| Design of millimeter-wave integrated power amplifiers |
|---|
| *project title* |
| **Technical University of Denmark** |
| *host institution* |

**Project description:**

With the advent of smartphones, tablets and connected cameras, the number of users of wireless networks is dramatically increasing. Cisco forecasts an 18-fold increase in wireless data traffic between 2011 and 2016. As a consequence, the capacity of wireless network must be increased to face this data explosion. In that respect there is at present an increased interest to exploit the millimeter-wave (mm-wave) frequency range (30-300 GHz) for wireless backhauling. The primary motivation for moving to mm-wave frequencies are the availability of large absolute bandwidth, small system size, and highly directive antennas. The recent world-wide allocation of the E-band spectrum (71-76 and 81-86 GHz) provides the opportunity for line-of-sight radio links with “fiber-like” multi-gigabit data transfer rates. The E-band spectrum falls within an atmospheric window with low attenuation, making transmission over fairly long distances (up to 10km) possible. This makes E-band wireless links attractive not only for mobile backhaul applications but also for bridging the gaps in optical fibre networks. In the pursuit for ever higher data rates, the underexploited deep mm-wave bands above 100 GHz are attracting significant interest. In particular, the frequency bands around the atmospheric windows located at 140-GHz and 220-GHz are promising for this purpose.

The progress in semiconductor device technology, in particular compound semiconductor transistors such as High Electron Mobility Transistor (HEMT) and Heterojunction Bipolar Transistor (HBT) devices, enables the development of wireless communication circuits operating at frequencies well above 100 GHz. At such high frequencies, monolithic microwave integrated circuit (MMIC) technology is mandatory. The main bottleneck in mm-wave systems today is the power amplifier (PA). The high operation frequency of semiconductor devices, in particular Silicon based, has been obtained by aggressive geometrical downscaling. As a consequence, the available output power per semiconductor device is limited. InP technology is particular well suited for applications in the high end of the millimeter-wave frequency band and even in the sub-millimeter-wave frequency band.

The overall objective of the project is to demonstrate high power amplifier MMICs for emerging D-band (110-170 GHz) wireless communication network using European based InP DHBT technology. In particular, the potential and limitation of the InP DHBT technology currently under development at the III-V Lab in France should be investigated. For the proposed application an output power at around 20 dBm (100 mW) must be targeted. To complicate matters, it is foreseen that higher order modulation formats will be employed to enhance the spectral efficiency in future mm-wave wireless communication links and this dictates strict linearity requirements to the power amplifiers. Therefore the power amplifier performance should be optimized at the 1 dB compression point.

Several open issues should be addressed during the project. These are among others:

1) Transmission line implementation (inverted µ-Strip, CPW, ECPW, ACPS) and requirements for single-mode propagation (substrate thickness, finite ground plane, overall CPW size)
2) InP DHBT device performance at D-band (optimum biasing, numbers of device fingers, emitter ballasting)
3) Design a passive low-loss power combining structures at D-band frequencies.
4) Design a multi-stage balanced power amplifier at D-band frequencies using optimized power cells.
5) Investigation stability and thermal issues.

The power amplifier design should be performed in Agilent ADS and performance of critical passive structures verified in HFSS. The complete layout should be transferred to Cadence for final design rule check (DRC) and layout versus schematic (LVS) verification. Tape-out is expected regularly over the following three years period. Next tape-out is planned in early 2015.