ECE 738, Spring 2018
Low Power VLSI Circuits for Wireless (5G) Communication
8:30am-11:20am Friday, EIT 3141. First class May 4, 2018

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Course Description

This course covers the design of analog and digital circuits used in modern wireless transceivers such as 5G standard. Millimeter wave integrated circuit and the underlying device characterization will be explored. A design example on MIMO beamforming and phase array, such as for applications on 5G system, will be included. In the course design trade-offs in the transceivers are illustrated with practical, real life circuit examples, with low power as an important design objective. A variety of circuits, both analog and digital, will be covered. The course begins with a discussion on the architectures of wireless transceivers. Circuits used in these transceivers will then be covered at the transistor level. These include circuits such as low noise amplifiers, mixers, power amplifiers, oscillators, phase locked loops, A/D and D/A converters, MIMO and antenna interface.

Course objectives

At the end of the course, students will
1. Understand the principle of wireless transceiver .
2. Evaluate wireless transceiver design using simulation tools including Cadence.
3. Design one such practical transceiver for standard such as 5G

Detail Description

1) Wireless Transceivers System:
- Architectures for specific system (4G and 5G/mm wave W-band)
  - Heterodyne Architectures
  - Homodyne (or direct conversion)
- Translation of system specs transistors specs
- Receiver architectures: superheterodyne, direct conversion etc, phase array 5G/mm wave beamforming
- Transmitter architectures: heterodyne, frequency translation architectures, polyphase. 5G/mm wave application: MIMO

2) Device and transistor models, millimeter wave application:CMOS/GaAs/HEMT
3) Low noise amplifiers (wideband/narrowband topology)
4) Mixers (Gilbert/passive architecture)
5) Power amplifiers (class A/B/C/D/E)
6) Oscillators and dividers: LC tank oscillators (Colpitts), ring oscillators etc.; dual modulus divider
7) Phase locked loops (integer-N/fractional-N/dual loop)
8) A/D and D/A converters: oversampled A/D converters/sigma-delta modulators
9) Beamforming, phase array, combiner for MIMO.

Primary reference

"VLSI for Wireless Communications", 2nd edition, B. Leung, Springer-Verlag, 2011.

Secondary References

1) Microelectronics circuits, Sedra and Smith 7th edition

2) Analysis and Design of analog integrated circuit, Gray, Meyer, Hurst, Lewis 5th ed
3) ISSCC 2018 short course on 5G and mm wave circuit
4) ISSCC 2017 Tutorial on mm wave circuit
5) ISSCC 2016 Tutorial on 4G low power wireless circuit
6) Millimeter-Wave Integrated Circuits Eoin Carey, Sverre Lidholm, Springer-Verlag, 2005.
7) mm-Wave Silicon Technology, 60 GHz and Beyond Editors: Niknejad, Ali M., Hashemi, Hossein (Eds.) Springer-Verlag, 2008
8) MMIC Design, I. Robertson, IEE, Short Run Press, 1995
9) Microwave transistor amplifiers, analysis and design, G. Gonzalez, Prentice Hall, 2nd edition, 1984
10) "Modern antenna handbook" (MIMO application), C. Balanis Wiley, 2008
11) Gray, Meyer, Hurst, Lewis, "Analysis and Design of Analog Integrated Circuits" Fifth Edition, Wiley, 2008
12) ISSCC 2018 short course on mm wave circuit

Tentative Marking Schemes

	Homework (4 expected)	Project	Final
Scheme :	30%-40%	30%-40%	30-40%