Basic Building Blocks of Microwave Engineering
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Lecture- 15
Microwave Attenuators

In this 15th lecture, we will see Microwave Attenuators. Now, attenuation you know if I have any device which has some loss. So, that is called insertion loss or attenuation insertion loss they are similar or same.

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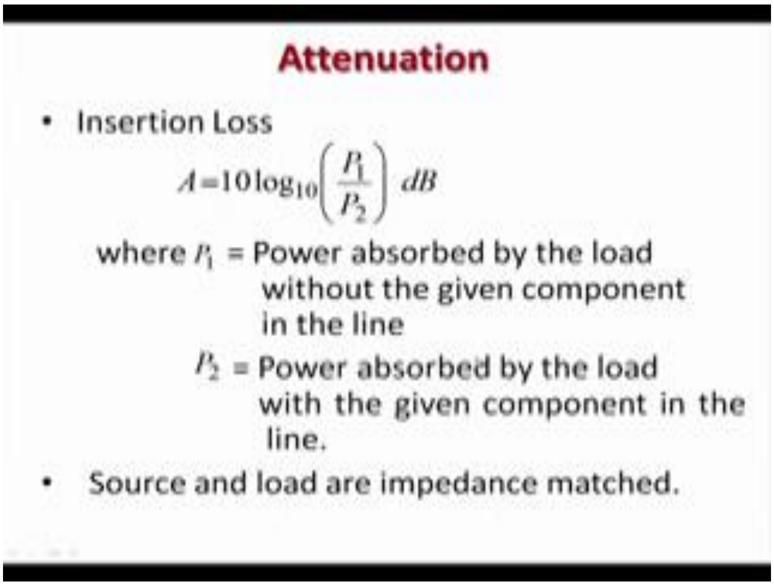

So, A is given by the ratio of P1 and P2 where P1 is power absorbed by the load without the given component, suppose I am not putting that device in the network. So, there is the power absorbed by the load and load is taking power now I put that device still there will be some other power. So, if I make that and make the ratio P1, P2 that is called attenuation.

So obviously, here will have to assume that source, load and all other components they are impedance match. So, in miss match no power is getting lost and in that case this will be the definition of attenuation.

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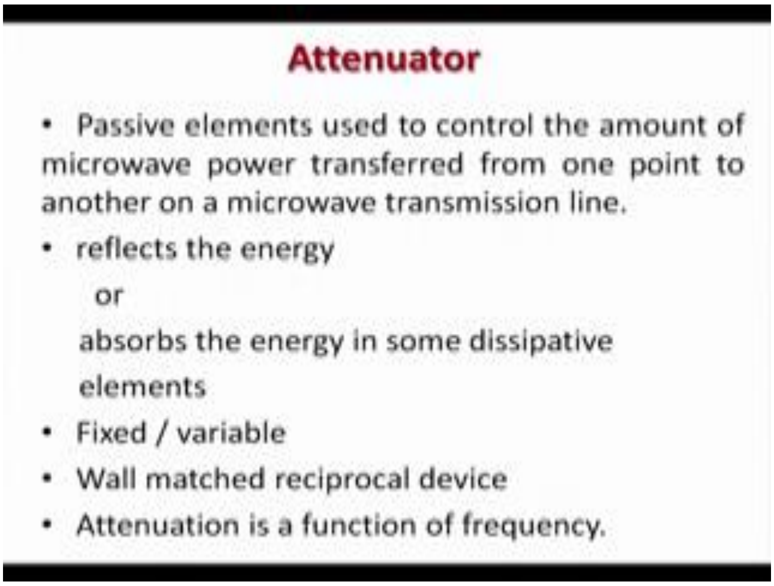

Now, attenuator is passive elements which are used to control the amount of microwave power transferred from one point to another on a microwave transmission line. So, you have two options, whatever power is coming if you want to attenuate either you reflect the energy or you consume the energy that is absorb the energy in some dissipative elements. Generally, this absorption is done. Now, there are attenuators which are available in microwave region they are either fixed or variable, fixed means always that device will be able to give you a fixed attenuation and variable you can change as many db of attenuation you want to change.

Now, many times you see that suppose I have a signal source and in the lab we face these suppose you have a signal source which gives you a 20 volt thing, but you want to see that signal that time you will need to connect it to the oscilloscope and oscilloscopes are they cannot handle 20 volt signal. So, you need to have an attenuator in between so that, your signal will come to 5 volt or something of every oscilloscope has a specification what its maximum voltage can handle.

So, attenuator is a must there then as I was saying that you see if you have a directional coupler then no problem that always in the couple port you can measure, but even in a radars suppose the directional coupler even after coupling of 10 db 20 db the power may be substantial and if you want to see that power or see the signal wave form in the oscilloscope or any spectrum analyzer and the problem is that power may be too high for them. So, you need to put attenuator there etc. Fixed or variable then not wall matched, it is a type of when a well matched reciprocal device and generally this is made of reciprocal devices and there is no directivity both way it should able to match, well matched the two ends it should be matched so that due to it no mismatch should take place and attenuation is a function of frequency because in high frequency things the way we attenuate they change with if we change the frequency of the signal.

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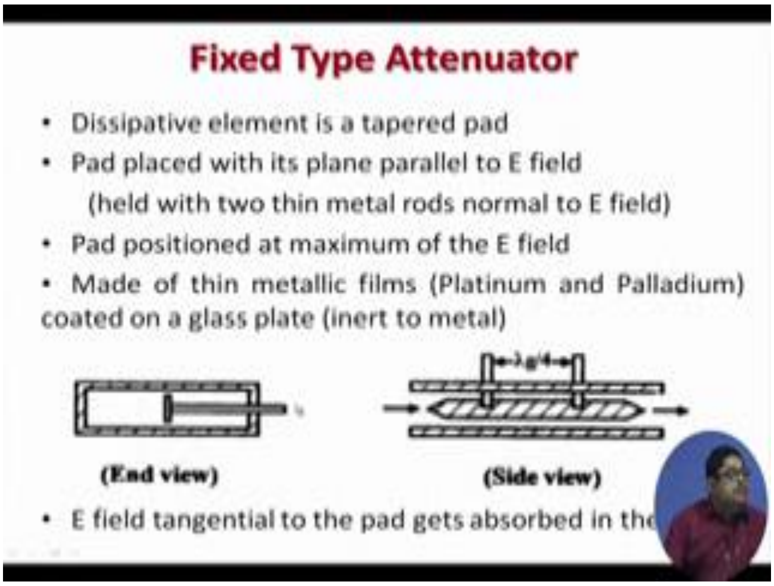

So, fixed type attenuator let us first see it is a dissipative element is this tapered pad, actually tapering we do so that, the mismatch is not seen gradually we change the impedance and if we give a resistive pad a metallic pad, then it will reflect as you know that metal absorbs the fields up to the skin depth. The pad is placed with this plane parallel to E field in a wave guide we know what is the E field and the pad is also placed with its E field parallel to it and it is held with two metal rods the length of lambda by g by 4 that means, we know that the magnetic field is varying with lambda g by 2. So, half of that variation we can put the pad. Pad also positioned at the maximum E field which we know in a rectangular wave guide, it is like this at the center where you have the rectangular wave guide thing.

So, that pad is also placed at the center, E field tangential to the field get absorbed in the pad and whatever tangential field is there in the field because on a metal the tangential field is falling which is getting absorbed in the skin layer in that direction this fixed type of attenuator.

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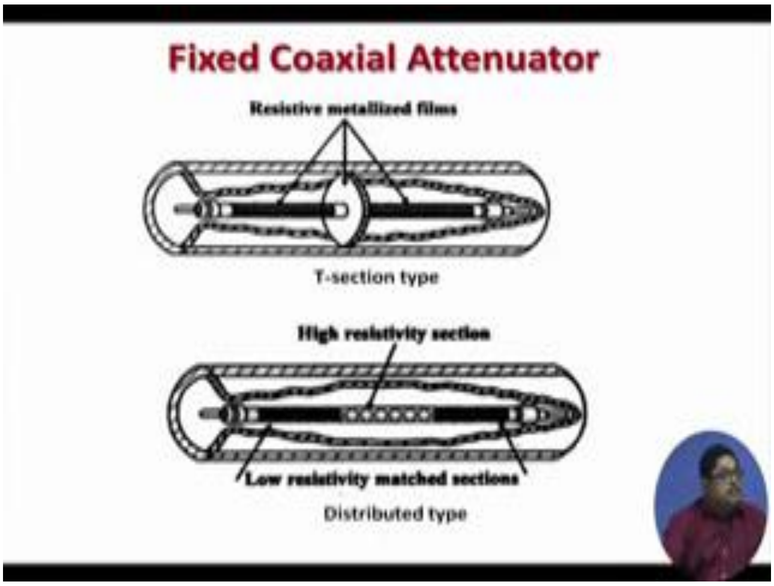

Now, this is fixed coaxial attenuator and this is distributed type attenuator. So, these are coaxial bar cells.

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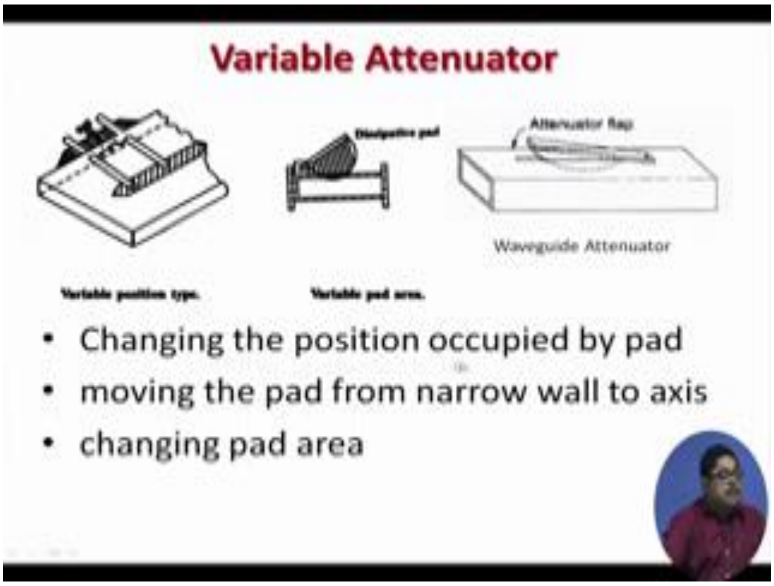

Now, variable attenuators by changing the position occupied by pad because pad suppose if it is moved from narrow wall and you see this is the narrow wall of the wave guide to the axis if we change the position what happens actually the you know from the narrow wall to the center of the axis the magnetic field etc changes, the value of the electric field changes. So, the electric field at the narrow wall is minimum 0 and at the maximum it is center.

So, if I change the pad position from narrow wall to the center of the guide we are changing basically the attenuation level changes and also sometimes this dissipative pad its area we can change, we can use it as a flap. One portion is going inside. Now, how many portions you are taking out by that you are changing the pad area and this is an example of that flip attenuator flap and it can change that area which you are going inside that determines how much attenuation you can take.

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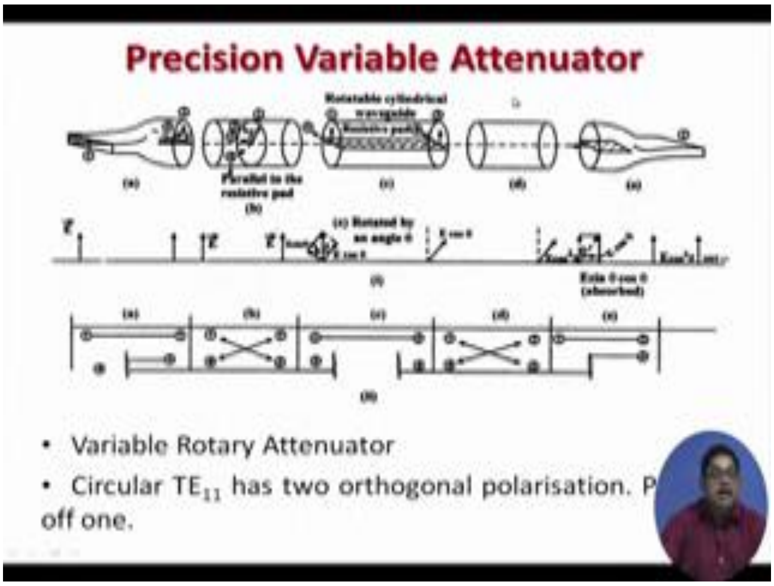

Precision attenuators are made of five parts and suppose you have a rectangular wave guide. Now, you convert to circular wave guide and these are basically a wave guide adopter. So, rectangular guide to circular if you make, now circular wave guide has this t 10 mode in a circular wave guide it will generate t 11 mode and it has got both polarizations, one is tangential to t 10 and another is perpendicular to that and that polarizations now you put the resistive pad. So, the one which polarization you want to suppress depending on that you put it there and then again whatever you have done here you do opposite then here the parallel to the resistive pad it was placed here also same and then this back to again t 10 guide.

So, whatever was the electric field that electric field after you change it to the circular one, you get a E sin theta type of variation and it is rotated by sin theta and then with that angle that component which is tangential will be destroyed or attenuated. So, basically by changing this theta you can change the attenuation level and this is the blocks.

So, circular TE11 has two orthogonal polarizations, pad cuts of one. By knowing the theta how much you are varying, you can change the attenuation level because if you vary theta basically you are varying sin theta and you know that this mapping is quite good and by that you can find out how much attenuation you are changing in the level.

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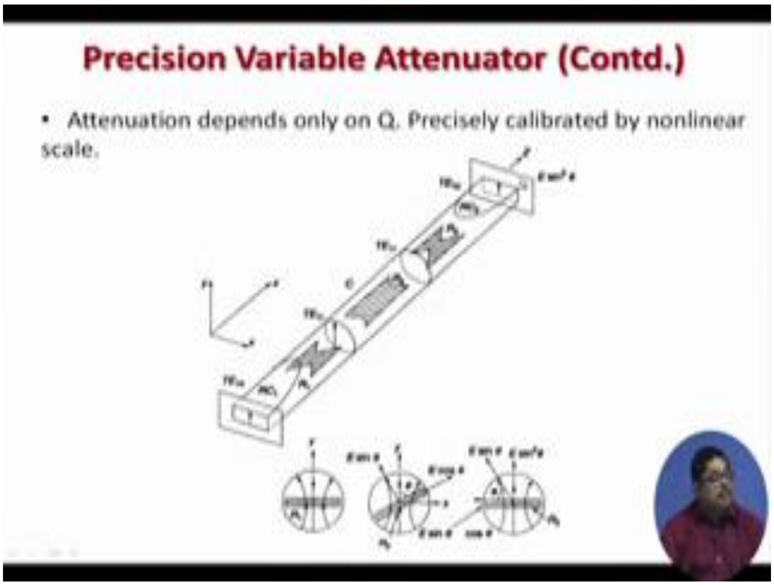

So, this is the diagram of a thing and also attenuation depends only on Q and precisely calibrated by nonlinear scale.

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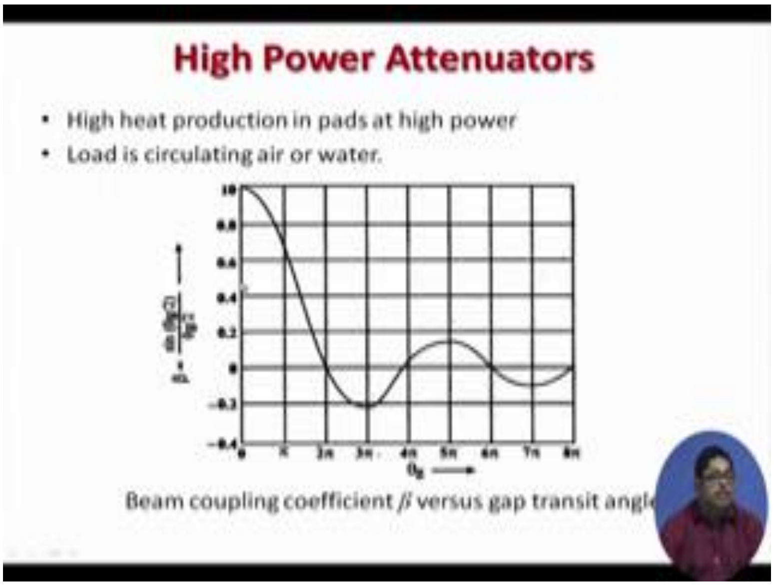

Now, if you have low power no problem, but if you have high power and if you give it to those attenuators then that pad is taking that power. So, it gets heated up and high heat production in pad set high power. Then, you need to have air or water circulation around the pad so that, the power can be taken away.

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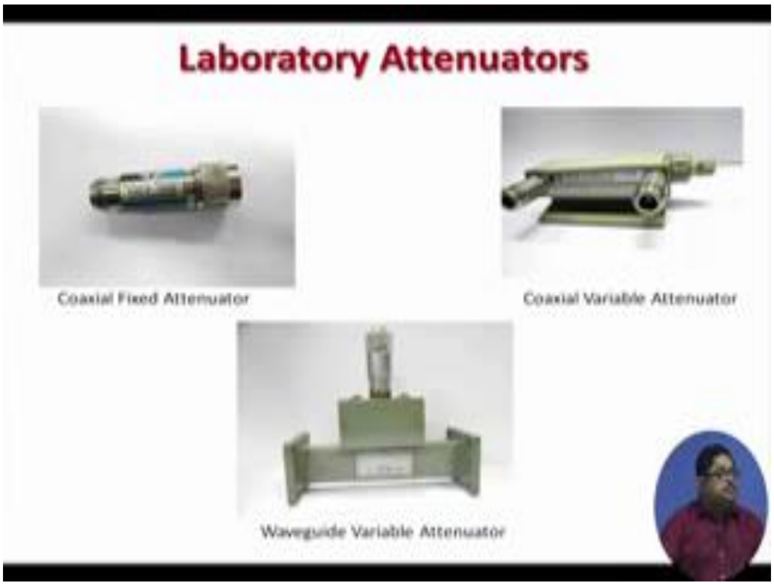

Then these are our laboratory attenuators, you see this is a coaxial fixed attenuator and there is a resistive pad inside coaxial variable attenuator these are for variable varying this attenuation because sometimes we need to vary the attenuation level to see where the we are getting the best of the signal and this is wave guide version of that and this is I think in my microwave laboratory is highly whenever you connect any network analyzer or spectrum analyzer generally with some signal.

Generally, we first put attenuator and make it quite high attenuation or highest attenuation do the circuit because if no signal goes you may not get the signal, but nothing in the path will get destroyed, but if you do not put any attenuation and if a high signal goes to the devices which cannot handle that then that device or equipment will go wrong. So, that is why we always put maximum level first then you go on decreasing the level and see at some point you will see that signal is has started coming.

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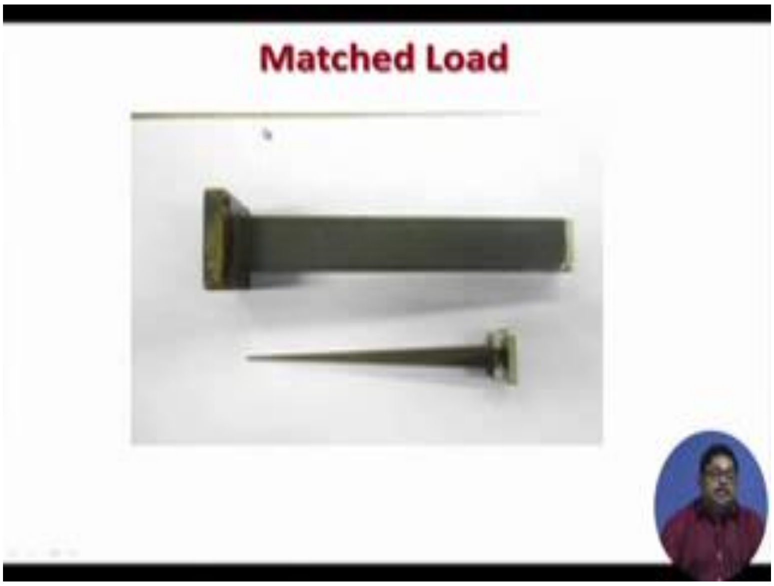

Now, there is also another attenuation thing that is matched load because many times we want that when a signal is going, I mean there should not be any reflected signal. So, what happens if the incident signal is totally absorbed then it cannot reflect back and that is done by the matched load and it has this pad, but that is tapered so that, gradually its impedance changes. A wave traveling has particular wave impedance. Now, with the T10 mode wave impedance this is designed.

Yesterday we have seen at some frequent that in wave guide when we discussed some 500 ohm was the impedance at 10 gigahertz probability of 1 0 mode. So, 500 ohm if you make then gradually you make it larger and so that, here area you will have to increase, but five hundred ohm if you want to match it will be very small its length a thickness.

So, that you do then wave will start coming here then you show your actual result and it is like inviting guest and you are taking a full power from him, this is called match load and if you open any match load actually this is from this side there is a screw by which you can take it.

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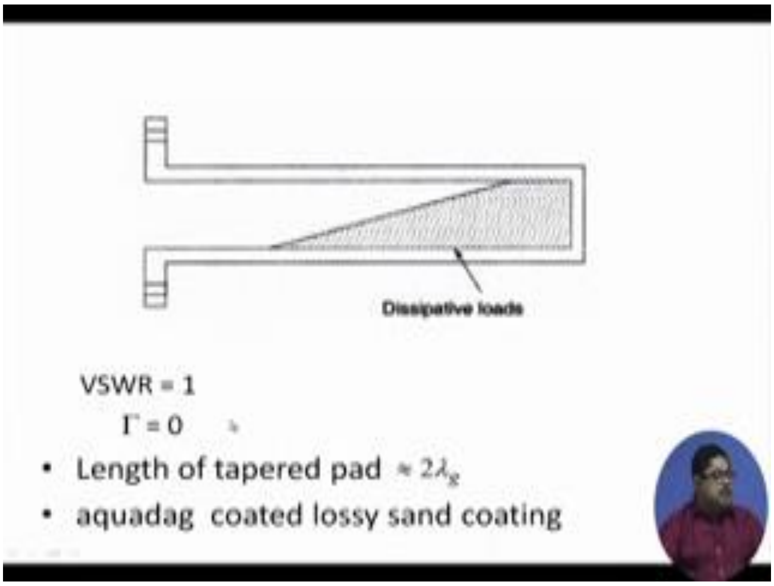

Then see this is dissipative load which is made of aquadag is some material and they give some coated thing like lossy sand coating. A match load does not have any reflection means its reflection coefficient is 0.

So, that is what I said 0 VSWR 1 and this length of the tapered pad is generally twice of guided wavelength so that, you give sufficient line. Tapering is for impedance matching as I am saying that we are initially inviting a wave comes then you start giving that attenuation and he comes here seeing that good impedance matching with me then gradually it goes on getting it. So, that is all about microwave attenuators.