Basic Electrical Engineering (TEE 101)

Lecture 40: Numerical Practice _ EMF equation of a Transformer

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Content

This lecture covers Numerical on:

- **EMF equation of Transformer**
- **Transformation Ratio**

Example 1. *A 40 kVA, single phase transformer has 400 turns on the primary and 100 turns on the secondary. The primary is connected to 2000 V, 50 Hz supply. Determine :*

(*i*) *The secondary voltage on open circuit.*

(*ii*) *The current flowing through the two windings on full-load.*

(*iii*) *The maximum value of flux.*

Sol^n :→ Given :

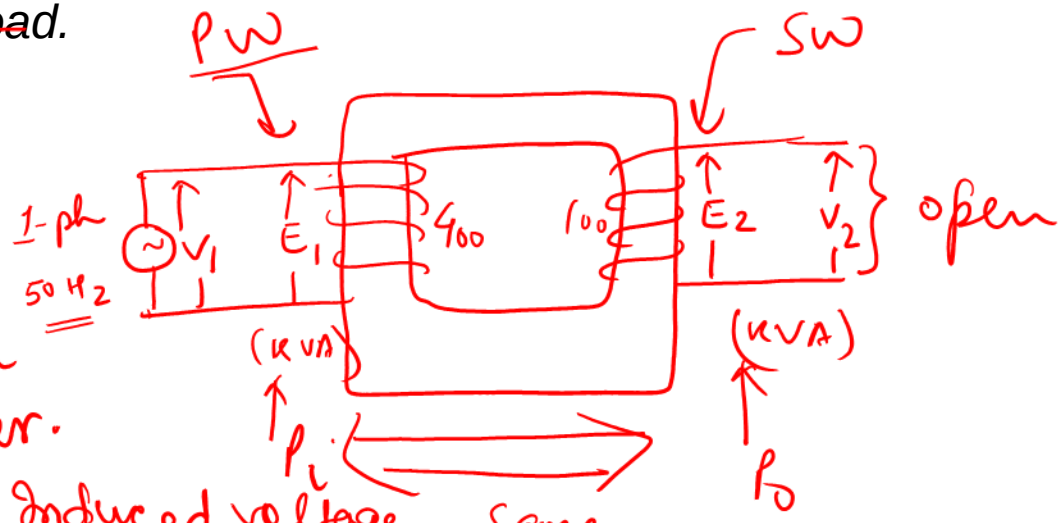
Power, $P = 40\,kVA$

$N_1 = 400$

$N_2 = 100$ ⟸

$N_1 > N_2$

↳ step down Xformer.



$V_1 = 2000\,V = E_1$

$f = 50\,Hz$

E_1 = Induced voltage same at primary due to SI

(i) The secondary voltage on open circuit

Let, V_2 is the voltage on the open secondary

E_2 ⇒ RMS value of the voltage induced at SW due to Mutual Induction

$E_2 = V_2$ or $V_2 = E_2$

V_2, E_2, V_1, E_1, I_1, I_2 } RMS values

volt - Turn Ratio

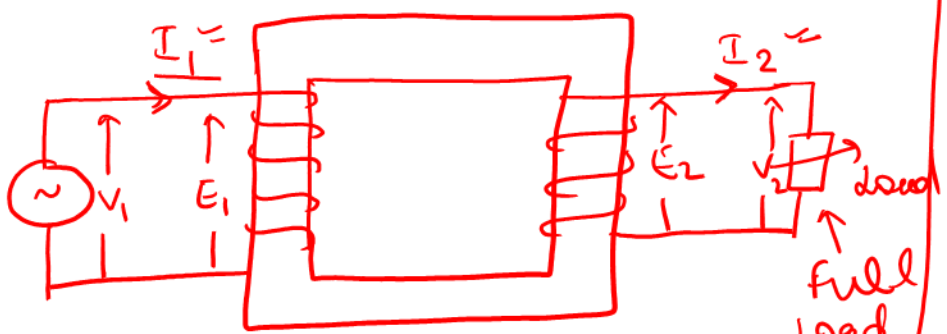
$$\frac{E_2}{N_2}\{\text{secondary}\} = \frac{E_1}{N_1}\{\text{PW}\}$$

$$E_2 = E_1 \times \frac{N_2}{N_1} = 2000 \times \frac{100}{400}$$

$$\boxed{E_2 = 500\ V}$$

$$\boxed{V_2 = E_2 = 500\ V}$$

(ii) I_1 & I_2 — full load values of Primary & Secondary current



$$I_1 = \frac{P(KVA)}{V_1}$$

$$I_1 = \frac{20 \times 1000}{2000}$$

$$\boxed{I_1 = 20\ A}$$

$$I_2 = \frac{P(KVA)}{V_2} = \frac{40 \times 1000}{500} \quad (\because P = VI)$$

$$\boxed{I_2 = 80\ A}$$

[PV ↑ PC ↓ / SV ↓ SC ↑]

Power on both sides of the xformer is same

(iii) From the emf eqn of the xformer we have

$$E_1 = 4.44 N_1 \phi_m f$$

ϕ_m → max. flux

$$\phi_m = \frac{E_1}{4.44 N_1 f} = \frac{2000}{4.44 \times 400 \times 50}$$

$$\boxed{\phi_m = 0.0225\ Wb}$$

Example 2. *The no-load ratio required in a single-phase 50 Hz transformer is 6600/600 V. If the maximum value of flux in the core is to be about 0.08 Wb, find the number of turns in each winding.*

(N_1 & N_2)
↑ PW ↑ SW

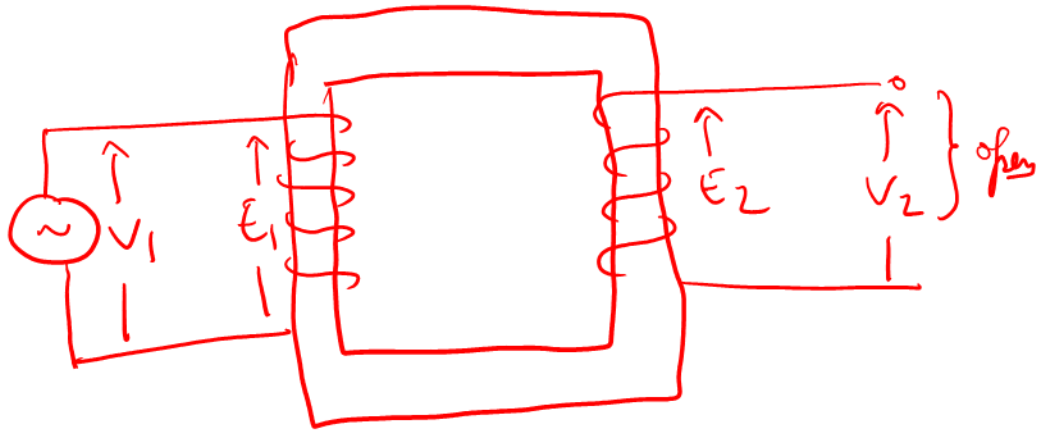
Sol^n :- Step down Xformer

6600 / 600 V

Primary voltage → E_1 or V_1

Supply voltage

Secondary voltage → E_2 or V_2



Given : $E_1 = V_1 = 6600\ V$

$E_2 = V_2 = 600\ V$

$\phi_m = 0.08\ Wb$

$f = 50\ Hz$

N_1 (i.e No. of turns of the PW)

N_2 (" " " " " " SW)

we can use the emf eq^n of the Xformer

$$E = 4.44 N \phi_m f$$

$$E_1 = 4.44 N_1 \phi_m f$$

$$N_1 = \frac{E_1}{4.44 \phi_m f} = \frac{6600}{4.44 \times 0.08 \times 50}$$

$$N_1 = 372$$

$$N_2 = 34$$

Volt to turn Ratio [Transformation Ratio]

$$\frac{E_2}{N_2} = \frac{E_1}{N_1}$$

$$N_2 = \frac{E_2}{E_1} \times N_1$$

$$N_2 = \frac{600}{6600} \times 372$$

Example 3. *A single-phase transformer is connected to a 230 V, 50 Hz supply. The net cross-sectional area of the core is 60 cm². The number of turns in the primary is 500 and in the secondary 100. Determine :*
(*i*) *Transformation ratio.* (*ii*) *Maximum value of flux density in the core.*
(*iii*) *E.m.f. induced in secondary winding.* $[E_2]$

Sol^n :

Given :

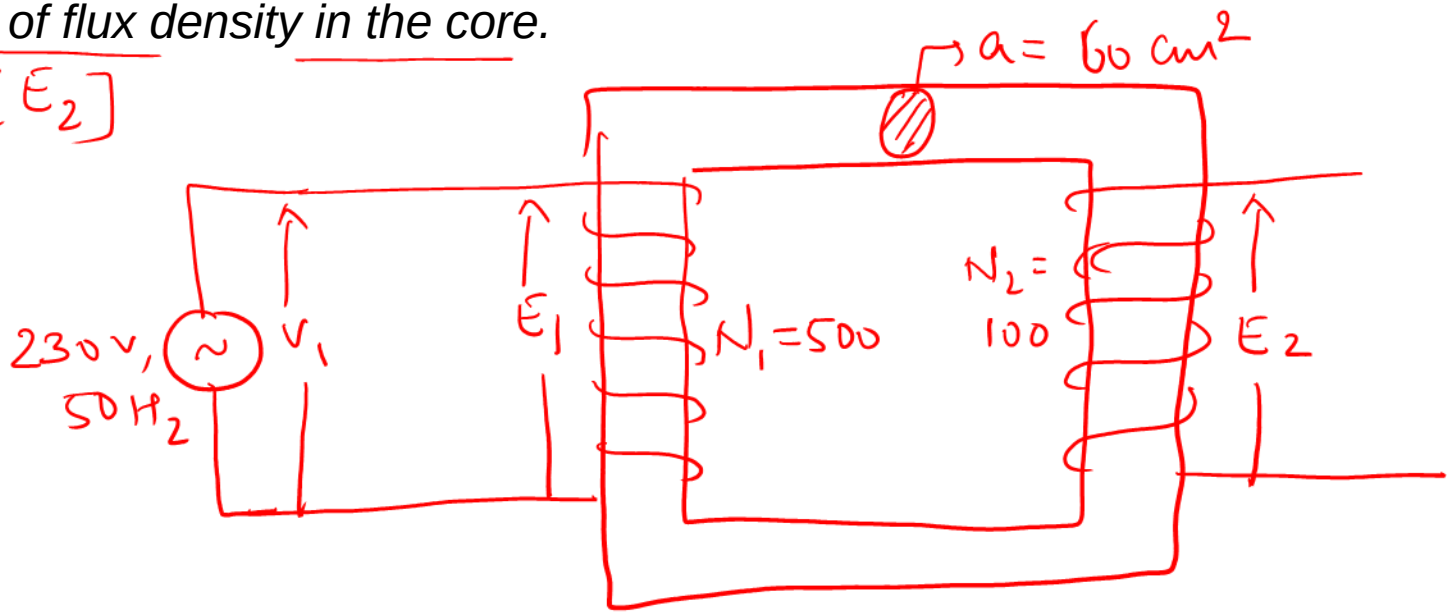
$V_1 = 230\ V = E_1$

$f = 50\ Hz$

$N_1 = 500$

$N_2 = 100$

$a = 60\ cm^2$



(i) Transformation Ratio (K)

$$\frac{E_2}{N_2} = \frac{E_1}{N_1} \quad \text{or} \quad \frac{E_2}{E_1} = \frac{N_2}{N_1} = K$$

$$K = \frac{100}{500}$$

$$K = \frac{1}{5} = 0.2$$

(ii) B_m (max value of flux Density)

$$B_m = \frac{\phi_m}{\text{area}(A)}$$

ϕ_m = max. flux

$$E_1 = 4.44 N_1 \phi_m f$$

$$\phi_m = \frac{E_1}{4.44 N_1 f}$$

$$\phi_m = \frac{230}{4.44 \times 500 \times 50}$$

$$\boxed{\phi_m = 0.00207 \text{ Wb}}$$

$$a = 60 \text{ cm}^2 = 60 \times 10^{-4} \text{ m}^2$$

$$B_m = \frac{0.00207}{60 \times 10^{-4}} = 0.345 \text{ T}$$

$$\boxed{B_m = 0.345 \text{ T}}$$

(iii) E_2

Volt to turn Ratio

$$\frac{E_2}{N_2} = \frac{E_1}{N_1}$$

$$E_2 = E_1 \frac{N_2}{N_1} = 230 \times \frac{100}{500}$$

$$E_2 = 230 \times 0.2$$

$$\boxed{E_2 = 46 \text{ V}}$$

Example 4. *3300/300 V single-phase 300 kVA transformer has 1100 primary turns. Find* :
(*i*) *Transformation ratio.* (*ii*) *Secondary turns,* (*iii*) *Voltage/turn*.

(K) (N2) E1/N1 or E2/N2

Sol^n :

$V_1 = E_1 = 3300\ V$

$V_2 = E_2 = 300\ V$

$P = 300\ kVA$

$N_1 = 1100$

$N_2 = ?$

(I) Transformation Ratio (K)

$$K = \frac{E_2}{E_1} = \frac{N_2}{N_1}$$

$$K = \frac{300}{3300}$$

$$K = \frac{1}{11} = 0.091$$

(II) Secondary Turns (N_2)

$$\frac{E_2}{N_2} = \frac{E_1}{N_1}$$

$$N_2 = \frac{E_2}{E_1} \times N_1 = \frac{300}{3300} \times 1100 = 100$$

$$N_2 = 100$$

(III) V/T $\frac{E_1}{N_1}$ or $\frac{E_2}{N_2}$

(iii) $\frac{E_1}{N_1} = \frac{3300}{1100} = 3$

$\frac{E_2}{N_2} = \frac{300}{100} = 3$

Volt to Turn Ratio is 3

Thank You