Grounding Speech

Slide 1

Good afternoon. My name is Tom Field and I work in the transmission planning group here at DSW. I will be going over how to use the safety grounding tables in the 2006 PSSM for DSW. I am handing out a set of questions for you to fill out during the presentation. This is your quiz for the session. Please print your name at the top. I will handout the solutions at the end.

Slide 2

We had run grounding studies in the past, but the tables for the regions were not in the 2005 PSSM. They are in the 2006 PSSM in appendix K.

Slide 3

This shows the Appendices in the 2006 PSSM. You can see the DSW grounding tables are in appendix K.

Slide 4

There are actually 3 different tables for the DSW grounding data. They aren't labeled Table 1, Table 2, and Table 3, but I will be referring to them this way. Table 1 is just for the substation. It has grounds given for the lines and the buswork in the substation. Table 2 is for a single grounding configuration on each entire line and Table 3 is for the line grounds with specific break points for changes in grounding conductor numbers.

Slide 5

This is Table 1 of the PSSM. This table lists the substation bus name, the bus kV, 3 phase fault, SLG fault, the max fault which is the maximum of the 3 phase and SLG fault which is used for calculating the number of grounding conductors needed, and 3 grounding conductor cable sizes. Under each grounding conductor, there is an SBS for the substation bus and an LNS for lines in the substation with a number behind each corresponding to the conductor set.

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This table was generated by placing 3 phase and SLG faults on all of the DSW buses as well as some buses outside of DSW. The maximum is for the maximum of the 3 phase or SLG fault. Again, SBS is for the substation bus and LNS is for the lines in the substation. The line rating rating in Table 1 is not to be used for lines outside of the substation. For lines outside of the substation, you have to use Table 2 or 3.

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To calculate the number of ground cables given in Appendix K, Table 10.1 which contains the thermal properties for grounding conductors was used. You can see the 3 conductor types used in the DSW tables and 2 sets of fault times next to them. These fault times or fault clearing times are actually the time that the specific conductor can carry a specific current without exceeding its thermal capabilities. The two times given are 15 seconds and 30 seconds and you can see the corresponding fault current capability next to each for the specific conductor. The 15 second time is used in our calculations for the substation bus fault grounding and the 30 second time is used for the lines and the lines in the substations.

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Again, the 15 second time is used for the substation grounding cables. The 30 second time is used for the line grounding cables. For more than 1 conductor, a 90% de-rating is applied to calculate the number of conductors required. The equation for this is in your handout. We will go over this in more detail during the next example.

STOP – finish Example 1 – 5 minutes – has everyone finished example 1?

Slide 9

For 1/0 ground conductor, the limit is 21,000 A for the bus using the 15 second fault time, so only 1 grounding conductor is required since we have a max fault value of 5,178 A. The limit is 15,000 A for the line, so there is still only 1 required for the max fault current of 5,178 A.

STOP – finish Example 2 – 5 minutes – has everyone finished example 2?

Slide 10

We have a fault current of 41,901 A. For the bus, the limit is 21,000 A for 1 1/0 conductor in Table 10.1 as shown in your handout for this problem. This is the limit where you have to go from 1 conductor to 2 conductors. We know we are above 1 conductor, so lets see if 2 conductors will work. The limit for 2 conductors is 21,000 A X 2 which is the number of ground cables X 0.9 which is the 90% derating factor. This gives 37,800 A which is less than our fault current of 41,901 A. The 37,800 A is the limit where we have to go from 2 to 3 conductors. Since are above this limit, we know we can't use 2 conductors. So now let's try 3 conductors. The limit for 3 conductors is 21,000 A X 3 X 0.9 = 56,700 A. Since we are below this limit, 3 conductors are required for the buswork.

For the line, the limit for 1 1/0 conductor in table 10.1 is 15,000 A. Since are above this with a max fault current of 41,901, we have to see if 2 conductors are sufficient. The limit for 2 conductors is 15,000 A X 2 X 0.9 = 27,000 A. We are above this, so now let's see if 3 conductors are sufficient. The limit for 3 conductors is 15,000 X 3 X 0.9 = 40,500 A. Again, we are above this, so now let's see if 4 conductors would be sufficient. The limit for 4 conductors is 15,000 X 3 X 0.9 = 54,000 A. We are below the limit for 4 conductors and above the limit for 3 conductors, so we have to use 4 1/0 conductors for grounding the line in the substation.

Slide 11

Table 2 is used for the ground conductor on the line between 2 substations. This is based on the maximum fault current at the two substation buses on each end of the line. The maximum of these two maximums is used to calculate the line grounding just like we did in Table 1 using the 30 second fault time. This value is applied to the entire line between the two substations. You can see the home bus name, the remote bus name, the bus kV at each bus, and the maximum fault current at the home and remote bus. The number of 2/0 grounding cables for the entire line is shown. You can see that there are multiple remote buses for a single home bus. Each remote bus represents a line connected to the home bus.

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Again, the same calculations used in Table 1 for the line in the substation are applied to the line in Table 2 using the maximum fault current for the entire line. In this table, only 2/0 cables are used for the grounding cables. Again, the 30 second time is used and the 90% derating factor is applied.

STOP – finish Example 3 – 5 minutes – has everyone finished example 3?

Slide 13

You can see the home and remote bus along with their kV, the number of grounds on the line, and the maximum fault current at each end of the line is all of the data that is given in Table 2.

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Each line is entered twice in Table 2, so you have an entry for each line using the different ends as a home and remote bus. This is shown here for the Adams to Apache line. This was done to help you find the line you need.

Slide 15

In this example, you can see the difference between the line grounds required in the substation at each end using Table 1 and the line ground given for the line in Table 2.

STOP – finish Example 4 – 5 minutes – has everyone finished example 4?

Slide 16

As you see in this example, Buckeye requires 1 line ground and Liberty requires 2 line grounds, but the line between the two requires 2 lines grounds. Because of these differences, we developed table 3 which we will talk about later in the presentation.

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Since we don't want to place more grounds than we have to when working on a line, we developed Table 3 which gives breakpoints for changing the number of grounding conductors. This table was created from a spreadsheet that we have which is farily wide. When it was put in the PSSM, it was placed on 2 pages this year, but we will probably eliminate some columns and try to put in landscape next year to place on a single page. We don't have all of the lines in the table this year, so if you are interested in a particular line and it is not in this table, you will have to use Table 2. We will try to get all of the lines with breakpoints in the table next year.

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This shows page 1 of Table 3. You can see the home bus and all of the remote buses connected to it. Each of these represents a different line. You can see the KV at each end, the maximum home bus fault current, and the number of cables required on the bus at the home bus. We will eliminate the PTI bus numbers, remote bus kV, and owner in the table next year because you don't need these columns.

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Page 1 contains the substation data. The bus names at each end of the line and the fault current and grounding requirements in the substation for the home bus are given in this table. The number of 2/0 conductors required on the home bus uses the same equations used for Table 1 with the 15 second clearing time and the 90% de-rating factor applied to the maximum fault current on the bus.

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This shows the second page for Table 3. This page contains the line data. You can see the length of the line which is also the distance of the remote bus from the home bus, the number of line grounding cables required at the home bus for the line in the substation, four break points, the remote bus maximum fault current, and the maximum fault current for the line. The grounding for the line in the station at the home bus will remain the same to the first breakpoint. At the first breakpoint, there is a distance given which is the distance from the home bus where a change in conductors is required. At this point, the conductor number listed next to the break point will be used to the next break point or the remote bus if there are no other break points for the line. The last break point conductor number will remain the same to the remote bus. Some lines do not have a break point and will remain the same number of conductors from the home bus to the remote bus. The column with Cap Bypass may be removed in the future. All of the conductors are 2/0.

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Again, page 2 of Table 3 contains the line data and the grounding of the line in the substation at the home bus.

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This shows that the 2/0 conductor at the home bus is for the line which means a 30 second clearing time is used, the maximum fault current is used at the bus, and the 90% derating factor is applied for multiple conductors. This is the same as the Table 1 calculation for the line in the substation.

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Table 3 was developed by placing faults in 2% increments along the line from the home bus. At each 2% increment, a 3 phase and a SLG fault are placed. The maximum of these two is used with a 2/0 conductor 30 second clearing time and 90% derating factor applied to determine if there is a change in conductors from the home bus. If there is a change, the distance from the home bus and the new number of conductors is put down as a breakpoint A. After this, 2% increments are used on the line until another breakpoint is found. If a break point is found, then the new number of conductors and distance from the station are put down as breakpoint B. This is repeated until the last break point is found which would be the same to the remote bus. Again, all of the distances given for breakpoints are measured from the home bus.

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In this example, please fill in the blanks from the two pages of the table for the shiprock to San Juan line.

STOP – finish Example 5 – 5 minutes – has everyone finished example 5?

Slide 25

The data on page 1 is shown in black and the data on page 2 is shown in green. You can see that the substation information is on page 1 and the line information is on page 2 from this.

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This just shows the example calculations that were used to determine the data in the table for this line at the home bus. Again, these are the same calculations that were performed in Table 1.

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This just shows how the grounding at the remote bus should be calculated. Table 3 doesn't give the grounding at the remote bus because it is the grounding from the last break point or the home bus if there aren't any breakpoints. However, you can use this calculation to verify that it is the same as the last breakpoint or that of the home bus if there aren't any breakpoints by using the maximum fault current given at the remote bus.

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So far, we have been looking at lines with the same ground along them. In this example, we have a breakpoint between Liberty and Buckeye where the number of grounding conductors changes.

STOP – finish Example 6 – 5 minutes – has everyone finished example 6?

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Here you see that the number of ground conductors for the line at the home bus is used to the first break point. The conductor given at the first breakpoint is used the rest of the way to the remote bus because there are no other breakpoints. If there was another breakpoint, the number of conductors at the first breakpoint would be used to the next breakpoint. You should compare this to example 4 which used just 1 conductor type for the entire line from Table 2. If you used Table 2 for this line, you would have needed 2 2/0 conductors for the entire line, but if you used Table 3 for this line, you would only need 2 2/0 conductors for the first half mile of the line from Liberty. Again, this is why we developed Table 3.

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Now we have a more complex example with 2 lines, multiple breakpoints on one of the lines, an increase in conductors on one line and a decrease on the other.

STOP – finish Example 7 – 5 minutes – has everyone finished example 7?

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You can see on the Mead to Marketplace line that the grounding cables increase from 2 at Mead to 3 8.4 miles from Mead. The conductors stay 3 to the end of the line at Marketplace. On the Mead to Perkins line, you can see that the grounds stay 2 from Mead to the first breakpoint 9.7 miles from Mead. At this point, the conductors change to 1 until you get 227.9 miles from Mead. At this point, the conductors change back to 2 until you reach the end of the line at Perkins.

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This is the last example. This example shows that most lines have two entries similar to Table 2. You can look for the line using either end for the home bus. Since the substation grounding information is only given for the home bus, you may be interested in a particular station. However, the more important part of this is in calculating how far you are from a substation. This will usually be the reason you use one particular bus as your home bus on the line. For this example, we will be looking at the Mead to Perkins or Perkins to Mead line.

STOP – finish Example 8 – 5 minutes – has everyone finished example 8?

Slide 33

As you can see, the distances to the two break points are different depending on which end of the line you are on. If you use Mead as the home bus, you use 2 cables from Mead for 9.7 miles. Then you change to 1 cable until you are 227.9 miles from Mead. Then you go back to 2 cables until you reach Perkins. If you use Perkins as the home bus, you use 2 cables from Perkins for 9.7 miles. Then you change to 1 cable until you are 232.7 miles from Perkins. Then you go back to 2 cables until you reach Mead. So this is why you might want to use one or the other ends for the home bus depending on where you are working on the line.

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If you look at the distances given in the two different home bus scenarios of example 7, you will see a 4.8 mile difference. This difference is due to the increments used in the calculations. The distances are calculated in 2% increments. Since we don't know where in a 2% increment the number of conductors will change, we use the beginning of the 2% distance when increasing conductor types and the end of the 2% distance when decreasing conductor types. This is done so we always over-estimate instead of under-estimating the number of conductors needed at any particular point on the line just as we do in Table 2 when we use only 1 conductor number for the entire line.

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We talked about some things that would be done in the future to improve these tables. These are some of the future refinements that we will make to the Tables next year.

Slide 36

Does everyone have their name at the top of their quiz? I think everyone passed. I am handing out the solutions now so you can check your work.

Are there any questions?

Thank you for paying attention through my presentation.