

5.4: A Single-Chip, Dual-Band, Tri-Mode CMOS Transceiver for IEEE 802.11a/b/g Wireless LAN

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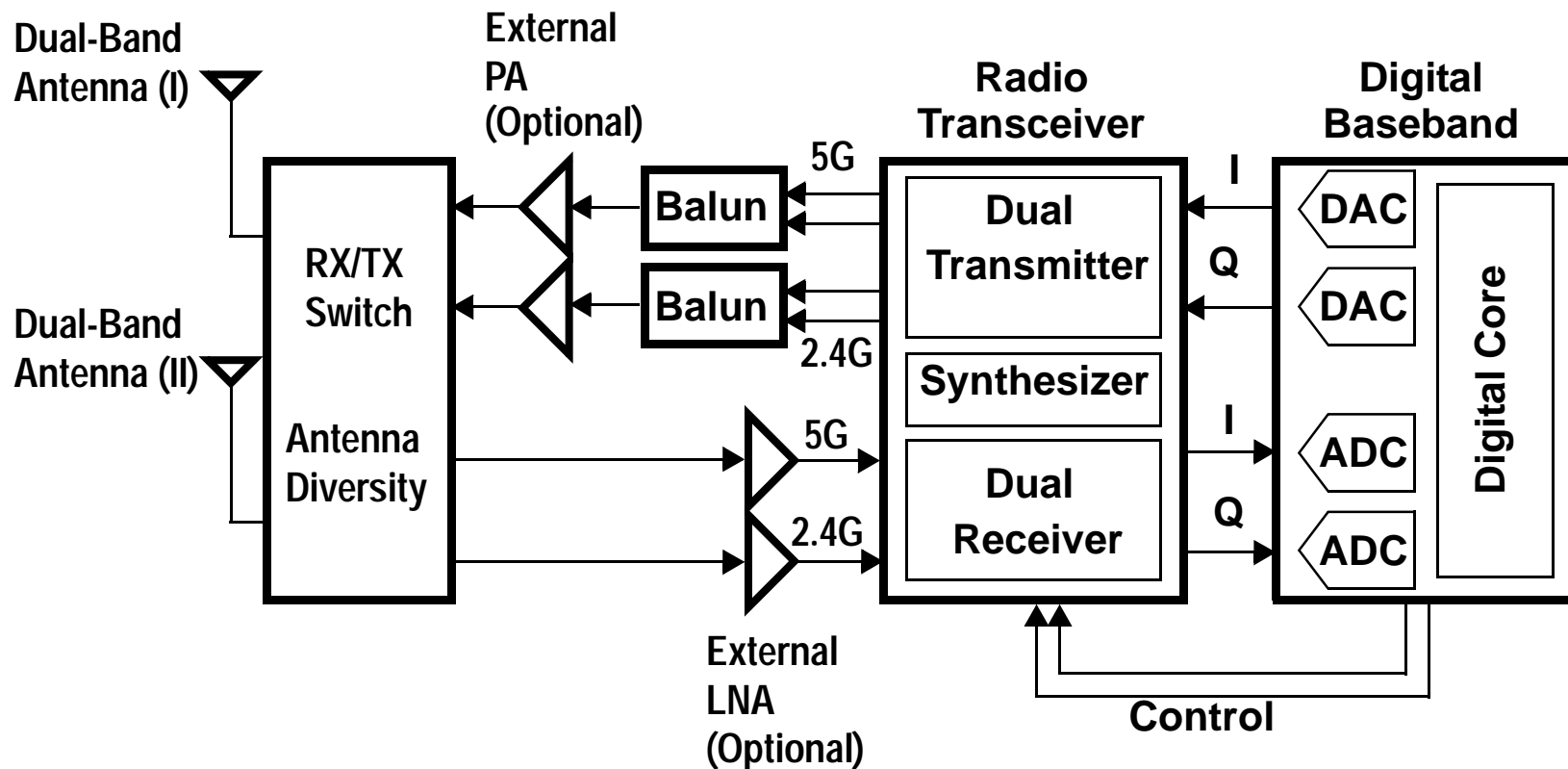
Outline

- ❑ **Introduction**
- ❑ **Overall System Architecture**
- ❑ **Circuit Design**
 - **Receiver**
 - **Transmitter**
- ❑ **Summary**

IEEE 802.11 Wireless LAN

	IEEE 802.11a	IEEE 802.11b	IEEE 802.11g
Available Spectrum	555MHz	83.5MHz	83.5MHz
Frequency of Operation	5.150 - 5.350 GHz 5.470 - 5.825 GHz	2.400 - 2.483 GHz	2.400 - 2.483 GHz
non-overlapping channels	27	3	3
Modulation	OFDM	CCK	CCK/OFDM
Data Rate	6 - 54 Mbps	1 - 11 Mbps	1 - 11 Mbps 6 - 54 Mbps

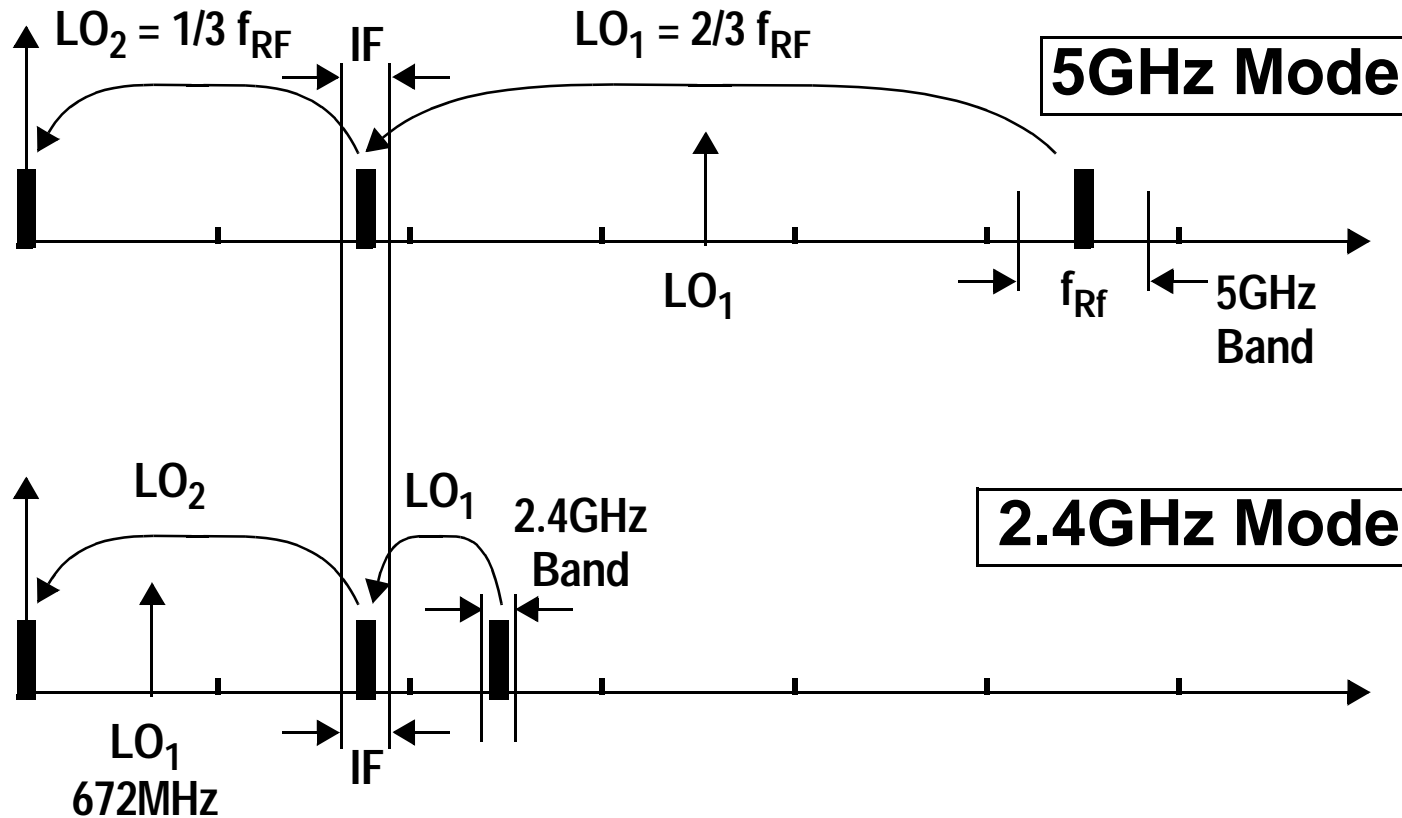
Overall System Architecture



Transceiver Architecture

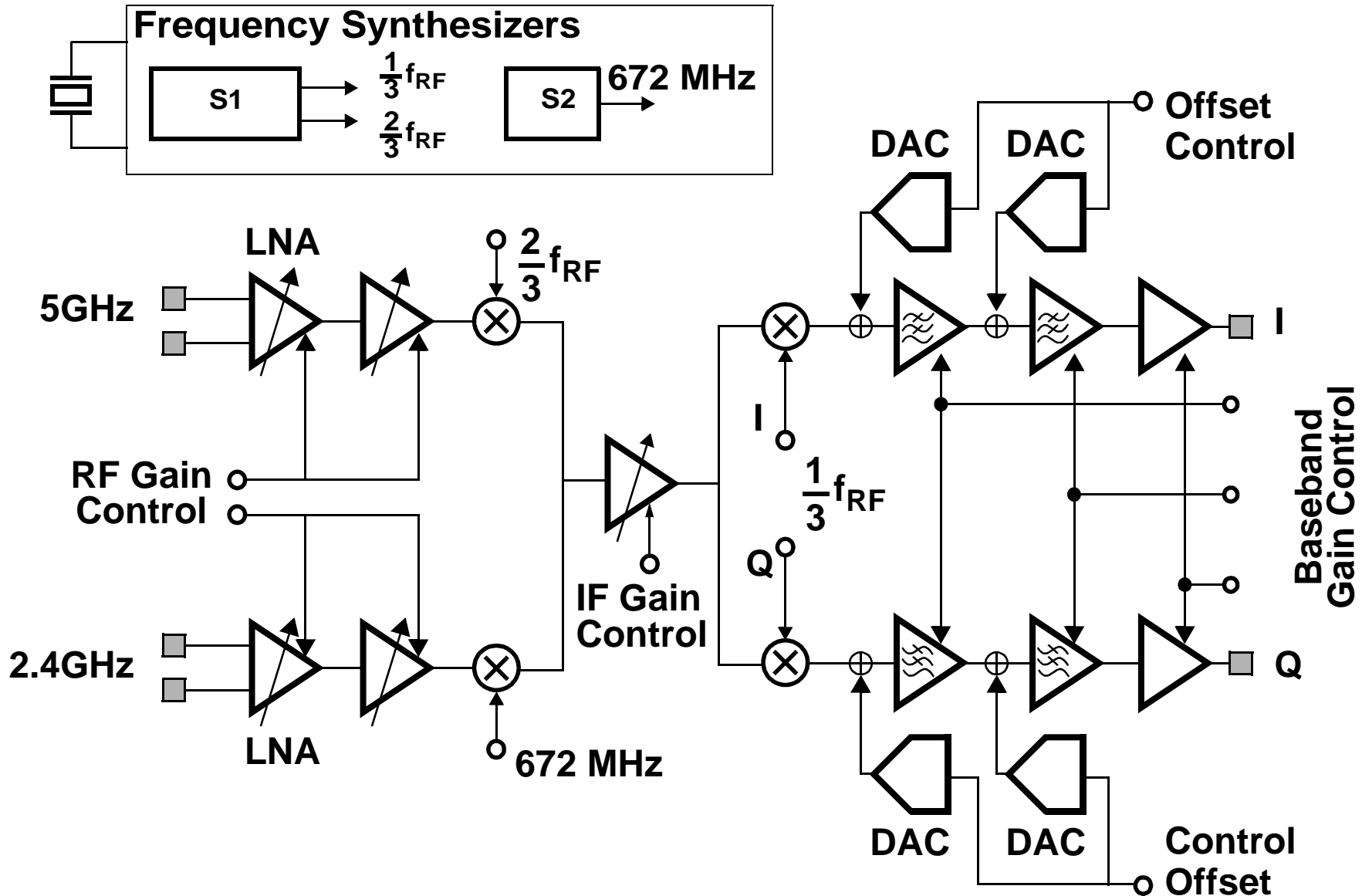
- ❑ **Dual conversion with sliding IF**
 - **Low LO leakage**
 - **Weak LO pulling**
 - **No need for complicated DC offset cancellation**
 - **Can be designed to have comparable power dissipation to direct conversion**

Frequency Plan

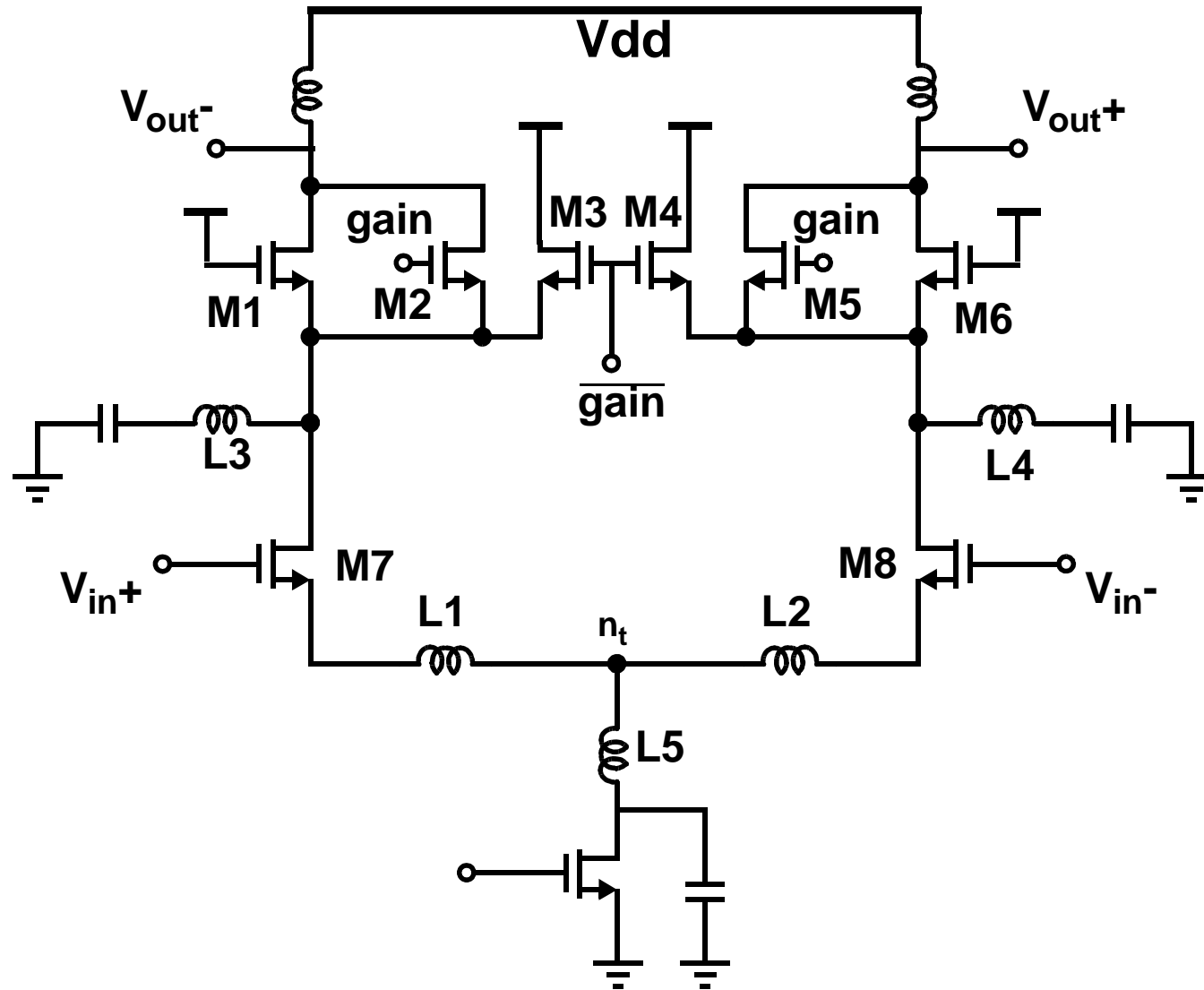


- Share the signal path between different modes
 - Reduce the die size

Receiver Block Diagram

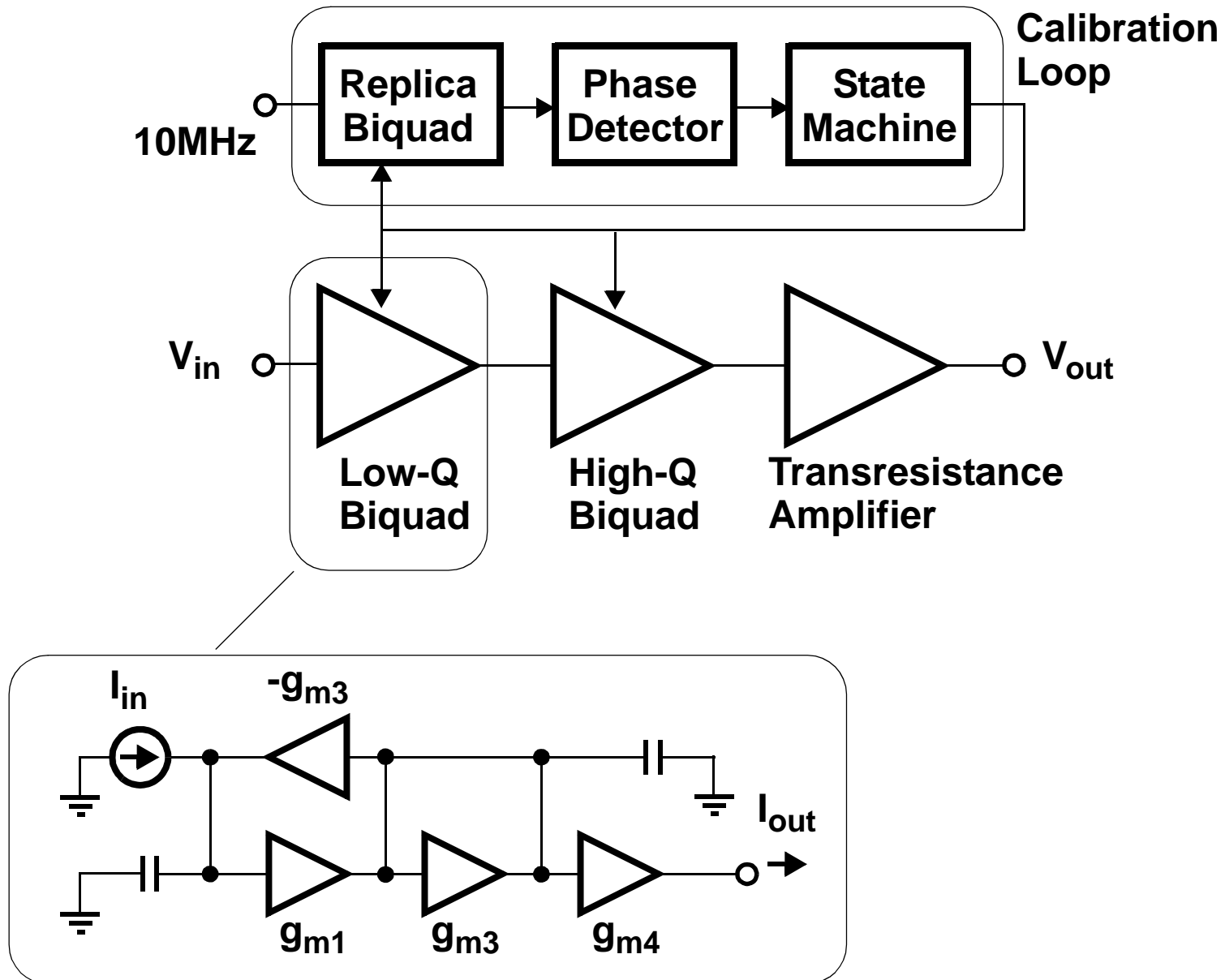


Low-Noise Amplifier (LNA)



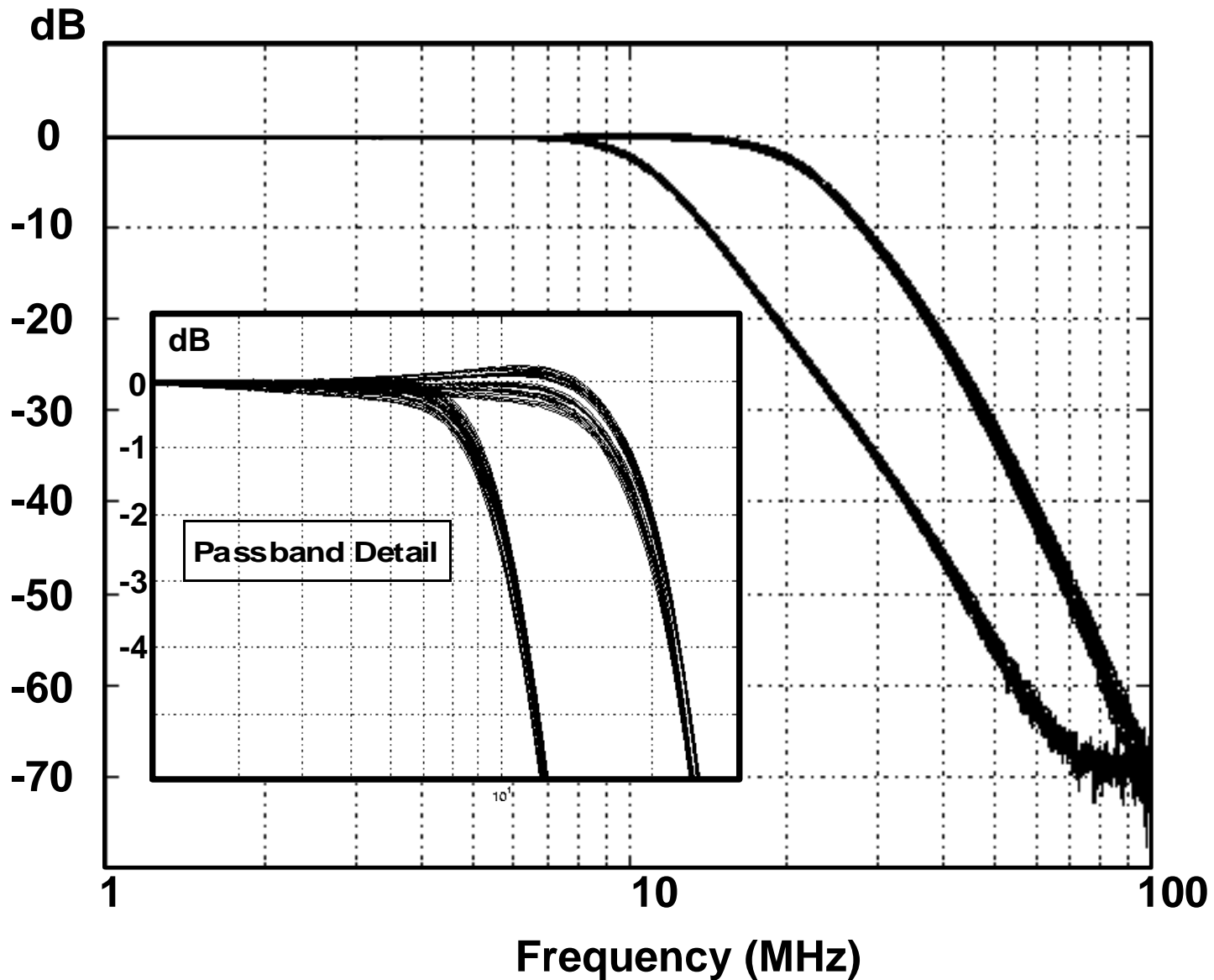
Overall Receiver NF = 4.5/5.5dB @ 2.4/5GHz

Receiver Baseband Filters

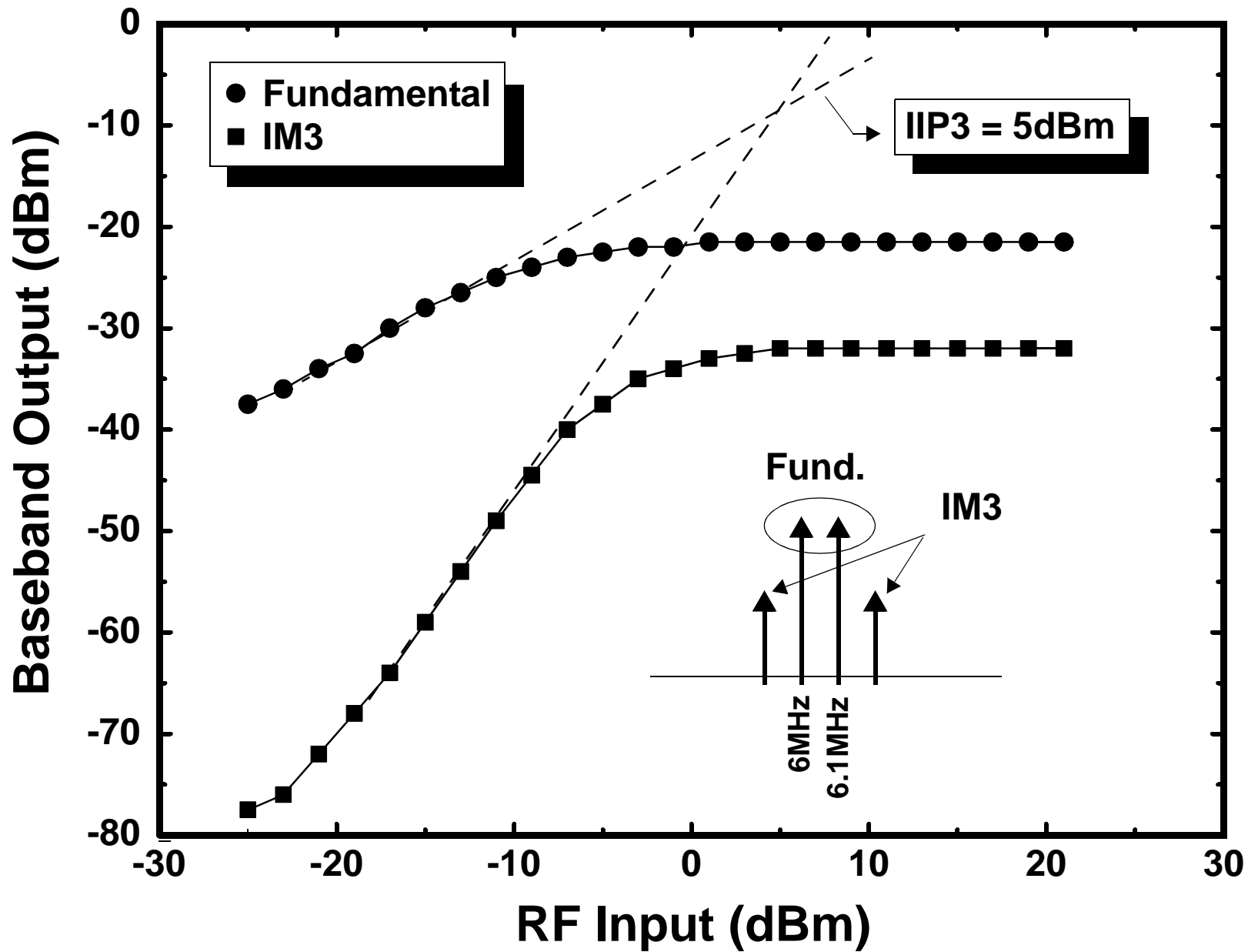


Baseband Filters Frequency Response

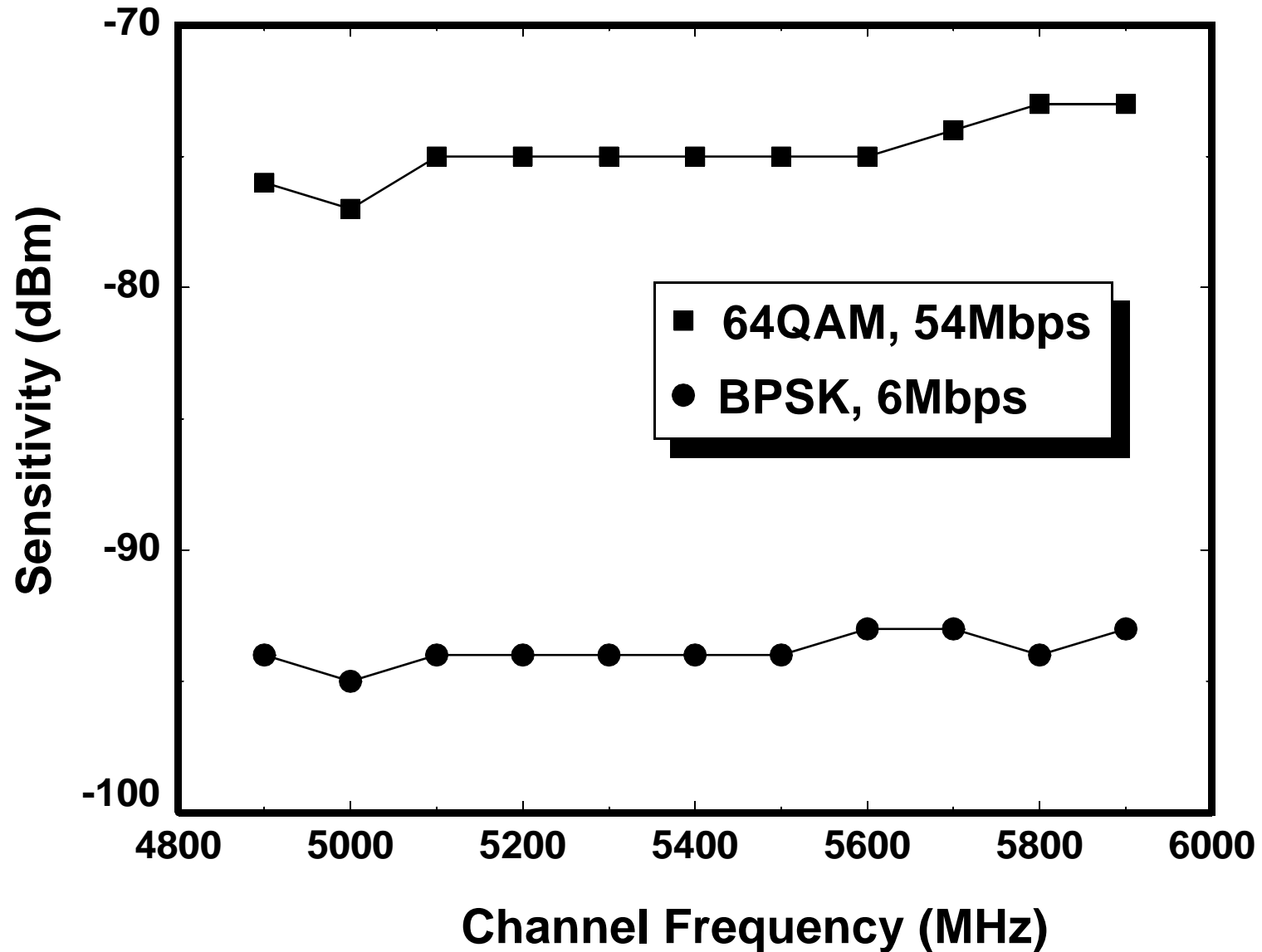
Over Process and Temperature



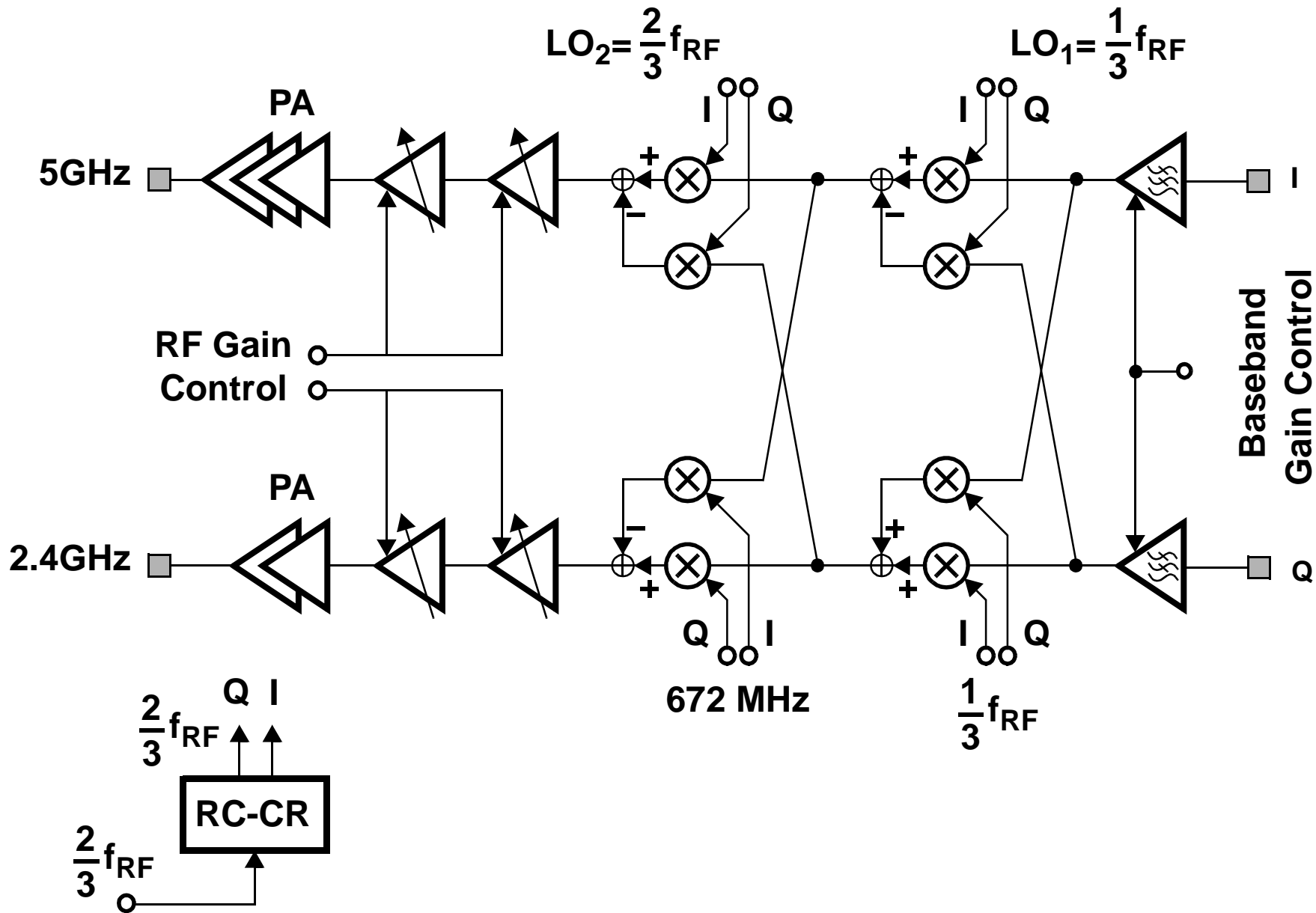
5GHz Receiver Linearity



5GHz Receiver Sensitivity

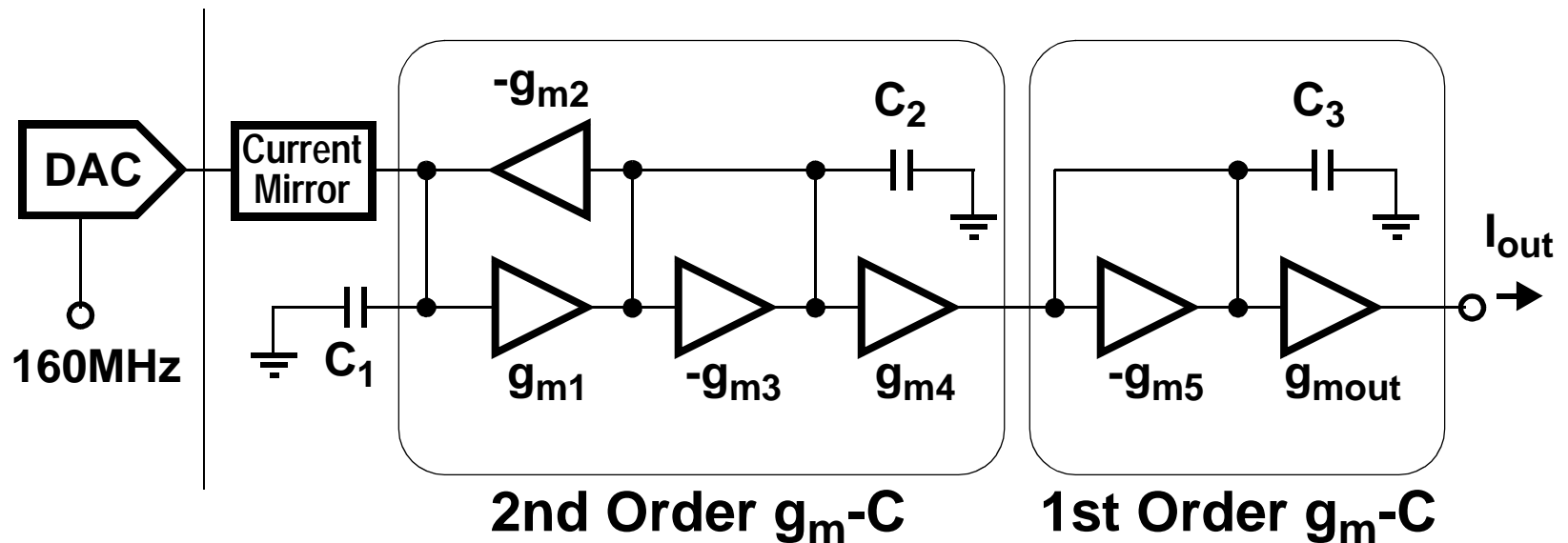


Transmitter Block Diagram



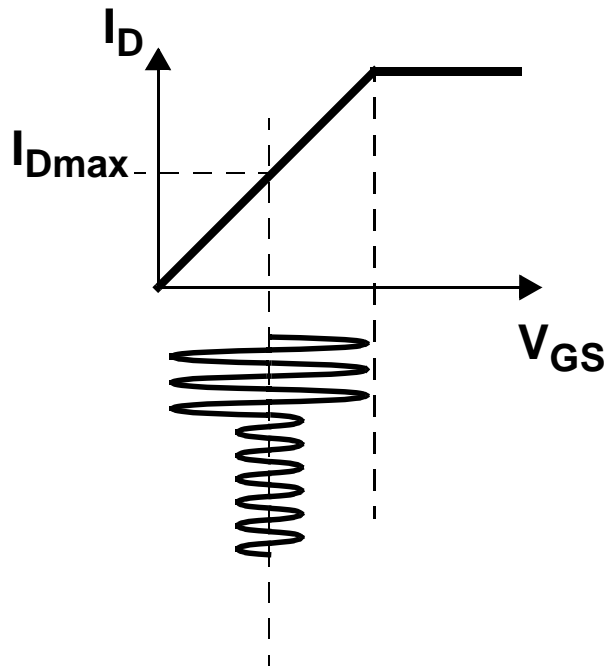
Transmitter Baseband Filters

- ❑ 3rd order Butterworth, with $f_{3dB} = 15\text{MHz}$
- ❑ Needs to be flat within 0.5dB in the passband
- ❑ Requires 40dB attenuation at the DAC sampling frequency of 160MHz
- ❑ No auto-tuning required

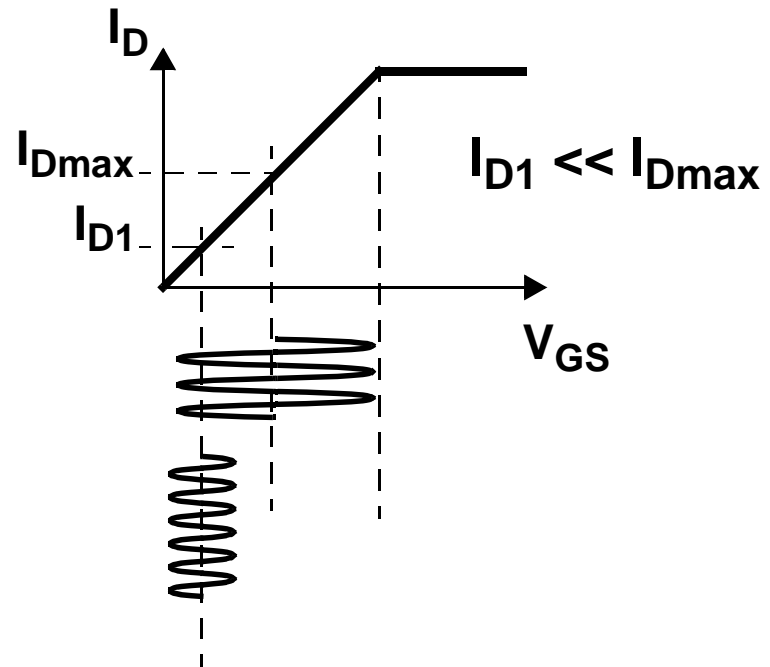


PA with Dynamic Biasing

Conventional Class A

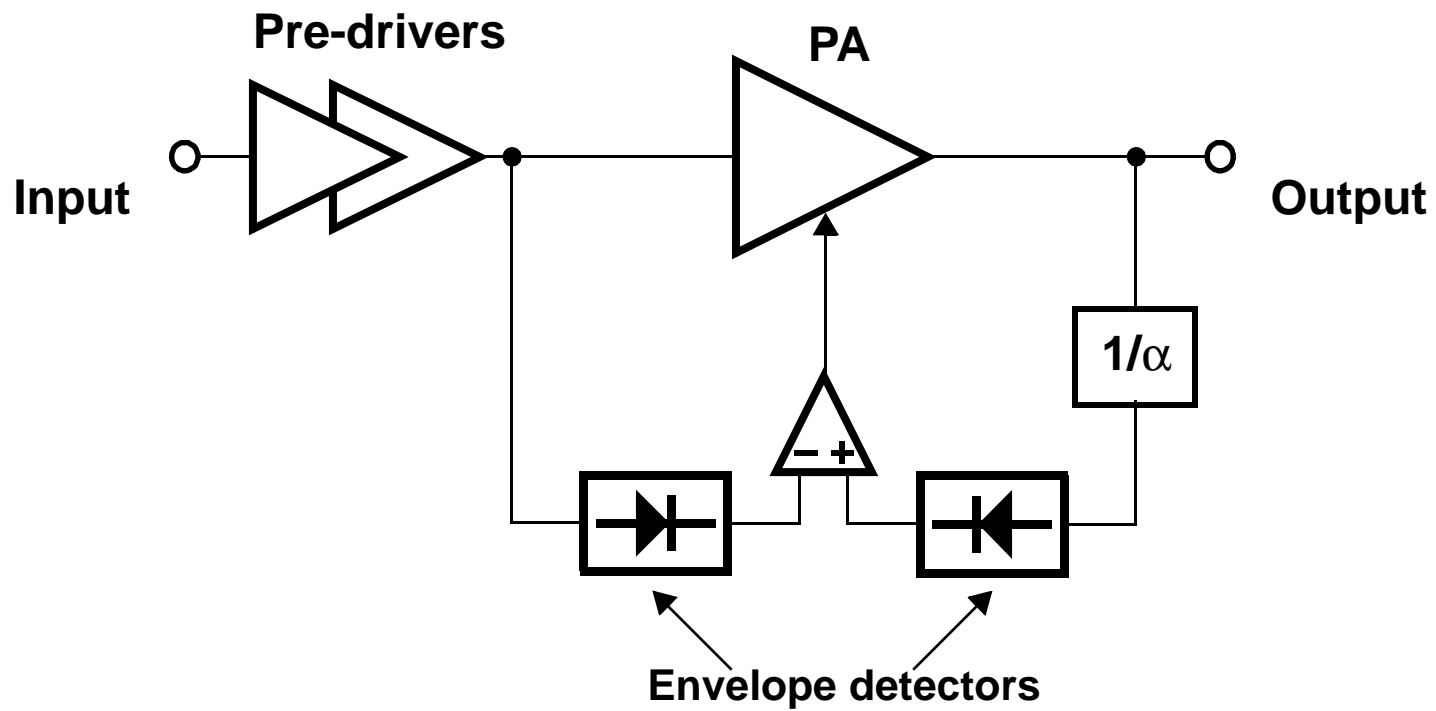


Dynamically Biased

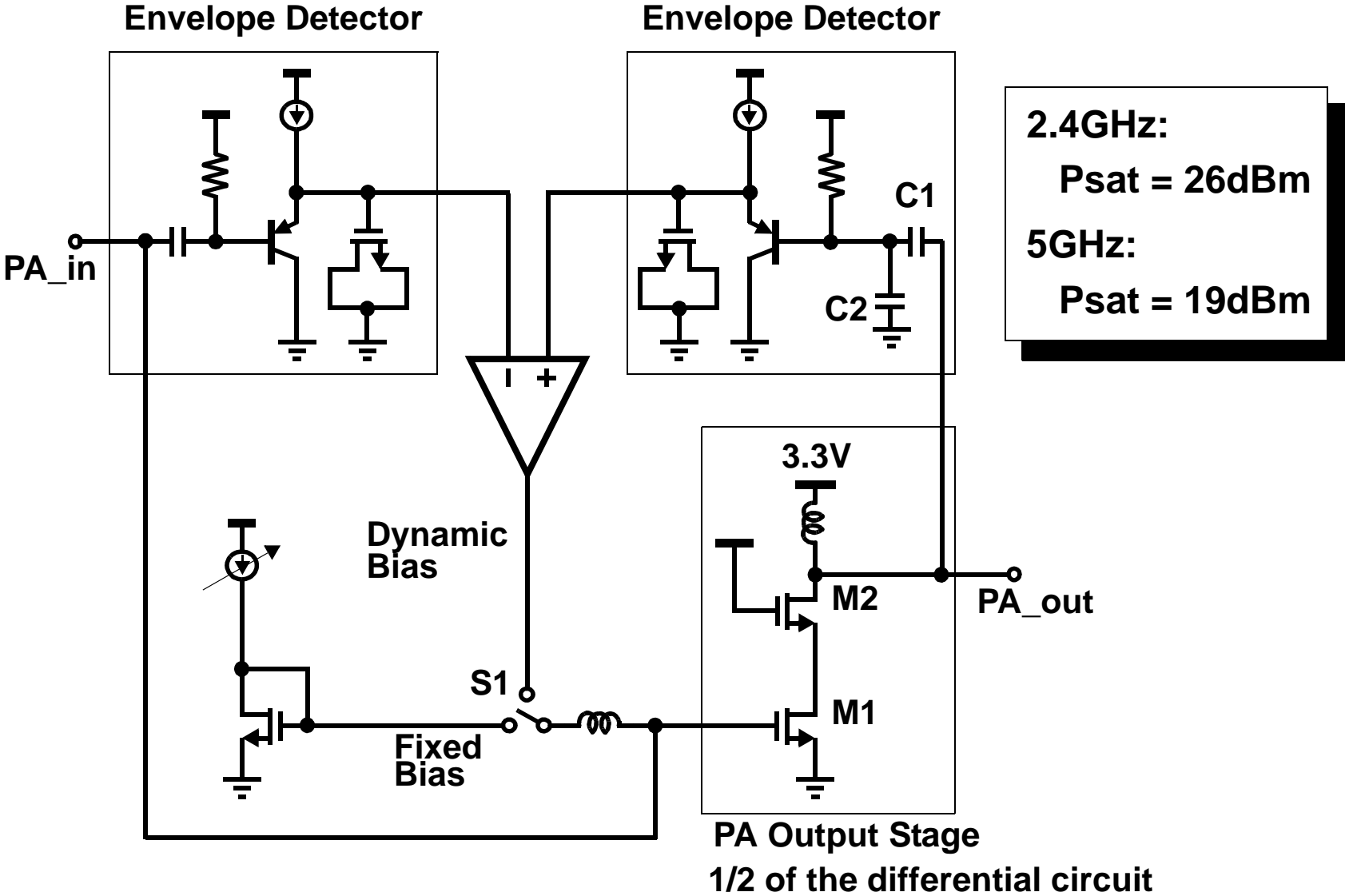


- ❑ OFDM signal has a 17dB peak-to-average ratio
BUT signal peaks are infrequent

Simplified PA Block Diagram

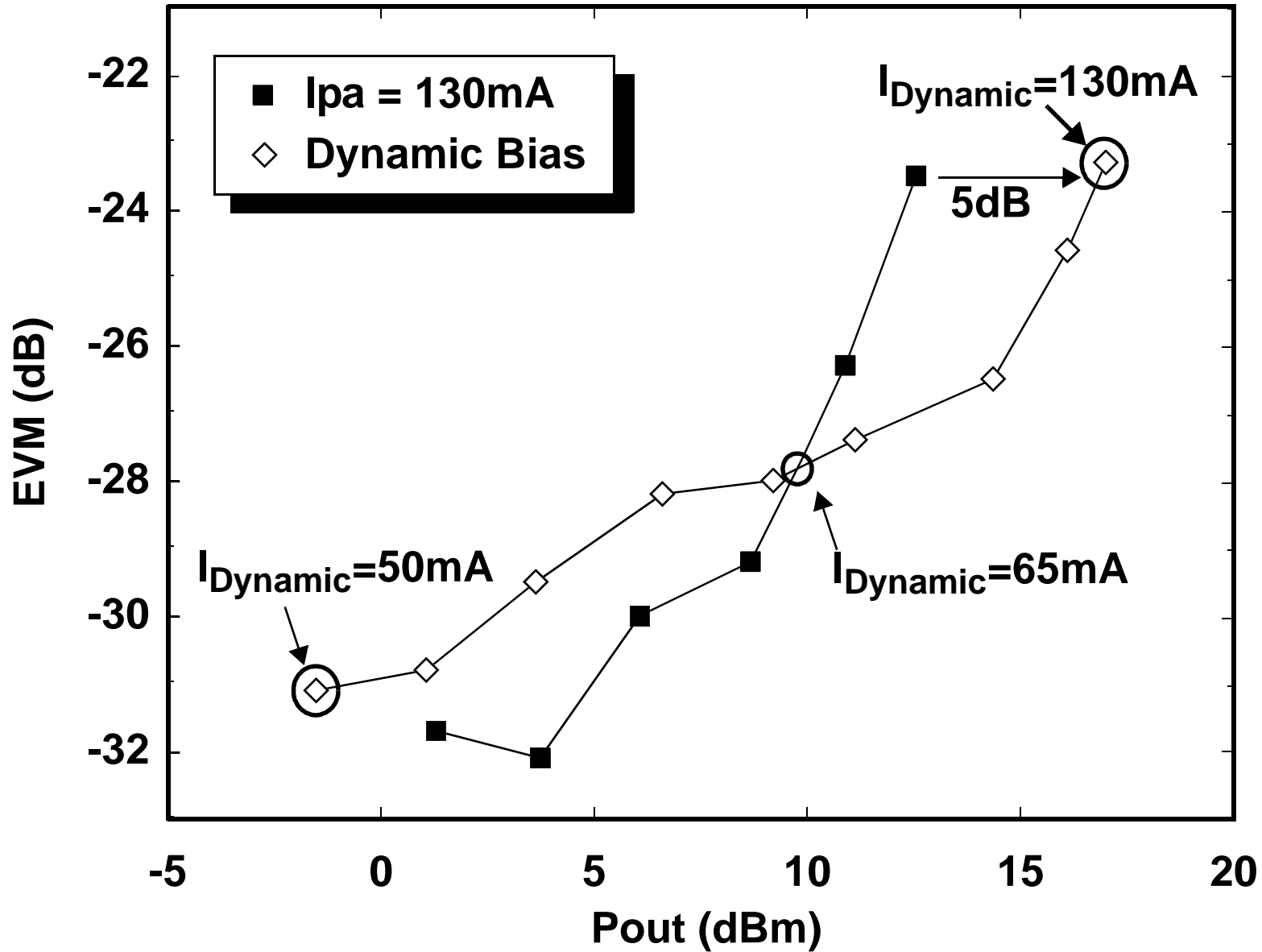


Simplified PA Schematic

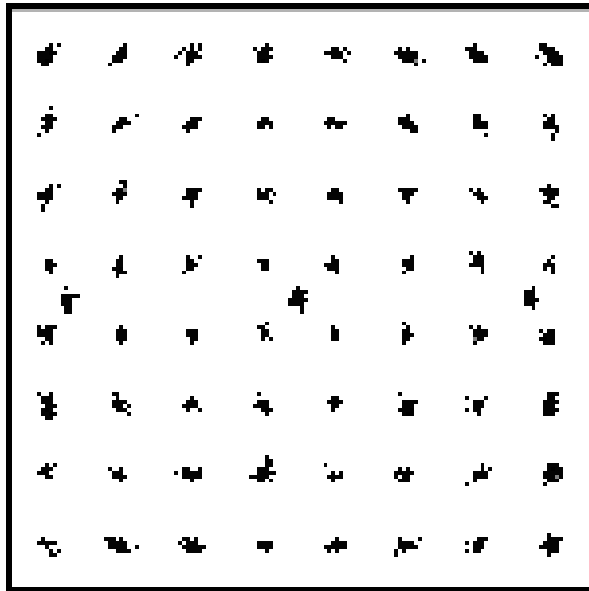


2.4GHz PA Characteristics

64-QAM

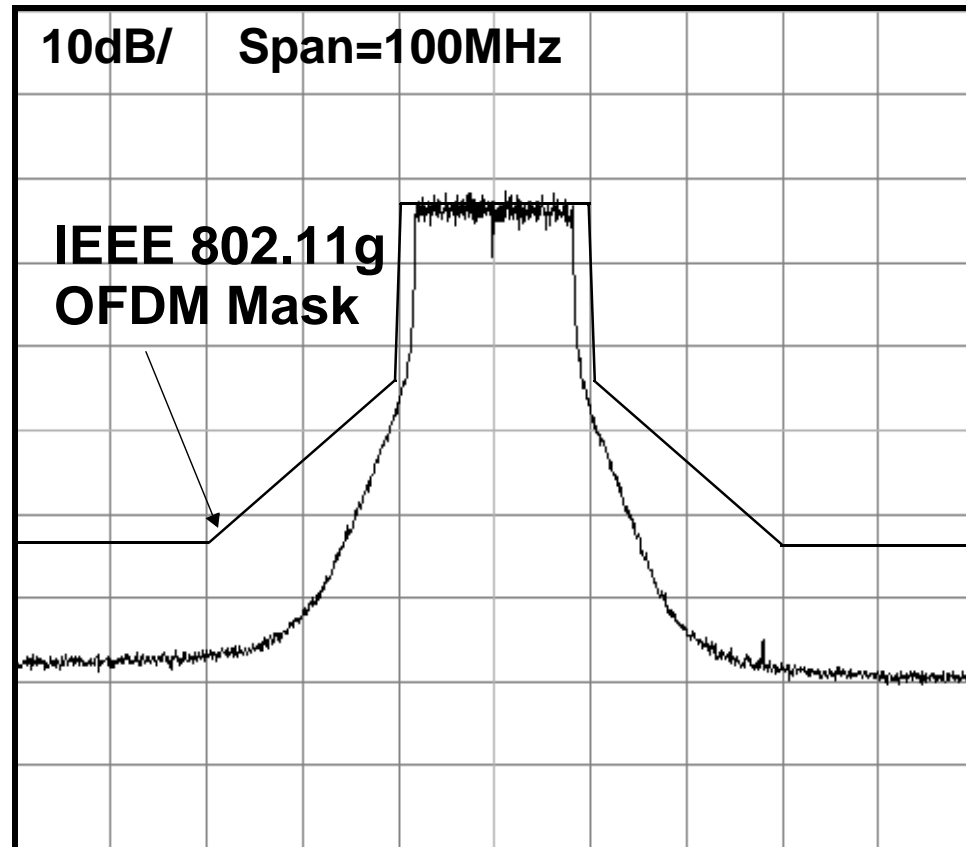


2.4GHz Transmitter Performance



EVM	-32.32 dB
Mag Error	-34.62 dB
Phase Error	1.41 deg
Rate	54 Mbps

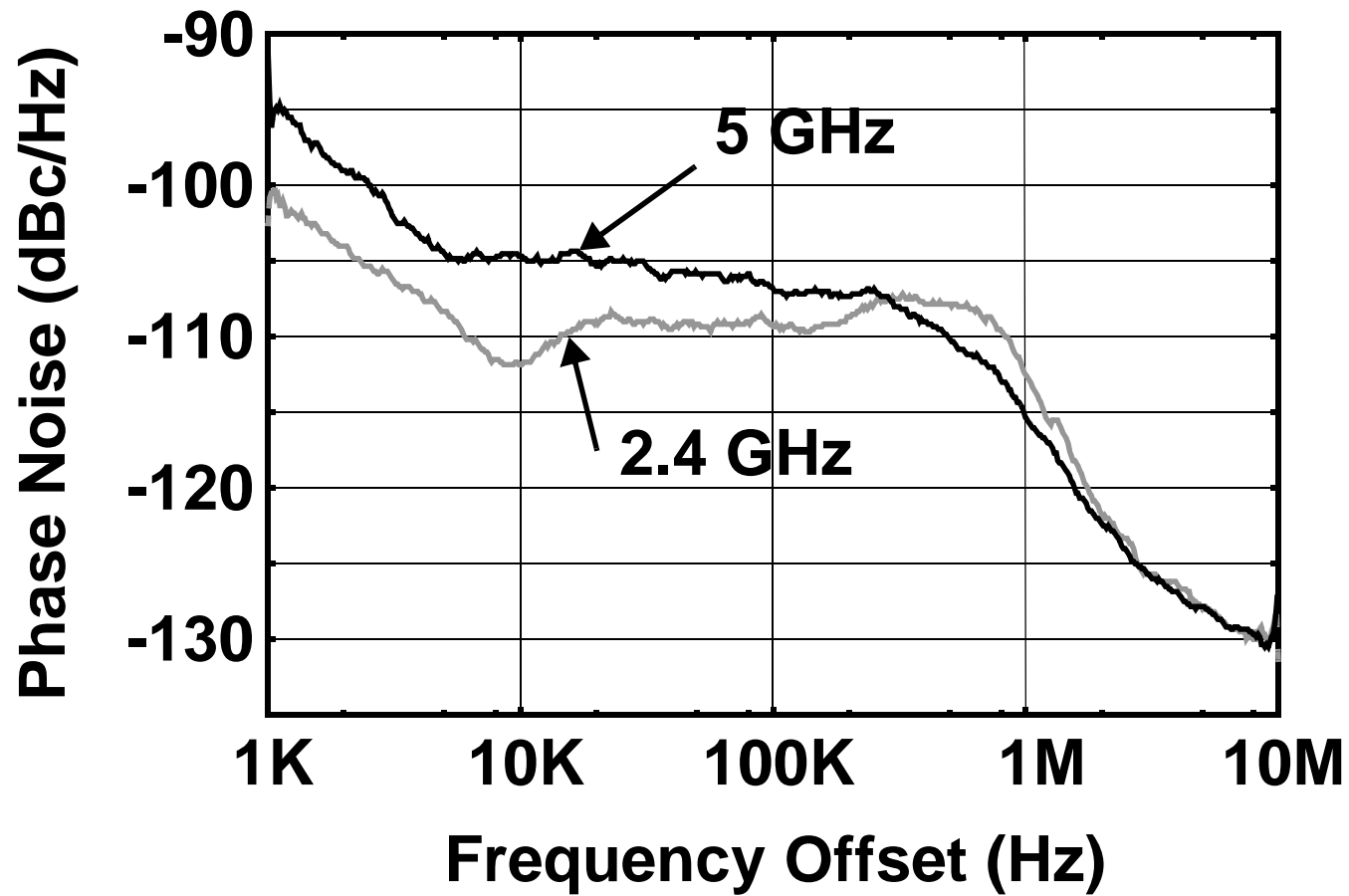
EVM @ $P_{out} = 5\text{dBm}$



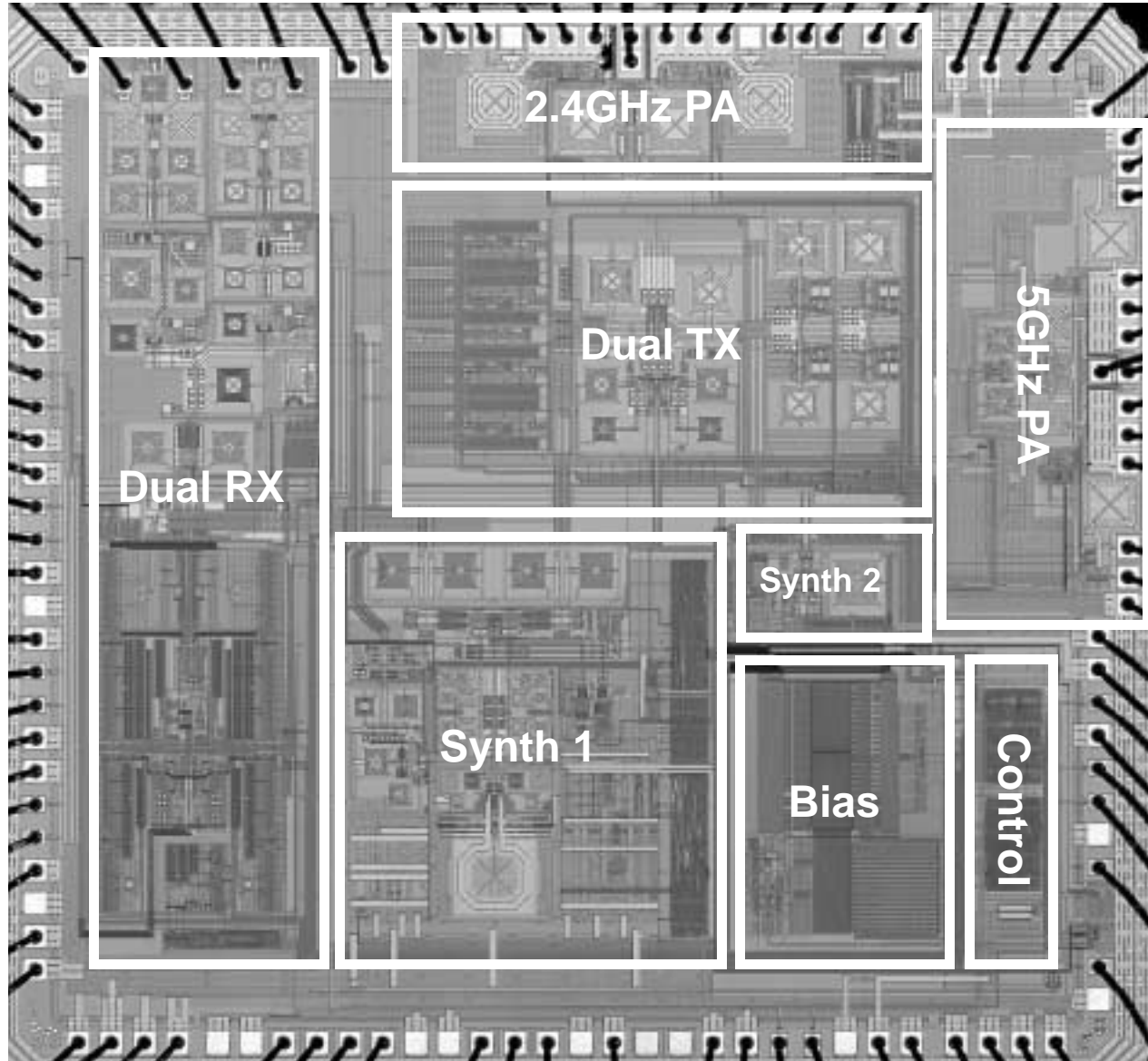
Spectral Mask

Synthesizer Phase Noise

Measured at the RF output



Die Micrograph



Measured Performance

Technology	0.25 μm CMOS, 1P5M
Transmitter Power Dissipation 2.4 GHz 5 GHz	741 mW @ Pout = 5 dBm 710 mW @ Pout = 5 dBm
Receiver Power Dissipation 2.4 GHz 5 GHz	370 mW 320 mW
TX EVM 2.4 GHz 5 GHz	-32 @ Pout = 5 dBm -30 @ Pout = 5 dBm
RX Noise Figure 2.4 GHz 5 GHz	4.5 dB 5.5 dB
Phase Noise @ 100 kHz offset 2.4 GHz 5 GHz	-109 dBc/Hz -107 dBc/Hz

Conclusions

- IEEE 802.11a/b/g radio transceiver in 0.25 μm standard CMOS
- No external filters
- Sharing of the blocks between the 2.4 and 5GHz modes of operation: reduced die size
- Integrates:
 - Dual-band Receiver
 - 4.5/5.5dB noise figure for 2.4/5 GHz
 - Dual-band Transmitter
 - -32/-30dB EVM @ $P_{\text{out}}=5\text{dBm}$ for 2.4/5 GHz
 - Frequency Synthesizers
 - -109/-107 dBc/Hz @ 100KHz offset for 2.4/5GHz

Acknowledgements

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