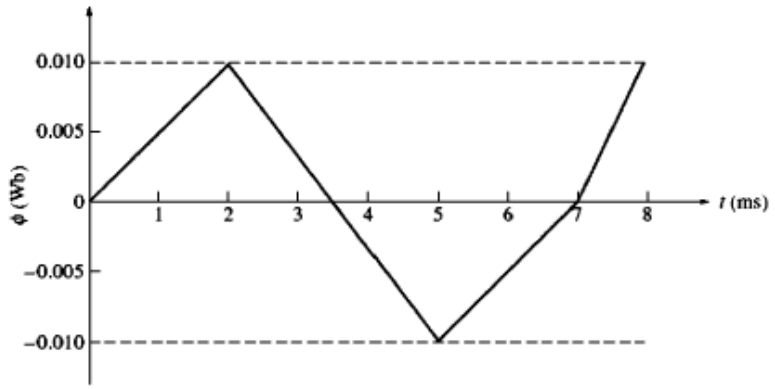
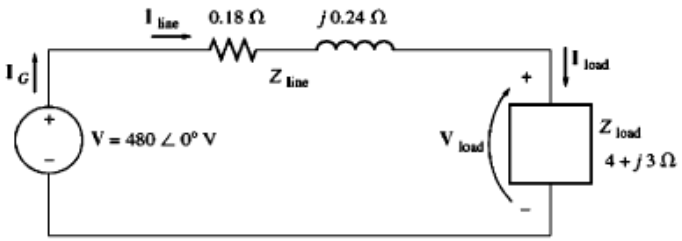
Mathematical Problems on Transformer

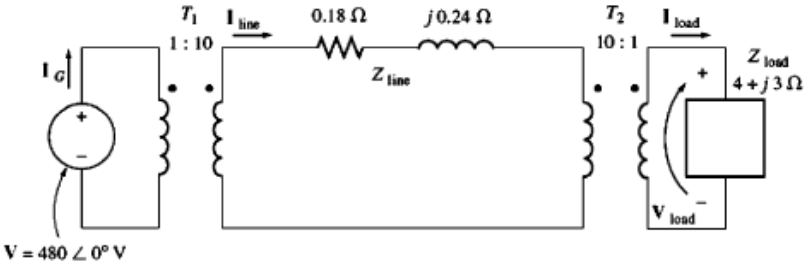
1. The flux in the transformer core is given by the equation, $\varphi = 0.05 \sin 377t \ Wb$. If there are 1000 turns on the primary and 500 turns on the secondary, determine the induced primary voltage and secondary voltage.

2. The following figure depicts the magnetic flux in a ferromagnetic core. If there are 100 turns on the primary coil, sketch the voltage present at the coil terminals.



3. A single-phase power system consists of a 480-V 60-Hz generator supplying a load, Z_{load} = 4 + j3 Ω through a transmission line of impedance, Z_{line} = 0.18 + j0.24 Ω.
   a) If the power system is exactly as described above calculate the loss in the transmission line.
   b) If a 1: 10 step-up transformer is placed at the generator end of the transmission line and a 10: 1 step-down transformer is placed at the load end of the line what will the transmission line losses be now?





4. A 15 kVA, 2400-240V, 60 Hz transformer has a magnetic core with a cross-sectional area of 50 cm^2 and a mean effective length of 66.7 cm. The application of 2400V causes a magnetic field intensity of 450 A-t/m (rms), and a maximum flux density of 1.5T. Determine the no. of turns in each winding and also the magnetizing current.

5. The hysteresis and eddy current losses for a 75 kVA, 480-120V, 60 Hz transformers are 215W and 115W respectively. The magnetizing current is 2.5 percent of rated current, and the transformer is operating in the step-up mode. Determine
   a) exciting current
   b) no-load power factor
   c) reactive power input at no load

6. A 100 kVA, 60 Hz, 7200-480V, single phase transformer has the following parameters in ohms:

R_{HS}=3.06,	R_{LS}=0.014	$X_{m,HS}$=17809
X_{HS}=6.05,	X_{LS}=0.027	$R_{fe,HS}$=71400

The transformer is supplying a load that draws rated current at 480V and 75 percent lagging power factor. Determine

a) Equivalent resistance and equivalent reactance referred to the high side
b) Input impedance of the combined transformer and load
c) Input voltage at the transformer
d) Input impedance at no load
e) Exciting current and its components (at no-load)

7. A 500 kVA, 7200-240V, 60Hz transformer with 2.2 percent impedance was severely damaged as a result of a dead short across the secondary terminals. Determine

a) short circuit current
b) required percent impedance of a replacement transformer that will limit the low-side short circuit current to 60000 A.

Note that, for large transformers (rated above 100kVA) $X_{pu} \gg R_{pu}\ and\ Z_{pu} \approx R_{pu}$ X_{pu}

8. The percent resistance and percent reactance of a 50 kVA, 2400-600V, 60 Hz transformer are 0.8 and 1.2 respectively. If an accidental short circuit of 0.01Ω (resistive) occurs at the secondary (when 2500V is impressed across the primary), what will be the high-side fault current?

9. The equivalent low-side parameters of a 250 kVA, 4160-480V, 60 Hz transformer are $R_{eq,LS}$ = 0.0092 Ω and $X_{eq,LS}$ = 0.0433 Ω. The transformer is operating in the step-down mode and is delivering rated current at rated voltage to a 0.84 power factor lagging load. Determine

a) No load voltage
b) Actual input voltage at the high side
c) Voltage regulation

10. The following test data are obtained from short-circuit and open-circuit tests of a 50 kVA, 2400-600V, 60Hz transformer:

V_{oc}=600V	V_{sc}=76.4V
I_{oc}=3.34A	I_{sc}=20.8A
P_{oc}=484W	P_{sc}=754W

a) Determine all the transformer model parameters
b) What will be the regulation and efficiency if the transformer operates at rated load and 0.9 power factor lagging?
c) What will be the regulation and efficiency if the transformer operates at 85% rated load and 0.9 power factor leading?

11. A 150 kVA, 7200-600V, 60 Hz, single phase transformer operating at rated conditions has a hysteresis loss of 527 W, an eddy current loss of 373W, and a conductor loss of 2000W. The transformer is to be used on a 50 Hz system, with the restriction that it must maintain the same maximum core flux and the same total losses. Determine
    a) new voltage rating and new kVA rating
    b) conductor loss, hysteresis loss and eddy current loss at new operating condition

12. A 150 kVA, 7200-600V, 60 Hz, single phase transformer is to be used on a 50 Hz system, with the restriction that it must maintain the same maximum core flux. Determine new voltage rating and new kVA rating.

13. An autotransformer with a total of 600 turns is connected to a 60Hz, 2400V driving voltage. A load connected to the secondary draws 4.8kVA at 0.6 power factor lagging. If the secondary embraces 200 turns, neglecting losses and leakage effects, determine
    a) secondary voltage, secondary current, primary current
    b) apparent power conducted, apparent power transformed

14. A 120V, 60Hz air conditioner is to be operated in a remote area where the voltage drop in the long transmission line results in a utilization voltage of 102V. Determine
    a) required voltage ratio for satisfactory performance
    b) voltage ratio of a standard buck-boost transformer that most closely meets the requirements of the load
    c) voltage at the load with the buck-boost transformer installed
    d) Sketch the appropriate connection diagram showing the input and output terminals

15. An electric boiler rated at 50 kW, 240V, and 60 Hz is to be operated from a 60 Hz system whose utilization voltage is 269.5 V. Determine
    a) required voltage ratio for satisfactory performance
    b) voltage ratio of a standard buck-boost transformer that most closely meets the requirements of the load
    c) voltage at the load with the buck-boost transformer installed
    d) Sketch the appropriate connection diagram showing the input and output terminals

16. Three Single Phase transformers are used to supply a total of 750 kVA at 450V to a balanced three phase load. The three-phase input to the bank is 2400V. Determine
    a) Bank ratio and transformer ratio if connected as Wye-Delta
    b) Bank ratio and transformer ratio if connected as Delta-Wye
    c) Bank ratio and transformer ratio if connected as Delta-Delta

    If each transformer is rated at 400 kVA and the bank is delta-delta connected, will the bank be able to carry the load if one transformer is disconnected?

17. Two 4160-450V transformers are to be purchased to supply a 450V, 90kW, 0.75 lagging power factor three-phase load. The transformers are to be connected in open delta. Specify the minimum power rating required for each transformer.

18. Two 100 kVA, single phase, 60 Hz transformers are to be operated in parallel. Determine the circulating current in the paralleled secondaries when rated voltage is applied across the paralleled primaries.

Transformer	Voltage Ratio	$R_{eq,LS}$	$X_{eq,LS}$
A	2300-460	0.0288 Ω	0.07 Ω
B	2300-450	0.0284 Ω	0.06 Ω

19. Three 2400-480V transformers are operated in parallel. Determine the percent of bank current carried by each transformer. Calculate the maximum apparent power the bank can supply without overloading any of the transformers.

Transformer	kVA	Nameplate Impedance
A	100	3.68%
B	167	4.02%
C	250	4.25%

20. Two 7200-240V, 75 kVA transformers are to be operated in parallel. The per-unit impedances are $Z_{A,pu} = 0.01 + j\ 0.055$ and $Z_{B,pu} = 0.02 + j0.038$. Determine the contribution in bank current from each transformer. Calculate the maximum apparent power the bank can supply without overloading any of the transformers.