Power Quality
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Lecture - 20
Shunt Active Power Filters

Welcome to the course on Power Quality. Today we will discuss this topic of Shunt Active Power Filters.

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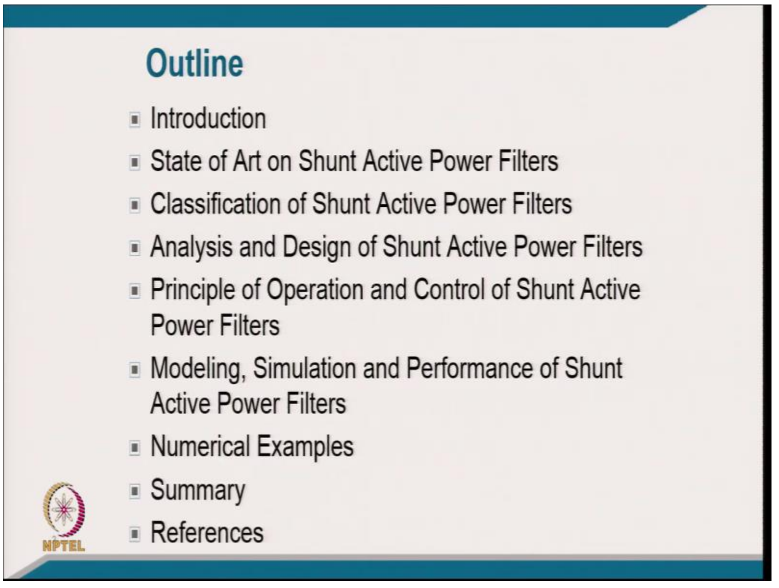

Coming to the outline of presentation, we would like to cover introduction, state of art on shunt active filter, classification of shunt active filter, analysis and design of shunt active filter, principle of operation and control of shunt active filter and modeling, simulation and performance of shunt active filter, then numerical examples, summary and references.

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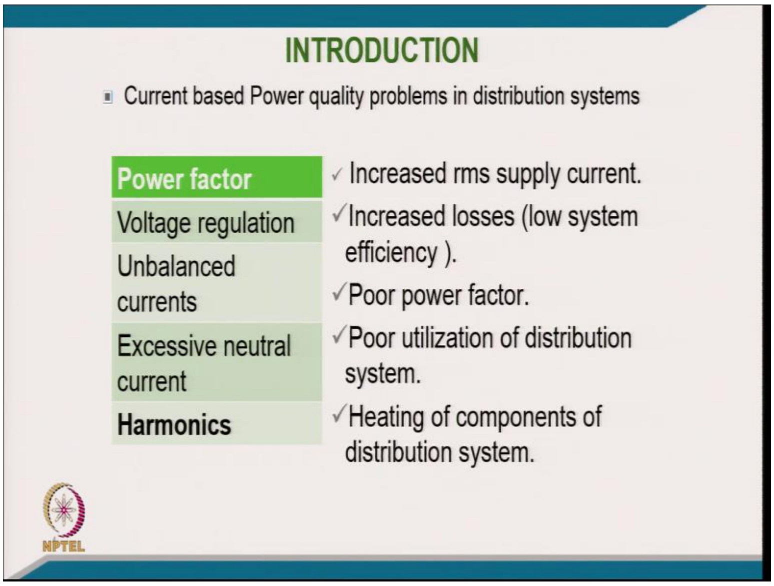

Current based power quality problems in distribution system are again highlighted here in this screenshot.

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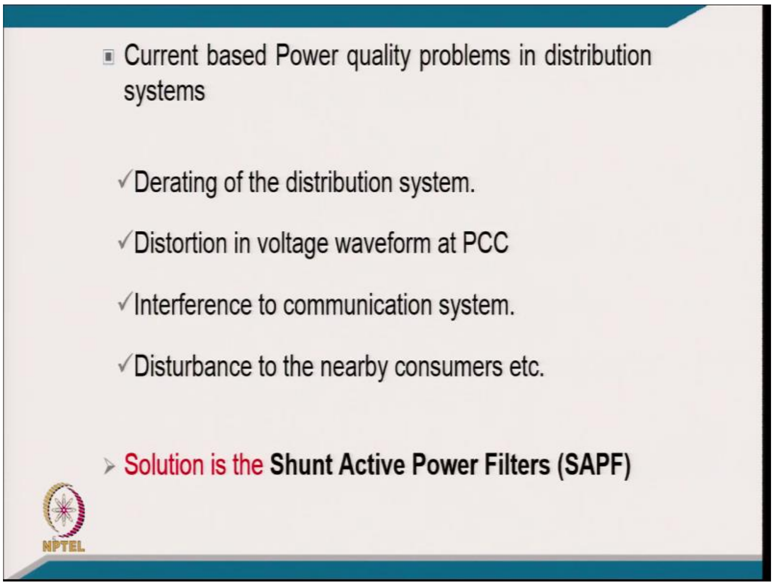

Then the current based power quality problems result in derating of the distribution system, distortion and voltage waveform at the point of common coupling, interference to communication system disturbance to nearby consumers.

The complete solution to these problems is the Shunt Active Filter which will be discussed here in detail.

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Shunt Active Power Filters are now matured technology used for providing harmonic current, compensation of reactive power, load balancing, and neutral current compensation.

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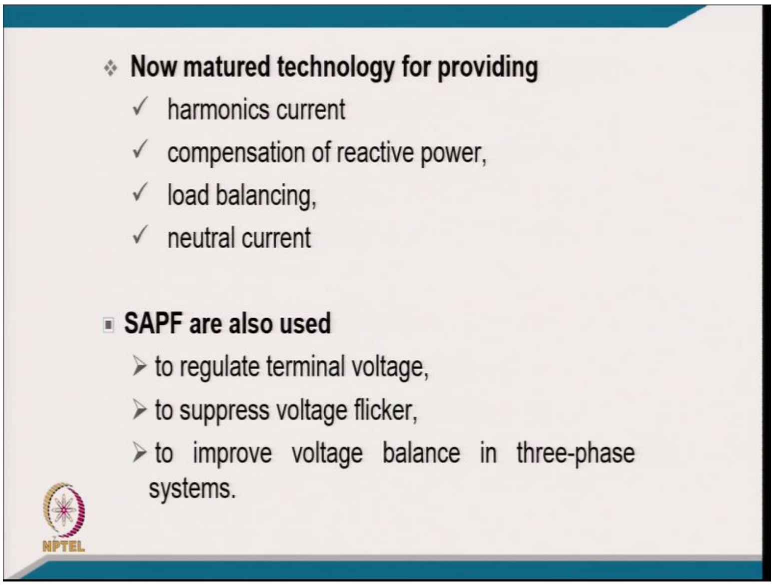

Also, the Shunt Active Power Filter is used to regulate the terminal voltage, to suppress the voltage flicker, and to improve the voltage balance in the 3-phase system.

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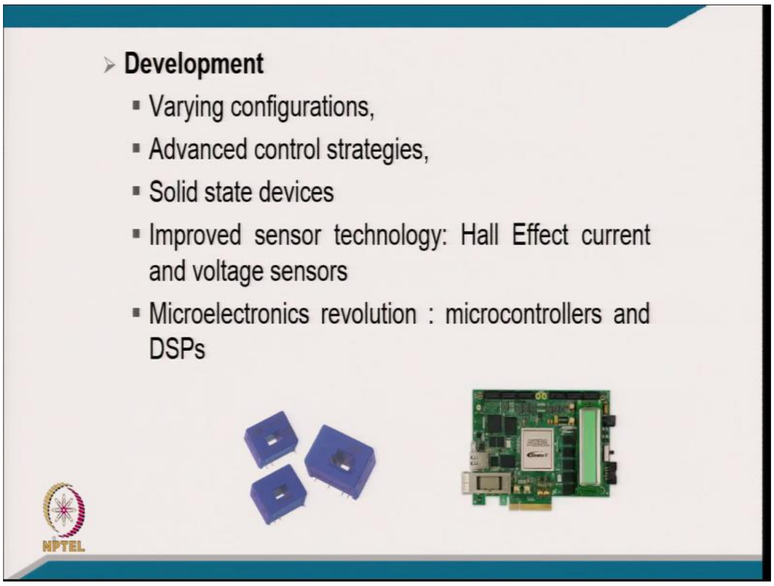

And of course, they are developed in varying configurations, have advanced control strategies, and utilize different solid-state devices. Improved sensor technology like Hall Effect current sensor and voltage sensor for giving a feedback signal is used for its control.

And then the microelectronics revolution has reduced the cost of microcontrollers and DSPs which have made it easier to implement the control for the Shunt Active Filters.

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This is typically an industry made shunt active filter.

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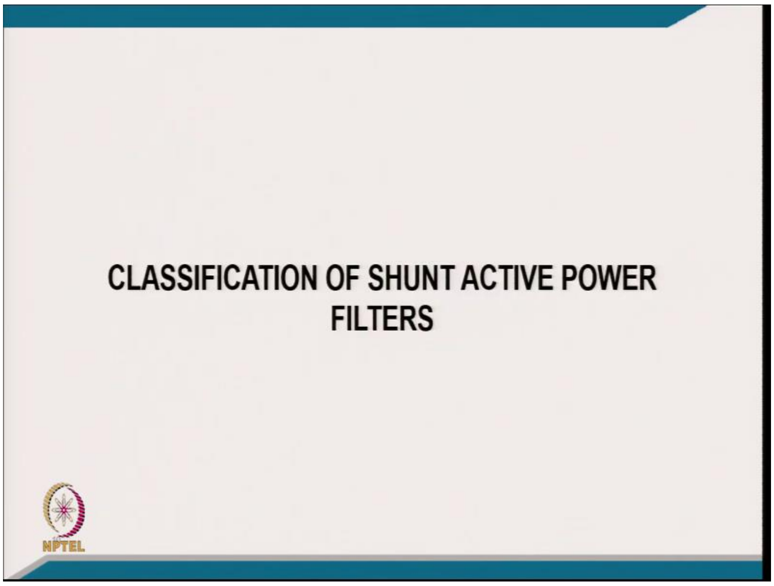

Now coming to the classification of Shunt Active Power Filter.

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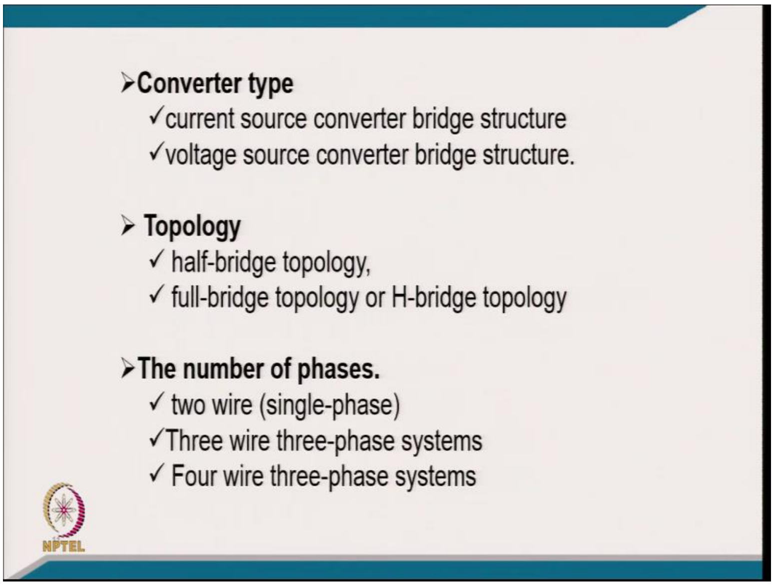

It is classified in the converter type as current source converter or voltage source converter. In the topology-wise classification, we can have a like a half-bridge topology and full-bridge topology or H-bridge topology.

Then another classification in the on the number of phases. It can be two wire single phase system, three-wire three-phase system or four wire three-phase system.

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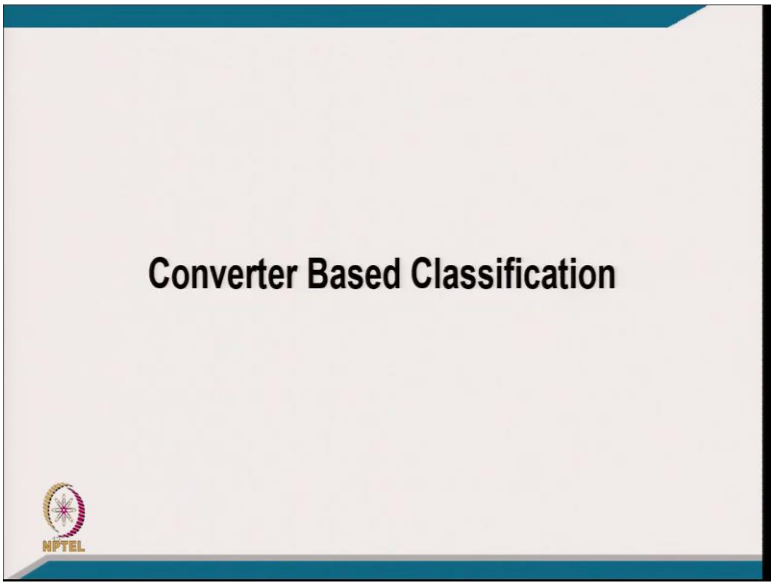

Now coming to the converter based classification.

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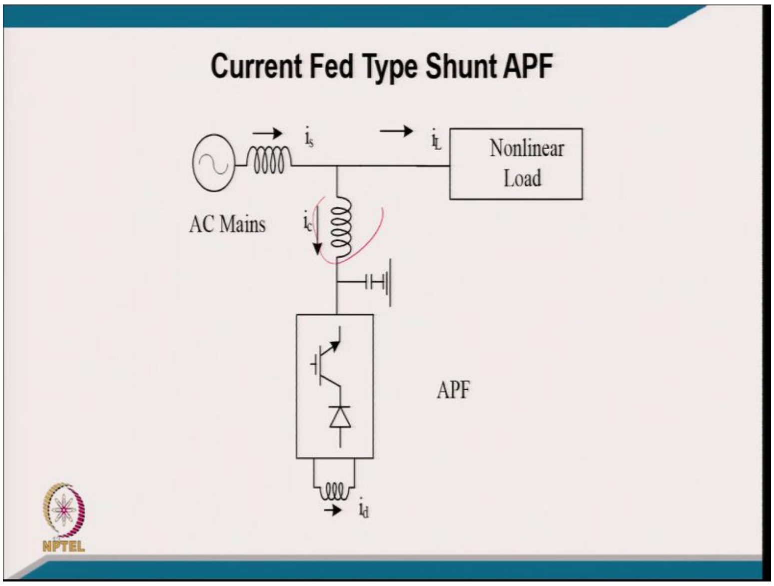

We can have a current source converter for the shunt active filter. Additionally, we have the non-linear load and supply system with the source impedance.

This inductor is needed on the DC side. The drawback of this configurations is that the inductor is costly, bulky and noisy. While, designing the DC inductor is not so easy.

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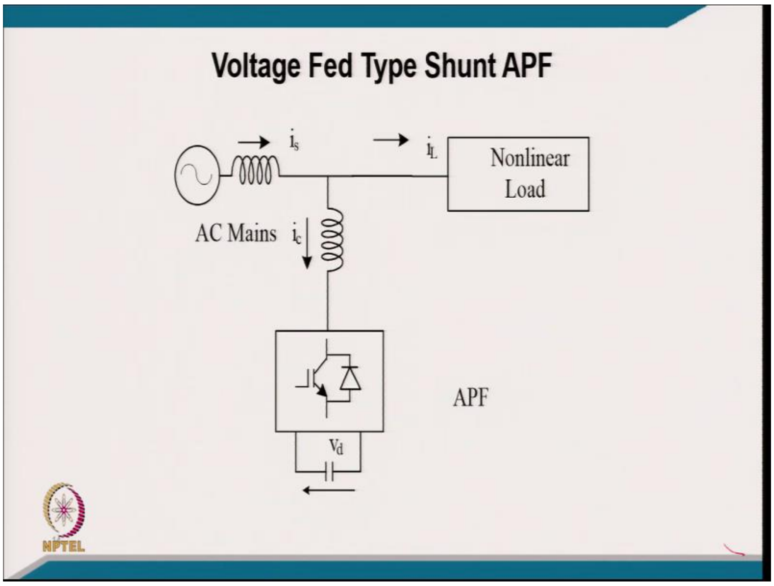

This is a shunt filter with a DC link capacitor. It is an electrolytic capacitor. This makes the voltage fed type shunt active power filter cheap, less losses, and small size.

Because of these reasons, voltage source converter based shunt filter are more popular.

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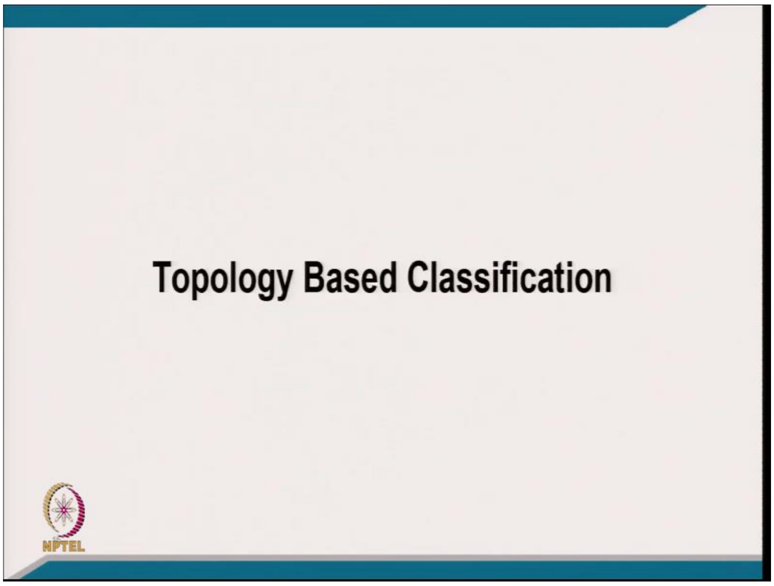

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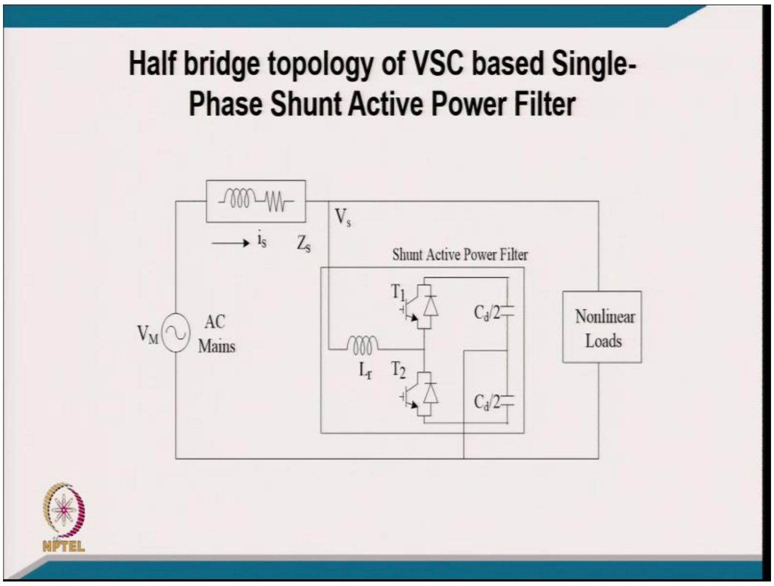

Topology-based classification, we have a half-bridge for shunt active filter using voltage source converter. But the major drawback of this is that the current flow through the capacitor is large. Thus, size of the capacitor or value of capacitor is very high. It cannot be scaled for large rating.

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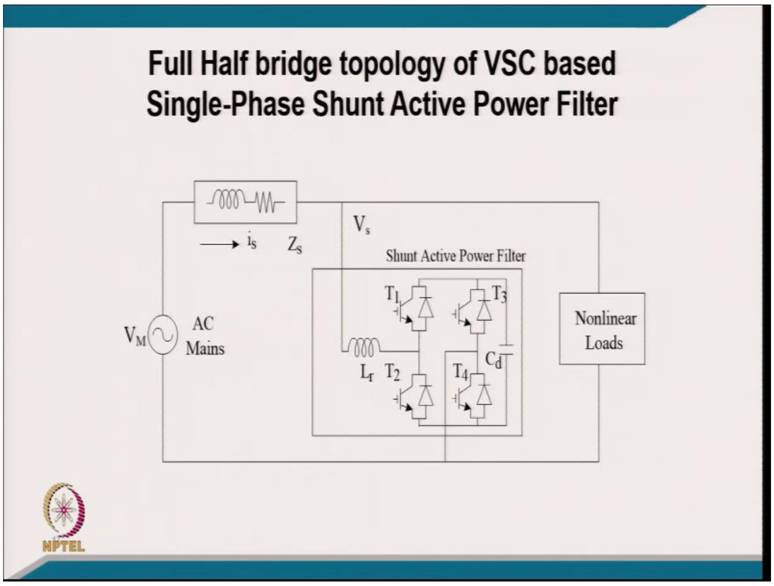

But this is the bridge structure with a capacitor filter. You can use it at higher rating. This bridge structure have a many benefit. You can use the unipolar switching.

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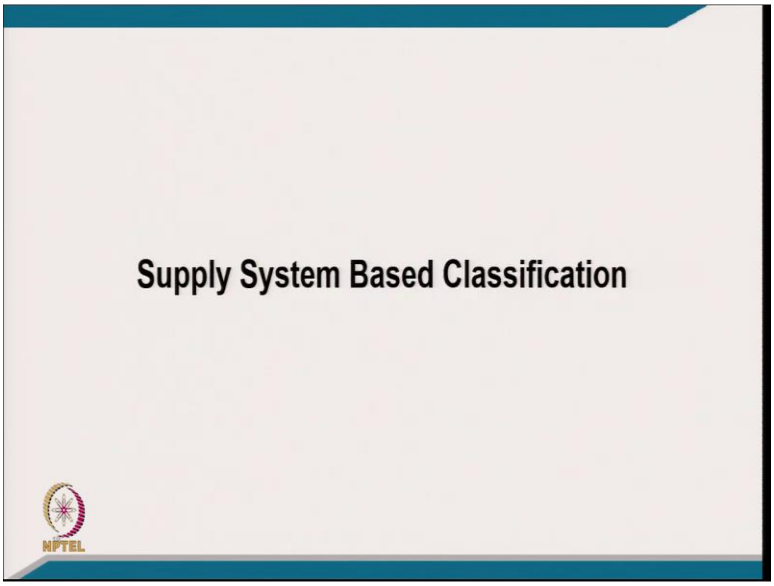

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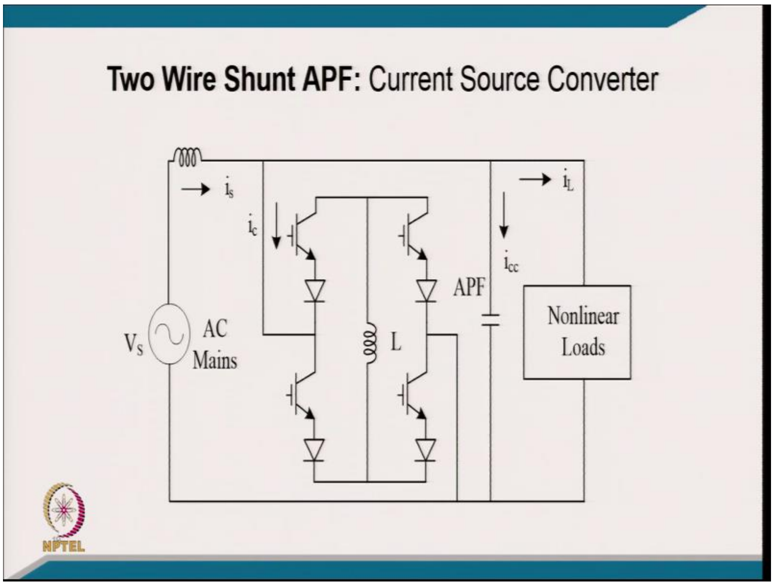

Coming to supply-based classification and supply based classification we have single phase two-wire systems, three-phase three wire systems and three phase four wire systems, and few other configurations which are presented in the screenshots underneath.

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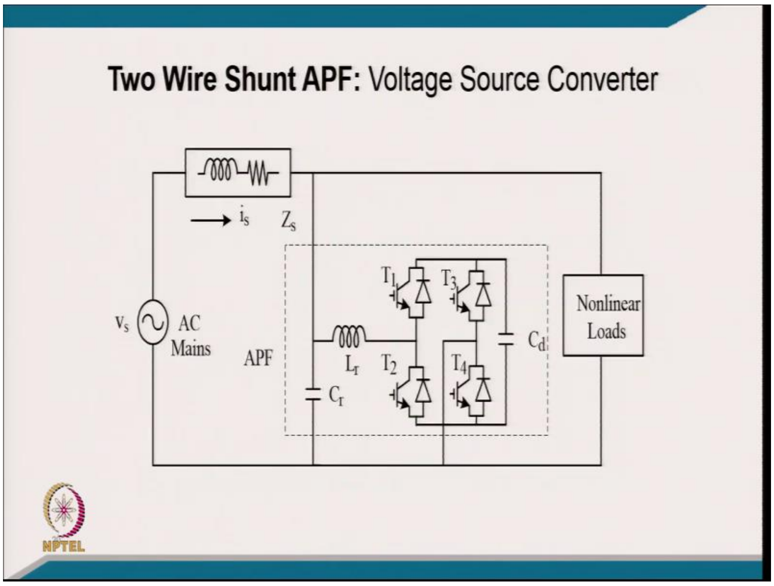

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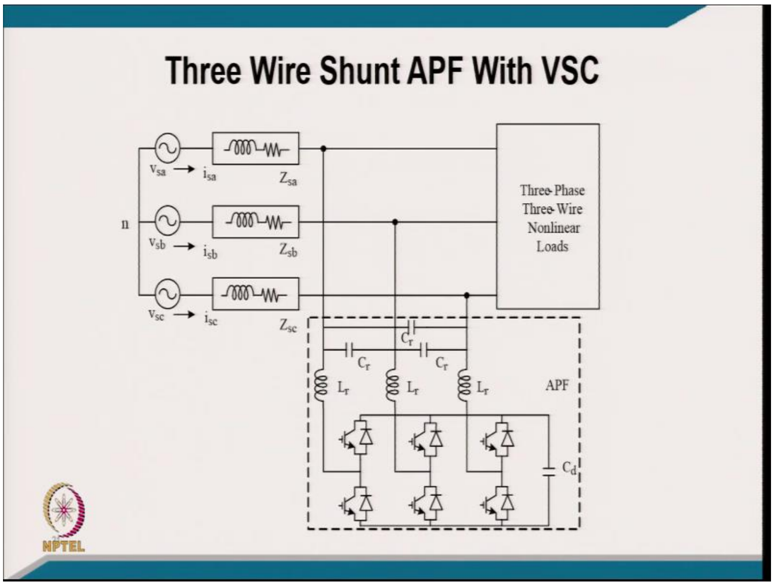

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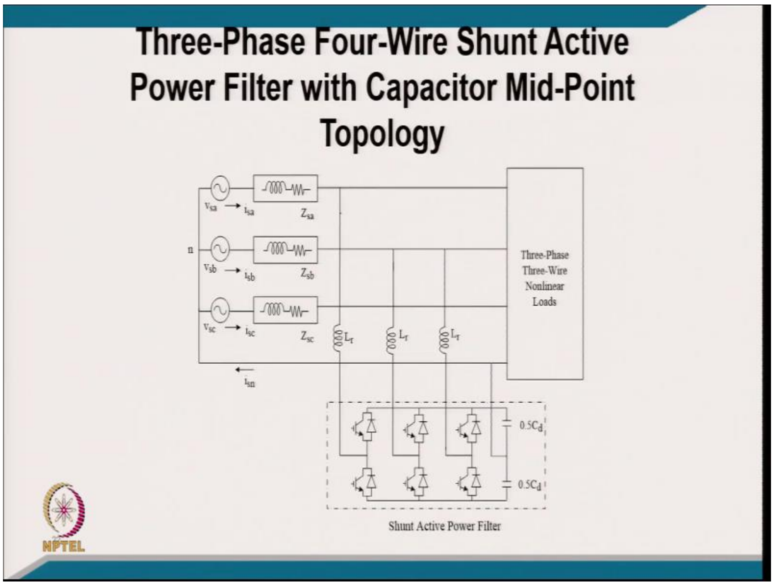

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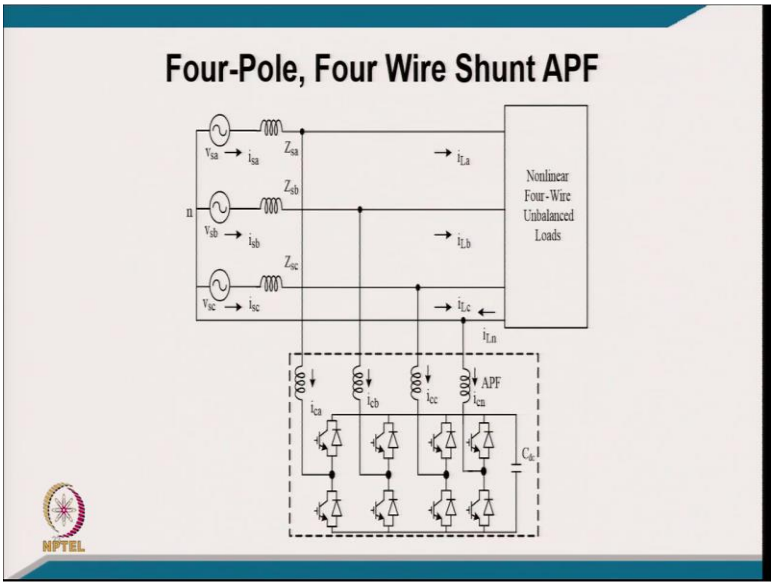

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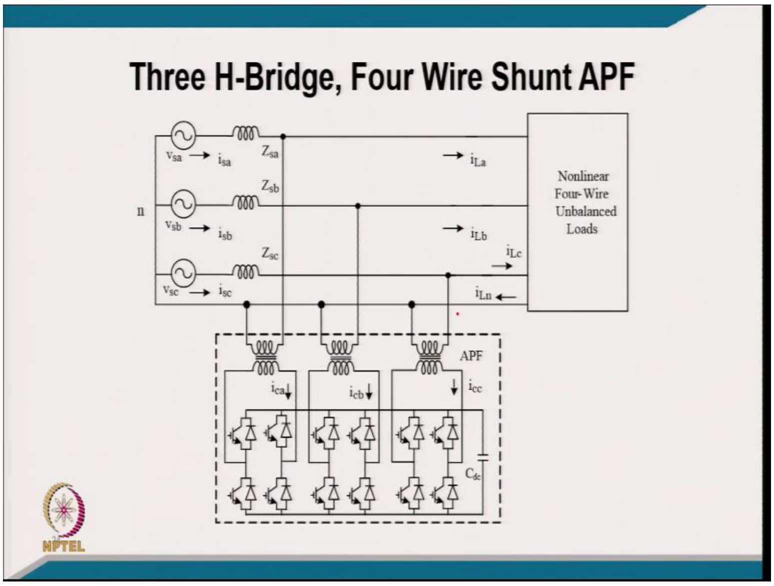

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Now, coming to Principle of Operation and Control of the Shunt Active Filter.

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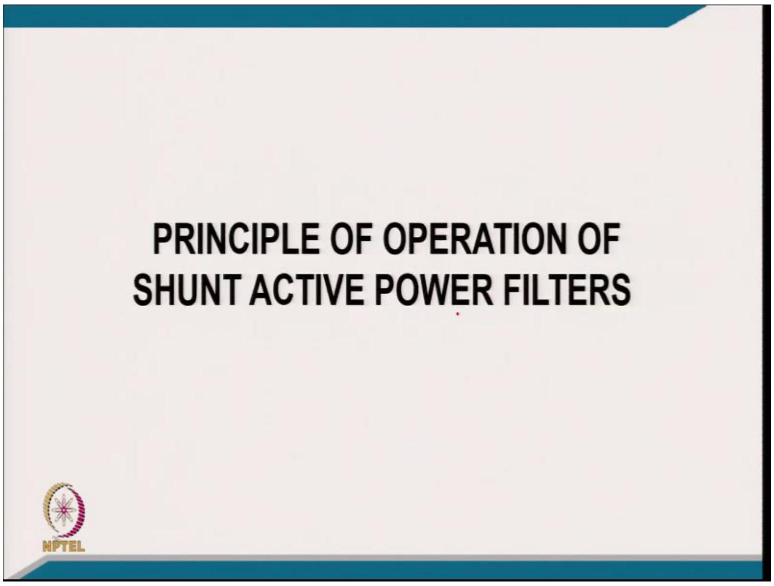

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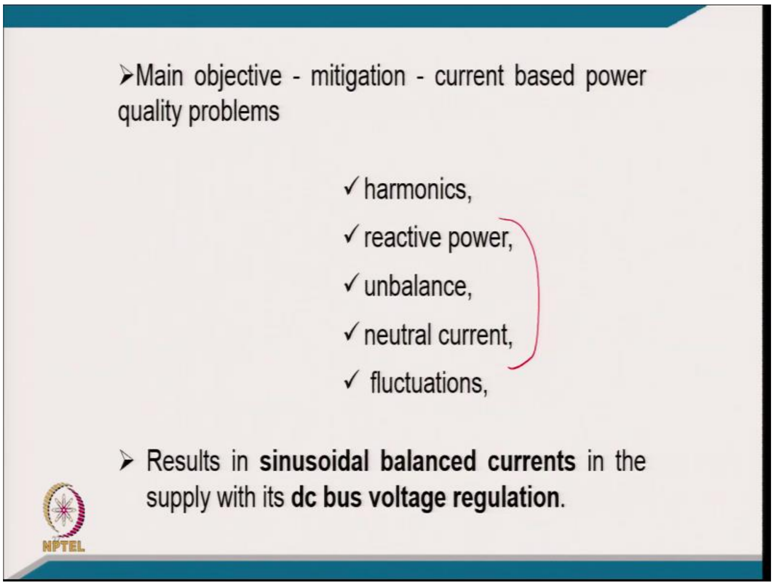

The main objective is mitigation of current based power quality problems like harmonics, reactive power requirement, unbalance current, and excessive neutral current.

However, KVA rating of the converter is undoubtedly increased to accommodate for all the functionalities.

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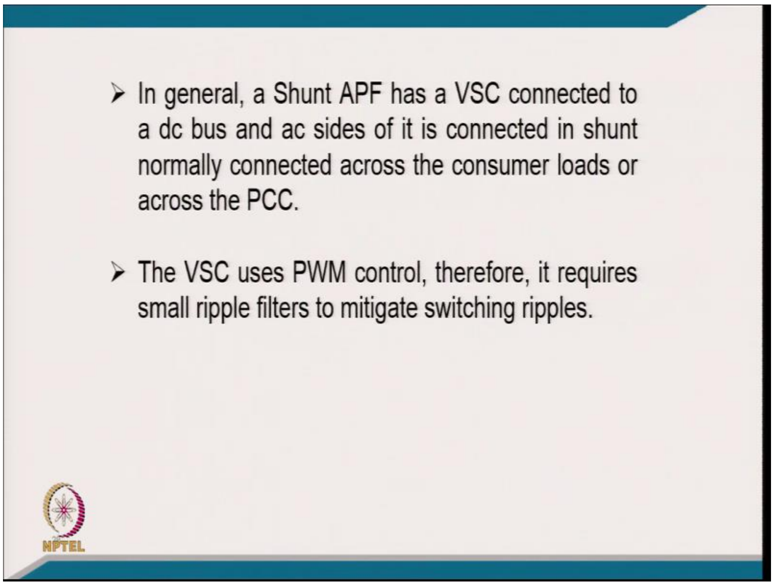

In general, a Shunt Active Power Filter has a voltage source converter connected to the dc bus and ac side of it is connected in shunt normally across the consumer load and across the PCC, point of common coupling voltage. The voltage source converter uses pulse width modulation control. Therefore, it requires a small ripple filter to mitigate the switching ripple.

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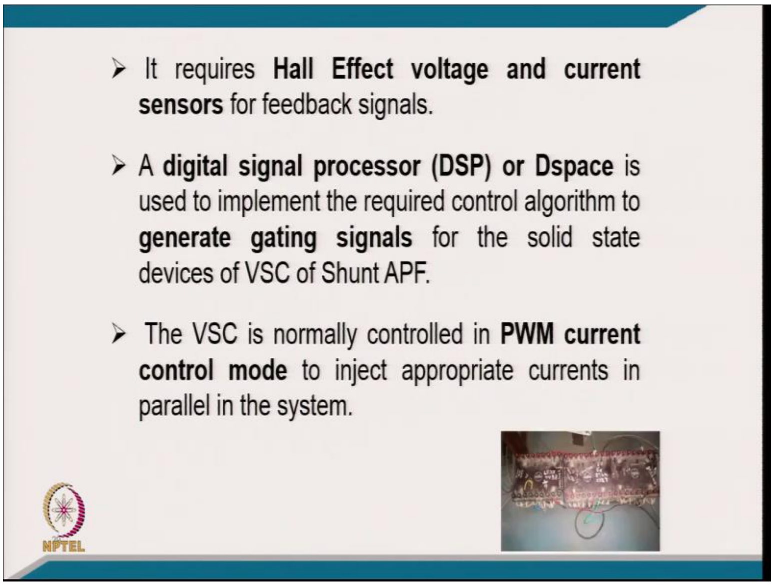

It also requires Hall effect voltage sensor and current sensor for the feedback signal for implementing the control algorithm in the DSP.

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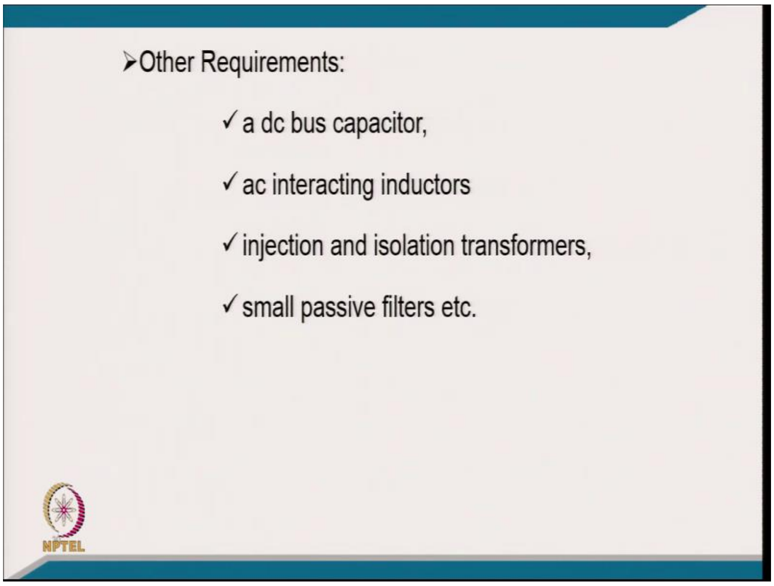

Other requirement is like a DC bus capacitor. To sustain the DC bus, you require interfacing inductors in between the supply voltage and the PWM voltage generated by the voltage source converter.

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The below discussion and screenshots detail the design and analysis of the three phase three leg shunt active power filter.

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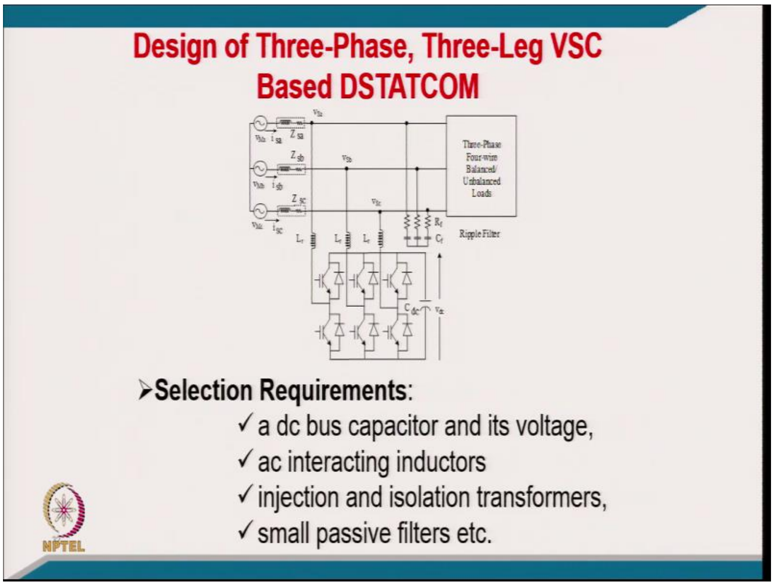

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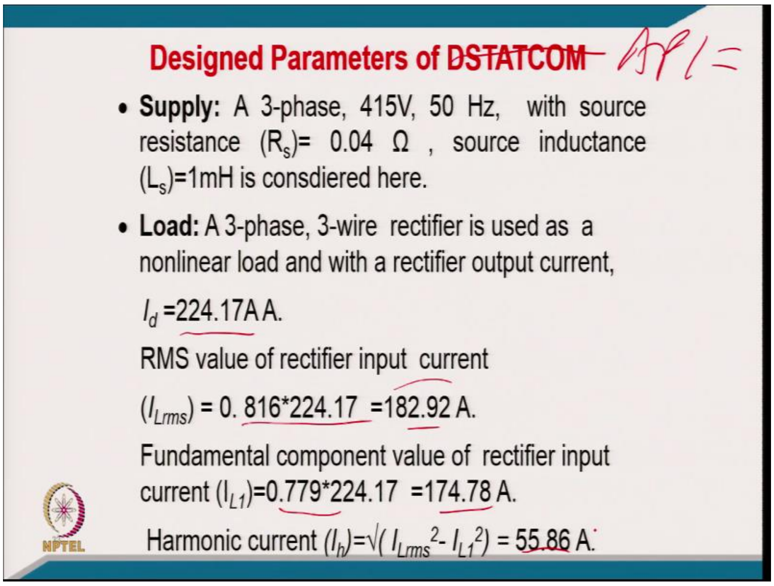

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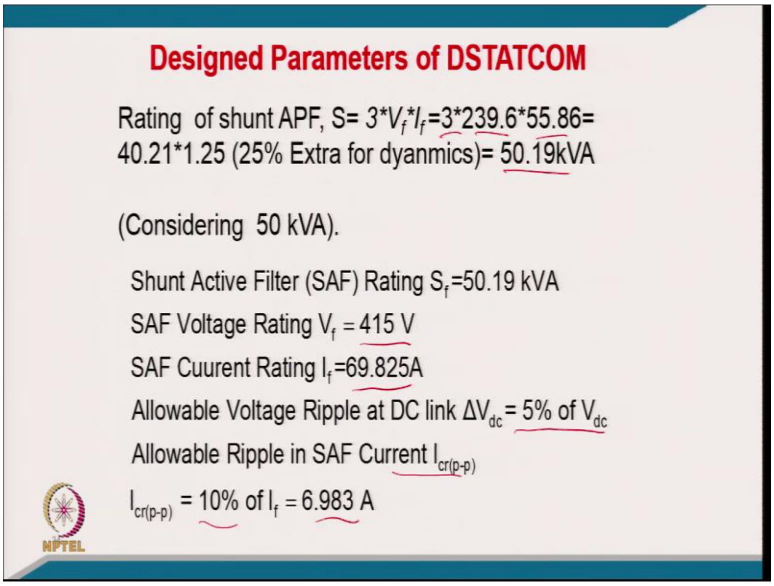

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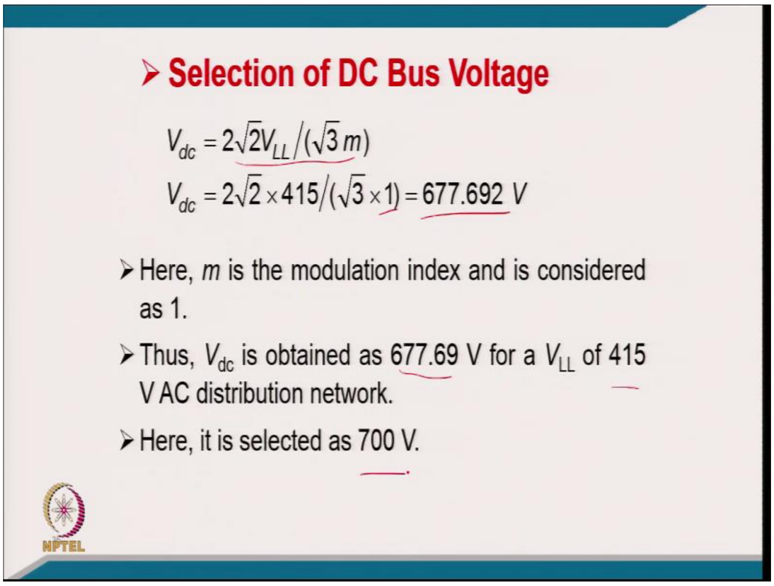

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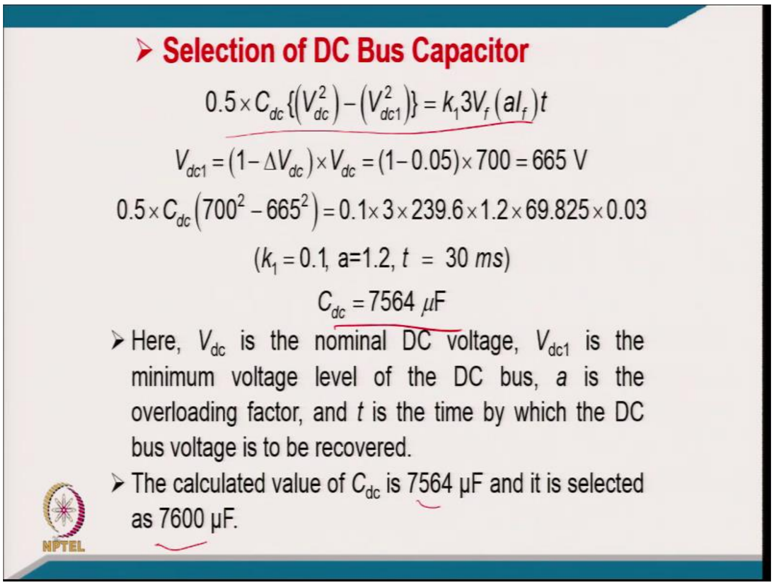

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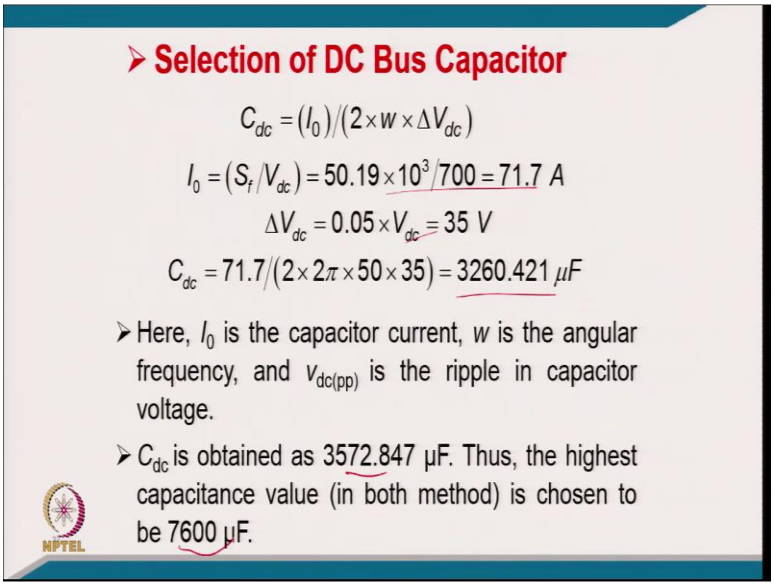

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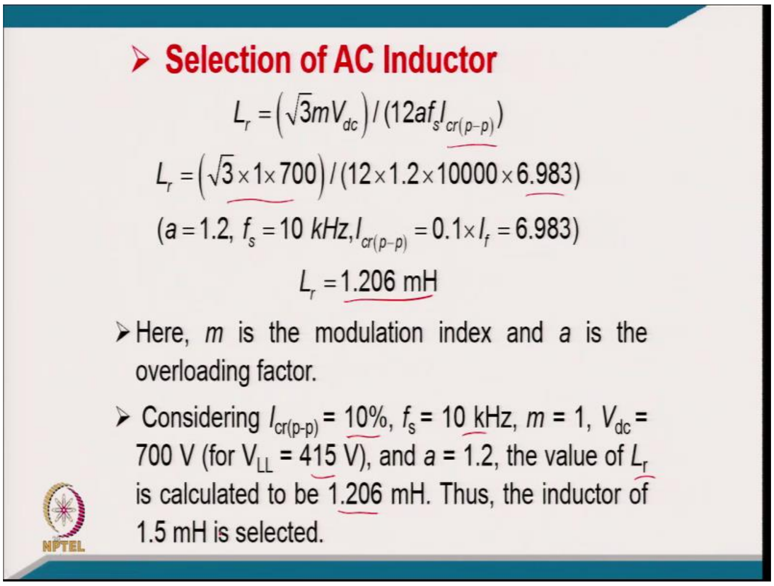

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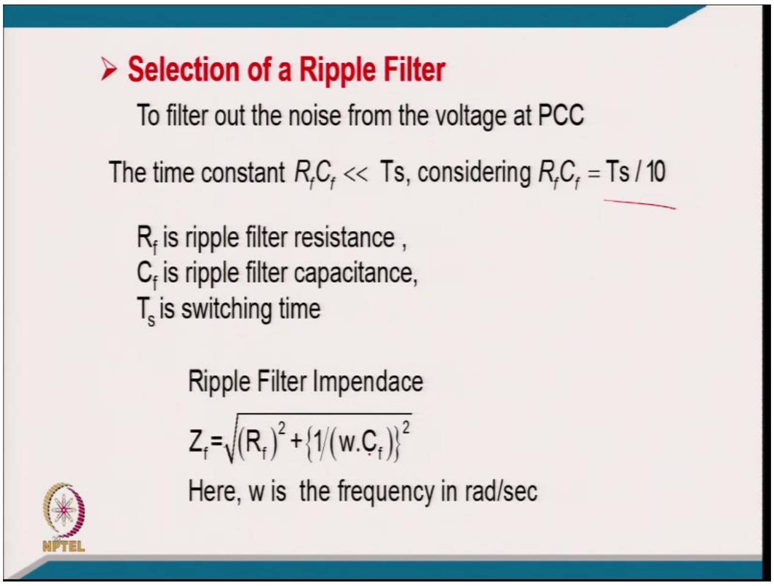

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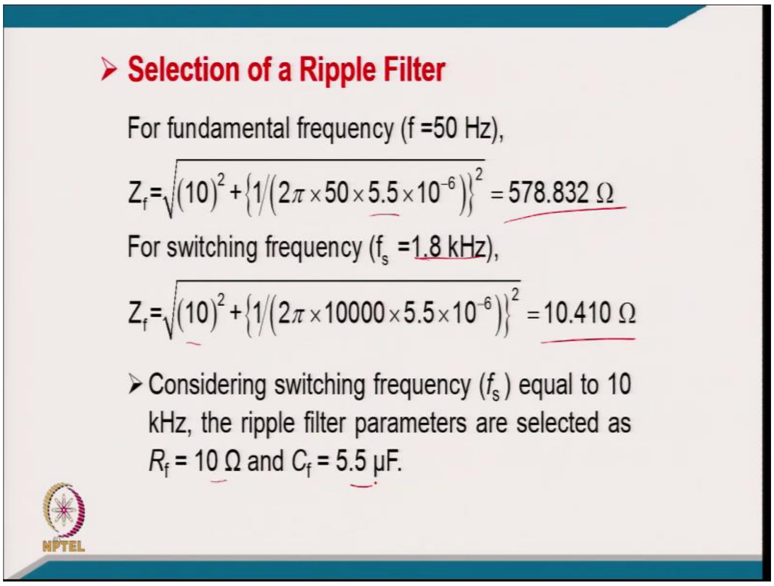

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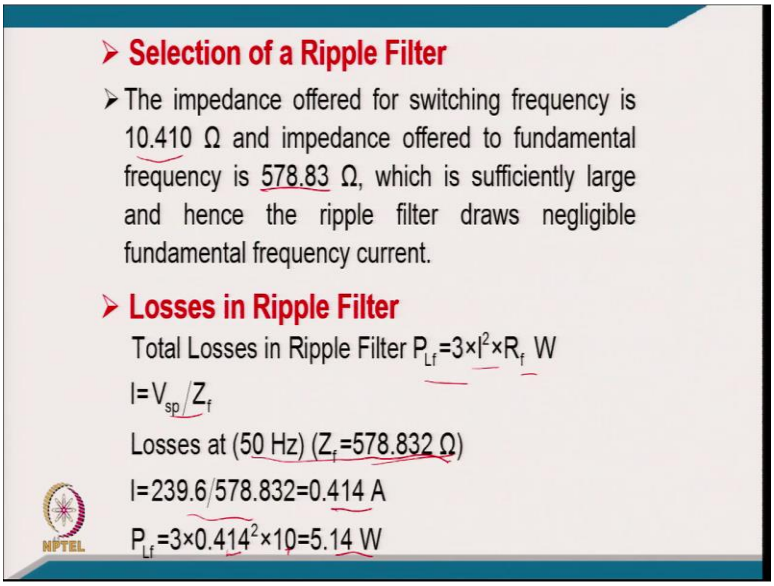

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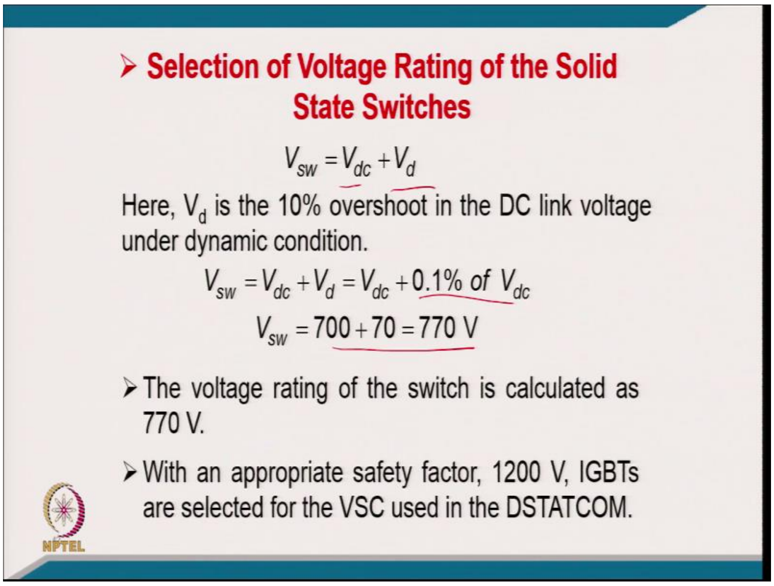

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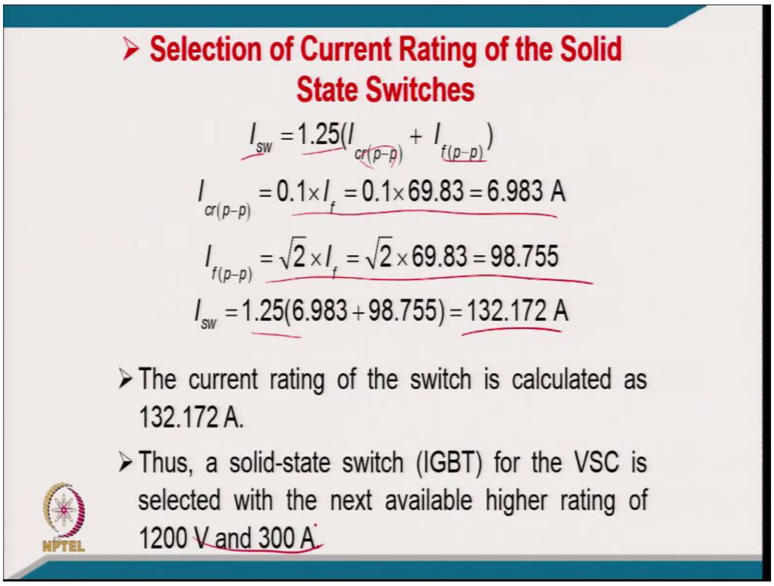

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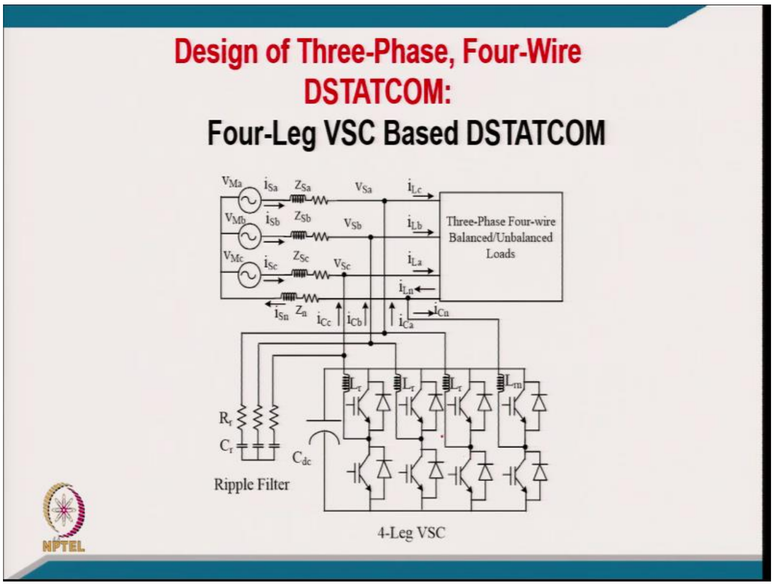

The below discussion and screenshots detail the design and analysis of the three phase four leg shunt active power filter.

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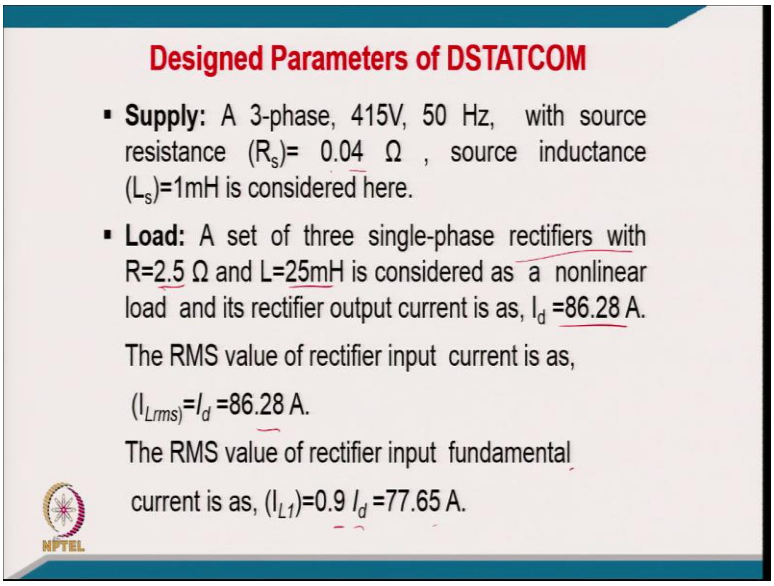

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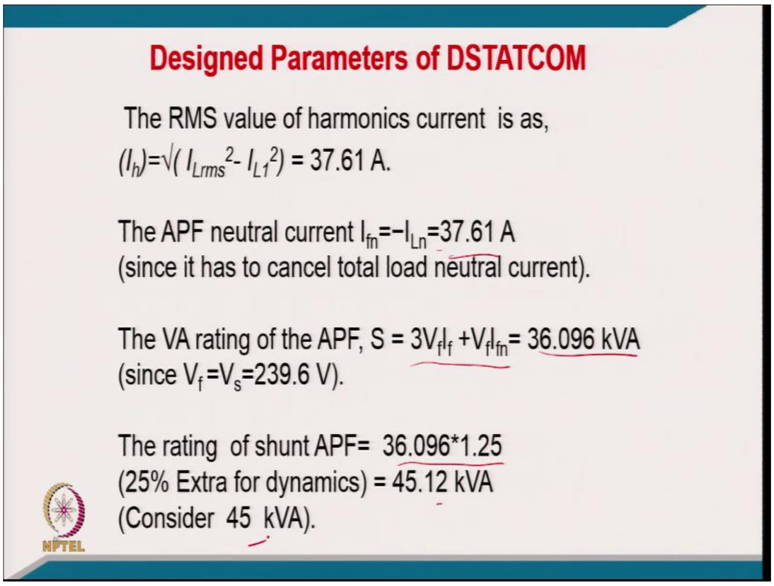

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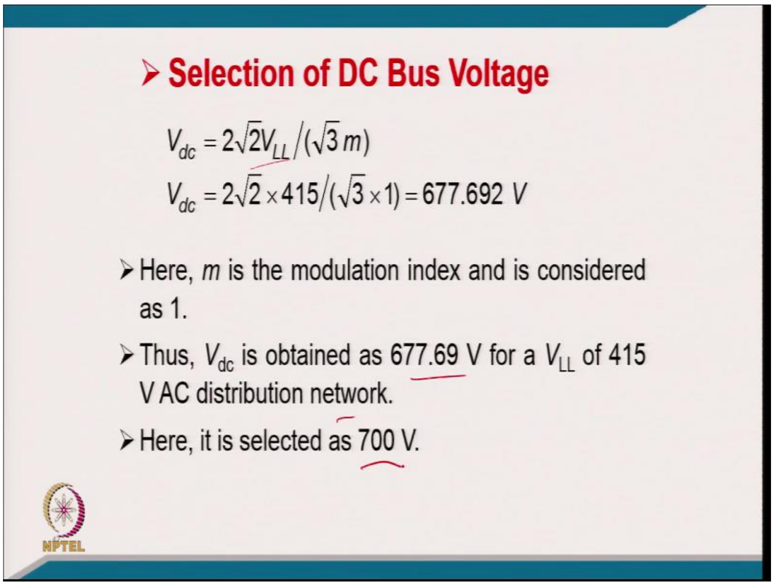

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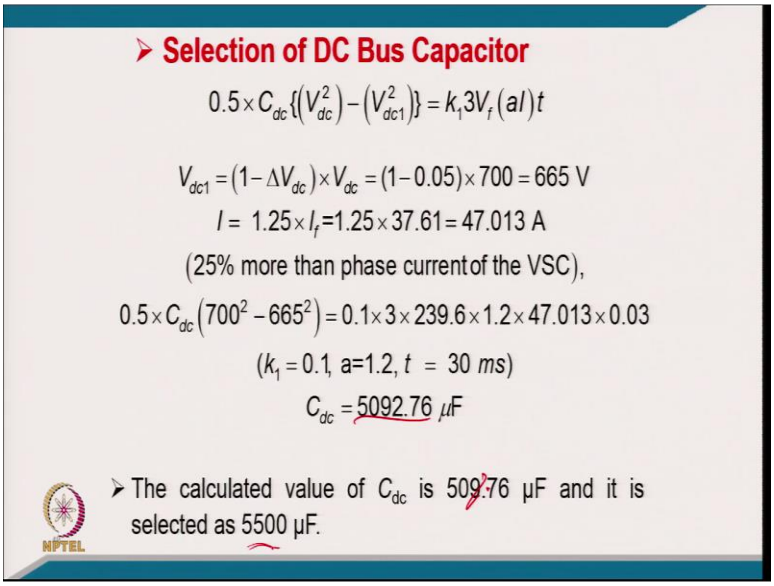

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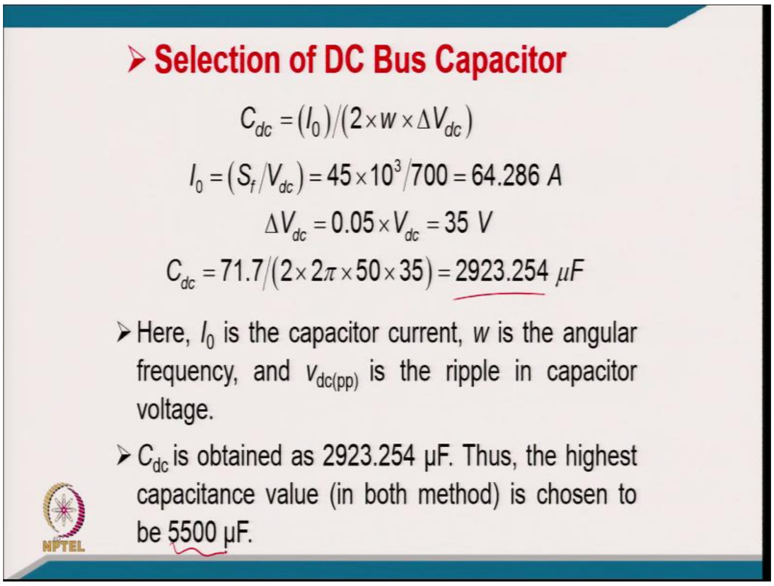

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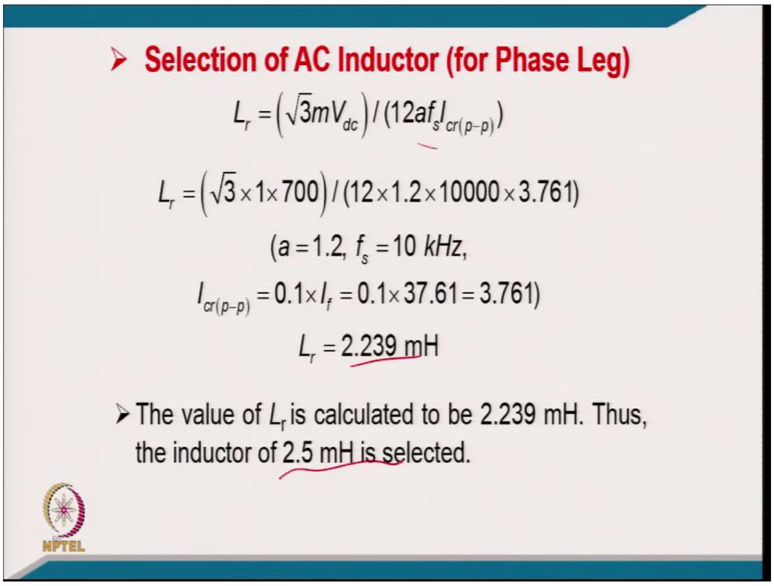

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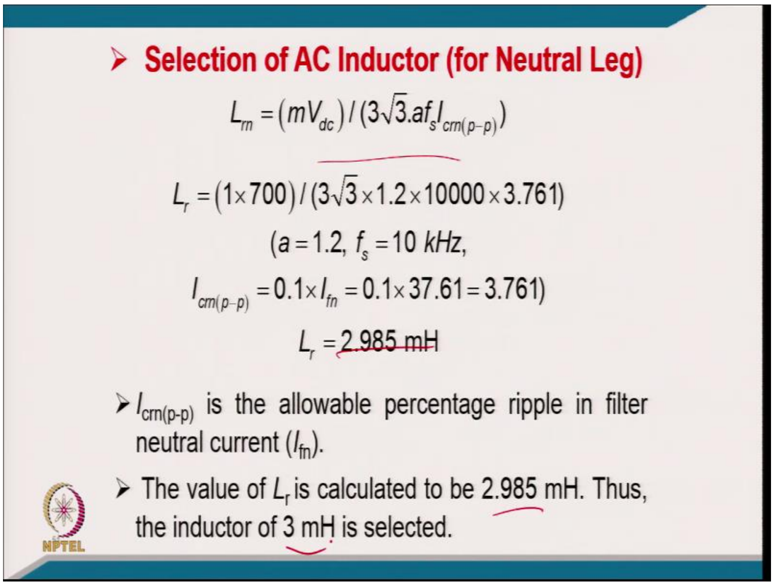

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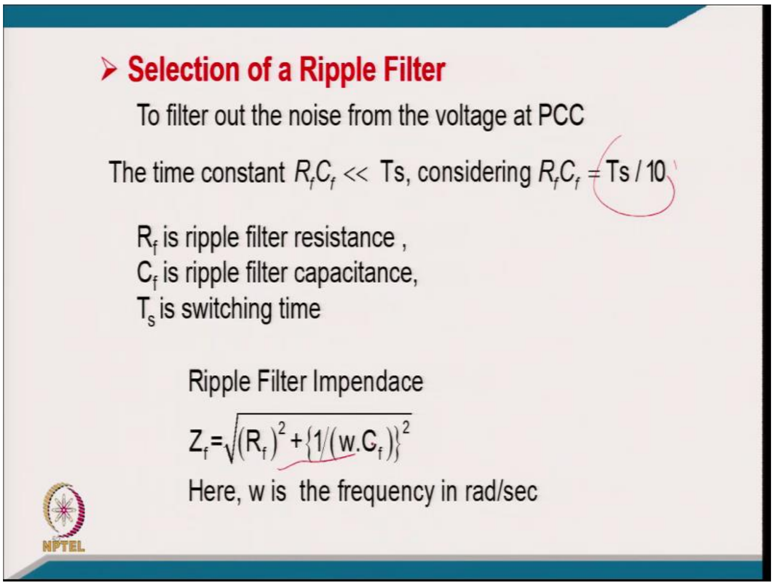

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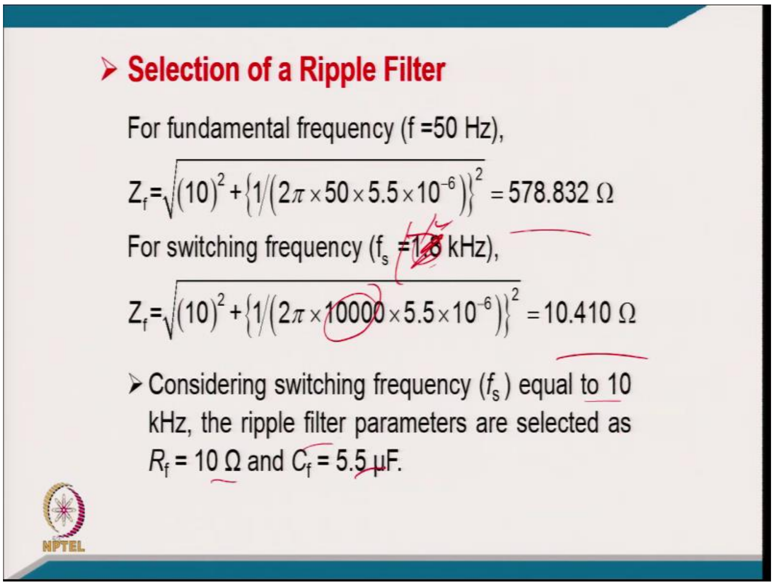

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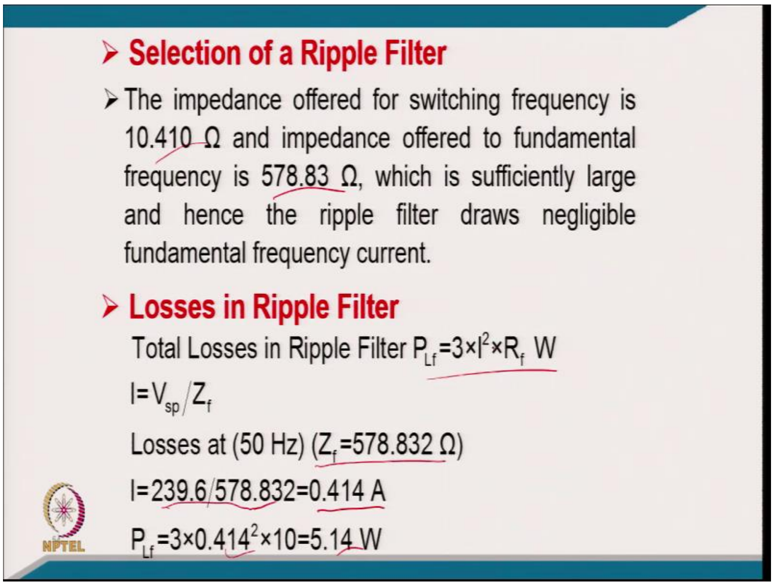

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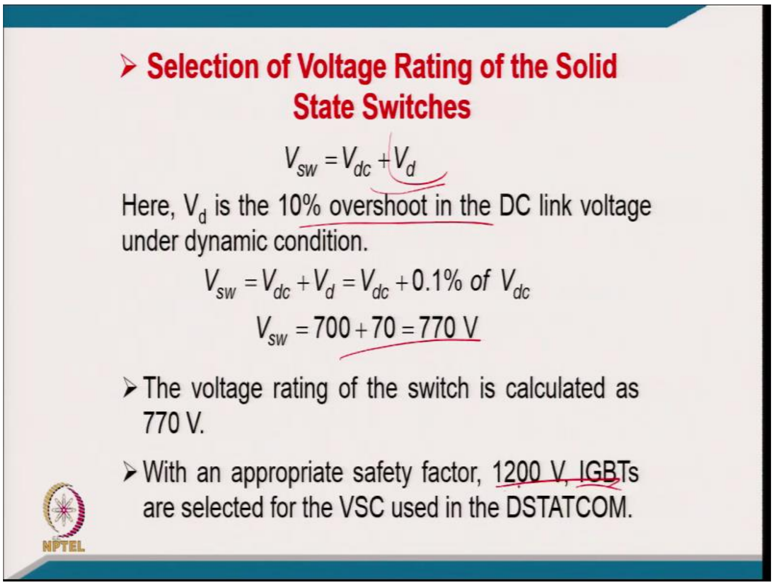

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