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A 17–26.5 GHz 42.5 dBm broadband and highly efficient gallium nitride power amplifier design

Key words: 17–26.5 GHz; High efficiency; Broadband; Gallium nitride; Power amplifier

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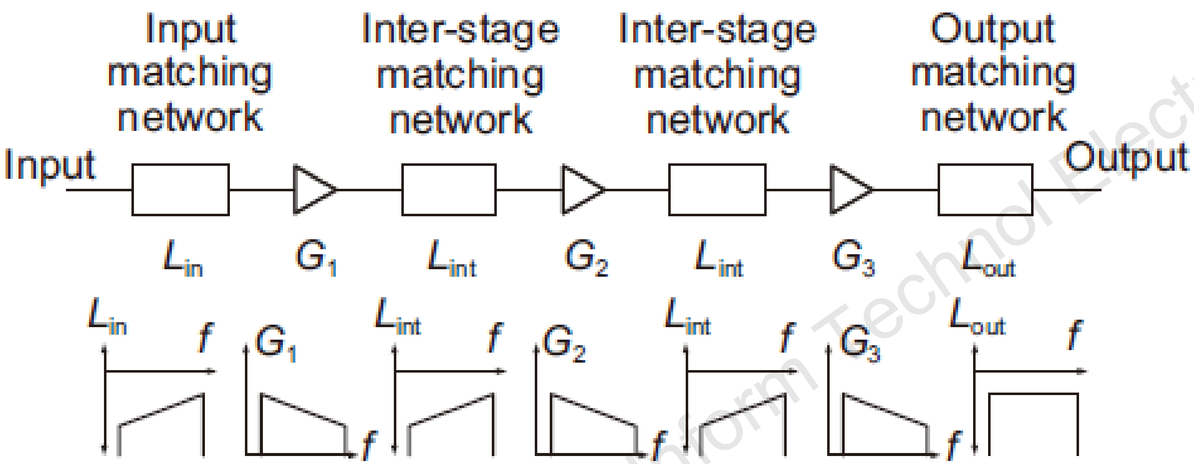
Motivation

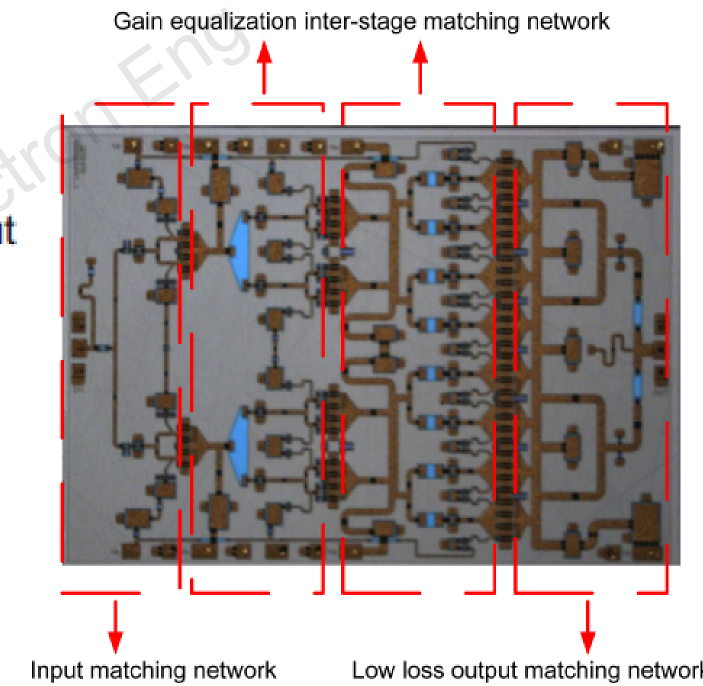
1. A wideband power amplifier is one of the key components in mobile communication systems and radar systems because it is a key component of radio frequency (RF) front-end systems, and its performance occupies a dominant position in the entire system function.

2. Because of the high frequency characteristics, high power, high efficiency, high temperature resistance, high radiation resistance, and other excellent characteristics, gallium nitride (GaN) monolithic microwave integrated circuits (MMICs) have broad application prospects in the microwave and millimeter wave bands.

3. Compared with the distributed power amplifier, the power amplifier with broadband low-loss reactance matching technology can obtain higher power and higher efficiency.

Method

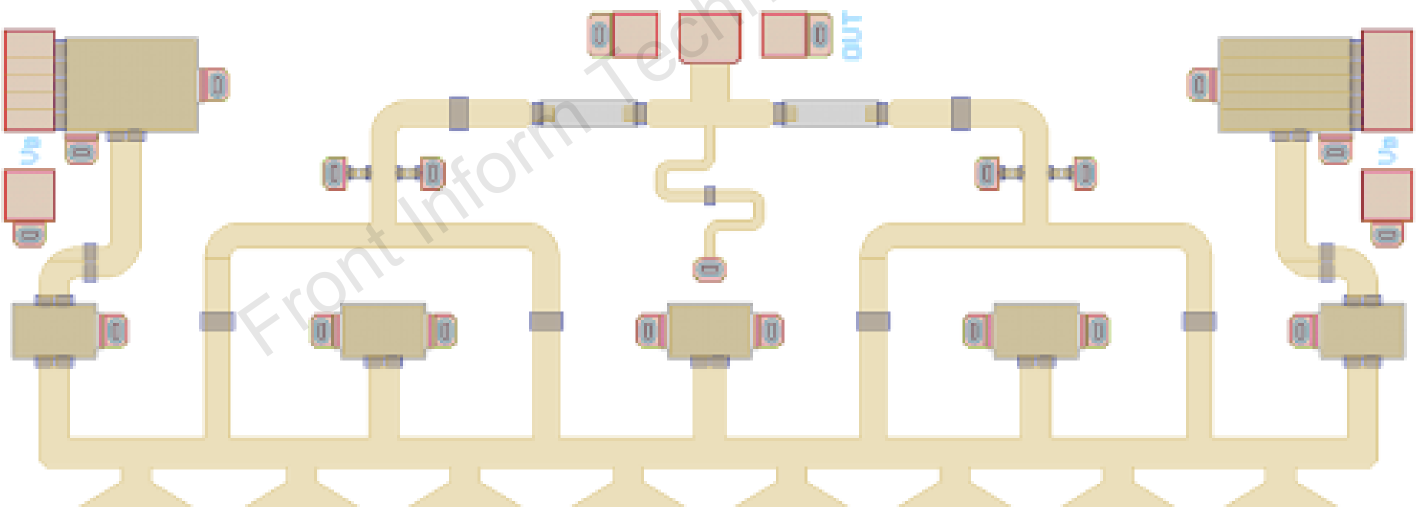




The design idea and structure of a typical three-stage power amplifier

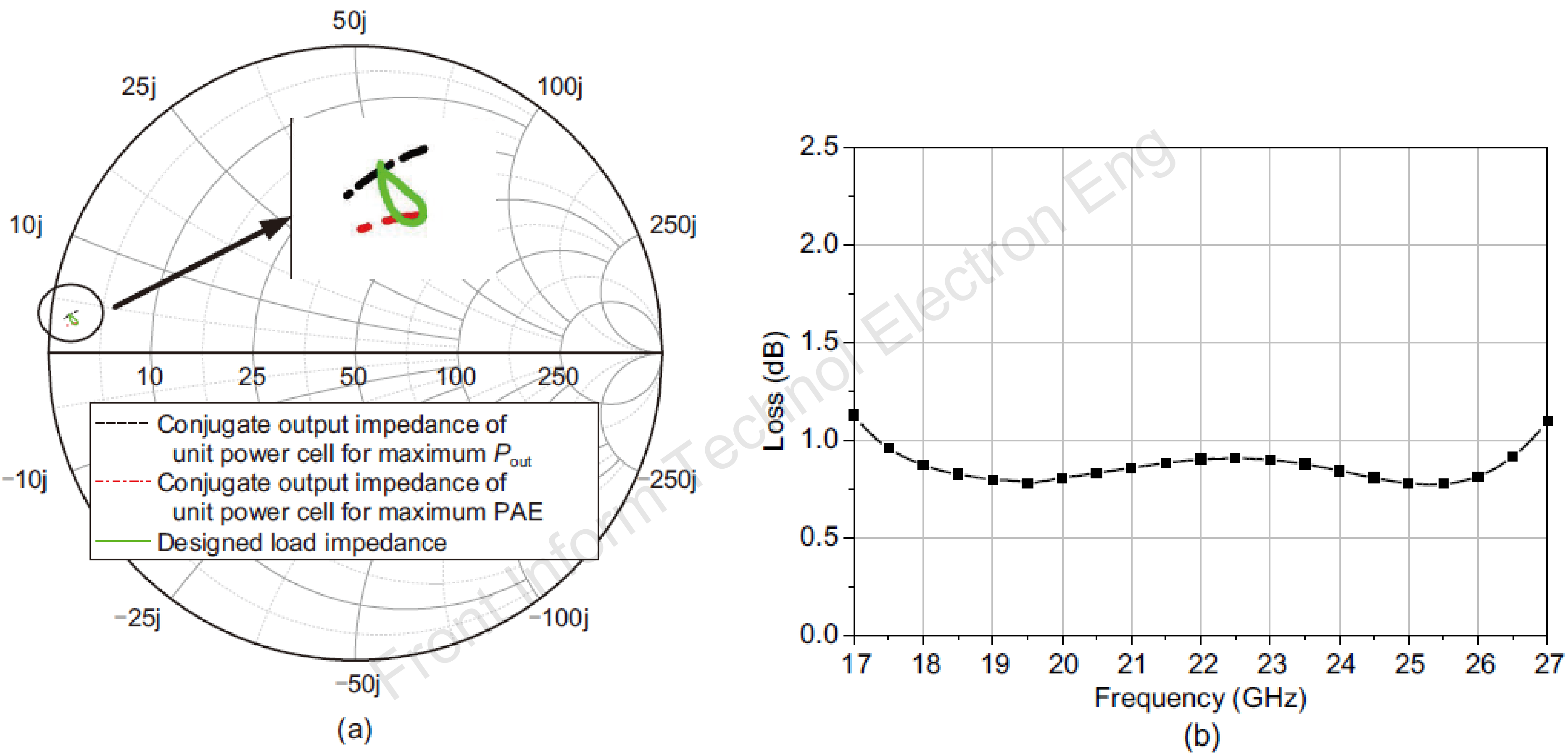
Method (Cont'd)

To reduce the insertion loss, in the output matching topology of the power amplifier, second-order LC impedance transformation and busbar bias structure are used to achieve broadband low-loss impedance matching.



The layout of the output matching network

Method (Cont’d)



The simulation results of the output matching network in the Smith chart (a) and output matching loss in the Cartesian coordinate system (b)

Method (Cont'd)

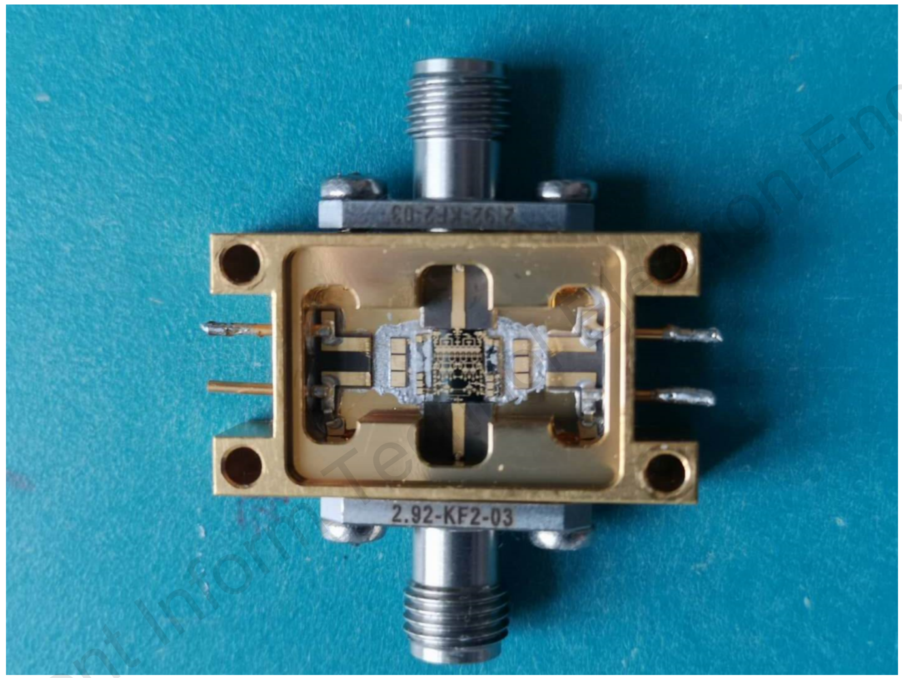
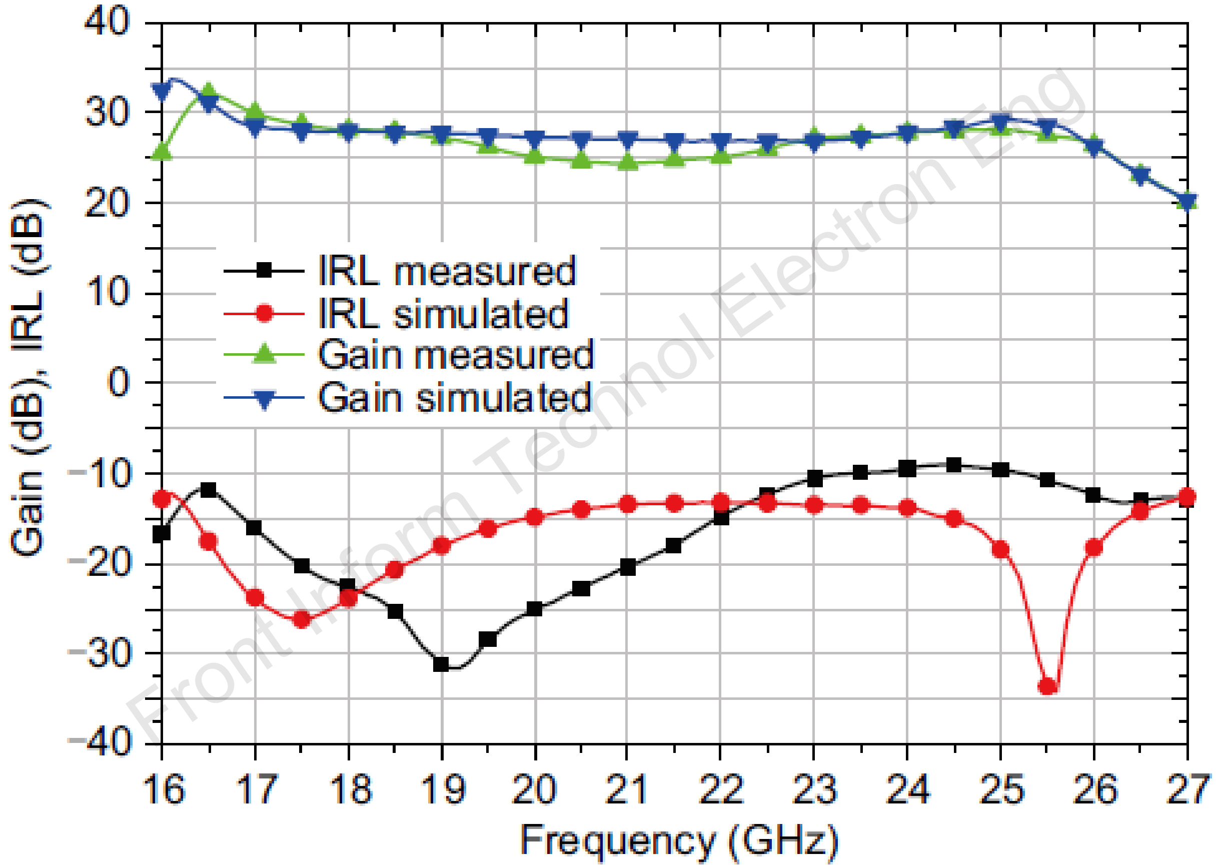


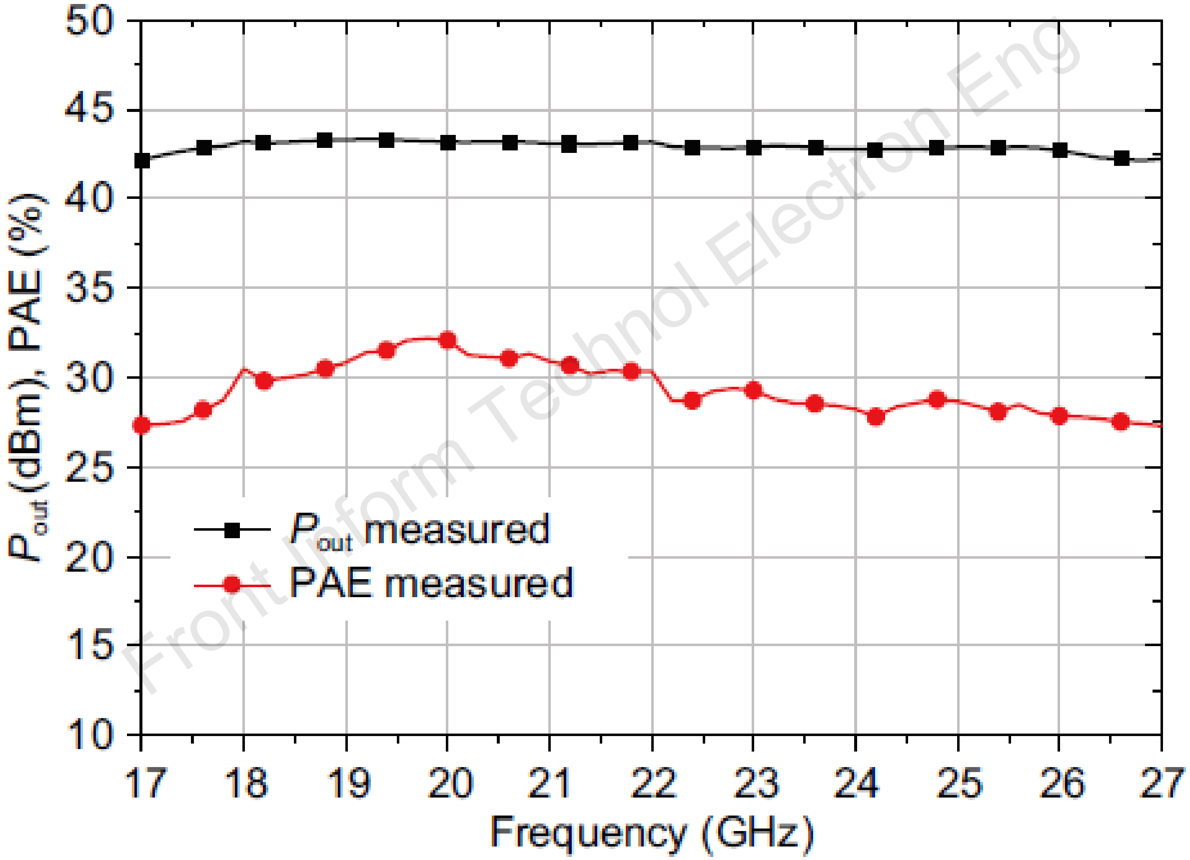
Photo of the power amplifier installed in a metal cavity

Major results



The simulation and measurement results of small signal characteristics (IRL: input return loss)

Major results (Cont'd)



The measurement results of large signal characteristics

Major results (Cont’d)

Performance comparison of power amplifiers

Reference	Frequency (GHz)	P_{out} (dBm)	PAE (%)	Size (mm^2)
Duffy et al., 2019	18.5–24	36.5	28–40	8
Din et al., 2017	17.2–20.2	40.0	38.0	–
Northrop Grumman, 2015	18–23	38.5	30–35	10
Qorvo, 2016	17–20	40.0	26–35	8.3
This work	17–26.5	42.5	27–32.1	12.6

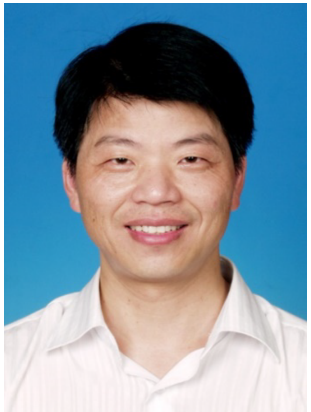
Conclusions

1. Low loss output matching circuit structure is proposed.

2. An appropriate inter-stage matching network is used to compensate for the gain roll-off effect of the transistor and to improve the gain flatness in 17–26.5 GHz.

3. A GaN power amplifier with wide bandwidth, high power, and high efficiency is proposed. Results show that the power amplifier has over 42.5 dBm saturated output power in the frequency range of 17–26.5 GHz, with a maximum power added efficiency (PAE) of 32.1%.

Ming LI, doctor of engineering, senior engineer. He joined Nanjing Electronic Devices Institute in 2013 and has been engaged in chip design, thermal design, and stability design of GaAs/GaN spaceborne high efficiency and high linearity power amplifier in microwave and millimeter wave bands for a long time. He has participated in and presided over dozens of new product projects, one national key research and development plan project. Many of millimeter wave power amplifier products have been applied to the field of high-speed and high-capacity communication satellites and Mars probes. The technical indicators have reached the international leading level and filled the domestic gap. He has won the second prize of National Defense Science and Technology Progress of the Ministry of Industry and Information Technology twice (2013 and 2020). His current research interests include GaAs/GaN microwave and millimeter-wave integrated circuits.



Zhiqun LI received the BS and MS degrees from University of Bordeaux I, France, in 1982 and 1983, respectively. From 1993 to 1996, he studied in Laboratory of Microelectronics, University of Bordeaux I, France, and received the PhD degree in electronic engineering. From 1996 to 1998, he was a post-doctoral researcher in Laboratory of Biological Medical, Biganos, France. He was an Assistant Lecture from 1983 to 1989 and Assistant Professor from 1989 to 1993 at University of Science and Technology of China, Hefei, China. From 1998 to 2002, he was with Hefei Sensing Electronic Company in Hefei high and new tech development zone working on medical electronic equipment and sensor devices. Since 2002, he has been with Institute of RF-&OE-ICs, Southeast University and has been now engaged as a professor and a doctoral supervisor. He is now director of the Engineering Research Center of RF-ICs & RF-Systems of Ministry of Education of China and director of Institute of RF-&OE-ICs. He has won the first prize of Anhui Science and Technology Award (2021), the second prize of Science and Technology Award of China Electronics Society (2021), the second prize of Jiangsu Provincial Science and Technology Progress Award (2006), the second prize of National Teaching Achievement Award by Ministry of Education of China (2014 and 2018). His current research interests include RF integrated circuits and system, microwave and millimeter-wave integrated circuits.