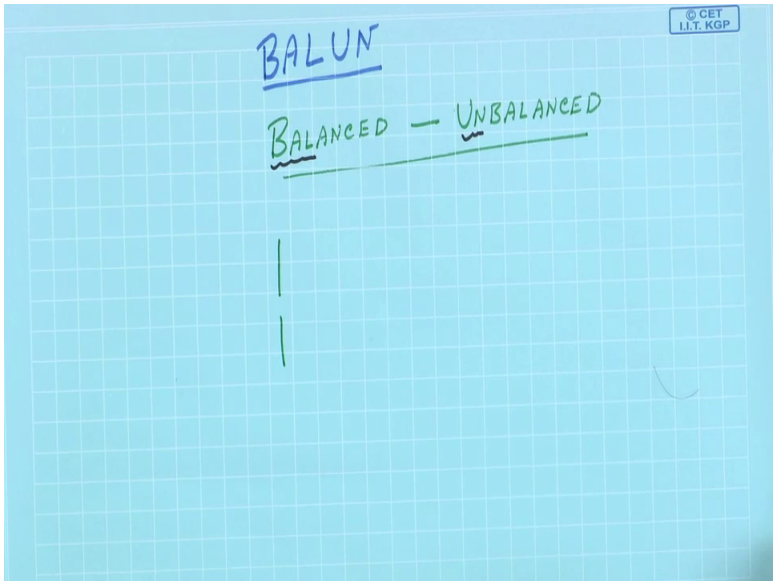
Analysis and Design Principles of Microwave Antennas
Prof. Amitabha Bhattacharya
Department of Electronics and Electrical Communication Engineering
Indian Institute of Technology, Kharagpur

Lecture – 14
Balun

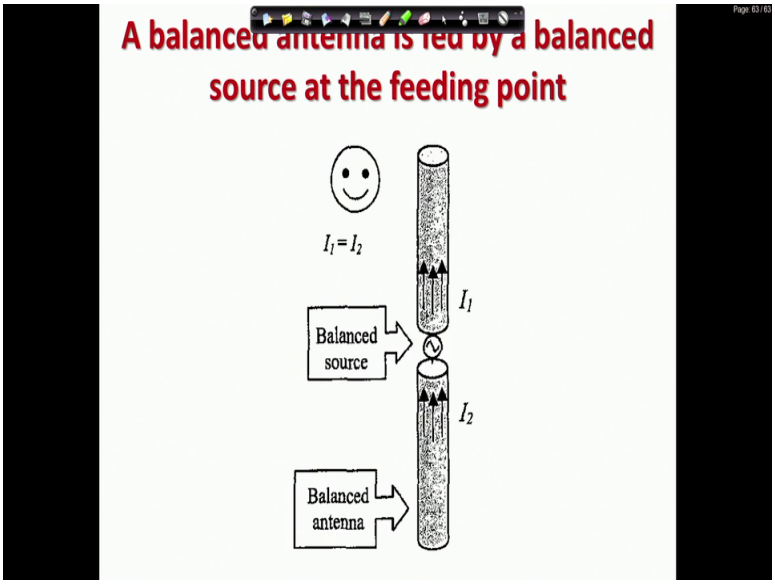
(Refer Slide Time: 00:18)



Welcome to this lecture. Today will see Balun, it is balanced to unbalanced. So, the acronyms of BAL from balanced it is taken BAL and from unbalance it is taken UN that gives you Balun. Now why the need Balun? What is the need of this Balun? Actually a balanced antenna usually has at least one symmetric plane which can be grounded due to the symmetric structure.

For example, a dipole antenna has a symmetric plane, you can see here that it has a symmetric plane which crosses the antenna axis at the feeding point; thereby dividing the antenna into two half's which are called two poles.

(Refer Slide Time: 00:59)

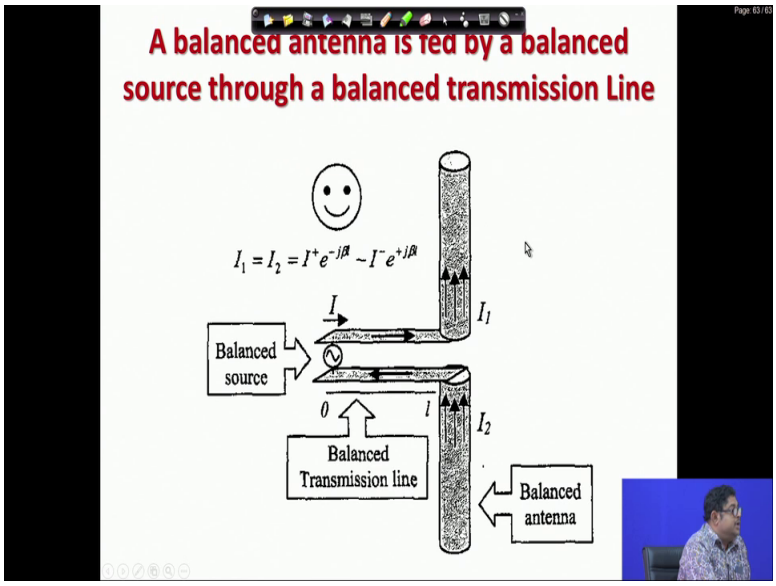


If these two poles assume same current distribution the radiation efficiency is maximum, the current should go in one direction and the same current should return to the other one. The goal is to feed the antenna in such a way that these two poles have exactly the same current distribution that is the even symmetric.

Now, this can be done please look at the view graph that if we put the source if we put the source here, now source generally we deal with balance sources; balance sources means it has a positive as well as a negative polarity. So, the positive polarity will be connected to one of the negative polarity with under balance source balance antenna no problem and we can say that I 1 is equal to I 2. Obviously, you see this in reality always you we call that this is I 1 and this is I 2 because in reality this I 1 and I 2 are never equal. Why? Because this whatever current is returning because through the displacement current actually this current returning, but also both of this poles they are also getting some noise etcetera. So, that is called common mode current.

But for radiation I need a differential mode current like this one current is going here another current here; that means, there is a phase difference between them 180 degree phase difference between these two current, this should be there. So, this differential mode current only can radiate. So, this is desirable here we are assuming that noise is not there. So, if we can make this balance source is driving this then we have I 1 and I 2 and the antenna designer is happy.

(Refer Slide Time: 03:22)

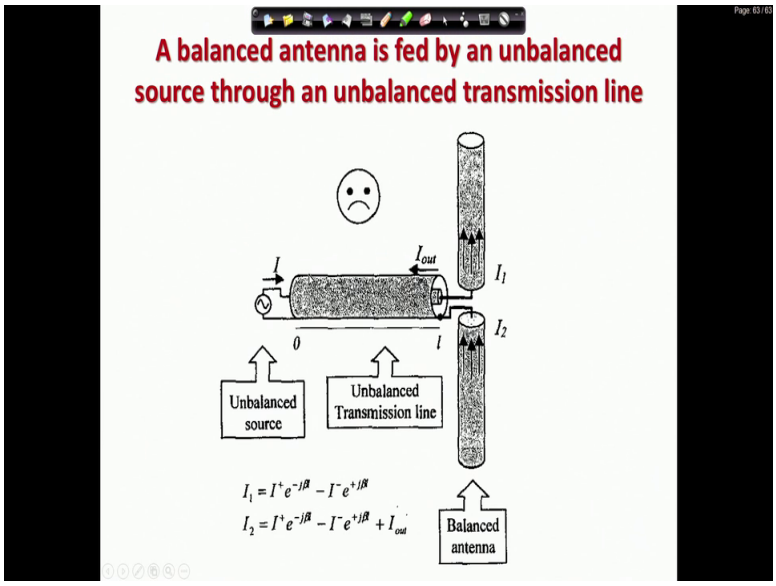


The next one is, but this is not practical the earlier case that was not practical because I cannot put the source into the center of the antenna; basically source is at a distance. So, to do that there is a transmission medium or transmission line and if we have two wires, so, I have a source again a balance source, I have a two wires and one of the wire is connected to the upper hub the another wire is here.

This is a balance transmission line to a transmission line is a balance transmission line because current is going here in one direction, the same current is returning in the other direction. So, again this is now here due to since it is a distributed transmission line, here is a forward going current wave and backward going current wave, but that is giving that I 1 and I 2 same; obviously, without noise.

So, again the antenna designer is happy, but this is true for low frequencies at high frequencies. What will happen if we do this? This antenna this transmission line would not be able to take the power here it will start radiating. So, what we do we shield the antenna and the best possible shield is we give it a coaxial thing, that means, two conductors one is inside another is outside.

(Refer Slide Time: 04:55)



Now, how do we connect them to the thing? You see; obviously, you see this is a to prevent the radiation from the transmission line. What we do? There is an outer shield and that outer shield is connected to the lower half and the inner conductor that is taken out the direct conductor is put here.

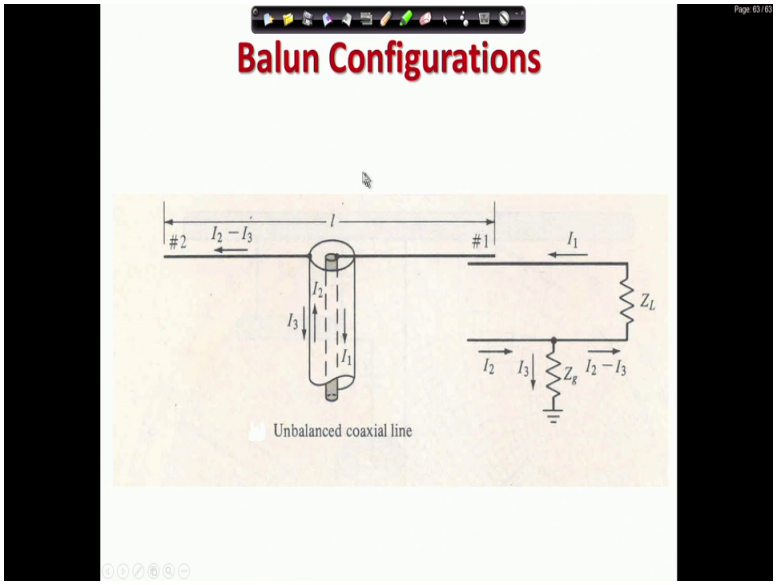
Here you see the problem is that this lower half this half, actually this you can do any half you can connect like this; this lower half it is connected to the shield of the outer conductor. So, to the outer conductor it is loosely coupled; that means, through that shield it is getting coupled, but the this one is directly coupled. You can say that why we are connecting it to the shield we can directly connect to the conductor. If we do that actually we are short circuiting the inner conductor and outer conductor; that means, there would not be any current in the differential mode current will be 0.

That is why we cannot do that and we do it like this, but this means the whole thing that there is an extra impedance, seen because of this loose coupling there will be some impedance between this shield of the outer conductor and the ground and some current will flow through that. That will make this I 1 and I 2 unbalanced because they would not be now together you see thus these are same, but this there will be another current component I out through this outer one.

So, this is the source of all problems in high frequency because high frequency there was shield. So, in high frequency we need to have a coax type of thing and that gives rise to

this. Even at higher frequencies if we have instead of coax if we use web guide that is a single conductor. So, that will also suffer from something like this ok

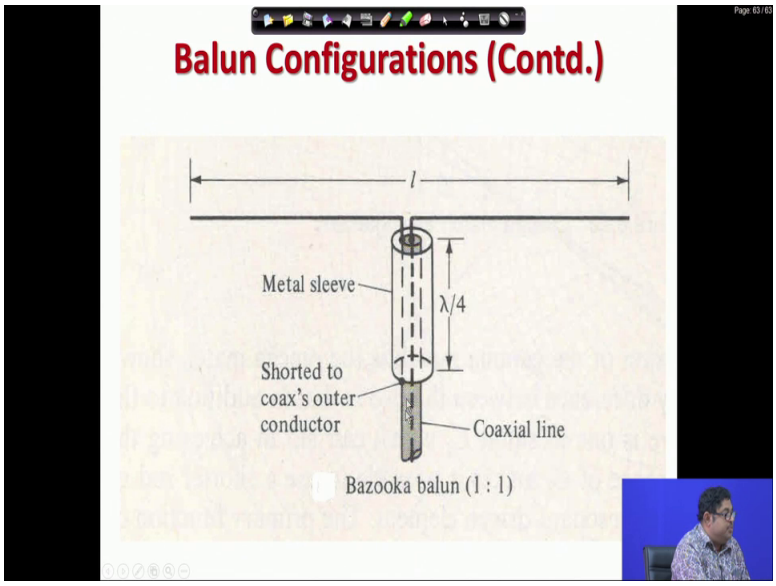
(Refer Slide Time: 07:26)



So, [FL] so, you see that net effect of all these is this flow of I 3 to the outer of the conductor. Here you can understand that I 1 is one current going, I 2 is that current returning, but then while it is getting connected there is an there is an extra impedance Z g which is undesired and that is giving this I 3 thing. So, to the load that is a free space load it looks that the current one side is I 1 another side is I 2 minus I 3.

Even if we make I 1 and I 2 same they would not be together. So, our job is to choke this I 3. Actually a Balun's job is to choke this I 3, that it will do.

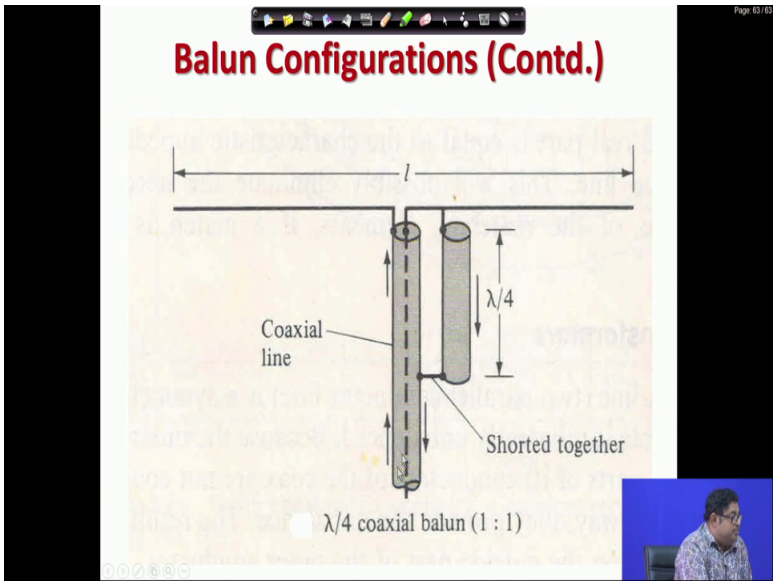
(Refer Slide Time: 08:22)



One way of doing this is called a one of the Balun is this Bazooka Balun, it is very popular. What you do that whatever previously you are doing apart from that you put another metal sleeve this outer metal sleeve you see inside everything is like the previous one you have a metal sleeve and that metal sleeve is shorted to coax outer conductor here and what is the length of this metal sleeve lambda by 4, so that means, it is shorted here.

So, at this point it is having an infinite it is an open circuit. So, it is having an infinite impedance; that means, this Z g it is giving that is infinite. So, that will make I 3 very small and that will try to balance this I 1 and I 2 because I 3 is becoming reduce; this is the Bazooka Balun.

(Refer Slide Time: 09:25)



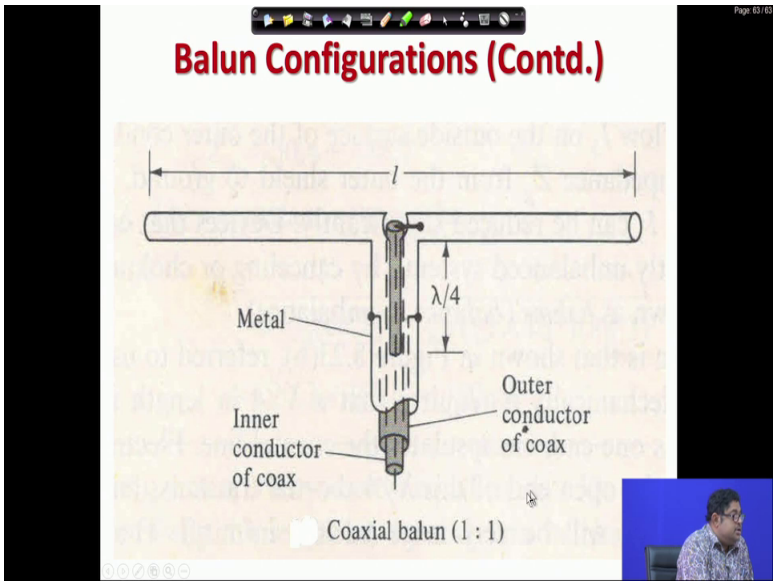
Now, there is another possibility is instead of putting that metal sleeve, you can put a another transmission line here of lambda by 4, here you are shorting as before. Here what you are doing you are putting that this one; in previous case it was not put anywhere here you are putting it to the, that line one or the inner conductor connecting one.

So, whatever here it is doing you see here the here it is shorted here it is open so; that means, already the outer conductor and inner conductor their currents are 180 degree out of phase you are giving another one 180 out of phase because of this lambda by 4. So, that makes that whatever current is flowing I 3, the opposite current is flowing in the I 1 and. So, not opposite the same current is flowing in I 3.

So, again that is we making the two Balun; this is called lambda by 4 coaxial Balun. Now here you can say that actually this lambda 4 why it was chosen. Actually any length of line of this would have done the purpose, but if we do not take lambda by 4 then the antenna operations will be disturbed because antenna operations have that relation that two currents are 180 degree out of phase.

Now, only lambda by 4 can make that. In any other case the two currents will balance each other, but the operations would not be; that means, inner conductor and outer conductor currents would not be out of phase.

(Refer Slide Time: 11:25)



And this is this third configuration. So, this one is outer conductor this the inner conductor coax inner conductor this one I think this is now. So, Balun then what it actually is job is now to make this balanced to unbalanced this unbalanced comes.

Because yes that I have already said so, but current flow direction opposite. So, you get a the parallel auxiliary line yes. So, I think I have said in the Balun. So, this is you see typical actually we will see in the any VI chip particularly our TV boxes etcetera they have that Balun without that Balun actually you do not get a good reception because the efficiency is poor.

Because the if the two things are not equal two currents in differential mode then actually it appears that there are lot of noise because noise also have the same effect that it makes the equal, but a common mode currents. So, without Balun actually it becomes that common mode current increases. So, to reduce that the Balun is used and if you put the Balun you will see that the antenna can radiate or receive the current quite efficiently, if you remove the Balun the antenna would not be its efficiency will drastically go down.

And that you can check that just remove the Balun and see the reception quality in any TV will be poor because Balun actually improves the differential mode characteristic it is something like what we call CMRR in by a operating a thing or you will see (Refer Time: 14:48) people that if you have a multiple transmission lines then the common

mode, if you do not suppress you will get lot of noise in the or interference in the other ones.

So, to reduce that interference this Balun is used and it is problem of high frequency because we are using coaxial line. So, generally in VI chip and also yes UI chip, VI chip, this prob VI chip UI chip TV transmission this problem is there because coaxial is the medium, but you have a dipole there.

We will later see that a design actually the TV antenna was this common mode and differential mode this current concept was cleverly used to design a actual TV antennas, this VI chip, TV antennas which is called folded dipole array because you see. One of the still problem is there that dipole has a radiation resistance of 73 ohm whereas, free space has a radiation resistance of 377 ohm.

So, if dipole is directly used to receive there will be lot of reflection because it is a huge mismatch. So, can we have a dipole, but it will behave as a 377 ohm or 400 ohm radiation resistance actually that problem will be solved by understanding this differential mode and antenna mode concept, but that is a for a later lecture.

Thank you.