[4D-5]

A 2-6 GHz Fully Integrated Tunable CMOS Power Amplifier for Multi-Standard Transmitters

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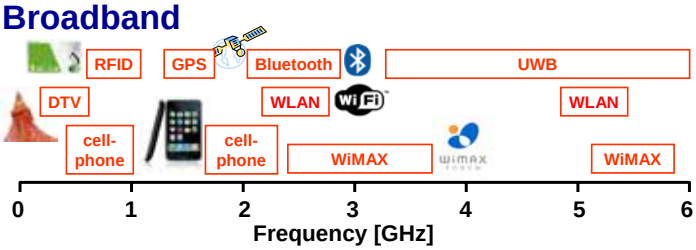
Introduction

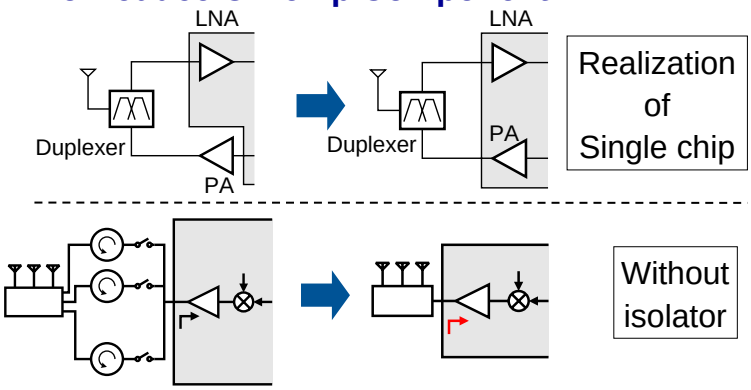
Broadband



Broadband device(PA) is necessary to support current various communication methods.

Problems of Reported Wideband PA
Large area, Insufficient output power, etc.

To Reduce Off-chip Component



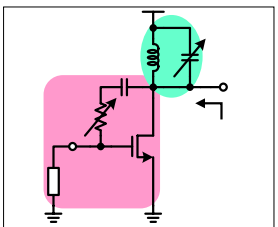
Characteristic of Proposed Circuit

Output Impedance Tuning

If $r_{ds}=\infty$, $Z_{out}=\frac{R_f+R_s}{g_m R_s+1}\,//\,\frac{1}{j\omega C}\,//\,(R_L+j\omega L)$

When $f=\frac{1}{2\pi\sqrt{LC}}$ (Resonance freq.)

$$Z_{out}=\frac{R_f+R_s}{g_m R_s+1}\,//\,\frac{L}{CR_L}$$

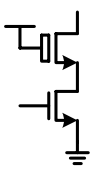


- Tune C to cancel imaginary part of Z_{out}
- Tune R_f to match Z_{out} to 50Ω

In fact, r_{ds} is small…

Solution •Cascode topology

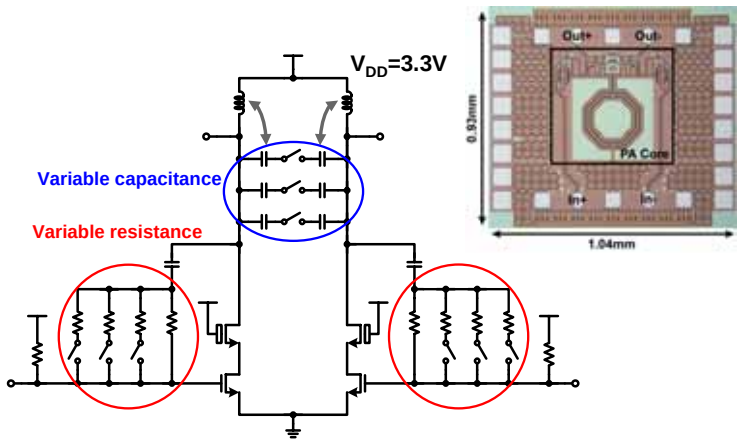
Cascode & Thick-oxide Transistor



- Low breakdown voltage of transistor
  - In submicron CMOS process, V_{DD}=1~2V
  - Output power ∝ (Voltage)^2

Solution
- Use thick-oxide transistor
- Apply cascode topology and share output voltage

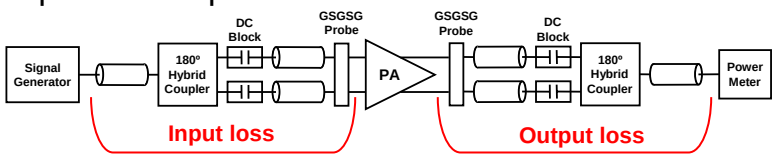
Schematic & Chip Micrograph

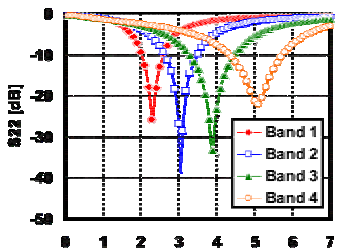


[Schematic of the proposed PA & Prototype by 0.18μm CMOS]

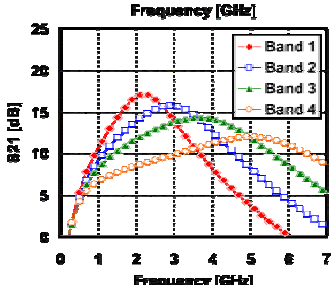
Measurement Results

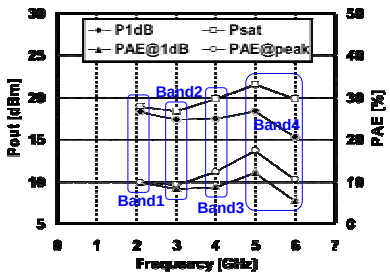
•Input and output losses are calibrated from results.





Technology	0.18μm CMOS
Freq.[GHz]	**2.1-6**
V_{DD}[V]	3.3
P_{1dB}[dBm]	15-18
P_{sat}[dBm]	18-22
PAE_{max}[%]	9-17
Output matching	**Tunable**





	Technology	V_{DD} [V]	Freq. [GHz]	P_{1dB} [dBm]	P_{sat} [dBm]	PAE_{max} [%]	Area [mm^2]	S_{22} [dB]	Output matching	Topology
[1]	0.13	2.0	2.0~8.0	3.5	7~10	2	–	<-5	Wideband	Distributed
[2]	0.13	1.5	0.5~5.0	10~17	14~21	3~16	3.6	<-6	Wideband	Distributed +Transformer
[3]	0.18	2.8	3.7~8.8	14~16	16~19	8~25	2.8	<-8	Wideband	Distributed
[4]	0.13	3.0	1.0~2.5	–	28~31	18~43	2.56	–	Wideband	Power mixer +Transformer
This work	0.18	3.3	**2.1~6.0**	15~18	18~22	9~17	0.23	<-8	**Tunable**	Feedback

[1] C.Grewing, *et al.*, IEEE RFIC Symp.Dig., June 2004.
[2] J.Roderick and H.Hashemi, IEEE ISSCC Dig. Tech., Feb.2009
[3] C. Lu, *et al.*, IEEE Trans. Microw. Theory Tech., Nov. 2007
[4] S. Kousai and A. Hajimiri, IEEE ISSCC Dig. Tech., Feb. 2009

Summary

- Realization of an isolator-less PA
- Z_{out} matching from 2.1 to 6.0GHz
- P_{1dB} more than 15dBm

➡ The first tunable PA at 2-6GHz