Summary

# Master thesis

## Design and Characterization of Radio-Frequency Circuits in Horizontal Current Bipolar Transistor Technology

This thesis describes design of **VCO** (voltage controlled oscillator) with a negative resistance in the 180 nm HCBT technology and analysis of a **frequency mixer** designed as Gilbert cell in the same technology. Both are covering the frequency range from 800 MHz to 5 GHz.

**VCO** is designed in the two different versions depending on the location of the resonant circuit, and two versions with different numbers of the HCBTs in the differential pair with the resonant circuit on a chip. The oscillator is simulated using the software tool "ADS" and the layout is designed using the software tool "Cadence".

Basic VCO parameters are: output frequency, frequency tuning range (high value is wanted), output voltage amplitude (high value is wanted), higher harmonics suppression (high value is wanted), phase noise (low value is wanted), supply current and consumption (low values are wanted).

Structure of the designed VCOs can be divided into the two basic parts. First part is the *resonant circuit* built of inductor and varactors (voltage tunable capacitors). Second part is the *negative resistance* designed as differential pair with the HCBT transistors.

For obtaining desired value of the VCO parameters above, the resonant circuit quality factor should be high and the HCBT transistors in differential pair should have high input impedance and high current gain. However, influence of the HCBT on the VCO characteristics is highly dependent on the resonant circuit quality factor. For higher quality factors, which is the case for exterior coil design, HCBT influence is more pronounced. For interior coil design, quality factor of the resonant circuit is low and has dominant influence on the VCO characteristics.

Two separated analysis are conducted for the **frequency mixer** – a simulation part using the software tool "ADS" and an on-chip laboratory measurement using laboratory equipment and the software tool "Labview".

In the simulation section influence of the HCBT parameters, Re (emitter series resistance) and Nk  (high current roll of coefficient), on the mixer characteristics, linearity (IIP3, high value is wanted) and conversion gain (CG, high value is wanted), are examined and explained. In the on–chip measurements, influence of the HCBT DC point on IIP3 and CG of the mixer are examined and explained.

Gilbert cell (mixer) can be divided into the two major parts: *the* *input differential pair* and *the* *quad*.

Simulation results showed that the HCBTs in the quad have major influence on the mixer IIP3 and CG.

Increase in Re and Nk results in monotonous lowering of CG and change of IIP3 that has few distinguishable parts. Firstly it is constant, then slightly falling, after that grows and reaches maximum after which falling asymptotically to the final value. Physical background of that behaviour is explained in this thesis.

Measurement of the influence of the HCBT DC point on IIP3 and CG of the mixer showed that the supply voltage and the current influences on IIP3 and CG. That influence is strongest on the margin between normal active and saturation region of the HCBT.