EE441 **ENERGY CONVERSION**

EXPERIMENT 4

EQUIVALENT CIRCUIT OF A SINGLE PHASE TRANSFORMER

Objective:

- To perform the no-load (open circuit) and short circuit tests
- To calculate the single phase transformer's equivalent circuit parameters

Equipment:

- Single phase transformer
- Measurement devices: Ammeter, Voltmeter, Wattmeter

Procedure:

- Sketch equivalent circuit diagram of a single phase transformer.
- Record nameplate values of the transformer.
- First apply DC test, thus measure primary and secondary winding resistances.
- Apply open circuit test; Measure and record I, V and P values.
- Calculate core resistance and magnetizing reactance values using open circuit measurements.
- Apply short circuit test; Measure and record I, V and P values.
- Calculate equivalent impedance, resistance and reactance first, then determine primary and secondary values.

Questions:

- Briefly state terms; referred to low-voltage side and referred to high-voltage side.
- If one wants to observe hysteresis loop of a transformer via an oscilloscope, what would be the circuit setup you would propose to her ?
- Convert equivalent circuit referred to secondary.

EXAMPLE PROBLEM

A 2000-VA 230/115-V transformer has been tested to determine its equivalent circuit. The results of the tests are shown below.

Open-circuit test	Short-circuit test
$V_{OC} = 230$ V	$V_{SC} = 13.2$ V
$I_{OC} = 0.45$ A	$I_{SC} = 6.0$ A
$P_{OC} = 30$ W	$P_{SC} = 20.1$ W

All data given were taken from the primary side of the transformer.

Find the equivalent circuit of this transformer referred to the low-voltage side of the transformer.

(a) <u>OPEN CIRCUIT TEST:</u>

$$\left|Y_{EX}\right| = \left|G_C - jB_M\right| = \frac{0.45\text{ A}}{230\text{ V}} = 0.001957\text{ S}$$

$$\theta = \cos^{-1}\frac{P_{OC}}{V_{OC}I_{OC}} = \cos^{-1}\frac{30\text{ W}}{(230\text{ V})(0.45\text{ A})} = 73.15°$$

$$Y_{EX} = G_C - jB_M = 0.001957\angle -73.15°\text{ S} = 0.000567\text{-}j0.001873\text{ S}$$

$$R_C = \frac{1}{G_C} = 1763\,\Omega$$

$$X_M = \frac{1}{B_M} = 534\,\Omega$$

<u>SHORT CIRCUIT TEST:</u>

$$\left|Z_{EQ}\right| = \left|R_{EQ} + jX_{EQ}\right| = \frac{13.2\text{ V}}{6.0\text{ A}} = 2.20\,\Omega$$

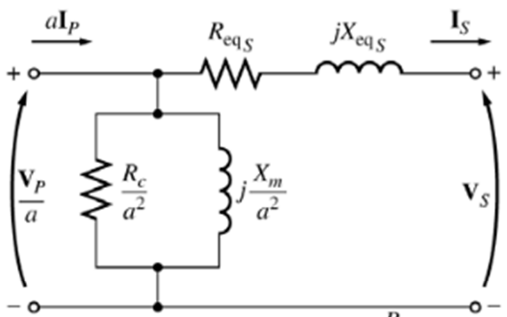
$$\theta = \cos^{-1}\frac{P_{SC}}{V_{SC}I_{SC}} = \cos^{-1}\frac{20.1\text{ W}}{(13.2\text{ V})(6\text{ A})} = 75.3°$$

$$Z_{EQ} = R_{EQ} + jX_{EQ} = 2.20\angle 75.3°\,\Omega = 0.558 + j2.128\,\Omega$$

$$R_{EQ} = 0.558\,\Omega$$

$$X_{EQ} = j2.128\,\Omega$$

To convert the equivalent circuit to the secondary side, divide each impedance by the square of the turns ratio ($a = 230/115 = 2$). The resulting equivalent circuit is shown below:



(b)

$$R_{eq\,S} = \frac{R_p}{a^2} + R_S$$

$$X_{eq\,S} = \frac{X_p}{a^2} + X_S$$

$R_{EQ,S} = 0.140\ \Omega$ $\qquad$ $X_{EQ,S} = j0.532\ \Omega$

$R_{C,S} = 441\ \Omega$ $\qquad$ $X_{M,S} = 134\ \Omega$