Fall 2011: ELEN 6903 (Power Amplifier and Wireless Transmitter Circuits)

Efficient generation of large amounts of signal power at radio-, microwave and millimeter-wave frequencies has been a significant challenge since the dawn of electronics. This is especially true in the realm of silicon-based RF and mmWave ICs due to the low breakdown voltages of silicon-based transistors and the lossy nature of silicon-based active and passive devices. Consequently, the power amplifier has traditionally been the most challenging block among ICs for wireless applications. An added challenge is the need for linear PAs and transmitters that can support complex, spectrally-efficient modulation schemes, as linearity and efficiency cannot be achieved simultaneously in conventional PAs and transmitters.

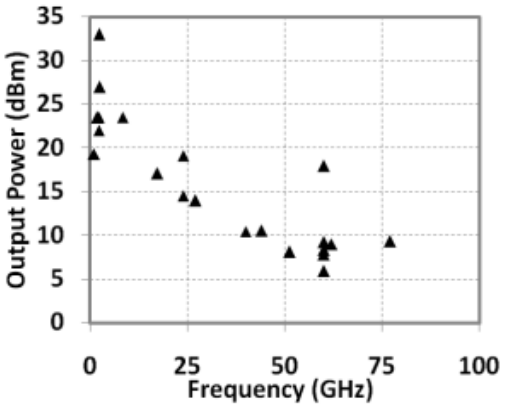

Figure 1. Output power of recent silicon-based transmitters at RF and mmWave frequencies.

Due to these challenges, PA and transmitter circuits and architectures are a hot topic of research, particularly in recent times. This seminar course will cover advanced PA topologies and transmitter architectures that target high output power, efficiency and linearity. Specific topics include:

- Introduction to PAs and Transmitters - challenges and opportunities.
- PA/Transmitter metrics: Output power, Efficiency (drain efficiency, PAE, efficiency under backoff, average efficiency under modulation), Linearity (AM-AM, AM-PM, EVM, ACPR).
- Class A, AB, B, C, and F PAs. Switching PAs (Classes D and E).
- Advanced switching PA classes (finite-choke Class E, Harmonic-tuning in Class E, Inverse Class D).
- Impedance transformation for PAs and power combining (transformer-based combining, Wilkinson-based combining, spatial and quasi-optical combining).
- Linearizing transmitter architectures (Outphasing/LINC/Chereix, Doherty, Polar/Kahn/Envelope Elimination and Restoration, Envelope Tracking Digital Polar Transmitters).
- Supply modulators for PAs.
- Transmitter Predistortion

Class Timing: Tuesdays and Thursdays, 2:40pm-3:55pm

Grading: Two critiques on recent research papers in the form of oral and visual presentations (25% each), and one final IC design project (50%).

Pre-requisites: ELEN 4312, ELEN 4314 and ELEN 6312 or their equivalents are required. ELEN 6314, ELEN 6318 and ELEN 6320 are pluses, but not absolutely required. Students are encouraged to contact Prof. Harish Krishnaswamy (harish@ee.columbia.edu, CEPSR 1025) if they do not meet/have questions about the requirements.