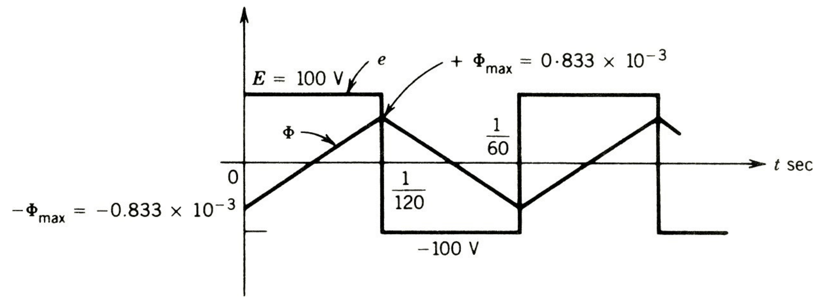

FIGURE E1.7

The waveforms of voltage and flux are shown in Fig. E1.7.

(b)

$$B_{\max} = 1.2 \text{ T}$$

$$\Phi_{\max} = B_{\max} \times A = 1.2 \times 0.001 = 1.2 \times 10^{-3} \text{ Wb}$$

$$N(2\Phi_{\max}) = E \times \frac{1}{120}$$

$$E = 120 \times 500 \times 2 \times 1.2 \times 10^{-3}$$

$$= 144 \text{ V} \quad \blacksquare$$

1.3.1 EXCITING CURRENT

If the coil of Fig. 1.17*a* is connected to a sinusoidal voltage source, a current flows in the coil to establish a sinusoidal flux in the core. This current is called the *exciting current*, i_Φ. If the $B-H$ characteristic of the ferromagnetic core is nonlinear, the exciting current will be nonsinusoidal.

No Hysteresis

Let us first consider a $B-H$ characteristic with no hysteresis loop. The $B-H$ curve can be rescaled ($\Phi = BA$, $i = Hl/N$) to obtain the $\Phi-i$ curve for the core, as shown in Fig. 1.18*a*. From the sinusoidal flux wave and the $\Phi-i$ curve, the exciting current waveform is obtained, as shown in Fig. 1.18*a*. Note that the exciting current i_ϕ is nonsinusoidal, but it is in phase with the flux wave and is symmetrical with respect to voltage e. The fundamental component $i_{\phi 1}$ of the exciting current lags the voltage e by 90°. Therefore no power loss is involved. This was expected, because the hysteresis loop, which represents power loss, was neglected. The excitation current is therefore a purely lagging current and the exciting winding can be represented by a pure inductance, as shown in Fig. 1.18*b*. The phasor diagram for fundamental current and applied voltage is shown in Fig. 1.18*c*.

With Hysteresis

We shall now consider the hysteresis loop of the core, as shown in Fig. 1.19*a*. The waveform of the exciting current i_ϕ is obtained from the sinusoidal flux waveform and the multivalued $\Phi-i$ characteristic of the core. The exciting current is nonsinusoidal as well as nonsymmetrical with respect to the voltage waveform. The exciting current can be split into two components, one (i_c)

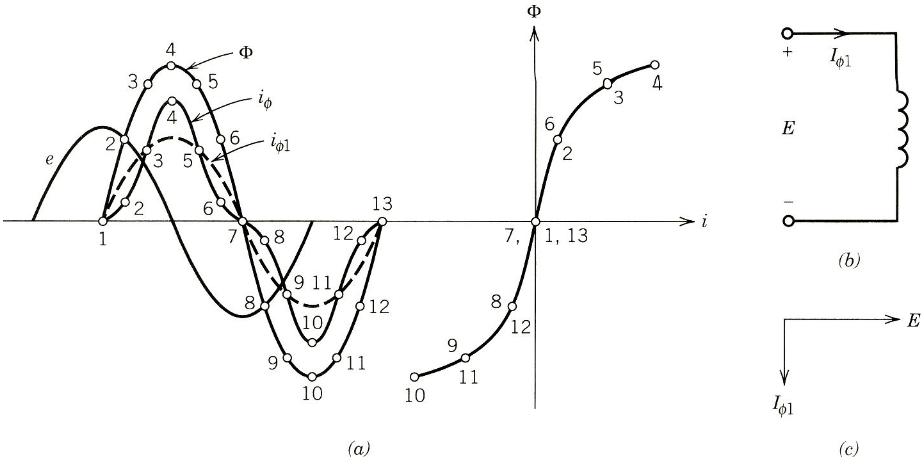

FIGURE 1.18 Exciting current for no hysteresis. (*a*) Φ−*i* characteristic and exciting current. (*b*) Equivalent circuit. (*c*) Phasor diagram.

in phase with voltage e accounting for the core loss and the other (i_m) in phase with Φ and symmetrical with respect to e, accounting for the magnetization of the core. This magnetizing component i_m is the same as the exciting current if the hysteresis loop is neglected. The phasor diagram is shown in Fig. 1.19*b*. The exciting coil can therefore be represented by a resistance R_c, to represent core loss, and a magnetizing inductance L_m, to represent the magnetization of the core, as shown in Fig. 1.19*c*. In the phasor diagram only the fundamental component of the magnetizing current is considered.

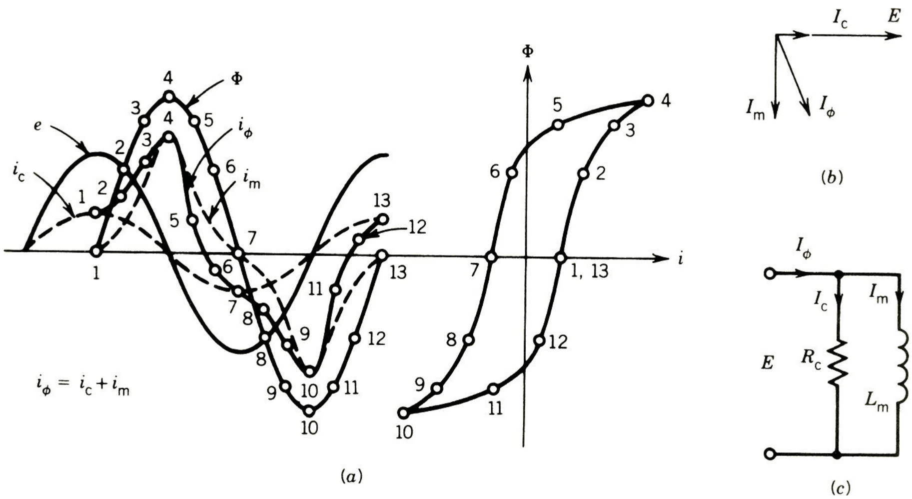

FIGURE 1.19 Exciting current with hysteresis loop. (*a*) Φ−*i* loop and exciting current. (*b*) Phasor diagram. (*c*) Equivalent circuit.