Power System Protection and Switchgear
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Lecture 11
Current Based Relaying Scheme 6

So, in the last class we have discussed one example.

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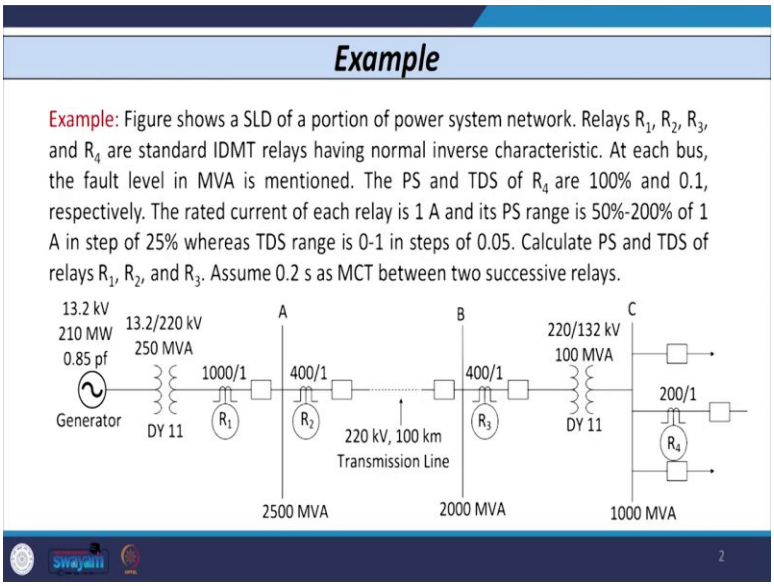

So, this is the example which we have discussed and we have calculated the plug setting of this four relays, that is R1, R2, R3 and R4. So, again let us further proceed for this.

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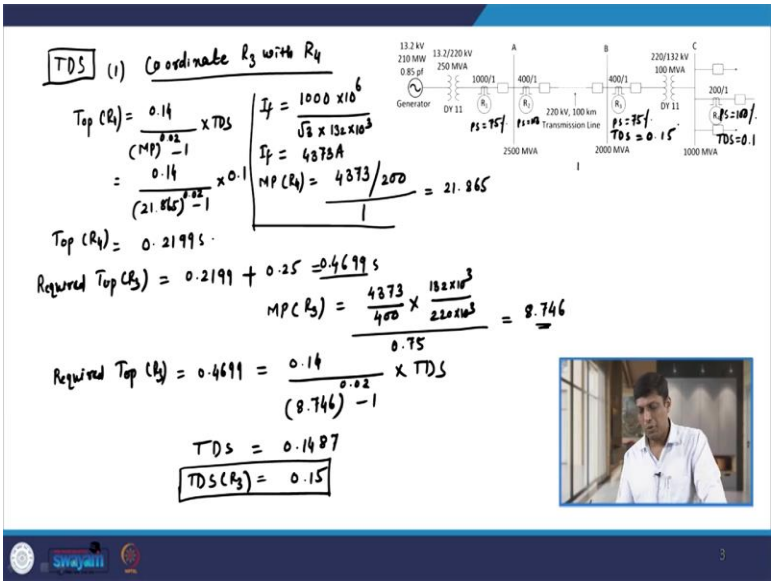

In this example, the plug setting and time dial setting of relay R4 that is given and we need to calculate the plug setting and time dial setting of other relays that is R1, R2 and R3. So, in the last class we have solved and we have calculated the plug setting of R3, R2 and then R1.

So, with this let us start further our discussion with, how to calculate the time dial setting of this relays. Now, as I told you earlier that the, whenever we want to decide the plug setting, then plug setting is always decided based on the full load current of the feeder or any apparatus. Similarly, if I want to decide time dial setting, then time dial setting of any relay that can be decided based on fault current. So, usually at each and every bus fault level is given in terms of MVA or maybe sometimes fault current is given or in some other cases the breaking capacity of circuit breakers that can also be given in MVA.

So, with that MVA you can find out the fault current in ampere, and then you can utilize that fault current for further calculating the time dial setting of relays. So, let us start with the time dial setting of relay R3. So, first we coordinate relay R3 with R4. The reason is the TDS of R4 that is given as 0.1. So, when we coordinate the relay R3 with relay R4, you can see that the highest level, fault level that is given near relay R4, that is thousand MVA. So, utilizing this thousand MVA, we need to calculate the time of operation of relay R4 and then we add some margin, this is known as minimum coordination time.

So, we will have required time of operation of relay R3 and then we can find out the time dial setting of relay R3. So, as you can see that in the figure between relay R3 and R4; the one bus that is the at bus C, the fault level that is given as 1000 MVA. So, for this fault level let us find out, what is the magnitude of fault current for this fault level that is thousand MVA. So, we have to divide it by root 3 and we have to again find out what is the value. So voltage level, voltage value for this case; that is 132 KV.

So, for 132 KV if you calculate it, then you can find out the value that is 4373 ampere, so this is the fault current. Now, utilizing this fault current, let us calculate the multiple of pick up current of relay R4. So, if I calculate this, then the value as I told you earlier the multiple of pick up current is given by fault current; referred to CT secondary. So, CT secondary of relay R4 that is 200 divide by the plug setting of relay R4 that is 100 percent; so that is 1.

So, we can see that the value that is given as 21.865. So, this is the value of multiple of pick up current of R4. So, utilizing this let us calculate the time of operation of relay R4. So, the equation that is given by 0.14 divide by MP raised to 0.02 minus 1 into TDS. So, if I put the value here, 0.14 MP is we have already calculated 21.865, raised to 0.02 minus 1 into TDS. TDS is already given 0.1. So, if we solve this then we can have the value 0.2199 second.

So, this is the time of operation of relay R4 with fault level that is thousand MVA, given at bus C. So, even if I consider this or if I consider immediately after the relaying point R4, both are same. Now, so required time of operation of relay R3 that is given by 0.2199 second plus we have the minimum coordination time margin, let us say it is 0.25 second. So, the final value that is given by 996 and 4. So, 0.4699 second, so that we can have.

So, this is the required time of operation of relay R3. Now, for this same value of fault current that is 4979, let us calculate the multiple of pick up current for relay R3. So, as relay R3 is on the other side of the transformer, so the same fault current 4373 divide by CT ratio of R3. So, that is 400 and here we need to multiply with the turn's ratio of the transformer. So, that is 132 KV divide by 220 KV and whole this is divided by the plug setting of the relay R3, so that is 0.75.

So, if you calculate this value, then it comes out to be 8.746. So, if I use this then required time of operation of relay R3, this is already we have calculated 0.4699 second, which is equal to 0.14

divide by MP raised to 0.02. So, MP is 8.746, so 8.746 raised to 0.02 minus 1 into TDS, that is TDS of R3 which need to calculate.

So, if you solve this, we have the TDS that is equal to 0.1487. Now, as I told you the time range, range of TDS that is 0 to 1 second in steps of 0.05. So, higher than 0.1487 available; that is 0.15, so TDS of R3 we can select that is 0.15. So, we have already calculated the TDS of R3. So, let us write down here that is 0.15. So, now we need to calculate the TDS of relay R2. So, now when we calculate the TDS of relay R2 we need to coordinate relay R2 with relay R3 and again we need to coordinate it at fault level given at bus B; that is 2000 MVA. Let us coordinate second case relay R2 with relay R3.

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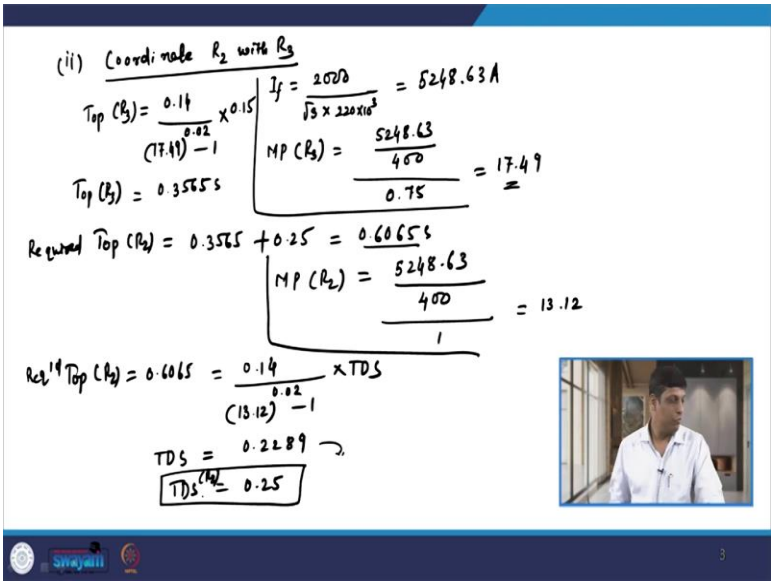

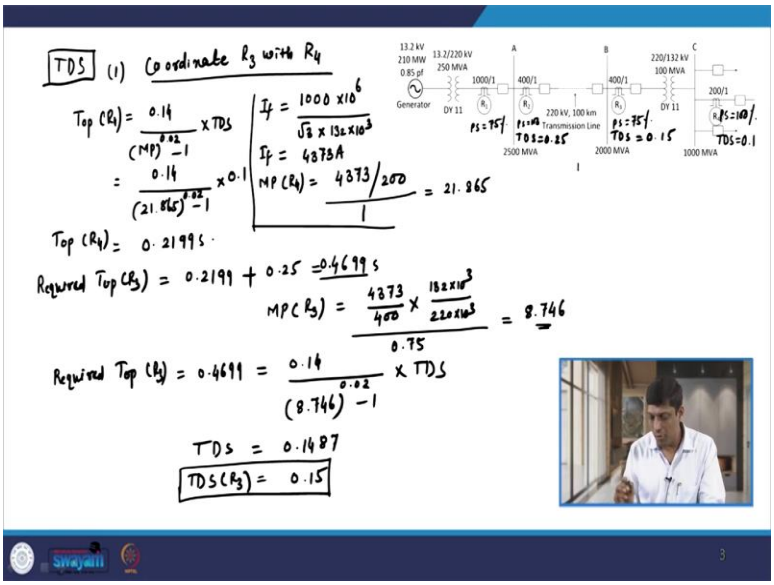

So second, let us coordinate relay R2 with relay R3. So, to coordinate this let us consider the 2000 MVA, that is the fault level at bus B. So, let us calculate the fault current 2000 MVA multiply by root 3 and the voltage level. So, you can see that at bus B, the voltage level is 220 KV. So, we can calculate 220 into 10 raised to 3.

So, we have if we calculate it; it is 5248.63 ampere. So, you have the value of current that is this. So with this current let us calculate the multiple of pick up current of relay R3. So, that is 5248.63 divide by CT ratio of relay R3 that is 400 and whole that is divided by the plug setting of the relay R3. So, we have this is 400 and whole that is divided by plug setting of relay R3 that is 0.75.

So, if we do it then we have the value 17.49. So, this is the multiple of pick up current of relay R3. So, with this value now let us calculate what is the time of operation of relay R3 that is 0.14 divide by MP that is 17.49 and whole raised to 0.02 minus 1 into TDS. TDS of relay R3 we have already calculated and we have marked that is 0.15. So, we can put the value that is 0.15.

So, if I solved this, then we have the value 0.3565 second. So, this is the time of operation of relay R3 for fault level given at bus B that is 2000 MVA. So, required time of operation of relay R2 that is given by 0.3565, plus some minimum coordination time interval that is between 2 successive relay that is 0.25.

So, if I add this, then we have the value 0.6065 second. So, now for the same fault level, let us calculate the multiple of pick up current of relay R2. So, for same fault current that 5248.63, divided by CT ratio of relay R2. So, relay R2 it is given at 400 and its plug setting is 100 percent. So, this is 400 whole divided by 1, so we have the multiple of pick up current that is 13.12. So, if I use this value, so we can have the required time of operation of relay R2, which is equal to 0.6065, that is equal to 0.14 divided by MP, that is 13.12 raised to 0.02 minus 1 into TDS.

So, if we solve this we can have the value of TDS, that is equal to the 0.2289. So, if I next available range beyond this, that is 0.25. So, we can select the value of TDS of relay R2 that is 0.25. So, that let us mark this value here also, so TDS for relay R2 that is 0.25 we have already calculated. So same way, let us coordinate relay R1 with relay R2 for the fault level that is 2500 MVA.

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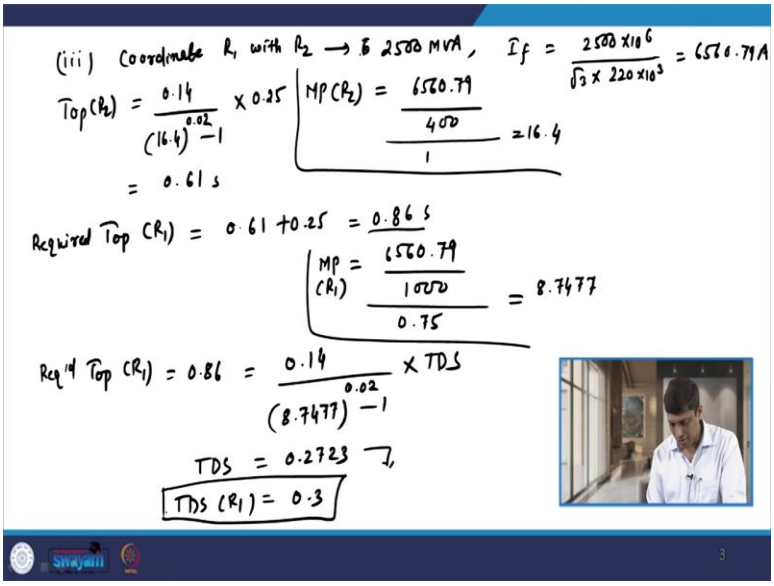

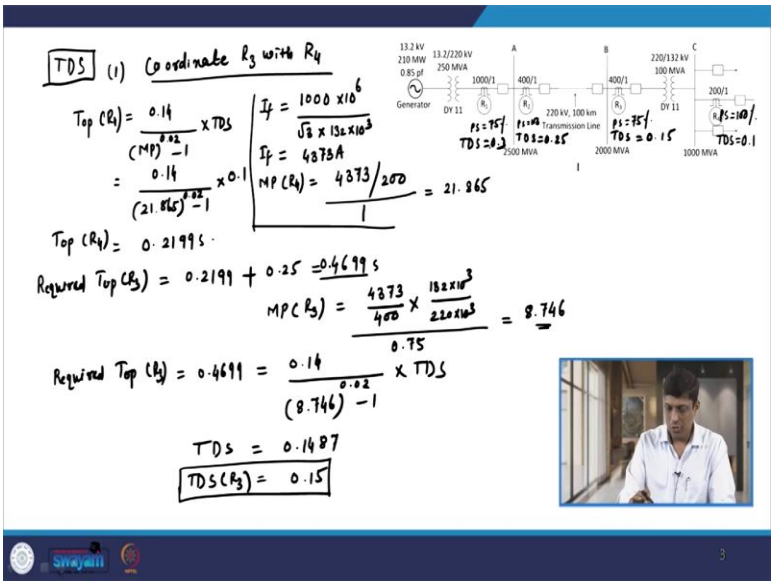

So, let us coordinate relay R1 with relay R2 for fault level that is 2500 MVA. So, for this let us calculate the fault current that is 2500 into 10 raised to 6, divide by root 3 into voltage level that 220 KV and if we solve this, then we have the value that 6560.79 ampere. So, for this fault current let us calculate the multiple of pick up current of R2, that is 6560.79, divide by if I consider what is the ratio of relay R2 that is 400 by 1 and its plug setting is 100 percent.

So, the 400 and divided by 100 percent. So, if we solve this, the value comes out to be 16.4. So, if I utilize this value, you can calculate the time of operation of relay R2 that is at 2500 fault level MVA, that is 0.14 divide by MP that is 16.4 raised to 0.02 minus 1 into TDS. TDS of R2 we have already calculated that is 0.25. So, if I solve this, then we have the value 0.61 second. So, based on this the required time of operation of relay R1 that is given by 0.61 plus 0.25 that is a minimum coordination time.

So, if I solve this, then we have the time that is 0.86 second. So, for the same fault level, now let us calculate the value of multiple of pick up current of this is for relay R1. So, that is equal to 6560.79 divide by CT ratio of relay R1 that is 1000 and its plug setting is 0.75. So, this is 1000 divide by 0.75. So, if we solve this, then that comes out to be 8.7477 and if I use this value, then we have the required time of operation of relay R1. We have already calculated 0.86 second, which is equal to 0.14 divided by MP, that is 8.7477 whole raised to 0.02 minus 1 into TDS.

So, if I, if we calculate this, the value of TDS comes out to be 0.2723. So, next higher range available that is 0.3. So, we can select the TDS of relay R1 that is as 0.3. So, if I go for the

previous case, let us mark it as TDS of R1 that is 0.3. So, in this example we have calculated the earlier plug setting of relay R3, R2, R1 based on the plug setting of R4 and now later on, we have calculated the time dial setting of R1, R2, R3 based on the TDS value given for relay R4. So, this is all about this example.

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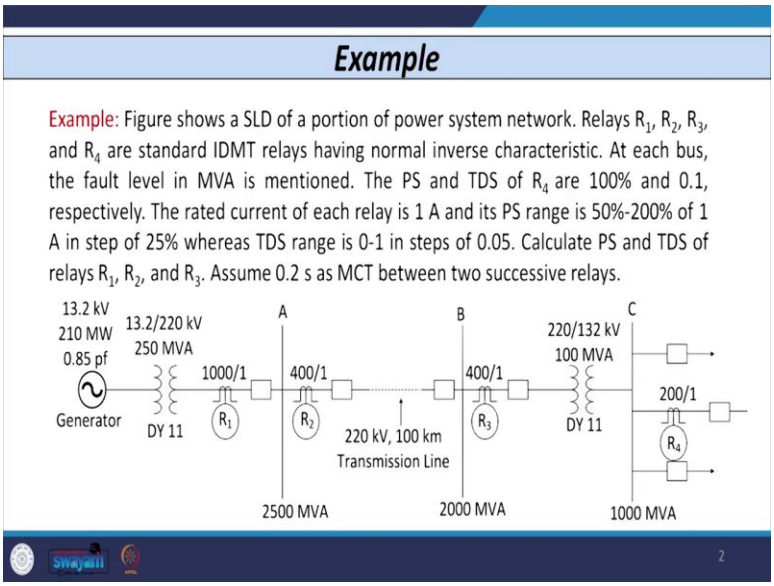

So, now with this background, this is all see whatever example this we have solved, that is for the phase over current relays. So, now let us solve the, another example which is based on the ground relays, because ground relays as I told you earlier it is connected in the residual circuit. So, let us consider this example for the ground relays.

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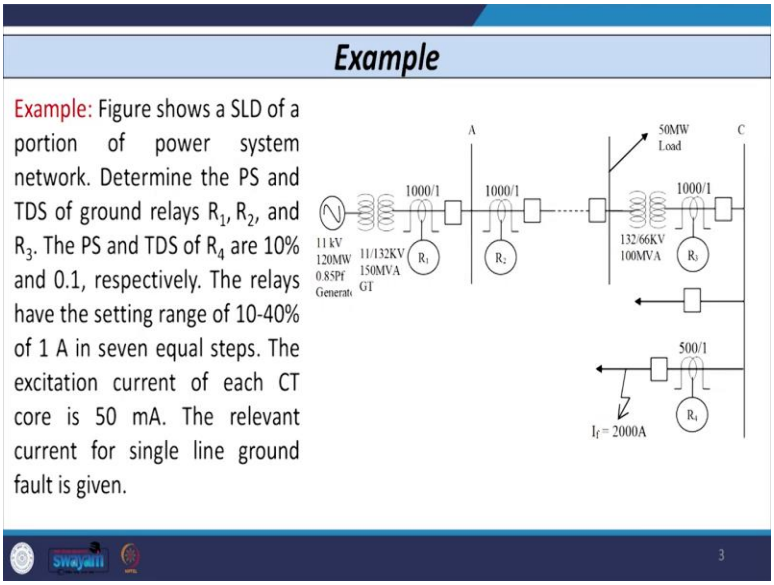

So, here in this example, the one generator is given that is 11 KV 120 megawatt 0.85 power factor. Another generator transformer is given that is 11 by 132 KV and then relay R1 is given, relay R2 is given. Then we have another transformer step down transformer, then relay R3 is given and another relay that is also connected that is relay R4 at another feeder.

Now, here in this example instead of giving fault MVA at different bus, only the fault current at respective bus that is given. So, for example the fault current immediately after relay R4 that is given as the 2000 ampere and the other case that is also given. So, let us solve this what we need to do is, in this case the plug setting and time dial setting of relay R4 is given, that is 10 percent and 0.1 and we need to find out the plug setting and time dial setting of R1, R2 and R3. The excitation current of each line CT that is also given as 0.05 ampere, 50 mA and with this background we need to solve the example. So, first let us just draw the circuit.

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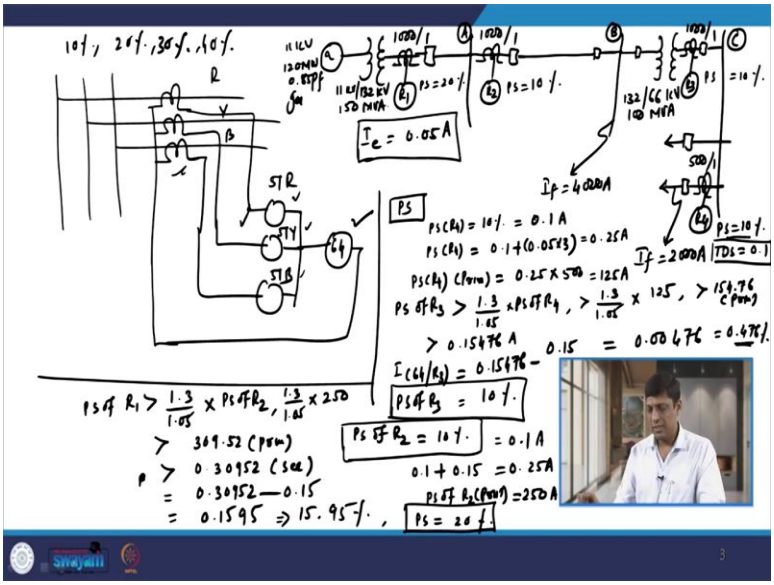

So, here we have the first is the generator given. Then we have the transformer, then we have the breaker and then bus is given; that is bus A. Now, here the relay connected that is R1 and its value that is given as CT ratio is 1000 by 1. The other relay that is also connected here, so here this is your bus B. The other relay R2 is connected here and you have the value again, CT ratio is 1000 by 1. The fault level at this bus that is given as 4000 ampere and you have the another transformer here and with this transformer you have the relay connected on this side.

Let us say the relay R3 and its CT ratio is also 1000 by 1 ampere. This is your bus C and with this bus you have the feeder connected, multiple feeders are connected at this bus and here one relay R4 that is given, whose CT ratio is 500 by 1 and the fault current immediately after this relay R4 that is given as 2000 ampere.

The plug setting of relay R4 that is given as 10 percent and its TDS value that is given as 0.1. The excitation current of each line CT that is given as 0.05 ampere and you need to calculate the value of plug setting and time dial setting of the three relays R1, R2 and R3. So, with this background let us solve.

Now, see before I just mention here one thing we need to remember is that R1, R2, R3 and R4 are group of relays. So, this relays are nothing but the we have the phase relays as well as the ground relays. So, for example if I consider relay R1, then this relay R1 is nothing but we have the three lines connected like this and we have the three line CTs like this. So, if I have the R

phase, Y phase and B phase here, then we have the three relays connected one in R phase, another in Y phase and another in B phase and we have the another relay connected like this.

So, this is I told you earlier, so this is your 51 R relay, this 51 Y relay and this is 51 B relay. 51 stands for over current relay that is phase relay. So, we have three phase relay in each phase. So, how to solve calculate the plug setting and time dial setting of this relays, we have already considered in previous example.

Now, in this example we are talking about this relay that is ground relay, it is indicated by the number 64. So, it is basically ground relay. Plug setting of this ground relays are normally lower than phase relays as I told you earlier, because it is connected in the residual circuit. So, we need to consider the excitation current of the three line CTs, when we consider this example.

So, let us start solving this example with this background. So, let us start with the plug setting of the relays R3, R2 and R1. Now, before I start let us consider, what is the value of transformer rating? So, the rating of the transformer given here that is 132 by 66 KV and it is 100 MVA transformer. So, this rating that is 132 by 66 KV and it is 100 MVA transformer, this is given. So, on this side you have 66 KV and on this side you have the 132 KV and the rating of the earlier transformer that is also given.

This is 11 KV by 132 KV and its MVA rating is 150 MVA, it is basically generated transformer connected with the generator and this generator is also 11 KV and its value is 120 megawatt at 0.85 power factor. So this is given, this is your generator. So, with this background now let us solve the, let us decide the plug setting. Now, plug setting of relay R4 is given as the 10 percent. So, if I write plug setting of R4 that is given as 10 percent. So, it is basically 10 percent of secondary that is 0.1 ampere.

Now, if I consider three excitation current of three line CTs. One is given as 0.05. So, if I multiply with this 0.05 into 3 it becomes 0.15. So, the plug setting of relay R4 considering excitation current of three line CTs, then it is 0.1 plus 0.05 into 3, because we have three line CTs. So, this comes out to be 0.25 ampere. Now, when I transfer this current to the primary of the CT connected with relay R4, then we have the plug setting of relay R4 on primary side. So that value is 0.25 multiply by CT ratio that is 500, value is 125 ampere.

So, when we decide plug setting of relay R3, plug setting of relay R3 that is given by greater than 1.3 1.05 into plug setting of relay R4 on primary side. So, this value is 1.3 divide by 1.05 into 125. So, if I calculate this value should be greater than 154.76, this is primary side, primary of relay R3. If I transfer this current on secondary side, I have to divide this 154.76 by 1000 ampere. So, we have 0.15476 ampere secondary side. Now, this current that will flow through here on the secondary side.

What is the current through ground relay 64? So, the current through ground relay 64 that is I through 64 in case of R3, that is given by 0.15476 minus we have to subtract the CT excitation current of three line CTs that is 0.15. So, this comes out to be 0.00476 or in percentage it should be 0.476 percentage. So, plug setting of R3 should be greater than this, so plug setting of R3. Now, the plug setting range available for the ground relays R1, R2, R3, R4 are in steps of 10 percent, 20 percent, 30 percent and 40 percent in steps of 10 percent.

So, next available range higher than 0.4 percent that is 10 percent. So, we can select the plug setting of R3 that is 10 percent. So, let us write down plug setting of R3 that is 10 percent; that is one thing, so we decided the plug setting of relay R3. Now, what about relay R4? Now as relay R2 and R3 between two relay R2 and R3, the star delta transformer is available and as I told you while deciding in the plug setting and time dial setting rules for ground relays. When we have star delta transformer involved between two successive relays R2 and R3 in this case. Then we can set the plug setting and time dial setting of relay R2 independently.

So, in this case I can consider the plug setting of relay R2, that is 10 percent same as R3. Even we can set the lower value also if lower range is available. So, we have already decided the plug setting of R2 that is 10 percent. Now, let us decide the plug setting of R1. So, plug setting of R1 that is given by greater than 1.3, 1.05 into plug setting of R2. So, plug setting of R2 this value is 1.3, 1.05 into plug setting of R2. So, now what is plug setting of R2 given that is 10 percent. So, 10 percent that means this 0.1 ampere if I add again the CT excitation current 0.15.

Then it becomes 0.25 ampere secondary side, if I transferred this current on primary side, then this plug setting of R2 for primary side that is equal to 0.25 into 1000 ampere. So, that is 250 ampere primary side. So, this value that is 250 ampere and if I solve this, the value comes out to be the 309.2 ampere that is on primary side of relay R1. So, if I transferred it on secondary side,

then we have the value just divided by 1000. So, its value is 0.30952, this is on secondary side, that is something here.

So, what is the current flows through relay 64 R4 ground relay? So, that is nothing but the 0.30952 minus CT excitation current of three line CTs 0.15. So, this comes out to be 0.1595, so in percentage it should be 15.95 percentage. So, plug setting of R1 should be greater than 15.95 percentage. So, we can select higher range available that is 20 percent. So, plug setting we can select R1 that is 20 percent. So, plug let us write down plug setting here that is 20 percent. So, for all the three ground relays R1, R2 and R3, we have decided the plug setting of R1, R2 and R3.

So, now what is next remaining that is the time dial setting of relay R3, R2 and R1. The time dial setting of relay R4 is already given that is the 0.1 value. So, now let us select the time dial setting of relay R3, R2 and R1 based on the TDS value of relay R4 which is already given. So, this calculation we will consider in the next class. So, in this class we have completed the example of phase relays, how to set, how to coordinate or how to grade the phase relays available or installed in the multi section redial network.

Later on, we have also considered the another example which is of ground relays and in that we want to decide the plug setting and time dial setting of the ground relays. So, we have already calculated the plug setting of ground relays based on the plug setting of the ground relay. Already available that is near the load and what is remaining that is the time dial setting of the other three ground relays, that we will discuss later on. Thank you.