Course name: EMI /EMC and Signal Integrity: Principles, Techniques and Applications.
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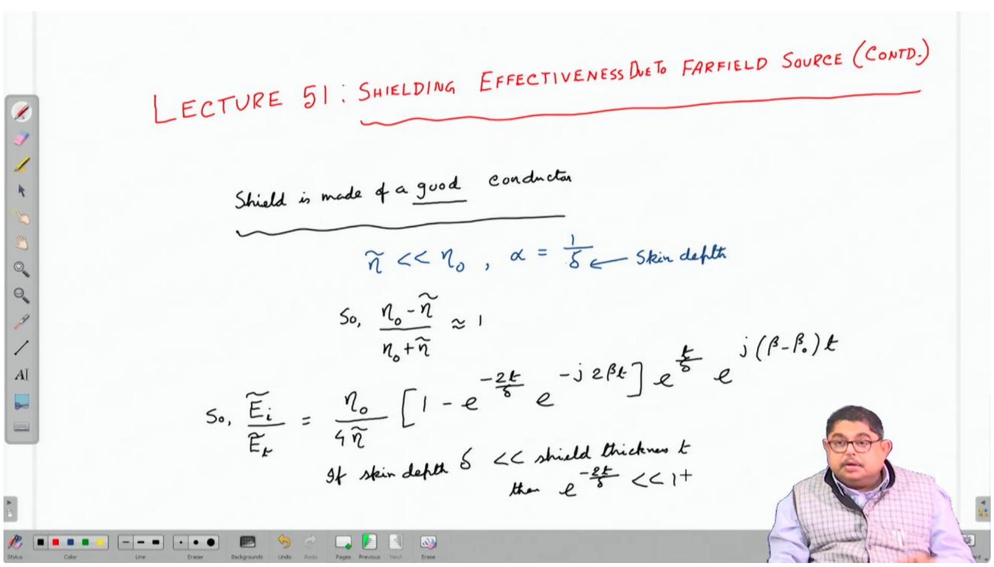
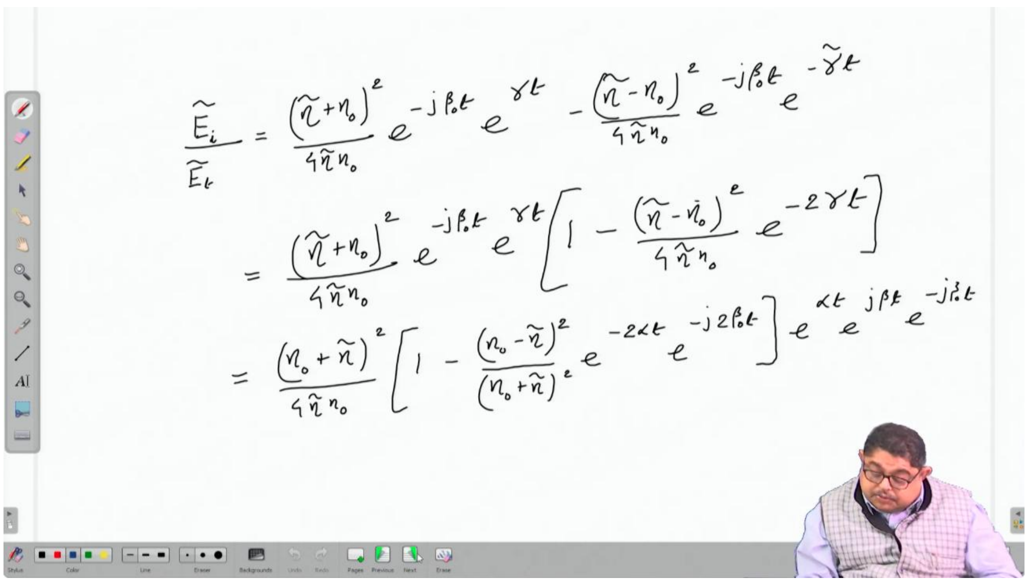
Week :11
Lecture 51: Shielding Effectiveness Due to Farfield Source (Continued)

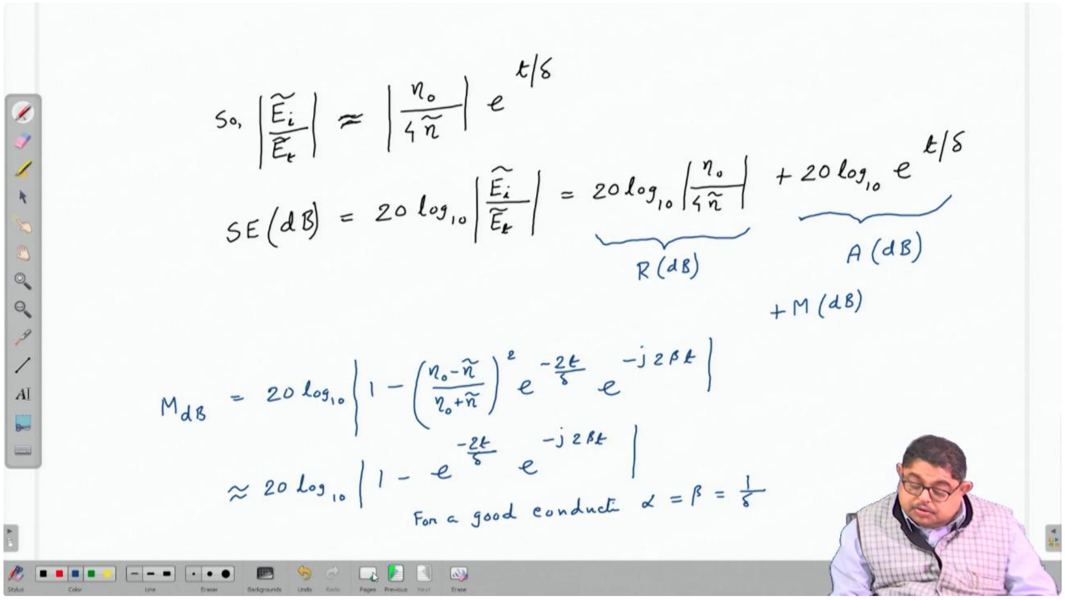
Welcome to the lecture of the course on EMIMC and Signal Integrity Principles, Techniques and Applications. We were seeing or we have derived an expression of shielding effectiveness in the last class that we will now customize for a shield which is a good conductor because that is more practical. So, shield is made of a good conductor. So, if the shield is good we know that what are the effects that intrinsic impedance of the shield will be much less than the free space intrinsic impedance. So, with this we get eta naught minus eta by eta naught plus eta will be basically 1. Also for good conductor we know the alpha is given by the inverse of the skin depth. So, this is the skin depth alpha is the attenuation constant of the shield material. So, what will happen to our so, E I by E t expression that we derived that will be eta naught by 4 eta into 1 minus e to the power minus 2 beta t by delta then e to the power minus j 2 beta t then e to the power t by delta e to the power j beta minus beta naught. Now, if skin depth delta is much much less than the shield thickness t then what is e to the power minus 2 t by delta it becomes very very small than 1.



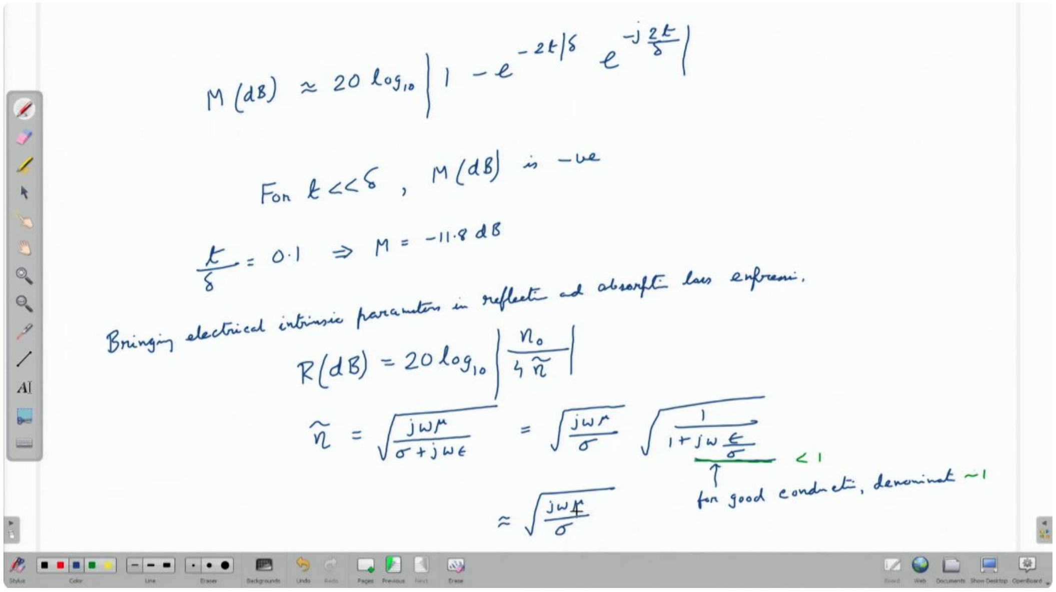
So, what happens to our E I by E t magnitude because ultimately we will have to take this magnitude for before for taking log. So, this will be roughly eta naught by 4 eta e to the power t by delta. So, in dB scale we can say now that A c dB is 20 log E I by E t and this is the value and that is we can say 20 log 10 eta naught by 4 eta plus 20 log 10 e to the power e by delta. So, you can easily identify that this is the reflection loss. So, I can say this is R dB and this one is what is taking place inside the shield. So, it is the absorption loss, but we have previously seen that S e is equal to R plus A plus M that multiple reflection loss where it has gone actually we have neglected it. You see that when we took skin depth is very less than t this third bracket term that got neglected, but if skin depth is not such then this term exist. So, this is actually our multiple reflection term. So, if you go back further that this third bracket you see is a multiple reflected term. So, that we can take it that 1 minus this is the exact expression.



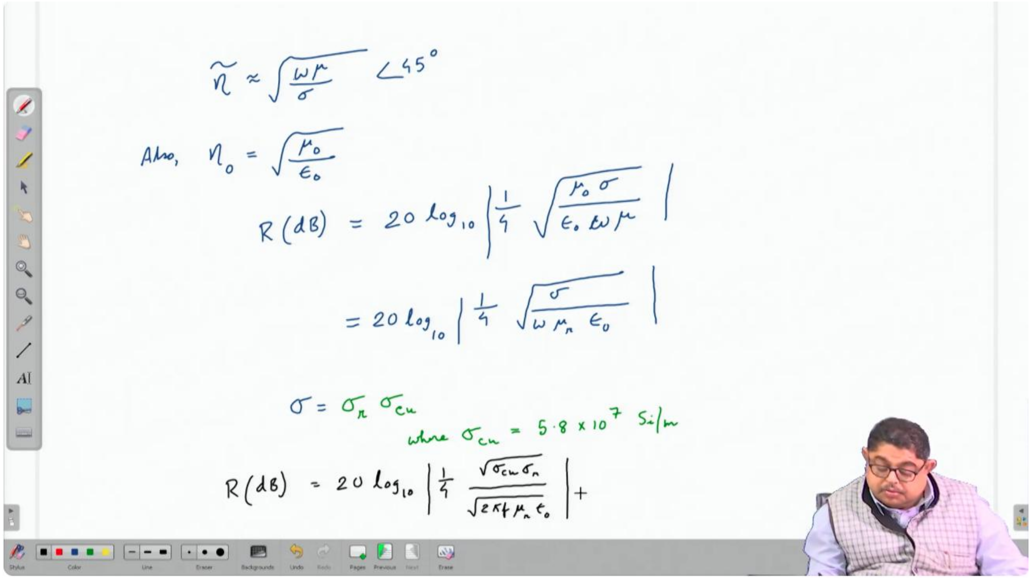
So, I will write that that here plus M dB, but it is negligible and what is that M dB? M dB is 20 log 10 1 minus eta naught minus eta by eta naught plus eta whole square e to the power minus 2 t by delta e to the power minus j 2 beta t is approximately 20 log 10 1 minus e to the power minus 2 t by delta e to the power minus j 2 beta t. So, you see that fields that are constructed for a from a good conductor and of considerable thickness for them the same can be neglected, but if not then this should also be taken. So, further there can be another point that for a good conductor for a good conductor we know that what is alpha? Alpha and beta both are equal to 1 by delta.



So, M dB is roughly 20 log 10 1 minus e to the power minus 2 t by delta e to the power minus j 2 beta t by delta. Now, for fields that are thin compared to skin depth that means, that is maybe there that it is smaller than skin depth that is for T is less than delta you can easily see from here that M dB is negative. So, that means shielding effectiveness gets reduced by the multiple deflections so that means, the effectiveness decreases. So, let us take for example, that T is actually this is a rare case, but let us take T is equal to 0.1 that means, skin depth it is very small T is one tenth of that that if you calculate this number this will be M will be minus 11.8 dB. So, whatever shielding effectiveness you are getting it is decreasing that by roughly 12 dB. So, it is not a good one good phenomena. Now, what we will do? We will mainly do with because this is a rare case. So, mainly we will do with the reflection loss and absorption loss. Now, we have derived their expressions in terms of intrinsic impedances instead of that we will put the material parameters themselves into them. So, that will be further simplification of those two. So, bringing the electrical intrinsic electrical intrinsic parameters into reflection and absorption loss expression. So, we have found that what is R dB? R dB is 20 log 10 eta naught by 4 eta. Now, what is eta? Eta also we have seen that it is root over j omega mu by sigma plus j omega epsilon. So, that is root over j omega mu by sigma then we get 1 by 1 plus j omega epsilon by delta. Now, for good conductors for good conductors we can see this factor omega epsilon by sigma because sigma is still quite high. So, it is reducing this part. So, we can say that the denominator much much for this factor is less than 1. So, for good conductor I will say this factor this factor is less than 1. So, denominator is roughly 1 so that means this part goes. So, we can say that is roughly root over j omega mu by epsilon.



So, that means eta is we can say root over omega mu by sigma magnitude part and this part is 40 degree phase. Also we know also eta 0 is what root over mu naught by epsilon naught or 27, 27. So, R dB in terms of this parameter this equation is nothing new it is same as the previous R dB expression only thing is we are putting them and so that a better expression comes. So, R dB is 20 log 10 1 by 4 root over mu 0 sigma by epsilon naught mu r epsilon naught omega mu naught omega mu naught. So, that is 20 log 10 1 by 4 root over sigma by epsilon naught omega mu r epsilon naught. How I got this because mu r I can write as mu naught into mu r. So, this mu naught and this one got cancel. So, I got this now generally in EMC engineers they refer the conductivity of any material with respect to conductivity of copper because conductivity of copper is known. So, they write epsilon as epsilon r epsilon r into epsilon cu copper where epsilon cu is equal to 5.8 into 10 to the power 7 Siemens per meter. So, now these values can be put and so R dB becomes is 20 log 10 1 by 4 root over sigma cu sigma r by by this 2 pi a square.



So, R dB I am continuing. So, again I am new next new page. So, I am writing this R dB is 20 log 10. Let me take all the known values together and unknown values as a separate. So, it will be 1 by 4 root over 5.8 into 10 to the power 7 the conductivity of copper divided by 2 pi into 8.854 into 10 to the power minus 12 this is the epsilon naught per and what remains is 20 log 10 root over sigma r by mu r into f. Now, if you calculate this it will come as 168.14 plus you can say 10 log 10 epsilon r by mu r into f. So, now you see we are getting a picture that reflection loss is higher at lower frequencies and also it is higher for high conductivity metals because it is proportional to epsilon r is inversely proportional to frequency. It decreases its frequency response is it decreases at a rate of minus 10 dB per decade with frequency. So, for copper let us find for copper mu r will be 1 sigma r will be 1. So, what will be R dB? R dB is 168.14 plus 10 log 10. Now, you will have to tell frequency. So, I can say that at let us say 1 kilohertz R dB will be 10 log 10 into 1 by 10 to the power 3. So, this is equal to 138 dB at 1 megahertz. It will be 1 megahertz means 10 to the power 6. So, you will have to divide from 168 to the power 6. So, that will be 98 dB. Now, let us see for steel. So, this justifies that at lower frequency reflection loss is good at higher frequency the more we increase the frequency the reflection loss for good conductors they decrease. For steel, but to make the shield it should be in sheet form. Now, that is important that because these various materials particularly metals they have different values of their electrical parameters for different shapes. So, for steel it has a in sheet form it has a relative permeability of 1000 and epsilon r is 0.1 that means it is one tenth the conductivity of copper, but at 1 kilohertz the reflection loss for a steel made shield is if you calculate it will be 98 dB at 10 megahertz this is 58 dB. So, obviously, copper gives better shielding effectiveness, but you know it is much much costlier than this steel, steel is much cheaper. So, generally it is made with steel and you can easily find that at any frequency what will be the reflection loss. Similarly, we will have to find out an expression involving the intrinsic parameters for absorption loss and from that we will have to see what is its frequency variation etcetera and we will have to draw proper conclusions for that. So, that we will do in the next class because today time is up. Thank you.