The Effect of Coupling Network Length on COA Performance

Venkatesh Seetharam*, Chris Tompkins, L. W. Pearson
Holcombe Department of Electrical and Computer Engineering
Clemson University, Clemson, SC 29634-0915
vseetha@clemson.edu
Chris.Tompkins@alumni.ces.clemson.edu
pearson@ces.clemson.edu

Coupled oscillator arrays (COAs) are useful in beam steering applications. High-Q oscillators have been shown to have poor locking ranges which are highly sensitive to shifts in oscillator frequencies. When these oscillators are used in COAs, fabrication tolerances reduce the probability for array locking. Hence high-Q oscillators are undesirable for COA applications. Wide injection locking range oscillators overcome the shortcomings of the high-Q oscillators and seem attractive for COA applications. Oscillator interaction depends critically on the coupling network. Oscillators were designed for wide locking ranges. Mutual injection locking ranges as high as ±6.5% were measured, however similar oscillators with different coupling lengths exhibited poor injection locking ranges. With well designed oscillators, the array interaction depends critically on the coupling network.

The oscillators generally exhibit series or shunt resonance. It has been shown that the length of the coupling network depends on the nature of the resonance. Series resonant oscillators require odd multiples of half wavelength coupling lines, while shunt resonant oscillators require even multiples of one wavelength coupling lines for operation in the desired mode.

Non-optimal coupling lengths lead to poor array operation, shifts in ensemble frequency, and possibly improper mode of operation. With the array of oscillators tuned to a common frequency and coupled with a coupling length that differs slightly from ideal, the ensemble frequency deviates slightly from the individual oscillators' center frequency and the locking range will be less than optimal. With a coupling network that is off by approximately half a wavelength, it will be shown that the array may lock with a limited locking range, but the array is actually operating in an undesired mode.

It may be advantageous to allow post fabrication adjustment to fix the center frequency of the coupling lines. If the coupling lines are designed slightly higher than the desired center frequency, open stubs can be introduced at the center of the coupling network to correct the discrepancy. The stub helps in reducing the center frequency. Adjusting the length of the stub alters the center frequency as long as the stub is less than a quarter wavelength. These stubs also lower the Q-factor of the coupling network, which must be much lower than that of the oscillator according to COA theory.