EE 6240 - RF Integrated Circuits

Aug - Nov '11

Note Title 6/9/2011

Textbooks: 1) RF Microelectronics (Systems)
by Behzad Razavi
Prentice Hall of India

2) The design of CMOS Radio Frequency Integrated Circuits (Ckts)
by Thomas H. Lee
Cambridge University Press

other ref: 3) VLSI for Wireless Communication
by Bosco Leung
Prentice Hall Electronics & VLSI Series

Course Format: 4 Projects = 40 %.
1 Final Exam = 30 %.
5-6 HW = 10 %.
Journal Paper Seminar = 20 %.

* All HW & projects are due at the beginning of class (on the due date)

Pre-requisites: 1) EE 5390 - Analog IC Design (or similar)
2) Understanding of MOSFET operation
3) Understanding of basic signals & systems - Fourier Series, Fourier Transforms (i.e. able to think in both time and frequency domains)

Topics Covered in this course:

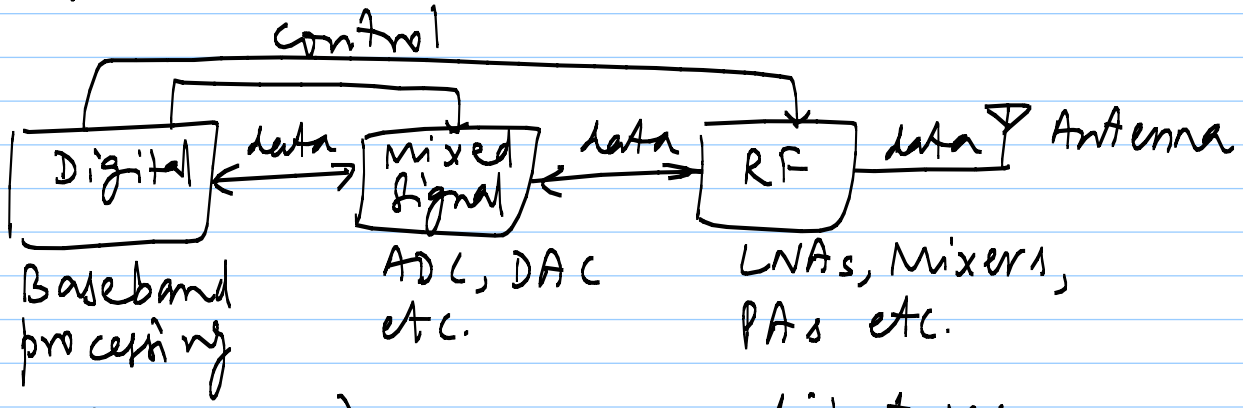
- → RF basics. Analog & Dig. modulation
- → S-parameters, resonance, impedance matching
- → Inductors, caps, varactors etc.
- → short-channel MOS operation
- → Intro to noise & distortion
- → RF Tx & Rx architectures
- → LNA, mixer, VCO, PA design & operation
- → RF layout

Lecture #1 - Introduction to RF

RF = Radio Frequency

- any frequency that carries information (wired or wirelessly)

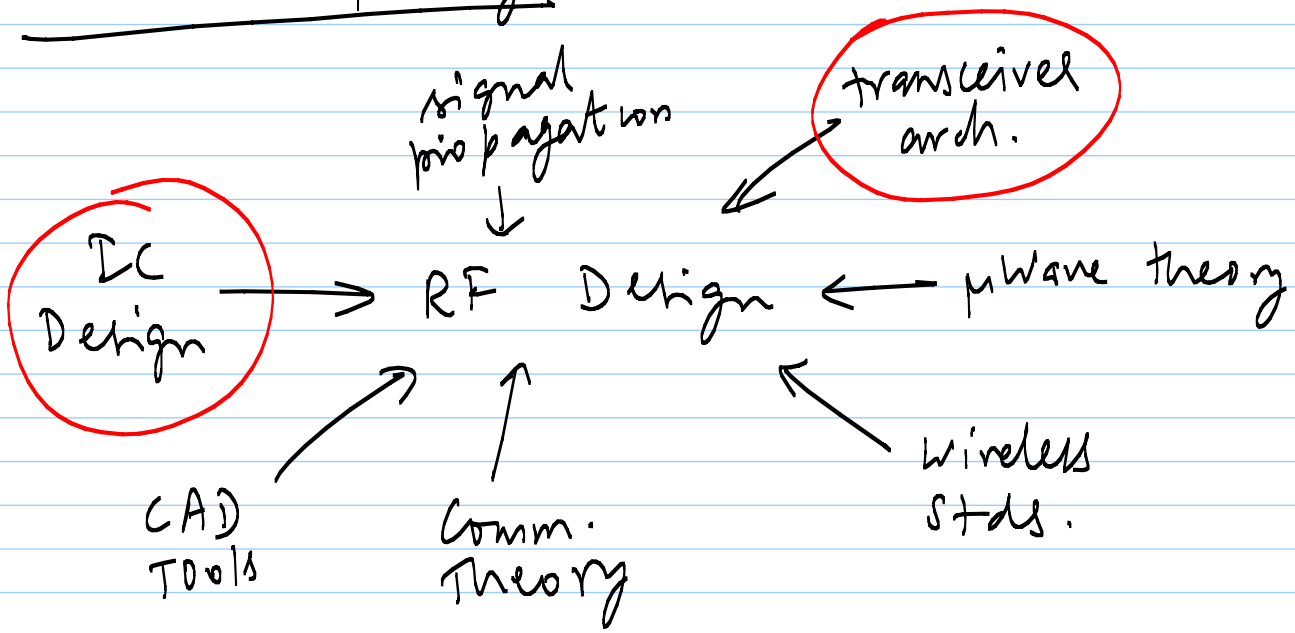
e.g. AM-FM radio, TV, cellular, WiFi ...



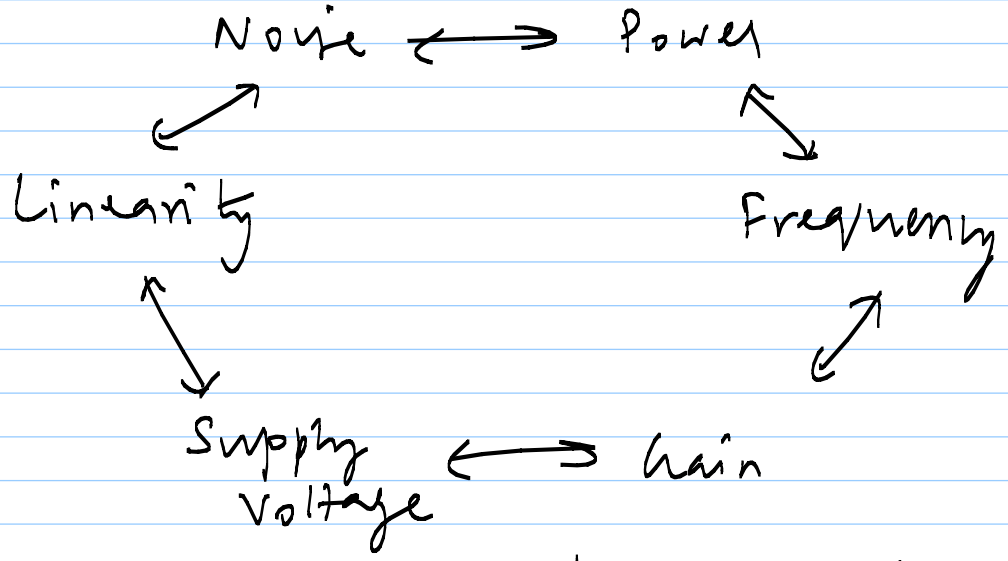
RF systems ⇒ 1) transceiver architectures
2) Interaction with M.S. & BB

RFICs ⇒ 1) Design of LNAs, Mixers etc.
2) New circuit topologies

Multi-disciplinary!



RF Design Tradeoffs:



Note! CAD tools are indispensible!
however: rely on circuit design knowledge

Why CMOS?

CMOS digital gates:

→ require very few devices per gate
→ dissipate power only while switching

} In contrast with Bipolar & GaAs tech.

→ dimensions of MOS devices can be easily scaled down
→ lower fabrication cost (simple mask set etc.)

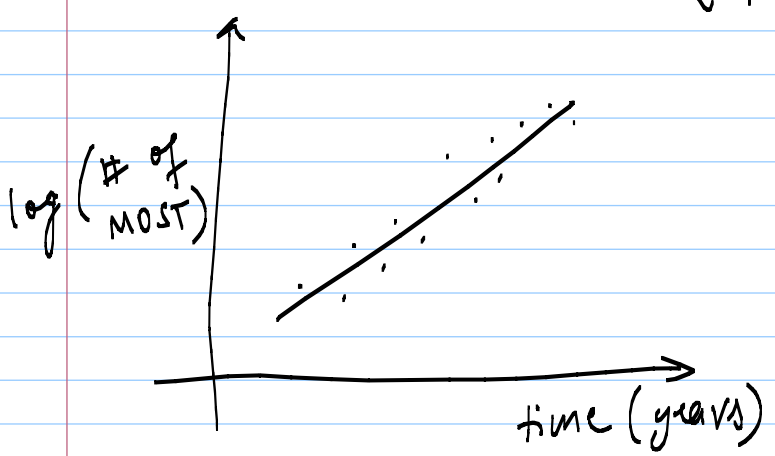
} may no longer be true!

CMOS for analog:

→ possibility of SoC (system-on-chip)
→ reduce cost

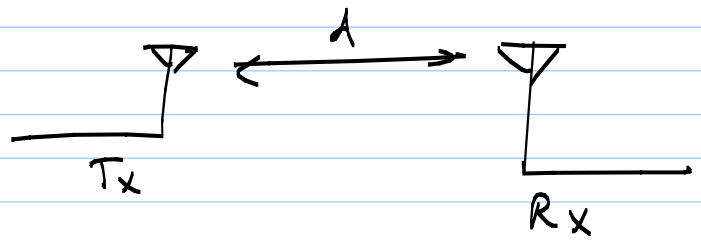
Issues with CMOS:

→ CMOS is no longer cheap!
  * # of masks is large
  * lithography is getting very expensive
→ leakage current ⇒ static power consumption
→ for Analog, MOSFETs were slower & noisier than BJTs (gap has shrunk due to scaling)

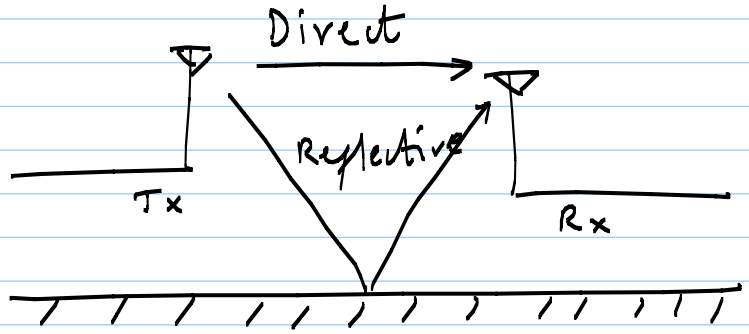


Moore's Law: # of transistors on an IC doubles every 2 years

Path loss :

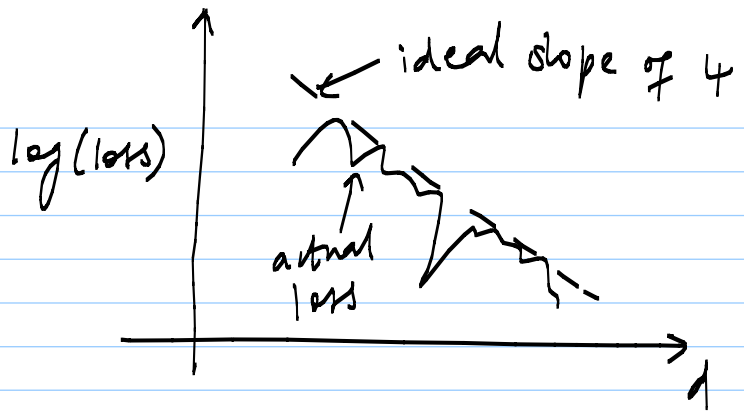


Power loss $\propto d^2$ (theory)



Power loss $\propto d^4$ (empirical)

Multipath Fading :



Diversity : Redundancy in Tx or Rx path

Space/Antenna div. = 2 or more antennas

Frequency div. = 2 or more carrier freq. (frequency hopping)

Time div. = data is sent more than once to overcome short-term fading