Computer Aided Power System Analysis

Prof.Biswarup Das
Department of Electrical Engineering
Indian Institute of Technology – Roorkee

Module No # 08
Lecture No # 36
Line Outage Sensitivity Factor (Contd.)

Hello welcome to this lecture on computer aided power system analysis so we are now discussing the process of calculating line outage sensitivity factor. In that process we have in the last lecture looked into the concept of Thevenin equivalent impedance between two buses as well as between a given bus and the ground. So you would be utilizing those concepts for calculating the line outage sensitivity factor.

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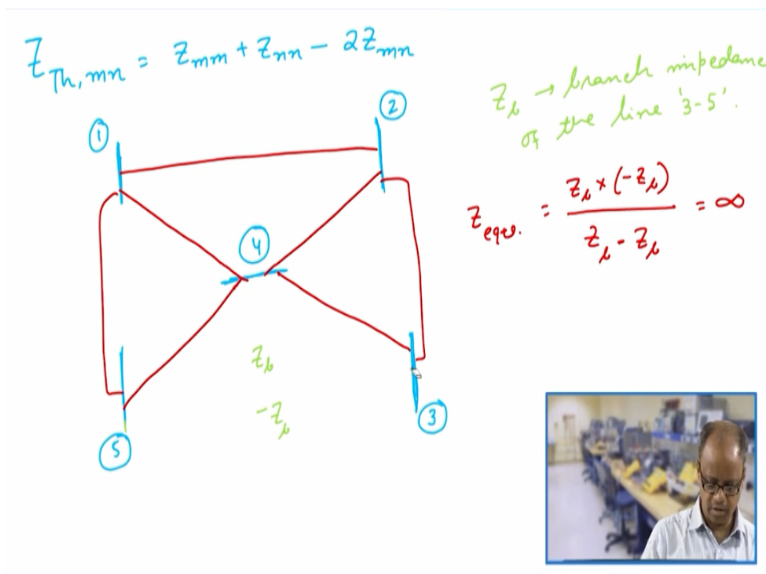

So just to recapitulate so what we have said that Z we said that Z thevenin n they said that Zmn + Znn – 2Zmn so this we have already seen now consider power grid so let us consider a power grid any power grid so this blue lines are all buses and it is a this and let us say that this red lines are lines so this red lines are power lines they can be any kind of connections so I am just taking this connections made it highly major circuits it does not matter.

So let us say this is bus 1 this is bus 1, 2, 3, 5 now when we are talking about LOSF what we are just simply trying to find out that what would be the change in the power flow over the other remaining lines when any particular line is switched off for example if let us say the line between the bus 3 and 5 is switched off so then we would like to estimate that what would be the new power flow over what this other line that is this line this and this.

So this is the basic purpose now the point is that how do we really simulate the fact that this particular line is switched off into our calculation now to do this suppose this line as got an impedance as suppose this line as got an impedance Zb. Zb is the branch impedance so Zb let us say the branch impedance of the line 3, 5 same. Now if I wish to simulate the outage of this particular line what we can do is we can simply add another line between same two buses in parallel with the original line having an impedance – Zb.

So what we are doing what we are simply trying to do is we are adding another line in parallel with the existing line having a impedance of – Zb so then therefore they are equivalent impedance of this two parallel lines with Zb and – Zb so then Z equivalent would be Zb into – Zb into Zb – Zb that is infinity so in infinity it is as it that this particular original line is switched off so then if it is infinity so then therefore actually it is as that this line is switched off.

So then therefore we can simply simulate the removal of line by adding a parallel line between same two buses having an impedance equal to the negative of the original line in impedance. Now how to incorporate this in our calculation so for this we have to again redraw what Thevenin equivalent circuit so if we redraw our Thevenin equivalent circuit between bus m and n.

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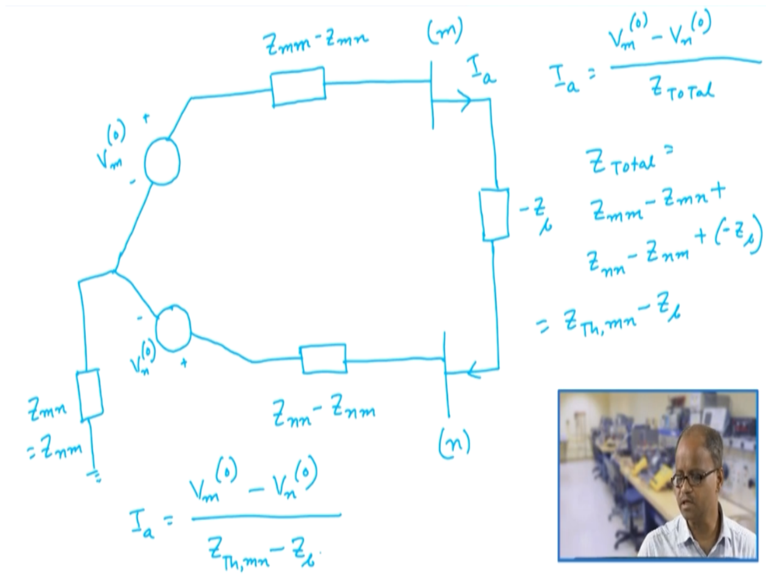

So let us say this is bus n now here in this case let us say this is bus m here in this case this is bus n so here m = 5 and n = 3 so now what we are trying to do is so we have got you know this then this and this is Zmm – Zmn this is Znn-Znm this is Vm0 this is Vn0 and here this is Zmn which is nothing but equal to Znm. So this is the Thevenin equivalent circuit and this is bus m this is bus n.

So please note that this Thevenin equivalent circuit is the equivalent circuit of the original network which in which the original line between bus m and n are is already existing now I want to add another line in parallel between bus 5 and 3 so then therefore because in this Thevenin equivalent circuit already the existence of the original line been taken care off. So then therefore if I wish to add another line between bus 5 and 3 bus m and n in the original circuit that can be simply simulated by adding that same line between bus m and n in the Thevenin equivalent circuit then this impedance is Zb right.

So then therefore when this line is connected then therefore this is some current which is going from this to this right so let us say this current is Ia so then what would be Ia now if I add so now I have to solve this current Ia in this loop so then this current Ia in this loop would be Vm0 – Vn0 / Znm – Zmn let me write it in more elegantly so it is Z total and what is Z total? Z total is it is nothing but series circuit Z total is Zmm – Zmn + Znn – Zmm + of – Zb.

Now this plus this = ZTh so then that is ZTh mn – Zb so then therefore Ia would be equal to Vm naught – Vn naught / Z Th mn – Zb so this is the current Ia so now because of this current Ia so then now basically there is no change in the in injection current at bus m because of this addition of this current because of this addition of this link having impedance – Zb. So then therefore because if this addition of this link – Zb between bus m and n now there is a change in injected current at bus m and n.

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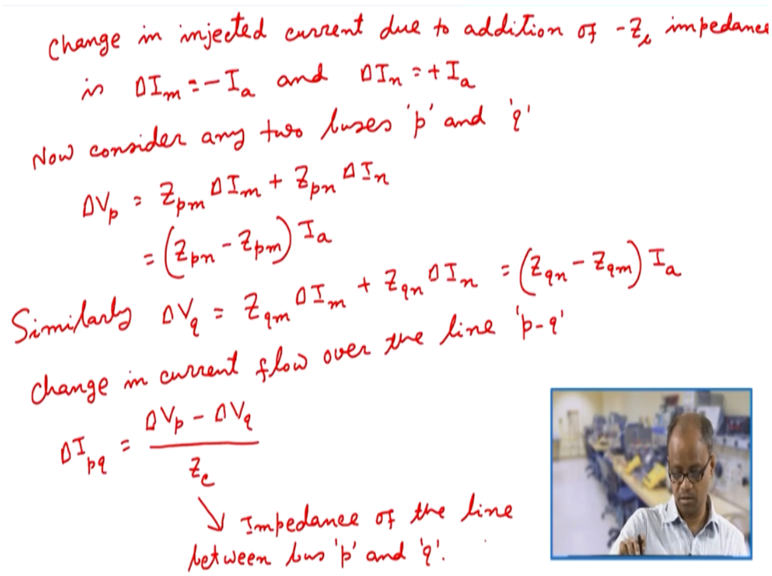

So the change in injected current and bus m and n we write it specifically so change injected current due to addition of – Zb impedance is delta Im = - Ia and delta In + Ia it is obvious from this because change in injected current now Ia is going away from bus m and Ia is coming into bus n so then therefore change in injected current at bus m would be – Ia and change in injected current at bus n would be + Ia right.

So then therefore what would be the change so now consider any two bus p and q. So then now because of change in injected current at bus m and bus n so delta Vp would be nothing but Zpm into delta In + Zpn into delta In so if I put it would be equal to Zpn – Zpm into Ia. Similarly delta Vq would be equal to Zqm into delta Im+ Zqn into delta In and if I substitute delta Im and delta In from here what I get is I get Zqn – Zqm into Ia so this is what I get right.

Now the current now so the current so then delta Ipq what is delta Ipq? So we change in current flow over the line pq would be what? That is given by delta Ipq is the current flow over the line bus p and q so it is delta Ipq so then that would be is equal to delta Vp – delta Vq / Zc what is Zc? Zc is the impedance of the line between bus p and q right. So this is the impedance between bus of the line between bus and q and we again note here that Zb is the line we must also you know we must also note that Z is branch impedance of the line.

So then here we should also write does Zb is impedance of the line between bus m and n please note that this impedance of the line between bus m and n and we are simply trying to analyze the effect of this outage of this line having impedance Zb on the remaining lines so that is what we are trying to do.

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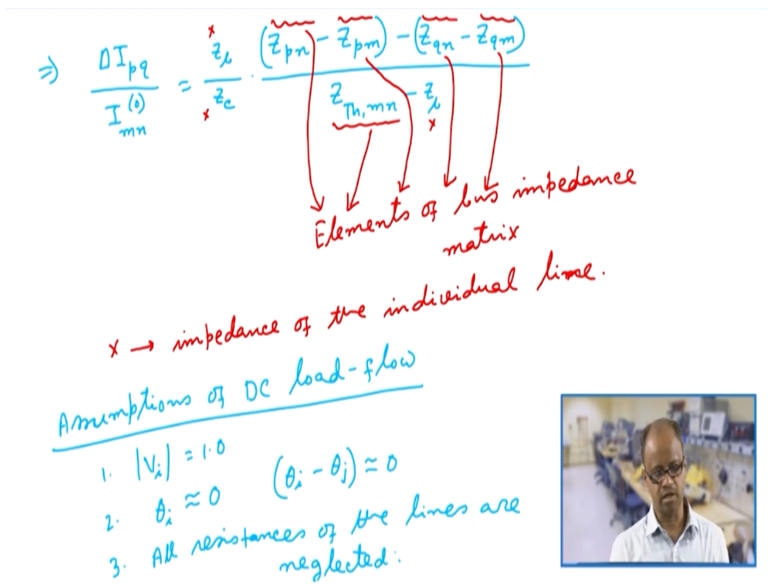

So then therefore delta Ipq would be delta Ipq is delta Vp - delta Vq by Zc now I substitute delta Vp and delta Vq so what is delta Vp Zpn – Zpm. So it is Zpn – Zpm – delta Vq is Zqn – Zqm so it is Zqn – Zqm divided by Zc into Ia we have done simply substituting delta Vp and delta Vq in the original equations and we get this so then therefore we can write down that delta Ipq is simply Zpn so this Zpm – Zqn – Zqm we should take some Zc we should actually write so Zc.

So when you are writing with small Z that denote the line impedance and when you are writing with capital Z that denotes the element of the bus impedance matrix so these two are very important because often we make mistake that we do simply confuse between these two we need to know that this Zc and this is Zc these are nothing but the individual bus impedance so then therefore what I should also do it here as follows Zc and here also similarly here also should Zb should be a small one actually it should be a small one very small z actually right.

So this is a small Z this is small these are all small z this was small z this is also small z so let us spend some time on this and this is Im Ia we have got the expression of Iaa Vm this so Vm – V naught so this is Vm naught Vn naught / Z theta hmn – small zb small zb so this is expression now what we do have? So then that I can write down as Zpn – Zpm – Zqm – Zqn / Z Thevenin mn – Zb we are purposely writing it has small and we are doing something that Vm – Vn0 into Zb into Zb / Zc.

So what we have done we have simply taken it here so this divided by this and this divided by this simply done this divided by Zb into Z divides now what is Vm naught – Vn naught / Zd? Vm naught – Vn naught / Zb is nothing but the original current flow through bus m n so we note that Vm – Vn naught Zb is Imn naught right. So then therefore what we can write down is delta Ipq = Zb – Zc into Zpn – Zpm – Zqn – Zqm / Z theta hmn – small zb into Imn0 right.

So then therefore change in the line current over the line Pq with respect to the original current flow over the line mn and the line mn is the line which is going which is actually experiencing outage so then therefore delta Ipq / Imn0 would be given as so then therefore delta Ipq / Imn naught would be given as Zb / Zc into Zpn – Zpm – Zqn – Zqm / Z theta hmn – Zb. So then by this if any line is getting outage so then we can simply then we can simply estimate that what would be the change in current flow over any line by this simple expression.

And in this simple expression everything is constant because now here we need to note something very carefully so that we do not do any mistake there are some quantities which are the elements of the bus impedance matrix so elements of the bus impedance matrix are this and this. So this quantities are elements of bus impedance matrix this is very important.

So this is also elements of bus impedance matrix on the other hand these three quantities this and these so these quantities are the impedance of the individual so while calculating this we must be very careful about this that which elements denotes the individual line and which elements denotes the elements of the bus impedance matrix.

So until and unless we careful enough we would be making a lot of mistakes so this must be very carefully understood and appreciated now here we have got the change in line current over any existing line because of the outage of the any given line but when we have started discussing the concept of sensitivity factors we said that we are actually trying to estimate what would be the change in the power flow that is basically real power flow over any remaining line due to the outage of any given line.

So then we need to now connect this expression with the expression of the power to so to do that to again take recourse to our basic assumptions of so we now we need to recollect assumption of this DC load flow we have to recollect assumption of DC load flow so what are this assumptions of the DC load flow we very quickly recollect them one is that all Vi = 1.0 second is that theta i all theta i is almost = 0 but not equal to 0 if course.

So then therefore theta i – theta j is also almost equal to 0 and then we all resistances are neglected of the lines are neglected. So these are the assumptions of the DC load flow so utilizing these assumption of the DC load flow in the next lecture we will see that how this same expression can be used to calculate the change in real power flow where in existing line because of the outage of any given line thank you.