This example illustrates an important point: solving even a simple one-loop circuit containing one resistor and one inductor is very complicated compared to the solution of a single-loop circuit containing only two resistors. Imagine for a moment how laborious it would be to solve a more complicated circuit using the procedure employed in Example 8.3. To circumvent this approach, we will establish a correspondence between sinusoidal time functions and complex numbers. We will then show that this relationship leads to a set of algebraic equations for currents and voltages in a network (e.g., loop currents or node voltages) in which the coefficients of the variables are complex numbers. Hence, once again we will find that determining the currents or voltages in a circuit can be accomplished by solving a set of algebraic equations; however, in this case, their solution is complicated by the fact that variables in the equations have complex, rather than real, coefficients.

The vehicle we will employ to establish a relationship between time-varying sinusoidal functions and complex numbers is Euler's equation, which for our purposes is written as

$$e^{j\omega t} = \cos \omega t + j \sin \omega t \qquad \textbf{8.12}$$

This complex function has a real part and an imaginary part:

$$\begin{aligned} \operatorname{Re}\left(e^{j\omega t}\right) &= \cos \omega t \\ \operatorname{Im}\left(e^{j\omega t}\right) &= \sin \omega t \end{aligned} \qquad \textbf{8.13}$$

where $\operatorname{Re}(\cdot)$ and $\operatorname{Im}(\cdot)$ represent the real part and the imaginary part, respectively, of the function in the parentheses. Recall that $j = \sqrt{-1}$.

Now suppose that we select as our forcing function in Fig. 8.4 the nonrealizable voltage

$$v(t) = V_M e^{j\omega t} \qquad \textbf{8.14}$$

which because of Euler's identity can be written as

$$v(t) = V_M \cos \omega t + jV_M \sin \omega t \qquad \textbf{8.15}$$