6G-RIC
Research and
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GEFÖRDERT VOM
Bundesministerium
für Bildung
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Innovative Concepts and Architectures for Transmitter Linearization in 6G Communication Systems

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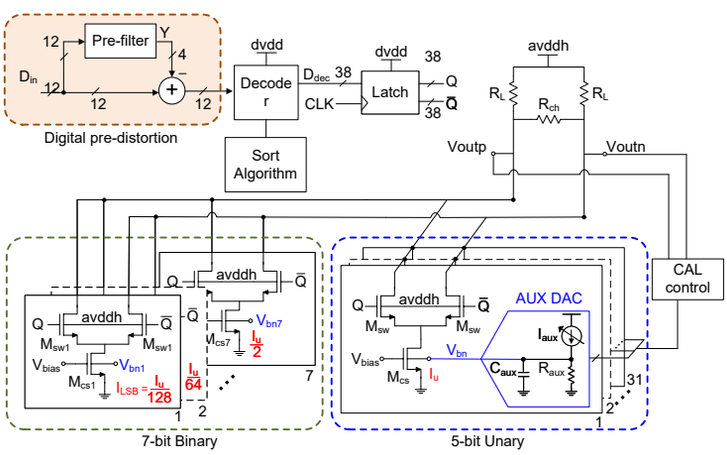
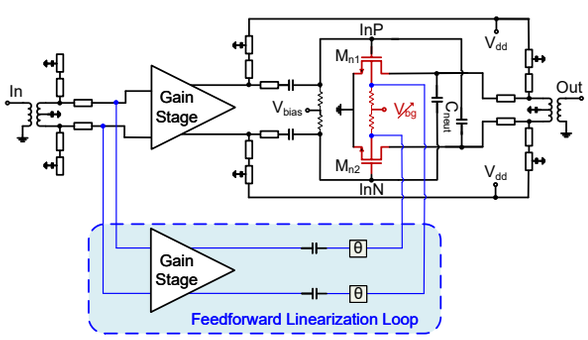
How to address the stringent requirements of Sub-THz transmitter design and mitigate distortions caused by nonlinearity? How to solve the mismatch and linearity degradation at higher frequencies due to finite output impedance in digital-to-analog converters? Is there an efficient linearization concept for D-band power amplifiers that maintains feasible power consumption?



(a) *A 12-bit current-steering DAC with pre-distortion enhancement*



(b) *CMOS power amplifier with active bias control utilizing back-gate feedforward loop.*

KEY FINDINGS

Future 6G transceivers aim to support data rates of up to 100 Gbit/s, requiring large signal bandwidths and complex modulation formats. However, designing communication systems for the sub-THz range presents challenges at the physical layer, including the need for high output power, efficiency, and strict linearity in the transmitter chain. High-speed, high-resolution DACs and power amplifiers (PAs) are essential for optimal performance. In high-resolution DACs, Spurious-Free Dynamic Range (SFDR) is a major limiting factor, especially at large signal bandwidths due to finite output impedance. Our study presents a power- and area-efficient digital pre-distortion technique, achieving an INL below 1 LSB and an SFDR exceeding 74 dBc across the Nyquist bandwidth at a 1 GS/s sampling rate. Including a frequency-dependent INL could further improve achievable sampling rates.

To meet transmitter linearity requirements, PAs often operate at power back-off, which reduces energy efficiency. Traditional linearization methods such as digital pre-distortion (DPD), commonly used in sub-6 GHz bands, are impractical in sub-THz systems due to the high power consumption and bandwidth required for A/D conversion in the feedback loop. We propose an open-loop feedforward method utilizing the back-gate. Early results for a Early results for a 64 QAM-signal with 10 GHz bandwidth show potential reductions of up to 10 dB in IMD3, EVM, and ACPR, with further testing in progress.

H. Ordouei and F. Gerfers, "Energy-efficient D-Band Power Amplifier Linearization Adopting Back-Gate Feedforward Technique in 22nm FD-SOI," 2024 IEEE Topical Conference on RF/Microwave Power Amplifiers for Radio and Wireless Applications (PAWR), San Antonio, TX, USA, 2024, pp. 89-92, doi: 10.1109/PAWR59907.2024.10438580.

H. Ordouei, C. Alija, P. Kurth and F. Gerfers, "A Digital Pre-Distortion Technique Canceling Code-and Voltage-Dependent Output Impedance Errors in Current-Steering DACs," 2023 IEEE International Symposium on Circuits and Systems (ISCAS), Monterey, CA, USA, 2023, pp. 1-5, doi: 10.1109/ISCAS46773.2023.10181739. WCAS Best Paper Award.