

**WSI (RFIC) Sunday 13:00 – 17:00 BCEC Room 152**

**Technology and Power Combining Techniques for Millimeter Wave Applications**  
**Half-day workshop reviewed by RFIC.**

**Organizer(s):**

Didier Belot, STMicroelectronics; RFIC TPC.

Eric Kerhervé, IMS Lab.

This workshop highlights the difficulties in designing silicon power amplifiers at MMW and RF frequencies. The presentations will focus on the limitations of CMOS, BiCMOS, bipolar and other advanced silicon technologies. In a second part, innovative design approaches such as power-combining techniques will be discussed in order to address the drastic specifications of radio communications from mobile phone standards (GSM, UMTS, WIMAX, WLAN...) to MMW standards (60GHz WMAN, 77GHz radar ...).

**Speakers:**

1. Wilhelm Keusgen, Fraunhofer HHI, Berlin, Germany

“PAs for MMW Applications: A Comparison of Technologies and Achievements”

This presentation will start with some basics on SiGe, CMOS and III/V device technologies and the pros and cons concerning their applicability for mm-wave power generation. Architectures, power combining principles and the achievable output power will be reviewed for the different technologies. Modern modulation techniques with non constant envelope need highly linear amplifiers. How to overcome the trade off between efficiency and linearity and what concepts are existing for improving both? Integration aspects and a comparison of the technology oriented achievements will conclude this talk.

2. Christine Raynaud, STMicroelectronics - CEA LETI

“Advanced CMOS (sub-0.25 $\mu$ m) Technologies for RF and MMW PA”

CMOS dominates the digital/baseband arena in multi-standard multi-mode wireless systems. It is also used for Bluetooth & WLAN transceivers. It will enable the front-end integration, with new digital PA architectures required for these multi-mode systems, especially in the millimeter wave range. The presentation explains why SOI CMOS may be the best candidate for the highest integration (multi-mode switch and PA) and performance.

3. Domine Leenaerts, NXP Semiconductors, Research

“Power Amplifier Design in CMOS Technology for Cellular and WLAN”

Where in the past RF Power Amplifiers (PA's) were the exclusive domain for non Si based technologies, this has recently changed. Modern CMOS processes have proven to be capable to cover the demands for RF PA's in wireless communication standards with moderate output power levels up to 20-24dBm. Very recently even the 1 Watt output

power level was reached, enabling the design of CMOS RF PA's for cellular applications. The presentation will discuss several (sub micron) CMOS PA designs and the associate techniques to cope with reliability.

4. Debopriyo Chowdhury, University of California  
“Matching Techniques from RF to MMW”

In recent years, there has been tremendous interest to integrate the power amplifier in CMOS technology, which has already become the platform of choice for digital and the rest of the RF circuits. The low breakdown voltage of nanoscale CMOS transistors, the conductive silicon substrate and the loss of on-chip passives make high-power efficient CMOS PA design challenging. Moving up higher in frequency to the mm-wave band increases the challenges even further due to modeling issues of active and passive elements and the operating frequency coming close to the limits of activity of CMOS transistors. In this presentation, we demonstrate some transformer-based power combining techniques at RF frequencies that can allow us to obtain high output power using standard low-voltage digital CMOS process. The application of such power combining and matching networks at mm-wave frequencies will be discussed as well, along with experimental results of 60GHz power amplifiers.

5. Ullrich Pfeiffer, University of Wuppertal  
“Innovative Power Combining Structures for MMW PA”

The push in frequency imposes a number of challenges for the design of mmWave and THz circuits in silicon. Challenges are to mitigate the roll-off of characteristic circuit parameters like minimum noise-figure (NF), linearity, phase-noise, conversion gain, maximum output power and efficiency. The talk will give an overview of analog and RF design concepts in SiGe process technologies, with the focus on high-power applications at mmWave frequencies and above. Key power amplifier design tradeoffs and high-frequency trends will be given. This includes innovative power combining structures and amplifiers as high as 160GHz.

6. Panel discussion