Direct-Conversion WCDMA Transmitter with −163dBc/Hz Noise at 190MHz Offset

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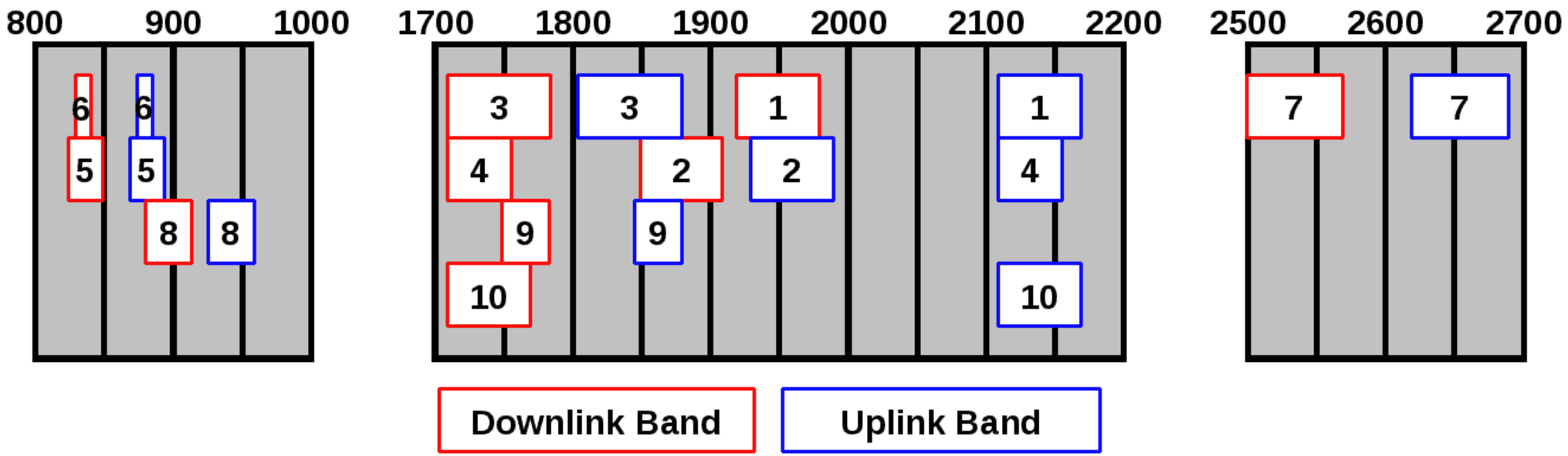
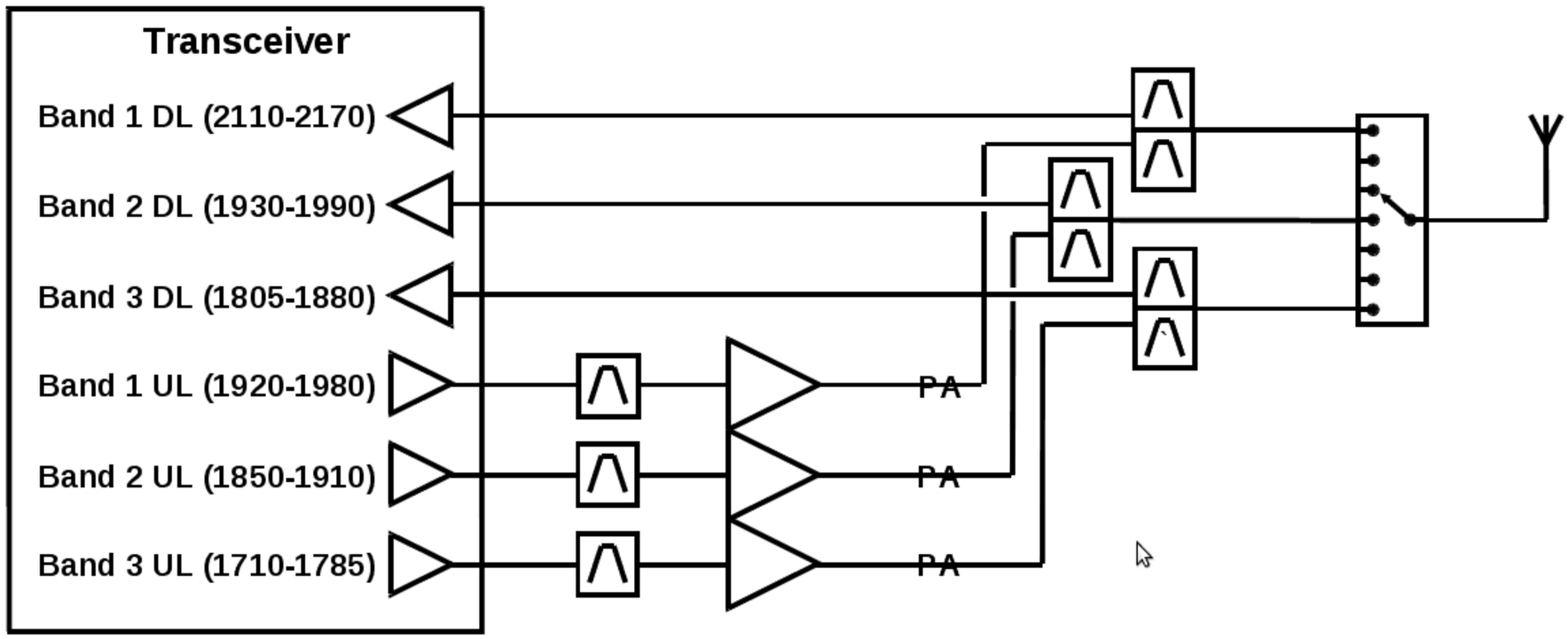
WCDMA Spectrum Available



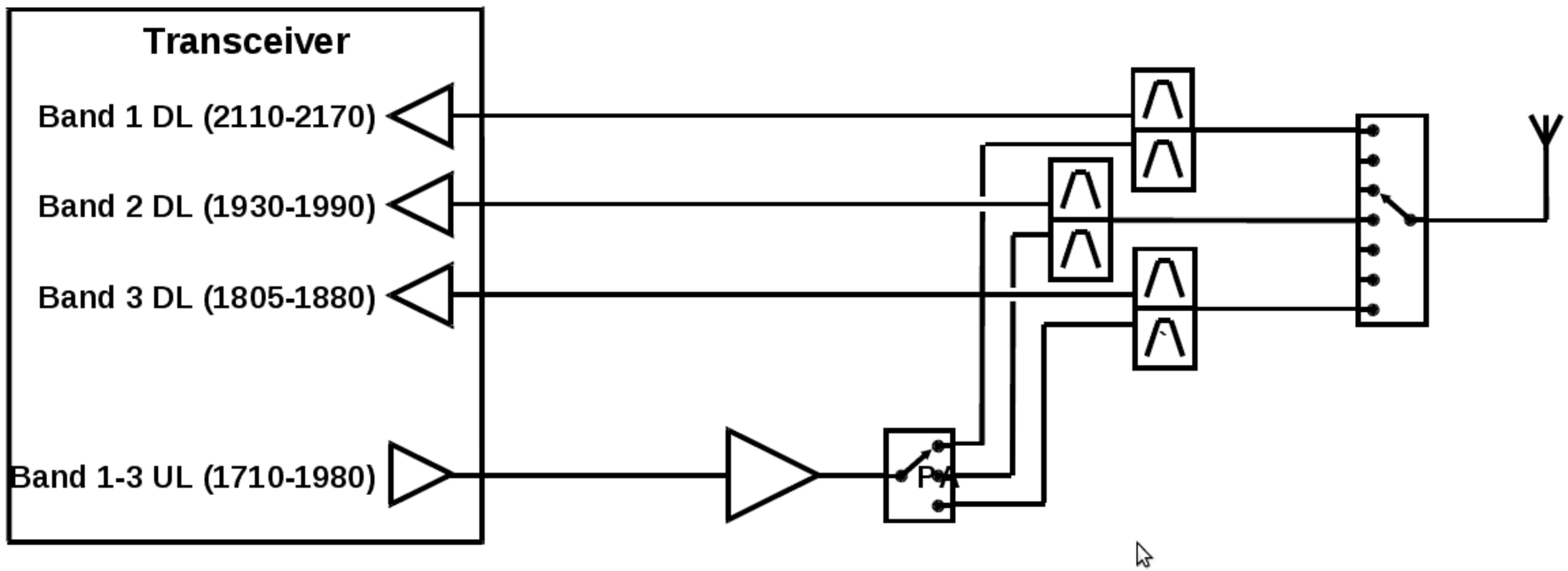
- 10 WCDMA bands now defined by 3GPP
- Most popular today is tri-band 1+2+5
- Emerging interest in bands 4/10, 3/9 and 8

Traditional Multi-Band WCDMA Front End



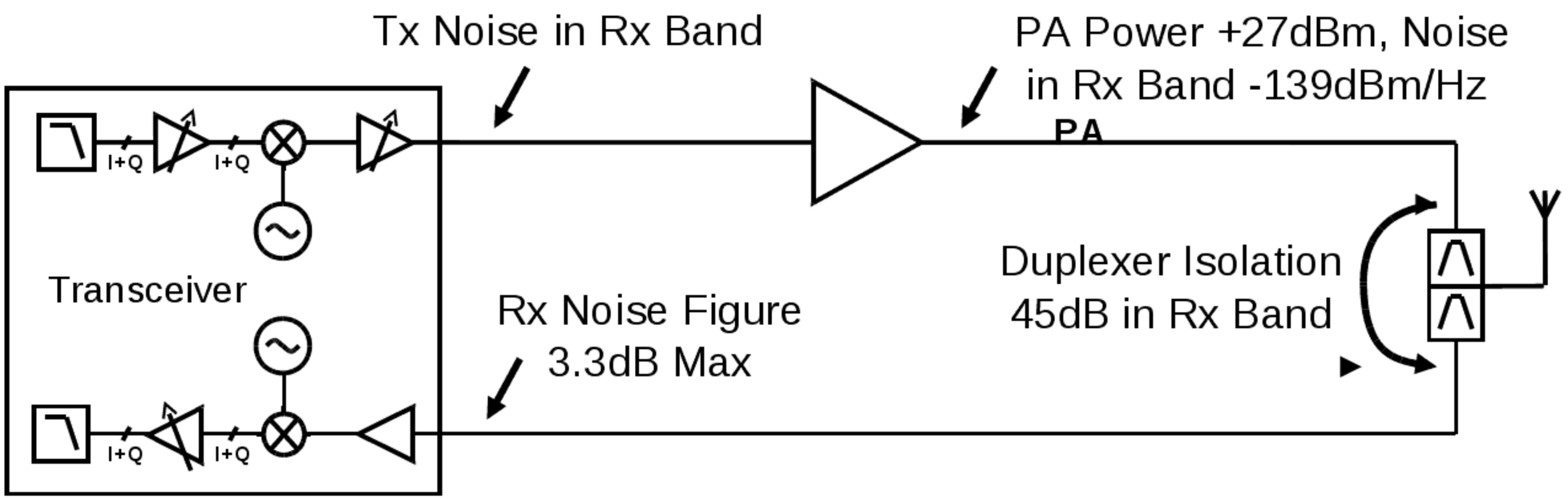
- Separate Tx SAW filters and PAs for each band
- Multi-band designs are large and expensive

Broadband Tx WCDMA Front End



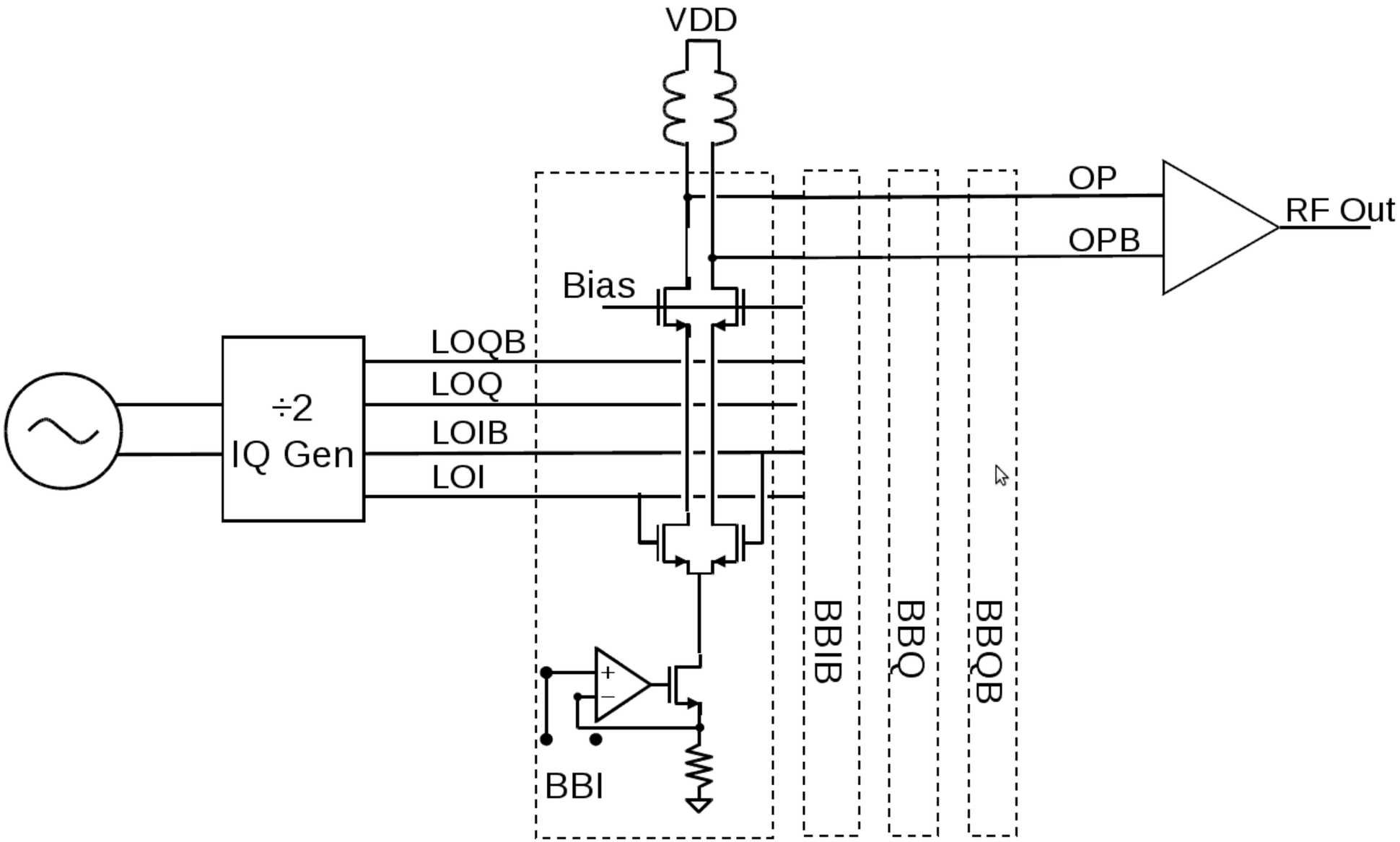
- Allows use of multi-band PAs
- Reduced incremental cost for additional bands
- Enables multi-mode PAs and tuneable filters

Tx Noise Requirement

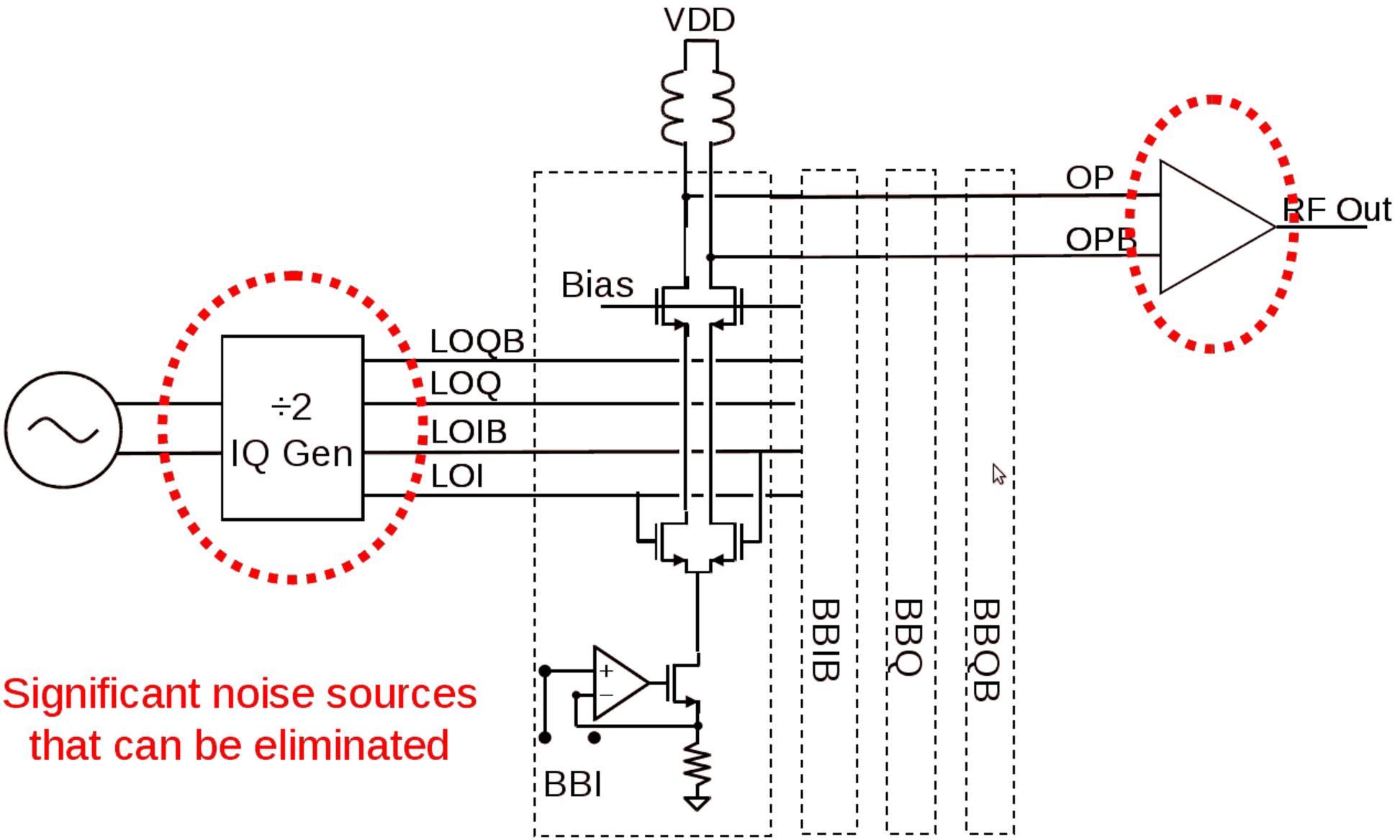


- State of the art PA has -166dBc/Hz noise in Rx band
- Duplexer trend is for smaller size not better isolation
- To keep Rx NF including Tx noise to less then 4dB need Transceiver Tx Noise in Rx Band of **-162dBc/Hz**

Conventional Homodyne Transmitter



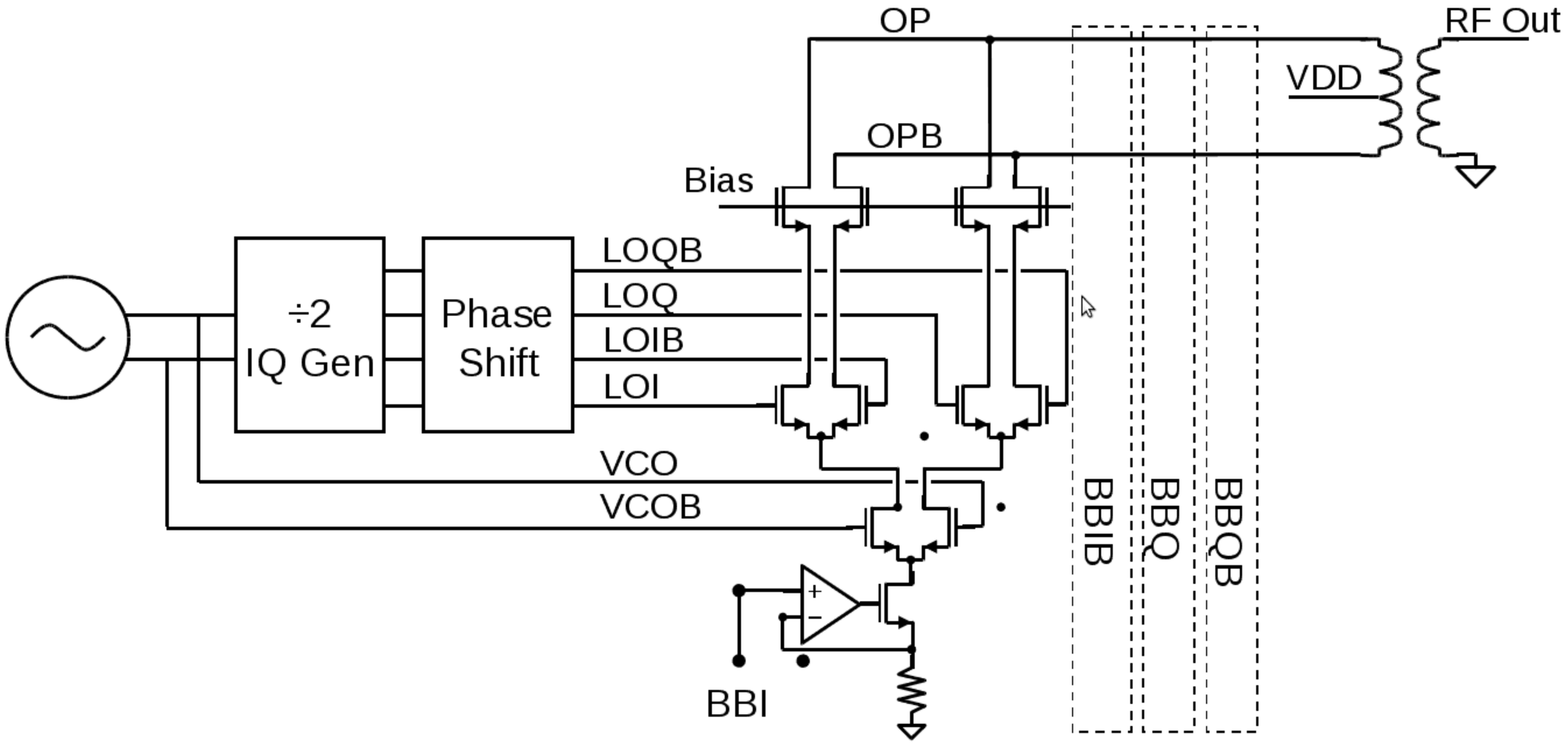
Conventional Homodyne Transmitter



Significant noise sources that can be eliminated

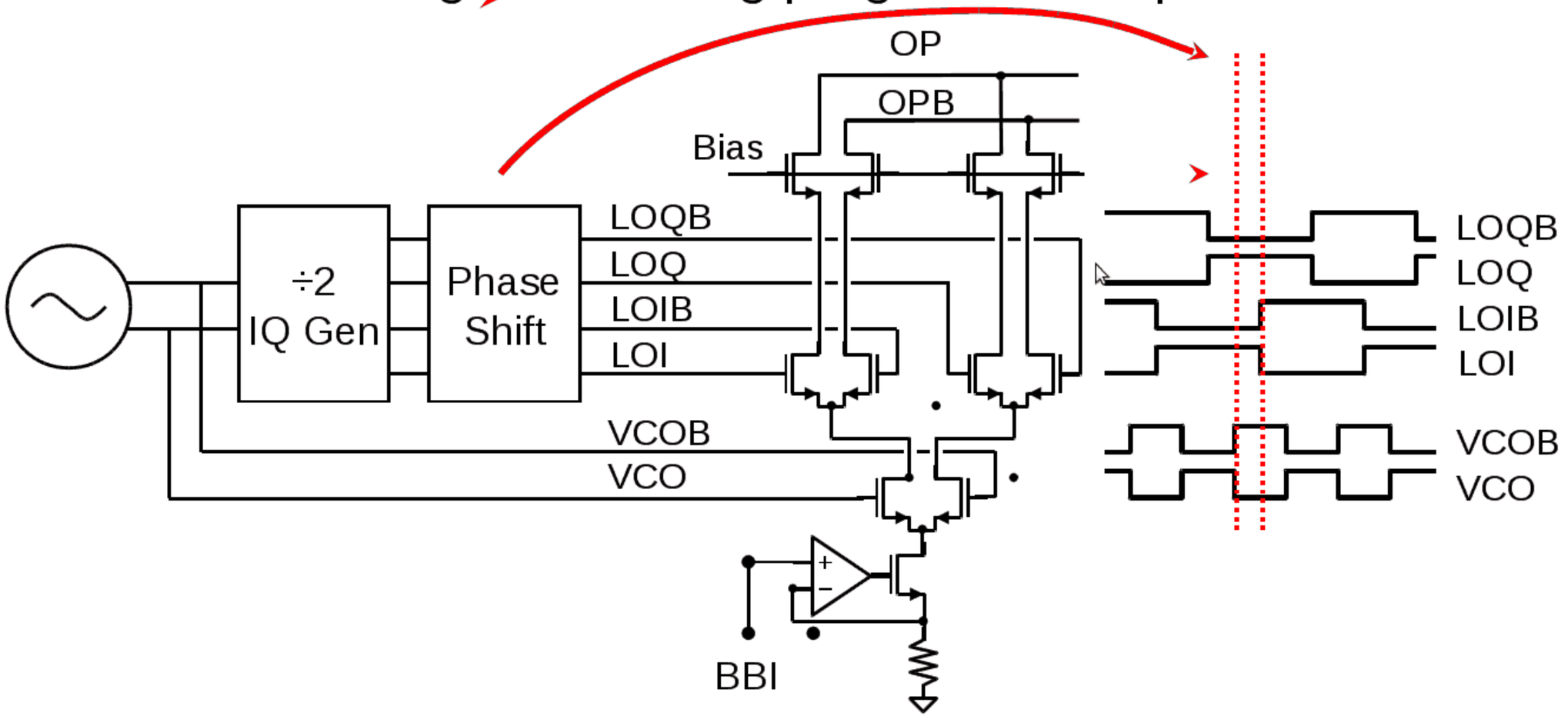
Low Noise Homodyne Modulator

- Additional VCO switch to suppress LO tree noise
- No separate driver stage

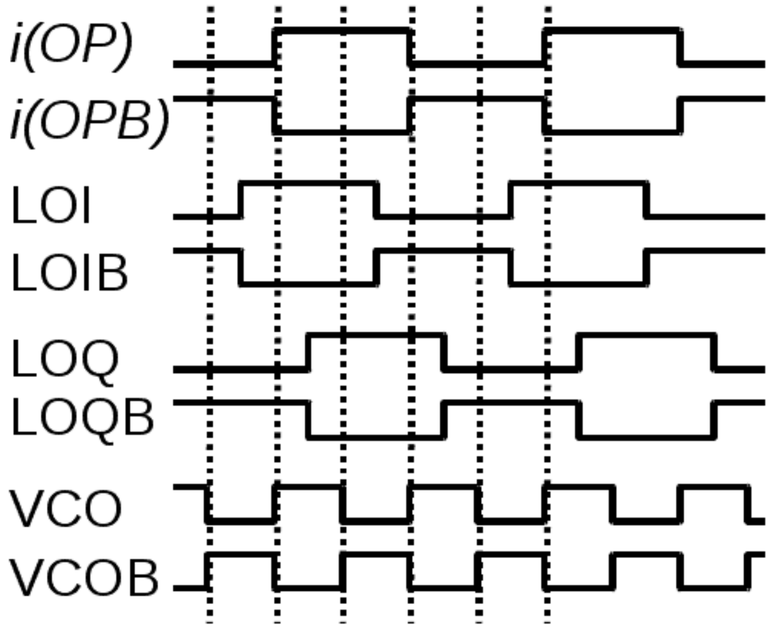


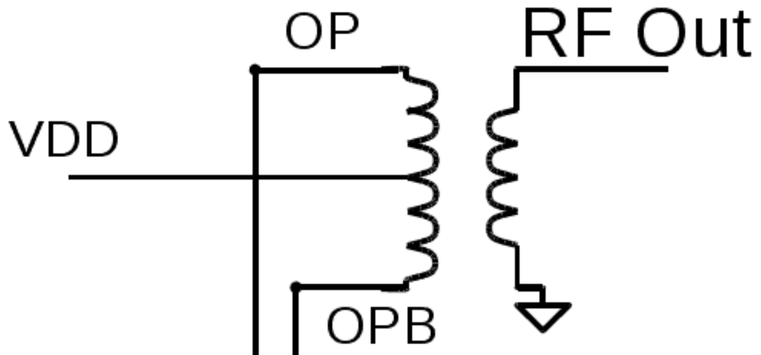
Principle of Operation

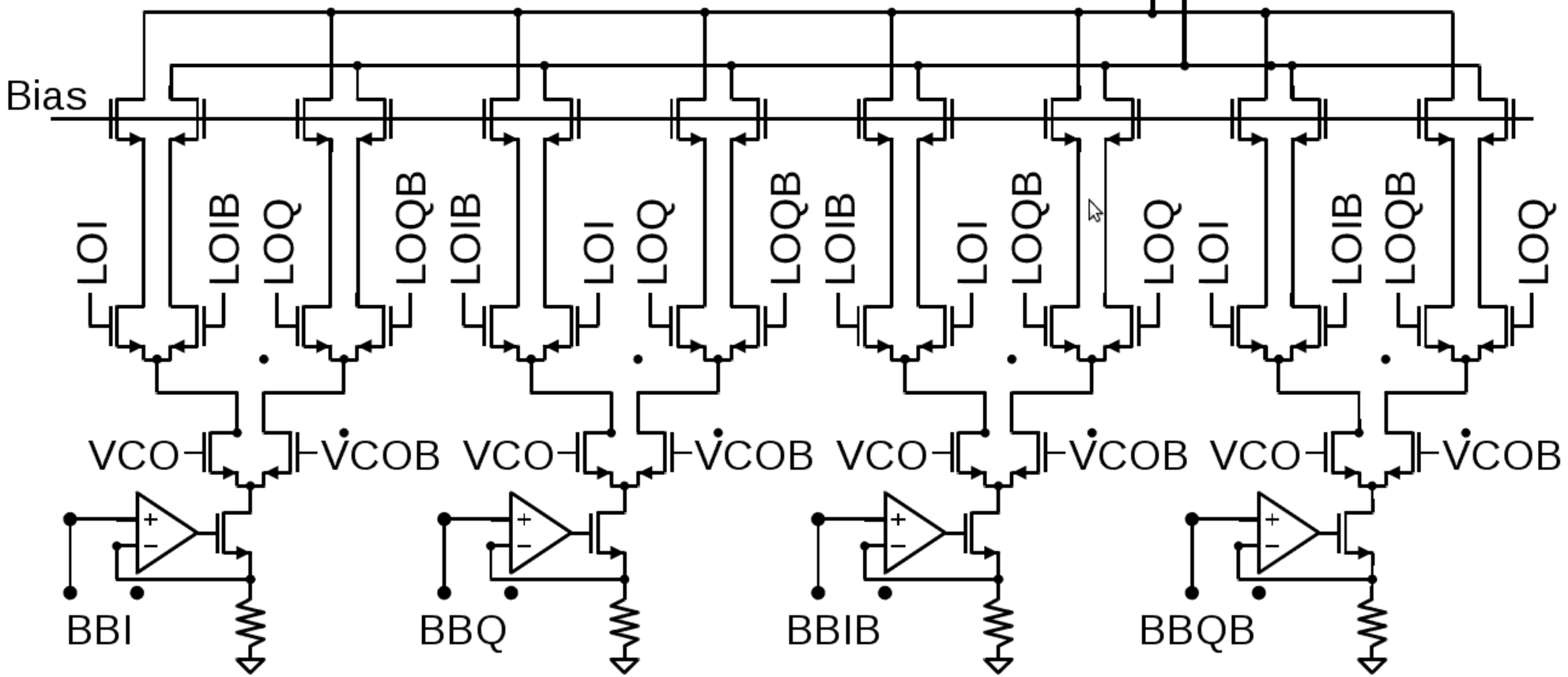
- LOI edge occurs when all current is through LOQ pair
- Align LO edge in centre of correct VCO half period
- Automatic alignment using programmable phase shift



Switching Sequence







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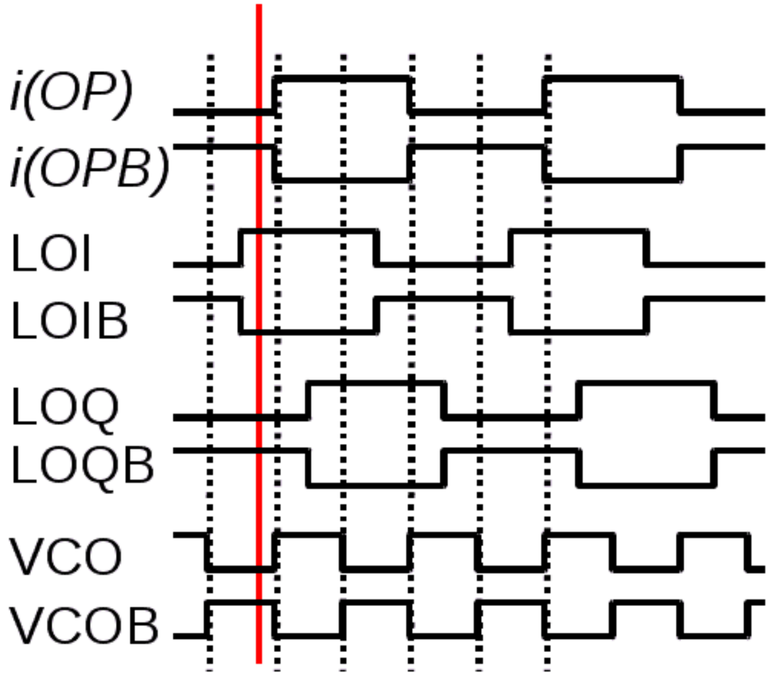

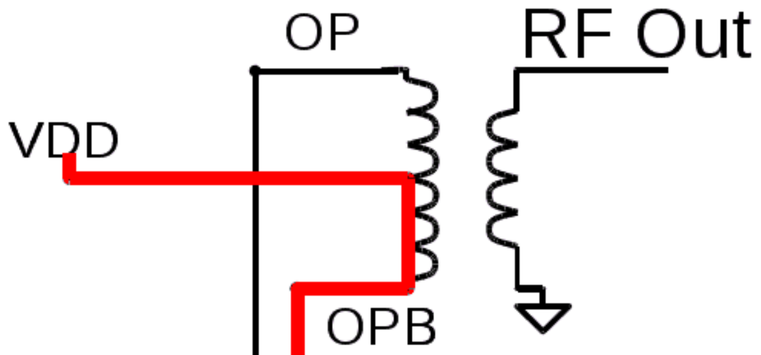

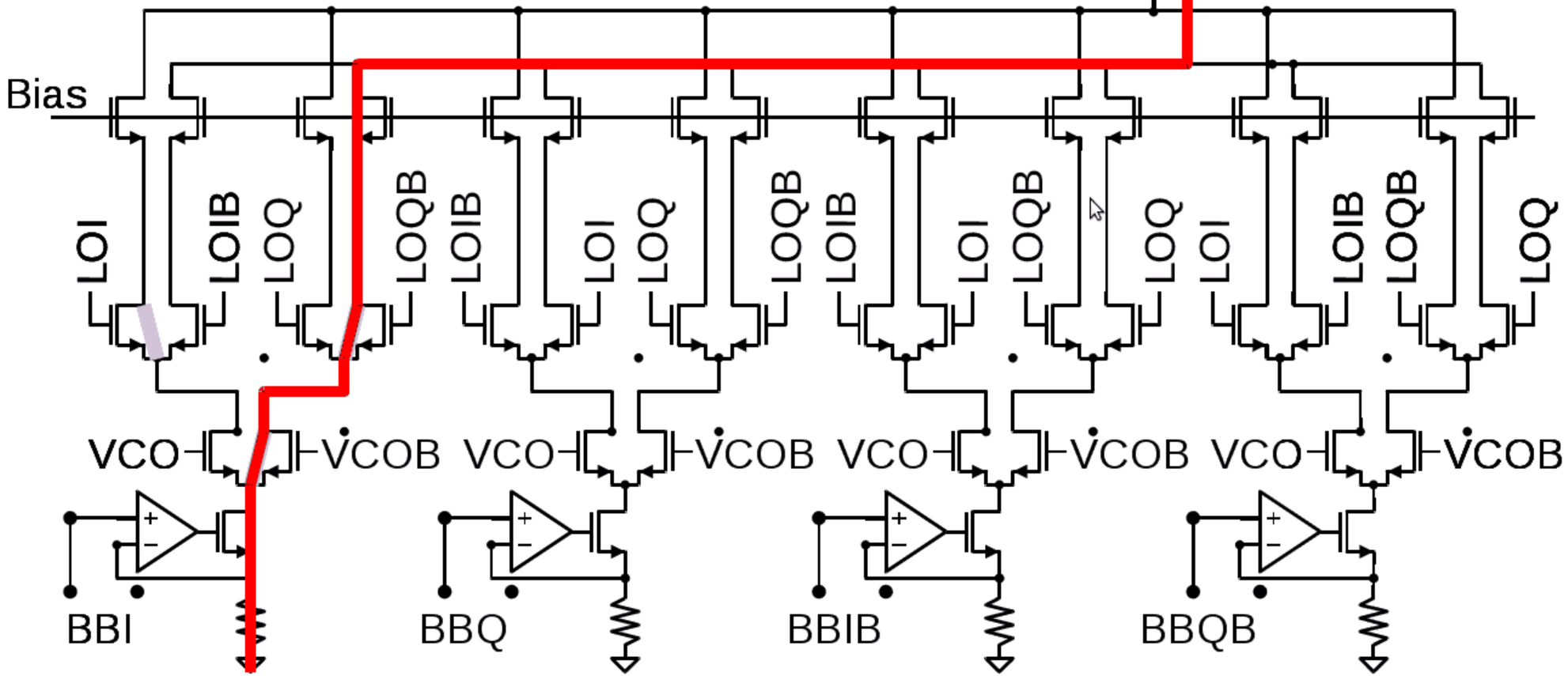

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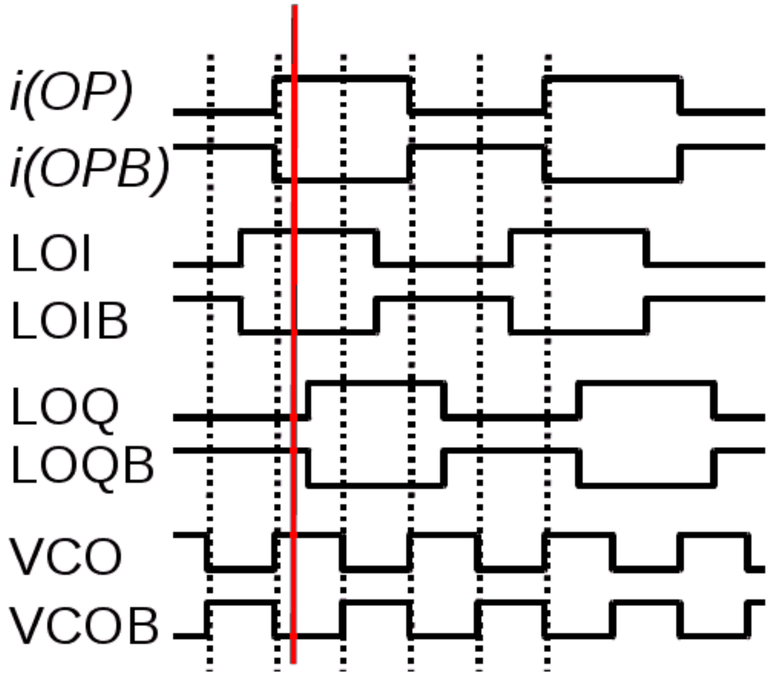

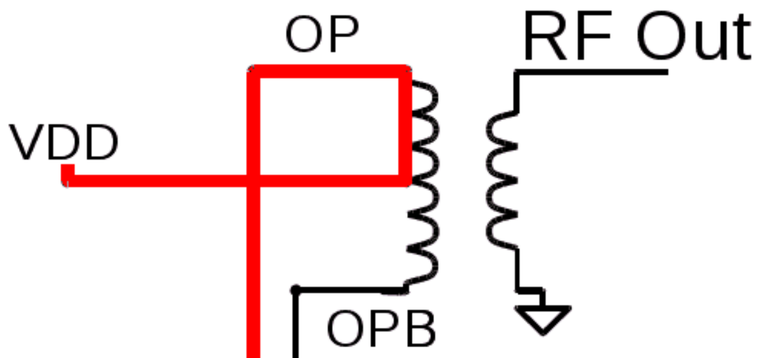

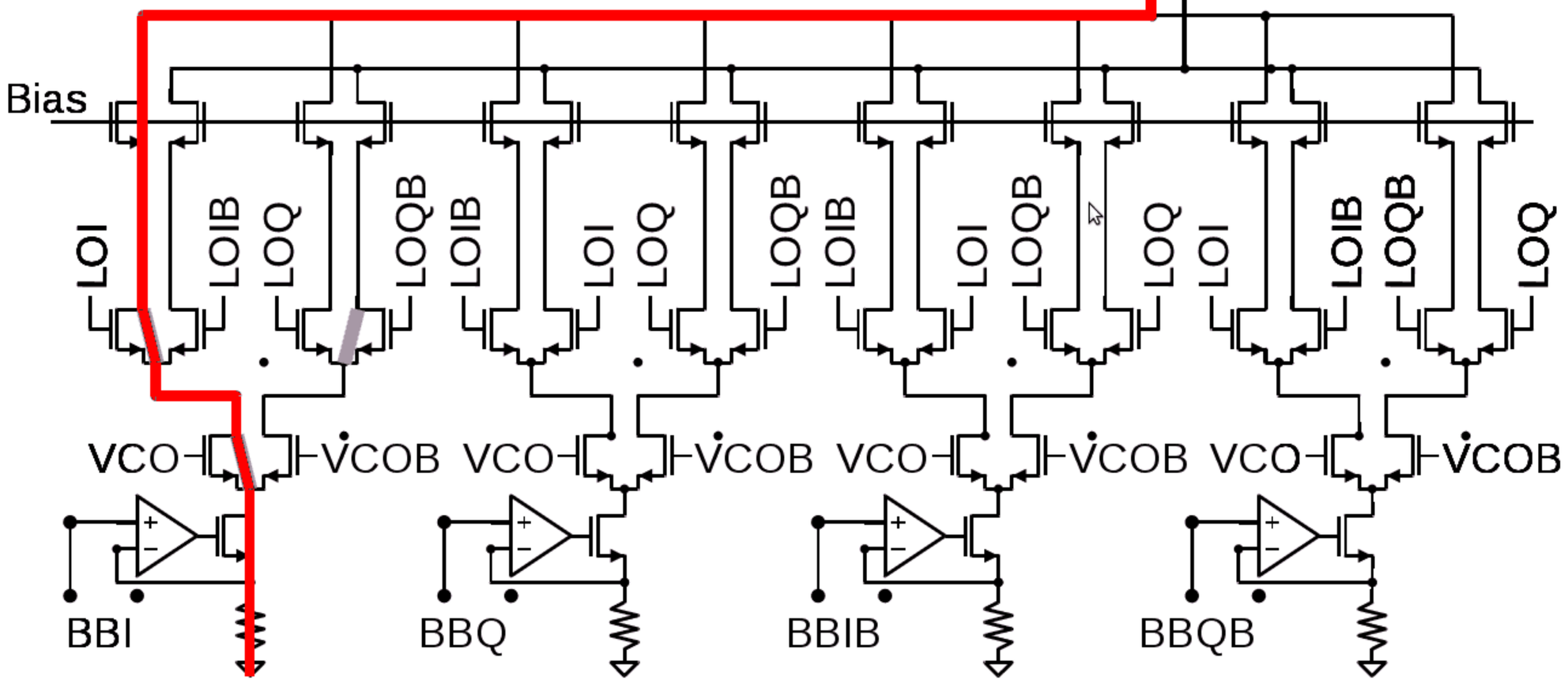

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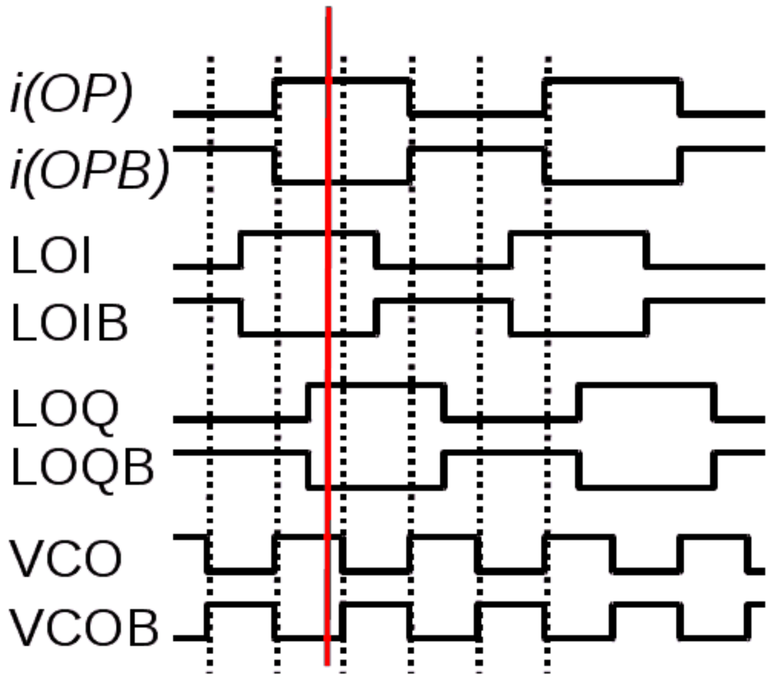

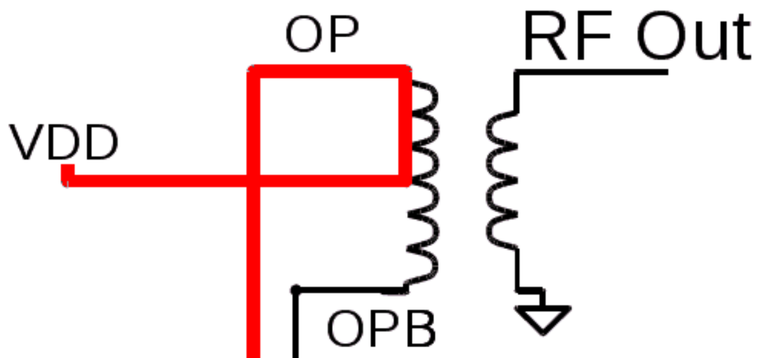

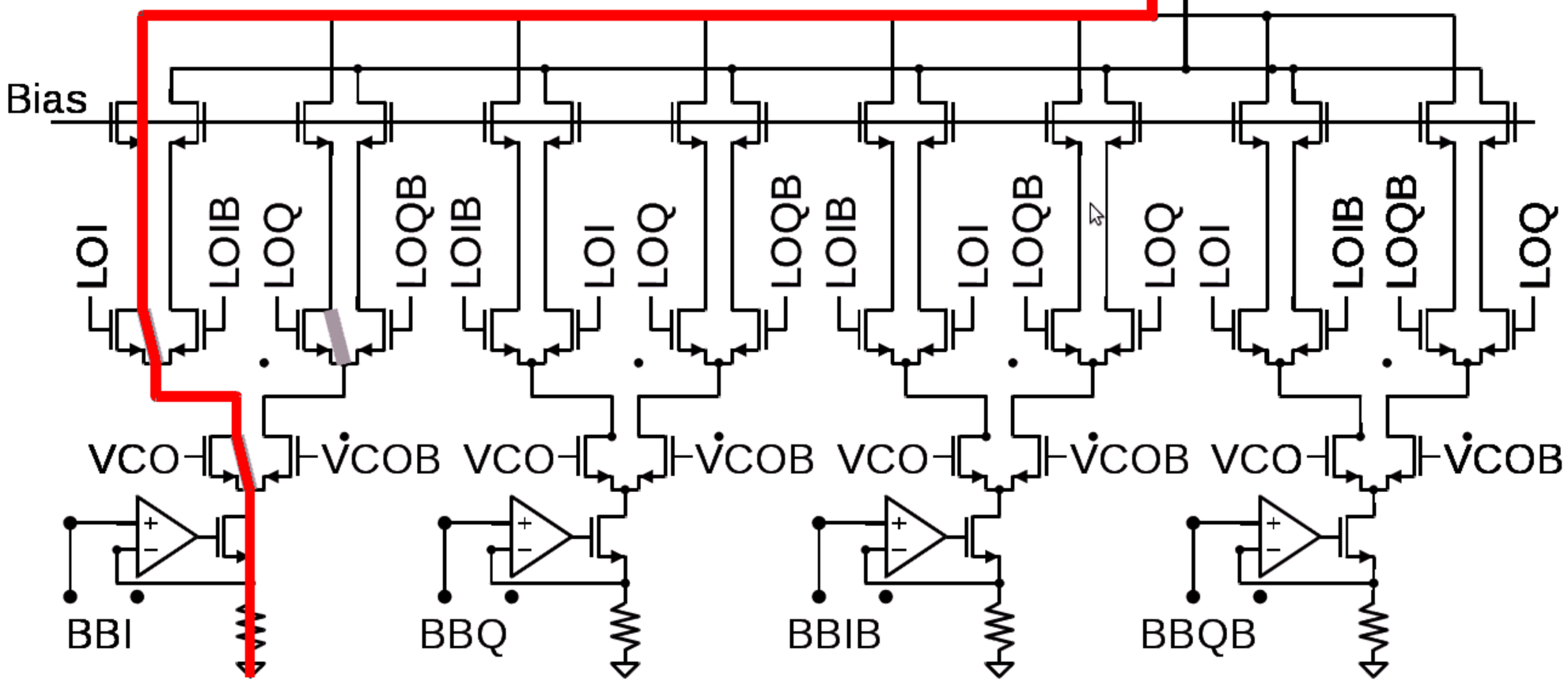

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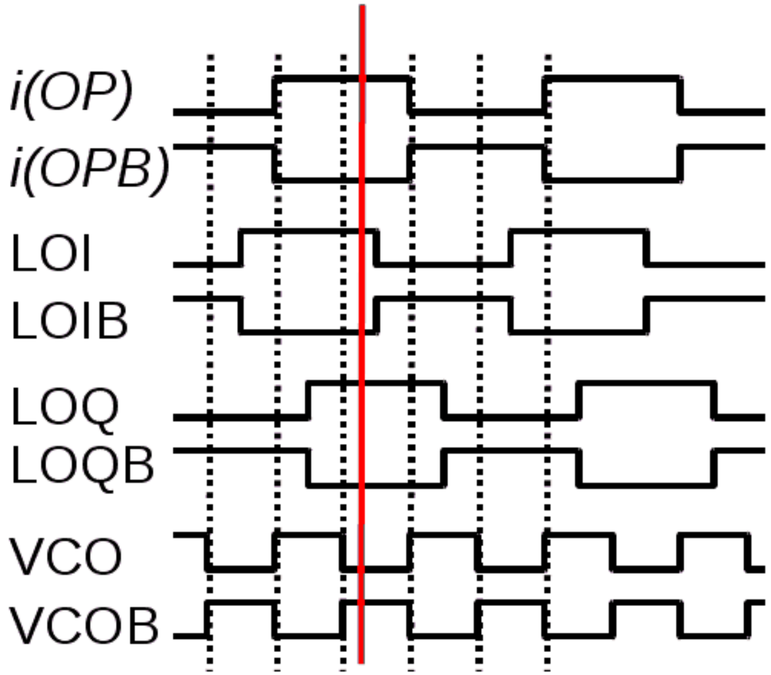

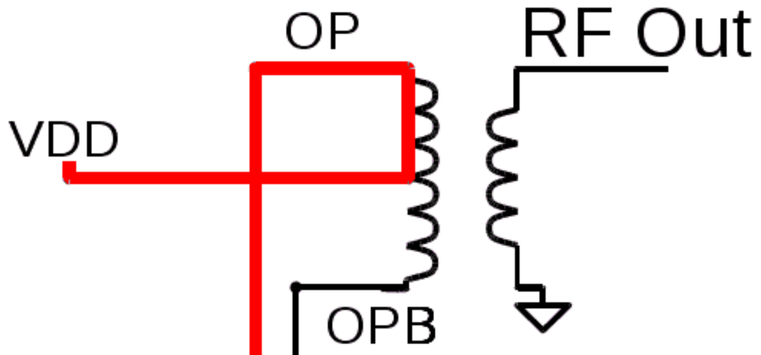

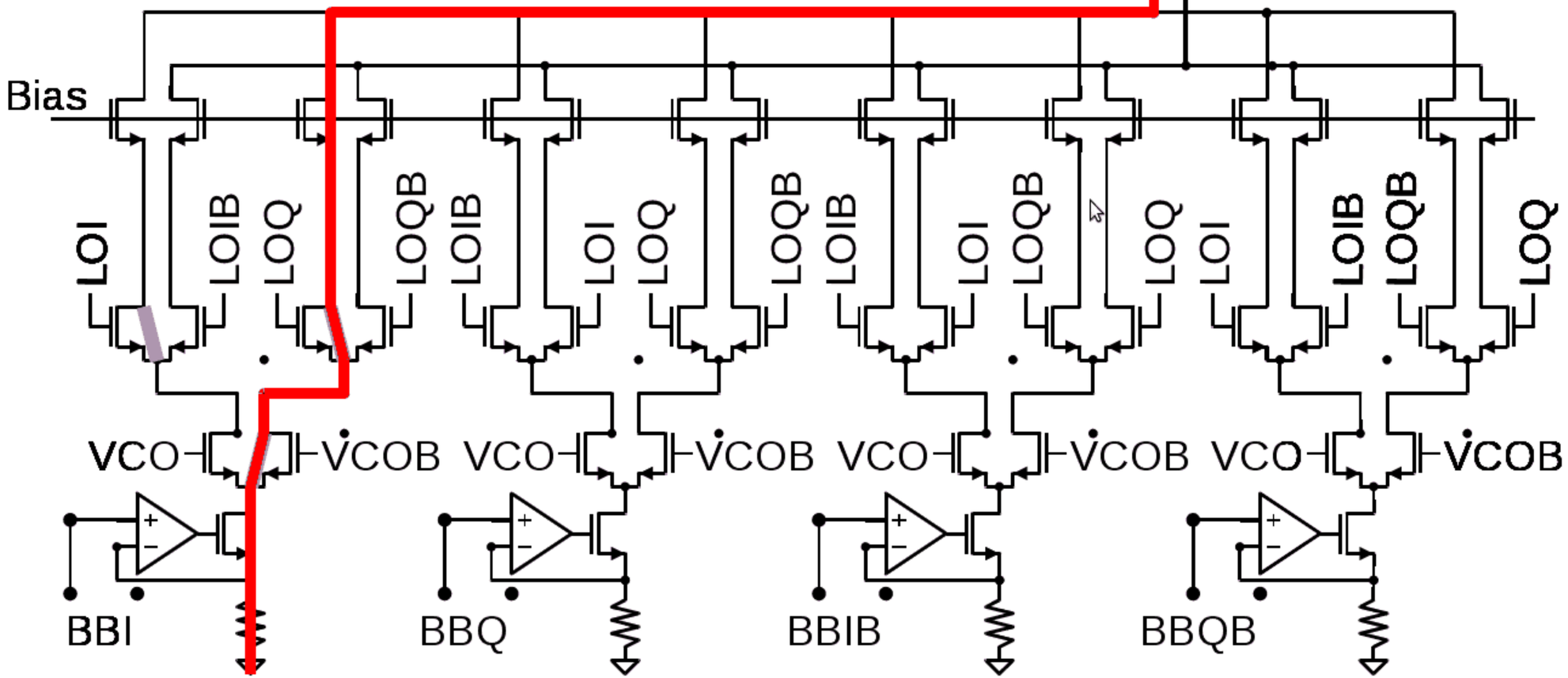

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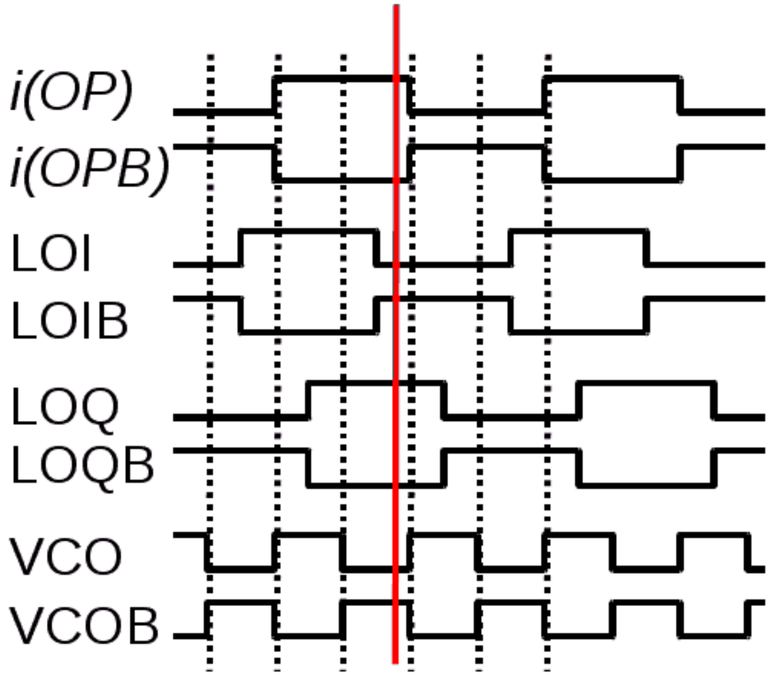

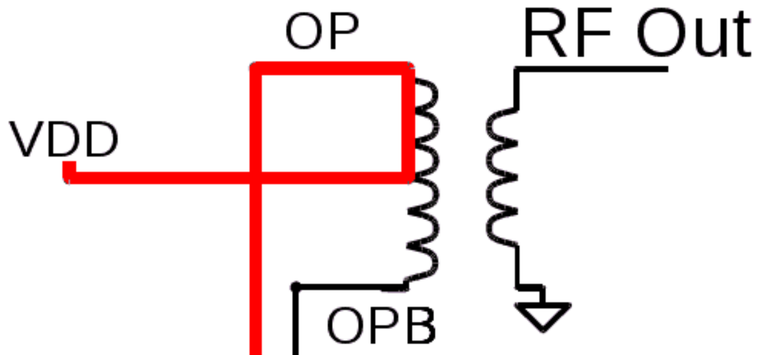

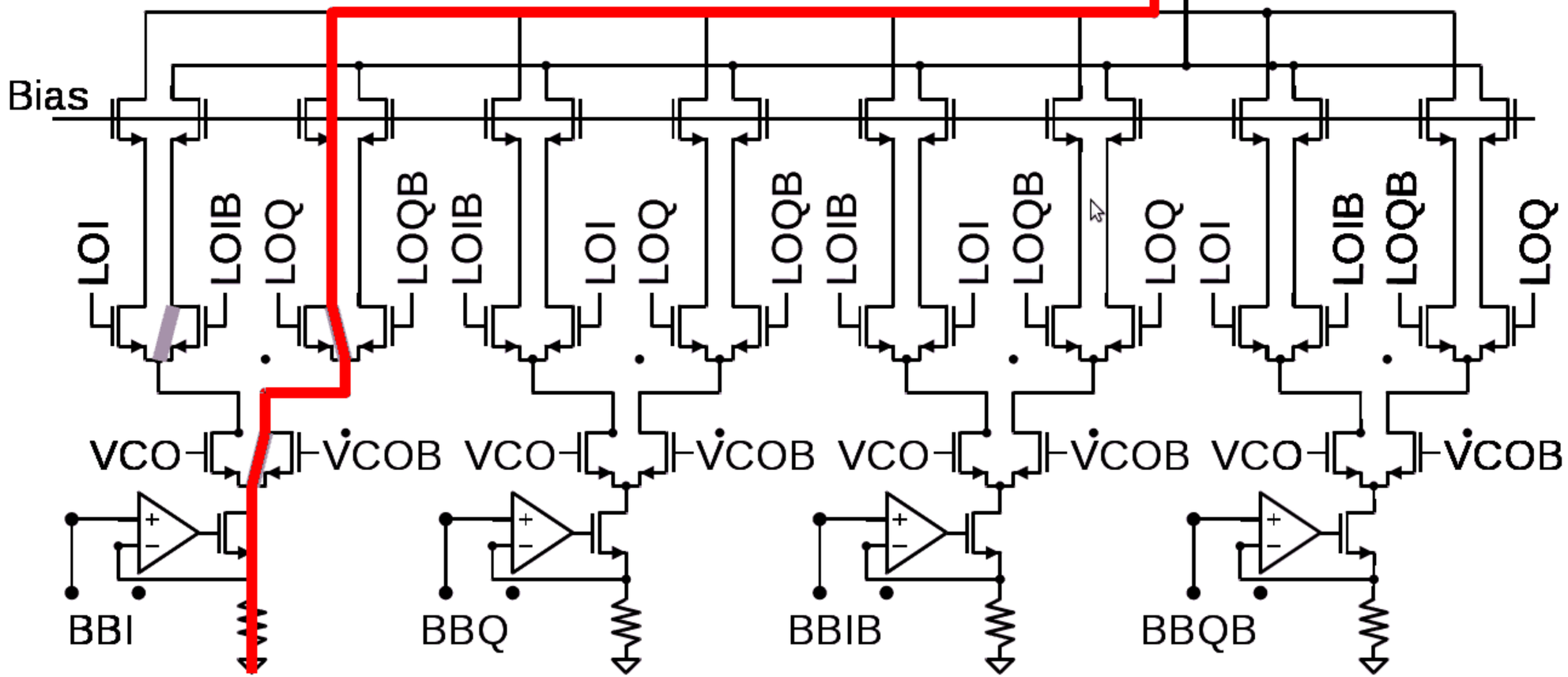

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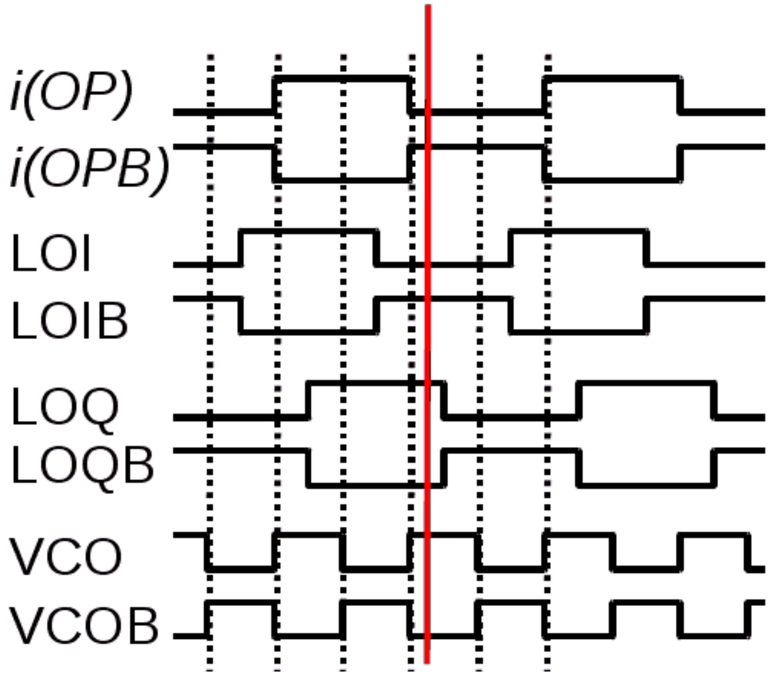

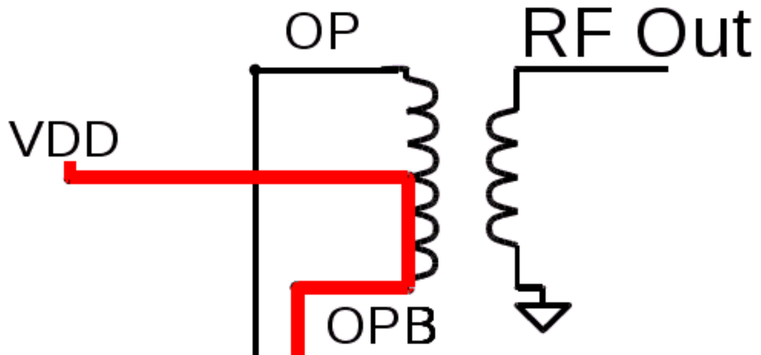

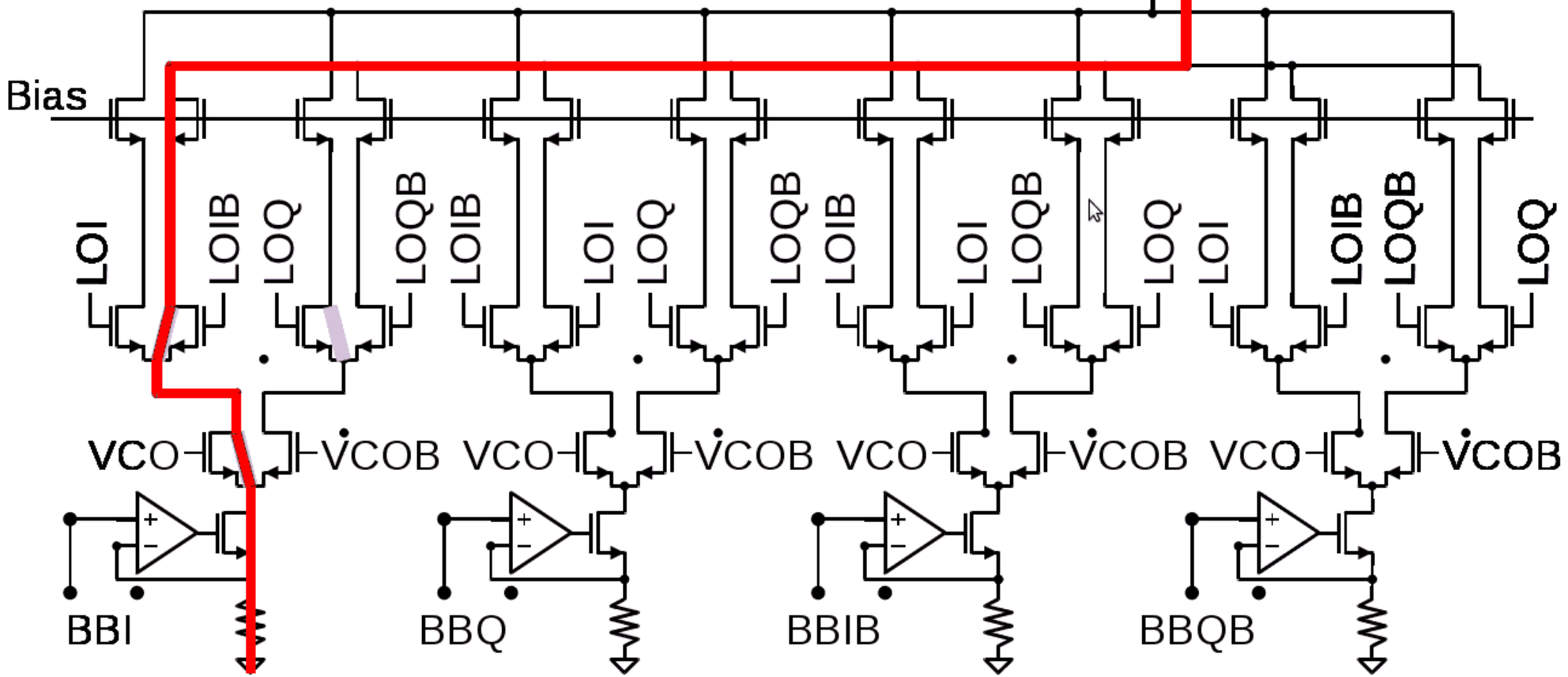

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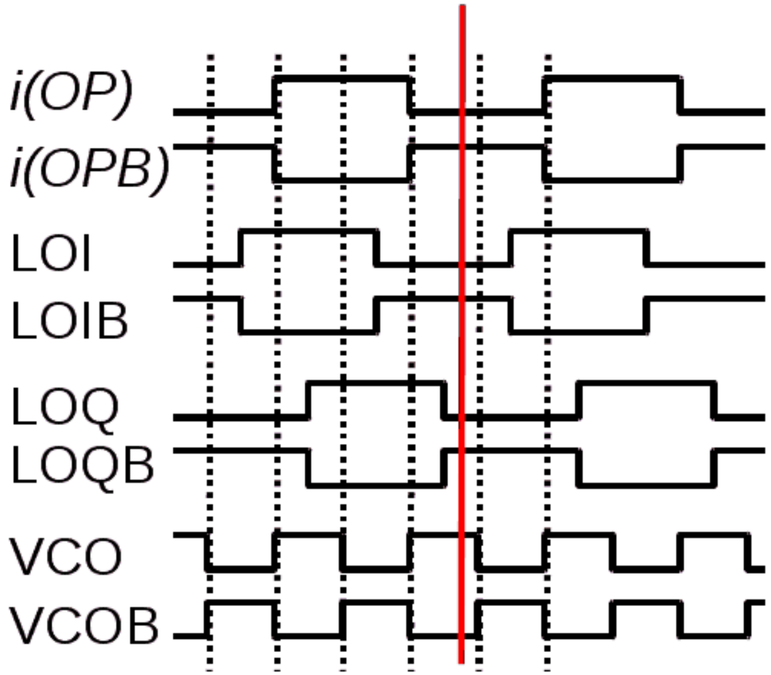

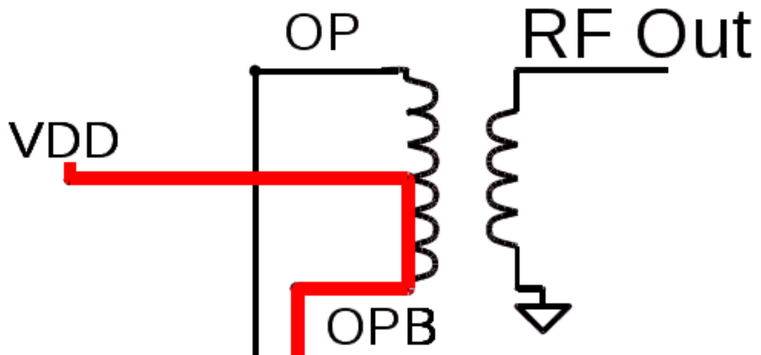

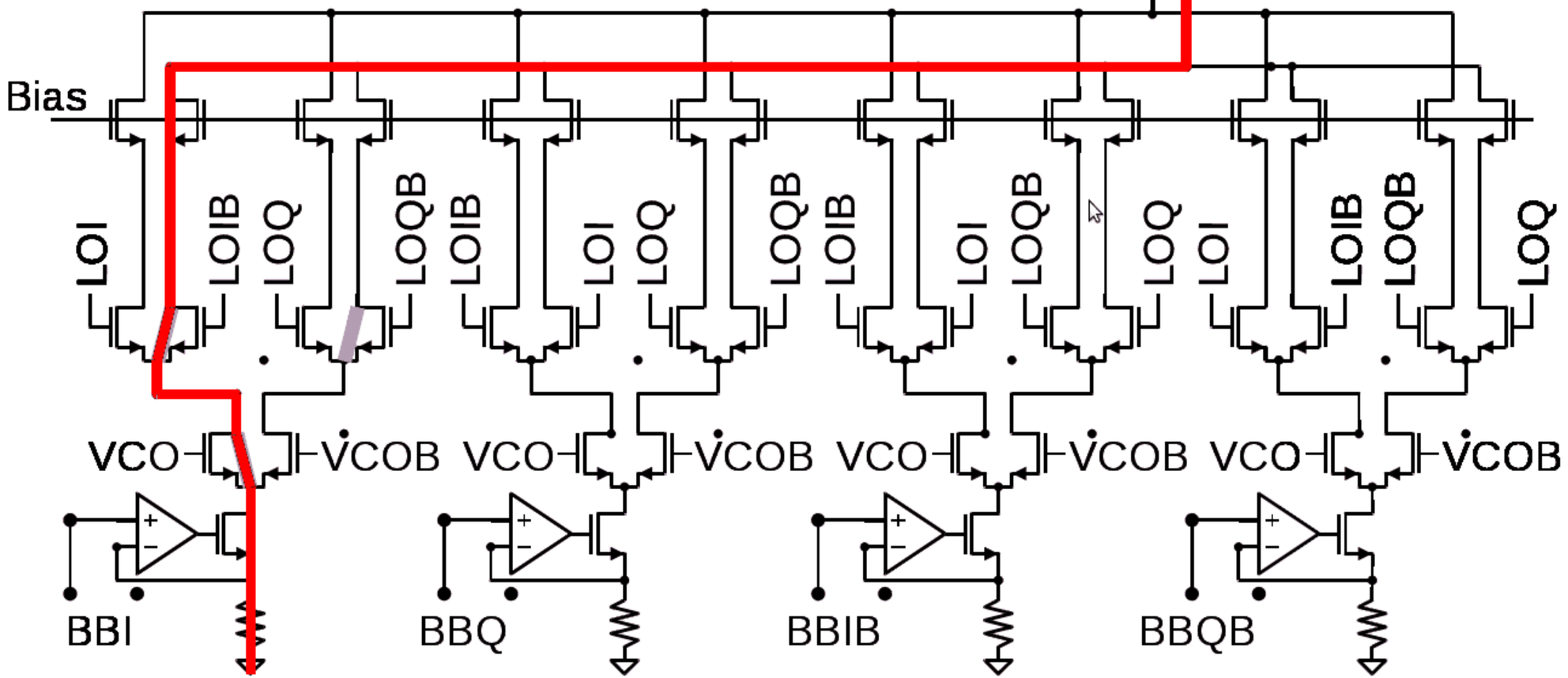

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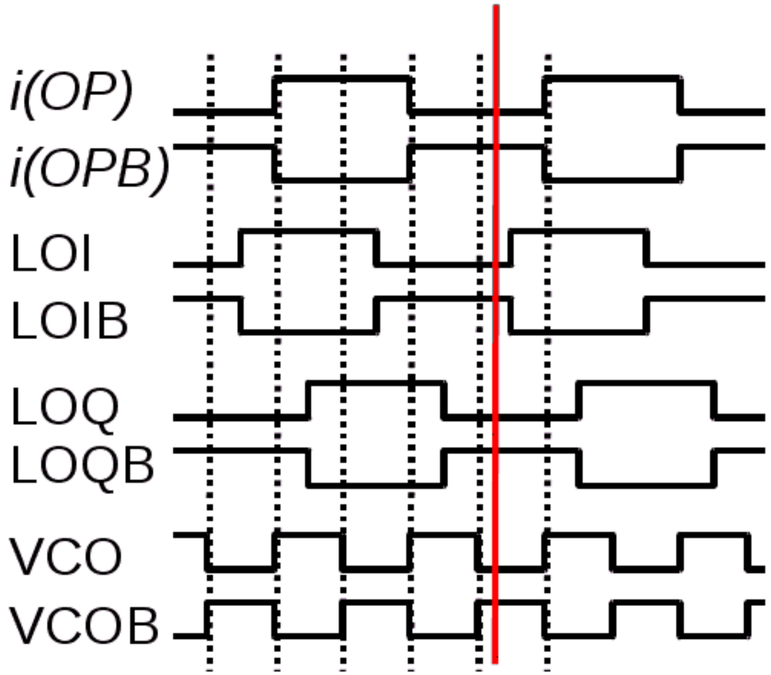

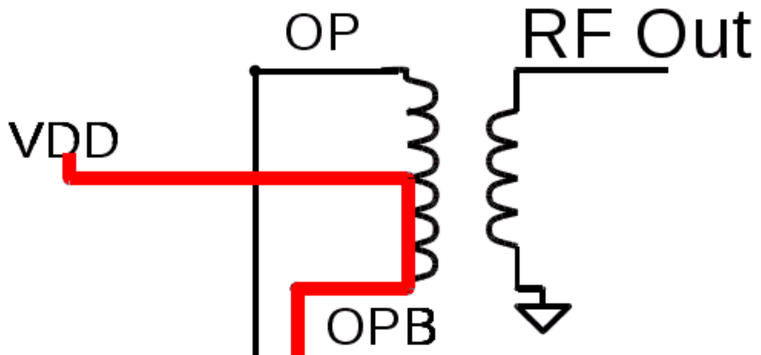

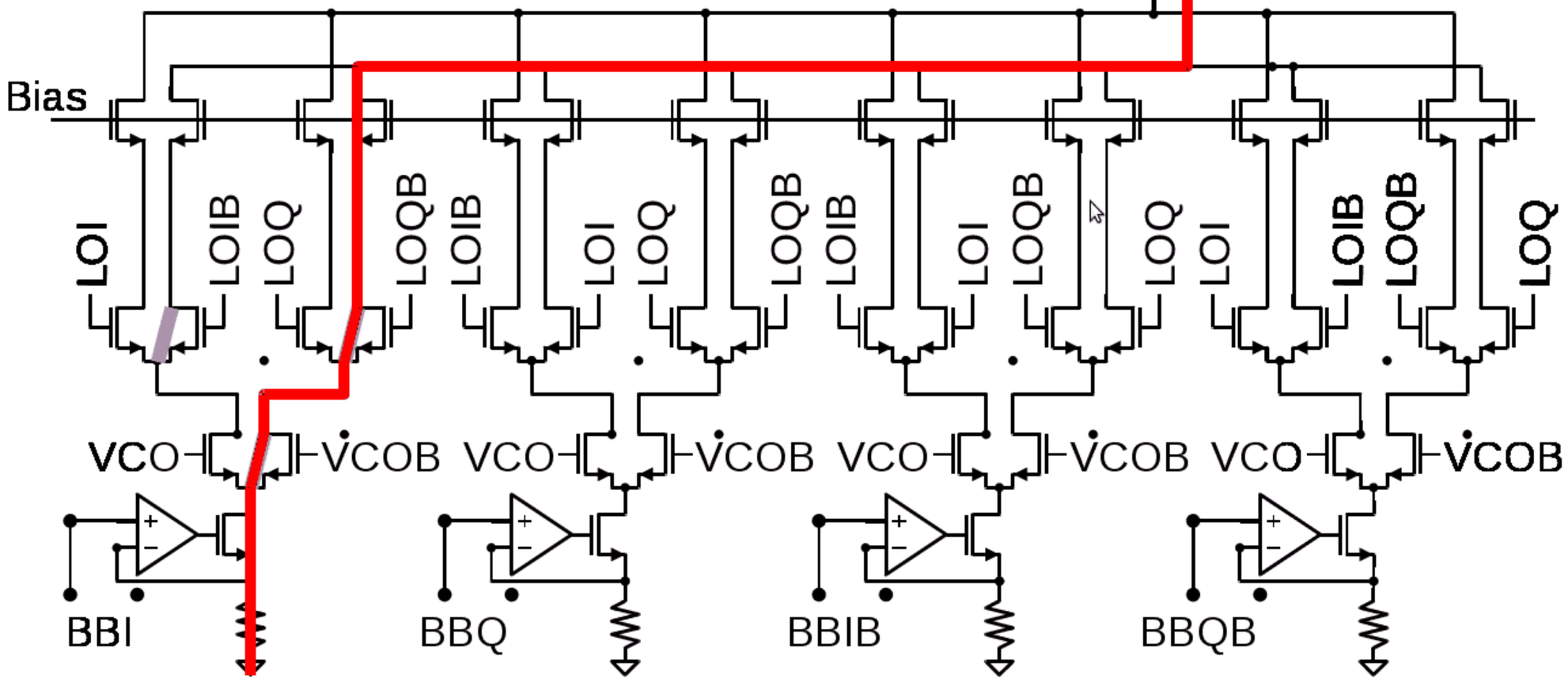

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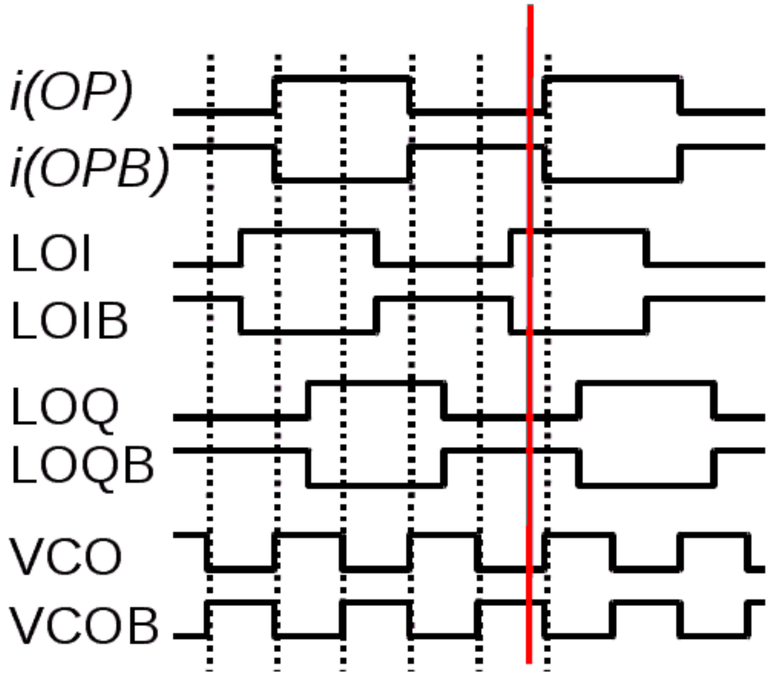
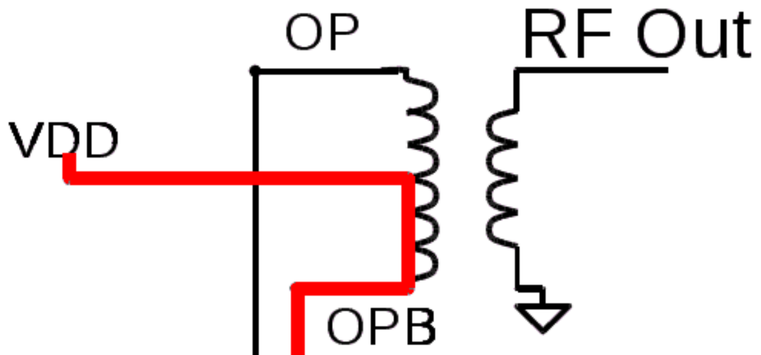
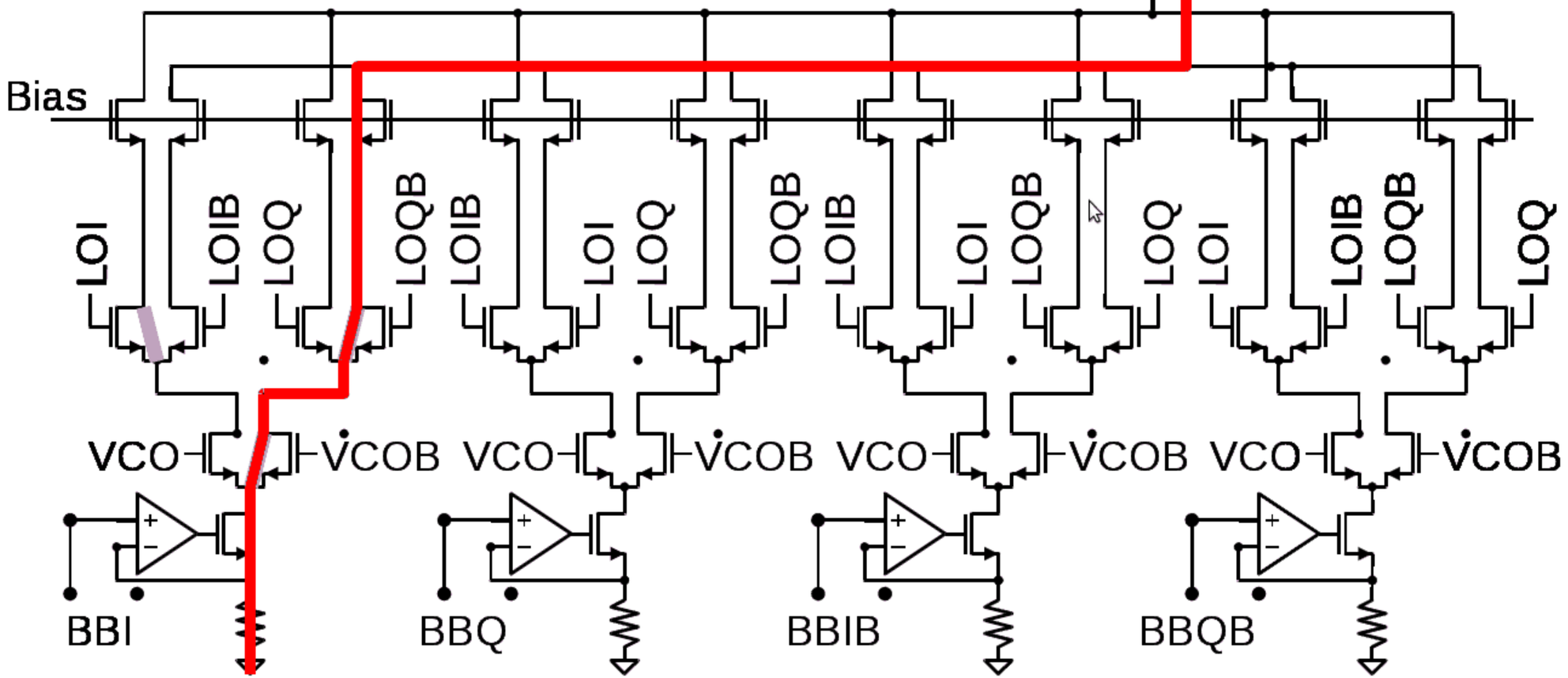
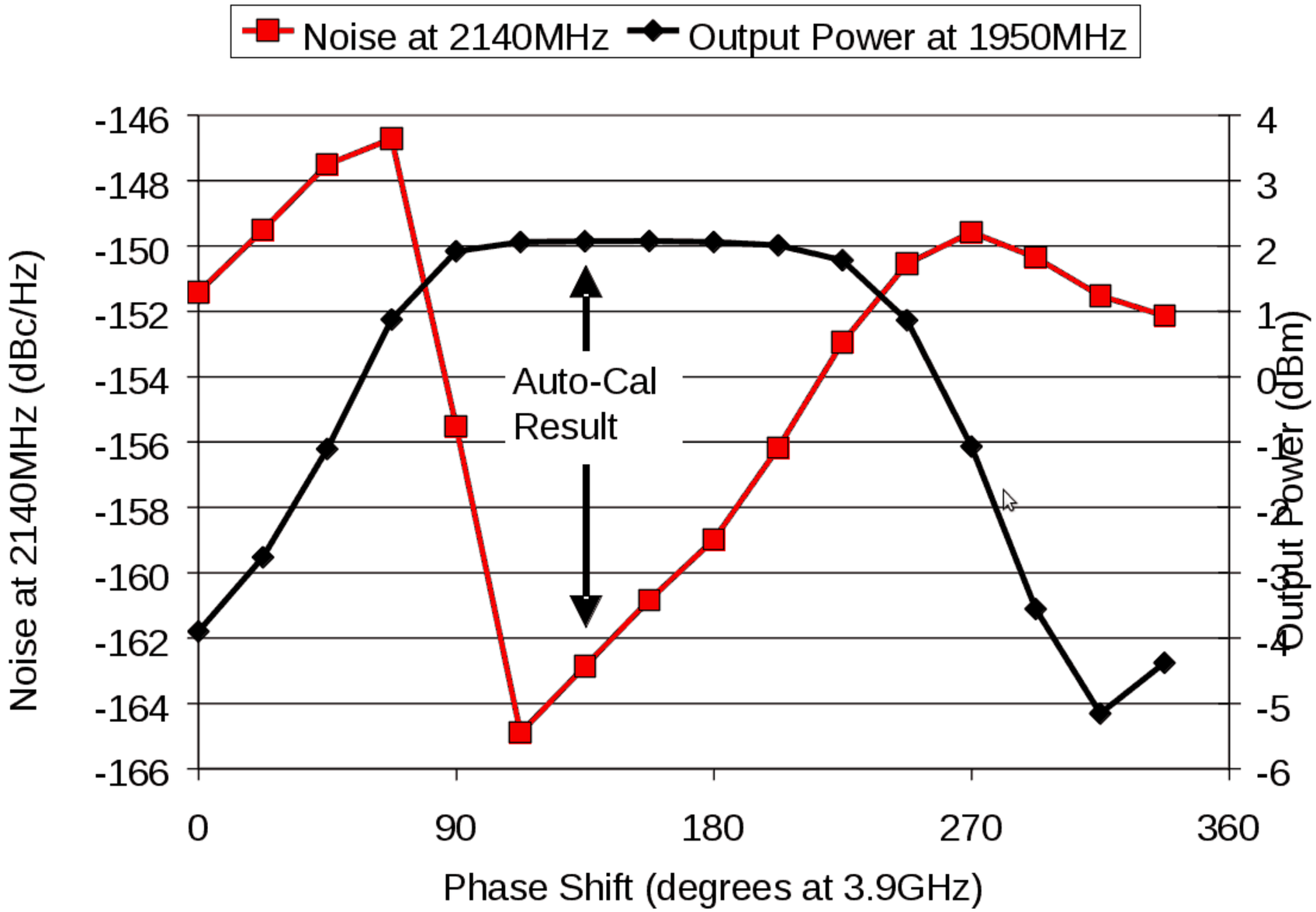


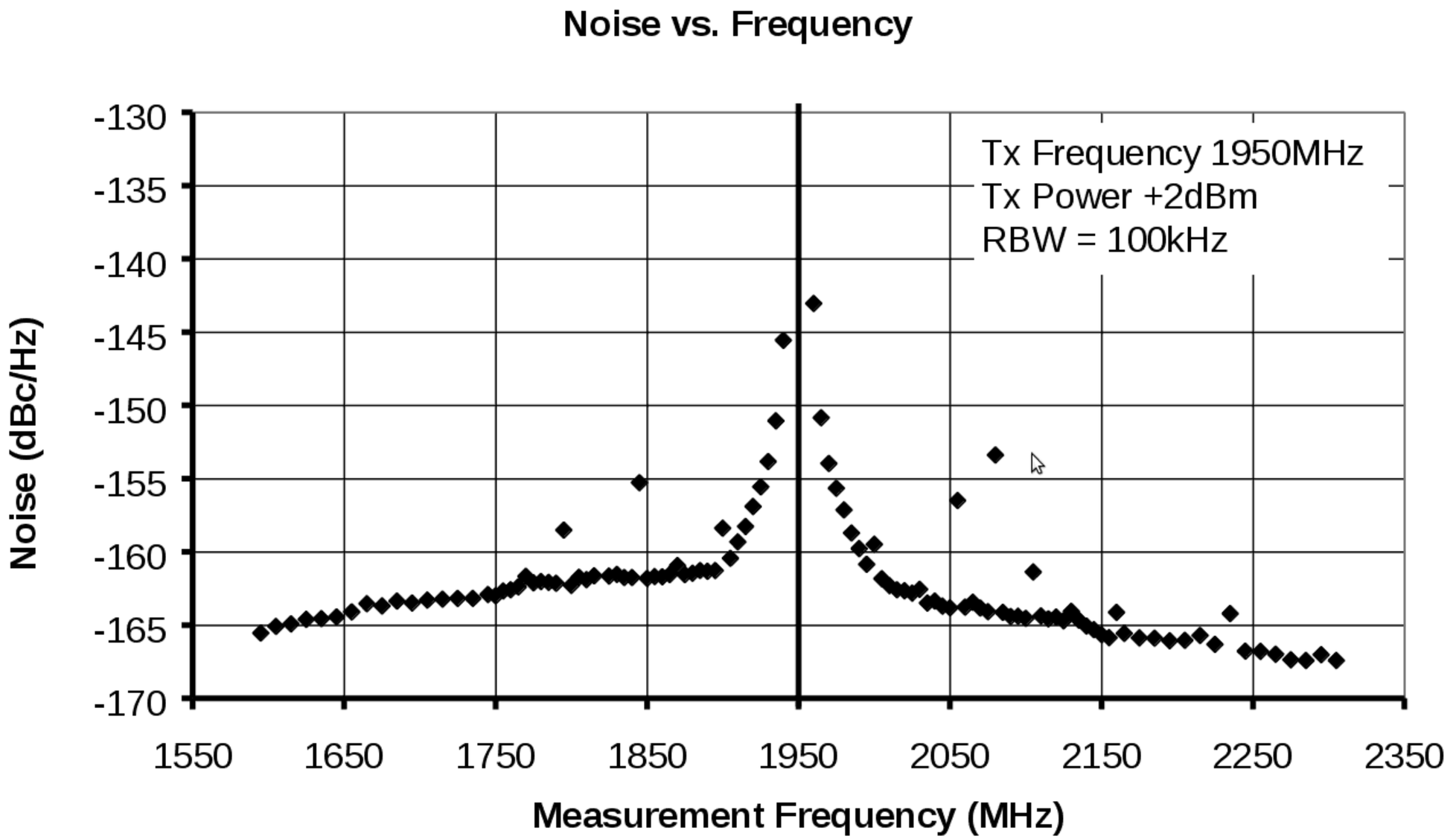




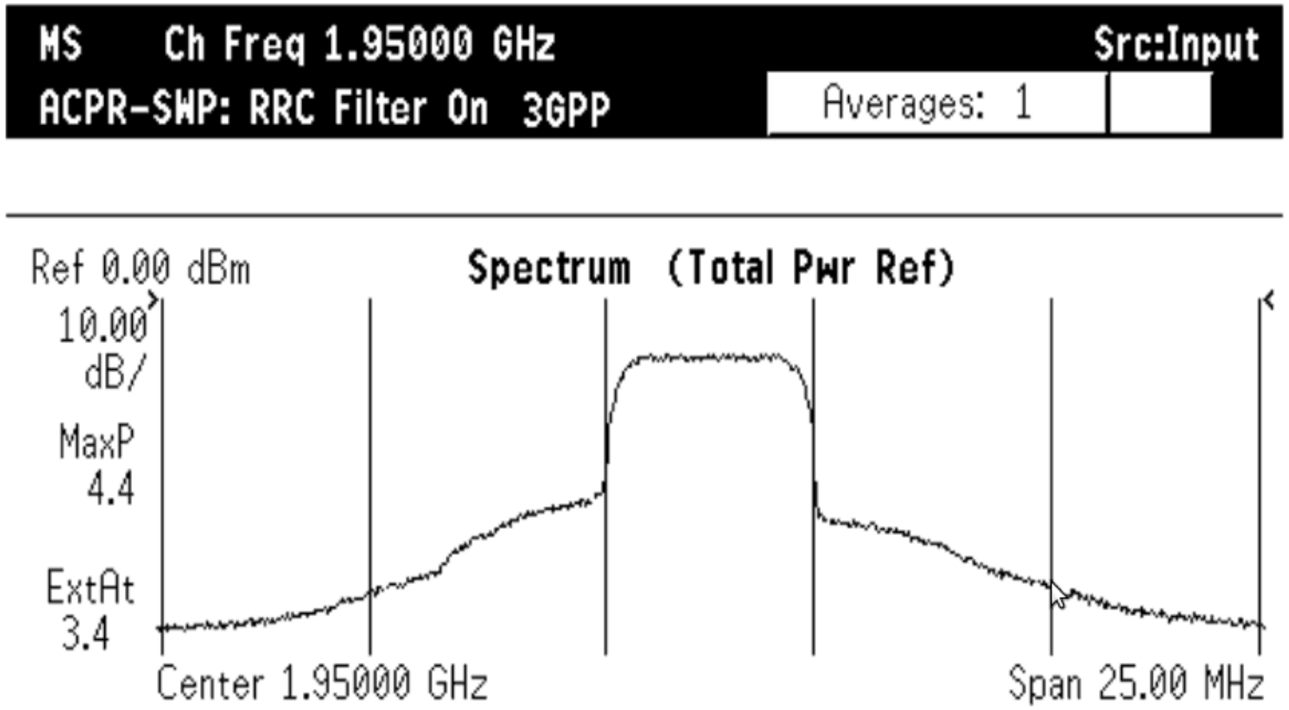
Effect of LO Phase Alignment to VCO



Typical Noise Performance



Typical ACLR Performance

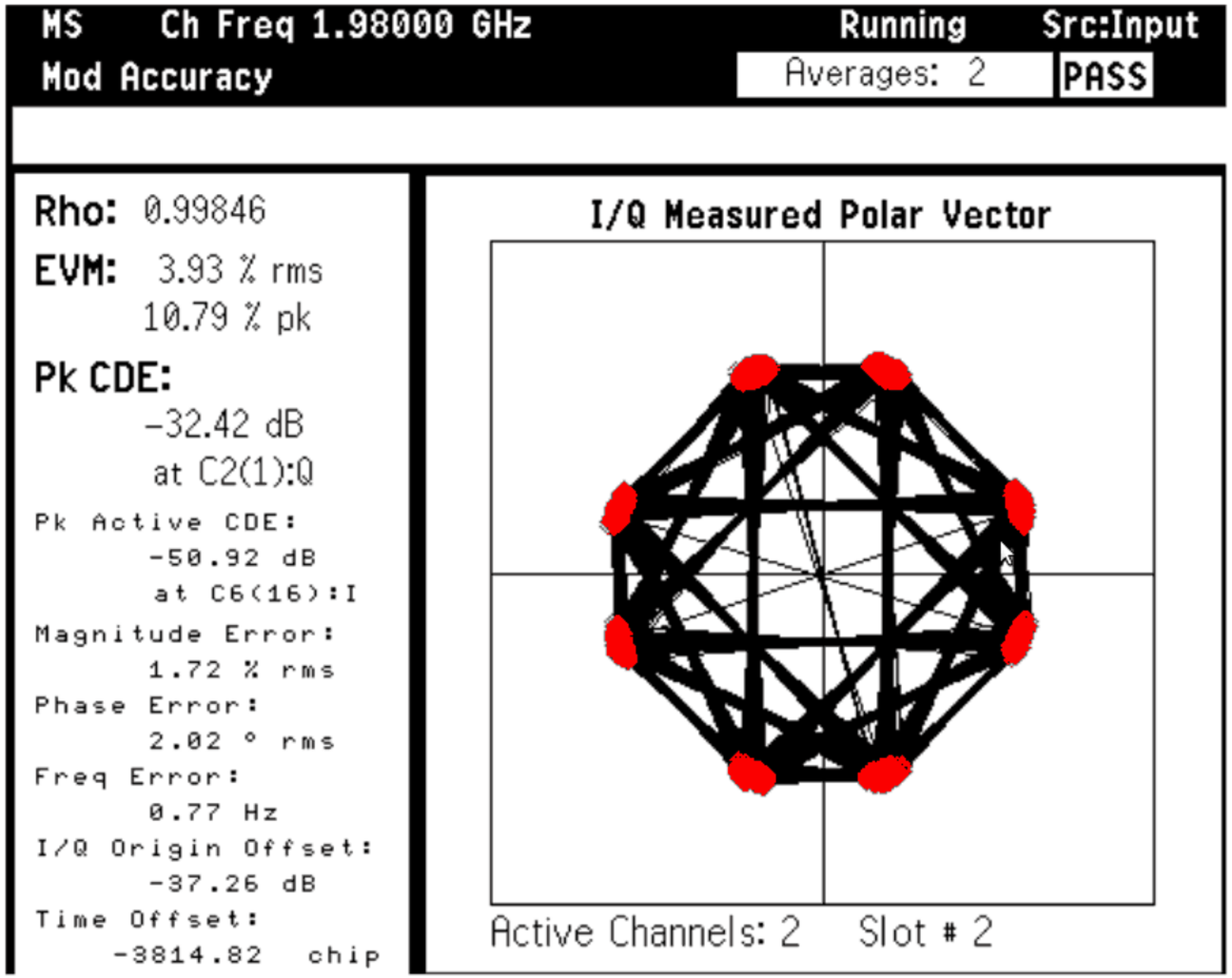


Total Pwr Ref: 3.77 dBm/ 3.84 MHz

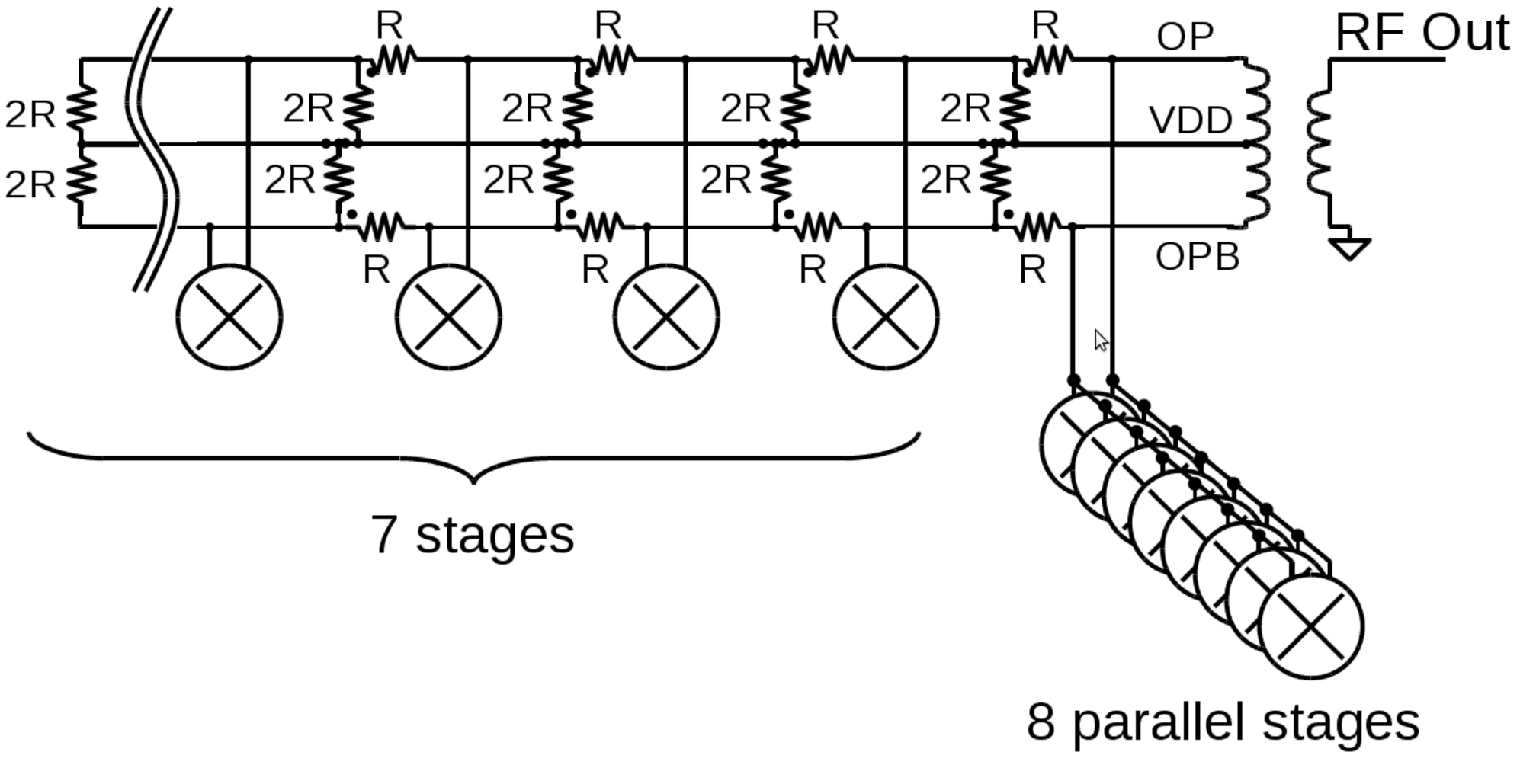
ACPR-SWP: RRC Filter On

		Lower		Upper	
Offset Freq	**Integ BW**	**dBc**	**dBm**	**dBc**	**dBm**
5.00 MHz	3.84 MHz	-46.33	-42.56	-50.84	-47.08
10.00 MHz	3.84 MHz	-72.48	-68.72	-70.68	-66.92

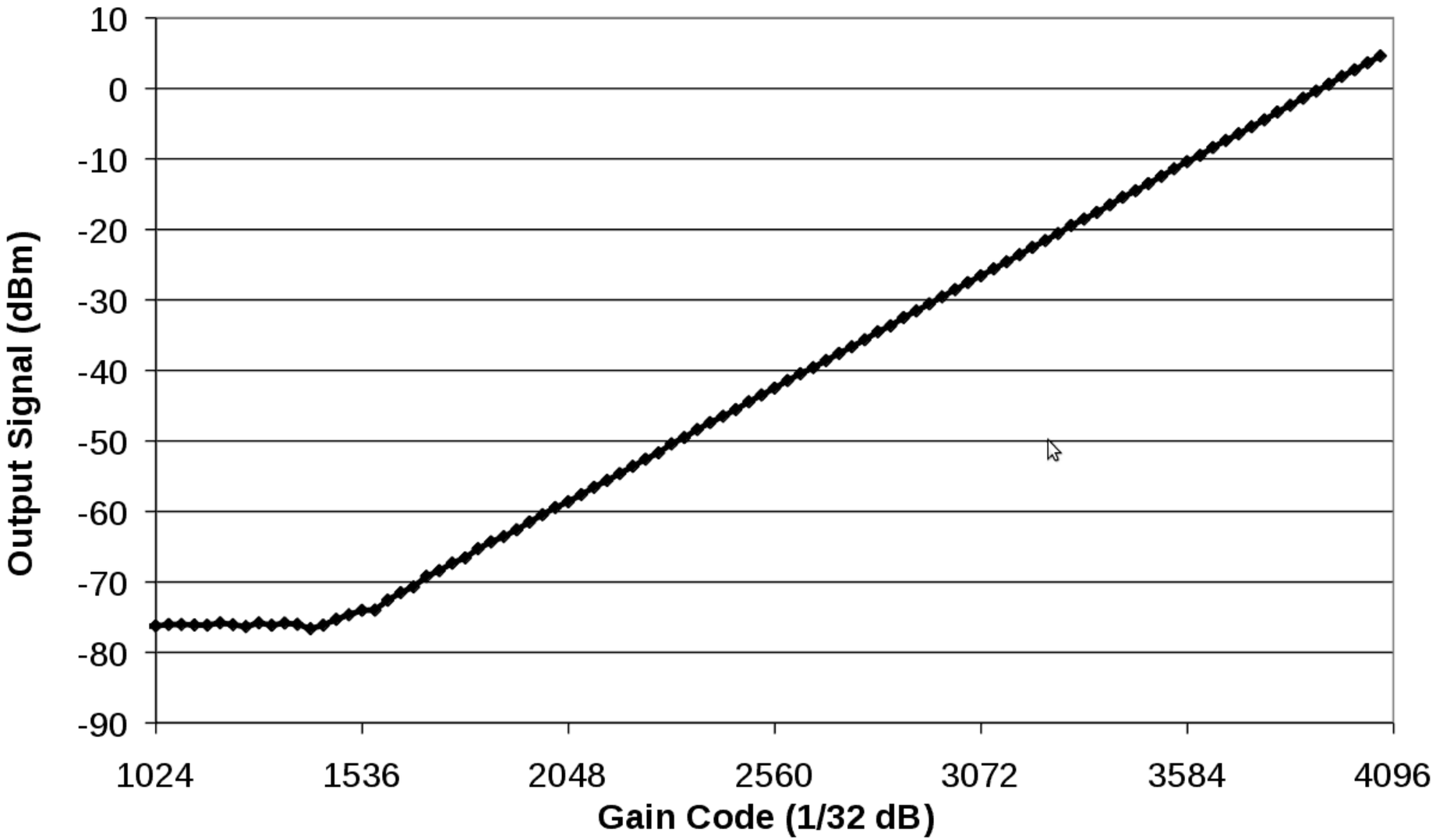
Typical EVM Performance



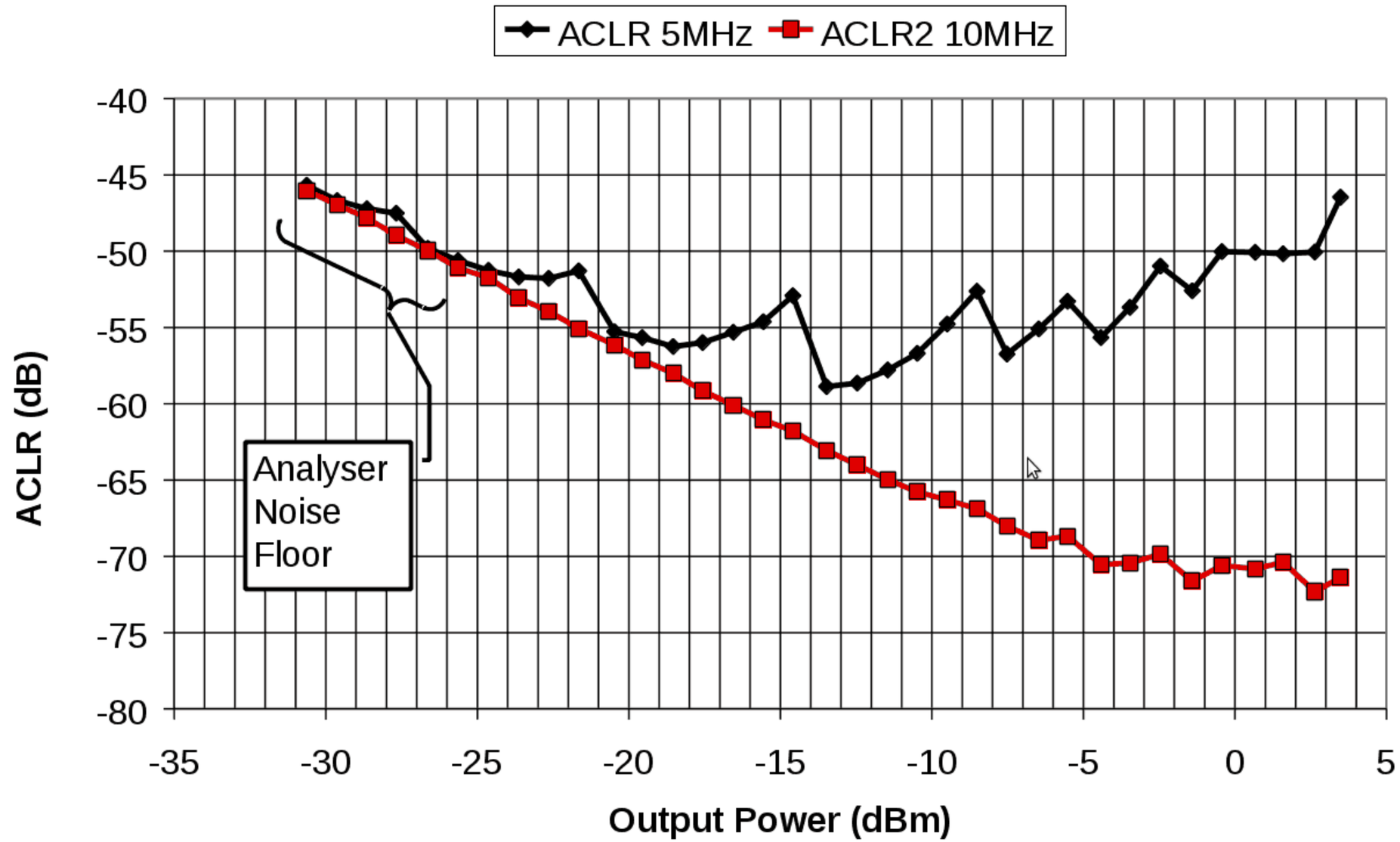
Gain Control



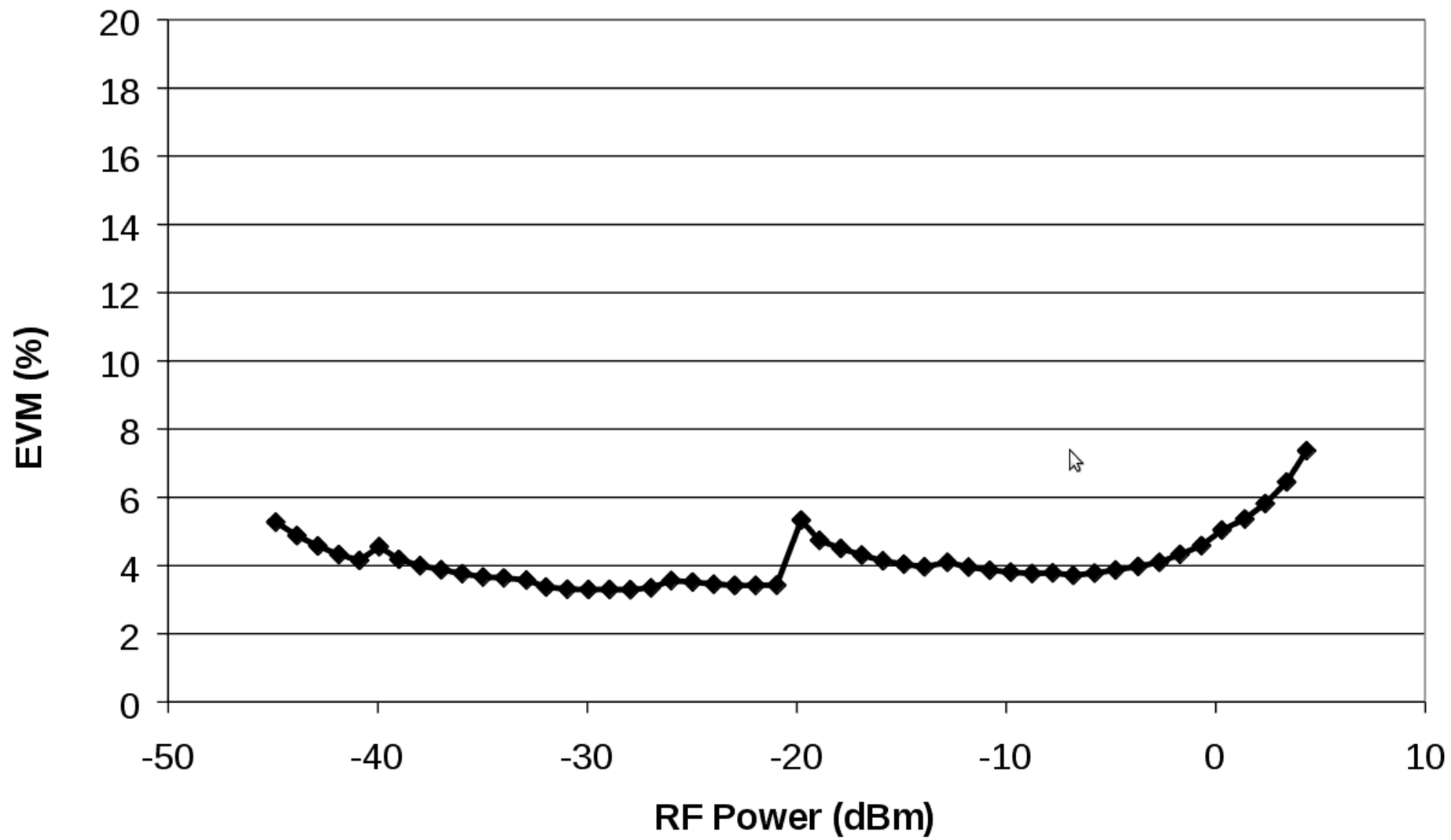
Gain Control Range



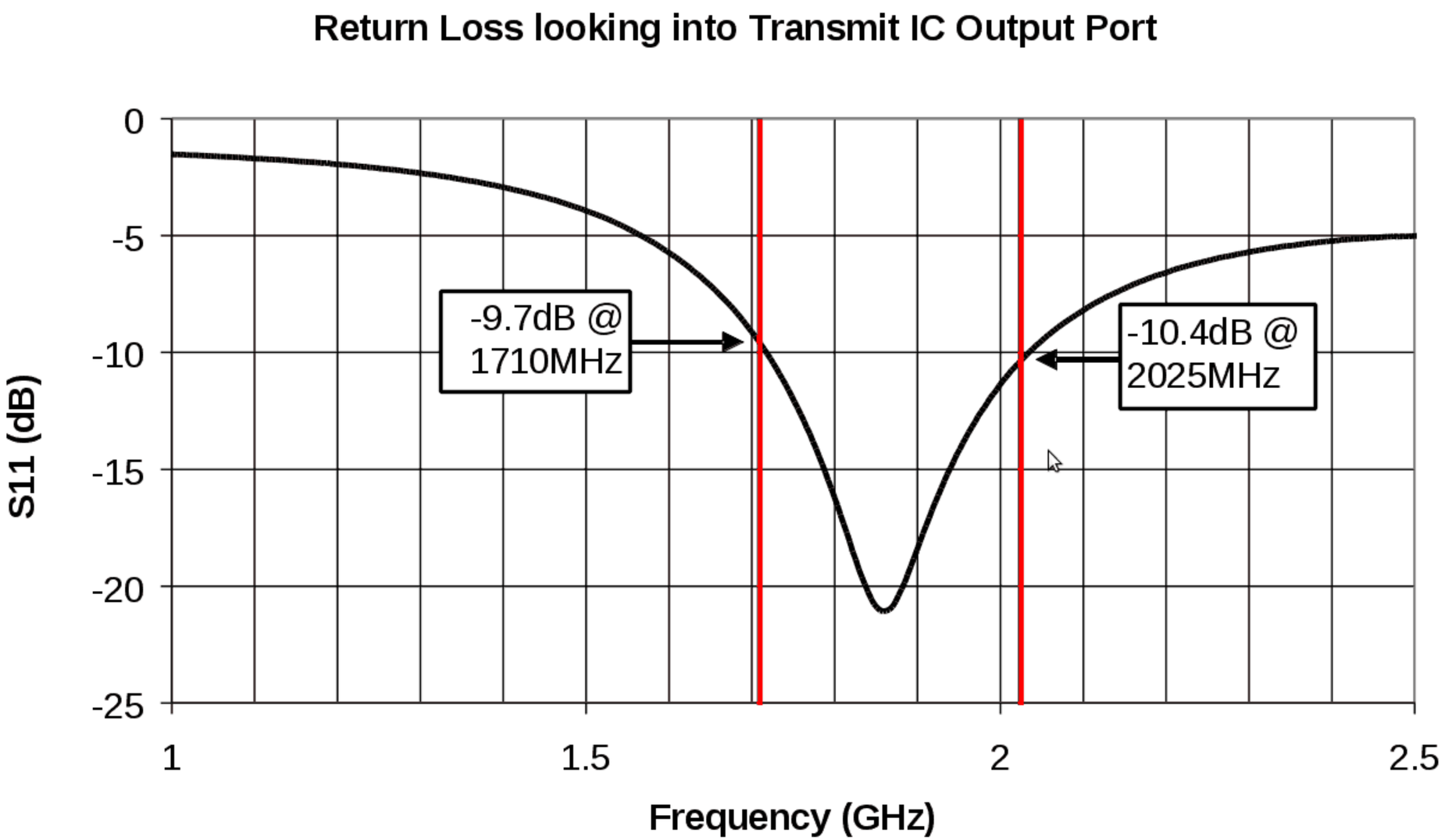
ACLR vs. RF Power



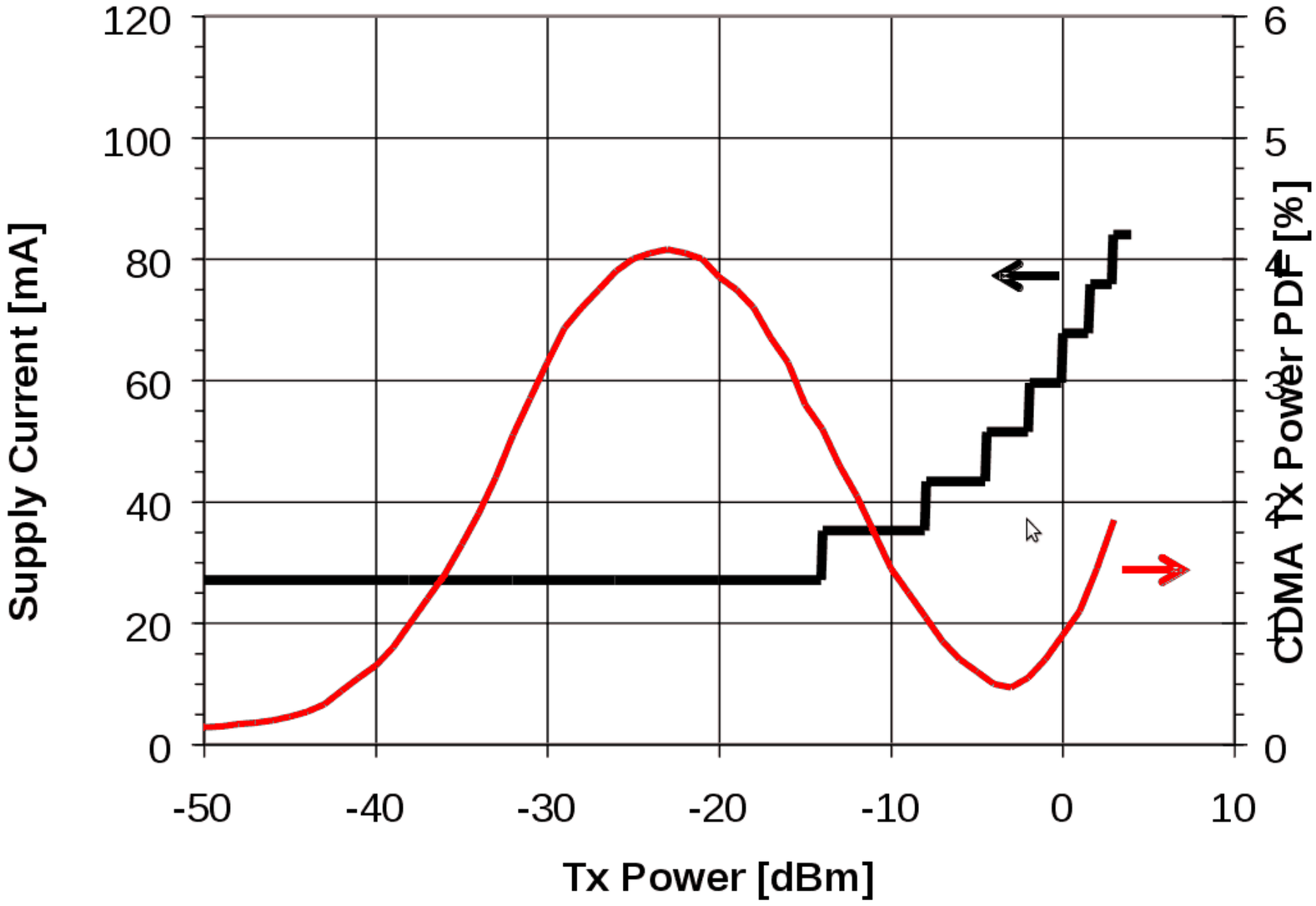
EVM vs. RF Power



Output Match

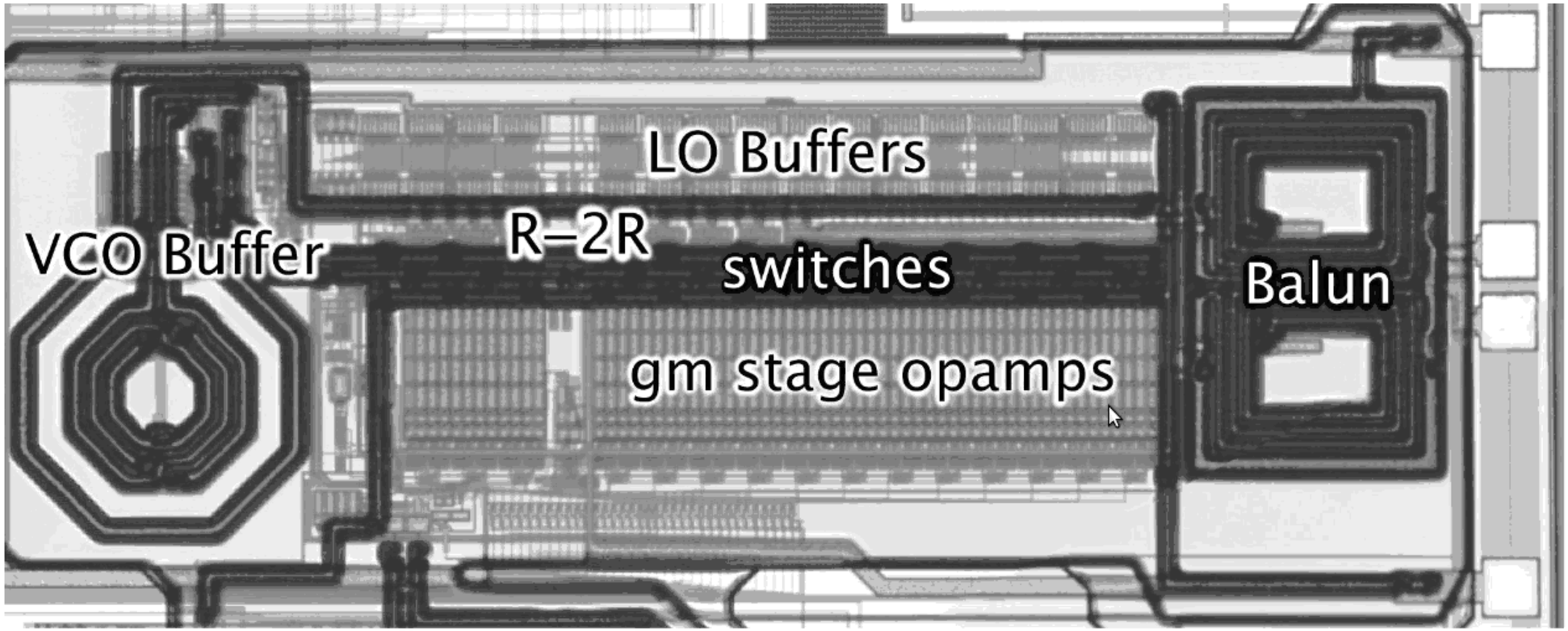


Supply Current



(Includes VCO buffer and LO path, but not VCO and sythesizer)

Die Photograph



0.8 mm² in 0.18µm CMOS

Performance Summary

Design	Process	Power [dBm]	ACLR [dBc]	Rx Noise [dBc/Hz]	Supply [V]	Current [mA]
Brenna et al ISSCC 2003	0.13µm CMOS	2.5	-38	-152	1.5	18 – 45
Kaczman et al RFIC 2005	0.35µm SiGe	9.5	-46	-142	2.8	49 – 64*
Tomiyama et al RFIC 2006	0.18µm SiGe	0	-38	-141	1.8	31 – 53
Koller et al RFIC 2006	0.13µm CMOS	10.75	-44	-152	2.7	26 – 80*
This Work	**0.18µm CMOS**	**3.8**	**-46**	**-163**	**2.8**	**27 – 84**

* Includes synthesizer and VCO