B.A. Mork **EE 5220 - HW#7** Spring 2022

Steady-State and Transient Long-Line Analysis Due after spring break

You may work on this alone or in pairs.

For the steady-state portion, do the following: From derivation in Lecture 17, slide "8" (page 12 of .pdf file) we can group the terms of the transmission line equations in two different ways: a) For ABCD parameter phasor analysis, we can use the hyperbolic formulation; b) Using the exponential form, we can approach it in terms of incident and reflected quantities.

Develop a MatLab or spreadsheet calculation tool (for working with complex numbers, Matlab may be better suited; spreadsheets can also do it but are not optimal). In addition, you may also decide to use ATP to model steady-state 60-Hz performance of the same line to double-check relationship between sending end and receiving end.

a) Develop your engineering analysis tool: Steady-state positive-sequence phasor analysis of long-line behavior using simplified per-phase representation. Work with parameters in actual units (not per unit). Inputs should be:

- z & y in ohms and S per mile or per km, as obtained from Line Constants .lis file.
- Length in miles or km.
- Base kV and MVA.
- Load in complex power S = P + jQ.

- The program shall calculate values for γ, α, β, Z_C, τ, and the ABCD parameters. Verify that your program is correct by using Case 1 of Homework 6 as test case.
- The program shall calculate the voltage and current of the line as a function of distance x, from zero (receiving end at right end of plot) to length ℓ (sending end of line, on left end of plot). Suggest that you break the line length into 30-50 increments, i.e. use a matlab storage vector of 30-50 or a spreadsheet column of 30-50 cells to hold the values of V and I along the length of the line.
- Make 2 plots of the voltage and current "profiles" along the length of the line. On first plot, show the incident, reflected, and total voltage. On the second plot, do the same for the current. It shall be flexible enough so that parameters can be quickly changed and the profiles automatically replotted.

b) Now that you have a tool you can use... Using the Case 1 line of length 200 km, and applying rated L-N voltage at sending end,

- Demonstrate the Ferranti Rise (increase in receiving-end voltage when receiving end is open-circuited),
- "Fix" the above problem by demonstrate reactive compensation at receiving end of line. What value of shunt reactor is required to bring the voltage down to 1.0 per unit?
- Demonstrate SIL and show that you have a "flat line." What is advantage of SIL over shunt compensation? Is SIL practical to implement in system operations?
- Demonstrate any other steady-state behaviors of long lines that you think are important, eg. maybe you can overplot the voltage profiles for loads that are: open circuit, short circuit, inductive, capacitive, SIL, shunt compensated, etc.

For the transient portion of this assignment, it is assume you've already gone through the ATP simulations of the traveling wave example TravWave.acp. If not, then do so now. Figure out how to use this line model and enter parameters for it, and understand the effects of characteristic impedance, propagation constant, source impedance, and receiving end impedance.

In your submission:

- Describe the assumptions made and give some basic documentation of your program implementation.
- Give a brief description of the different operating scenarios that you've investigated, along with printouts of the voltage profiles and parameters.
- Make overall recommendations for loading long lines and operation of a system which contains long lines. Insert key plots and equations into the report, and attach you hand-calcs, notes, and any additional plots.
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