National University of Singapore

Department of Electrical & Computer Engineering

EE-1002:Circuits and Systems

Tutorial - 7 (Transformers and Rectifier Circuits)

Year 2013-14

Q.1 The high-voltage (HV) side of a step-down transformer has 800 turns, and the low-voltage (LV) side has 100 turns. An rms voltage of 240 V AC is applied to the HV side, and the LV side is connected to a load impedance of 3 Ω. Determine,

(a) The current and voltage on the LV side.

(b) The current on HV side.

(c) The primary input impedance from the primary voltage and current.

(d) The primary input impedance using the load impedance on the secondary side.

(Ans. (a) 30 V and 10 A, (b) 1.25 A, (c) 192 Ω)

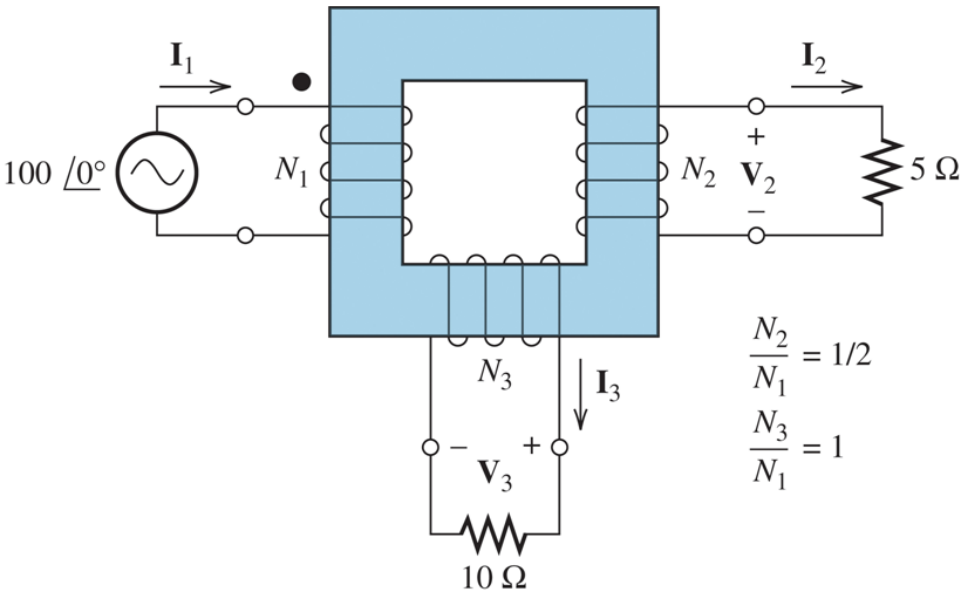

Figure 1: Q.2

Q.2 Consider a transformer with three windings as shown in Fig. 1.

(a) Place dots on windings to indicate the sense of coupling between coil 1 and coil 2. Between coil 1 and coil 3.

(b) Assuming that all the flux links all of the turns, determine the voltages $\mathbf{V_2}$ and $\mathbf{V_3}$.

(c) Assuming that the net mmf required to establish the core flux is zero, find an expression for $\mathbf{I_1}$ in terms of $\mathbf{I_2}$ and $\mathbf{I_3}$ and the turns ratios. Determine the value of $\mathbf{I_1}$.

(Ans. (b) $\mathbf{V_2} = 50\angle 0^0$ V and $\mathbf{I_2} = 10\angle 0^0$ A, $\mathbf{V_3} = 100\angle 0^0$ V and $\mathbf{I_3} = 10\angle 0^0$ A and (c) $\mathbf{I_1} = 15\angle 0^0$ A)

Q.3 An autotransformer is a device that consists of a single continuous winding with a tap brought out at some intermediate point to provide an output voltage as shown in Fig. 2.

Assume that the flux ϕ links all the turns and negligible mmf (magnato-motive-force) is needed to establish the flux.

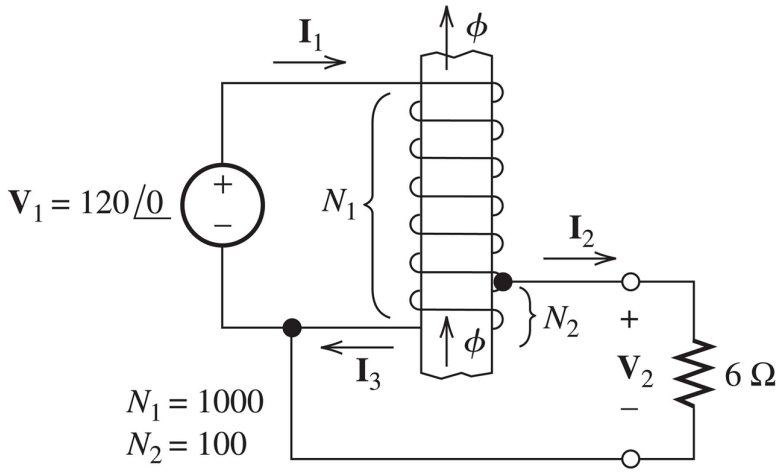

Figure 2: Q.3

Given the values of $\mathbf{V_1}, N_1$ and N_2, determine the values of $\mathbf{I_1}, \mathbf{I_2}, \mathbf{I_3}$ and $\mathbf{V_2}$.

(Ans. $\mathbf{V_2} = 12\angle 0\ V, \mathbf{I_1} = 0.2\angle 0\ A, \mathbf{I_2} = 2\angle 0\ A$ and $\mathbf{I_3} = -1.8\angle 0\ A$)

Q.4 In a real-transformer there are two types of losses namely: (1) the combined copper loss in the primary ${I_1}^2 R_1$ and secondary windings ${I_2}^2 R_2$ that is variable with output load and (2) core (iron) loss $\frac{{V_1}^2}{R_c}$ that can be considered to be constant for a given input voltage V_1. Show that the transformer efficiency for a variable output load is maximum when the combined copper loss is equal to the core (iron) loss.

Q.5 A full-wave rectifier circuit is used to design a DC power supply for a given application. The rectifier circuit has a 230 V AC source at 50 Hz and connected to a resistive load of 200 Ω. Determine the corresponding average output current and the peak-to-peak ripple in the output voltage.

Now, if the specifications for the DC Power Supply is to have a peak-to-peak voltage ripple of no more than 1% of the average output voltage then determine the value of the capacitor filter to be connected at the output side. Sketch the corresponding output voltage and the current drawn from the AC source.

(Ans. $\simeq$ 1.0 A and $\simeq 5000\ \mu F$)

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