Power System Protection
Professor A K Pradhan
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur
Lecture – 39
Steps in Differential Relay Processing

Welcome to NPTEL course on Power System Protection, we are going with transformer protection, differential relaying principle.

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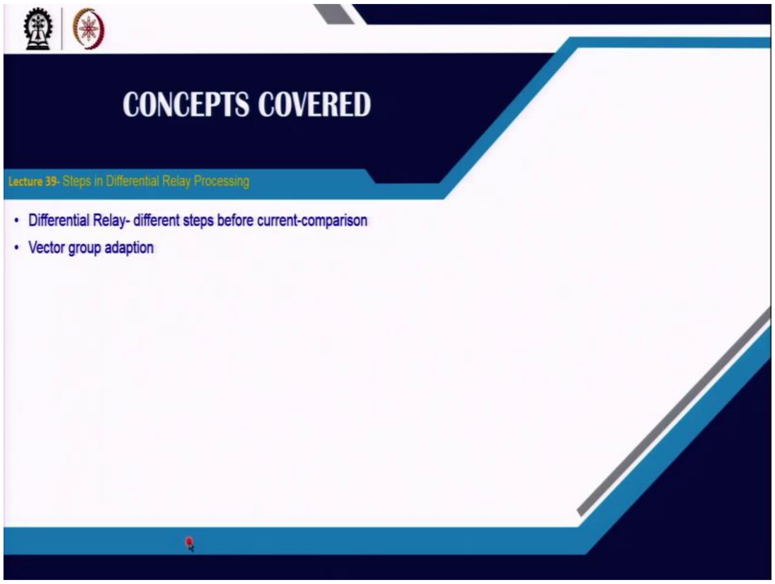

In today's lecture we will discuss on different steps before processing by the differential relaying. In the process we will go for this vector group adaptation, the current normalizations, these things we have already addressed in the last lecture, but how those things are being processed that we will learn today and at the end we will have examples on external and internal faults in a transformer and how the differential relay performs during that time that we would like to see.

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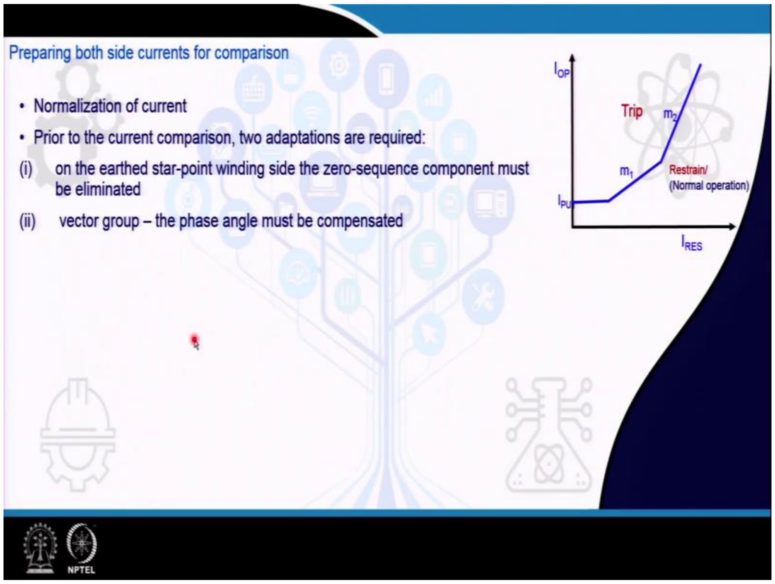

Now, in the last lectures, we have seen that differential relay is a promising technique for transformer protection. But it needs proper processing of the current like the normalization aspect before the corresponding differential of high voltage winding side current and the corresponding low voltage side winding current are being analyzed.

Now, that happens to be phase to phase basis for each of the phase and any of the comparison if the corresponding differential current or the operating current as we mentioned becomes significantly high and it falls above this characteristics then it becomes trip basis on, otherwise we assume that the corresponding state, corresponding situation is a normal operation condition and the relay does not allow for any trip decision it remains silent.

We know how to normalize the current using the current, the CT ratio of one side or the two side that is high voltage or the low voltage side. You remember, one side we consider for the high voltage and two for the low voltage in our convention. But before going to this the differential calculation for the assessment by the relay on trip or restrain, so for that two more steps are required, important steps. One is that the zero-sequence elimination, why that is required, but that is most essential when the side of the transformer is star grounded where the zero-sequence current is expected to flow. There is another one important step that is vector group, in last class we discuss that for different vector group connection of the transformers there is a shift angle between the high voltage side to the low voltage side.

In that case we need essentially to process the corresponding current, particularly low voltage side so that the phase displacement can be compensated. These two are the important steps that are to be processed before the final comparison needs to be accomplished in a differential relay principle, we will learn each step in details.

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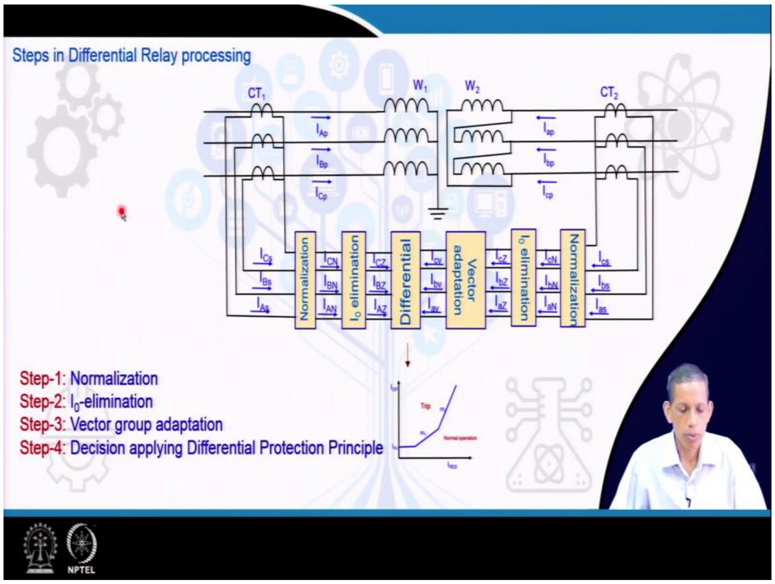

In overall the differential relay processing, the differential current processing the corresponding characteristic which we talk about here for calculating the operating current and the restraining current and to make a judgment whether the operating current above the corresponding characteristic or not. This judgment is obtained through different steps of the processing of the currents available from the CT.

Now, let us consider the winding one referred to the high voltage side, CT's are there, the digital relay acquires the corresponding sample, thus the normalization which you have learn in the last class about that calculation of the normalized current. So, that goes from the CT secondary current, capital C here refers to the high voltage side and so we have this a b c three phases, the corresponding currents after the normalization are I_{AN}, I_{BN}, I_{CN} after the normalization.

Then as already mentioned if it is a star grounded system also require zero-sequence eliminations, subtraction of the zero-sequence current from each of the phase current and then we get I_{AZ}, I_{BZ} and I_{CZ}, the Z here refers to the zero-sequence elimination perspective. So, this is the processing from the high voltage side.

Now, come to the low voltage side, winding two side. So, we have the CT_2 corresponding signals are available to the relay here and then it goes for this normalization and in the normalization we have the I_{cN}, I_{bN}, I_{aN} available in the low voltage side, and then zero-sequence eliminations if it is required and so, then the I_{aZ}, I_{bZ}, I_{cZ} phase currents are available after the zero-sequence elimination and then we can say that in the low voltage side we have a vector group adaptation, this is essentially required for the phase shifting that is being observed due to the vector group. We will have more discussion on each of this step for the processing of the relay. Then finally from the high voltage side and low voltage side the corresponding currents are available and that is being processed for the differential current and the restraining current and see whether it is a trip decision, or no trip decision.

So, we see four important steps are there in this process of calculating the differential current, first is the normalization, then the zero-sequence elimination, vector group adaptation in one side in the method which we learn following is only carried out in the low voltage side, there are methods available in other literature, other manufacturers, different manufactures, they carry out this vector group adaptation in different ways also, that are different ways but the only purpose is to compensate the corresponding angle with respect to the high voltage for the low voltage currents. Fourth step, decision applying differential principle that is the final step where the corresponding trip or no trip basis will be carried out.

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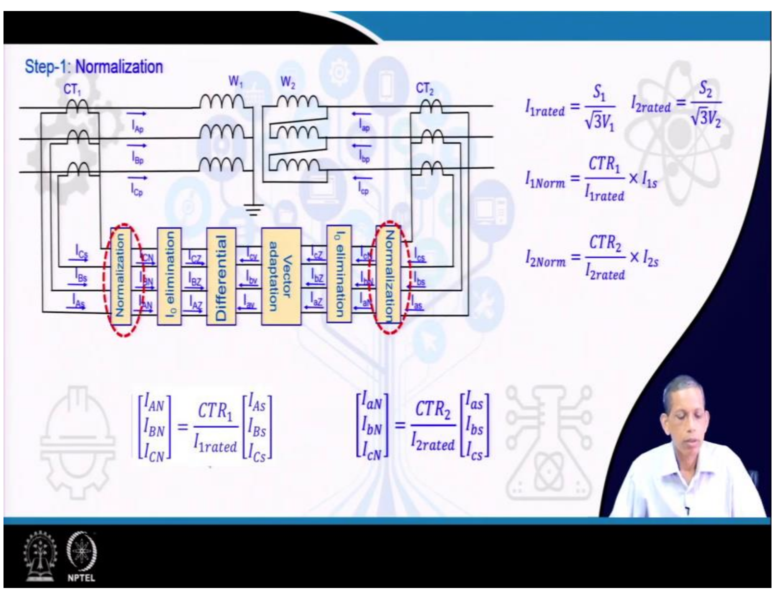

Now, we see here that the first step is the normalization current that we have learned in the last lecture. So, in this case we find the corresponding rated current from the MVA rating of the transformer and the corresponding voltage. If we take into account the corresponding current voltage then these rated current is also in adjustment with tap changing position of the transformer also. Then similarly calculate for the rated current for this one using the corresponding current actual voltage of the system from that one and we can calculate the corresponding rated current on the system also from the kV rating of the transformer that we consider, it depends upon the rating on winding one, winding two and so.

Now, the normalization is obtained as already observed in the last lecture about the CT ratio one upon the rated current of that first winding that is high voltage winding into the corresponding secondary current in the available to here in this perspective. Now, the I_2 normalization for the second winding also is carry like that, if we have third winding we can carry out like this for the third winding also.

So, in general for the three phases after the corresponding normalize current can be available from the CT ratio for the high voltage side upon I_{1rated} and then we have the available currents from the CT secondary. And similarly for the low voltage side also the normalized current can be available from the CT ratio 2 upon I_{2rated} and then we have the three phase currents I_a, I_b, I_c in the secondary side of the low voltage side.

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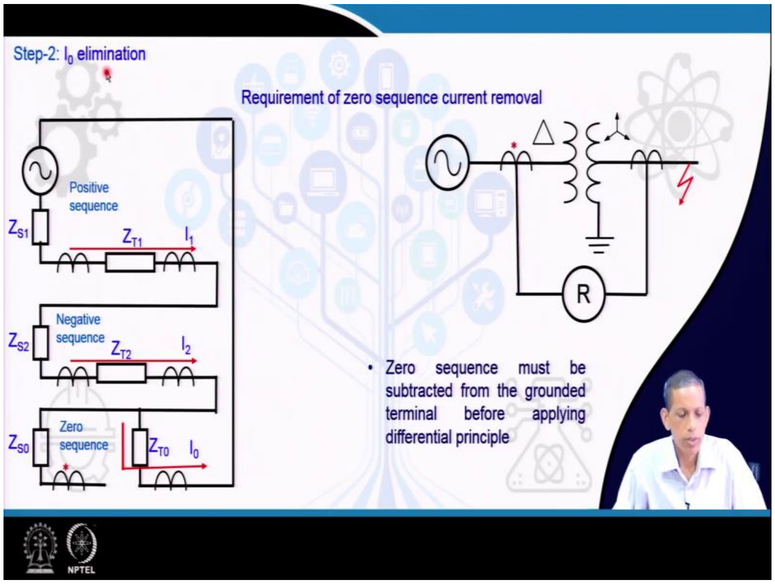

Second step is on I_0 elimination, so a zero-sequence eliminations. Let us first see why we require this. Now, this is a simple system, a transformer fed from an AC source, three phase transformer of course, this side is delta, this is star, star grounded and so. So, we have CT this side and CT this side and this is the differential relay which does the calculation for operating current, restraining current and make a decision perspective analysis.

Now, for this system for a fault external to the relay if we see the corresponding sequence diagram becomes like this, so this is the fault point, so we have positive sequence diagram, negative sequence diagram and zero-sequence diagram. This side being delta, so therefore the corresponding for the delta star connection the corresponding transformer, zero-sequence diagram becomes this for the transformer and then we have like this.

Now, in this case if you see then the positive, negative and zero-sequence are connected in series considering this to be a line to ground fault case and then what we see here that the positive, negative and zero-sequence are connected in series and if we see this path of flow of current, so this path of flow of current like this and this and then from this to this.

So, it clearly says that these two CT's which are there to the left and right of this delta side and the star side, in both the CT's positive sequence current flows, negative sequence current also flows but if you see here the zero-sequence current flows only in the right hand CT that is star grounded side CT, no zero-sequence current flows in delta side, we have marked here star to this here also star. So, the zero-sequence current does not flow in the star and that we know from our power system analysis knowledge also that this delta connection, the zero-sequence current which flows in this side that flow becomes a circulating current inside the delta winding, it does not allow the current to flow in the line side of the delta winding connection. That is what in agreement from this sequence component perspective also which we have learned at the beginning of the lectures on power system protection. So, that implies that for this fault a zero-sequence component will be flowing in the star grounded side and will not flow in the delta side. So, that becomes an additional current which the corresponding CT's sees in the delta and the star.

So, that additional current must be subtracted before the comparison otherwise corresponding comparison or differential current becomes erroneous one. So, that leads to the situation of zero-sequence current must be subtracted from the grounded terminal before applying differential principle to the transformer protection.

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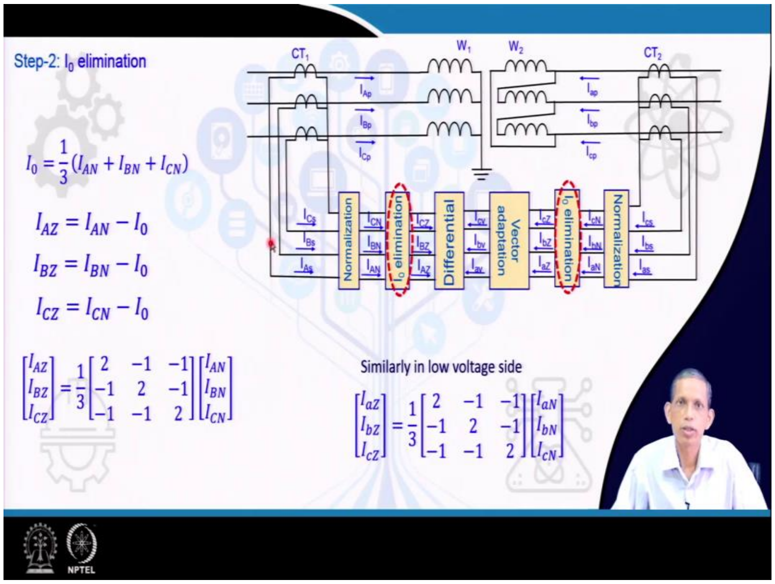

Now, how do we do this zero-sequence elimination? So, we know the zero-sequence current is

$$I_0 = \frac{1}{3}(I_{AN} + I_{BN} + I_{CN})$$

Similar relation holds also for the low voltage side. So, like that from the individual phase current we subtract the corresponding zero-sequence current, this is high voltage side, so from each one we subtract the zero-sequence current and then after that we get

$$I_{AZ} = I_{AN} - I_0$$

$$I_{BZ} = I_{BN} - I_0$$

$$I_{CZ} = I_{CN} - I_0$$

I_{AZ}, I_{BZ}, and I_{CZ}, the Z here corresponds to the, after the zero-sequence elimination or subtraction from the each phase currents in the high voltage side. So, if we put this in a matrix form then that becomes equals to

$$\begin{bmatrix} I_{AZ} \\ I_{BZ} \\ I_{CZ} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} I_{AN} \\ I_{BN} \\ I_{CN} \end{bmatrix}$$

Similarly, low voltage side also applying the same matrix calculation method from the phase currents of the low voltage side we can get the corresponding currents following the zero-sequence elimination represented in a form given by

$$\begin{bmatrix} I_{aZ} \\ I_{bZ} \\ I_{cZ} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} I_{aN} \\ I_{bN} \\ I_{cN} \end{bmatrix}$$

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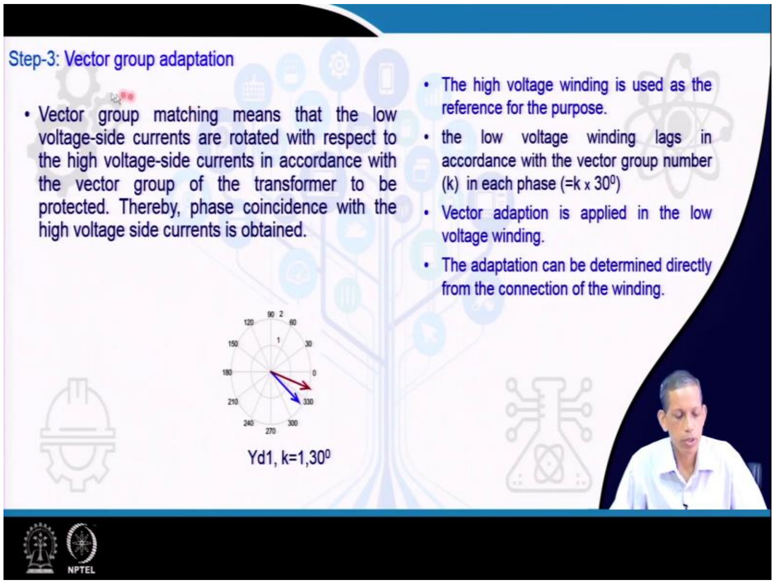

Now, next important step is, step three is vector group adaptation. In the last lecture as we already mentioned, we talk about there is a phase shift due to the different vector groups and we say that we take the corresponding reference at the high voltage winding and with respect to this corresponding low voltage winding the corresponding current lags depending upon the vector group. The vector matching means that the low voltage side currents are rotated with respect to the high voltage side currents in accordance with the vector group of the transformer to be protected. Thereby, phase coincidence with the high voltage side currents is obtained. So, this whole purpose as already mentioned, and which you have seen in our earlier lecture also that suppose you have a winding one connections, where k becomes equals to 1 and we see that the corresponding for our CT connections such that, in the last lecture we have seen that the low voltage current lags the corresponding high voltage current of the same phase by an angle of 30^0.

So, to have proper comparison, there must be a line to two in one way and that situation with respect to considering the high voltage reference the corresponding low voltage must be shifted by this 30^0 and that is what you can say that the phase coincidence has to be down before the corresponding differential principle is to be applied.

So, in general what we say that, we consider the high voltage winding to be as the reference, the low voltage winding lags in accordance with the vector group number k and this how much angle? ($k \times 30^0$) corresponding the vector group it is k, it means that k into thirty degree by that angle the corresponding low voltage of that phase will be lagging to the high voltage current.

The vector adaptation is applied in the low voltage winding only and the adaptation can be determined directly from the connection of the winding, so we require only information of the k that is the vector group number only. So, now the point this is the philosophy we will follow in our approach but as already mentioned different manufactures go for different calculation way to get the corresponding phase coincidence for the two winding sets high voltage to low voltage.

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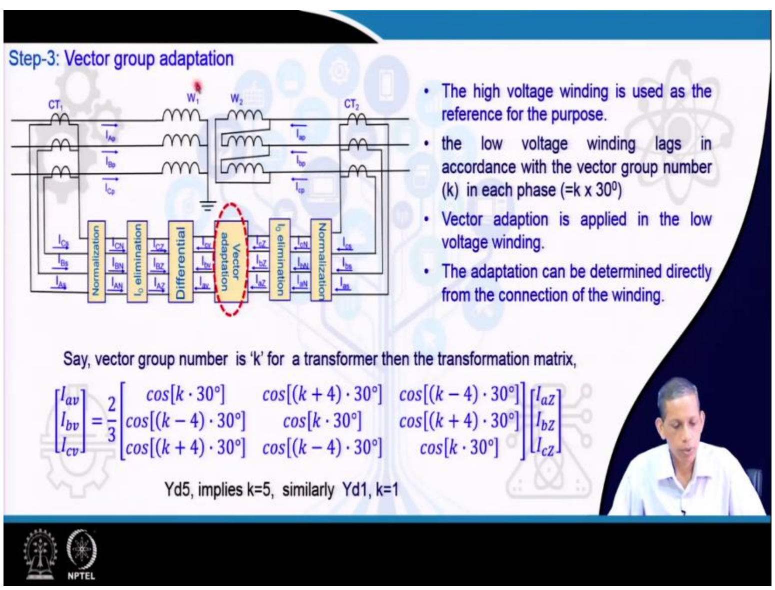

Now, for this vector group adaptation, how that is being done, we have a matrix form like we see for the zero-sequence elimination also. So, in this case the vector group adaptation is we are accomplished in the low voltage side, so this I_{av}, I_{bv}, and I_{cv} this is after the corresponding vector group adaptation and from what the corresponding I_{aZ}, I_{bZ}, I_{cZ} that is after the zero-sequence elimination. So, from this current we are going to this current using this transformation matrix given by

$$\begin{bmatrix} I_{av} \\ I_{bv} \\ I_{cv} \end{bmatrix} = \frac{2}{3} \begin{bmatrix} cos[k \cdot 30°] & cos[(k+4) \cdot 30°] & cos[(k-4) \cdot 30°] \\ cos[(k-4) \cdot 30°] & cos[k \cdot 30°] & cos[(k+4) \cdot 30°] \\ cos[(k+4) \cdot 30°] & cos[(k-4) \cdot 30°] & cos[k \cdot 30°] \end{bmatrix} \begin{bmatrix} I_{aZ} \\ I_{bZ} \\ I_{cZ} \end{bmatrix}$$

Here k stands for the group number, the vector group number. Suppose we say this transformer is Yd5 it implies k equals to 5 if the transformer is Yd1; k equals to 1 and so. Then cos (k+4) 30^0, suppose k is 1 means this is cos (1+ 4) is 5 so (5 × 30) is 150^0, that is shifted by 120 degree, (k - 4), so then this becomes equals to (1- 4) ×30^0 becomes -90^0 so that is what again we are talking in terms of that and then we multiply that. Now, this whole purpose is that to orient the corresponding I_a, I_b, I_c with respect to the high voltage winding and that vector group adaptation things we obtain from this one.

This matrix comes from the fault analysis using sequence component, positive sequence voltage or current in terms of this that it leads by an angle of 30^0, jθ to the corresponding aspect in the particular transformer Yd1 and so. Then we also learn in case of the corresponding negative sequence that the corresponding it happens to be reverse one, it happens to be - 30^0 or lagging perspective angle and so. So, considering the positive sequence and negative sequence perspective the corresponding $e^{j\theta}$ comes here and using that the corresponding matrix in terms of the cos terms which we are getting here.

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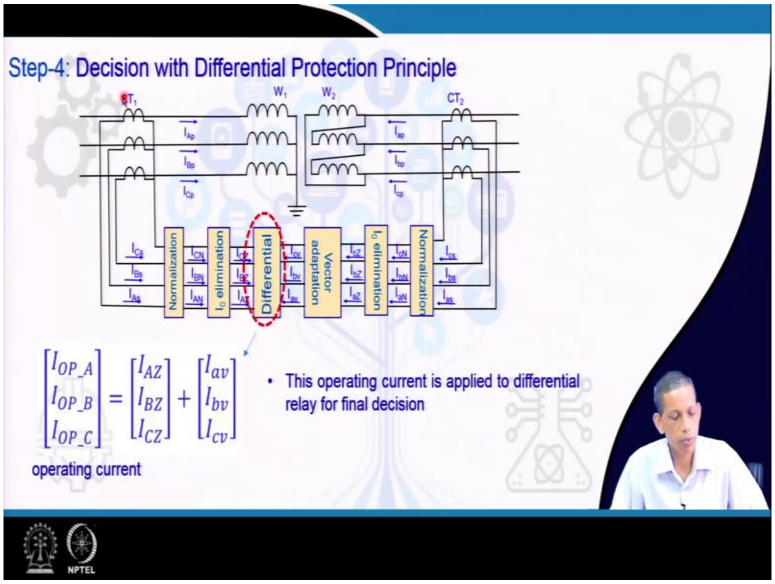

Now, the final step is on decision with the differential principle, so we already got vector group adaptation then from this side we have already zero-sequence elimination perspective, this is low voltage side, this is high voltage side and then the middle one is about the differential current is to be calculated and the corresponding differential characteristic principle has to be applied.

So, for that the operating current in phase A, phase B and phase C are obtained by

$$\begin{bmatrix} I_{OP\_A} \\ I_{OP\_B} \\ I_{OP\_C} \end{bmatrix} = \begin{bmatrix} I_{AZ} \\ I_{BZ} \\ I_{CZ} \end{bmatrix} + \begin{bmatrix} I_{av} \\ I_{bv} \\ I_{cv} \end{bmatrix}$$

So, we have this addition this depends upon the principle we have already applied depending upon the CT connection perspective and all this thing. This operating current is applied to the differential relay in this percentage by differential relay characteristics and there the relays is if it is greater than this I_{OP}, if it is greater than the $m_1 I_{RES}$ or $m_2 I_{RES}$ then relay makes a trip decision otherwise it remains in a restrain position.

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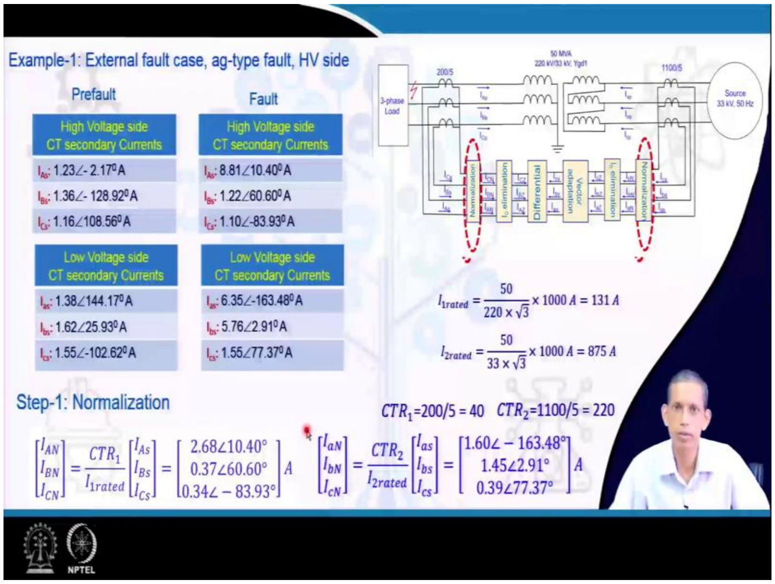

We will go to examples, how the corresponding steps are being accomplished and then how the differential relay can make a judgment whether the fault is external or internal. First we have considered for an external fault, *ag*-type fault in high voltage side. So, a simple system we have considered, a 33 kV source grade and then we have a transformer, the transformer is 220:33 kV and then the transformer is Ygd1 and 50 MVA transformer.

We have high voltage side capital A B C, and low voltage side small a b c as we have already defined and then the corresponding steps are to be accomplished from the CT secondary that will be processed by the numerical relay platform. A three phase load is connected which is being fed from this source to this transformer.

So, for an external fault of *ag*-type in high voltage side, the recorded data are prefault, this is normal loading condition that becomes I_{as}, I_{bs}, I_{cs} are the secondary current available through the CT secondary to the relay or having some little more than 1 A current, this is the status of the loading condition.

Then the low voltage side CT secondary current in the prefault side is also similar having greater than 1 A or so after the transformation through the 5 A CT and so. Now the fault data are like this, so the fault is in phase A to ground and you notice the phase A becomes significantly high $8.81\angle 10.40^0$ A and the other two phases are having negligible current as compared the fault current and they are almost in the normal state as you have seen the prefault.

Now, in the low voltage side which is the source side here, the primary side so called, then the corresponding current which happens to be I_{as} equals to 6.35 and I_{bs} equals to 5.76, I_{cs} equals to 1.55 so we notice the two phases instead of one phase current in the high voltage side two currents are now in case. This is due to reason here if you see here the fault is in A phase, so this current increases. Therefore if you go to the low voltage side this corresponding winding in phase A, this current will be proportional current flow, but this is connected to the phase B winding like this, so therefore phase A and phase B winding, the corresponding phase A and phase B line side currents are being affected. And that is the reason we see here, high amount of current is considered in phase A and phase B but we see here, next we will go step by step, so in first step we will see that the rated currents at the terminals are

$$I_{1rated} = \frac{50}{220 \times \sqrt{3}} \times 1000\ A = 131\ A$$

$$I_{2rated} = \frac{50}{33 \times \sqrt{3}} \times 1000\ A = 875\ A$$

Based on that we select the CT ratio to be 1.25 times and so as already we have learned from that and this CTR 1 is high voltage side becomes 200: 5 with a ratio of 40 and the low voltage side with the ratio of 1100:5 that is 220 factor happens to be there. Now, we can go for the normalization perspective after the CT ratio are being frozen and the high voltage side we got the corresponding normalized currents to be

$$\begin{bmatrix} I_{AN} \\ I_{BN} \\ I_{CN} \end{bmatrix} = \frac{CTR_1}{I_{1rated}} \begin{bmatrix} I_{As} \\ I_{Bs} \\ I_{Cs} \end{bmatrix} = \begin{bmatrix} 2.68\angle 10.40° \\ 0.37\angle 60.60° \\ 0.34\angle -83.93° \end{bmatrix} A$$

Similarly, in the low voltage side after applying the normalization the current values are

$$\begin{bmatrix} I_{aN} \\ I_{bN} \\ I_{cN} \end{bmatrix} = \frac{CTR_2}{I_{2rated}} \begin{bmatrix} I_{as} \\ I_{bs} \\ I_{cs} \end{bmatrix} = \begin{bmatrix} 1.60\angle -163.48° \\ 1.45\angle 2.91° \\ 0.39\angle 77.37° \end{bmatrix} A$$

So, this is first step about the normalized current both at high voltage level and the low voltage levels.

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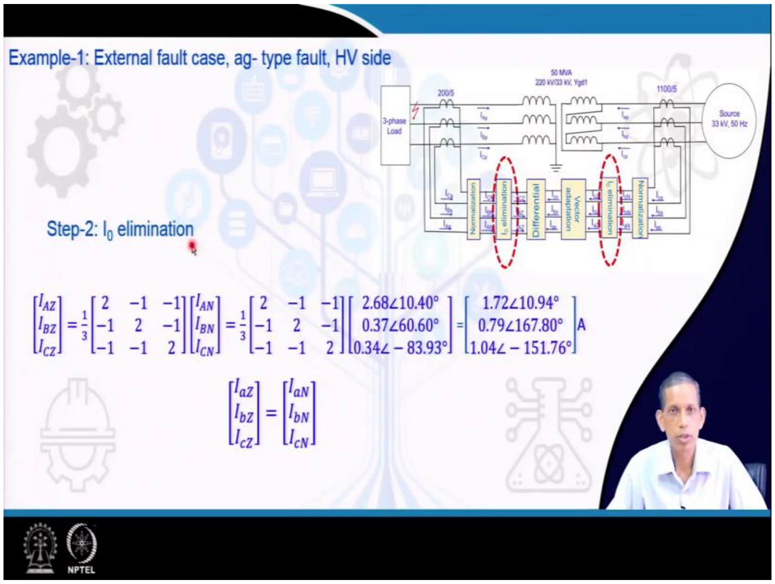

Next step is on zero-sequence elimination, so straight forward this transformer the high voltage is connected in star grounded, so zero-sequence current will flow in this side, no more zero-sequence current will flow in this delta side perspective. Now, in that case we see that zero-sequence current has to be subtracted, so as already mentioned one third of the matrix, the zero-sequence corresponding matrix and then the normalized current is being multiplied with that and then we got I_{AZ}, I_{BZ}, and I_{CZ}.

$$\begin{bmatrix} I_{AZ} \\ I_{BZ} \\ I_{CZ} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} I_{AN} \\ I_{BN} \\ I_{CN} \end{bmatrix} = \frac{1}{3}\begin{bmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{bmatrix}\begin{bmatrix} 2.68\angle 10.40° \\ 0.37\angle 60.60° \\ 0.34\angle -83.93° \end{bmatrix}$$
$$= \begin{bmatrix} 1.72\angle 10.94° \\ 0.79\angle 167.80° \\ 1.04\angle -151.76° \end{bmatrix} A$$

Similarly, we can obtain for the low voltage side I_{aZ}, I_{bZ} and I_{cZ}. In this case there is no zero-sequence current in the delta side, so we can get same I_{aN}, I_{bN} and I_{cN} which are the normalized currents in low voltage side.

$$\begin{bmatrix} I_{aZ} \\ I_{bZ} \\ I_{cZ} \end{bmatrix} = \begin{bmatrix} I_{aN} \\ I_{bN} \\ I_{cN} \end{bmatrix}$$

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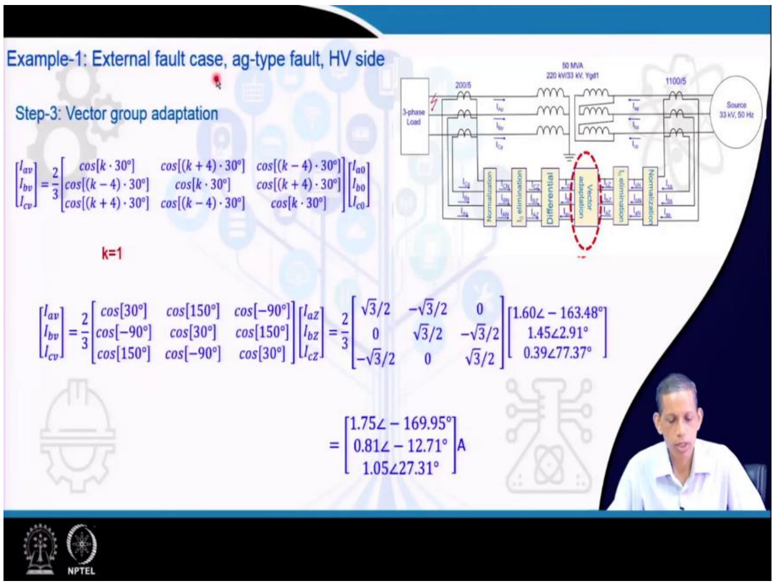

Now, for this external fault we will go for this step three, that is the vector group adaptation, the phase angle coincidence perspective and so. So, we have the corresponding matrix, k equals to 1 here because this is a Yd1 connection, so substituted value of k then you got the corresponding angles to be cos30, cos 150, cos(-90) and so then this rotating kind of thing.

So, we got the corresponding low voltage side currents after the vector group adaptation are

$$\begin{bmatrix} I_{av} \\ I_{bv} \\ I_{cv} \end{bmatrix} = \frac{2}{3}\begin{bmatrix} cos[30°] & cos[150°] & cos[-90°] \\ cos[-90°] & cos[30°] & cos[150°] \\ cos[150°] & cos[-90°] & cos[30°] \end{bmatrix}\begin{bmatrix} I_{aZ} \\ I_{bZ} \\ I_{cZ} \end{bmatrix}$$

$$= \frac{2}{3}\begin{bmatrix} \sqrt{3}/2 & -\sqrt{3}/2 & 0 \\ 0 & \sqrt{3}/2 & -\sqrt{3}/2 \\ -\sqrt{3}/2 & 0 & \sqrt{3}/2 \end{bmatrix}\begin{bmatrix} 1.60\angle-163.48° \\ 1.45\angle 2.91° \\ 0.39\angle 77.37° \end{bmatrix} = \begin{bmatrix} 1.75\angle-169.95° \\ 0.81\angle-12.71° \\ 1.05\angle 27.31° \end{bmatrix} A$$

So, this is the corresponding currents we are getting after the vector group adaptation, so we reach up to this step from the low voltage side.

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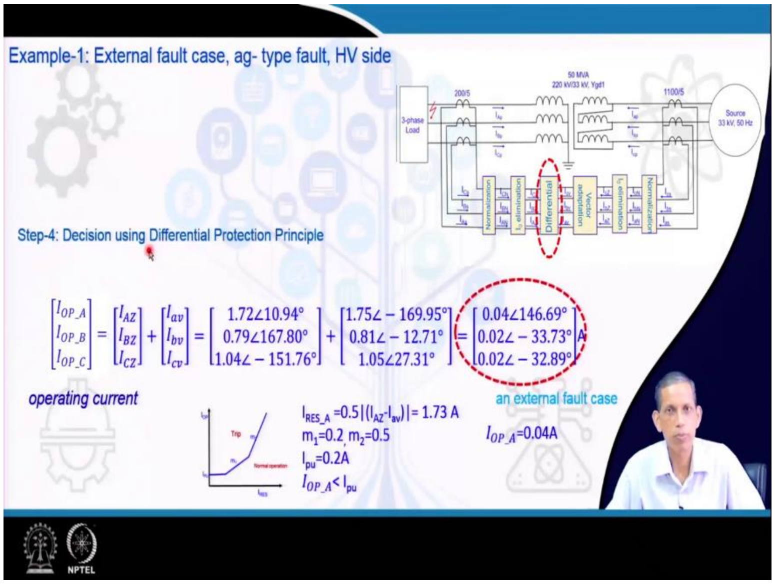

The fourth step is on the decision process, the differential current calculation and the restraining current and then applying the corresponding trips. So, we got the corresponding operating current to be

$$\begin{bmatrix} I_{OP\_A} \\ I_{OP\_B} \\ I_{OP\_C} \end{bmatrix} = \begin{bmatrix} I_{AZ} \\ I_{BZ} \\ I_{CZ} \end{bmatrix} + \begin{bmatrix} I_{av} \\ I_{bv} \\ I_{cv} \end{bmatrix}$$

$$= \begin{bmatrix} 1.72\angle 10.94^\circ \\ 0.79\angle 167.80^\circ \\ 1.04\angle -151.76^\circ \end{bmatrix} + \begin{bmatrix} 1.75\angle -169.95^\circ \\ 0.81\angle -12.71^\circ \\ 1.05\angle 27.31^\circ \end{bmatrix} = \begin{bmatrix} 0.04\angle 146.69^\circ \\ 0.02\angle -33.73^\circ \\ 0.02\angle -32.89^\circ \end{bmatrix}$$

It seems the corresponding values are pretty much smaller than the corresponding values from this side. So, if we see these values, the value seems to be smaller. Now, the relay will decide based on the trip, the percentage based trip characteristics, now let us calculate the restraining current in phase A for k is taken as 0.5

$$I_{RES\_A} = 0.5|(I_{AZ} - I_{av})| = 1.73\ A$$

m_1 we have considered this part is 0.2 and m_2 we have considered as 0.5, so now I_{OP} considered is 0.2 A this is normalized current. Now, what is, let us say phase A current is the I_{OP} comes out to be considered 0.04 A magnitude part only we have considered, for this characteristic relations, so this 0.04 A is less than the corresponding I_{pu} threshold value.

So, therefore this is the first check with the relay does and this corresponding I_{OP} current phase A which is highest here out of these three, that does not qualify this first test. So, therefore the relay confirms that this is not at all trip basis on it is a restrain or normal situation for the transformer. So, this confirms that this is a fault, but this is external to a transformer, it has nothing to do with the transformer.

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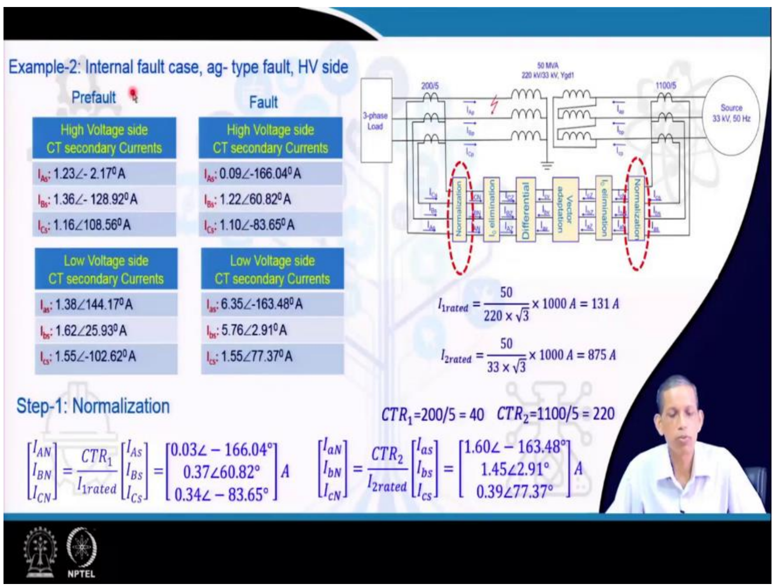

Next case we will go for an internal fault case, so same arrangement for the transformer, only the corresponding fault is created in between the two sensors, group of sensors CT and you have created a fault internal to this arrangement. So, it is in zone fault in this case. For this case the prefault condition remaining same for this both high voltage and low voltage side.

Now, the fault, if you see phase A fault is created, phase A to ground fault is created, so in this case the corresponding current from this high voltage side this current decreases substantially because this load side no source is there. So, therefore the current flows from here to here and this side the current flowing is very substantially lower now.

The other two phases remains almost intact and in the delta side because this phase current becomes larger due to this fault, so, therefore the delta side phase A and phase B current becomes significantly high as already explained in the external fault case also. Now, this fault current will apply the corresponding four steps for this differential relaying principle, normalizations, we apply the same principle like the CT ratio and the rated current and we got the normalized current using the CT ratio and all these things to be 1.6, 1.45 and 1.39.

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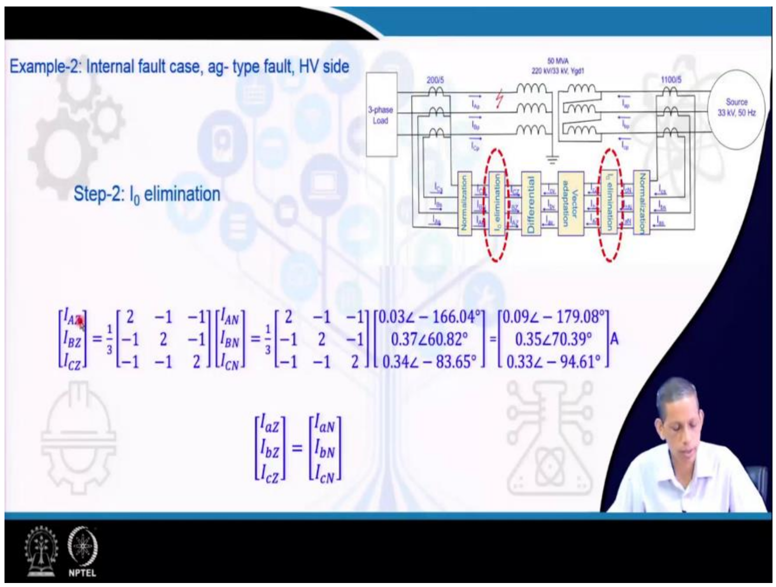

Zero-sequence eliminations I_{AZ}, I_{BZ} and I_{CZ} capital and then a small I_{aZ}, I_{bZ}, I_{cZ} the way we did for the earlier case of external fault case multiply this matrix and got the corresponding currents to be 0.09, 0.35, 0.33 for the high voltage side. And then the same is for the low voltage side the I_{aN}, I_{bN} and I_{cN}.

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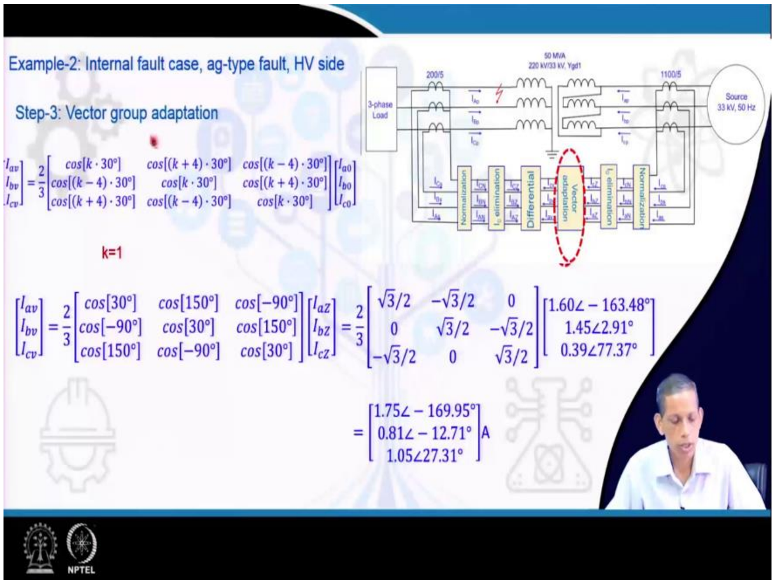

Now, step three is on the vector group adaptation, so for k equals to one, these matrix we have already seen for external case, two third upon root three by two and so, and then use the corresponding I_{AZ}, I_{BZ} and I_{CZ} values and get the corresponding value to be 1.75, 0.81, 1.05, in the low voltage side I_{av}, I_{bv}, I_{cv}, where the v stands for vector group adaptation. So, we have reach up to these third steps here which is being carried out in the low voltage side.

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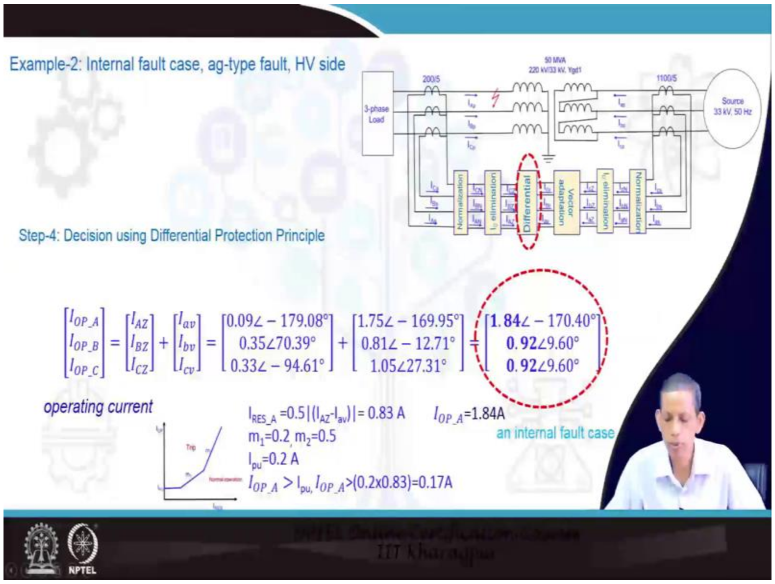

Now, final step is on the decision making process, so for the operating current for each phase of A, B and C we get the corresponding this plus this and then we add these two current phase or current and got the values of 1.84, 0.92, 0.92. Now, see here as compared to the external fault case like highest there was 0.04, here we are getting 1.84, compared to the values of different phase currents of this order.

So, that shows the corresponding current here is significant, particularly phase A case and we have this fault is ag-type fault for the transformer and it is in zone fault, internal fault to the transformer. So, for this case I operating considered as 1.84 for phase A, and then restraining current $0.5|I_{AZ} - I_{av}|$ that is being calculated comes out to be 0.83 ampere, m_1 is 0.2 and m_2 is 0.5 like the earlier case, I_{pu} is 0.2 A.

In this case the $I_{OP} > I_{pu}$, so that is the first check, 1.84 is greater than 0.2. The I_{OP} current is also 0.3 times of this 0.83, which gives you 0.2 ampere, so this I operating 1.84 is also greater than 0.2 ampere. So, that means the corresponding point falls in the trip region and therefore it is ensured that this is an internal fault in this case. So, this corresponding relay is able to detect the internal fault successfully and for the earlier case or for the external also it identified correctly.

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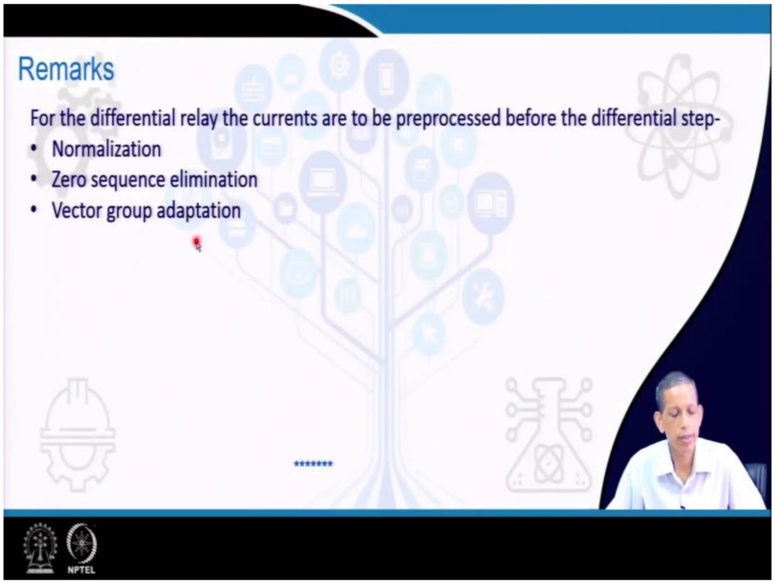

So, we see that the differential relay essentially requires four steps and all four steps are important. The normalization of the current has to be carried out, the zero-sequence elimination to subtract the corresponding zero-sequence current is also required and then to have the corresponding phase shift carried out by different vector groups that are to be carried by the vector group adaptation.

This we can say that in the method which we have followed here is being accomplished in the low voltage side. So, once you do this, prepare the corresponding currents from the high voltage side and low voltage side then we can make the corresponding comparison or the differential current and at that also we calculate the restrain current and apply the percentage by differential relative characteristic to see whether the point lies above the trip characteristics or below, if it lies above then it is an internal fault, otherwise the relay will go for restrain operation. Thank you.