A SURVEY OF WIDEBAND LOW NOISE AMPLIFIERS DESIGN TECHNIQUES FOR COGNITIVE RADIO

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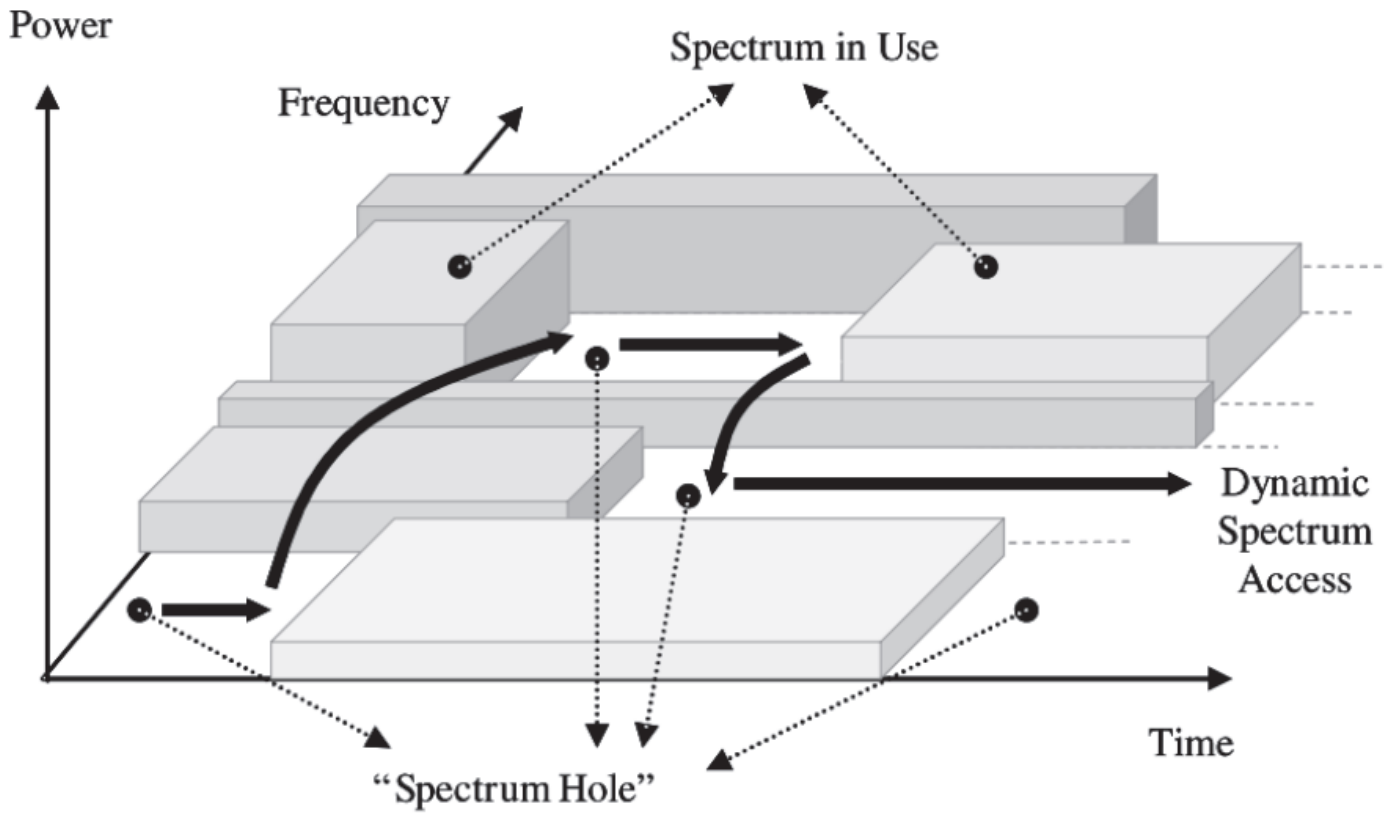
Outline

- Introduction: Cognitive Radio
- WBLNA design challenges
- Feedback and noise-cancelling WBLNA
- Linearization techniques for WBLNA
- Conclusions

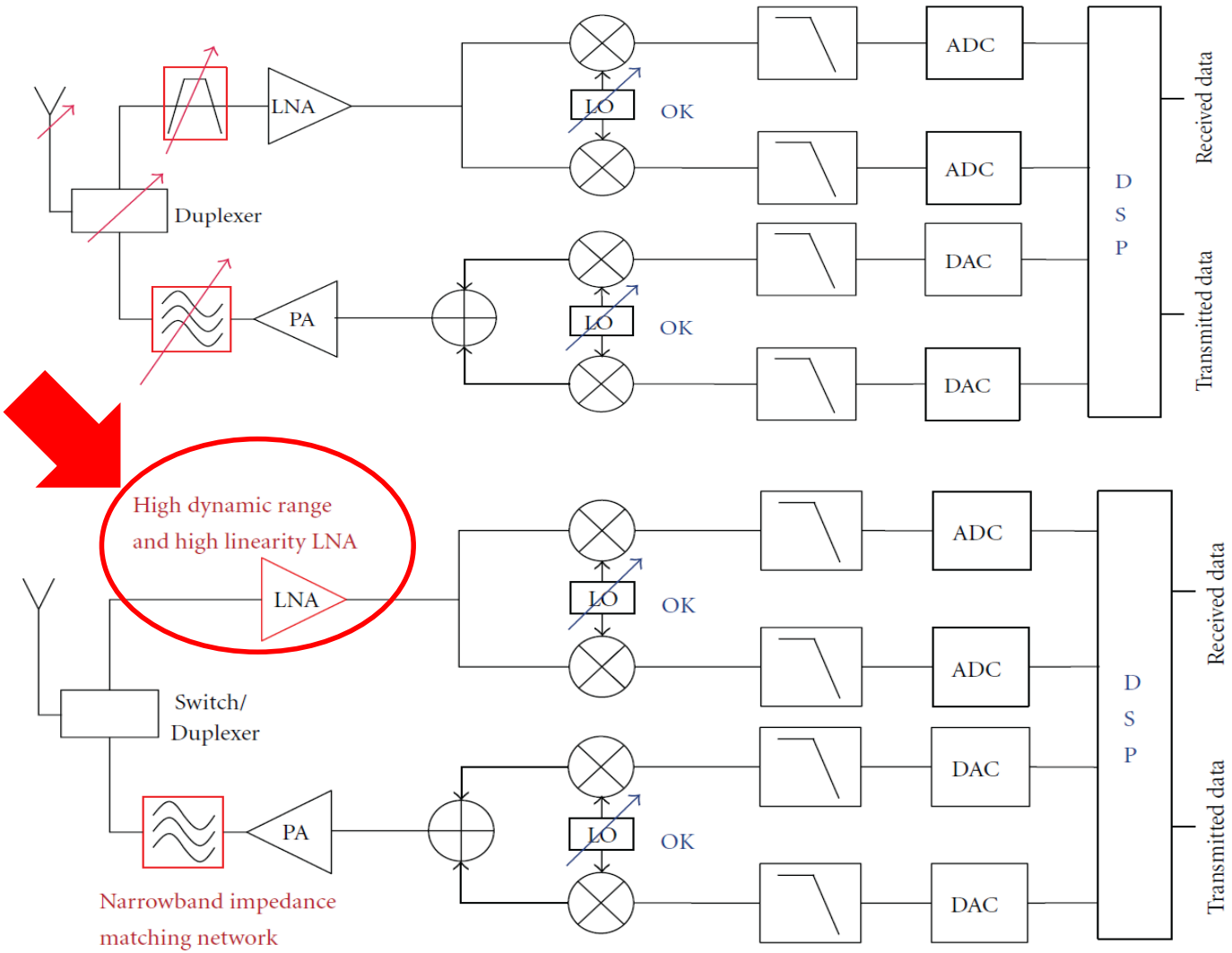
Introduction: Cognitive Radio

- An intelligent radio capable of deciding for itself to change its frequency band based on spectrum activity monitoring



Introduction: Cognitive Radio

- Transceiver architectures:



Multi-Narrowband

Wideband

WBLNA Design Challenges

Over 2-3 decades of frequency:

- Input impedance matching (feasible with feedback)
- Noise Figure < 3dB (feasible with noise-cancelling)
- Gain > 10dB (feasible with cascading amplifiers)
- IIP2 (linearity) >> 0dBm (big challenge)
- IIP3 (linearity) >> 0dBm (big challenge)

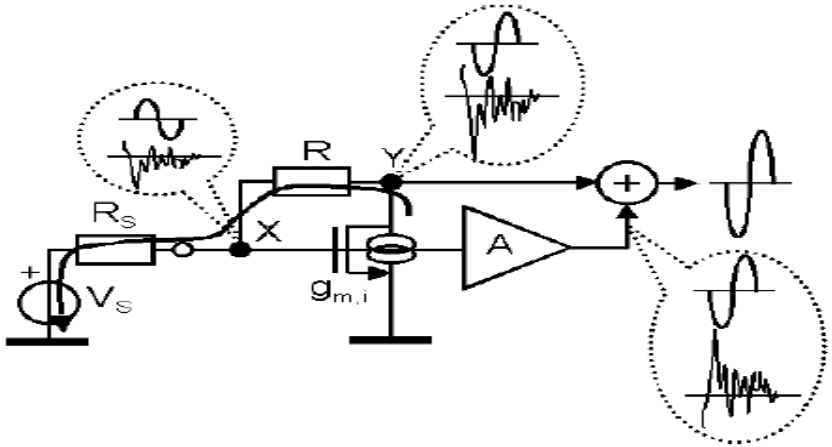
WBLNA Design Challenges

IIP2 and IIP3 mitigation:

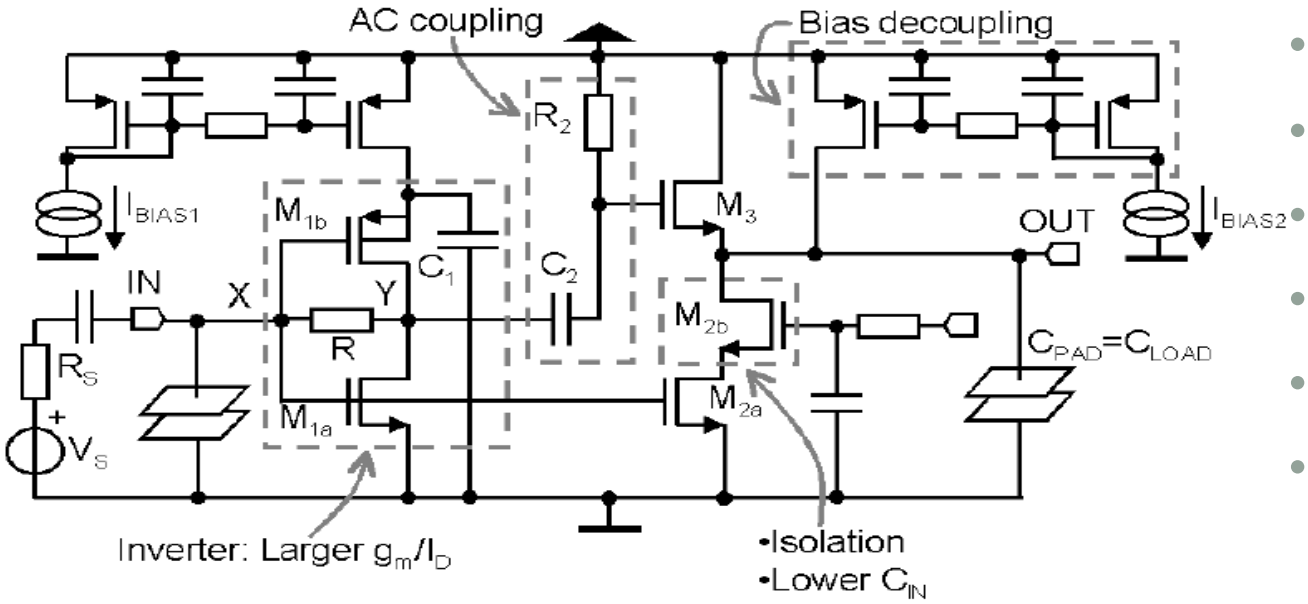
- Use differential topologies
- Use feedback
- Cancel nonlinear terms
  - Subtract signals
  - Cancel signal series expansion 2nd and 3rd order terms

Feedback and noise-cancelling WBLNA

Single-ended amplifier [10]:



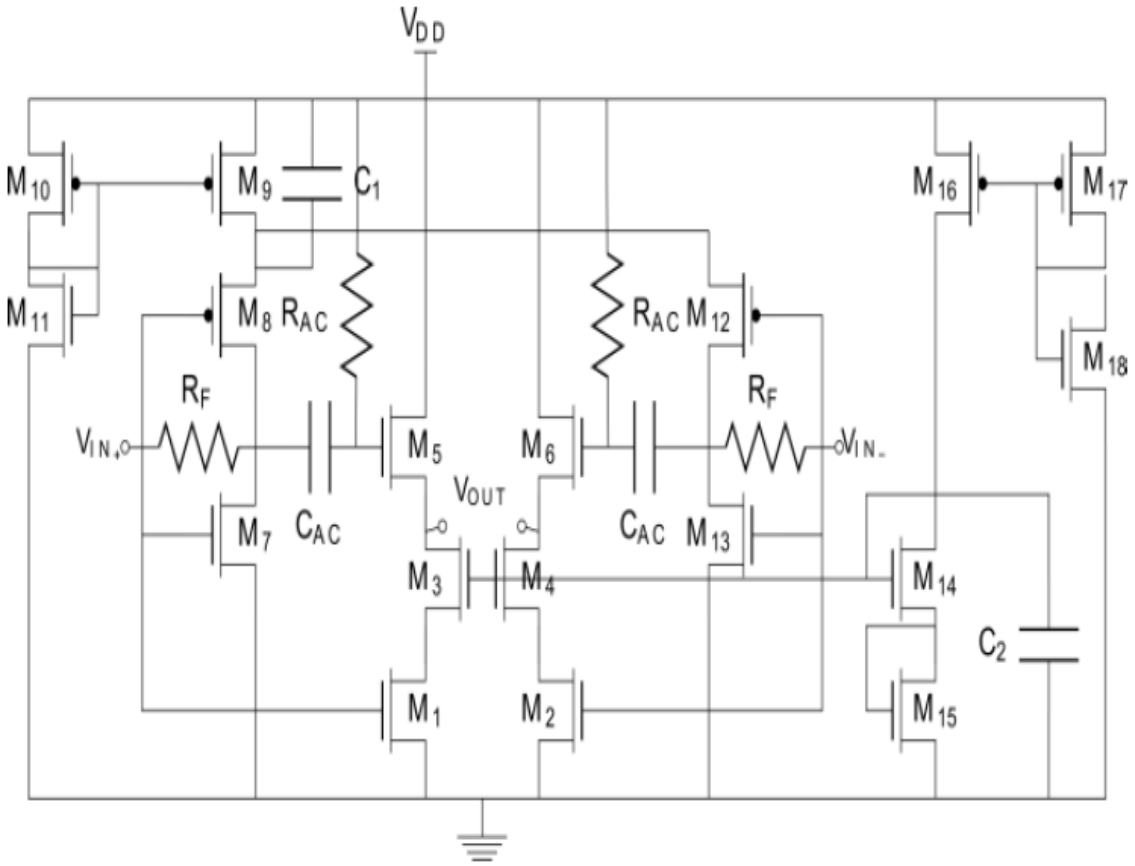
- Noise generated by A is decoupled.
- Noise is still partially cancelled with mismatch.



- BW: 0.2 – 1.6 GHz
- Gain: 13.7 dB
- NF: < 2.4 dB
- IIP2: 12 dBm
- IIP3: 0 dBm
- Tech: 250 nm

Feedback and noise-cancelling WBLNA

Differential amplifier (Pimentel, 2012) UFRGS [9]:

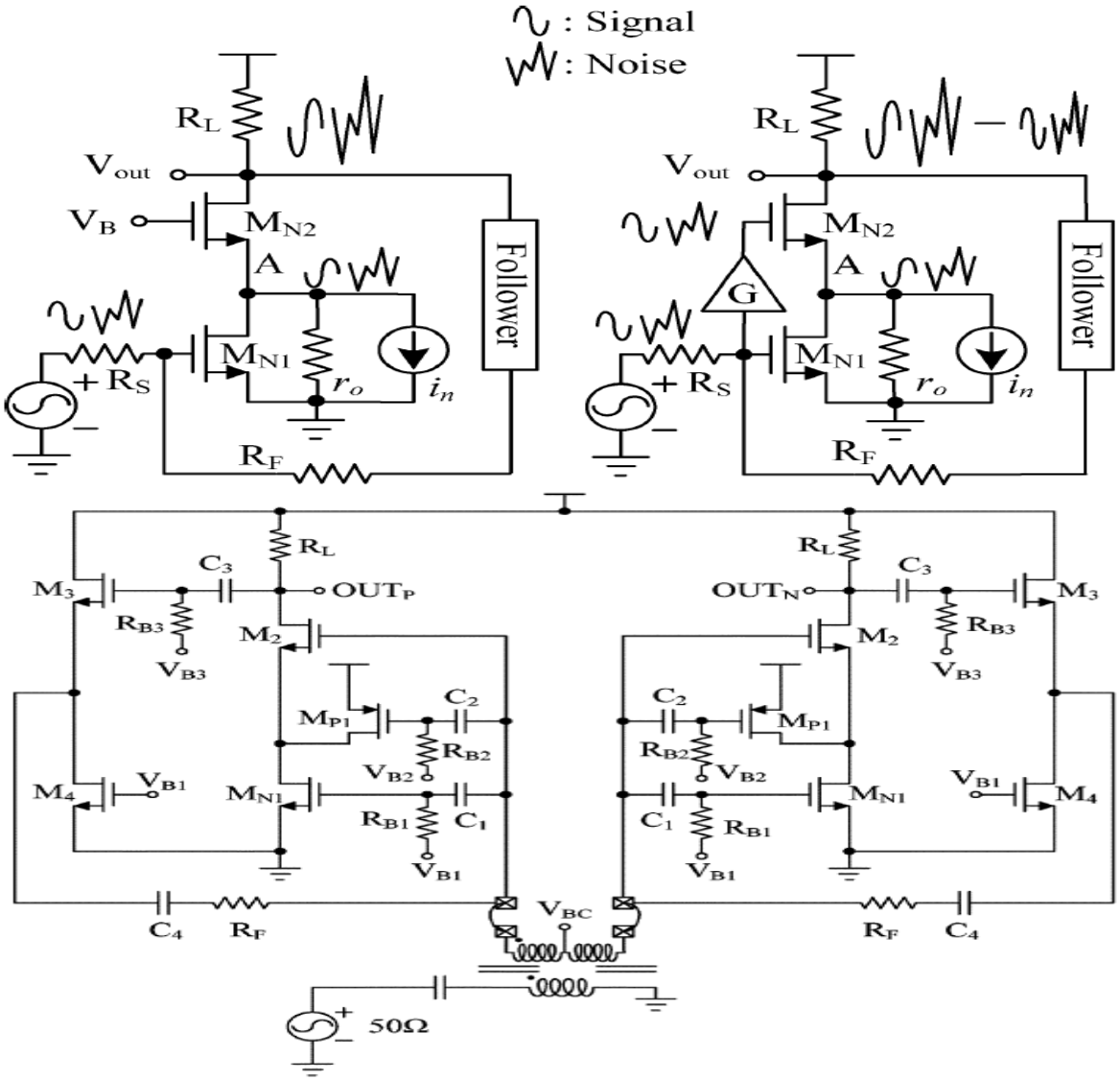


- Improved noise figure with common-mode rejection.

- BW: 0.05 – 1 GHz
- Gain: 11-12 dB
- NF: 3-5 dB
- IIP3: 0.72 dBm
- Tech: 130 nm

Feedback and noise-cancelling WBLNA

Feedforward differential cascode amplifier [8]:

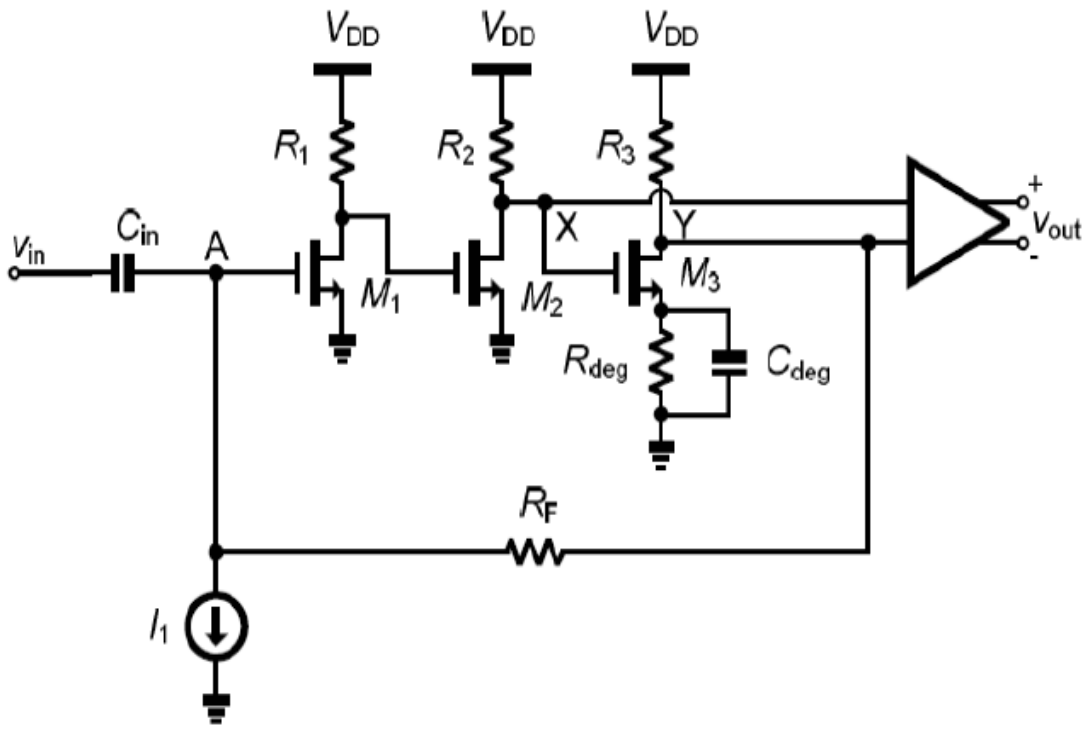


Complete Receiver:

- BW: 0.6 – 3 GHz
- Gain: 42-48 dB
- NF: 3 dB
- IIP3: -14 dBm
- Tech: 130 nm

Feedback and noise-cancelling WBLNA

Cascaded amplifiers with differential output [5]:

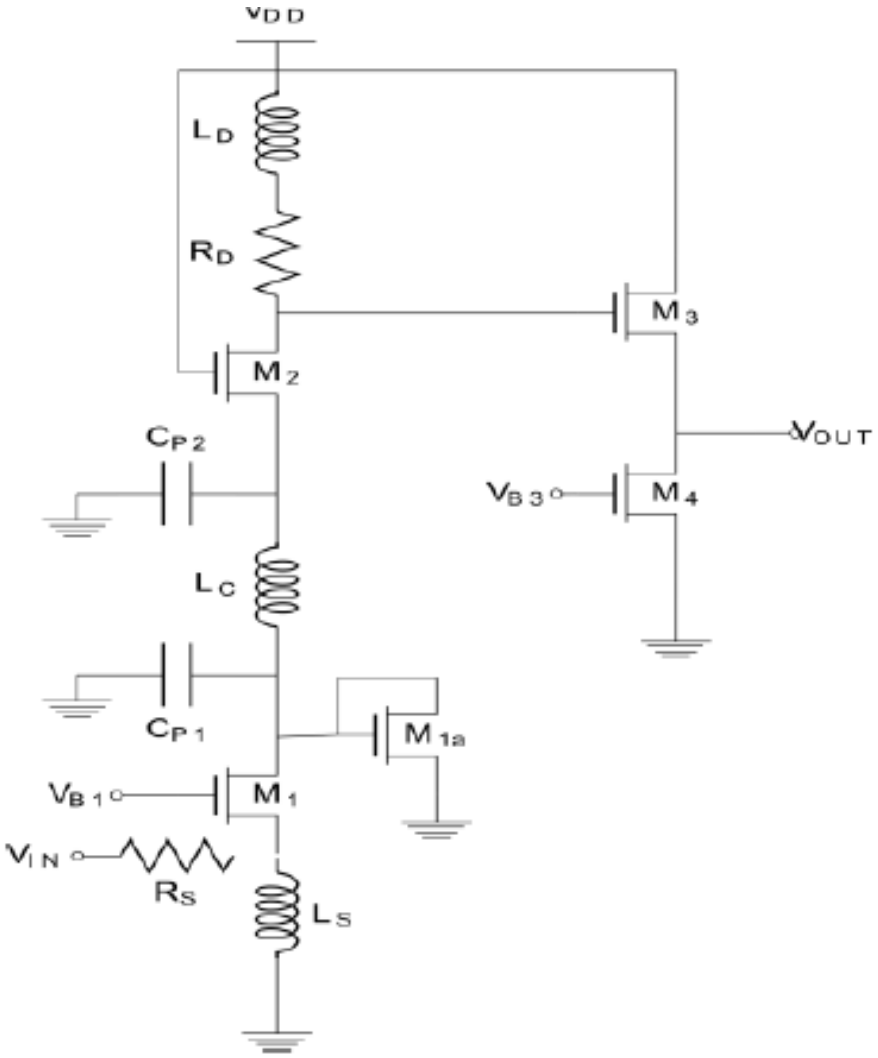


- Resistive and capacitive degeneration on the output.
- Last stage gain 0 dB.
- Improved nonlinearity cancellation.

- BW: 0.05 – 10 GHz
- Gain: 24-25 dB
- NF: 2.7-3.6 dB
- IIP3: -2 to -10 dBm
- Tech: 65 nm

Linearization techniques for WBLNA

Cascode CG with diode and buffer (Sánchez-Sinencio 2009)[11]:



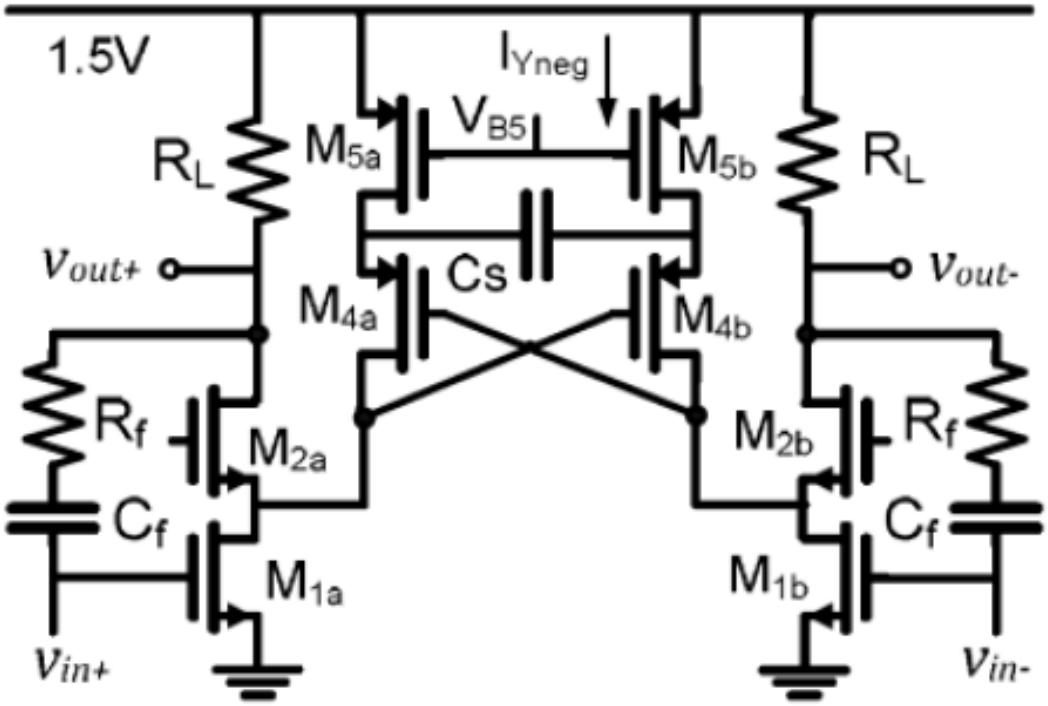
- Subtract currents in order to cancel nonlinear terms.

Linearized CGLNA:

- BW: 1.5 – 8.1 GHz
- Gain: 8.6-11.7 dB
- NF: 3.6-6 dB
- IIP2: 7.6-23 dBm
- IIP3: 11.7-14.1 dBm
- Tech: 130 nm

Linearization techniques for WBLNA

Negative Impedance + differential resistive feedback [12]:



- Use negative impedance to cancel series expansion terms.
  - BW: 0.1 – 1 GHz
  - Gain: 12-17 dB
  - NF: 4-5 dB
  - IIP3: 1-11 dBm
  - Tech: 160 nm

Conclusions

- Feedback + noise-cancelling can achieve NF < 3 dB and wideband input impedance matching.
- Linearization technique in order to cancel nonlinear terms improves > 10 dBm IIP3 and also IIP2.
- IIP2 can be improved using differential topologies.
- Single-ended topologies might be needed depending on antenna and attenuator connections.
- Linearization techniques may not achieve NF < 3 dB.

Thank you!

Any questions?

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