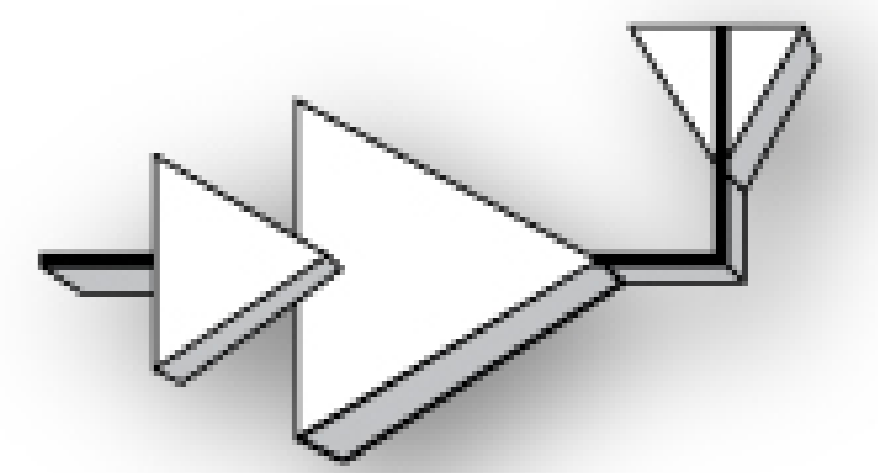


A CMOS Power Amplifier for WCDMA/GSM Handset Applications



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Motivation

◆ CMOS PA

- + High integration (easy to integrate with CMOS Tx)
- + Low cost (good to commercial products)
- Low linearity (due to large knee voltage)
- Low efficiency (due to lossy substrate)
- Low breakdown voltage

◆ Multimode CMOS PA

- High linearity → support various applications
- Broad band → cover various band
- High efficiency → increase battery life time

Power Stage

◆ Cascode structure

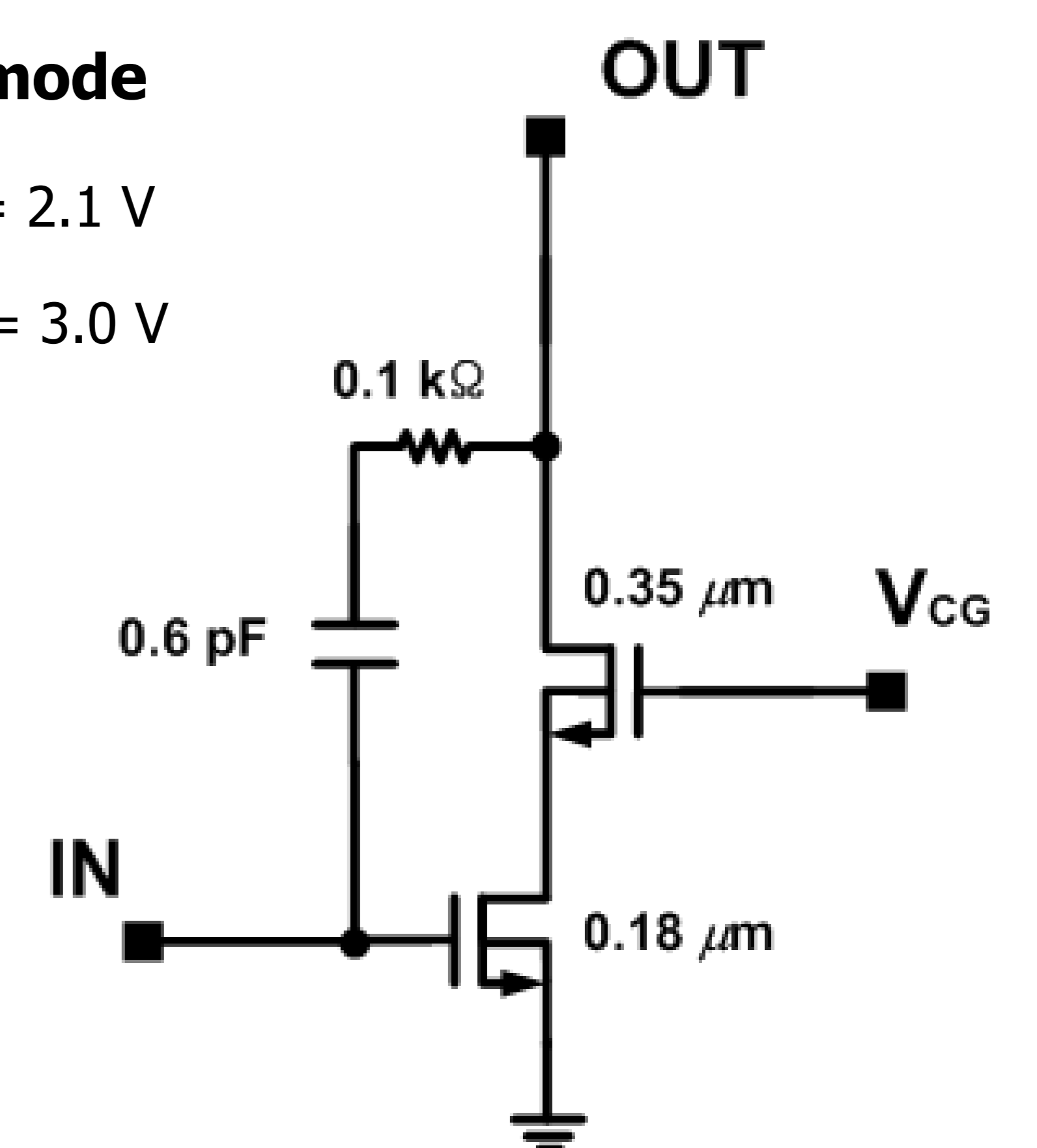
- 0.18- μm (CS) / 0.35- μm (CG)
- Reduces voltage stress

◆ V_{CG} controls to change mode

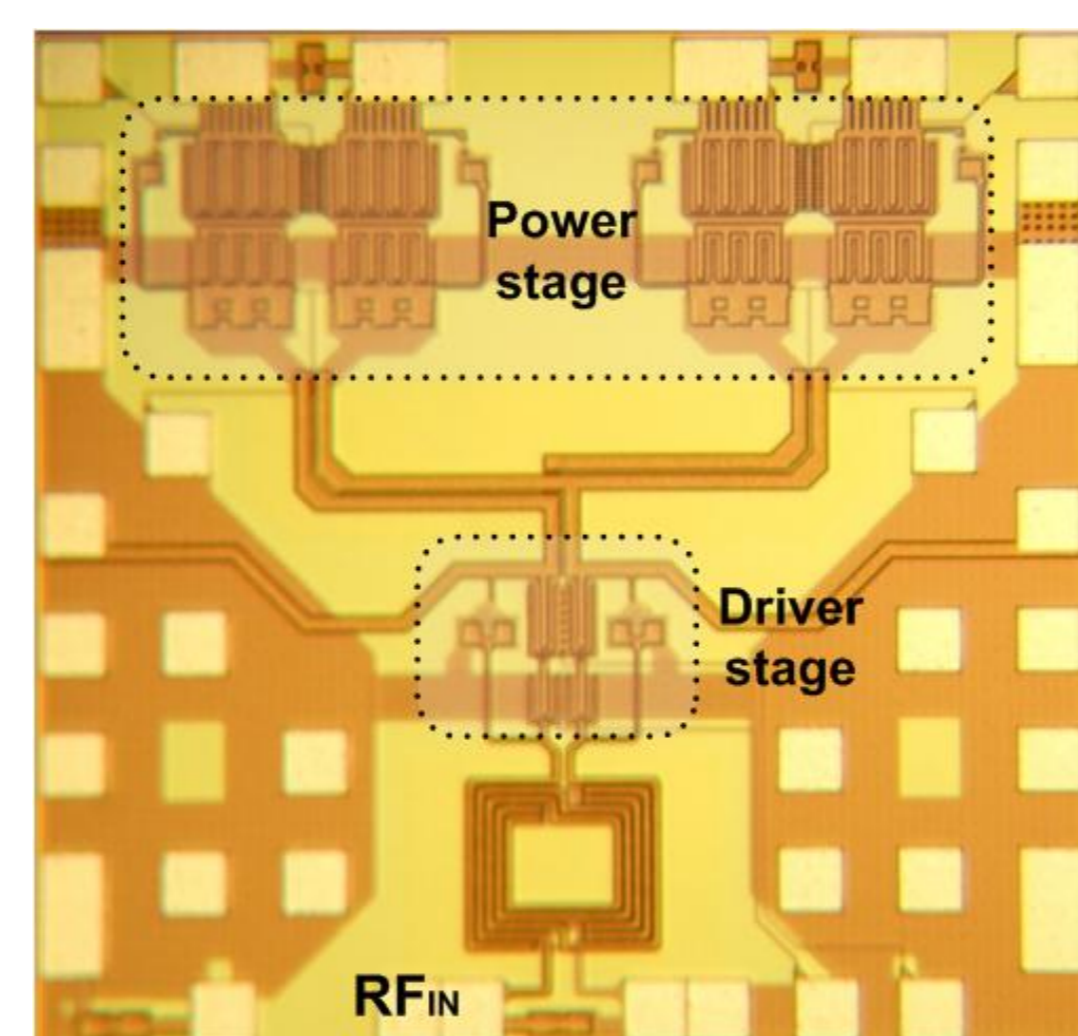
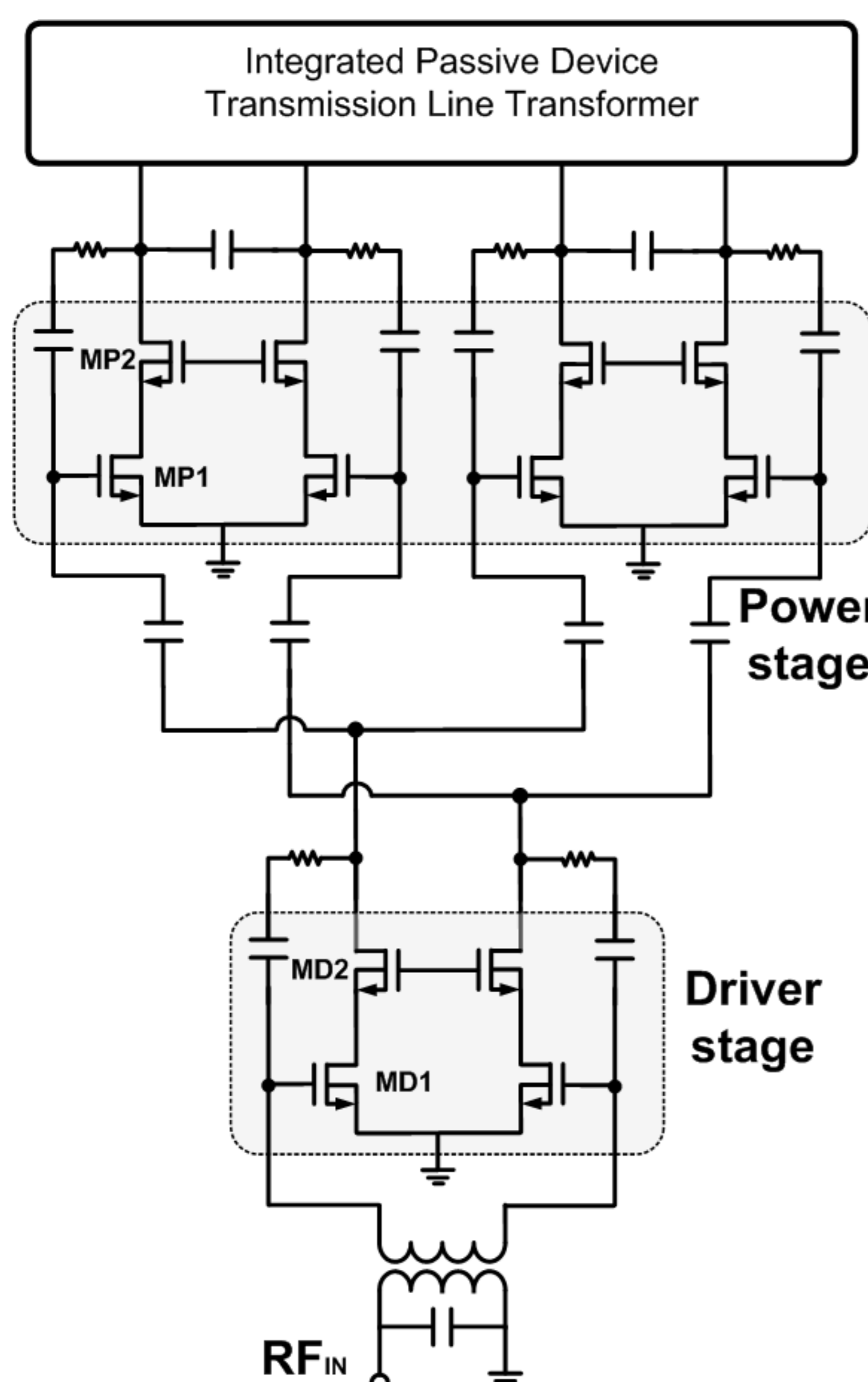
- WCDMA(Linear) mode $V_{CG} = 2.1\text{ V}$
- GSM(Saturation) mode $V_{CG} = 3.0\text{ V}$

◆ R-C Feedback

- Improves linearity
- Improves stability



Schematic

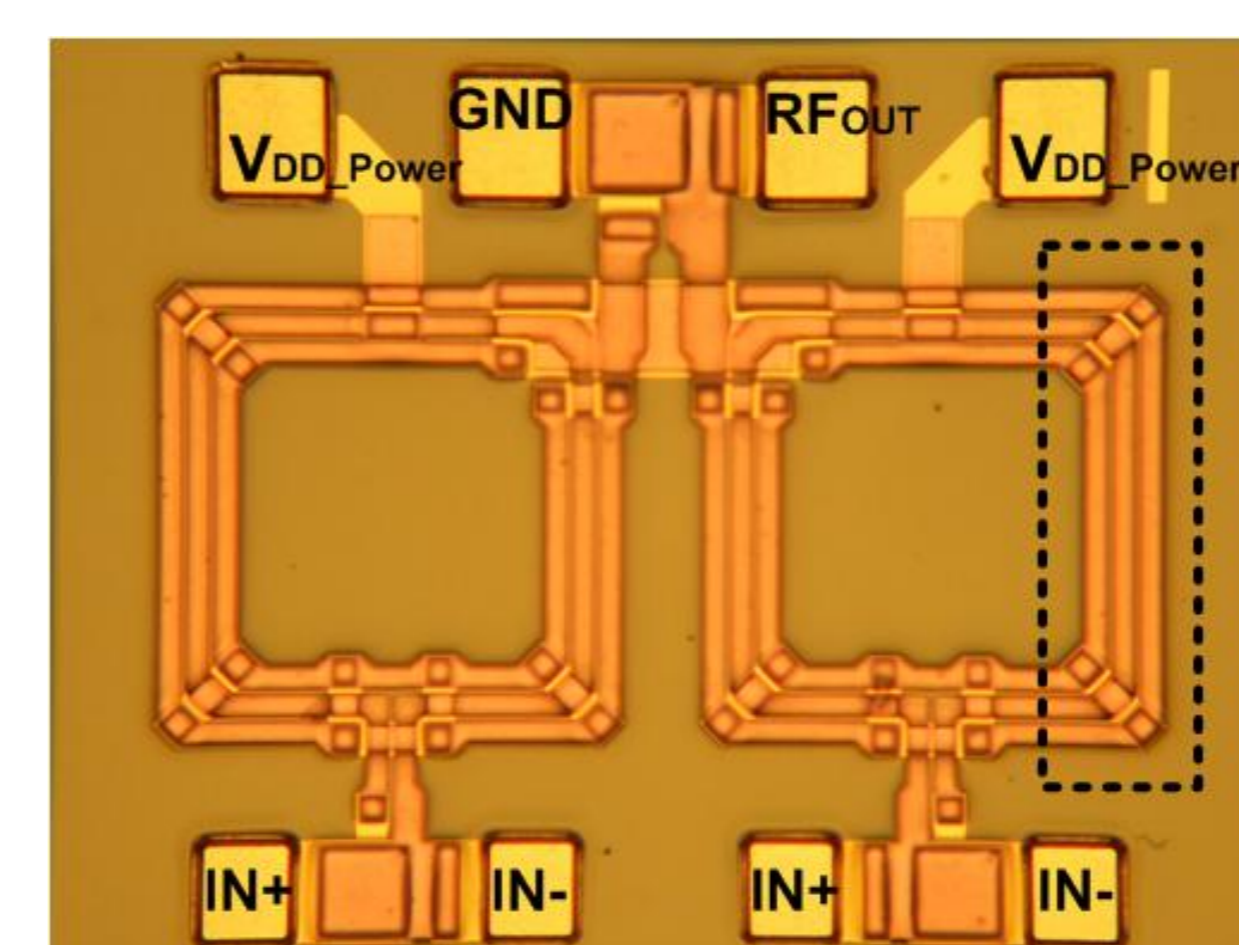


1.3 mm X 1.3 mm
In TSMC 0.18- μm process

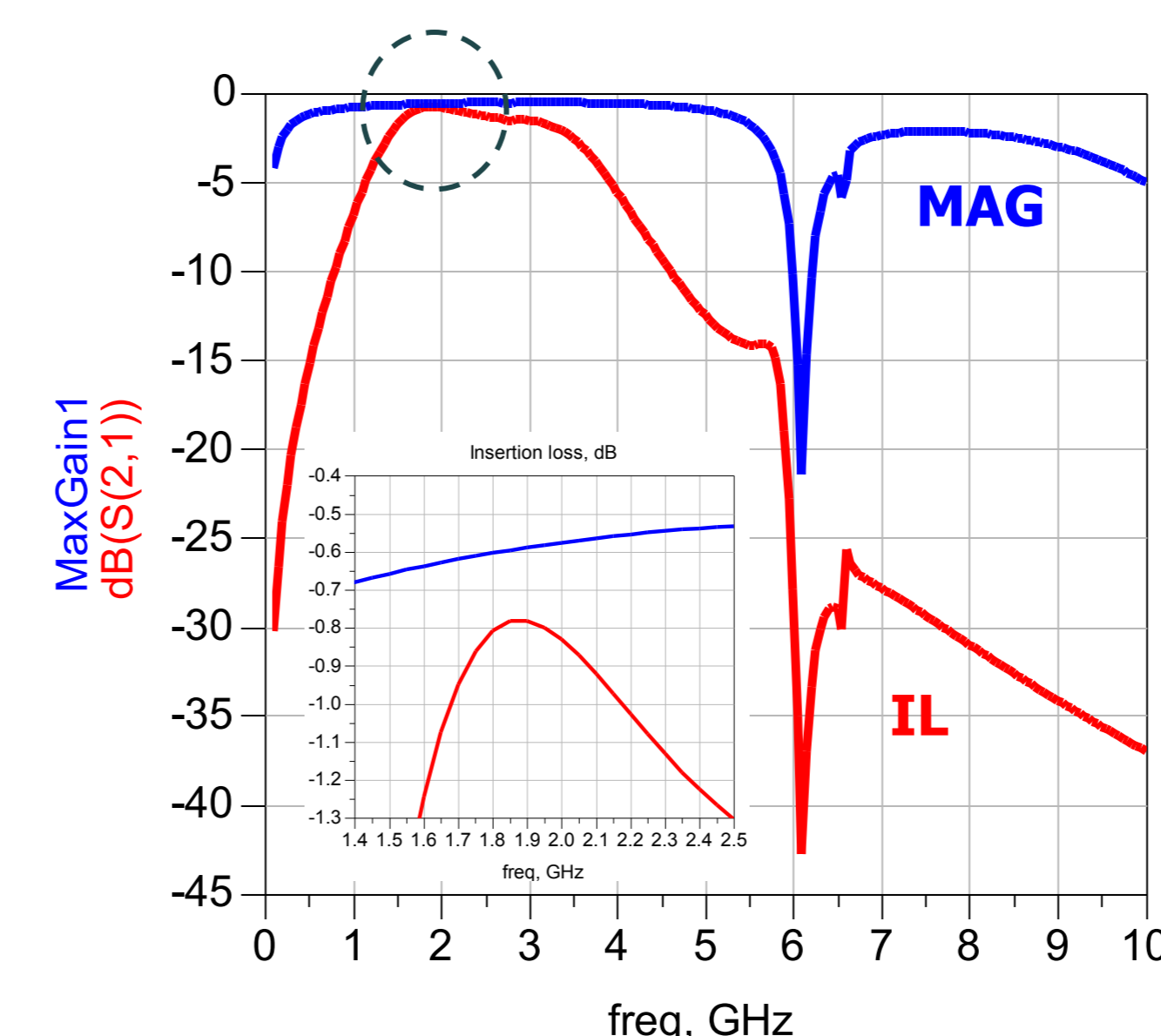
◆ 2-stage CMOS PA

- All matching components integrated without output matching network
- Total gate width [μm]
- MD1 : 768
- MD2 : 1,024
- MP1 : 3,072
- MP2 : 4,096

Output transformer



1.1 mm X 1.0 mm
Integrated Passive Device (IPD)

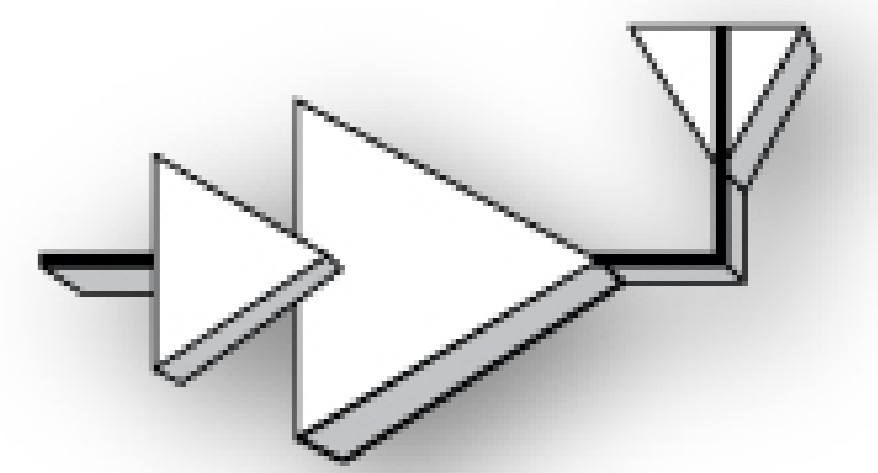


Simulated insertion loss(IL) and maximum available gain(MAG) of transformer

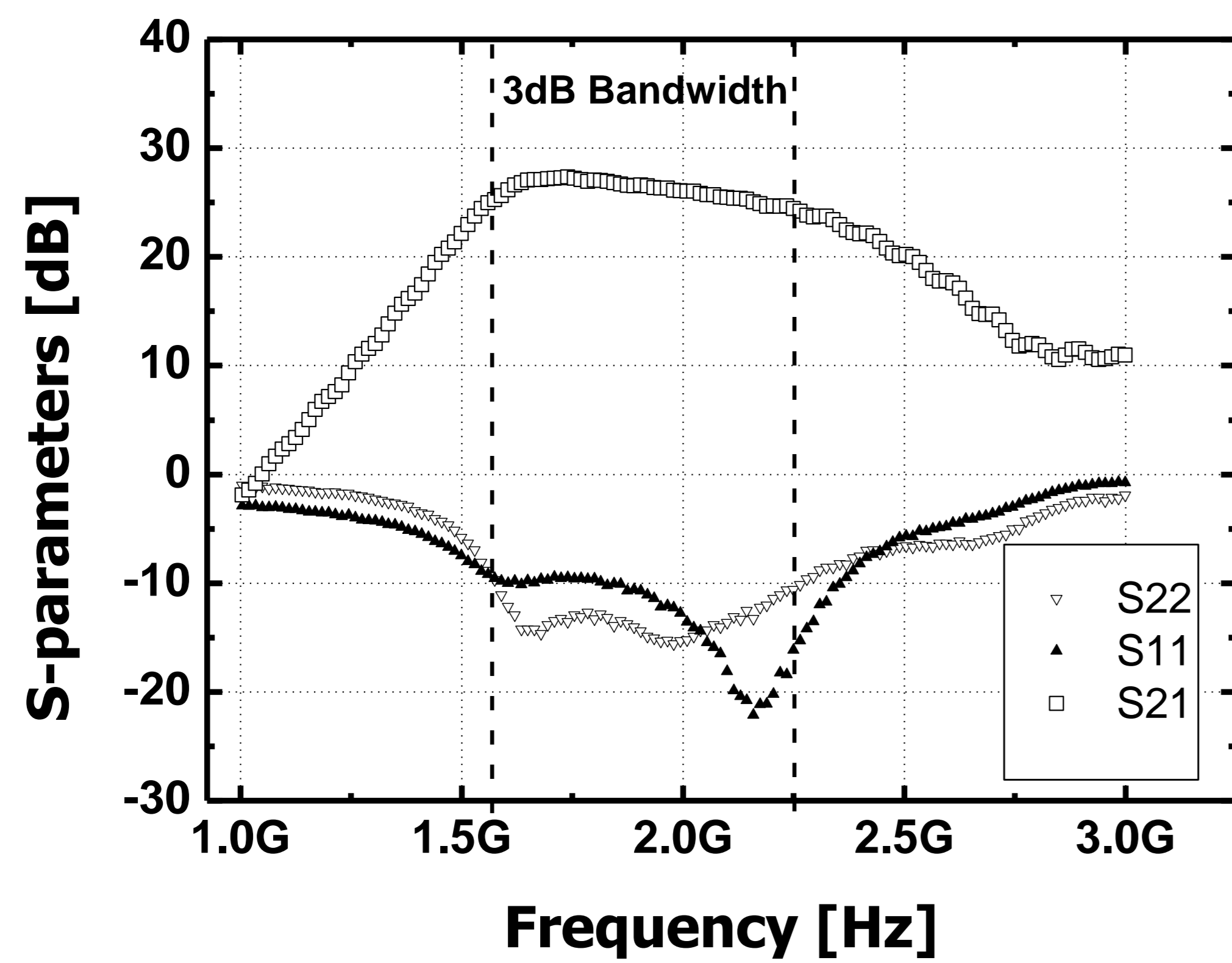
◆ Characteristics of transformer

- IPD process
 - High resistive Si substrate
 - Thick metal
- Very symmetrical structure
 - Reduce 2nd harmonic
- Broad band
- Filtering 3rd harmonic
- MAG : -0.59 dB / IL : -0.78 dB @1.9GHz

This work was supported by Samsung Electro-Mechanics in Korea

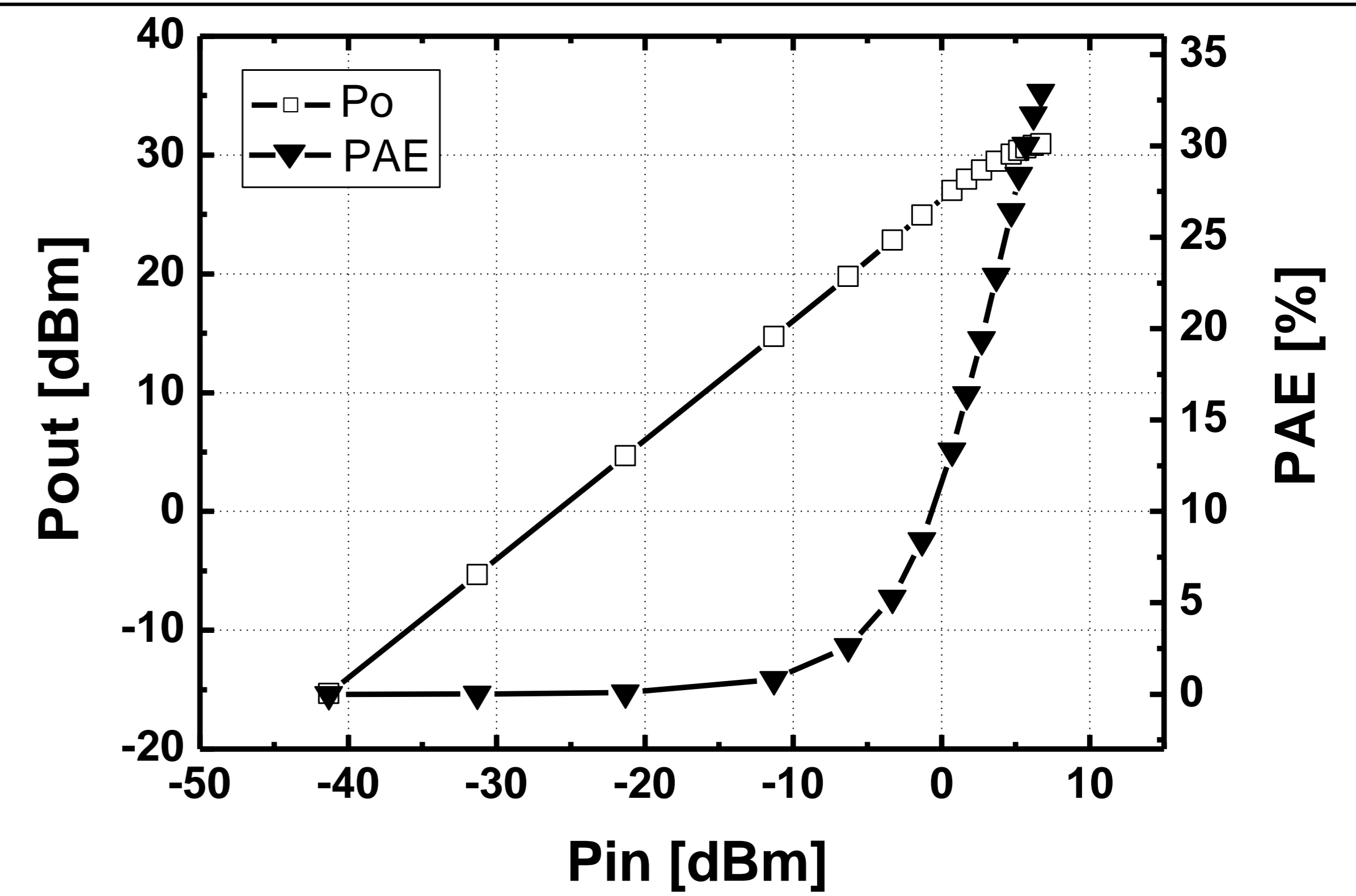


S-parameters (WCDMA mode)



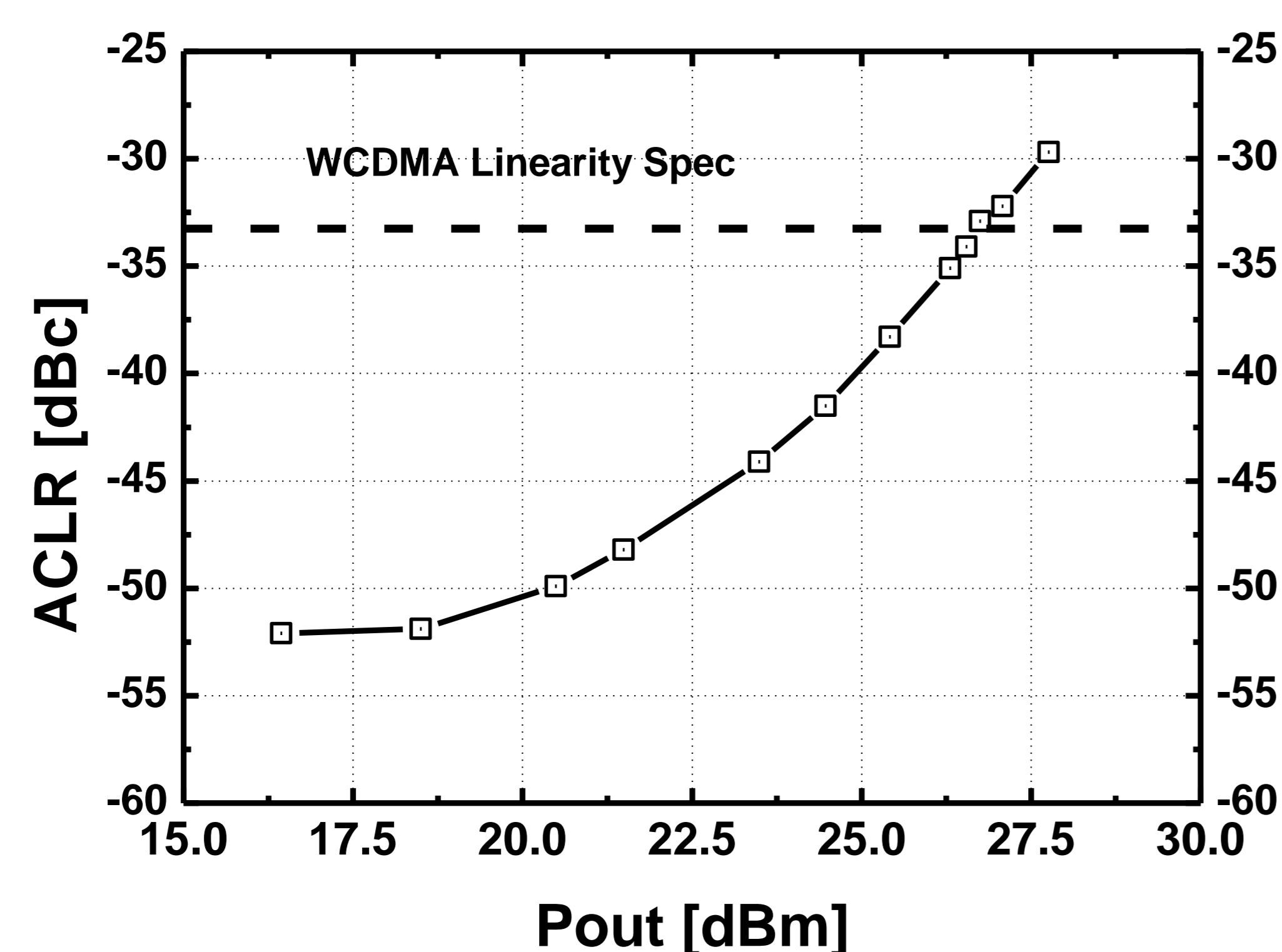
- Small signal gain : 26.3 dB (@1.95GHz)
- 3dB Bandwidth : 0.65 GHz (1.6 – 2.25 GHz)
- S11 & S22 < -10dB (1.6 – 2.25 GHz)

P_{out} and PAE (WCDMA mode)



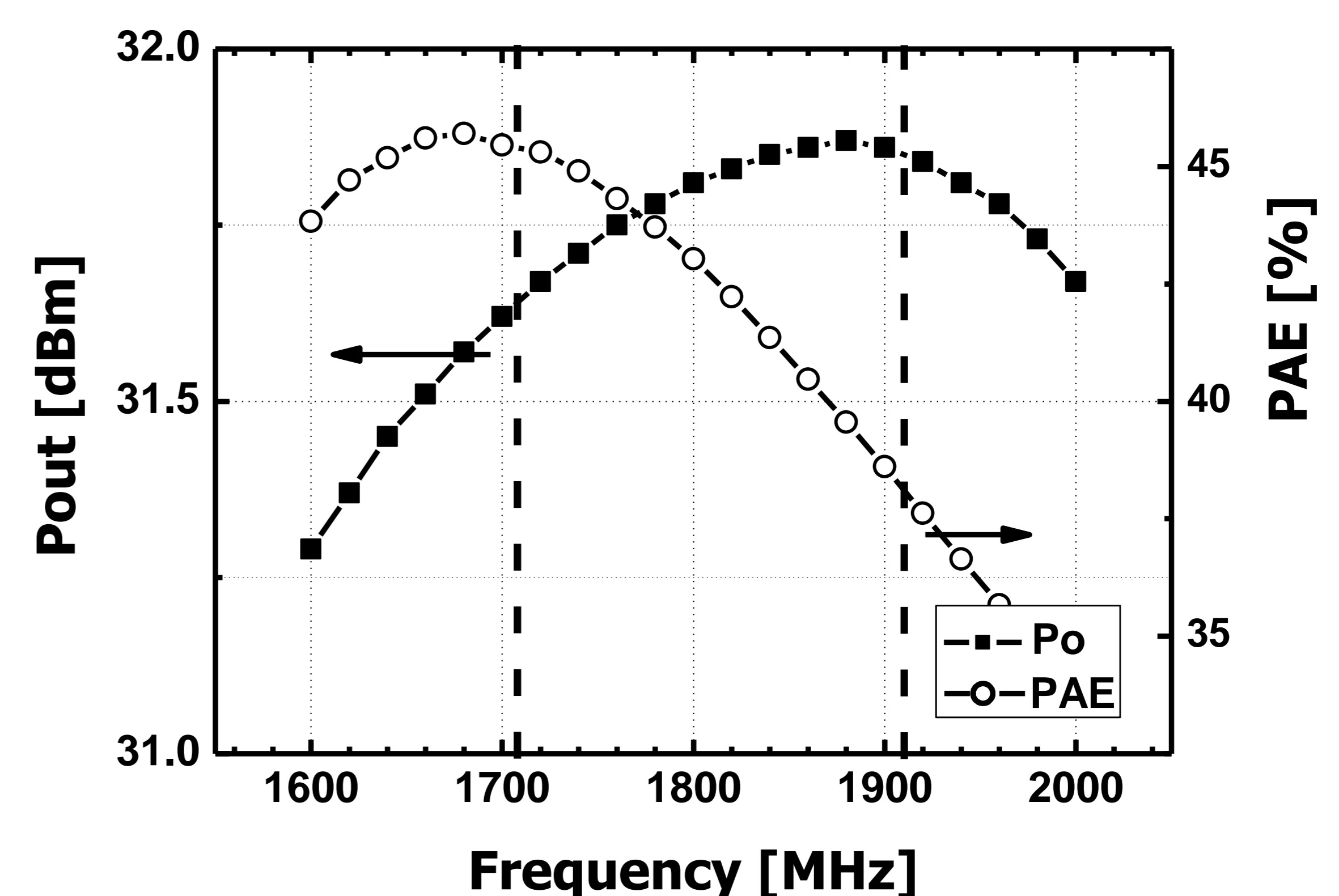
- Frequency : 1.95 GHz
- 1 tone Input power sweep from – 41.3 to 6.7 dBm
- P_{1dB} : 30.6 dBm & PAE : 30.0 % (@P_{1dB})

ACLR (WCDMA mode)



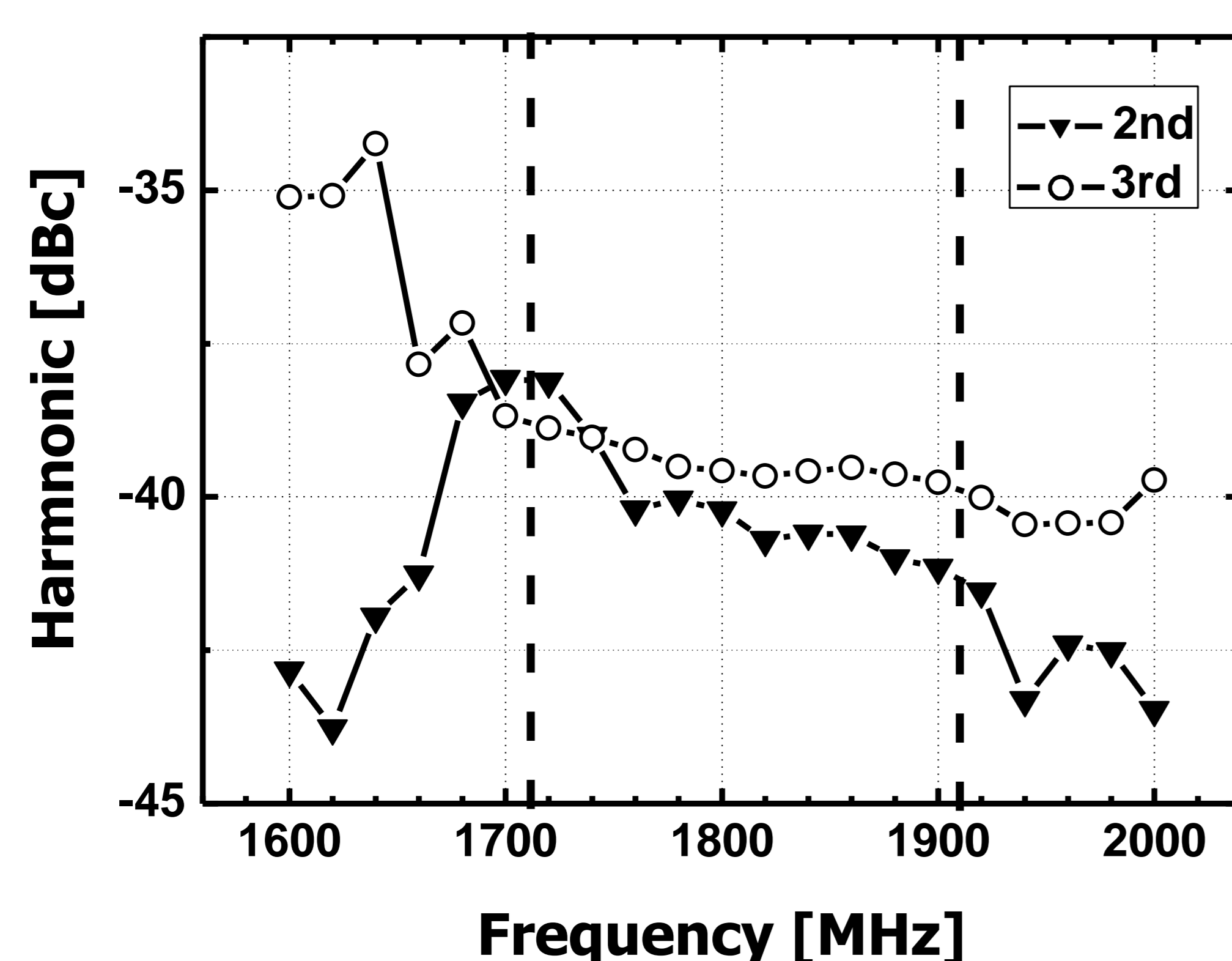
- Modulated signal - 3GPP WCDMA (1.95GHz)
- Linear power_{MAX}(-33dBc @5MHz offset) : 26.75 dBm
- WCDMA Class3 requirement of P_{out} > 26 dBm

P_{out} and PAE (GSM mode)



- Input power : 10dBm
- Frequency sweep from 1600 to 2000 MHz
- P_{OUT} > 31.6 dBm & PAE : > 38.0 % (GSM band)

Harmonics (GSM mode)



- 2nd Harmonic < -38.07 dBc (GSM band)
- 3rd Harmonic < -38.8 dBc (GSM band)

Performance summary

	WCDMA mode	GSM mode
Frequency [GHz]	1.95	1.81
Gain [dB]	26	22
P _o [dBm]	26.75	31.8
PAE [%]	19.5	42.2
Etc [dBc]	ACLR : -33 @5 MHz offset	2 nd harmonic : -42 3 rd harmonic : -40

Conclusions

- Two wireless communication standards (WCDMA & GSM) with a single CMOS PA
- Improve linearity by feedback, biasing cascode and filtering 2nd harmonic in WCDMA mode
- Improve P_{out}, PAE, harmonics by IPD transformer in GSM mode