

ABSTRACT

This dissertation develops broadband radio-frequency (RF) phase control as its main contribution to real-time RF signal processing for wireless front ends. Here, real-time denotes continuous processing of the RF waveform by a configured circuit. The principal research problem is how a finite network of weighted delays can provide tunable phase control across a broad band while managing magnitude variation and implementation complexity. The RF signal processing (RFSP) phase shifter combines a direct contribution with a Hilbert-derived quadrature contribution to control phase and magnitude. The theory connects causal synthesis, branch count, delay mapping, and gain control to finite-band accuracy.

A 5-branch RFSP is implemented in a 150 nm GaAs pHEMT process and characterized over 1.5–15.5 GHz. The single-quadrant study combines PCB-level circuit measurements with a 4-channel radiation experiment using calibration within 1 GHz subbands. A complementary port configuration reverses the delay ordering to access a second phase quadrant. On-wafer two-chip relative-phase measurements span nominal 0° – 180° targets, with maximum RMS phase and magnitude errors of 3.06° and 0.72 dB over the characterized band. These measurements are distinguished from the calculated array factors and from the absolute phase range of an individual path. A further fabricated RFSP integrates an absorptive input SPDT for internal direction selection. Developed from an initial 1–40 GHz objective, the 2–27 GHz design is evaluated using frequency-specific two-path phase, magnitude, and reflection simulations. The second phase-target group is limited to 25 GHz, with residual state-dependent errors. This study distinguishes a broad calibration range from the instantaneous bandwidth available at one control setting.

Supporting studies examine related phase and delay relationships in separate circuits for fixed and switchable single-sideband conversion, second-harmonic feedback for intermodulation suppression, and tunable spectrum discrimination using a Butler matrix. An appendix presents RF transformer measurements and a simulated isolated gate-driver application. Together, the RFSP and supporting studies show how controlled waveform relationships can implement distinct front-end functions, with the broadband phase shifter providing the main connection between synthesis, integrated implementation, and measurement.