Yao Yao, Zhijiang DAI, Mingyu Li, 2024. A novel topology with controllable wideband baseband impedance for power amplifiers. *Frontiers of Information Technology & Electronic Engineering*, 25(2):308-315.
https://doi.org/10.1631/FITEE.2300074

A novel topology with controllable wideband baseband impedance for power amplifiers

Key words: Baseband impedance; Concurrent dual-band; Power amplifier

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Motivation

Five-generation wireless communication (5G) is characterized by high data rate, massive connections, and low latency, which requires that power amplifier (PA) will transmit broadband signals. Then the signal’s instantaneous bandwidth may exceed 400 MHz, and new challenges have emerged in the design of PAs. Because of the influence of the transistor’s nonlinear capacitance and nonlinear operating state, the baseband signal will be generated under multi-tone/broadband signal excitation. Conversely, the baseband signal will act on the transistor, which influences the memory effect and produces new modulation components.

Main idea

This paper presents a novel topology to control the baseband impedance of a power amplifier to avoid performance deterioration in concurrent dual-band mode. This topology can avoid pure resonance of capacitors and inductors *LC*, which leads to a high impedance at some frequency points. Consequently, it can be applied to transmitters that are excited by broadband signals. In particular, by adjusting the circuit parameters and increasing stages, the impedance of the key frequency bands can be flexibly controlled, which can prevent PA performance deterioration under concurrent dual-band mode.

Framework

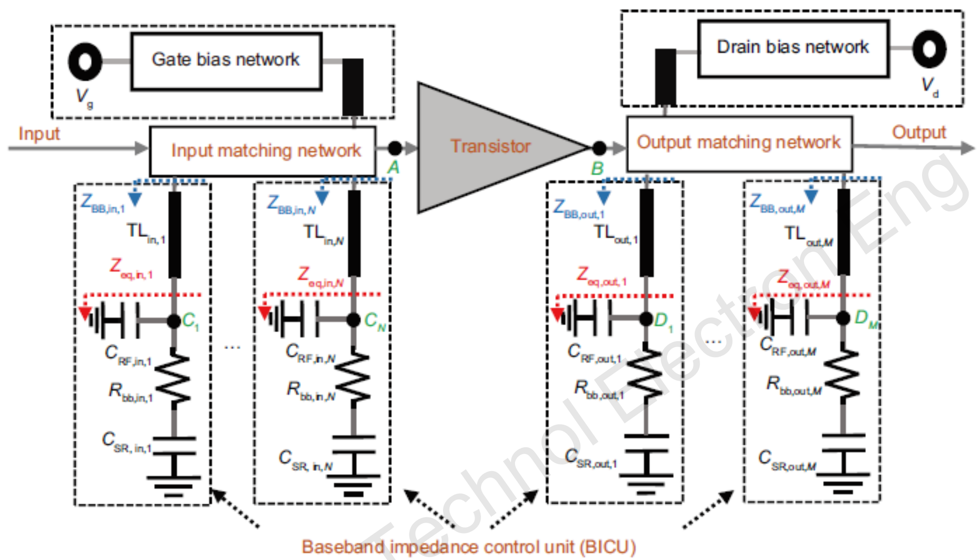


Fig. 1 The proposed topology to control baseband impedance ($Z_{\mathrm{eq,in},i} = 1/(\mathrm{j}\omega C_{\mathrm{bb,in},i}) + R_{\mathrm{eq,in},i}$, $Z_{\mathrm{eq,out},j} = 1/(\mathrm{j}\omega C_{\mathrm{bb,out},j}) + R_{\mathrm{eq,out},j}$)

The baseband impedance control unit (BICU) is connected in parallel with the input/output matching network, and each unit is composed of a microstrip transmission line (TL), a radio frequency (RF) capacitor C_{RF}, a resistor R_{bb}, and a low-frequency capacitor C_{SR}. The primary function of RF capacitor C_{RF} is to short the RF signal and reduce the loss of the fundamental signal in the BICU. The function of C_{RF} is to form series *LC* resonance with the circuit between points *A* and C_i, or *B* and D_j and to reduce the baseband impedance. The R_{bb} function is introduced to avoid pure *LC* resonance among the BICUs. To control the baseband impedance in a wideband, four BICUs are shunted in the input and output matching networks.

Method

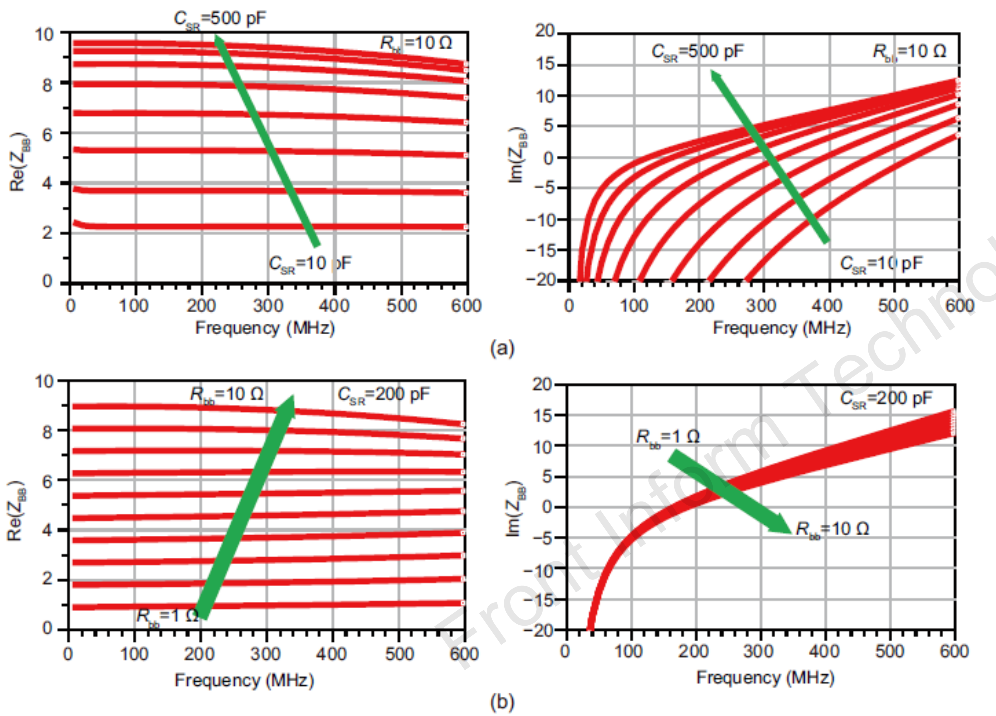


Fig. 3 Impedance of a baseband impedance control unit: (a) Z_{BB} vs. C_{SR}; (b) Z_{BB} vs. R_{bb}

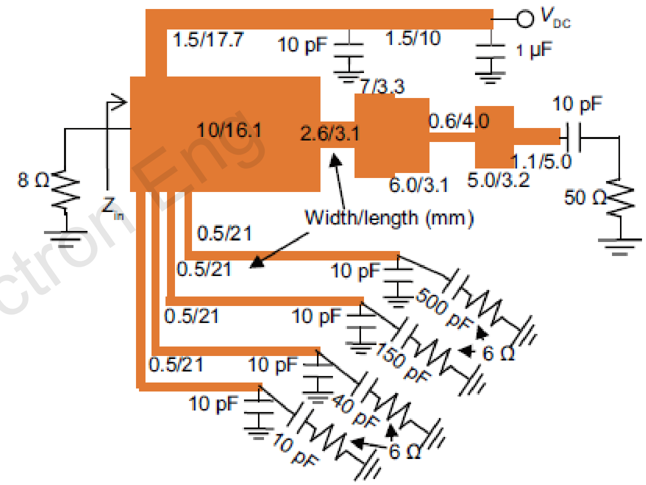
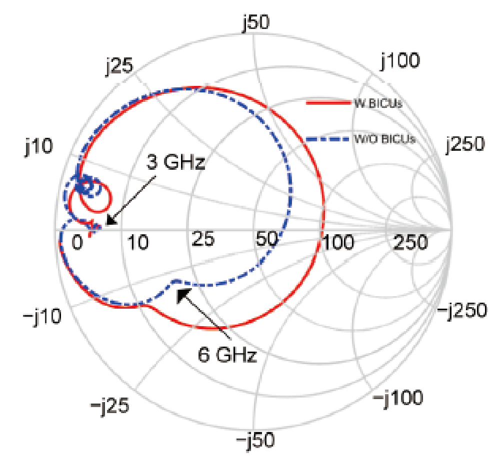


Fig. 4 Output matching network with four baseband impedance control units



S11 with/without BICUs

Major results

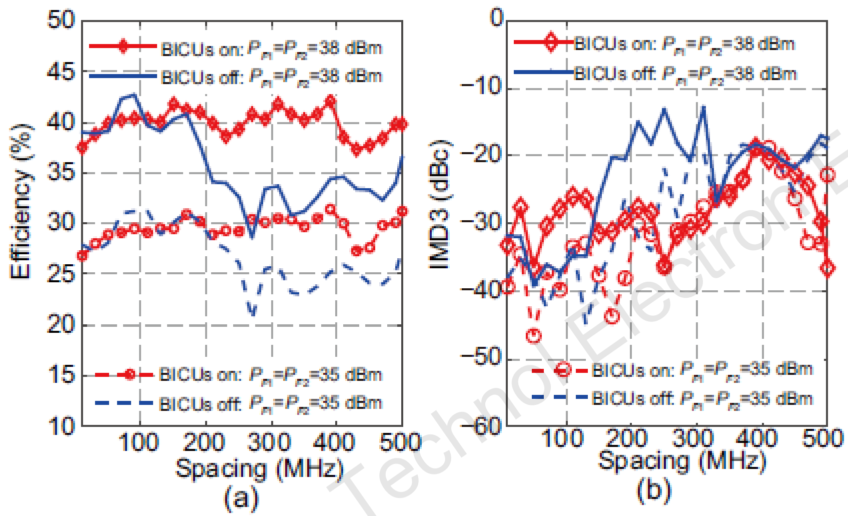


Fig. 12 Measured efficiency (a) and IMD3 (b) under concurrent two-tone excitation (F_1=1.8 GHz, F_2 = F_1+spacing)

Table 1 Comparison with reported power amplifiers under two-tone excitation

Reference	Baseband bandwidth (MHz)	Center frequency (GHz)	IMD3 (dBc)	Output power (dBm)	DE (%)
Chen et al., 2013	10–15	1.9/2.7	–	36.5	38*
Nunes et al., 2018	10–400	2.0	–	44.5*	43*
Barros et al., 2019	50–400	2.55	−30–−22	39	42*
This work	10–500	2.0	−27–−22	41	40

* Estimation results. DE: drain efficiency

Conclusions

In this paper, a novel baseband impedance control network topology is proposed, and a power amplifier design example is presented to further explain the application of the topology. The experimental results show that the baseband impedance can be controlled up to 500 MHz with low impedance, and there is no resonance generation when four parallel BICUs are used. In addition, the proposed topology can help avoid PA efficiency deterioration with an increase in the tone spacing. This topology offers an opportunity to control more complex baseband impedance with more BICUs, such as the application of tri-band concurrent mode.

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