Exploiting the Spatial Signature of Mutual-Coupling in HF Receive Arrays

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SUMMARY

We are interested in large HF-band receiving arrays such as those used in skywave Over-the-Horizon Radar, strategic HF communications, or direction-finding systems. These arrays have many wavelengths in size and operate over the full HF-band, more than three octaves, and are commonly linear or circular in geometry. For receive-only systems, mismatched antenna elements are typical used at HF-band frequencies to reduce high external noise while retaining a desirable external noise to internal noise ratio over the whole band.

Each array element partly absorbs and partly rescatters the electromagnetic signals that are impinging on the array. This rescatter includes inter-element interaction, which is called mutual-coupling. Ensuring that a plane-wave signal arriving at the array remains plane-wave following signal reception and digitisation is called array calibration and is an important practical aspect of building receiving arrays. Devising array calibration schemes is complicated by the presence of mutual-coupling, and techniques that simplify calibration by eliminating mutual-coupling effects are of interest.

Using Computational Electromagnetic Modelling, we show that mutual-coupling has a spatial signature dependent on the array geometry and with energy level versus direction determined by the spatial signature of the impinging signal. For example, we demonstrate that mutual-coupling energy concentrates from the two end-fire arrival directions in a linear array corresponding to the array axis. For all other directions-of-interest, we can ignore mutual-coupling effects in the linear array, simplifying array calibration.

Other array geometries have a different mutual-coupling spatial signature, and this signature may or may not allow simple spatial calibration. For this reason, we conjecture that the impact of the mutual-coupling spatial signature on array calibration complexity should be a consideration when selecting array geometry.