

Basics of Microwave, Millimeter-wave, and Terahertz Front-end Chip Design

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This tutorial is intended for Graduate level with understanding of basic electronic circuits and may use ADS software.

Tutorial Abstract:

Automotive radars, high-data rate communication, astronomy, non-destructive detection and high resolution imaging/sensing, as well as healthcare and biomedical applications have been creating a steadily growing market for the millimeter-wave and Terahertz systems.

To benefit from the full potential of the above applications, full understanding of the high frequency design aspects of the enabling technologies including the system front-end semiconductor integrated circuits plays a crucial role to cope with:

- Global optimum performance issues
- Multifunctional operation issues
- System-on-chip and system-in-package issues
- Cost issues

Although high frequency circuitry, compared to digital circuitry, occupies only a small part of the system, it has many challenges and needs breakthroughs including: understanding of Microwave/Millimeter-wave/Terahertz circuit operation, system specification dependence, off-chip (package) environment, precise on/off-chip components modeling, design goal trade-off, and design tools sophistication/intelligence.

The tutorial objective is to facilitate insight into the design of integrated circuit/chip for the above applications by providing practical understanding of the following issues:

- Understanding of different types of key building block circuits including: amplifier, switch, mixer, oscillator, frequency divider, frequency doubler, and power divider.
- Understanding of PRACTICAL issues in the circuit design
- Brief study of the microwave/millimeter-wave active semiconductor devices including BJT, CMOS, FET, HEMT, HBT
- Understanding of the device modeling for circuit design
- Studying how to put these circuits onto one chip to build sub-systems
- Understanding of the device/circuit nonlinearity and noise.
- Study of both legacy Microwave and emerging Millimeter-wave/Terahertz front-end subsystems development status including mixer, frequency divider, amplifier, frequency quadrupler core, and transmit (TX)/receive (RX) chipset comprising a voltage-controlled oscillator (VCO), a buffer, a modulator, a power amplifier, a frequency tripler, and an antenna.