EMF Equation

Prasad Mehendale

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Abstract

DC generators produce emf. This emf is finally used to deliver power to the load connected across the generator. The emf equation expresses emf in terms of physical parameters of the generator. All these can be easily measured (except the flux). In this article we derive this equation from the fundamentals.

EMF equation for a DC generator

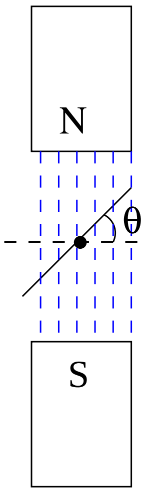

Figure 1: EMF-equation

In figure (1), Flux linked with the coil of N turns is given by:
$\psi = N * \Phi$

However, Φ changes sinusoidally in a rotating machine. So, $\theta = \omega t$; where ω is angular velocity of the coil.
$\Phi = \phi * cos(\omega t)$

Now from Faraday's law, we have induced emf:

$$\begin{aligned} e &= \frac{-d\psi}{dt} && (1) \\ &= -N * \frac{d\phi}{dt} && (2) \\ &= -N * \phi * \omega * (-sin\omega t) + cos(\omega t) * \frac{d\phi}{dt} && (3) \end{aligned}$$

Because the flux per pole is constant for a given machine,
$cos(\omega t) * \frac{d\phi}{dt} = 0$ is the transformer emf
The rotational voltage is only considered now, and is given by:

$$e = -N * \phi * \omega * (-sin\omega t) \tag{4}$$

Taking average of this voltage over a half cycle gives V_{DC}

$$V_{DC} = \frac{1}{\pi} \int_0^\pi N * \phi * \omega * [sin(\omega t)].d(\omega t) \tag{5}$$

Finding the integral with the limits mentioned, we have;

$$V_{DC} = \frac{2 * N * \omega * \phi}{\pi} \tag{6}$$

In the equation above, ω contains electrical frequency.
So, $\omega = 2 * \pi * frq * (Poles/2)$
$2 * N = Z$=number of conductors on armature, N is number of turns in a coil
$frq = rps$=rotations per second
$rpm = rps * 60$
Z conductors are divided in groups that are in parallel (paths=a)
Substituting above in equation 6, we have

$$V_{DC} = \frac{\phi * Z * rpm * P}{60 * a} = E_a \tag{7}$$

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