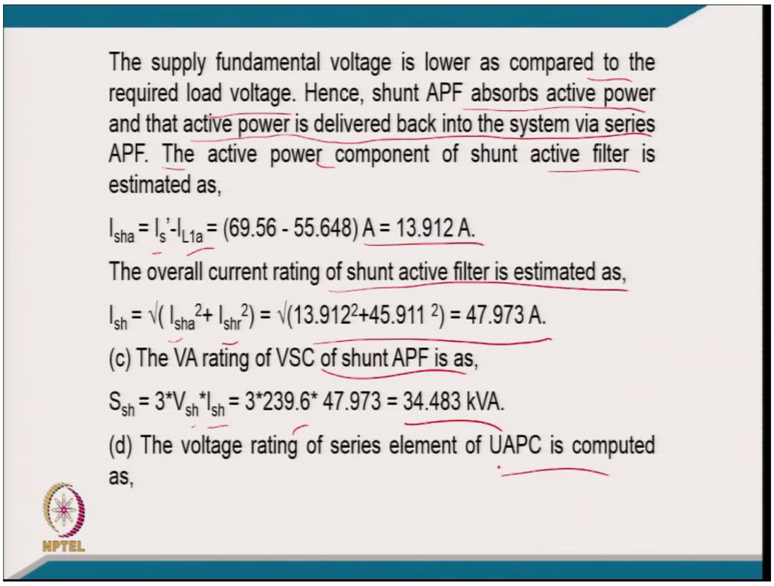

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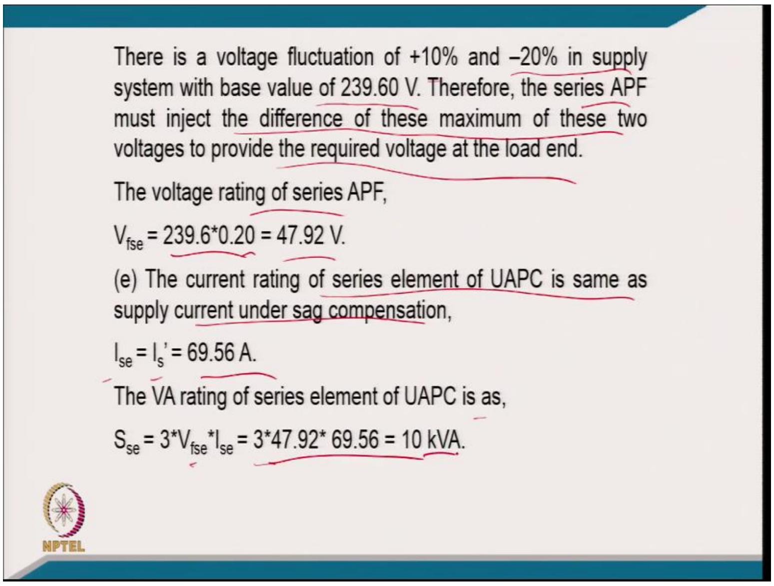

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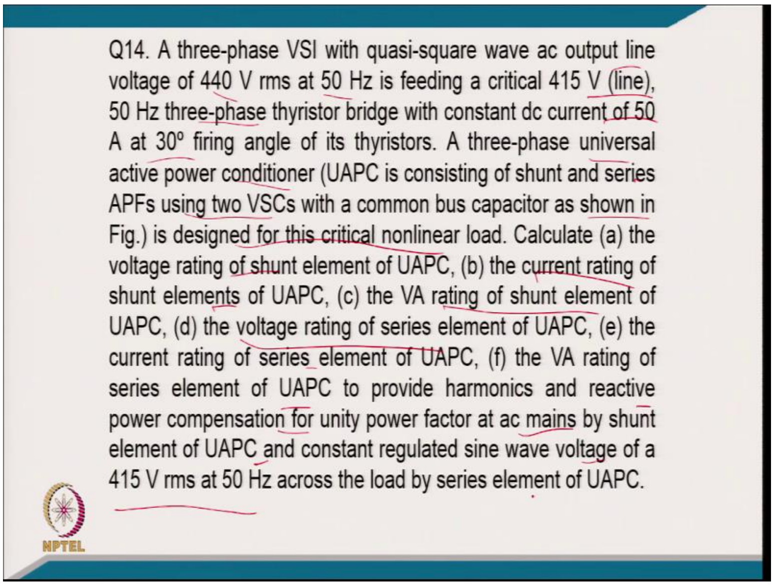

Well coming to the 14th numerical problem a three phase VSI with quasi square ac line voltage of 440-volt rms and 50 hertz is feeding 415-volt line 50 hertz three phase thyristor bridge with the constant dc current of 50 ampere at 30 degree fire angle of its thyristor a three phase universal active power conditioner consisting of series and shunt active filter the 2 VSC with the common dc bus capacitor is design for this critical load.

Calculate the voltage rating of shunt active filter the current rating of shunt active filter VA rating of shunt active filter voltage rating of series active filter and current rating of series element and VA rating of series active filter to provide the harmonics and reactive power compensation for unity power factor ac mains by shunt element and constant regulated sine wave voltage of 415 volt 50 hertz across the load by series element of UA.

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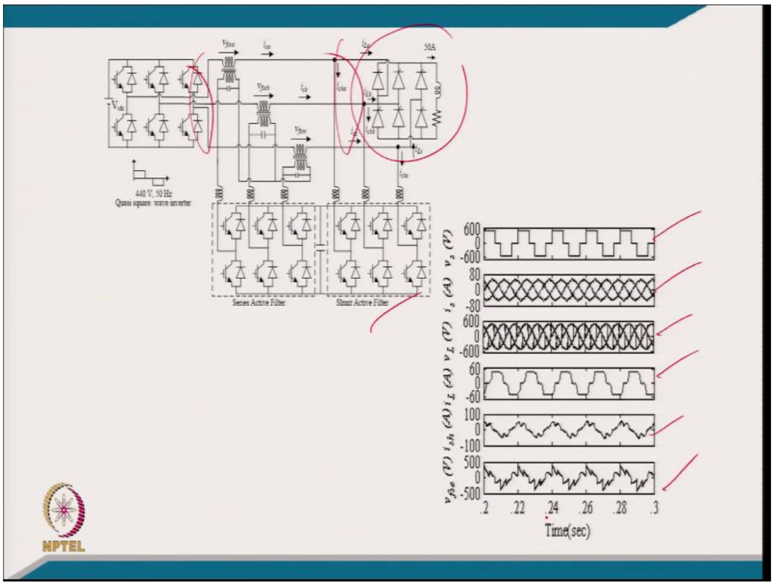

The explanation of the numerical problem is described in the screenshots herein.

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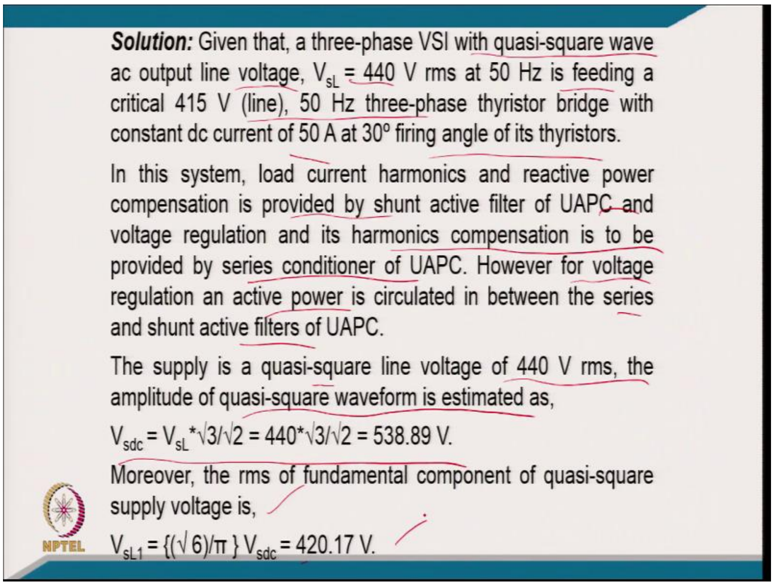

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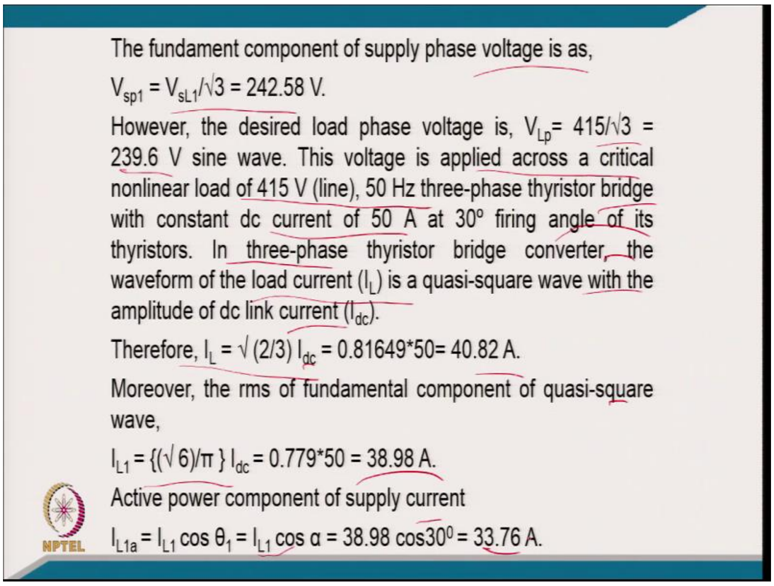

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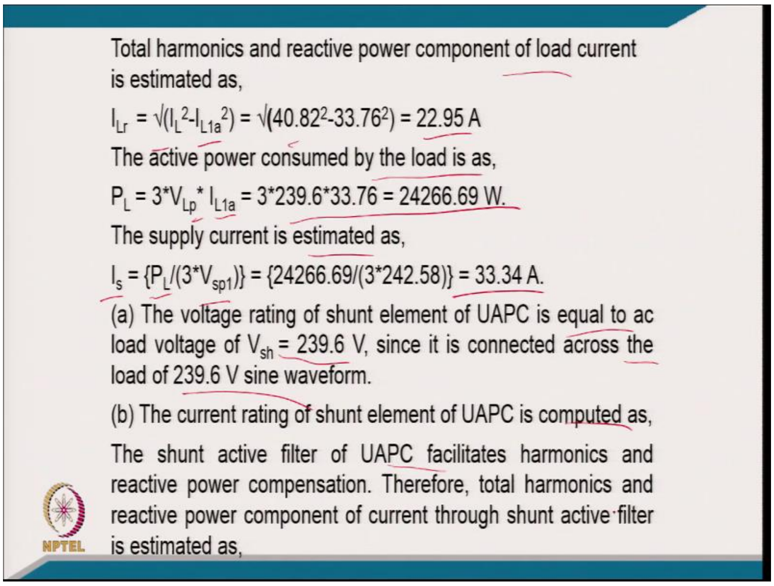

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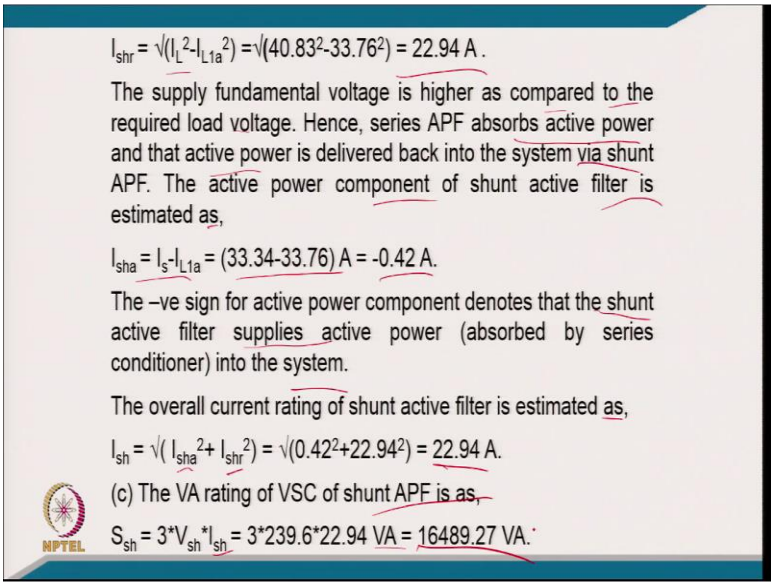

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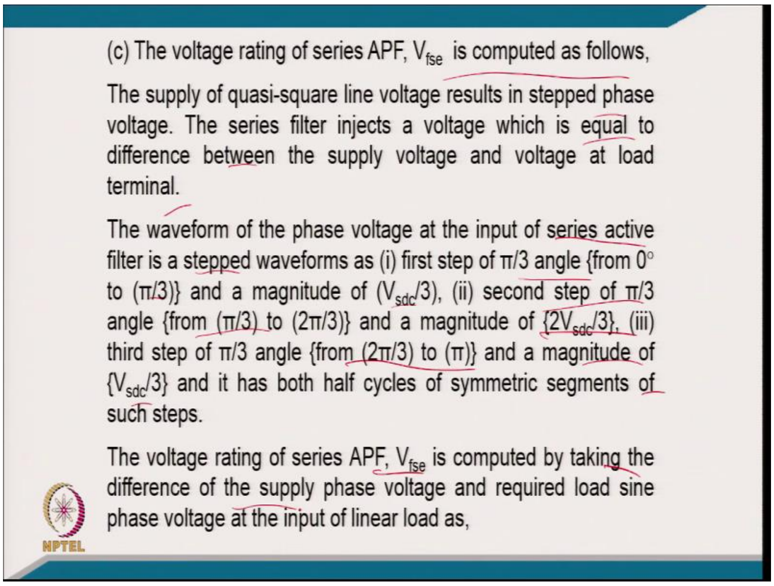

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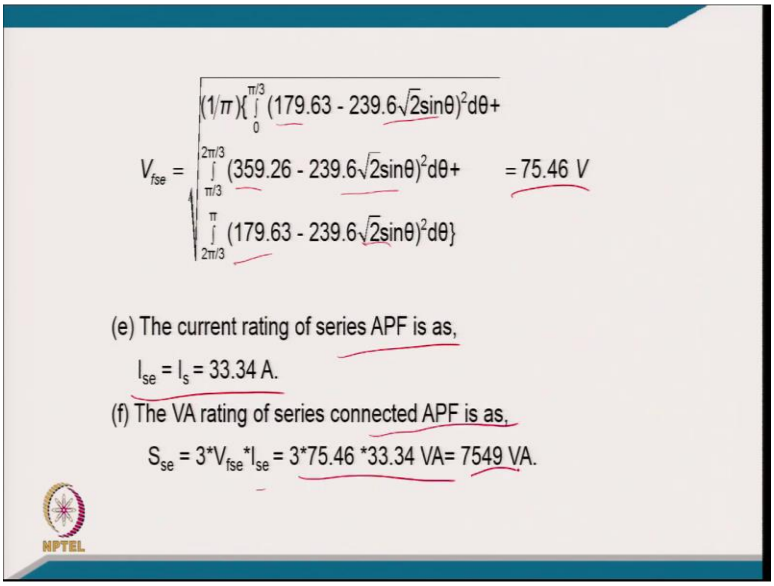

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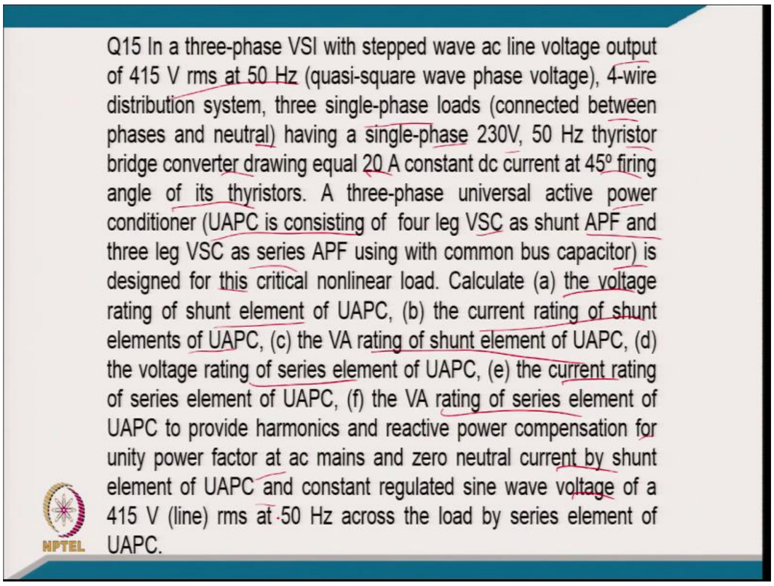

Coming to the 5th problem 15th problem in the three phase voltage source inverter with a stepped waveform of ac line voltage output of 415 volt 50 hertz quasi square wave. Four wire distribution system three single phase load connected between phase and neutral having a single phase 230 volt 50 hertz thyristor bridge converter drawing the 20 ampere, constant dc current at 45 degree fire angle of its thyristor.

A three phase universal active power conditioner consisting of 4 leg voltage source converter as a shunt active filter and 3 leg voltage source converter as series active filter using common dc bus capacitor is design for this critical non-linear load. Calculate a voltage rating of shunt active element current rating of shunt active filter, VA rating of shunt active filter.

The voltage rating of series active filter current rating of series active filter VA rating of series active filter to provide harmonics and reactive power compensation for the unity power factor at ac mains and zero neutral current by shunt element and constant regulated sine wave voltage of the 415 volt at 50 hertz across the load by series element.

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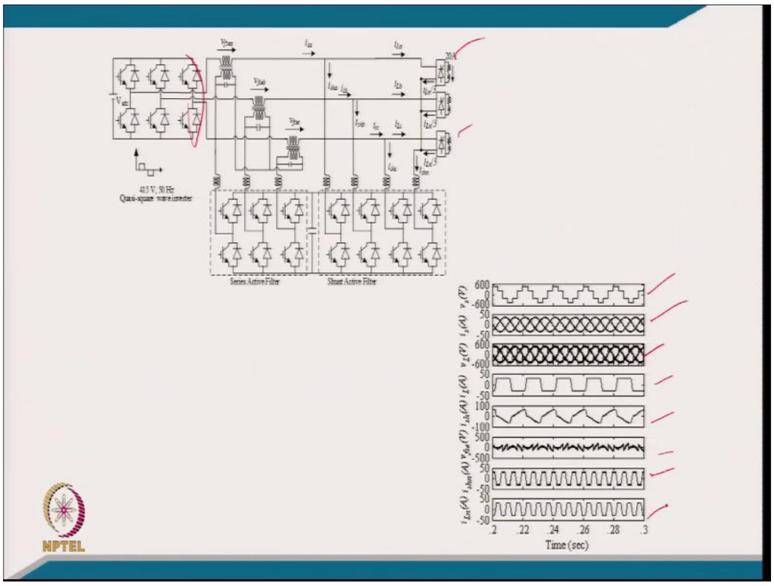

The explanation of the numerical problem is described in the screenshots herein.

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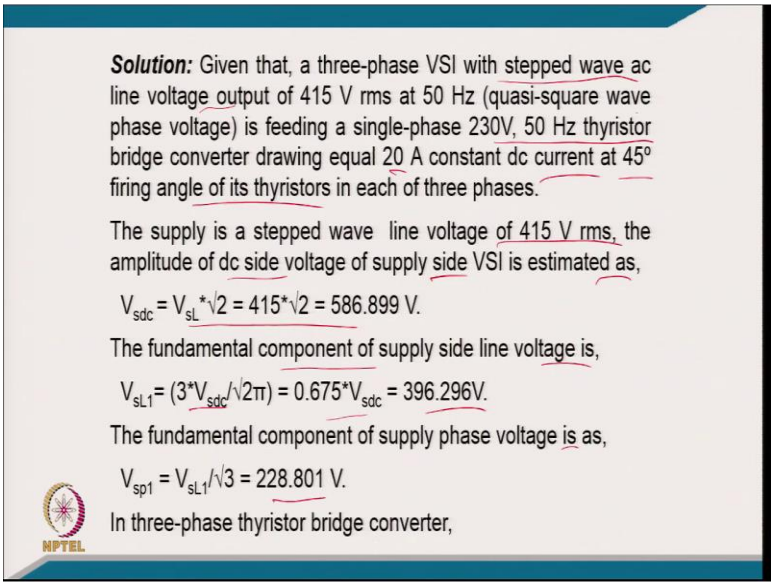

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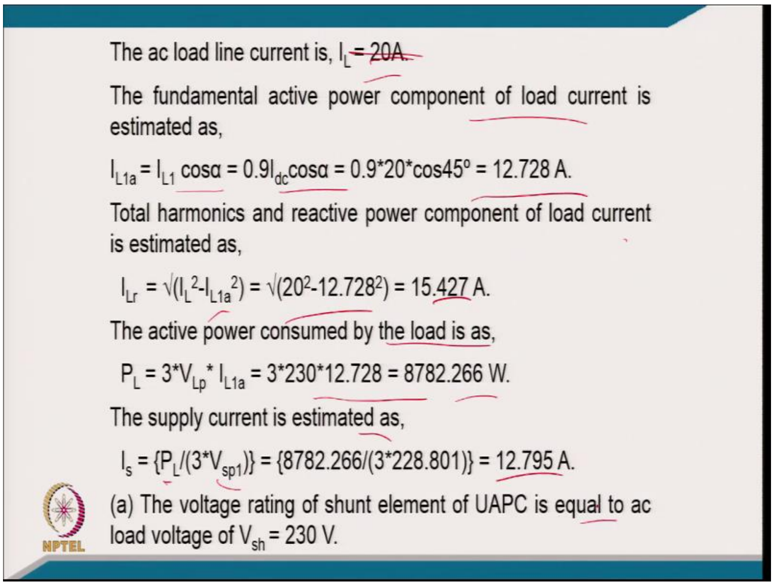

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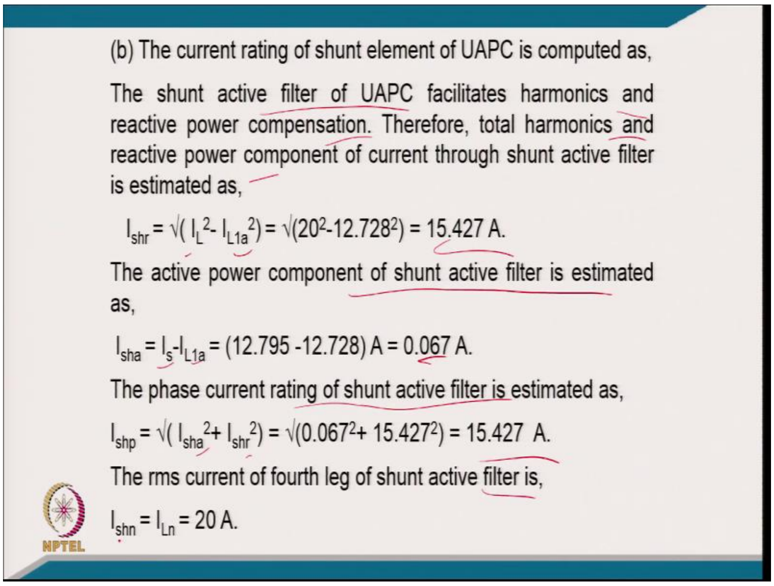

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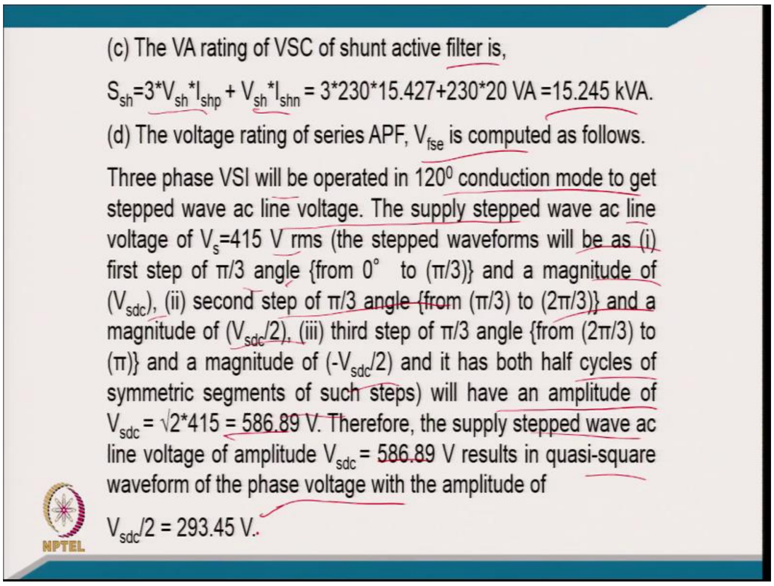

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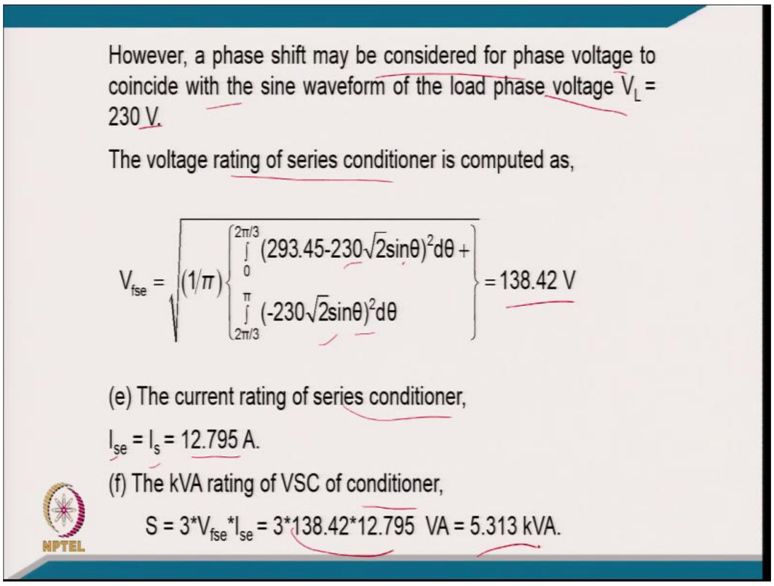

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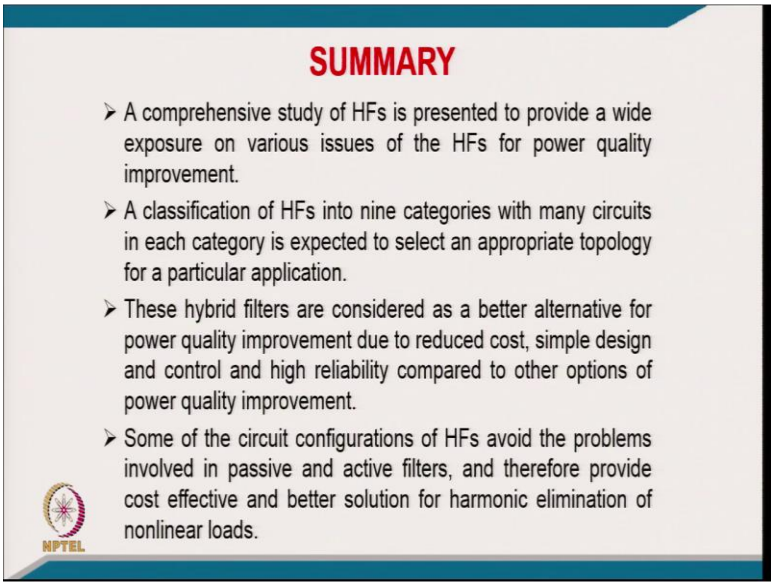

With this we conclude this hybrid filter, we will like to summarize here

A comprehensive study of hybrid filters is presented to provide the wide exposure on various issues of hybrid filter of for power quality improvement. A classification of hybrid filter into nine category with many circuits in each categories are expected to select an appropriate topology for the particular application.

These hybrid filter are considered as a better alternative for power quality improvement due to reduce cost simple design and control and high reliability compared to other option of power quality improvement. Since the circuit configuration of hybrid filter avoid the problem of involved in passive and active filter and therefore, provide cost effective and better solution for harmonic elimination of the non-linear load.

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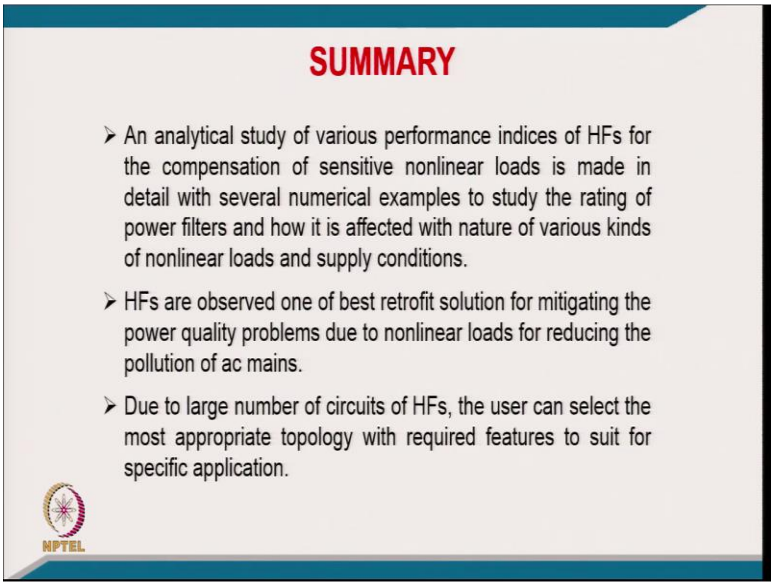

Any analytical study of various performance indices of hybrid filter for the compensation of sensitive non-linear load is made in the in detail with several numerical examples to study rating of power filters and how it is affected with the nature of various kind of non-linear load and supply condition.

Hybrid filter are observed one of the best retrofit solution for mitigating the power quality problem due to the non-linear load and for reducing the pollution in ac main. And due to large number of circuits of hybrid filter user can select most appropriate topology with required feature to suit specific application.

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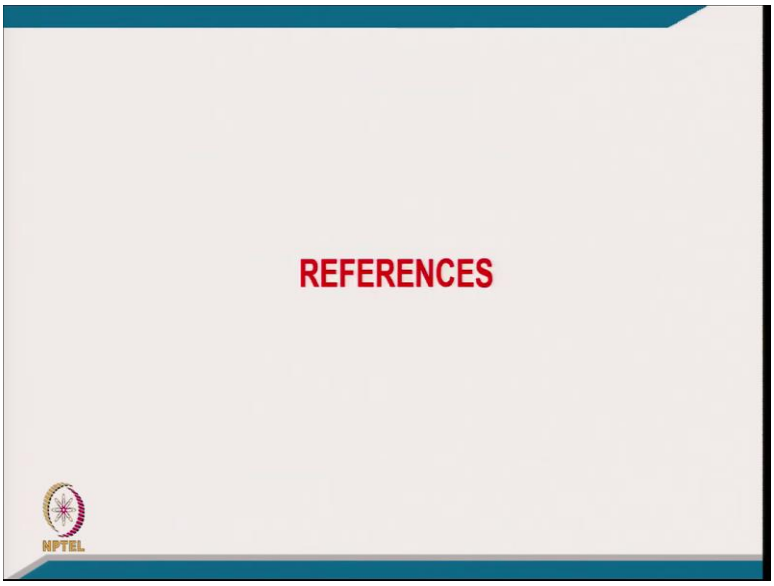

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And of course, these are the references which we have refered.

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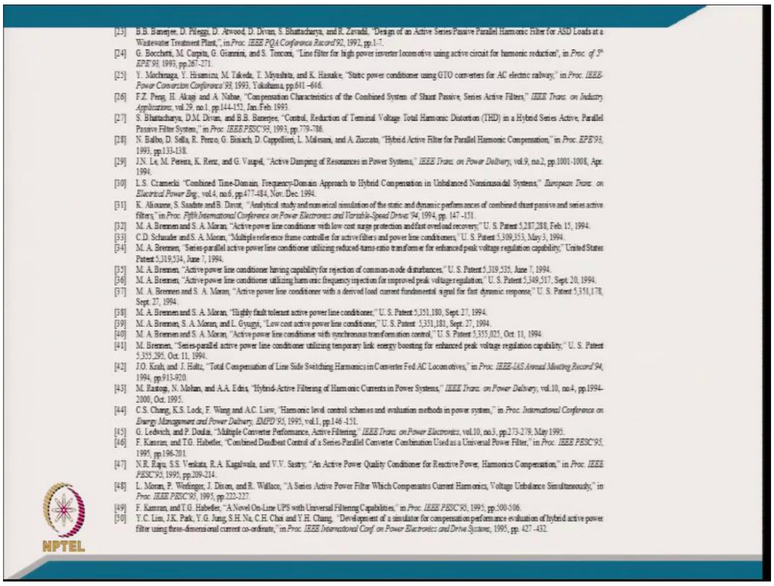

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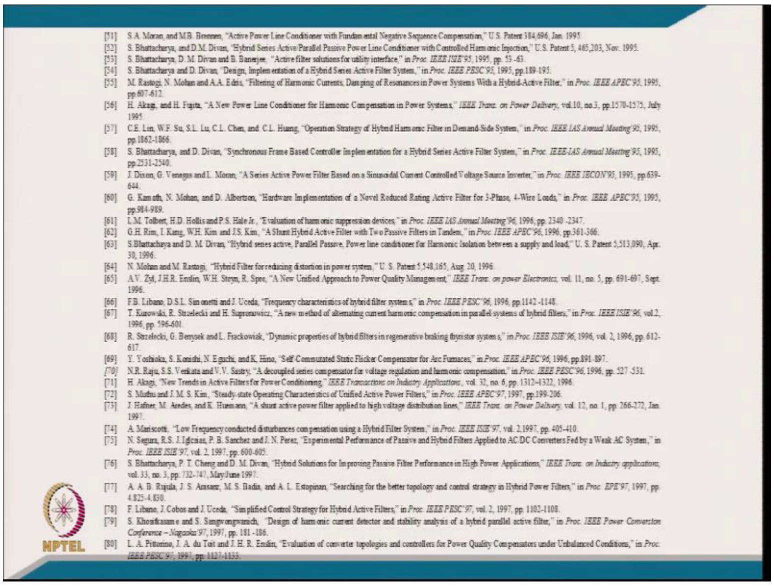

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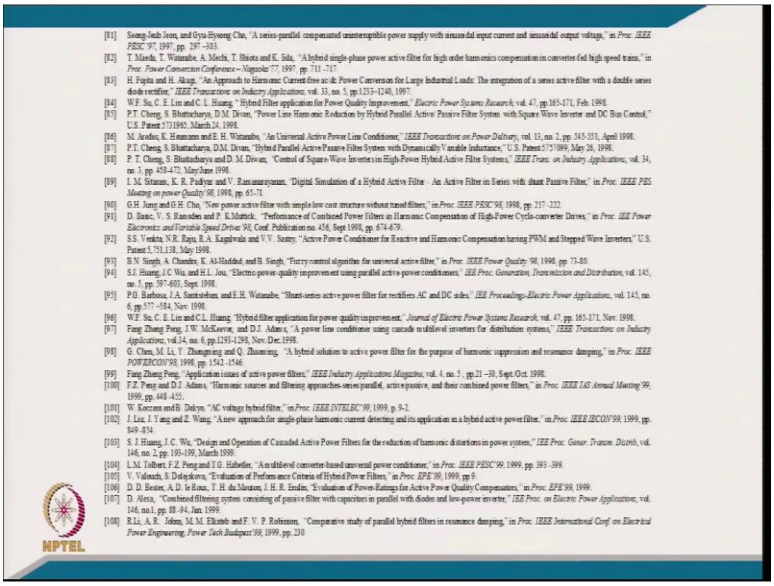

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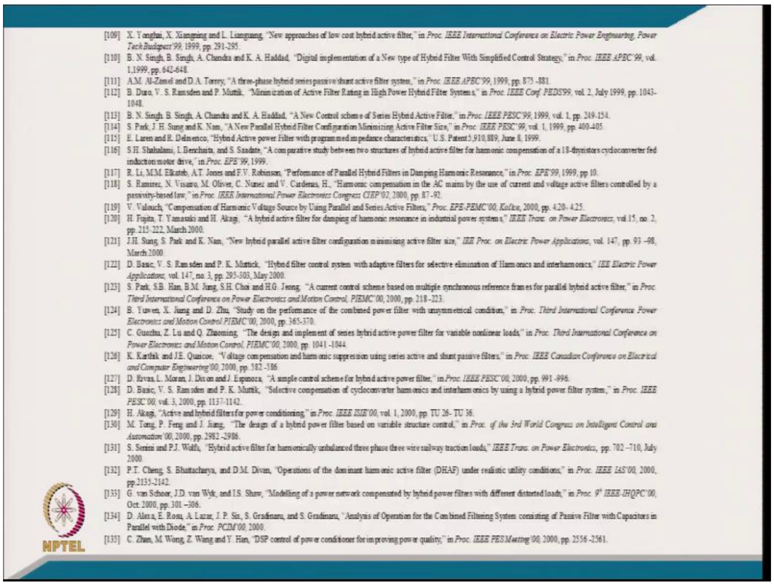

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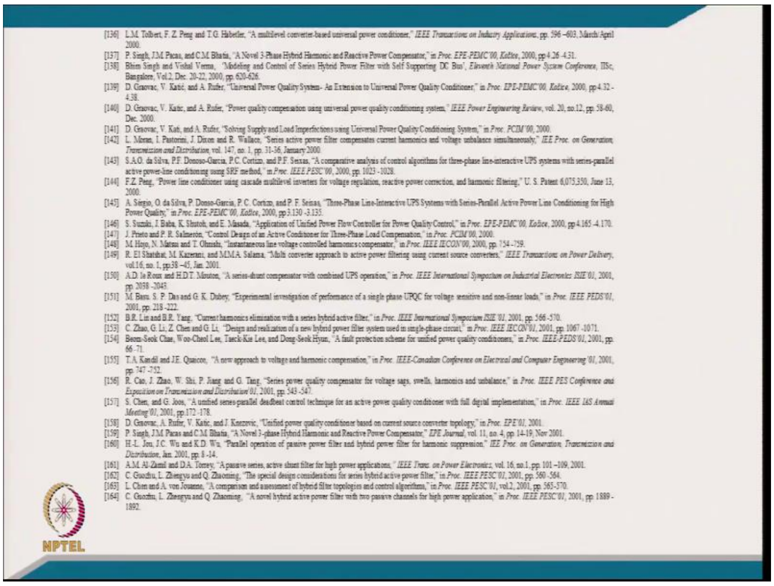

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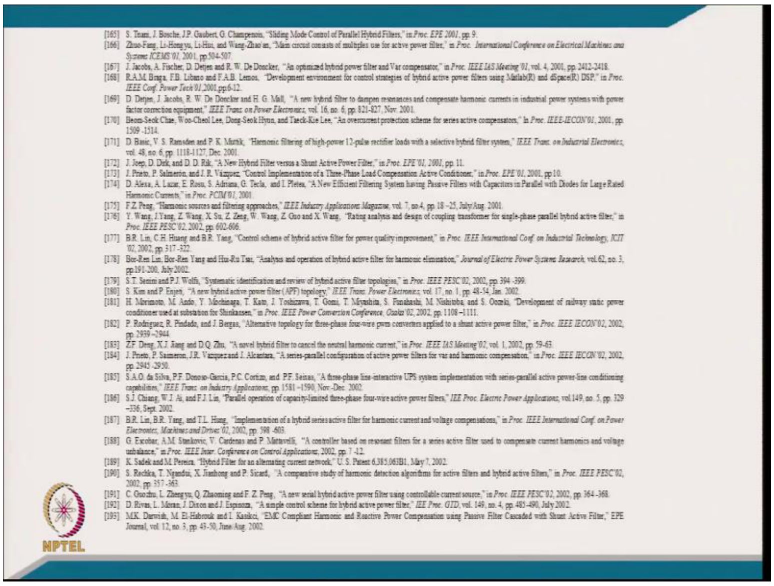

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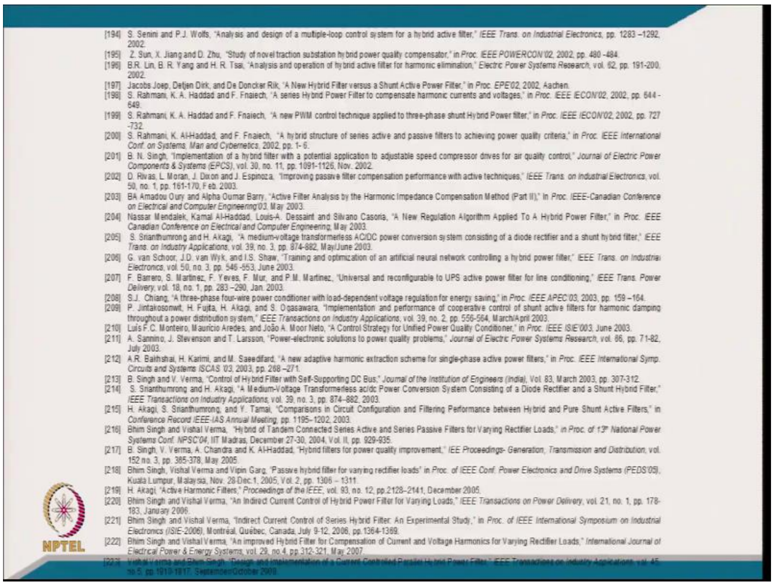

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