RFIC and MMIC Design

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Electronic Industry Trends

• Integrate and Minimize size:
  – Reduce power and cost.
  – Repeatable Results.
  – High Performance.
What is RFIC and MMIC

Radio Frequency Integrated Circuit
Monolithic Microwave Integrated Circuit

- Working in 1GHz to 100GHz
- We are combining active and passive components in one common substrate
RFIC vs. MMIC

RFIC
- Main Market
  - Advance Process
- IV
  - Silicon
  - Silicon-Germanium
- Cheap
  - MOSFET
  - BJT
  - HBT

MMIC
- Unique Market
  - Low invested Process
- III-V
  - Gallium-Arsenide
  - Indium-Phosphide
  - Gallium-Nitride
- Hi-Performance
  - HEMT
  - HBT
Transistors and Passive Components

- Diodes
- BJT
- MOSFET
- MESFET
- Resistors
- Capacitors
- Inductors
- Transmission Lines
Small Building Blocks

- Power amplification (Low Noise Amplifier, High Power Amplifier)
- Sources (Oscillators, Voltage Control Oscillator, Comb generator)
- Microwave mixing (passive and active, IQ mixers, self oscillating mixers)
- Limiters (automatic gain control and power protection)
- Attenuators (Analog and Digital control)
- Phase shifters (Analog and Digital control)
- High frequency switching
- Filters (active and passive)
- Antenna
Large system

- Communication Receive Transmit
- Automatic Control
- Sources and Phase Look Loops
- Accurate Measurement Equipment
Example of Receiver
Area of work for RFIC and MMIC

- Analog and RF design. Application in the Physical Layer.
- Tune transistors with bias and size allowed by the manufacture.
- Use distributed components and lump components.
Design Stages

1. Get customer specification

2. Get a design kit (PDK) from the manufacturer (Fab)
   1. Models and Layout components available for work in the Simulation and Layout software.

3. Build the circuit schematic
   1. Choose an architecture with customer specification and with Fab technology
   2. Design and simulate your circuit.

4. Build the circuit layout
   1. Place the components layout according to your schematic and achieve circuit size area specification.
   2. Modify your schematic if needed.

5. Send layout file to the manufacture

6. Measure your circuit at the lab
Student Background

The background subjects are significant advantage in Planning, Tuning and Debugging RFIC/MMIC circuit. These subjects are:

- Semiconductor physics
- Analog Design
- RF Transmission Lines and Reflections
Monolithic semiconductor technology:
- Background on Silicon and GaAs applications.
- Semiconductor Material.
- Diode, BJT and FET devices.
- Second order effect.
- High frequency properties.

Passive components:
- Resistors, Capacitors (MIM, MOM and MOS) and Varactors (Diode and MOS).

Amplifier design:
- Gain, Stability and Bandwidth.
- High power design and Efficiency.
- Low noise.
- Tx/Rx budget (noise and intermodulations)

Oscillator design:
- Feedback.
- Negative resistance.
- Quality factor.
- Startup condition.
- Phase noise.
Syllabus

Mixer Design:
- Diode mixer
- Active mixer
- Multiplier

Band-Gap Reference design:
- Temperature supply and process independent reference.
- Current mirror
- Startup problem

PLL Design:
- Architecture and transfer function
- VCO
- PD/PFD
- LPF passive and active
- Divider
Course

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Mark
– Exam 70%
– 2 Labs total 30% (2 labs
  Room 330)

RFIC/MMIC course aim is:
– Introducing Design Background.
– Providing Basic Analysis
  capability in Microwave Design
  Experience.
– Expose Student to Design Tools
  for Schematic, Layout and
  Simulation results.