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Explicit formulas for the calculation of the (local) phase center of an arbitrary antenna

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In this paper we derive explicit formulas for the calculation of the phase center of an arbitrary antenna. Such a formula permits to describe the phase center dependence from observation aspect and frequency.

The phase center of an antenna is a virtual point that can be associated to the antenna, which permits to treat the antenna as a point source from which the field spreads spherically outward [1]. Its exact location is of interest in the design of reflector antenna systems where the illuminating field of the primary feed antenna, usually a horn, must emanate from the reflector focus [2-4]. Indeed, a displacement or misalignment between the feed phase center and the reflector focus results in a degradation of the reflector system radiation properties [5]. The determination of the antenna phase center is also important in high-precision global navigation satellite systems (GNSS) like GPS, in radar systems (including SAR and MIMO radars), MIMO communication systems, electromagnetic compatibility tests, antenna measurements, biological sensing, etc.

Despite the phase center of an antenna is a very basic concept which is found in textbooks, to authors' best knowledge, a systematic general formulation for its definition and explicit calculation is not yet available. Some recent attempts have tried to address this issue either analytically or experimentally [7-8].

In the present paper we consider a generic antenna represented by a radiation integral (which can be either a surface integral of surface current densities or a volume integral of volumetric current density). The radiation integral is then expressed in its plane-wave spectral form at a large but finite distance from the antenna. The asymptotic evaluation of such an integral provides the radiated field at a given point in its Geometrical Optics format, from which the local direction of propagation and wavefront curvatures are explicitly obtained. Such parameters permit the derivation of the antenna phase center associated to the given observation aspect. The final formulas giving the antenna phase centers resemble those associated to the barycenter or center of mass, therefore the phase center can also be interpreted as the electromagnetic barycenter of a radiating current system. The explicit formulas are directly implementable in simulation tools where the currents are obtained by numerical calculations like the Method of Moments, thus representing a ready to use post processing for antenna analysis and design, in particular for the assessment of phase center stability.

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