Maggy Smith

Mr. Nickson

Physics

10 May 2017

Protective Relays in Power Lines

Protective relays present in power lines have triggered energetic collapses such as those that occurred in 1965 and 2003 in the northeastern US and Ontario province in Canada and in 1999 in southern Brazil. During these events, entire states failed to ensure that a great portion of their citizens had an opportunity to use electricity several days in a row. This paper explains why these events did not result in removing the relays from the lines.

Every power plant produces electricity thanks to an electric generator. In this device, a turbine rotates in the constant magnetic field thanks to transformation of the primary energy. Therefore, the magnetic flux in the circuit of the turbine is the following (see Figure 1):

$$\Phi B = BA \cos \theta \tag{1}$$

Where $\theta = 2\,\pi f t$, f is the rotation frequency, B and A are the magnetic field inductance and area of the turbine circuit respectively. From Faraday's law of induction, it follows that f is

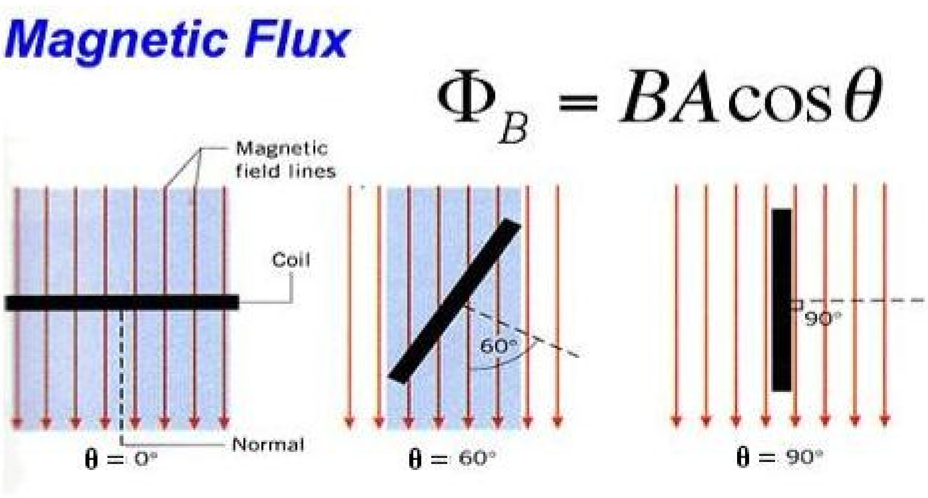

Figure 1 (DiMauro, n. d.).

the line frequency. Lentz's law determines the direction of the circuit current (see Figure 2). The magnetic field exerts the force on the current. From Fleming's left hand rule (see Figure 3), it follows that the force opposes the turbine rotation. Hence, using electricity on the part of consumers hinders the turbine rotation.

Actually, blackouts occur when the power plant does not have enough capacity to prevent the line frequency from falling below the standard value. Such an event is harmful due to the following: The abnormal deviation of the line frequency from the standard value

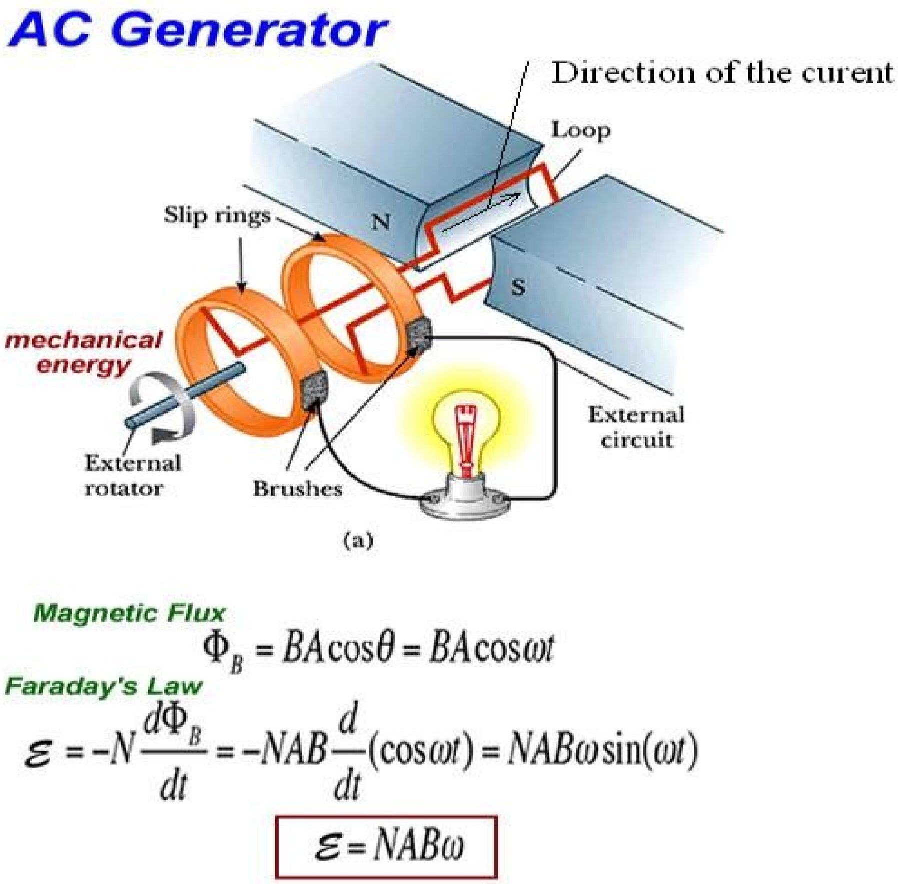

Figure 2 (DiMauro, n. d.).

can produce the resonant effects in the electrical devices situated in large areas since the impedances of device parts depend on the frequency.

However, a blackout is harmful to electrical appliances too. Specifically, an abrupt change in the voltage the power socket delivers results in the appearance of components with extremely high frequencies in the spectrum of the signal. Although such event exerts much greater influence on the impendences of device parts than an abnormal shift in the value of the line frequency does, its duration is very short. In addition, there are devices (e.g. surge protectors) that reduce the risk due to blackouts drastically. Hence, one should not remove

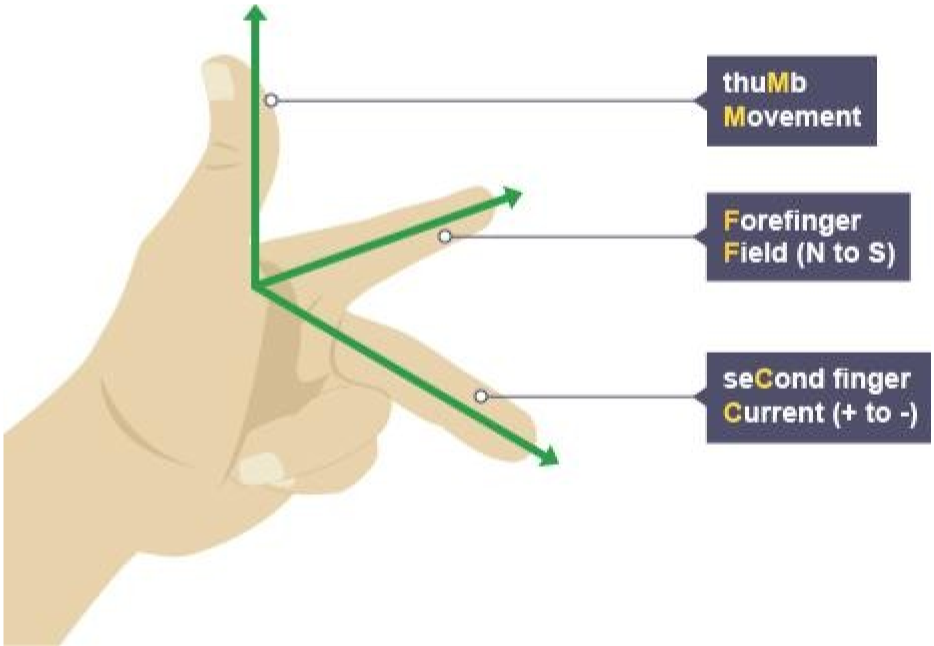

Figure 3 (Bitesize, n. d.).

the protective relays from the power lines because energetic collapses are less harmful than long-term shifts in the values of the line frequency.

References

Bitesize. (n. d.). *The motor effect*. Retrieved from http://www.bbc.co.uk/schools/gcsebitesize/science/triple_aqa/keeping_things_moving/the_motor_effect/revision/3/

DiMauro, T. (n. d.). *Faraday's law of induction*. Retrieved from http://sdsu-physics.org/physics180/physics196/Topics/faradaysLaw.html