On the Antenna Reception in the Presence of Generalized Excitation

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Complex antenna systems composed by an antenna feed and a focusing structures such as reflectors or lenses, when investigated in reception, are often characterized via their effective area. The phase of the signal received in the antenna is typically not accounted for. The reason for such approach for the complex antennas is that a single incident plane wave incident into a focusing system is transformed into a continuous set of coherent plane waves, and the voltage generator for an equivalent circuit applicable in these configurations has not been developed.

In this paper, we will develop an equivalent circuit for antennas in reception that can be used for these complex antenna systems. Resorting to an original application of the reciprocity theorem, the open circuit voltage is represented with three alternative reaction integrals that are demonstrated to give the same result. The first reaction is performed on a surface surrounding only the gap of the antenna and in the presence of the antenna itself, a second is performed on a surface at large distance from the antenna, a third one is performed on the surface surrounding the antenna.

While the first integral is simply another expression for the definition of the open circuit voltage, the second integral highlights that the voltage induced on a receiving antenna is maximum when the incident field has the same distribution as the conjugate of field radiated by the antenna in transmission. This situation is what we here proposed as field matching condition. In this situation 100% of the power incident on the antenna can be received by the load. Finally the third representation shows that the field matching can be observed also comparing the incident field on the antenna surface (evaluated in absence of the antenna) with the conjugate of the equivalent currents that are generated on the antenna in transmission.

An engineer tasked to optimize the design of a feed can decide to base his considerations on his knowledge of the incident field angular or spatial distribution depending if he is more capable of influencing the antenna far field pattern or the antenna currents.