Achievable Coupled-Oscillator Array Performance

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Coupled-Oscillator arrays (COAs) were introduced by Stephan (K. D. Stephan, IEEE Trans. Microwave Theory Tech., Oct. 1986, pp. 1017-1025) and a substantial knowledge base has been built by York (*e.g.*, R. A. York, P. Liao, and J. J. Lynch, IEEE Trans. Microwave Theory Tech., Nov. 1994, pp. 2040-2045). A few groups, including that of the present authors have elaborated upon this seminal work. Our primary interest has been the optimization of COAs to the end of low-cost deployable arrays at millimeter wavelengths. This presentation summarizes our current understanding of COA performance and presents theoretically extrapolated results for arrays of practical scale. (By necessity, experimentation to date has been on small-scale models—16 and fewer elements.)

The key to good array performance lies in fabricating individual oscillator cells with wide locking range and strong cell-to-cell coupling. An array designed in this way exhibits low random phase error among cells. A further fundamental consideration is the matching of the free-running frequencies among all of the cells. The frequency matching is difficult in light of the wide-locking-range goal. A recent Ph.D. thesis by Wang (Holcombe Department of Electrical and Computer Engineering, Clemson University, 2003) deals with simultaneous optimization of frequency sensitivity and locking range.

The use of wide locking range oscillators (or, crudely stated, low-Q oscillators) leads to an array whose output exhibits extremely poor phase noise properties. The COA phase noise may be brought close to that of an external source to which the array is injection locked, allowing independent control of the phase noise. We recently conducted an experimental study of COA phase noise under a number of different locking configurations. We present these new results in this presentation.

Computations from a complete model of a COA, comprising a Runge-Kutta solution to the equation developed by York, *et. al.*, are presented for cases of practical scale.

A promising COA architecture employs a mixer in the path between each oscillator element and its antenna. Consequently, one must be concerned with noise introduced in the mixing process. The computational model indicated in the forgoing paragraph is subjected to this mixer noise and the calculations are repeated, thereby providing the most complete model data possible for deployable-scale COAs.