Power Quality Improvement Technique
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Lecture – 34
Hybrid Active Power Filter – II

Welcome to our NPTEL lectures on the Power Quality Improvement Technique. This will be our second lectures on the Hybrid Active Filter. We were discussing about some combinations of this active and the passive filter. So, this is also a possible solution to have all series combination in between. These are passive combinations.

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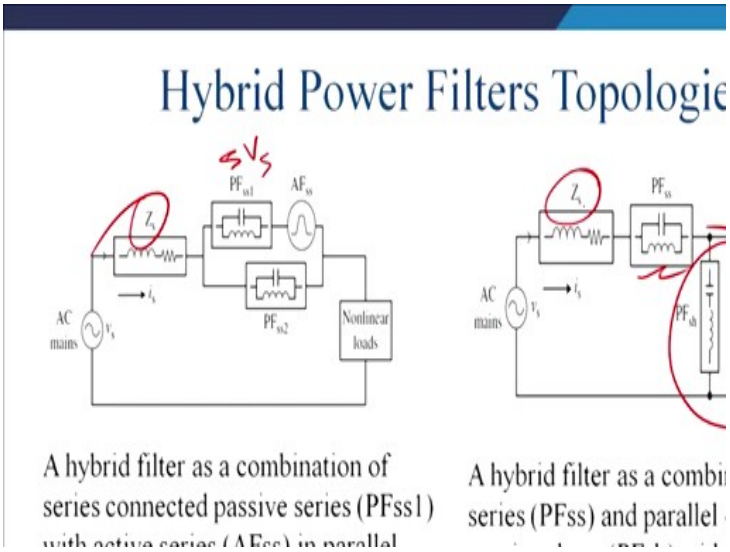

Generally, it will mitigate maybe fifth harmonic voltage and also some portion of it and this will mitigate the seventh harmonic voltage. This way it has been made. So, it is called the hybrid filter as combination of the series connected passive filters with active series in parallel with passive series filter. So, this is also a combination. Generally, it is been preferred where source impedances are high.

Similarly, you can have another combination. These are the two-shunt filter, one is active another is passive and with that you have another series filter. So, this is a hybrid filter. It is a combination of the passive filter and two passive filters and these are the active and the passive shunt with the series passive. This has been done where we do not have much problem on the source inductance.

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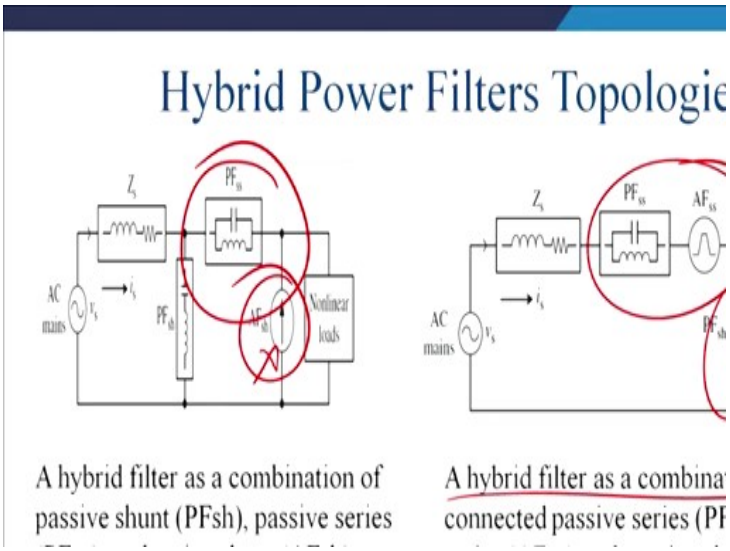

Now we can have a 'T' network. 'T' network gives good amount of attenuation as you know. The is the 'π' network. So, here first passive so, it will sink or takeout the buck of the harmonic contamination. Then what happens? This will block the fifth and seventh voltages mainly and thereafter what happens? This will mitigate the remaining part of the harmonic. Because it may detune due to the fluctuation of the voltages and thus you may not get a desired THD and ultimately this will have a final cleanup operation.

The hybrid filter is the combinations of the passive shunt, passive series and active shunt filters. Same way you can have the cleaning up operation in the series part. Mostly it will clean up the voltage and thereafter whatever remaining will be sink into the shunt component. The hybrid filter as a combination of the series connected passive series with the active series and the passive shunt filter.

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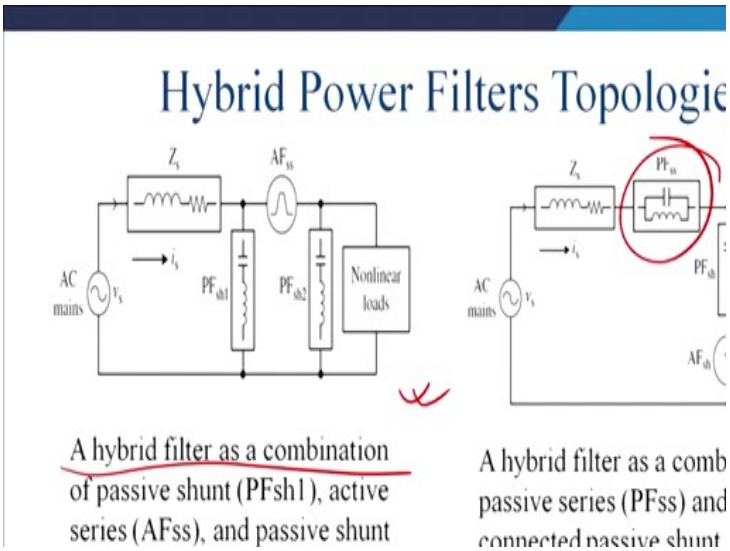

Hybrid filter as the combinations of the passive shunt, active series and the passive shunt filter. This has been shown. Similarly, you can have the Z_s and you can have this device as a series shunt series and thereafter your combination of the active and the passive filters. The hybrid filter is a combination of the passive series and series connected passive shunt with active shunt filter. A hybrid filter is a combination of the passive shunt and series connected active shunt with passive shunt filters.

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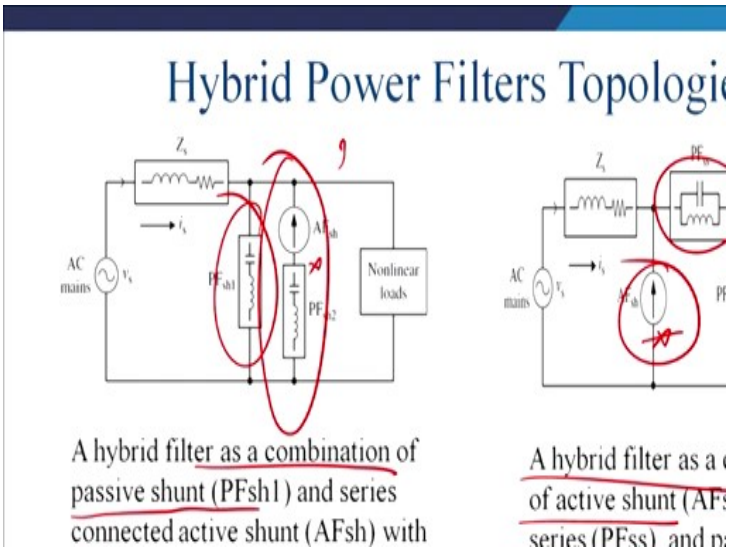

So, you have this passive shunt. Then again you have active passive shunt and this will mainly a shunts active filter solution where dominant harmonic will be mitigated by the passive, but it may detune and for this is in this cleanup operation is been done with the combinations of the active passive. I have shown you previously. Please recall a shunt active power filter of this combination. Where it can also reduce the rating of the devices apart from the compensations of the voltages.

Similarly, you can have a shunt combination. Generally, it is not been preferred because mostly this mitigation has been done by this and thereafter you have a series shunt series active filter then the series passive filter then the shunt passive filter. So, the hybrid filter is a combination of the shunt active, if you are looking from the source side and the passive series and the passive shunt filter.

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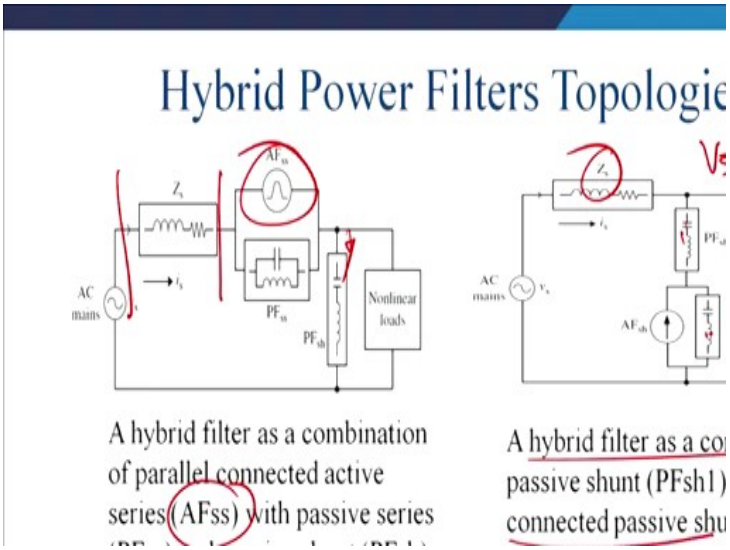

A hybrid filter is a combinations of parallel connected active series AFss with passive series and passive shunt. Ok. Thereafter you see here, this is the harmonic source because of that the source inductance. Then this will mitigate the harmonic voltages and this is also will mitigate the harmonic voltages and whatever the harmonic current will be there since that harmonic voltage is less that will be sinking to it.

This is the combinations where this is double tuned as you have seen in case of the passive filter with that you can have a active shunt filter. Mostly this solution is there. When there is a low source inductance and thus you do not have a greater value of the

voltage. Because you know if there is a fifth harmonic voltage even if you connect the resistive load, this will show.

So, this fifth harmonic voltage arises due to the fifth harmonic current when it passes through the source inductance and for this reason these topologies has some merits and has gained the attention to the researcher. The, hybrid filter as a combination of the passive shunt and parallel connected passive shunt with active shunt filters.

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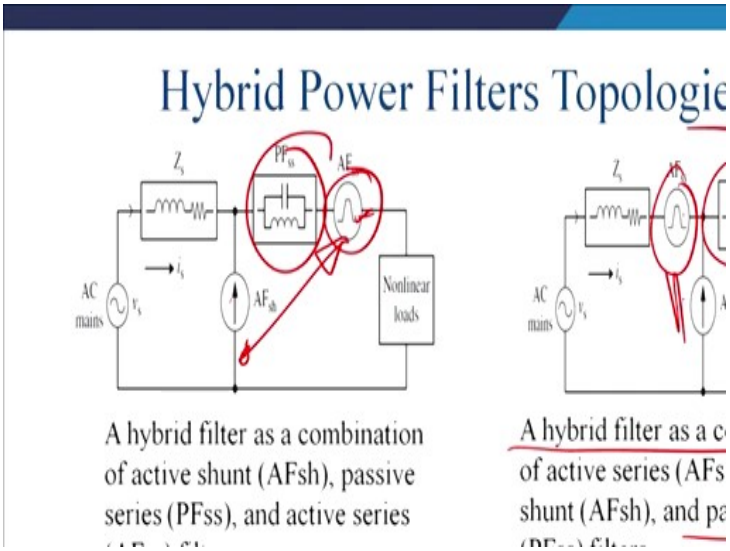

Now, you have this passive filter. Thereafter this is series connected parallelly. You have both active and passive and so, it is essentially an UPQC, but I was always saying that you should have a right shunt combination. You see that this is a left shunt combination. In UPQC I have said we generally prefer right shunt right shunt right shunt, but this is a left shunt combination. With that you know to reduce the rating of this series active filter, you have put a passive filter and that will mitigate the value

Similarly, you can have. This is essentially an UPQC and this will be a normal UPQC. This is a normal UPQC with right shunt combination and then also you left something to be compensated by your series filter. This is said to be the hybrid filter as a combination of the active series and active shunt and the passive series filter. So, I was telling then that where you use the left shunt, there is something you try to use left shunt. Essentially, it will provide the path to sink for the harmonic, then you block it and thus the rating of

this fifth and seventh harmonic compensation require to be less and similarly rest you block it here.

Here you mitigate the fifth and seventh harmonic and you compensate it. Whatever you are been tracked out, lastly that has to be mitigated by this passive series filter.

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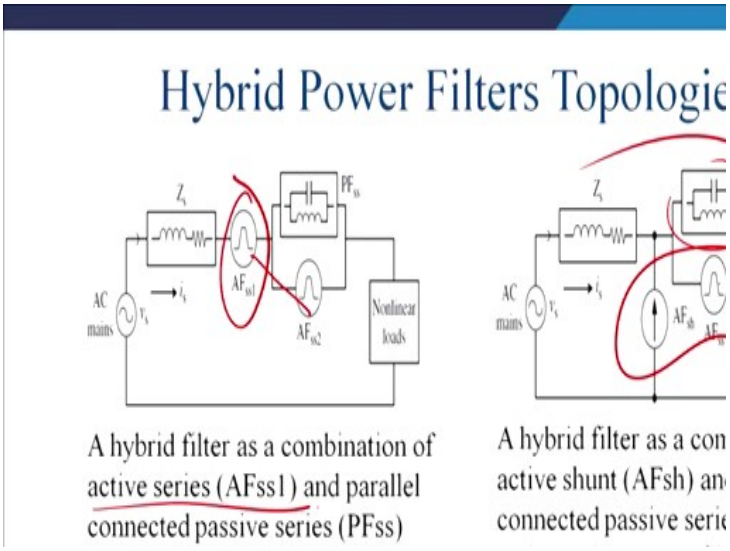

To reduce the rating since this device sees the whole rating, we try to reduce the rating of it by this kind of combination. So, you have series-series combinations. So, this will see the whole rating. The parallel to it you will have this combination. This voltage will be the same. So, it will be equivalent to the fifth harmonic voltage or seventh harmonic voltage where it has been tuned and thus you have a compensation on the rating. This hybrid filter is a combination of the active series and parallelly connected passive series with the active series filter.

Similarly, this part is a UPQC. This essentially is with a left shunt combination and with that you have a passive series filter to reduce the rating of the active series filter. So, we will call it as hybrid filter.

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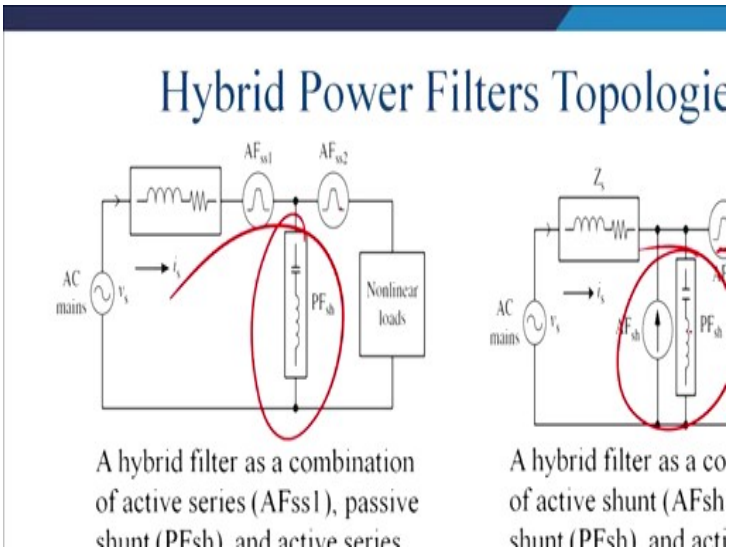

Similarly, you can have two active series filter and this can be a passive filter and then you can have two passive filter. You can have, sorry. Pardon me. You can have two shunt filter one is active, another is passive and another is the series active filter. So, this is also a combination.

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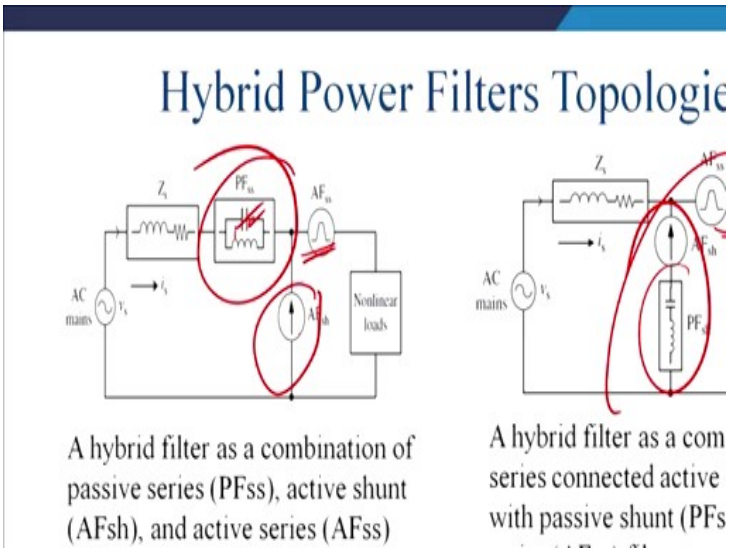

Now, you have series passive, you have series active and passive. This combination is also very useful. This one first mitigates the voltage harmonic which arises mainly from

this fifth and seventh and ultimately this one will compensate the rest of the harmonic. Thus, overall rating gets reduced and shunt part will compensate the current part of it.

Similarly, you can have this combination and thus the rating of this shunt active power filter of the dc link voltage will be reduced as we have seen discussed in case of this kind of topology of the shunt active power filter, and that can be an extension also in UPQC. So, essentially it is an UPQC with a left shunt combination with that hybrid part. Shunt is hybrid and the series part are left out as it. In this case it is also an UPQC where the series part is hybrid and the shunt part are left right as it is.

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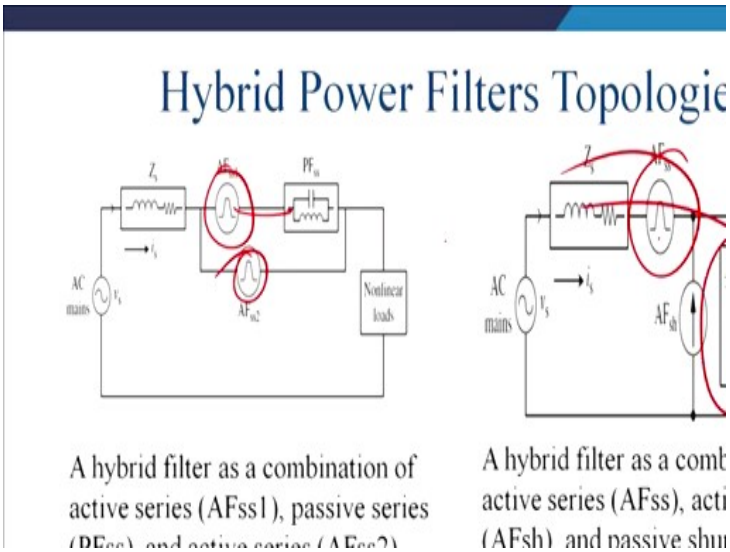

This combination is also possible, where you have a two series active and one series passive. This can be connected back to back and the task is to mainly compensate the major harmonics and whatever the remaining harmonic may be compensated by this one. So, that overall rating becomes reduced.

Please understand that you have to use an inverter. So, of course you will be beneficial if rating is low though you require two inverters. If the rating is not so high, it does not matter, you can have those inverters placed. Similarly, this one is an active series and the active shunt and thereafter you have this shunt. So, essentially it is a right shunt UPQC with extra shunt passive filter. Similarly, you can have a left shunt UPQC with a passive filter. Generally, it is been preferred now.

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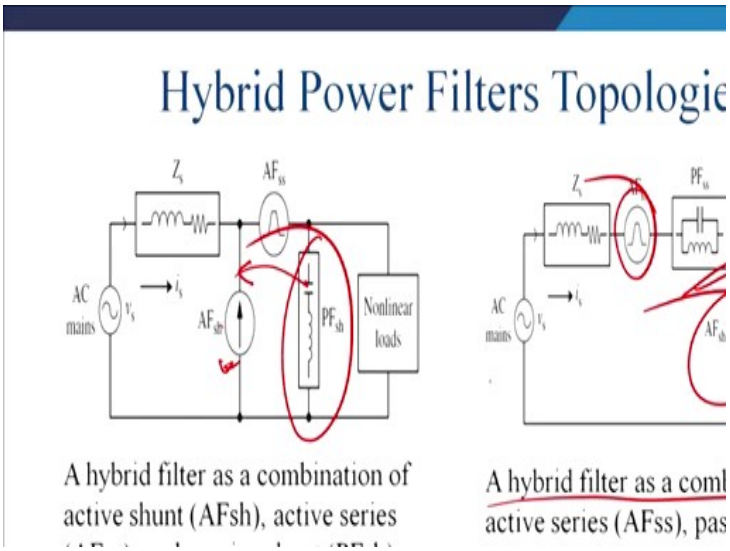

I was telling you the task of this entity is to cleanup so that UPQC can act better. So, you can have this notion. Again, this can be interchanged. First passive then active and thereafter we can have a hybrid filter with a combination of the active series, passive series filters and the active shunt filter. First you have a series filter. This will mitigate all the voltage harmonics coming out from this due to the source inductance. Then you have a passive filter. Thereafter the current part will be mitigated by it.

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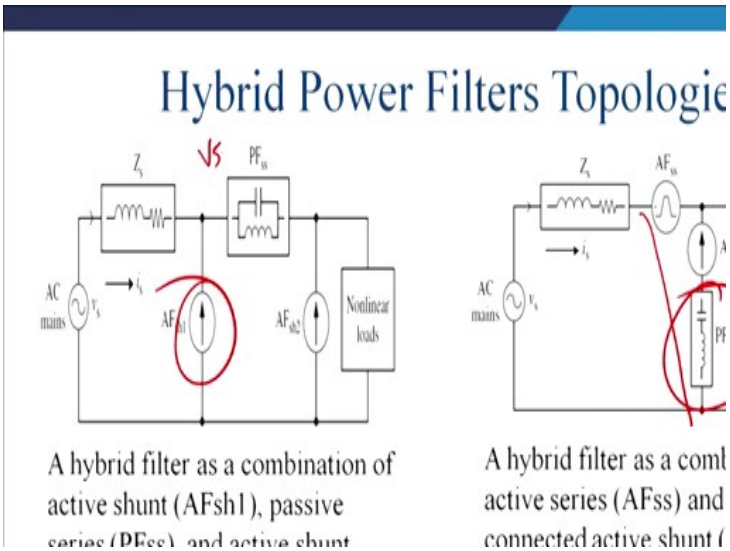

Again, this combination you see is two shunt filters, another is a series filter. Series filter essentially block these voltages fifth and seventh. This will supply the other harmonics. Fifth maybe supplied by it, seventh may be supply by it. So, its overall rating gets reduced and this is the also the combination. It is a combination where you got a shunt path which is here and this combinations of the passive filters and active filters and series part is left as it is.

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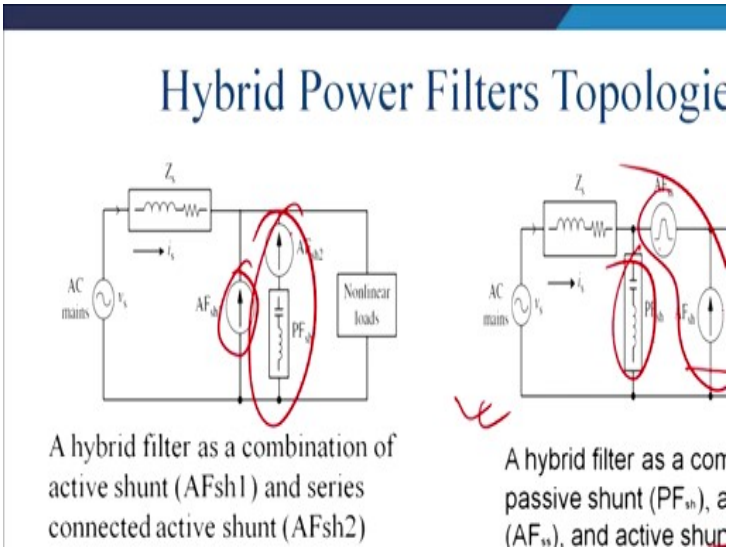

Similarly, this combination is there. There is a two shunt mainly it is to reduce the effect of the current harmonics. So, here you have a shunt active filter, this is a shunt hybrid filter and both had been placed so that this is may be the compensating the higher order harmonics and this is for compensating for the lower order harmonics. Same way you can have this, as was I was telling. That you can have the shunt passive shunt first, then active shunt. In between you have series essentially this part is a right shunt UPQC.

This hybrid combination of the passive shunt filter active, series filter and the active shunt filter. This combination is quite popular because as you can see that this combination is essentially an UPQC. So, with that you add on something and thus you get a better compensation.

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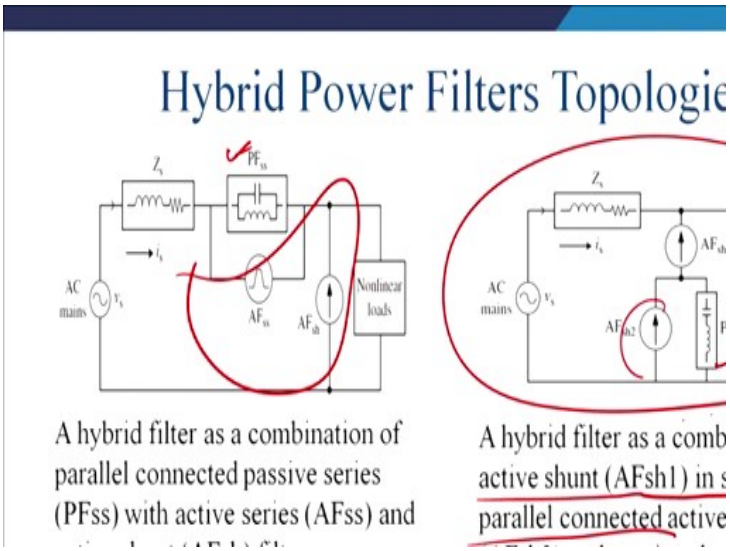

Similarly, you can have these combinations. Essentially all these entities are UPQC. With UPQC to reduce the series rating we will go for this solution and that is hybrid filter as a combination of the parallelly connected, passive filters with active series and active shunt filter. Thereafter it is this one and you have active shunt one, then this is passive and thereafter it is a double tuned filter and mostly it is active and this one is passive. So, essentially it is a hybrid shunt active power solution with passive entity that has been placed in parallel to another passive entity.

This hybrid filter is a combination of the shunt active power filter AFsh1 in series with a parallelly connected active shunt filter AFsh2 and the passive shunt. This filter PFsh.

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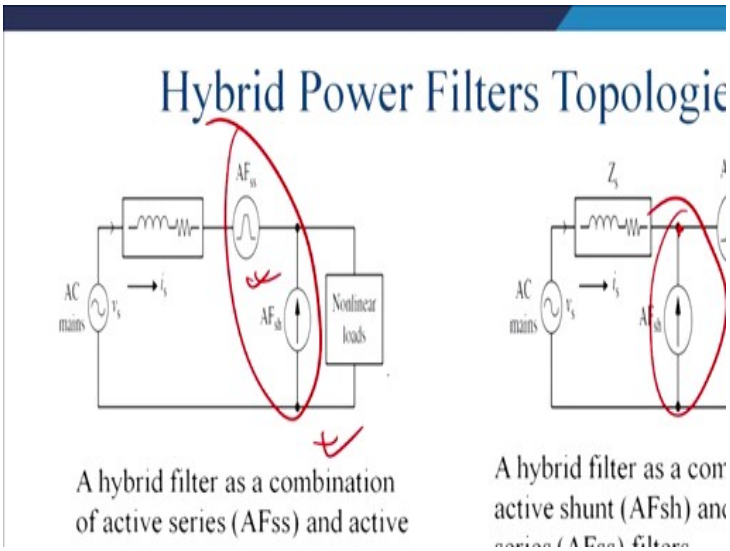

So, now as you understand this combination which is active-active combination. This is nothing, but a UPQC. Though you can say that it is active-active combinations and it is the normal UPQC. This is essentially the right shunt solution and we prefer the right shunt solution because first you mitigate the voltage harmonic, then you compensate the current harmonic. Here it is called the left shunt solution, but generally we do not prefer because we cannot clean the voltage at the PCC. Because since voltage is dirty then reference generation also becomes challenging and for this reason this method is been preferred.

But once you have this combination, and you know it has been preferred here. So, this is one of the preferred conditions. This one and the previous one is what we have seen. The add on is a passive element and it may be existing previously and thereafter you add a UPQC and thus the overall topology comes like this and that may be the conditions sometime. You are retro fitting it. This is history of conversion.

First it may be that capacitor only which has been placed to mitigate the power factor problem. Once you see the power factor problem and if you have adjustable speed drive it causes a problem. Hence you cannot leave this capacitor alone and for this reason you put an inductor. That inductor essentially got a selectivity, this LC combinations is a single tuned filter. Once you get a single tune filter you find that it is not enough to compensate because of the detuning problem and also the ageing problem and thus you

place an UPQC. Ultimately it becomes a left passive shunt UPQC. This is one of the solutions.

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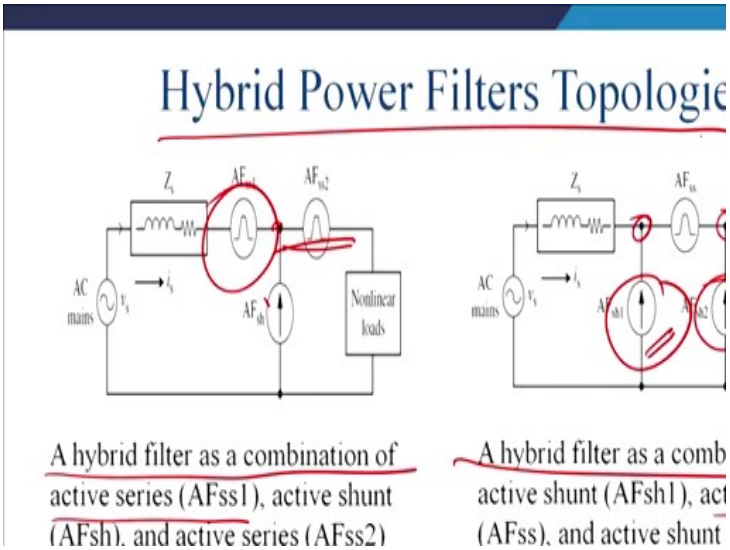

Now, we talk in more detail. Since this is the combination of the two series filter before cleaning and after cleaning of the current. This we will try to clean the PCC voltage and then only inject and ultimately the load side is quite high in between. Due to the source inductance some amount of the voltage also come into the picture. In between you again place a series active filter to mitigate those harmonics. It is called the hybrid filter as a combinations of the active series AFss1, active shunt AFsh and active series AFss2 filters.

The hybrid filter as a combination of the shunt filter and the active series filters and the active shunt filter. That also comes into the picture here. This is also there. You have two passive filters. We have Professor Bhattacharya acting on it, but this was missing. Since this voltage may be an add on, your PCC voltage may be less due to the sag. You do not have a problem, but here your PCC voltage may be high, but your voltage has been cleaned and thus you give a total solution and ultimately you have segregated the problem.

AFsh1 and AFsh2 may produce the other higher order harmonics and you get a total optimal compensation. Look total optimal compensation depends on many issues and on many areas and also sometime it has historical reason also. What kind of solution already

existed there? If it is totally a new side, then grid can be filled with this kind of entity. But most of the cases we require to retrofit it. Once you retrofit it then of course previous solution needs to be taken into the consideration and you have to accommodate it and thus you give a better solution.

That the main intention to understand the hybrid power topology. Of course, you do not go by this kind of topology at one go. If UPQC is sufficient why you go for it? See. You already find that there is a passive filter. Then you connect a UPQC. Then sometime this topological variance comes into the picture and that require to be analyzed and you have to give optimal solution. For this reason, we prefer these entities.

Now, this is one of the examples of it. You have seen the one leg block diagram. This is one of the shunt active power filter.

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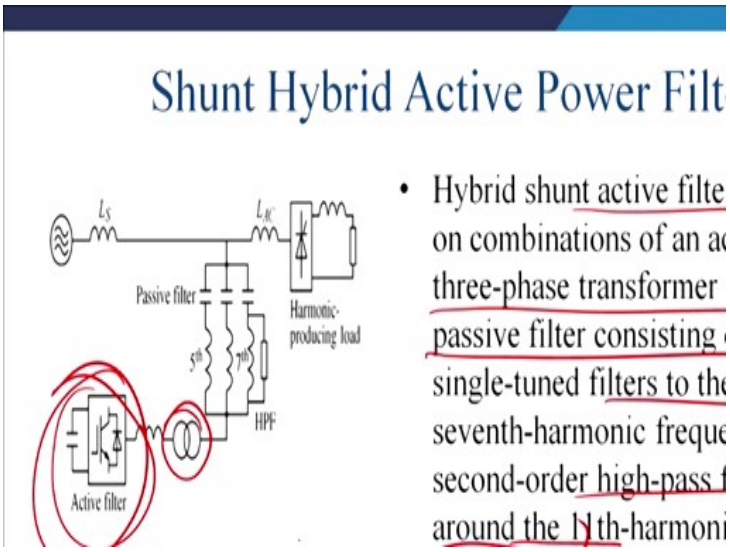

What is it? You have to match the circuit. So, here this is the circuit. Not this. This. So, you have an active and the passive combination. Generally, what happens? You have active power filter. It was a history and at that time it was a square wave kind of generation of a STATCOM with a GTO or thyristor and you step it up, because this rating required to be less because of the switching problem. Switch of that level was not available. So, we wanted to find solution which is a 2-level inverter and now you tune the passive filter into the fifth, seventh and the high-pass filter and ultimately this part is

a passive and this part is an active. Then little detune will be automatically adjust this active power filter and thus you get a better solution.

What you can say? That, active hybrid shunt active filters are based on the combinations of the active filter, three-phase transformer, passive filter consisting of two single tuned filters of the fifth and the seventh harmonic. These are the dominating harmonics and a second order high pass filter tuned to the eleventh harmonic frequency. So, this is a practical solution, what we have discussed till now with this one line diagram.

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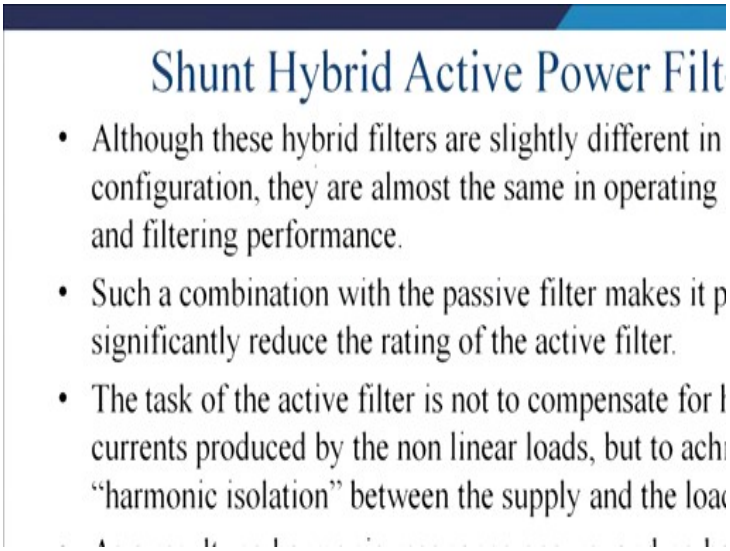

So, what we can say? That although this hybrid filters are slightly different and we have to understand the complexity of it. Different circuit in configuration are capable of almost the same operation principles as the passive filtering operation. Such combinations with the passive filter make it possible to significantly reduce the rating of the active filter. That is also a challenge sometime.

The task of the active filter is not to compensate for the harmonic current produced by the non-linear load, but also provide or achieve the harmonic isolation between the supply and the load. As a results no harmonic resonance occurs, no harmonic source current flows to the supply and thus it damps out the harmonic oscillations.

Thank you for your attention. We shall take out how does it can be done by this active filter in our next class and thereafter we will have a concluding class. We will conclude

what we have studied in the shunt active power filter, series active power filter, UPQC and most of the solution you have seen in a harmonic domain. We shall also discuss about the notches, spike and those solution and we will conclude our discussion.

Thank you.