Wideband Frequency Synthesis with Rapid Frequency Hopping

Sushil Subramanian and Hossein Hashemi
Ming Hsieh Department of Electrical Engineering

Motivation

Conventional Spectral Analysis:
- The sweep rate of synthesizer-based spectrum analyzers is limited to the acquisition and resolution of phase-locked loops (PLLs).
- Direct digitization and FFT require high-speed data converters that consume a lot of power.

Key Applications:
- GNSS with small sweep time and real-time power measurement.
- Secure communications over a wideband with rapidly hopping carrier frequency.
- Multi-band OFDM applications in ultra-wideband (UWB) communications.
- Multi-standard wideband downconversion with high-latency tolerant applications.

Objective: Design a low power, low noise Rapid Hopping Frequency Synthesizer with high spectral purity and frequency resolution.

Highlights of Architecture:
- Wideband frequency generation by the method of multiplication (covers 1-6 GHz).
- High resolution using a 15-bit frequency word (24 KHz at RF).
- Rapid hopping using a sine-weighted DDFS that has no state.
- High frequency is generated using injection locking of harmonics of baseband tones, thus making overall system low-power.

Proposed Architecture

Integrated Circuit Implementation

DDFS

- DDFS is a 15-bit accumulator with phase compression, phase segmentation and binary-to-thermometer converters.
- Theoretical SFDR of DDFS is 24 dB, due to the sine-weighted approximations.

Sine-Weighted DAC

- DAC is used to perform high-resolution approximation.
- Synthesizer includes a bank of phase shifters and finite impulse response filters with external calibration.
- Total hopping time of 10 ns due to register inclusion to meet stock requirements.

Schematic Simulations

Performance Results

Future Work

- Preparation of Chip Package and Testing Board.
- Design of complete system and possible use in existing software defined radio (SDR) applications.
- Enabling high-bandwidth modulation and secure transmitters using custom, real digital control circuits.
- Circuit Synthesis consists of two separate Acquisition and Tracking, two concepts of fast acquisition in fastest hopping synthesizer can be used in fast tracking applications?