Homework 3 – Transformers

This homework is to be solved using computational tools (such as MATLAB). You should show your work (how the resultant plot is obtained analytically, and required explanations). An example code is provided about using complex numbers in MATLAB.

A template is also provided. You should submit your homework by converting your .m file solution to pdf by using ***publish*** *command. Required explanations and several tips are given in the template. A sample is also given showing how your solution should seem.*

You are free to make the calculations by hand for hundreds of data points if you like.

Q.1. Consider the single-phase 30 kVA, 50 Hz, 2200V/220V step-down transformer in HW#2. The equivalent circuit parameters were found as:

R_1	1.6 Ω	L_1	70 uH
R_2	16 mΩ	R_c	32 kΩ
L_1	7 mH	L_m	14.6 H

At rated secondary voltage and for three different power factors (unity, 0.8 leading, 0.8 lagging);

a) Obtain and plot primary voltage against load current.

b) Obtain and plot voltage regulation against load current.

c) Obtain and plot transformer efficiency against load current.

d) Comment on the effect of power factor on regulation and efficiency.

e) Comment on the effect of loading on regulation and efficiency.

The current axis should be of at least ***100 points*** *and up to* ***%110 of rated current****. The 3 different characteristics should be plotted on the same graph. Use the complete equivalent circuit.*

Q.2. Consider the single line diagram of the distribution system from TEİAŞ Transformer Station (near AŞTİ) to METU EEE Department given in Figure 1.

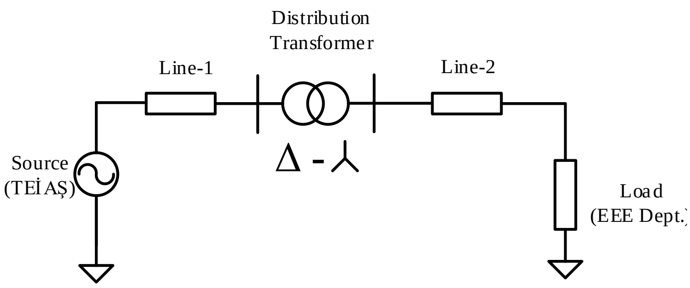

Figure 1. Single Line Diagram of the Distribution System of METU Campus

The system parameters are as follows:

Source: You may assume an infinite bus (ideal source). 34.5kV line-to-line, 50 Hz.

Line 1: Feeder between the source and distribution transformer in front of METU CAMPUS. Z_{l1} = 12 + j102 Ω/phase

Transformer: 700 kVA, 34.5kV/400V, 50 Hz step-down transformer. Z_t = 27 + j403 Ω/phase (referred to the primary side)

Line 2: Feeder between the transformer and the load (EEE Dept.). $Z_{l2} = 0.6 + j5$ mΩ/phase

Load: You may assume that the load is purely resistive throughout the question. The load profile for 24 hours is given in the attached file *"load_profile_METU.xlsx"*.

PART A:

At 7:00 p.m.,

a) On the same figure, plot the ***three-phase source voltages*** for two fundamental cycles.

b) Obtain and plot on the same figure, the ***three-phase line currents*** at ***line-1*** for two fundamental cycles.

c) Calculate the magnitude of the load voltage.

d) Calculate the phase of the source voltage. On the same figure, plot the ***phase-A source voltage (line-to-neutral)*** and ***phase-A line current at line-1*** for two fundamental cycles.

e) Calculate the power factor at source terminals.

PART B:

For 24 hours period,

a) Import and plot the daily load profile data. Using **smooth** function on MATLAB, obtain a smoothed load profile and plot on the same figure.

b) Obtain and plot the voltage magnitude at the load terminals for 24 hours period.

c) Obtain and plot the voltage regulation at the load terminals for 24 hours period.

d) Obtain and plot the overall efficiency of the system for 24 hours period.

Using complex numbers in MATLAB:

```
% definition
a = 3+j*4;
b = 4+j*5;
% addition & subtraction
add = a+b; % 7+9j
sub = a-b; % -1-j
% multiplication & division
mult = a*b; % -8+31j
divs = a/b; % 0.78+0.024j
% magnitude & phase
magn = abs(a);
phs1 = phase(a); %radians
phs2 = phs1*180/pi; %degrees
% power
P = 400e3; % active power: 400 kW
Q = 300e3; % reactive power: 300 kVAR
S = P+j*Q; % complex power
app = abs(S); % apparent power: 500 kVA
pf1 = cos(phase(S)); % power fator: 0.8
pf2 = P/app; % power fator-same result
% time domain expressions
Vp = 15; % peak value
phi = 30; % phase (degrees)
phir = phi*pi/180; % phase (radians)
Fs = 10e3; % sampling frequency: 10 kHz
fs = 100; % fundamental frequency: 100 Hz
t = 0:1/Fs:0.2; % time array
volt1 = Vp*sin(2*pi*fs*t); % reference phasor (no phase)
volt2 = Vp*sin(2*pi*fs*t - phir); % lagging
volt3 = Vp*sin(2*pi*fs*t + phir); % leading
% note that the trigonometric functions operate
% with radians (default)
```