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POYNTING VECTOR AND THE FLOW OF POWER

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Abstract- **This paper is just brush up on the fundamental and interpretation of Poynting vector. This paper starts with the introduction about poynting vector. And further discussed about the applications of poynting vector and also tells that how the total power flow along the cable will be determined by using poynting vector.**

I. INTRODUCTION

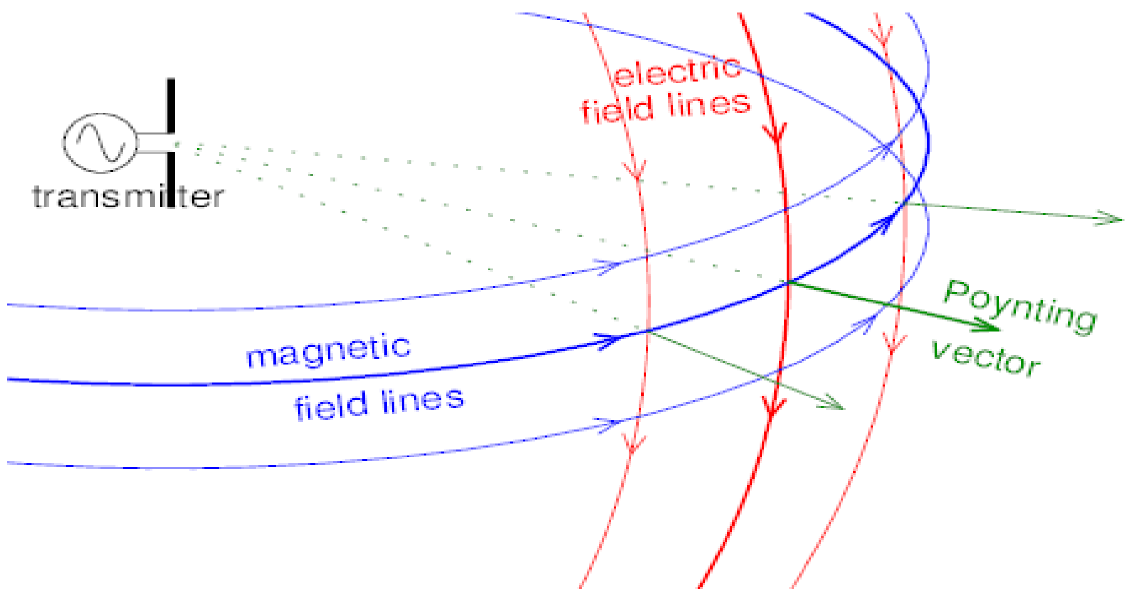
Poynting vector: On December 17, 1883 John Henry poynting submitted to Royal Society his famous paper that described and interpreted a remarkable formula:

$$\boldsymbol{P} = \boldsymbol{E} \times \boldsymbol{H}$$

Where ***E*** and ***H*** denote the electric and magnetic field intensities, is increasingly often referred to as the very fundamental of this theory. This is because the flux of the poynting vector to a volume , V, through its surface , S, is equal to the rate of energy , W, flow to this volume , i.e., to the instantaneous power, *p(t)*= dW/dt, of the load. Indeed, let us assume that electrical energy is delivered to a load exclusively by its three phase, three wire supply, denoted in this paper by R,S and T, with line to ground voltages *u*R, *u*S and *u*T and line current *i*R, *i*S and *i*T. In such a case, the flux of the poynting vector through only surface, S, that crosses the supply lines only once is equal to

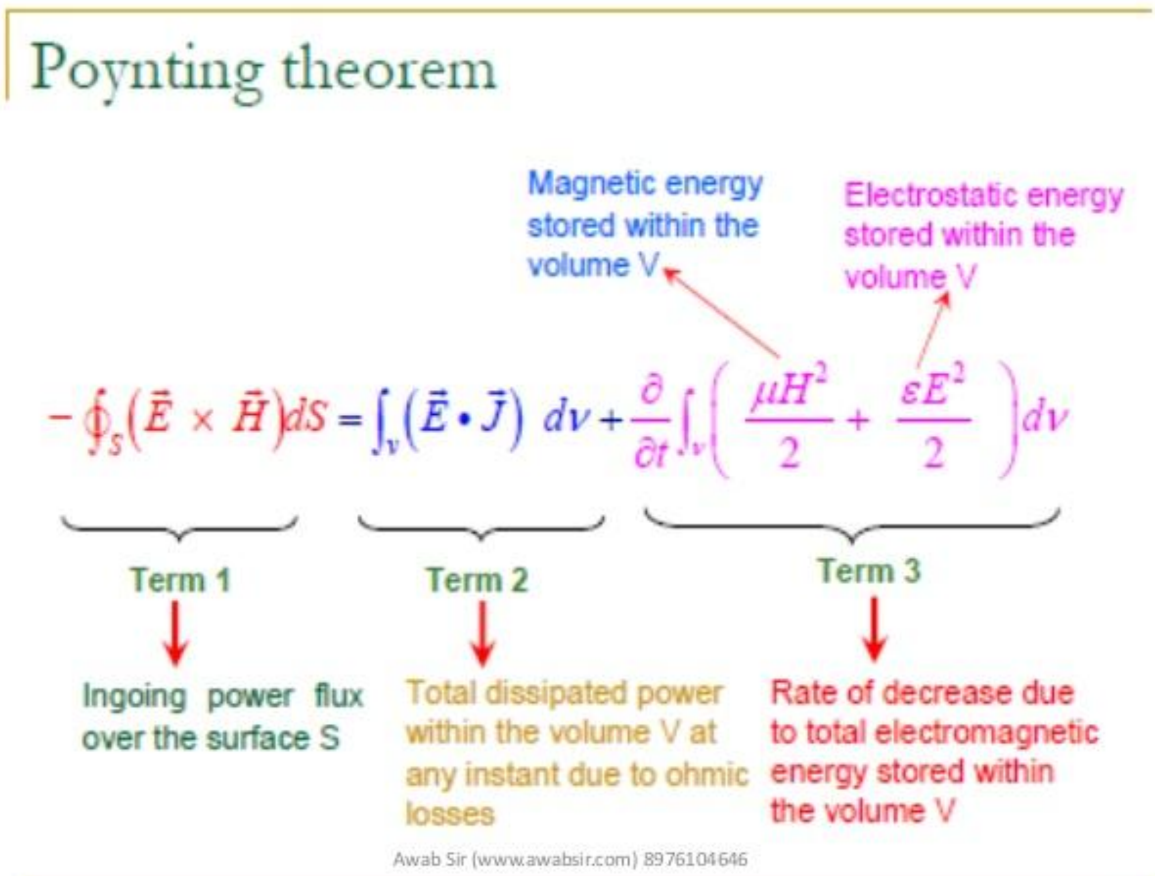
$$\iint \mathbf{p.dS} = u\mathrm{R}i\mathrm{R} + u\mathrm{S}i\mathrm{S} + u\mathrm{T}i\mathrm{T} = p(\mathrm{t})$$

Direction of poynting vector is shown in the figure given below:



II. INTERPRETATION OF E × H

The interpretation of **E×H** as the power flow per unit area is an extremely useful concept, especially in radiation problems. For example, an integration of **E×H** over a surface enclosing a transmitting antenna gives the power radiated by the antenna. Although this interpretation of **E×H** never gives an answer which is known to be erroneous, it sometimes leads to a picture which the engineer is loathe to accept. Most engineers find acceptable the concept of energy transmission through space, either with or without guiding conductors, when wave motion is present. However for many engineers this picture becomes distributing for transmission line propagation in the dc case. When **E and H** are static fields produced by unrelated sources, the picture becomes even less credible. The classic illustration of a bar magnet on which is placed an electric charge is one which is often cited. In this example a static electric field is crossed with a steady magnetic field and a strict interpretation of Poynting's theorem seems to require a continuous circulation of energy around the magnet. The picture of poynting theorem is illustrated in figure shown below:



One could say that the pointing vector provides us with an important physical interpretation relevant energy flow, as a load power flux or a power flux density. Unfortunately, even the existence of the pointing vector in the presence of electric and magnetic fields, E and H could be controversial. Consider for example, the situation shown in fig(1) , where an electric field is created by a charged capacitor and magnetic field is created by a permanent magnet. For sure, there is no energy flow in such a situation, although apparently the pointing vector is not equal to zero.

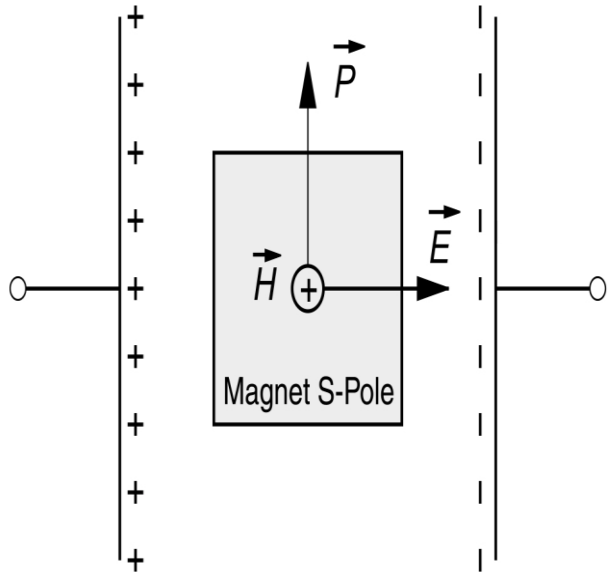


Figure.1 Situation where apparently the pointing vector occurs

Another such situation , may be more confusing for engineers who are not expert in electrodynamics, is shown in fig(2). Thus, it is not enough that electric & magnetic fields exist in a point of space for the pointing vector to exist and consequently, energy flow. The pointing vector is the energetic aspect of the mutual dependence of electric and magnetic fields by the Maxwell equation.

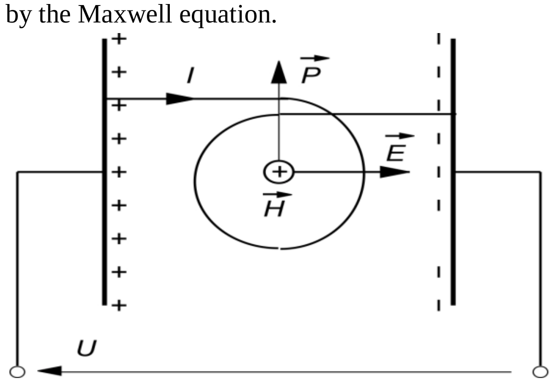


Figure.2 Situation where apparently the pointing vector occurs

III. CONCLUSION

The poynting theorem and the poynting vector are fundamental mathematical tools for calculating energy flow and its storage in electromagnetic fields. Their applications in various fields of electrical engineering are countless.

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