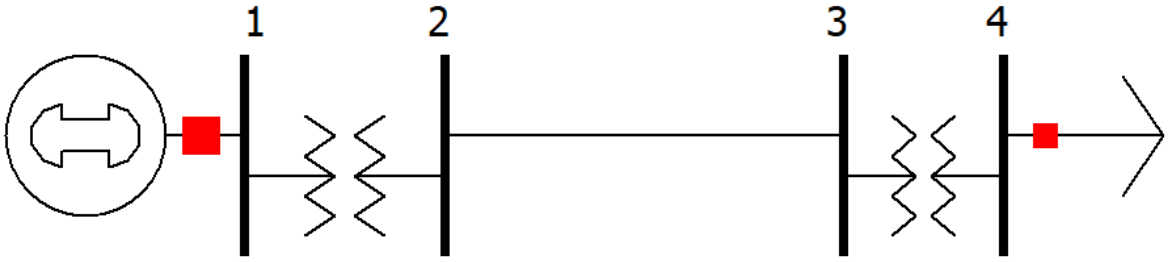
ECEN 460 SPRING 2024 (Birchfield) Quiz 6 13 Feb 2024

Name: _____ UIN: _____ Section: _____ Score: _____

(This quiz is just for practice.)

For the following three-phase system:



Generator	**Transformer 1-2**	**Transmission line**	**Transformer 3-4**	**Load**
75 MVA 20 kV X = 10% R = 0	80 MVA 20:161 kV Z = 15% X/R ratio = 10	Z = 14 + j26 Ω	55 MVA 161:34.5 kV Z = 12% X/R ratio = 8	Wye-connected with each phase Z = 20 + j10 Ω

1. Fill out the below table of system per-unit base values, starting with the two bases given.

	Bus 1	Bus 2	Bus 3	Bus 4
$S_{3\phi\ base}$	100 MVA	100 MVA	100 MVA	100 MVA
$S_{1\phi\ base}$	33 MVA	33 MVA	33 MVA	33 MVA
$V_{LL\ base}$	20 kV	161 kV	161 kV	34.5 kV
$V_{LN\ base}$	11.55 kV	92.95 kV	92.95 kV	19.92 kV
Z_{base}	4 Ω	259.21 Ω	259.21 Ω	11.9 Ω
I_{base}	2887 A	359 A	359 A	1673 A

2. Calculate the impedance of each device in per-unit on the device's own base (if applicable), in actual units, and in per-unit on the system bases above.

	Generator	XF 1-2	T-Line	XF 3-4	Load
$Z_{pu,dev}$	j0.1	0.015 + j0.15	N/A	0.015 + j0.12	N/A
Z_{actual}	j0.5333 Ω	0.075 + j0.75 Ω	14+j26 Ω	7.07+j56.08 Ω	20 +j10 Ω
$Z_{pu,sys}$	j0.1333	0.0188+j0.188	0.054+j0.1	0.027+j0.216	1.68+j0.84

3. Draw the equivalent per-unit circuit for this system, with all system per-unit values shown.

4. With the generator operated at rated voltage, calculate per-unit current on the system base, and actual current in Amps (a) in the transmission line and (b) supplied by the generator.

$V_{pu} = \frac{20\angle 0°\ kV}{20\ kV} = 1\angle 0°$
$Z_{total,pu,sys} = 1.78 + j1.377$
$I_{pu} = \frac{V_{pu}}{Z_{total,pu,sys}} = \frac{1}{1.78+j1.377} = 0.444\angle -37.7°$
$I_{tline} = I_{pu} \cdot I_{base,2} = (0.444\angle -37.7°) \cdot 259.21\ A = 115.2\angle -37.7°\ A$
$I_{gen} = I_{pu} \cdot I_{base,1} = (0.444\angle -37.7°) \cdot 2887\ A = 1283\angle -37.7°\ A$

For extra practice:

5. What if the generator's rated voltage is 18 kV?
    a. What would be the generator impedance base?
    b. What would the generator's actual impedance in Ohms?
    c. What would be the generator's impedance in per-unit on the system base?
    d. If the generator were operated at 18 kV, what would be the per-unit generator voltage on the system base?
    e. What would the new current values in 4 be?
6. Calculate the real and reactive power for each element, in per-unit and in actual units
    a. How much P and Q are the generator producing?
    b. How much P and Q are lost in the generator's impedance?
    c. How much P and Q are lost in the transformer 1-2's impedance?
    d. How much P and Q are lost in the transmission line?
    e. How much P and Q are lost in transformer 3-4?
    f. How much P and Q are absorbed by the load?
7. If you added a capacitor to bus 4 to produce 20 Mvar,
    a. What would its Q be in per-unit?
    b. What would its impedance Z be in per-unit?
    c. How do the current values in 4 change?