EECE 370 – Quiz 1 – Fall 2011 – Problems

A 40 kVA, 480/4800 V, step-up transformer has the following equivalent circuit parameters:

$R_p = 25\ \text{m}\Omega$ $X_p = 57.5\ \text{m}\Omega$ (Low-voltage side)

$R_s = 2.5\ \Omega$ $X_s = 5.75\ \Omega$ (High-voltage side)

$R_c = 500\ \Omega$ $X_M = 100\ \Omega$ (Low-voltage side)

Use the approximate equivalent circuit referred to the primary (low-voltage) side to answer the following two questions.

1. If the transformer is operating at full load with a power factor of 0.8 lagging, find the magnitude of the applied voltage to the primary winding (in V).
   a. 489.1 **
   b. 498.3
   c. 507.5
   d. 516.7
   e. 526.1

```
S=40*1E3
Rp=25E-3
Rs=2.5
Xp=57.5E-3
Xs=5.75
Rc=500
XM=100

Reqp=Rp+(480/4800)^2*Rs
Xeqp=Xp+(480/4800)^2*Xs

Ip=S/480

Vp=480+(Reqp+i*Xeqp)*Ip*(0.8-0.6i)

mag_Vp=abs(Vp)
```

2. If a voltage of 480 V is applied to the primary winding while the secondary winding is connected to a resistive load that draws the rated current, find the total losses (in W)?
   a. 9141.4
   b. 6016.4
   c. 3585.8
   d. 1849.7
   e. 808.0 **

```
Psc=Reqp*Ip.^2 + 480^2/Rc
```

3. A 75 kVA, 220/480-V single phase power transformer has a per-unit core-loss resistance (Rc) of 100 pu and a per-unit magnetizing reactance (Xm) of 80 pu. Find the excitation current (in A) when rated voltage is applied to the low-voltage winding.
    a. 2.2727 - j2.8409
    b. 3.4091 - j4.2614 **
    c. 4.5455 - j5.6818
    d. 5.6818 - j7.1023
    e. 6.8182 - j8.5227

```
S=75*1E3
Rc_pu=100
Xm_pu=80

Iex_pu=1/Rc_pu+1/(i*Xm_pu)

Iex=Iex_pu*S/220
```

The following data were obtained when a 25-kVA, 2300/460 V, 50 Hz transformer was tested:

	Voltage (V)	Current (A)	Power (W)
Open-circuit test	460	1.5	550
Short-circuit test	108.7	10.87	750

Refer to this data for questions 4 and 5.

4. Find the magnetizing reactance (X_m) referred to the low voltage side (in Ω).
    a. 376.4
    b. 404.5
    c. 445.0
    d. 507.8 **
    e. 621.0

```
Voc=460
Ioc=1.5
Poc=550

Soc=Voc*Ioc
Qoc=sqrt(Soc^2-Poc.^2)
XmL=Voc^2./Qoc
```

5. Find the equivalent series resistance (R_{eq}) referred to the low voltage side (in mΩ).
    a. 270.8
    b. 253.9 **
    c. 237.0
    d. 220.0

e. 203.1

```
Vsc=108.7
Isc=10.87
Psc=750

ReH=Psc/Isc^2
ReL=ReH*(460/2300)^2*1000
```

6. A 6.6 kVA, 440/220-V, 50 Hz step-down transformer has an equivalent series impedance of 3 + j4 Ω referred to the primary (high-voltage) side. The transformer is operating at full load with a power factor of 0.6 leading. Determine the efficiency of the transformer (in %).
    a. 94.6
    b. 92.1
    c. 89.8
    d. 87.6
    e. 85.4 **

```
S=6.6*1E3
I=S/440
Pout=S*0.6
Pin=Pout+3*I.^2
eff=Pout./Pin*100
```

7. Fig. 1 shows a ferromagnetic core with a depth of 10 mm having a small air gap of 0.5 mm. The relative permeability of the core is 2000 and the coil has N_T= 500 turns and carries a current of I= 1.5A. Other dimensions are shown in the figure. The fringing in the air gap increases its effective cross-sectional area by 5%. What is the magnetic flux density in the airgap?
    a. 1.422 T
    b. 1.675 T **
    c. 1.342 T
    d. 1.257 T
    e. 1.109 T

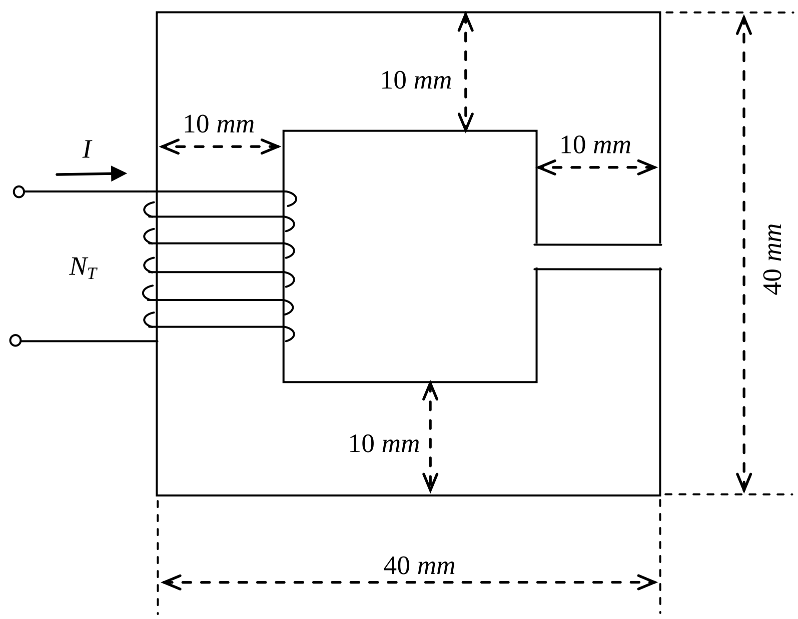

Fig. 1: Simple Ferromagnetic core

```
Ac=10E-3*10E-3
Ag=1.05*Ac
g=0.5*1E-3
lc=4*30E-3-g
u0=4*pi*1E-7
u=2000*u0
N=500
I=1.5


Phi=N*I./(lc./(u*Ac)+g/(u0*Ag))
Bg=Phi./Ag
```

8. Fig. 2 shows a non-uniform ferromagnetic core with dimensions as shown on the figure with the depth of the core being 50mm. The air gap width is L_G= 0.5mm. The relative permeability of the core is 3500 and the number of turns in each coil is N_T= 200 turns. The fringing in the air gap increases its effective cross-sectional area by 5%. What is the maximum current (I_{max}) that will keep the highest flux density in the core below a saturation level of 1.2T?
   a. 0.672 A
   b. 0.781 A
   c. 0.454 A **
   d. 0.596 A
   e. 0.530 A

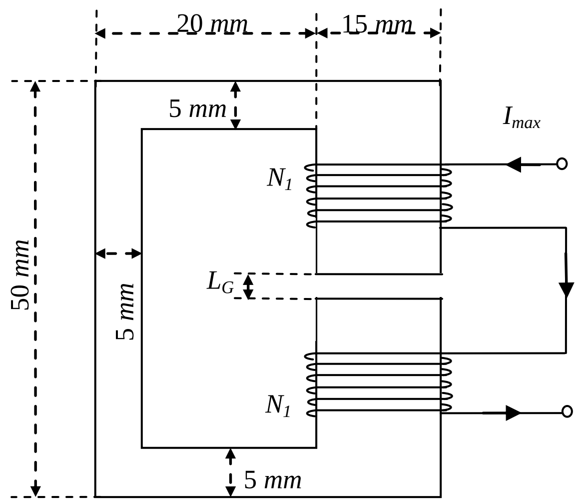

Fig. 2: Non-uniform core with two windings

```
u0=4*pi*1E-7
u=3500*u0

lc1=((50-5)+2*((20-2.5)+7.5))*1E-3
Ac1=5E-3*50E-3

g=0.5*1E-3
lc2=(50-5)*1E-3-g
Ac2=15E-3*50E-3

Ag=1.05*Ac2

N1=200

B1=1.2

Phi=B1*Ac1

Imax=(lc1./(u*Ac1)+lc2./(u*Ac2)+g/(u0*Ag))*Phi/(2*N1)
```

Consider the one-line diagram of a balanced three phase system shown in Fig. 3. Load 1 is Y-connected and has a phase impedance is $Z_{\phi 1}$= 4∠35° Ω, and Load 2 is Δ-connected and has a phase impedance of is $Z_{\phi 2}$= 8∠30° Ω. The capacitor bank is Δ-connected and has a phase impedance of $Z_{\phi C}$= 24∠-90° Ω. This data will be used in the following two problems.

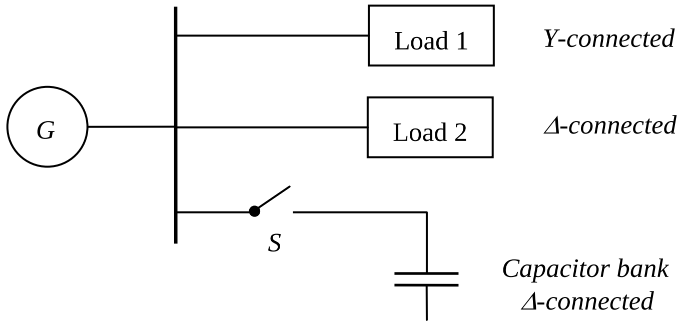

Fig. 3: Balanced three phase system

9. When switch *S* is open and the generator line voltage is 480 V, what are the active and reactive powers supplied by the generator?
   a. 122.01 + j76.24 kVA **
   b. 113.69 + j71.44 kVA
   c. 91.20 + j56.99 kVA
   d. 128.61 + j80.37 kVA
   e. 84.99 + j53.40 kVA

```
Z1=4
th1=35*pi/180

Z2=8
th2=30*pi/180

Zc=24

VL=480

PT=3*(VL/sqrt(3)).^2/Z1*cos(th1)+3*VL.^2./Z2*cos(th2)
QT=3*(VL/sqrt(3)).^2/Z1*sin(th1)+3*VL.^2./Z2*sin(th2)

ST=(PT+i*QT)/1000
```

10. When switch *S* is closed and the line current in Load 1, I_{L1}= 68∠-35° A, what is the reative power supplied by the capacitor?
   a. 20.81 kVAr
   b. 27.74 kVAr **
   c. 41.62 kVAr
   d. 33.29 kVAr
   e. 23.78 kVAr

```
IL1=68
VL=sqrt(3)*IL1*Z1

Qc=3*VL.^2./Zc/1000
```