(Updated: 5 Jan 2016)

The Transmission Line problems are always given in inches, feet and miles. Will the TL questions be given in metric form for our quiz and exam?
As some of you may need to work with the American engineers/counterparts in the future, I would imagine that it is no harm to know a bit about the conversion factor.

Will the formulas for GMD, GMR, Lphase etc be given during the exam?
No, they will not be given during the exam or quiz. We have explained the idea behind these formulae. Understanding the idea behind will help you to remember the formulae.

Do I need to remember the ABCD parameters for T-model T. line as well?
Yes. If you cannot remember them, please try to derive them. We have shown you how they are obtained in my hand-written lecture notes.

For the review exercise 17(P129), part(c) how do we solve this problem? I should set Vs = 230kV and find the VRnl right? Using VR = Vs/A, I cannot get the answer.
Yes, you should use Vs = 230kV and VR = Vs/A to solve for VR. Your A should be around 0.967311. Please check.

I use I = Is - (Y/2)Vs but I still cannot get the ans.
You should use Is= C*VR+ D*IR = C*VR since IR = 0. You should get C = j0.659639 mS. Remember to convert your VR (line-to-line) to phase voltage by dividing the previous VRnl by SQRT(3).

P 129, Review Exercise 17
c) When one end if the line is maintained at the rated voltage with the other end left open, calculate the voltage at the open terminals and the charging current drawn by the line?

I have used the nominal-pi model to analyse the problem.
A=D= 0.967
B=97.5j
C=6.596 *10^-4 j
Given VR=230KV

The voltage across the sending end,VS is found to be 237.8 KV.

I have attempted to find the charging current drawn by the line = Is - VS *(Y/2) but I can't get the answer. What is wrong with this approach?
It appears that your values of the A, B, C and D parameters are correct. I do not quite understand why you wish to subtract VS *(Y/2) from Is. VS *(Y/2) is the capacitor charging current at the sending end. If you subtract it, this means that you compute only the capacitor charging current at the receiving end. If you consider both currents, then the charging current drawn by the line is Is or

$I_s = C * V_R$

You must convert VR to phase voltage, i.e. 230/SQRT(3) before you use the above formula.

Review Exercise 17(c): When calculating Is using Is = CVr, why do I need to convert Vr (line-to-line) to phase voltage? Isn't Is the line current? I'm confused.

This formula, Is = CVr, is derived from the per-phase diagram. In the per-phase diagram of the three-phase balanced system, only the Y-connected source/load is considered for the analysis. As we represent any one of the three phases (a, b, or c) using any one leg of the Y-connect source/load, the voltage must be the phase voltage and not the line-voltage. Is is the line current as well as the phase current of the Y-connected system.

Review Exercise 19(b)(i) how to calculate the sending end voltage when supplying no load?

You should use Vs = A*VR where A = 0.9654 at 0.47 degree and VR = 138 kV (line-to-line).

My friends and I had tried to solve Review Exercise 19, under the chapter on POWER TRANSMISSION.

For part (c) particularly, none of us got similar solution as given in the lecture notes (Ans.: 117.5 KV)

It appears that $V_{S,\phi}$ (138/SQRT(3) at a certain delta angle) and I_R (30/(3*$V_{R,\phi}$) at -31.79 degrees) are given. You need to set up the following per phase equation:

$$V_{S,\phi} = A*V_{R,\phi} + B*I_R$$

After substituting the A and B transmission parameters from your previous step and the above $V_{S,\phi}$ and I_R quantities, you will get an equation involving only the magnitude of $V_{R,\phi}$ and delta angle. To get rid of the delta angle, you need to take the magnitude square at both sides. This will lead to a fourth order equation in terms of the magnitude of $V_{R,\phi}$ only. You will need to solve for $V_{R,\phi}$ **2 from the $V_{R,\phi}$ **4 equation just like solving the solution of a quadratic equation. You will get two answers for $V_{R,\phi}$ **2 (something like 4574.353296 and a smaller value). Use the first value and take the square root again. Next, you multiply the phase voltage by SQRT(3) and you will get the right answer. The other smaller value would not lead to a sensible operating voltage.

Review Exercise 19(c): I have tried to follow the approach that you have highlighted above. But I have some difficulties in taking the magnitude square on both sides of the equation so as to remove the delta angle. Can you give me some pointers?

$$V_{S,\phi} = A*V_{R,\phi} + B*I_R$$

$$[138/SQRT(3)]\angle\delta = 0.965\angle 0.47 * V_{R,\phi} + 125.66\angle 77.17 * 30/(3*V_{R,\phi}) \angle{-31.79}$$

$$V_{R,\phi}*[138/SQRT(3)]\angle\delta = 0.965\angle 0.47 * [V_{R,\phi}]^2 + 1256.6\angle 45.38$$

$$= 0.96497[V_{R,\phi}]^2 + j0.007915752[V_{R,\phi}]^2 + 882.607 + j894.455$$

$$6348[V_{R,\phi}]^2 = 0.93122976[V_{R,\phi}]^4 + 1717.538722[V_{R,\phi}]^2 + 1579044.334$$

The RHS of the last equation is obtained by taking Real part^2 + Imag part^2 of the previous step. From here, solve for $X = [V_{R,\phi}]^2$ using the solution of the quadratic equation. You will get $X = [V_{R,\phi}]^2 = 4574.353296$ and 398.062. Ignore 398.062 because SQRT of this value is never in the neighbourhood of 138/SQRT(3). Take the square root of 4574.353296 will give you $V_{R,\phi} = 67.634$ kV. Multiply this value by SQRT(3) will give you the right answer.

Review Exercise 19(c): I have already gone through the solution given in Edventure but I'm really confused about when to use phase quantity and when to use line-to-line quantities. Why do we need to convert to phase quantities here?
Voltage equations involving actual quantities for per-phase circuit representation can only be represented using phase quantities. The technique of the actual quantity calculation is covered in G260/EE3010. Please refer to the G260/EE3010 notes. In E315/EE3015, our emphasis is more on the per-unit system. Hence, we did not solve our problems using actual quantities. The per-unit system avoids all the headaches of handling SQRT(3) or 3. To minimize the confusion, please stick to the per-unit system.

If I'm using p.u. system and set Sb=30MVA,Vb=138kV,Vs=AVr+B(Sr/Vr)* take Vr as ref angle, then I have:

1angle(theta)=0.9654angle(0.47degree)xVr
angle(0degree)+0.198angle(77.17degree)x(1/Vr)angle(-31.79degree)

=> cos(theta)=0.9654Vrcos0.47+(0.198/Vr)cos45.38

sin(theta)=0.9654Vrsin0.47+(0.198/Vr)sin45.38

After squaring both sides of the equation and adding them up, I still cannot get the correct answer. Why? Is my method wrong?
Your solution looks fine to me. However, I don't get to see your remaining steps as to how you add them up. Here is the per-unit solution for you to check.
$S_b = 30$ MVA, $V_b = 138$ kV. Hence $Z_b = 634.8$ ohms and $B = 0.197952\angle 77.17$ and $I_R = 1/(V^*_{R,\phi}) \angle -31.79 = 1/(V_{R,\phi}) \angle -31.79$. Note that the conjugate has no effect on $V_{R,\phi}$ is at reference angle of zero degree.

$V_{S,\phi} = A^*V_{R,\phi} + B^*I_R$
$1 \angle\delta = 0.965\angle 0.47 * V_{R,\phi} + 0.197952\angle 77.17 * 1/(V_{R,\phi}) \angle -31.79$
$V_{R,\phi}\angle\delta = 0.965\angle 0.47 * V_{R,\phi}^2 + 0.9197952\angle 45.38$
$= (0.96497V_{R,\phi}^2 + 0.1390387) + j(0.007915852\, V_{R,\phi}^2 + 0.14090331)$
Taking the magnitude square on both sides leads to:
$V_{R,\phi}^2 = 0.93122976V_{R,\phi}^4 + 0.270563555V_{R,\phi}^2 + 0.039184993$
Solving the above using the technique described earlier, you will get $V_{R,\phi}^2 = 0.72528827$. Again, the other value can be dropped because it is too far away from 1. Hence, $V_{R,\phi} = 0.8516385$ pu (The negative value is ignored because the receiving end voltage cannot be negative.) or 117.5 kV.

For exercise 19, I notice that the constants A, B, C, D are actual units and not p.u. Thus the solution is performed using these constants. In the example given in the notes, A, B, C and D were calculated in p.u. Is there any difference between using the p.u. and the actual values? If so, when do I use which?
Most students prefer using the per-unit system. The reason is because we seldom have the opportunity to work with actual quantities in EE3015/E315. The three-phase problems were solved using actual quantities in EE3010/G260.

Whether you use the actual quantities or the per-unit system, the two techniques should give you the same answer in real quantities. There is no difference as far as the answer is concerned. For transmission lines without transformers in the circuit, working through actual quantities would be a preferred choice as the technique does not incur any overheads on entering to/exiting from per-unit calculations. However, if you do not remember the rules (e.g. voltages must be expressed as phase and not line quantities, load impedances must be converted into wye, etc) in dealing with the actual quantities, then you would invite more problems than savings in overhead conversion.

If you have ABCD parameters in actual quantities, you can convert them into per-unit by doing the following:

1) Divide the B parameter by Zb.
2) Multiply the C parameter by Zb.
3) A and D are already in per-unit. No conversion is needed.

For Review Exercise 19c, I have worked out both the per-unit and actual quantities solutions as shown above. Please go through them and decide for yourself which technique you prefer.

What happens if during exams, the question asked was to find the constants A, B, C, D like in the example. In this case there will be two different solutions, one calculated with the p.u and the other with the actual values. Are both accepted?
You probably are aware that in the quiz, I am the one who provides the answers for you to choose (MCQ). Hence, I would decide which format that I want.

In the final exam, I will specify whether I want to have all the A B C D parameters expressed in actual values or per-unit. If I don't specify, then it is all up to you to choose.

Review Exercise 20: The question says that "resistance of each conductor is 0.1075 ohm/km, why do we still need to divide the given resistance value by the number of conductors per phase (Otherwise we cannot get the result)?
This is because the two conductors in the bundle are shorted together at both ends. Hence the resistances of the two conductors are in parallel. We have a similar example in our tutorial where the resistance is divided by four for a 4-conductor bundle conductor.

With reference to Review Exercise 20, I calculated the parameters A, B, C, D using their actual values. With these, I managed to find the answer for the sending end voltage. However, my answer for the sending end current has to be divided by square root 3. I

understand that this current I found is referred as the line current and that why, there is a need to divide by square root 3 to get the phase current. By doing so, are we treating it as a delta connection by default since the question never state so?
With the correct values of the sending end voltage and current, I calculate its apparent power, Ss = root 3 (Vs)(Is*), whereby the Vs = (356525 angle 11.15 degree) and Is = (1153.134 angle 9.25 degree) are line to line values
The answer I got is (712.083 angle 1.9 degree) MVA. What is wrong with my method?
When you engage actual values in the transmission line equations, you must always remember that the voltages are phase quantities and currents are line quantities. For example, in the following TL equations,

Vs = A x Vr + B x Ir

Is = C x Vr + D x Ir

Vs and Vr: are phase voltages and Is and Ir are line currents.

Vr = 345/SQRT(3) and Ir = (400 – j10)/(SQRT(3) x 345) = 0.6696 kA at -1.4321 degrees. Vs that you obtained from the above must be a phase voltage. You need to multiply the phase voltage by SQRT(3) to get your final answer of 356.522 kV. I suspect that you may have left out SQRT(3) in your Ir calculation and by coincidence, you got the right line-to-line voltage for Vs. If this is the case, the solution will be marked as wrong even if the answer is correct. One cannot leave out SQRT(3) in the denominator as Ir cannot be greater than 0.6696 kA by a factor of SQRT(3) (This is already a line quantity and you cannot have anything more than the line quantity).

If you follow the guideline given above, I believe that your Is will be correct without the need to divide it by SQRT(3).

Similarly, the three-phase complex formula, Ss = root 3 (Vs)(Is*), is correct. You have used an incorrect Is value and this explains why your answer is higher by a factor of SQRT(3).

Review Exercise 20 (Follow-up Question): Thank you sir. I understood your explanations. The reasons I went wrong was that I treated the voltages and currents in the TL equation as line to line values.
I am glad that you have found out where the problem is.

Review Exercise 20 (Follow-up Question): You mention that the voltages are phase voltages and currents are line currents. So, can I deduce that the TL equation is derived from a star connected circuit since the nature of a star connected is as you describe, Line voltage = sqrt 3 of phase voltage and Line current = phase current?
Yes, the TL equations are derived from the per-phase equivalent star circuit and this can happen only for star-connected source/load. If it is delta, we can always transform it to star through a delta to star transformation. This is the foundation of our per-phase

equivalent circuit and I believe that it has been covered in G260/EE3010. My Week 2 hand-written notes presented during lecture also attempts to illustrate this point.

Review Exercise 20 (Follow-up Question): I want to confirm this with you because the question didn't state so. Can I treat it as default? Please advise me again.
Yes, when ABCD equations are expressed in actual quantities, you must treat them as phase voltages and line currents. You cannot possibly write a line-to-line voltage equation as per phase equation as it will involve circuits of two phases. Only through the neutral point of the star-connect source/load, you can write the per phase equation.

Review Exercise 20 (Follow-up Question): Overall, I still prefer to calculate in pu quantities.
Please use whatever technique that you are comfortable. For EE3015/E315, we do not teach the actual quantities calculation. Hence, it would be to your advantage to know only the per-unit technique. However, I want you to know that the per-unit technique is not efficient for generator and transmission line calculation not involving transformers. You spend a significant amount of time in converting actual values to per-unit values on entry and back to actual quantities when the solution is obtained. This conversion before/after the per-unit calculation is an unnecessary overhead if the problem never asks for per-unit values.

Also, when am I supposed to use the formula P = (EV/X) sin theta? I always in dilemma in choosing between this and P = VI cos theta.
On the choice between P = (EV/X) sin theta and P = VI cos theta, I think you meant P = (EV/X) sin delta and P = VI cos theta. You cannot use power factor angle (theta) for power angle (delta) in the first equation. Hence, it is clear that you should select the right equation to use if the values for the variables on the right-hand side of that equation are known.

T5.3: Understand from your notes that, for transmission line, we will only focus on short and medium lines. Apparently, if I am not wrong, the above question is actually 400km, which is deemed as a long transmission line. Isn't it a conflict with what you have told us?
Or, is the statement ' model it as a nominal-pie equivalent....' trying to imply that, we treat it as a medium line?
Yes, I agree with you that this should have been treated using the long transmission line model. However, the question has already pointed out (you also pointed out) that we treat this transmission line using the pi-model.