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種別(和文)	論文要旨
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

In this thesis, the phased-array technique is investigated for adoption into future ultra-wide transceivers for 6G communication. The 6G outdoor enhanced broadband mobile communication network and the 6G indoor point-to-point multimedia communication network are both investigated. Sub-THz signals are from 100GHz to 300GHz, which is one of the main candidates for the 6G communication spectrum. F-band (90GHz-140GHz) or D-band (110GHz-170GHz) could provide 50GHz or 60GHz bandwidth for modulated signals, easily supporting over 100Gb/s by amplitude modulation schemes. Besides, the FSPL of this frequency range is lowest at the sub-THz spectrum, and phased-array implementation could compensate and make them support long-distance communication. These characteristics make the F-band or D-band very suitable for outdoor enhanced broadband mobile communication networks. 300GHz-band has its special characteristics. Although the FSPL of the 300GHz-band is higher than the F-band or D-band, the 300GHz-band is attractive because it could provide a 70Gbaud modulated signal for ultra-high communication. The 300GHz-band signal has a more obvious sight-of-light, with the lowest interference compared to other sub-THz signals. These characteristics make the 300GHz-band very suitable for indoor point-to-point multimedia communication networks.

This thesis presented novelly proposed TRX/TX in 65-nm CMOS for 6G wireless communication networks. The phased-array technique was demonstrated both on a sub-THz (F-band) TRX and a 300GHz-band TX. The thesis also presents the design for the amplifiers, mixers, LO chain components (multipliers and phase shifters), on-chip antennas, and the PCB implementation for the phased-array system.

A sub-THz (F-band) full-duplex (FD) phased-array TRX integrating an RF self-interference (SI) canceller with differential feeding FD antennas is first presented in this thesis. The LO phase generation chain controls differential transmitter (TX) outputs for the phased-array operation. The differential feeding FD antenna with differential pairs of chips achieves over 35dB SI suppression. The SI suppression is improved by 20dB when the SI canceller is turned on. Without any digital-domain SI cancellation, a total SI suppression of >60dB is achieved over a 2 GHz bandwidth. The proposed neutralized mixer with over 20dB LO feedthrough suppression and wideband RF amplifiers support a large data rate at sub-THz frequencies. It is the world's first demonstrated sub-THz FD phased-array TRX, which demonstrated the FD technique for future IoT networks with the highest data rate among the present FD systems. In the over-the-air (OTA) measurements for FD mode, the proposed FD TRX achieves 6Gb/s in 8PSK and 4Gb/s in 16QAM. It also achieves a 112Gb/s data rate for OTA TX-to-RX. In addition, the sub-THz phased-array TRX.

To further increase the data rate for future 6G networks, the F-band phased-array TRX can be upgraded to the D-band phased-array TRX. This thesis also presents a D-band wideband passive single-ended up-conversion mixer with controlled LO feedthrough based on the above F-band neutralized mixer. The LO feedthrough was controlled by the varactor and neutralizing transmission line between the mixer LO and RF ports. In measurement, the proposed passive single-ended mixer had a conversion gain of -13.0±1.5dB with an ultrawide 3-dB bandwidth from 110GHz to 160GHz. The LO feedthrough suppression was from -38.9 to -24.4dBc at 135GHz by changing the varactor bias. The measured input P1dB compression point was 1dBm. This D-band novel neutralized mixer could be a common module for different systems for future 6G networks.

A 300GHz-band 16x4-element amplifier-last phased-array TX is also introduced. The array consists of four H-plane stacked PCBs, with four chips on each PCB in the E-plane. Each chip integrates four TX elements with PA-last architecture in 65nm CMOS. The proposed wideband PA is implemented with an optimized transistor layout, effectively decreasing its parasitic parameters and improving the transistor' s fmax to around 350GHz. The PA also uses an optimized dual-peak Gmax-core topology to achieve wideband interstage conjugate impedance matching. The wideband PA operates from 237 to 267GHz with gain higher than 20dB and avoids the power combining technique, improving TX power and area efficiency. The proposed TX also integrates an on-chip Vivaldi antenna with an average 4.3dBi directivity from 220GH to 280GHz after ion irradiation. The single TX on-PCB probe measured data rate is 108Gb/s in 16QAM and 95Gb/s in 32QAM, and the power consumption is only 209mW. The 2D patterns in E-plane and H-plane are also demonstrated by a 4x4 sub-array.

The introduced systems are implemented in 65-nm CMOS technology and the effectiveness of the proposed techniques was verified in clean-room, on-PCB probe measurement, and OTA measurements. The future directions and the possible improvements on the 6G phased-array transceiver systems are briefly presented in the last chapter of this thesis.