Electromagnetic Compatibility, EMC
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Module 4.3
Crosstalk near Field Coupling
Coupling to Shielded Cables

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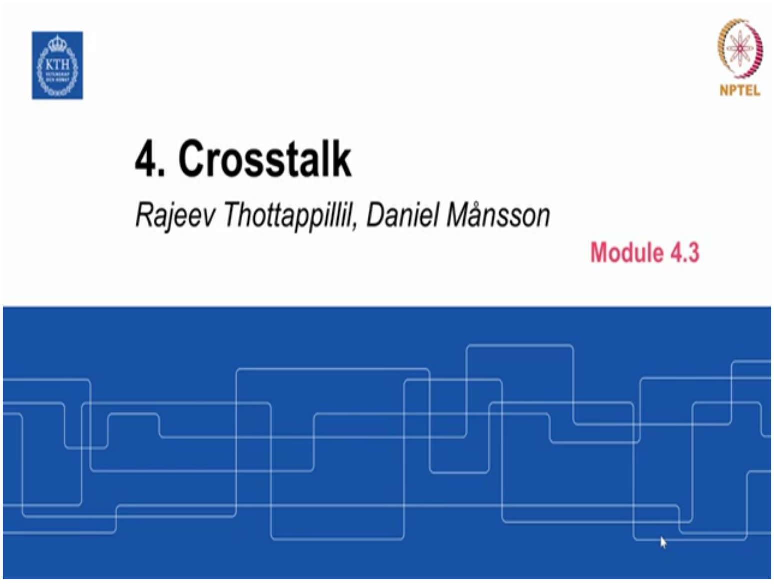

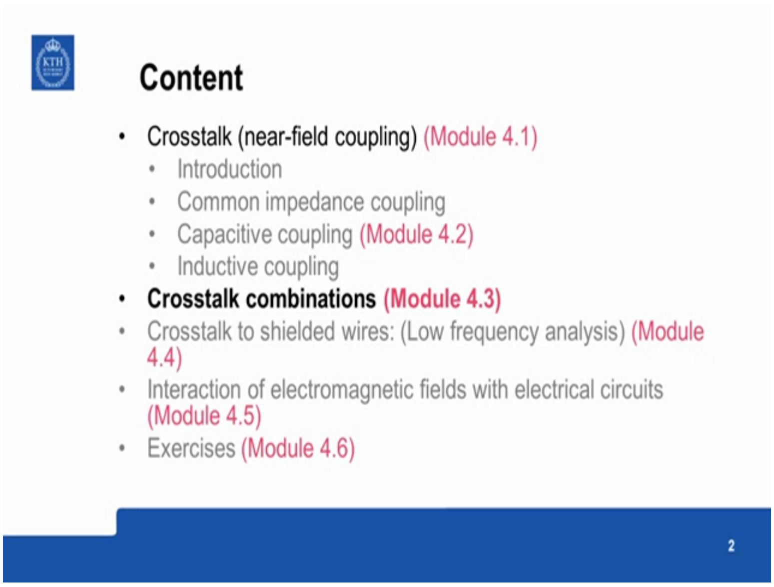

Crosstalk or near field coupling module 4.3, in this module we consider crosstalk combination, that is combination of capacitive coupling, inductive coupling and common impedance coupling.

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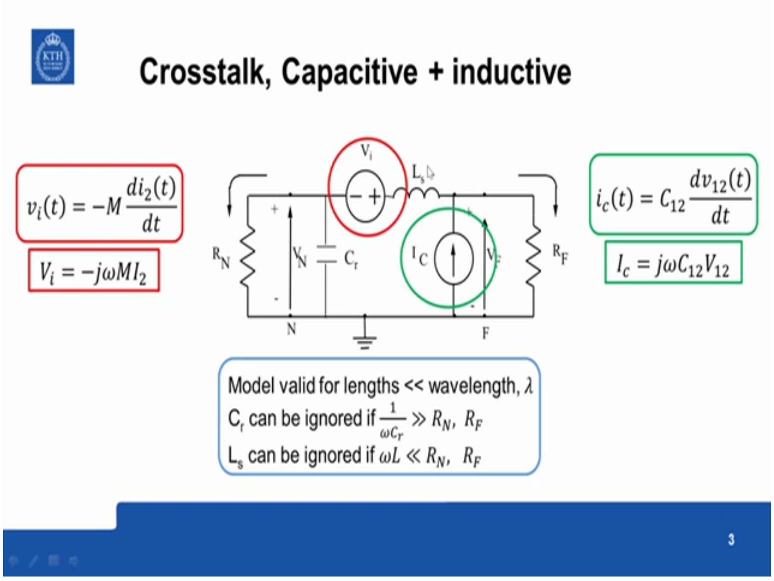

So what is shown here is the sequence circuit of the model for capacitive and inductive coupling combined into one, you can approach it that, ignore this part IC and then what you get is the situation for the model for inductive coupling in the field, if ignore this source VI then you get the situation capacitive for capacitive coupling, the source VI is given by the mutual inductance between source circuit and victim circuit and DI by DT, DI2 by DT, where this current I2 is, in this source circuit not the current in this circuit but in the source circuit, so this source independent of this circuit parameters over here, now this is the frequency combine minus J omega MI2.

Similarly for the capacitive coupling part, the source IC is even by C12 DV12 by DT, where C12 is the coupling capacitors between the victim circuit and the source circuit and DV12 is the voltage difference between source and victim circuit, again this current is independent of the victim circuit over here, so in frequency domain IC equal to J omega C12 V2, now we have the series inductors L, that is applicable for the victim circuit and you have the capacitors to the reference CR, so these, in some cases can be neglected but now problem is, as a matter of practice always include the series inductors and parallel capacitors to the reference, when you draw the model, then check to see if one can conveniently neglect the model out, so we can neglect CR, if 1 by omega CR, that is, if this impedance, capacity impedance is far greater than the impedance at the end, so in that case we can neglect this, so this has to be checked always and make sure before neglecting it.

Say for example where if the far end resistance or impedance is were higher, say of the order of 1 omega ohms so something like that and this capacitance and the frequency is extremely high of the order of 100 omega hertz and all, these conditions may not be true, so one has to really check that, similarly the series inductive impedance unless can be neglected only if this is far less than the impedance of the near end and the far end, so at very high frequencies sometimes these conditions may not be true, so one has to really check that, this two conditions before we moving, these capacitors has, before removing this inductance.

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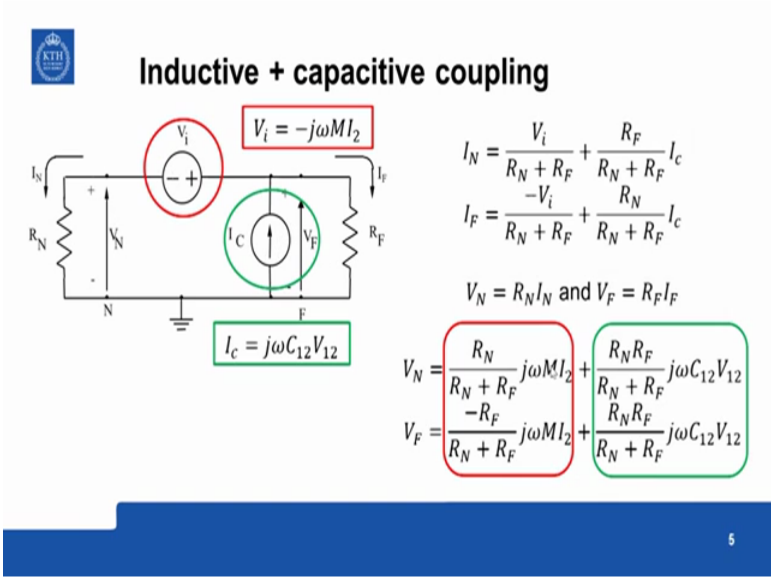

Now assume that we have such conditions as given above and we removed neglected the capacitance and the series inductance, then in that case the model is reduced to 2 resistance at the near end and the far end and 2 voltage sources, one representing the inductive crosstalk and other representing the capacitive crosstalk or the magnetic field interaction and inductive field interaction, note that we have reverse polarity here to be consistent with this near current over here, so the negative sign in front of this is absorbed into the source polarity, now for finding the voltage across this VN and VF, we can apply superposition theorem of this circuit analysis, so let us say VI equal to 0 that is the only capacitive crosstalk is available, well in that case, this current IN is shared, IC is shared between this and this, so it is IN will be RF by RN plus RF times IC in a from circuit analysis and this is for IF, so you have different currents split but then it is, in terms of voltage then it will be multiplied by RN and here to be multiplied by RF, that we will see the next slide.

Now if IC equals to 0, that is inductive crosstalk only, so if it is from their and only in the series voltage source then this voltage is dropped across this plus this, so the voltage drop across this, the total current IN equal to minus IF, in that case and this VN will be RN IN and VF equal to RF IF, so IN with inductive crosstalk is, this VI divided by RN plus RF and IF is minus VI, so if we combine this two together, we get the near end current and this is the far end current, so in general they are not equal, now let us see multiplied by these terminal impedances to get voltage as VN and VF.

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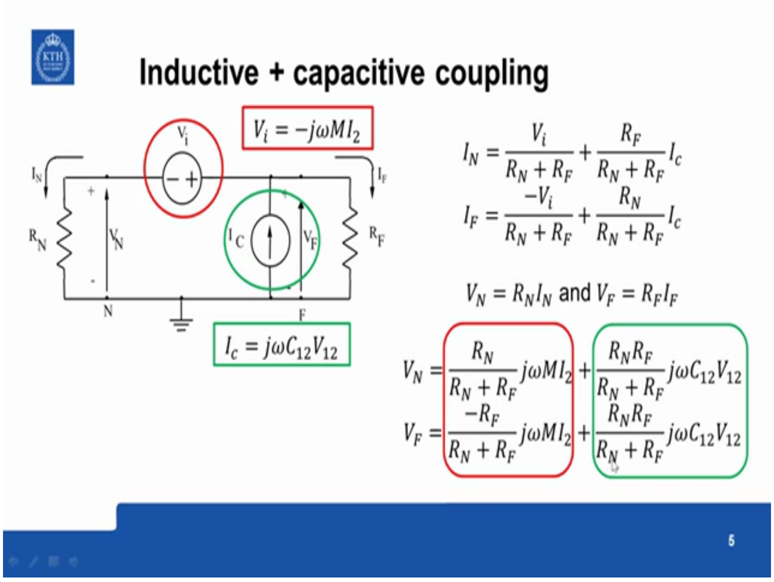

So there the two sources here VI minus J omega MI2, IC then you write it down IN, IF, so VN VF, so VN is victim by this expression and VF is victim by this expression, now the first turn in this represent the inductive coupling and the circumstance in both trapezes capacitive coupling, you can individually see some interesting properties says if you look at the capacitive coupling, whether it is near end or far end either identical RN and RF need not be the same, even than both will be equal and they have the same polarity.

Now here if you look at the inductive part of the coupling, one is, here it is positive and here it is negative, in the near end it is positive, in the far end it is negative and they have different magnitude, if because in general RN is different from RF, they will have say magnitude but opposite polarity, when RN equal to RF, also you will see that in the near end the crosstalk voltage is higher compared to the far end because you these two times R cancelling or they have opposite polarity, here it is same polarity, so near end crosstalk is higher, so remember that near end and far end are in relation to where the source is the original circuit because we do the source in the near end, the source of the, the source circuit we have the source in the near end, so that is the near end, the other one is the far end.

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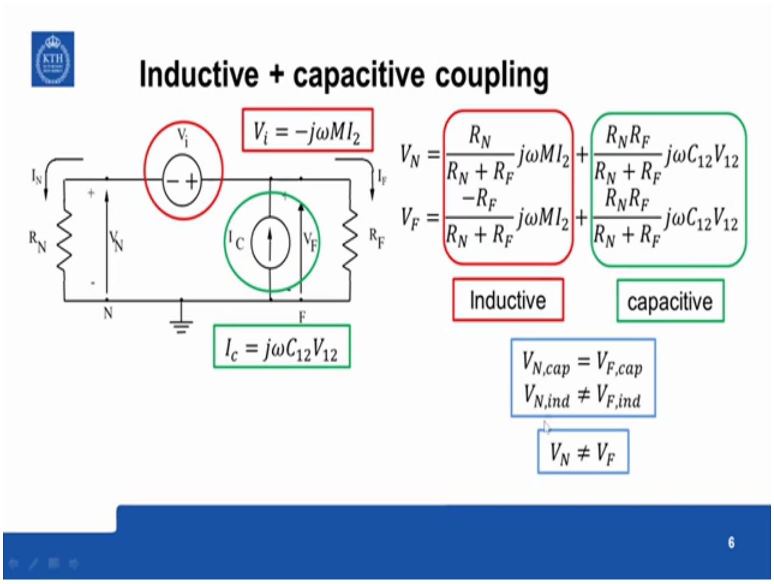

So the inductive in capacitive coupling, what I said just above, is recap here, the capacitive coupling part is saying, the both near end and far end, whereas inductive part is different, so in general VN is not equal to VF.

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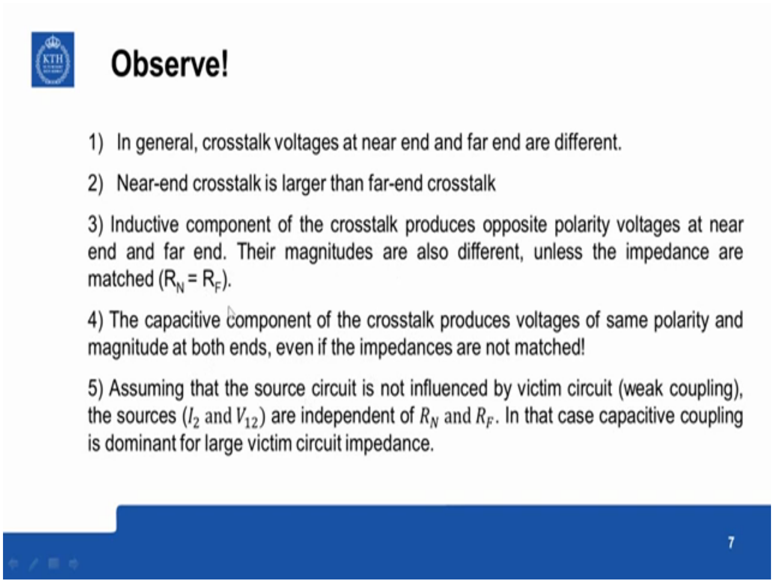

So crosstalk voltages that near end and far end are different, near end crosstalk is larger than far and crosstalk, inductive components of the crosstalk produces opposite polarity voltages at near end and far end. Their magnitudes are also different, unless the impedance are matched, the capacitive component of the crosstalk produces voltages of same polarity and magnitude at both ends, even if the impedances are not matched! Assuming that the source circuit is not influenced by victim circuit that is the weak coupling, then the sources I2 and

V12 are independent of RN and RF. In that case capacitive coupling is dominant for large victim circuit impedance, so all this things we can observe from the model.

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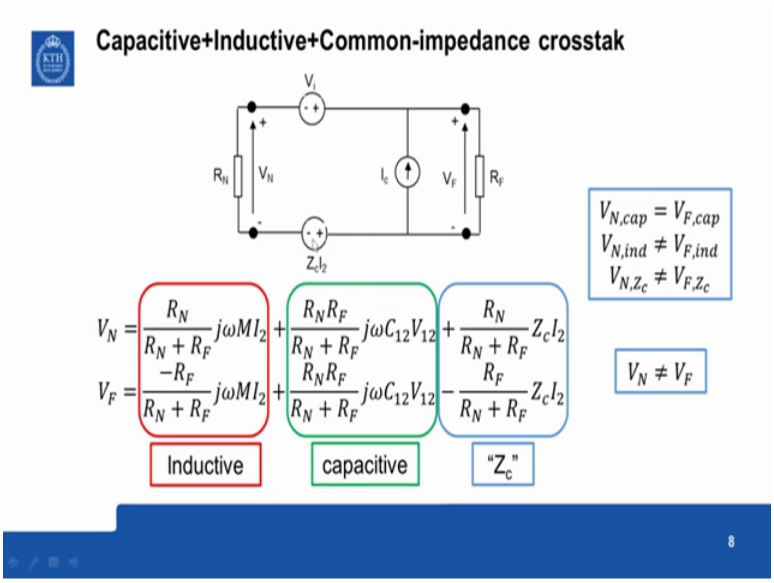

Now we also add the common impedance crosstalk to the equivalence circuit, we neglected the parallel capacitors to the ground and the series inductance, so this is the common impedances, the current is flowing, assume to flow like that, so this is the positive polarity, you can see that, the noise from the common impedance coupling, where this is the noise from the inductive coupling and this is from the capacitive coupling, so if you look at infinite equation, so here this is positive polarity, so this is disturb, sorry this is a RF.

So this is disturb because VI is equals to minus J omega I2, so this minus is coming from that wards and this is, this minus M minus J omega I2, so that cancels and it becomes plus, this inductive part and the capacitive part they are the same and for the common impedance part, here it is minus because it is become this dual line that, so in the far end part minus RF by RN plus RF ZCI2 and here it is positive, positive so the polarity of common impedance coupling, the voltage across and the inductive coupling, voltage across they are the same and similarly here both a negative, so common impedance coupling somewhat behaves more like a inductive coupling except that this is, this may not be a function of frequency that has, there is a function of frequency, this can be appear a sister or it could be the function of frequency or so if there is some inductive element involved in the common impedance.

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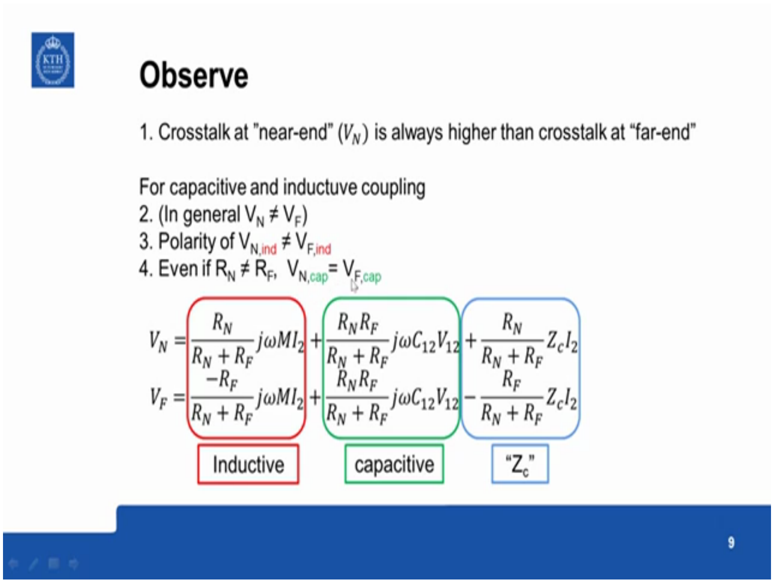

Now in this case also we find that near end crosstalk VN is always higher than crosstalk at far end VF, due to this negative polarity, for capacitive and inductive coupling in general, VN is not equal to VF in general and polarity of VN induce is not equal to VF induce their opposite polarity, even if RN is not equal to RF, VN the component of VN and VF due to capacitive coupling alone can be equal.

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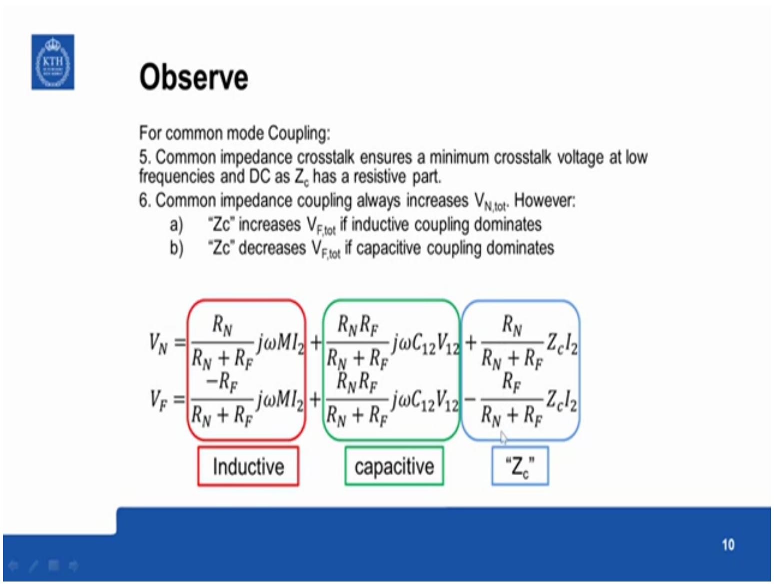

For common impedance, common mode coupling, the common impedance crosstalk ensures a minimum cost of voltage at low frequencies because when the frequency is extremely low or zero, you can see that these terms are disappearing, this terms are disappearing but this, because of DC resistance of common path, there will be some common impedance coupling, so common impedance coupling always increases VN total, however ZC increases VF total, if inductive, path is dominant, so if this part is negligible, so if it is a no impedance circuit in general, so this path may be dominant, then common impedance coupling increases the far end crosstalk and also increases the near end crosstalk, but if capacitive coupling is dominant, then it increases the near end crosstalk but may decrease the far end crosstalk, so you can find some difference between near end and far end with common impedance coupling, so that ends the model 3. Thank you.