Calibration of Phased Arrays for High Data Rate Wireless Communications

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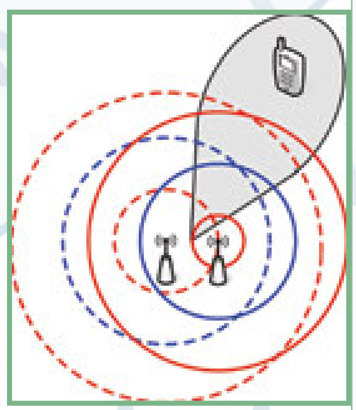
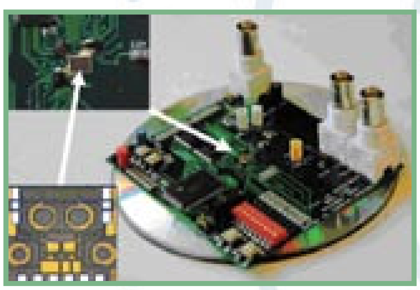
As wireless communications standards evolve, data rates increase significantly with each new generation. The 2G cellular standard accommodates data rates up to 20KBps, while the forthcoming 4G standard is expected to mandate data rates up to 1GBps. This trend forces engineers to find ways to increase data rates over wireless channels. As traditional time and frequency domain methods are exhausted, engineers are turning to spatial methods. One spatial method that shows great promise is the use of multiple-antenna transceivers.

A phased array is one type of multiple-antenna system, which transmits (or receives) the same signal on each antenna, but adjusts the relative phases and amplitudes. The constructive/destructive interference between these signals shapes the radiation into a beam. By adjusting the relative phases and amplitudes, the beam of radiated power can then be steered to "focus" it onto the desired user. This minimizes wasted power and increases the signal to noise ratio, thus enabling higher data rates.



AN ILLUSTRATION OF A PHASED ARRAY TRANSMITTER IN OPERATION. THE ELECTROMAGNETIC RADIATION OF EACH ANTENNA IS DEPICTED BY THE CONCENTRIC RED AND BLUE CIRCLES (DENOTING THE WAVE MAXIMUMS AND MINIMUMS, RESPECTIVELY). CONSTRUCTIVE INTERFERENCE OCCURS WHERE THE COLORS COINCIDE RESULTING IN THE FORMATION OF A RADIATION BEAM (SHOWN IN GREY), WHICH CAN BE STEERED TOWARD THE DESIRED USER.



THE SYSTEM WILL BE TESTED USING A CHIP-ON-BOARD PACKAGING METHOD WHERE THE SILICON DIE IS WIRE-BONDED DIRECTLY TO A PRINTED CIRCUIT BOARD, ALLOWING MEASUREMENTS TO BE TAKEN BY PROBING THE DIE. THE UPPER LEFT INSET IS AN ENLARGED VIEW OF THE WIRE-BONDED DIE ON THE PRINTED CIRCUIT BOARD. THE LOWER LEFT INSET IS AN ENLARGED VIEW OF THE SILICON DIE (THE WHITE SQUARES ARE THE PADS USED FOR PROBING).

Phased arrays rely on the ability to accurately set the relative phases and amplitudes in the different signal branches. Errors and mismatches create non-idealities in the radiation pattern, such as beam pointing error and reduced directivity. This requires a system for quickly and accurately setting the phase and amplitude in each branch of a phased array. The possibility being explored is to employ dual feedback loops: the first operates on the phase of the output and generates the phase shifter control voltage, and the second operates on the amplitude of the output and generates the variable gain amplifier control voltage. The inputs to the system are the desired phase and amplitude, and the negative feedback action of the loops forces the control voltages to settle to their required values.

Phased arrays are primarily used for radar and other specialized applications, and often use discrete components or costly compound semiconductor technology. The possibility of implementing key components of a phased array in CMOS technology opens the door for the widespread adoption of phased arrays in communications applications. This research currently implements phase and amplitude control for a transmitter. The next step will integrate the system with the other transmitter components and then test the unit as a whole. EE

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