Introduction to Smart Grid
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Lecture – 21
Smart Grid Protection – III

Good morning to all of you. In this lecture we will discuss about the Smart Grid Protection schemes. As already we have discussed one particular protection scheme that is the adaptive protection scheme for the micro grid environment and we will continue from there.

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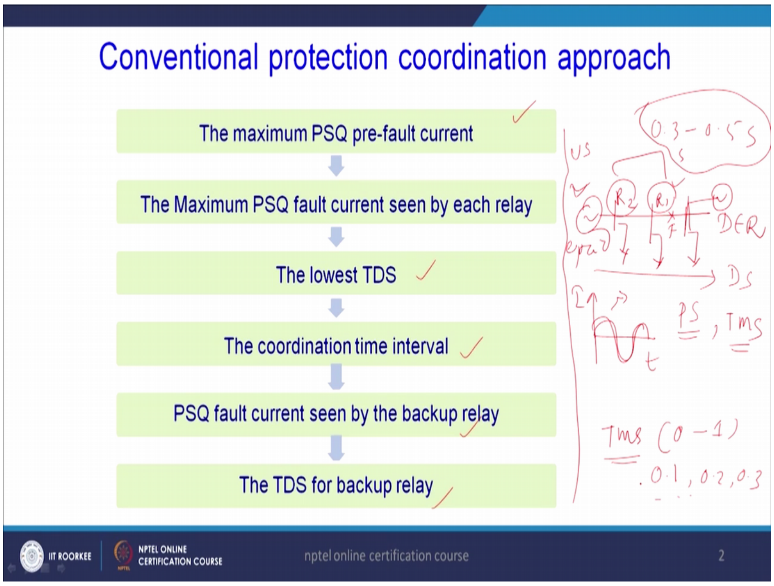

And already we have discussed that if we have like a radial network this is our grid and there are different buses and at different buses we have loads and let us say here 1 over current relay R 1 and here 1 over current relay R 2.

In the previous class we have discussed that this R 1 is treated as the primary over current relay to protect I mean to clear this particular fault F. And if this R 1 fails then this R 2 which is treated as the backup relay; this R 2 is going to clear this particular fault F and the gap between this 2 relay operation basically 0.3 to 0.5 second.

Now this particular process of clearing this fault using this primary and backup relay within certain time gap; that is a CTI coordination time interval this particular time 0.3 to 0.5 second is known as CTI is known as coordination approach of the over current relay.

And as I said from the beginning that in distribution network mostly we use in the 11 kV network the over current relays. But due to the penetration of this renewable sources let us say here one renewable sources DER is present due to this penetration of DER's what will happen? The current profile of different I mean lines or the current profile seen by different over current relays basically changed and that particular current profile if it is change; then the corresponding this plug setting that is if it I and t then this resultant current will change and corresponding plug settings should be changed.

And of course, the corresponding TMS that is time multiply setting should be changed; that means, in general if you will see that in our distribution network in conventional approach we use basically a fixed mode of like plug setting and fixed TMS, but due to the integration of renewable's or penetration of renewables this fixed mode of operation on the over current relay is not desirable.

It has to be adaptive in nature because every time this network is going to be changed with the presence of distributed and resources or with the absence I mean of this DERs or due to the different modes of operation like we have grid connected mode of operation. We have also islanded mode of operation and also due to the presence of different types of renewable sources; that means, if every time we are this particular relay will see different voltages are current profile.

So; obviously, this relay has to the fixed mode of operation of the relay should be changed and that is basically the way out towards the adaptive protection scheme for this smart grid environment. And this is a very just very preliminary discussion are basic level of discussion that what is the adaptive protection scheme and which are very much essential for this smart grid operation. And you will see that these are the step outs or ways out to have this conventional coordination approach of the directional or it is a directional over current relay.

When this directional element is added with the over current relay then the together it is called as directional over current relaying principle; which may be used for the smart grid operation. And here what we do initially maximum positive sequence pre fault current is basically stored or its calculated inside the process of the digital relay. And next by seeing this maximum fault current corresponding TDS or TMS is said and the coordination time interval is set. And then corresponding backup fault current is of the relay backup relay current is also set and then the TDS of the backup relay.

Basically there is a way out how to take the coordination from the private to backup. Initially, the primary relay will see maximum fault current what is the maximum fault current that should be calculated and its corresponding TMS. Basically let me clear here one point .that in a string of operation like it is a radial network and this is a upstream were treating where the grid is present, this the grid and this is my upstream site this is upstream and this is my downstream the power is let us say flowing from the grid site towards the load site or load centres.

So, in that case basically what we do, what we treat that the final the relay which is located at the end terminal or end feed up that is R 1 is having lowest TMS. The lowest TMS means the TMS this particular TMS varies within 0 to 1. And this lowest TMS means it may be 0.1, it may be 0.2, it may be 0.3 it varies and of course, this particular TMS setting is based on the lot of many numerous simulation studies of the network.

See when this relay settings are done we have to simulate sufficiently the system or network before going to install the digital over current relays or digital directional relays in the consigned or the prescribed network or the location where we are going to locate the over current relay or directional relay. We have to test it how this particular algorithm or idea or technique is going to performed if it is so and before going to implement in actual real field application.

And that is it is the testing is very very important and that is here the point by just mentioned, the lowest I mean the towards the end of this feeder like towards the downstream side this relay we keep basically the lowest TMS. The lowest TMS means the time of operationally should be very quick. If it is the very I mean the magnitude of this TMS is higher like maybe 0.8, 0.7 then the relay will take more time to trip for a particular fault position.

And keeping all this these are very basic concepts maybe as for as the coordinates of the directional over current relay comes in and this particular coordination interval should be also maintained. And to be honest here this DER Distributed Energy Resources due to the penetration of the renewable sources; this particular decorum is not anymore constant it may vary, as I said because the current magnitude is going to be changed.

The corresponding time of operation of the primary level change, the corresponding TMS also is going to be changed and the corresponding time and the TMS of the backup relay is also going to be are going to be changed. That is why in general in overall; if you will see we need a very good adaptive protection scheme if the renewable sources are penetrated to the micro grid system. Therefore, that we have proposed the first scheme that is a basically the adaptive protection scheme using the sequence currents.

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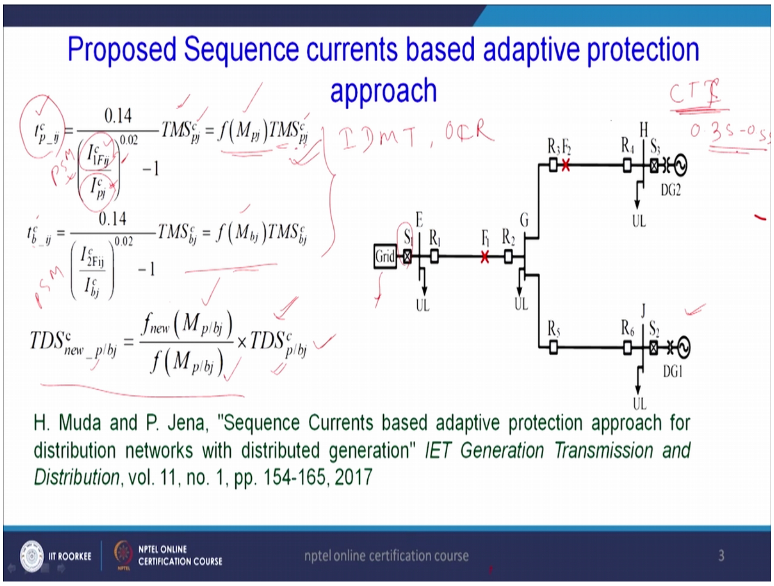

In this scheme what we did basically this is the expression from the IDMT characteristics based over current at relay right. This is the time of a operation and this is our basically the PSM; the fault current to the plug setting into the TMS, TMS is the Time Multiplier Setting. Now if you could see this time of operation of the relay this p stands for the primary relay i stands for the location relay and this j stands for the location; i stands for the which relay and j stands for what fault right at that location the fault has been incepted.

Now, the c stands for basically the mode of operation of the micro grid system. Already as I have discussed this mode of operation of the micro grid system is to know this system very very essential. Whether the micro grid is connected to the main grid or it is isolated from the main grid that is the island at mode of operation. So, to know that to inculpate that particular mode of operation; intentionally we have developed this technique that this c; the TMS this particular TMS is basically decided for this p means primary relay and for jth fault location and c is the mode of operation, what is the present mode of operation.

According to that we have to also set the TMS. Otherwise if the for a particular fixed mode of operation, fixed TMS we cannot use. Because as the micro grid operation changes then the TMS and plug setting should be changed accordingly; then only it will be adaptive in nature that is a first point and second one is this i b c i j that is the time of operation for the backup relay. As I said that every primary relay has its backup relay because if the primary fails to clear a fault though it will be late in but we have to clear the fault and that job is basically done by the backup relay. And this t b c i just stands for b stands for backup relay and the c stands for the mode of operation and i is basically which relay and j is the which fault position.

These are some symbols and the same expression we have written here; that means, if you could see this 2 equations; the time of operation of the over current relay basically is dependent on this function f of M p j or f of M b j; that means, this particular function is dependent on this plug setting multiplier. That is this fault current plug setting multiplier is nothing that is the fault current divided by the plug setting, this is the fault current and this is the plug setting. So, this ratio is basically the plug setting multiplier we have already discussed in the previous class.

Now if it is so; that means, my time of operation is going to be modulated or going to be changed if my fault current of the system of the network or the plug settings of the network is going to be changed. And yes of course, if this TMS is going to be changed then also my time of operation is also going to be changed.

So, keeping all those exercise in mind or concept in mind that how to set this time of operation for the backup and primary so that we are not going to lose any healthy section; we are also we are just we have to just isolate only the faulty section not the healthy section that is our target so that we can just reduced the on interrupted supply to the loads or the consumers.

Now, we have just kept I mean 1 concept here that is this new TDS, what will be the new TDS? How it will be decided; this will be the ratio of this primary to backup function, this is the new one and this is the old one into this old TDS. Let us say for example, I just want to discuss here what you mean by this old and new concept? Let us this particular micro grid was operating initial in the grid connected mode. So, that will be my old particular operation of the micro grid.

Now, let us say this due to some fault on the grid side this switch S1 is now open, due to this micro grid is going to be operated in the islanded mode of operation; that means, my new operation of the micro grid is islanded mode of operation and my old one was grid connected mode of operation. Now I will just come to another point here that after calculating this new TDS; what we will do? We will just calculate our corresponding time of operation of the primary and as well as the time of operation of the backup relay.

And here one more point I will add if you could see here that the time of this plug setting multiplier for the primary and the plug setting multiplier from the backup these 2. In case of plug setting for the primary relay we have taken this I 1 F i j, this 1 stands for positive sequence fault current seen by the primary relay. However, in case of backup relay we have taken this i 2 F i j c that is taken as the negative sequence fault current relay.

So, this negative sequence fault current relay is stated for the backup relay and the for the primary relay we have considered for the positive sequence fault current relay. The reason being is that if you could see that our aim is to how to coordinate the primary and backup properly without sacrificing the their coordination; that is the main issue. Basically what happens due to the integration of renewables what happens before operating the primary for a particular desired fault position the backup relay may react that is known as miss coordination between the over current relays.

To avoid these we have to set in such a manner the plug settings and corresponding TMS So, that the coordination between the primary and backup should be maintained that is the main goal that is what this coordination approach, all the proper coordination functioning of the primary and over current and backup over current relays.

Now for that purpose we have just derived or proposed this TDS new TDS which will be a function of course, the old TDS as well as the ratio of this f new to f old. If it is for the primary the expression is like this and the same expression holds good for the backup relays; that means, in overall I just want to explain that using this changed TDS and changed this particular plug setting we can always change I mean the time of operation to a proper manner so, that the coordination between the backup and primary or primary and the backup will be maintained as it is.

What is this miss coordination? It may happen that the backup relay will operate before the primary relay that is one point and second is that it may also happen that the backup relay will operate in too late. Let us say the CTI the desired time of operation is 0.3 second to 0.5 second. Now let us say this time of operation will exceed to 0.8 0.9 or sometimes 1, and the time of operation is too late; that is why may be in that way also the mis-coordination will take place between the primary and backup over current relay.

So, those are the issues and if you go through different papers and research articles in nowadays in power delivery or may be in IEEE different transactions in good journals then there we will see that a research is just in the very booming stage and they are trying to have very good adaptive techniques for distribution networks as well as renewables are concerned or micro grid system is concerned.

Now, I will discuss another new aspect that is we have added or new dimension we have added that is a fault direction estimation using superimposed currents.

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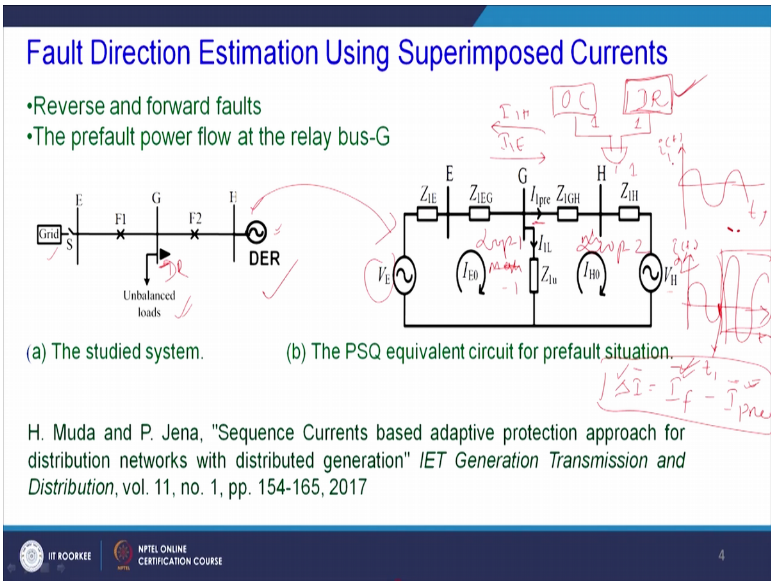

As I discussed earlier that this over current element then the directional element or directional relay. This 2 relays their decisions are basically going to be handed to take the final decision right? Here not we are not going to use only the decision of the over current relay to decide whether this is a faulty section or not, but we have to also add the decision of this directional relay that is DER directional unit and this if the both the relays like output will be 11 then the final output is going to be 1.

So, this we have also proposed a new scheme for this directional unit. In general basically many industries they are also following (Refer Time: 16:46) in the polarizing voltage and the operating current the angle can be decided deciding factor like whether the fault is in front of the relay or it is behind the relay then only we can decide whether this we have to clear the healthy section or faulty section that selectivity property is basically present without directional relay.

So, this is a system for what we are studying to propose this fault direction estimation technique using superimposed currents. The superimposed current means if you have a fault current, I mean this is the pre fault current this is i t and this is a time direction and let us say this is my fault current which has been increased, let us say here is 1 fault is incepted at times certain time t 1 and this is the time axis and this is my i t i 1 this is i 1, this is i 2 right.

So, in that case what will happen see here during fault after fault some fault current some current component is basically superimposed with my pre current; that means, this particular superimposed current component is known as superimposed current we denote like this delta I is equal to I fault minus I pre. These are in basically in Phasor mode right this delta I is equal to I F minus I pre.

Now, this superimposed current delta I is equal to the differentiation of I fault the Phasor minus I pre phasor, this 2 phases are subtracted from each other. If I will the subtracted this I pre from my I fault then whatever the component I will get that will be the superimposed component and this is the corresponding circuit to analyze this relaying platform under the corresponding positive sequence equivalent network for this particular single and diagram of the micro grid system where we have 1 unbalanced load, we have grid and we have DER.

Now you see that we have taken this MESH network this is my MESH 1 or loop 1 we can say this is my loop we can design it loop 2 and this is loop 1 by considering this 2 loops we have to solve to get the I pre current and I fault current because we have to calculate this superimposed component of the current.

And where we have to calculate? We have to calculate at this relay location here and if you could see the relay is located at bus G, this is basically the directional relay location and at that relay location we are going to calculate this delta I that is I f minus I pre. So, our target will be to calculate this I f and I pre.

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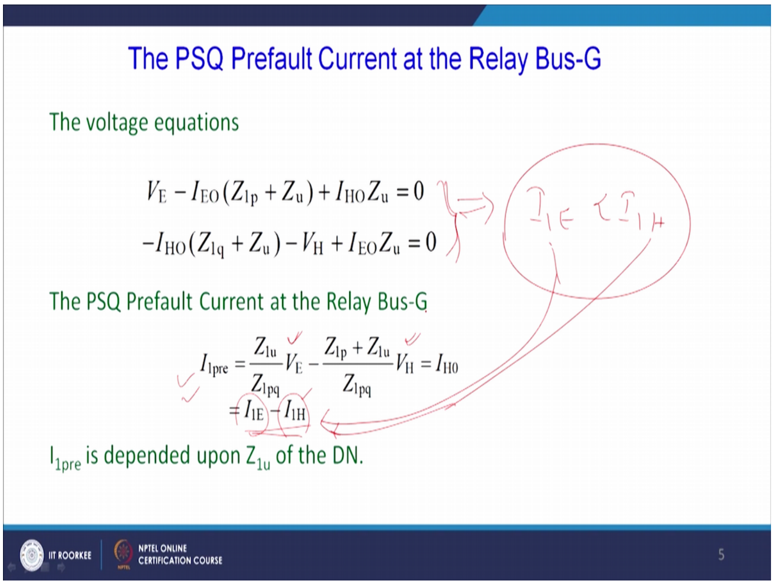

This are the equations for the loop 1 and loop 2 and by solving this we will get our I 1 pre is nothing that is I 1E minus I 1 H. This is very simple if you solve this 2 simultaneous equations we have 2 unknowns 2 currents 2 unknowns. So, 2 equations we can solve then finally, getting this I 1E and I 1H, the output of by solving this equation we will get I 1E and I 1EH.

And if you will take the difference of this 2 currents then we will reach at I 1 pre. Why this is I 1 pre? Because if you will see this is my basically I 1 pre. So, here the current which is flowing is basically this difference of this 2 currents. Now what is the I 1E? The current contributed by this source V E and this I 1H is nothing the current contributed the source VH.

See this particular picture the current which is for this particular relay the location is here this source V E will contribute some current, let us say that is I 1E and this V H will also contribute 1 current that is I 1 H. So, if we take the difference assuming that this we are just taking the convention left to right as plus and right to left as minus. So, by taking this difference so, I will get I 1 pre is equal to I 1E minus I 1 H that is what the first expression of I 1 pre.

Now, we are in the process of deriving the fault current and the relay location. From the beginning I said that this directional unit is based on the superimposed component of the fault current or the current component. So, to calculate the superimposed current we need the I pre and also we need the I fault. So, for the first part we have calculated this I 1 pre expression and the second part we are going to calculate the fault current position and finally, we will draw the Phasor diagrams where this I 1 pre will lie where this I 1 fault will lie or I 2 fault will lie so, accordingly we will just calculate the angles.

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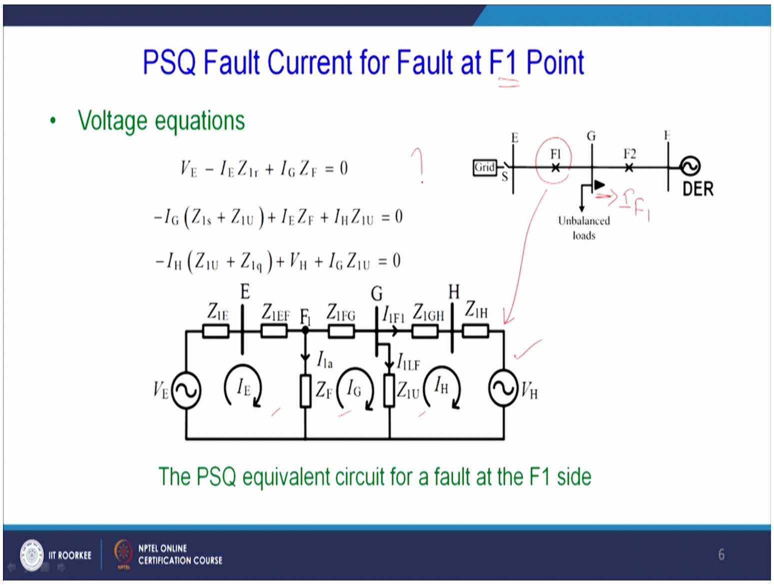

Now, this is a calculation for fault position F 1 what will be the fault current seen by this relay and that fault current is denoted by I F 1 and that fault position F 1. and similarly the if there is a fault and F 1. Now the corresponding circuits becomes like this is the corresponding positive sequence network. Now, here we have 3 loops 1 2 3 and 3 currents I E I G and I H.

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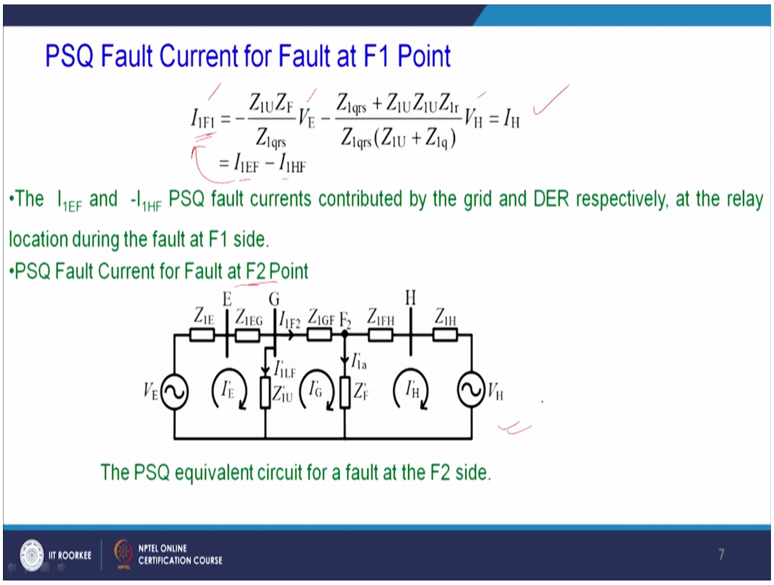

By solving this 3 will get the corresponding fault component that is I 1 F 1 the positive sequence fault current component. This is very easy that we could see here previously as already I have discussed for my case of like precurrents here you can see this V E and V H the corresponding currents and this is the resultant of this I 1 F 1, this 2 current resultant will just derive the fault current which is going to be seen by the relay which is located at bus g and this is the fault current for my particular fault position F 1.

Now, for fault F 2 this is the corresponding expression or the equivalent circuit for the network.

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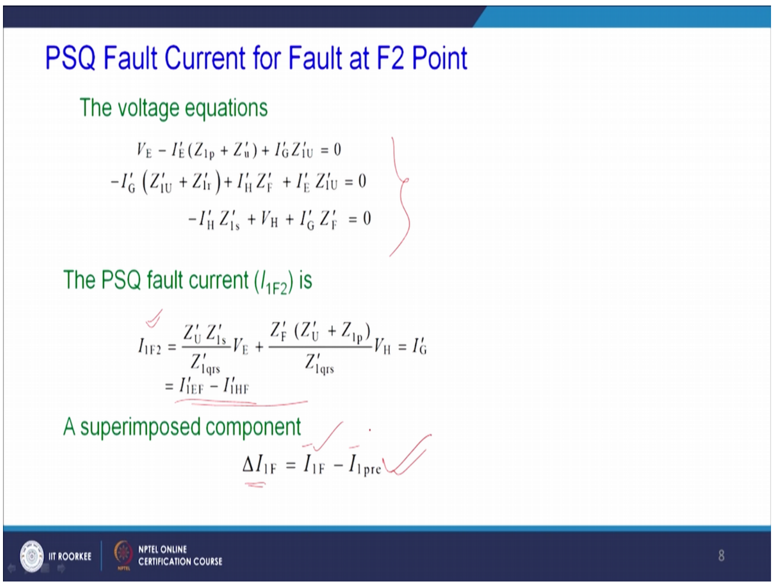

Now, after solving this 2 equations, so, this are the equations like expressions for I 1 F 2. This is very easy just simple mathematics we have to calculate and the corresponding fault current expression we have to find out. And remember in this case we are just searching for the position Phasor position of I F 1 I F 2 and I 1 pre so that we can calculate the corresponding difference, but in this fault current and pre fault current which is basically the superimposed current component.

And let us see here already we have discussed this superimposed component of the current is nothing this delta I 1 F is nothing, the fault current Phasor minus the pre fault current phasor.

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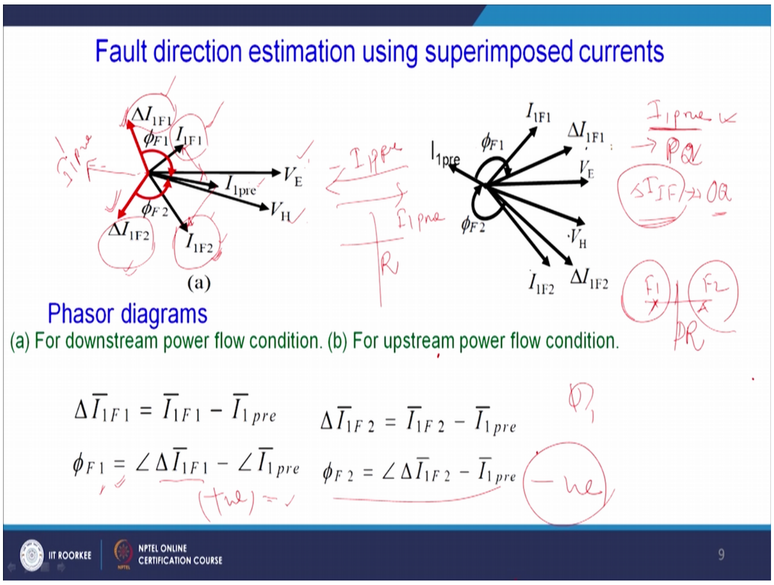

Now, you see that finally, we have reached here see this is V E and V H and this is my I 1 pre as I said the current contributed by this V E and V H the resultant is basically this I 1 pre and in general in a power network our current the network is basically inductive in nature and in case of distribution network the angle is very low and this angle this I 1 pre is lagging almost by very less I mean 2 3 degree with respect to the voltage which is available at bus E.

And if you could say from the previous mathematical expressions this is the position of I 1 F 1 and this is the position of fault current position for fault position F 2. By knowing this fault phases let us say we are now going to calculate the superimposed component for fault F 1. What will be the superimposed current Phasor position? If this is the fault current position for F 1 and this is the I 1 pre position so; that means, our delta I 1 F 1 will be like this.

So, it will just join from with respect to my I 1 pre if I will add this component it will reach to my fault component. Now the corresponding parallel component Phasor value will lie here. So, this is my superimposed fault current for the fault position at F 1 that is basically the fault which is present behind the relay right back side of the relay. Now seem the similar manner the fault current this I 1 F 2 lies here from the equations you can just derive the position on this I 1 F 2. And now the corresponding if you will add the corresponding superimposed component for this fault position then it will the corresponding parallel Phasor will lie here; that means, we got the 2 I mean the superimposed currents for fault F 1 and F 2 positions and now let us see what will be the angle between the superimposed fault current and the pre fault current.

Here let me clear you that in this case this I 1 pre is taken as the operating quantity. Now this delta I 1 basically F it may be F 1 fault or it may be superimposed F 2 fault and this is treated as I mean let me correct it this I 1 pre is known as basically the polarizing quantity p q and this delta I 1 F 1 is taken as the operating quantity right. Now as I already discussed sometimes in some researches some techniques they used voltages as a polarizing quantity, here we have taken current as the polarizing quantity.

Now, in this case the directional element is not dependent on the voltage information it is only dependent on the current information. Now this I 1 pre is basically the this polarizing quantity and this superimposed fault current component is treated as the operating quantity. Now let us see what was the angle this I 1 pre and delta I 1 F, this delta I 1 F is leading to I 1 F because in Phasor we always consider in the clock anticlockwise direction not in the clockwise direction we consider in the anticlockwise direction. So, that is why this delta I 1 F is leading with respect to the I 1 pre and the angle between this 2 if you will tell this phi 1 basically I have written here this phi f 1 is angle between this delta 1 f minus I 1 pre.

Now, this angle will be positive because the angle of delta I 1 F is higher I mean greater than this I 1 pre. Now similarly if you could see here this delta I 1 F is lying to this I 1 pre and this angle will be negative and this will be positive and this is a rule base basically how to decide that in what direction the fault has been inspected. If it is positive then this relay will declare that the fault is just behind this relay this is my F 1 and this is my F 2 so; that means, this direction relay will say if this angle is positive then the fault is behind this relay and if this angle is negative then this relay will say that the fault is in front of the relay.

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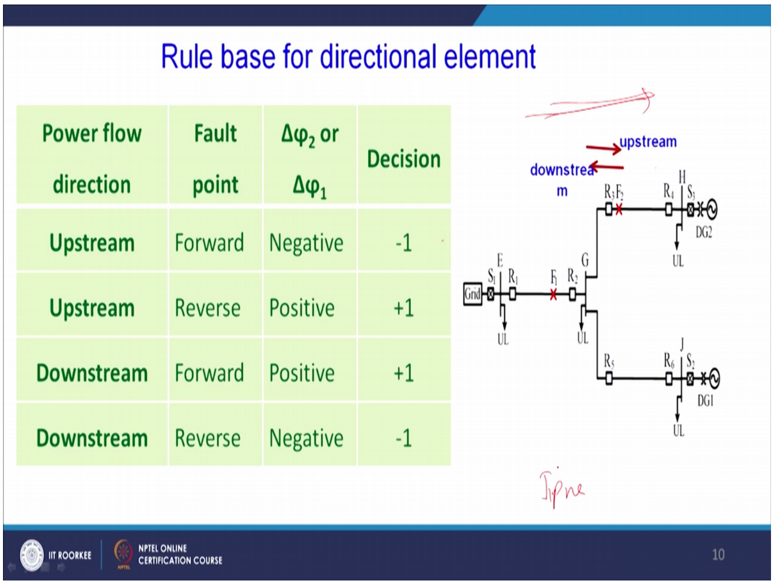

Power flow direction	Fault point	$\Delta\varphi_2$ or $\Delta\varphi_1$	Decision
Upstream	Forward	Negative	-1
Upstream	Reverse	Positive	+1
Downstream	Forward	Positive	+1
Downstream	Reverse	Negative	-1

Now, these are the rules as I said. Now the question is if the in this case we have to keep in knowledge the power flow direction whether the power flow is in upstream and downstream side. If it is from upstream to downstream side then the first row plus minus, if it is in the downstream side then the rule will be just changed minus and plus because in that case if the fault direction I mean sorry this pre fault current direction changes; that means, the I pre position is going to be changed in the Phasor diagram.

Here you can see if this is my I 1 pre direction when the power flow is basically from left to right this is my relay location then this will be my I 1 pre now if the this current direction power flow direction changes then the corresponding current direction will be changed that will be I minus I 1 pre that is why this instead of I 1 pre here so, it will be just opposite to this will be I 1 pre dash and that is why the corresponding angle will be opposite.

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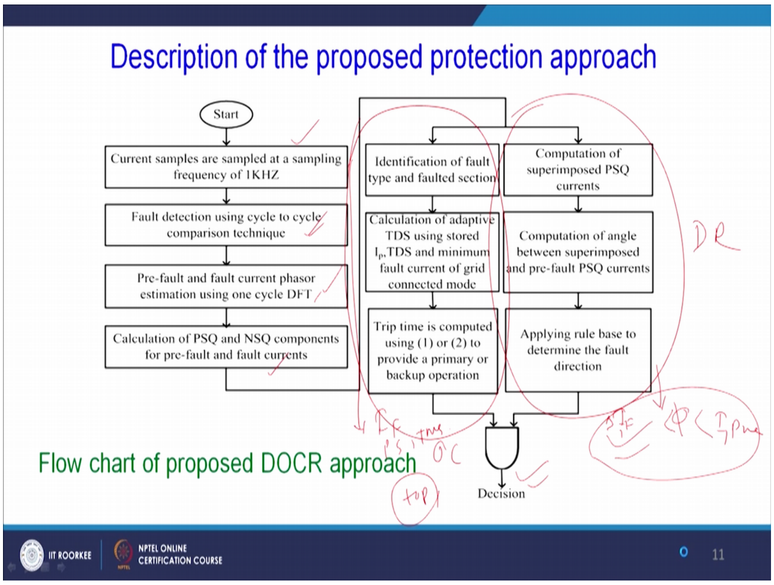

Now, this is a total flow diagram. How this particular technique is implemented? First one is the sample the old days I mean current at 1 kilo sampling period as we are not using here voltage information only the current. So, we have to sample the current signals at a sampling frequency of 1 kilo hertz second we have to detect whether there is a fault or not if there is no fault no need to trigger the directional unit algorithm and if there is some fault and that particular fault will be detected using 1 cycle to cycle based fault detection technique then we will this processor will calculate the phases of the current using this DFT that Discrete Fourier Technique.

After that we have to calculate this positive sequence components and because negative sequence component will be needed for the backup relay fault calculation and this particular being this particular section is for the over current relay and this particular section is responsible for directional relay and here we are going to calculate the fault current and also the plug setting TMS and corresponding time of operation using our previous proposed methods already we have discussed.

Now, this unit will responsible it will be responsible for finding this angle between this delta I f and I pre yes of course, it is positive sequence based upon imposed current fault current and positive sequence based pre fault current if this 2 the time of operation is and this angle is if it is within the limit within the desired set value then the decision is going to be taken and this particular system we have tested.

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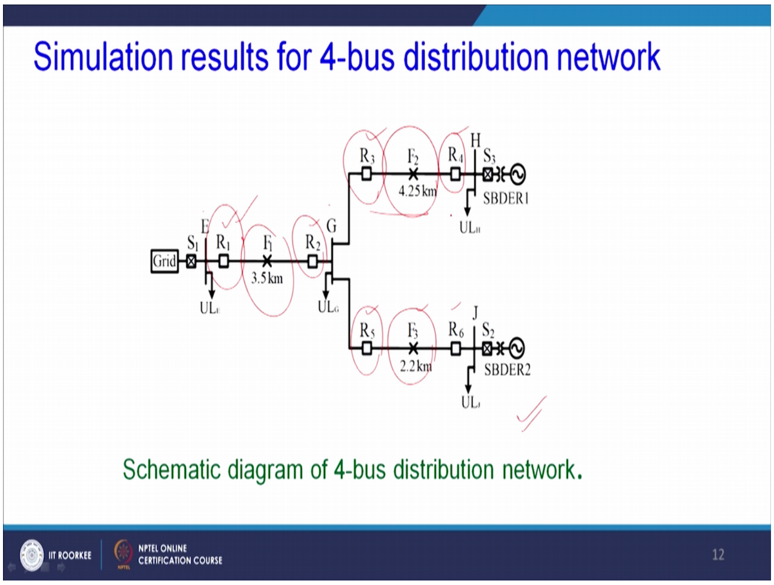

I mean this particular technique we have tested using a simple technique simple network like 4 bus network here and these are the relays you can see for this line E g this is the 1 relay protecting and this is R 2 and here we have this line R 3 R 4 and here for the f 3 we have R 5 R 6.

For F 2 let us say for f 2 this R 3 is treated as the primary relay and which is the backup relay and the backup relays R 1. Similarly for F 3 R 5 is the primary relay and R 1 is the backup relay. So, so many combinations will have like for F 1 R 2 is the primary and R 4 is the backup. So, we have different pairs of over current directional over current relays which are going to be coordinated using the proposed technique.

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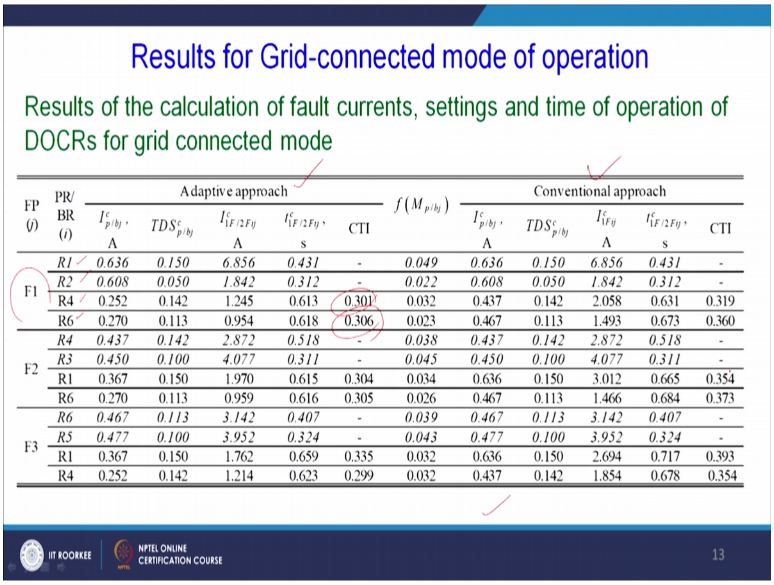

FP (j)	PR/BR (i)	Adaptive approach $I^c_{p/bj}$, A	Adaptive approach $TDS^c_{p/bj}$	Adaptive approach $I^c_{1F/2Fij}$ A	Adaptive approach $t^c_{1F/2Fij}$, s	Adaptive approach CTI	$f(M_{p/bj})$	Conventional approach $I^c_{p/bj}$, A	Conventional approach $TDS^c_{p/bj}$	Conventional approach I^c_{1Fij} A	Conventional approach $t^c_{1F/2Fij}$, s	Conventional approach CTI
F1	R1	0.636	0.150	6.856	0.431	-	0.049	0.636	0.150	6.856	0.431	-
	R2	0.608	0.050	1.842	0.312	-	0.022	0.608	0.050	1.842	0.312	-
	R4	0.252	0.142	1.245	0.613	0.301	0.032	0.437	0.142	2.058	0.631	0.319
	R6	0.270	0.113	0.954	0.618	0.306	0.023	0.467	0.113	1.493	0.673	0.360
F2	R4	0.437	0.142	2.872	0.518	-	0.038	0.437	0.142	2.872	0.518	-
	R3	0.450	0.100	4.077	0.311	-	0.045	0.450	0.100	4.077	0.311	-
	R1	0.367	0.150	1.970	0.615	0.304	0.034	0.636	0.150	3.012	0.665	0.354
	R6	0.270	0.113	0.959	0.616	0.305	0.026	0.467	0.113	1.466	0.684	0.373
F3	R6	0.467	0.113	3.142	0.407	-	0.039	0.467	0.113	3.142	0.407	-
	R5	0.477	0.100	3.952	0.324	-	0.043	0.477	0.100	3.952	0.324	-
	R1	0.367	0.150	1.762	0.659	0.335	0.032	0.636	0.150	2.694	0.717	0.393
	R4	0.252	0.142	1.214	0.623	0.299	0.032	0.437	0.142	1.854	0.678	0.354

This is a sample result you can see here this particular technique operates fine and this is a adaptive approach what we have proposed and this is a convectional technique and here the main point is CTI I just want to mention that that for fault F 1 position this R 1 is basically the primary and R 2 is primary R 4 is the basically back up R 6 is also back up.

In that case the time operation CTI is within 0.301 second; that means, the time of operation that coordination is perfect and here also if you if you will see the technique exceeds like 0.306 0.35 0.37, it exceeds 0.30. Here our CTI desirable CTI is 0.3 second, it should not exceed 0.3 second and which is actually obtained by the its adaptive approach this is for another result islanded mode of operation that the approach proposed approach operates properly the conventional approach fails.

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Results for Islanded mode of operation

Results of the calculation of fault currents, settings and time of operation of DOCRs for islanded mode

FP (j)	PR/BR (i)	Adaptive approach: $I^c_{new\_p/bj}$, A	$TDS^c_{new\_p/bj}$	$I^c_{1F/2Fij}$ A	$t^c_{1F/2Fij}$, s	CTI	f_{new} $(M_{p/bj})$	Conventional approach: $I^c_{p/bj}$, A	$TDS^c_{p/bj}$	I^c_{1Fij} A	t^c_{1Fij}, s	CTI
F1	R2	0.153	0.085	1.012	0.309	-	0.038	0.608	0.050	1.012	0.683	-
	R4	0.158	0.130	0.682	0.613	0.303	0.030	0.437	0.142	1.043	1.133	0.450
	R6	0.189	0.119	0.728	0.612	0.302	0.027	0.467	0.113	1.114	0.902	0.219
F2	R4	0.273	0.123	1.405	0.518	-	0.033	0.437	0.142	1.405	0.841	-
	R3	0.282	0.050	0.852	0.312	-	0.022	0.450	0.100	0.852	1.090	-
	R6	0.189	0.122	0.744	0.616	0.303	0.028	0.467	0.113	1.138	0.880	-0.20
F3	R6	0.328	0.119	2.418	0.407	-	0.041	0.467	0.113	2.418	0.473	-
	R5	0.334	0.063	1.278	0.324	-	0.027	0.477	0.100	1.278	0.703	-
	R4	0.158	0.130	0.665	0.623	0.299	0.029	0.437	0.142	1.017	1.167	0.437

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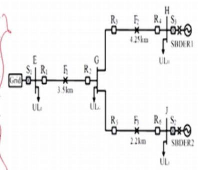
Performance evaluation of the proposed directional components

Results for superimposed PSQ directional element at R3 for different Mode of system operations

Fault	Mode	FP	I_{1pre} Mag (A)	I_{1pre} Ang (rad)	I_{1F} Mag (A)	I_{1F} Ang (rad)	ΔI_{1F} Mag (A)	ΔI_{1F} Ang (rad)	Φ_1	D
AG	M_1	F1	0.450	1.59	4.077	-2.28	4.423	-2.21	2.48	+1
		F2	0.450	1.59	1.209	-0.40	1.451	-0.69	-2.28	-1
	M_2	F1	0.282	1.53	0.852	1.25	0.586	1.12	-0.41	-1
		F2	0.282	1.53	0.967	-1.91	1.239	-1.84	2.91	+1
	M_3	F1	0.527	1.82	4.833	2.89	4.603	2.99	1.17	+1
		F2	0.527	1.82	0.765	-1.08	1.282	-1.18	-3.00	-1
ABC	M_1	F1	0.450	1.59	10.98	-2.84	11.11	-2.80	1.89	+1
		F2	0.450	1.59	3.249	-1.01	3.642	-1.07	-2.66	-1
	M_2	F1	0.282	1.53	2.799	0.21	2.742	0.11	-1.42	-1
		F2	0.282	1.53	2.153	-2.63	2.313	-2.53	2.23	+1
	M_3	F1	0.527	1.82	12.99	2.22	12.50	2.24	0.42	+1
		F2	0.527	1.82	2.215	0.74	2.020	0.51	-1.31	-1



* M_1-Grid connected, M_2-Islanded, M_3-Disconnection of DERs.

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And this is a result for directional unit you can see here for different falls different mode of operations; M 1 grid connected mode, M 2 islanded mode, M 3 disconnection of DER's. So, for different modes for different faults this AG means phase A to ground fault, this is 3 phase fault, the corresponding directional unit operates perfectly.

Thank you so much. Today we have this much.