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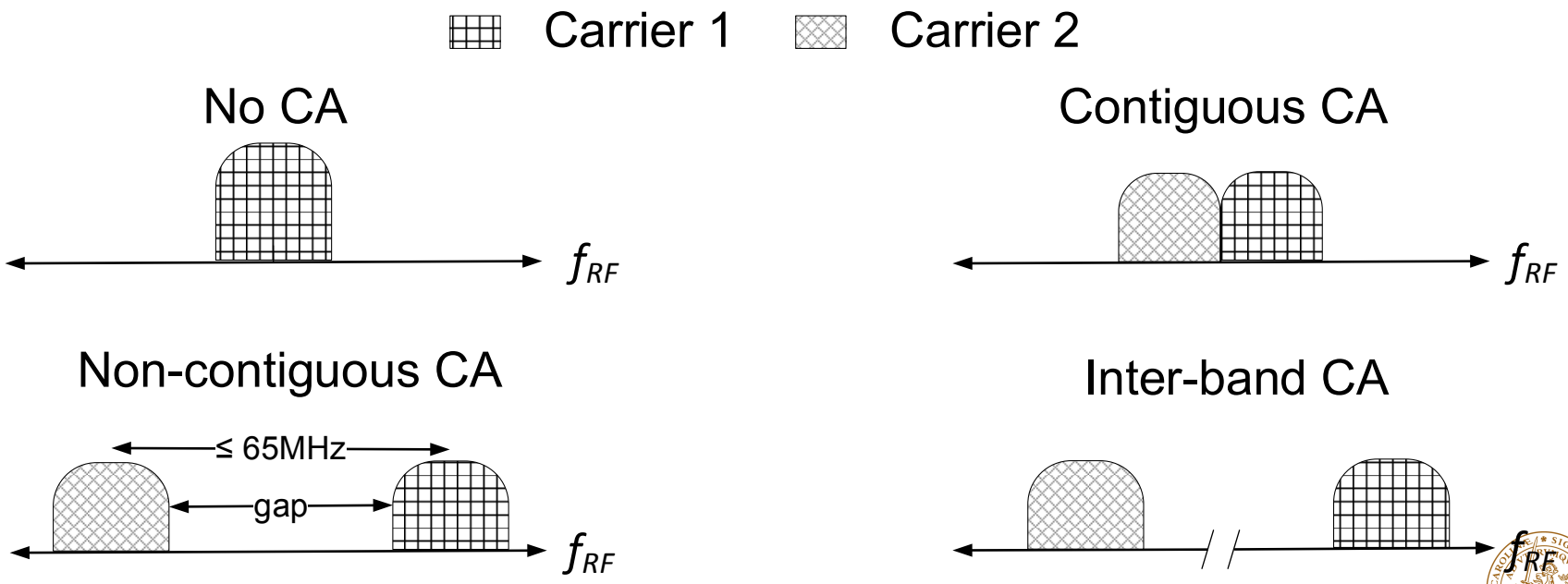
A Cellular Receiver Front-End with Spectrum Sensing

MOHAMMED ABDULAZIZ

Outline

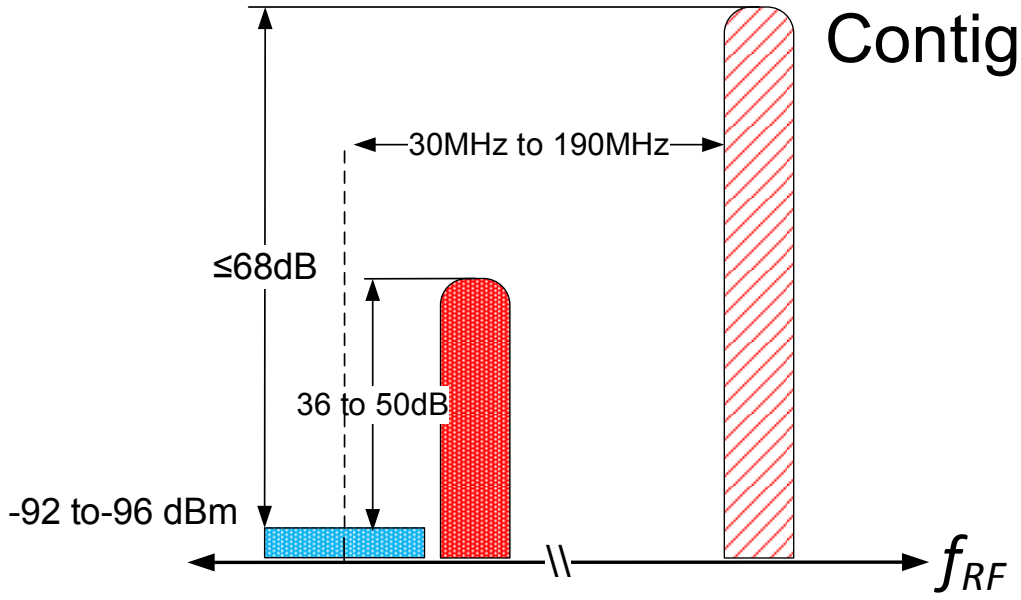
- LTE-A scenarios
- Motivation
- System architecture
  - NC-LNTA
  - OTA
  - Spectrum sensor architecture
- Measurements
- Conclusions

LTE CA scenarios



LTE blocking-1

- Single carrier or contiguous CA scenarios



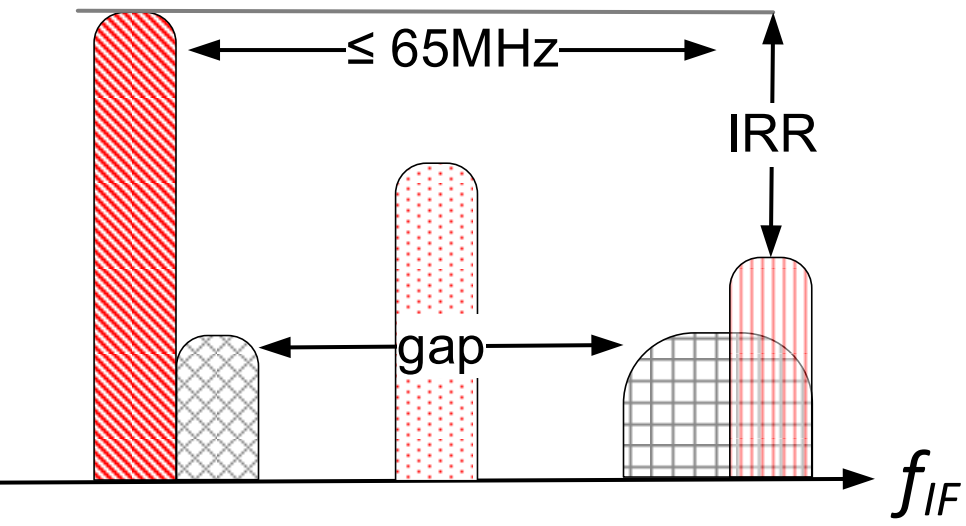
Contiguous CA or single carrier blocking scenarios

- Reference sensitivity
- ACS or IBB
- OBB (TX leakage)

LTE blocking-2

- Non-contiguous CA
- In-gap interference also exists.

Non-Contiguous CA



Adjacent channel interference
Carrier 1
Carrier 2
Adjacent channel image
In-gap interference

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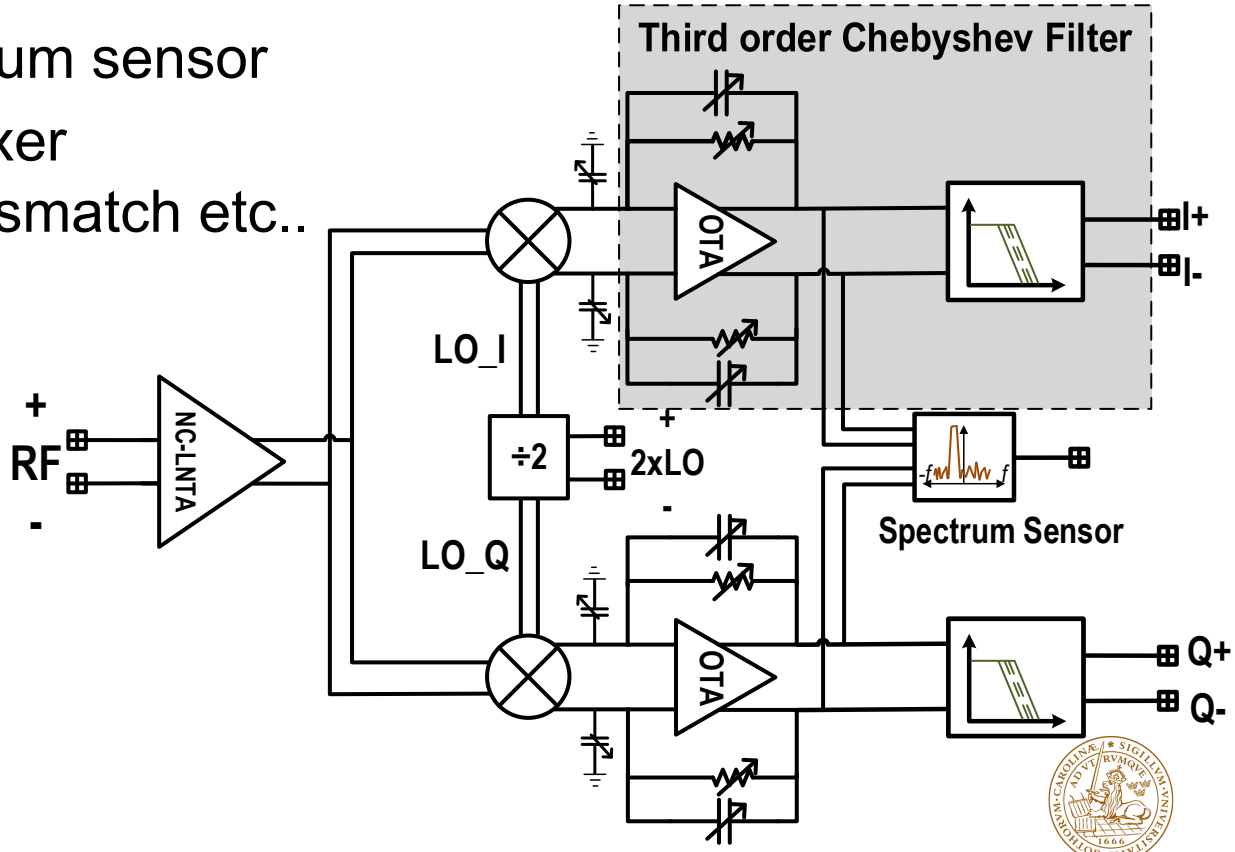
Requirements

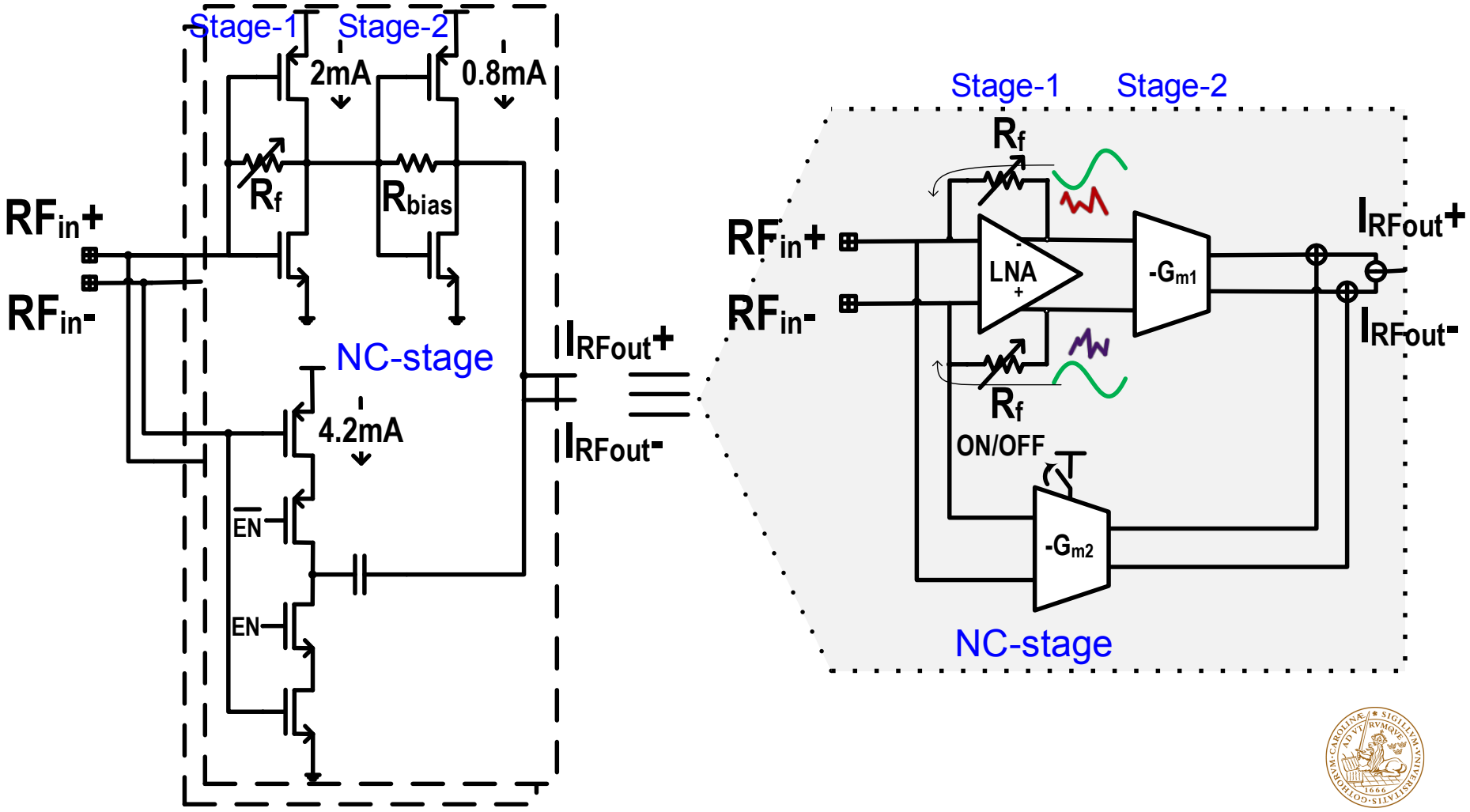
- In-band, band-edge and out-of-band linearity are equally important
- Narrow band blocking → high IRR
- Low power consumption
- Need to tune the RX-FE based on the working scenario (gain, mixer capacitor, noise cancellation etc.).

System architecture

- NC-LNTA
- Linearized OTA
- Integrated spectrum sensor
- Tunable gain, mixer capacitors, IQ mismatch etc..



Noise Canceling-LNTA



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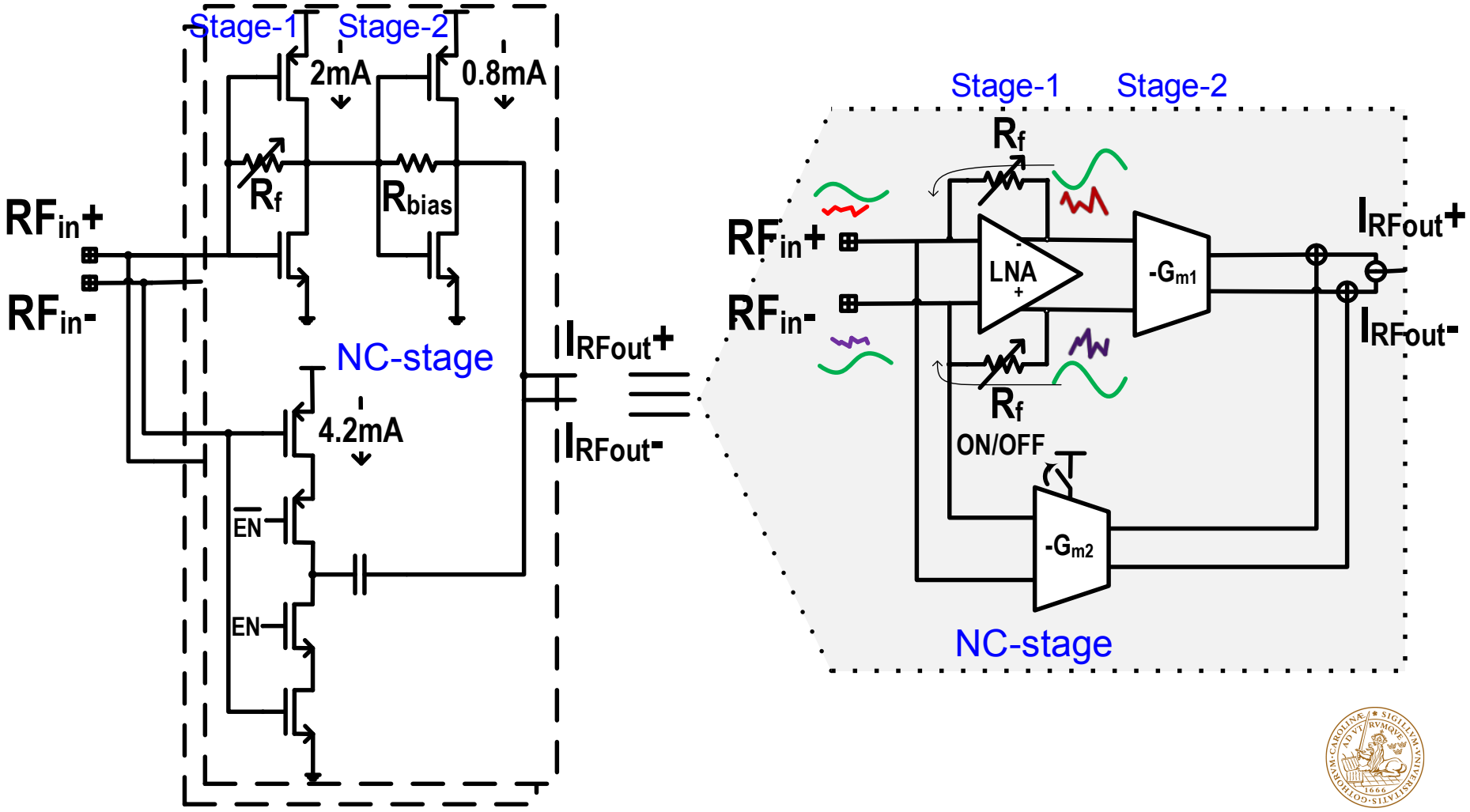
Noise Canceling-LNTA



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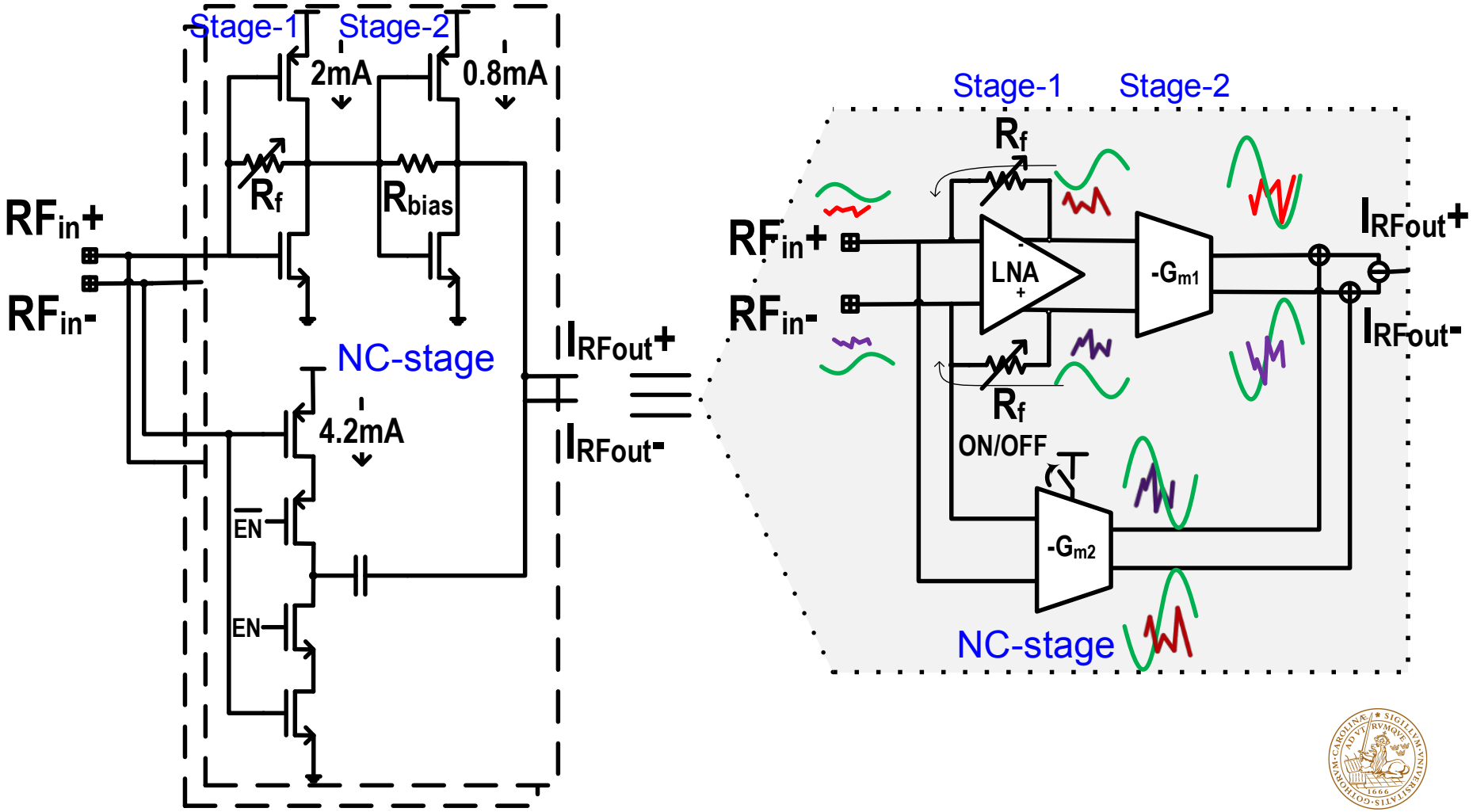
Noise Canceling-LNTA



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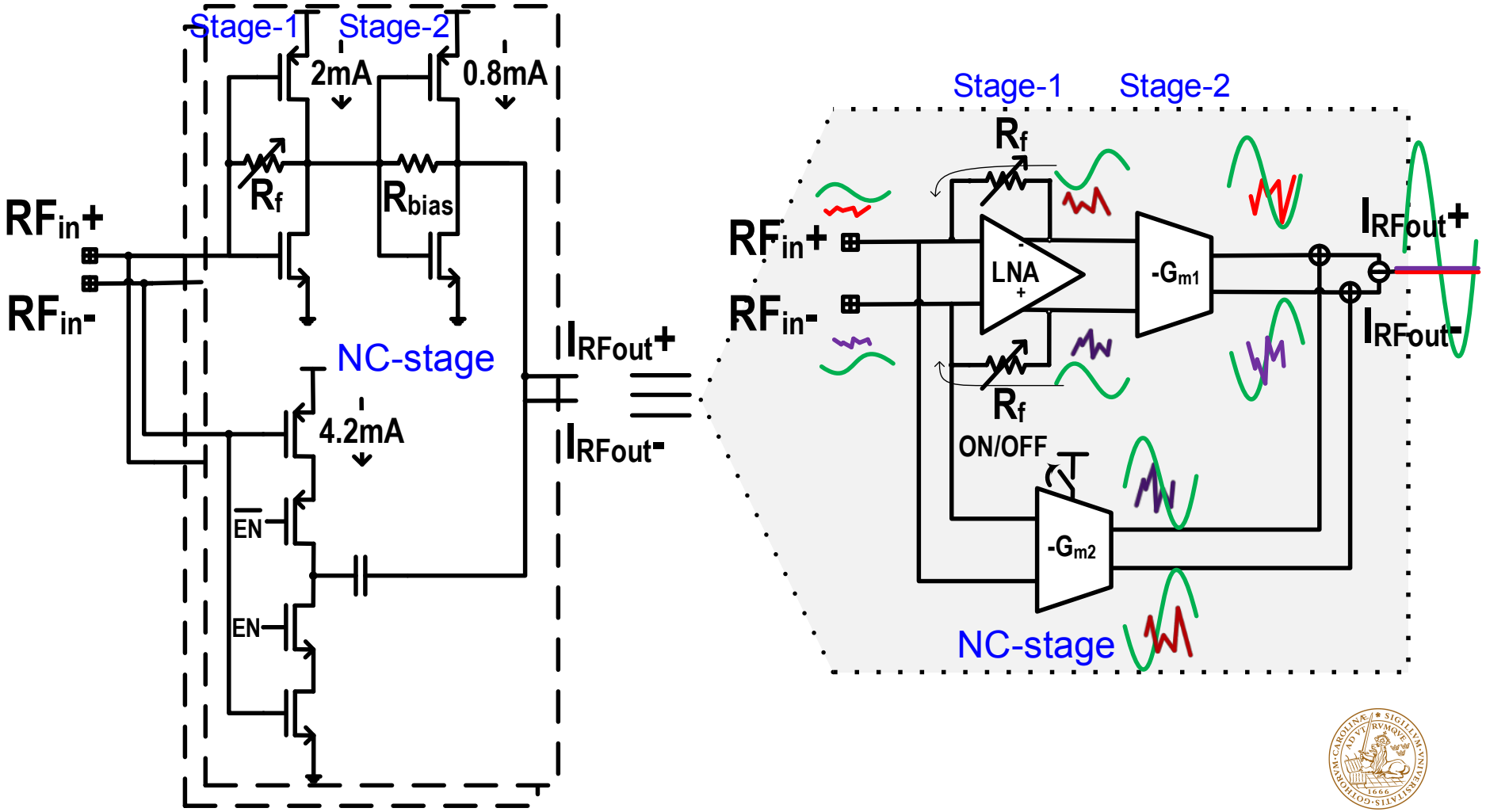
Noise Canceling-LNTA



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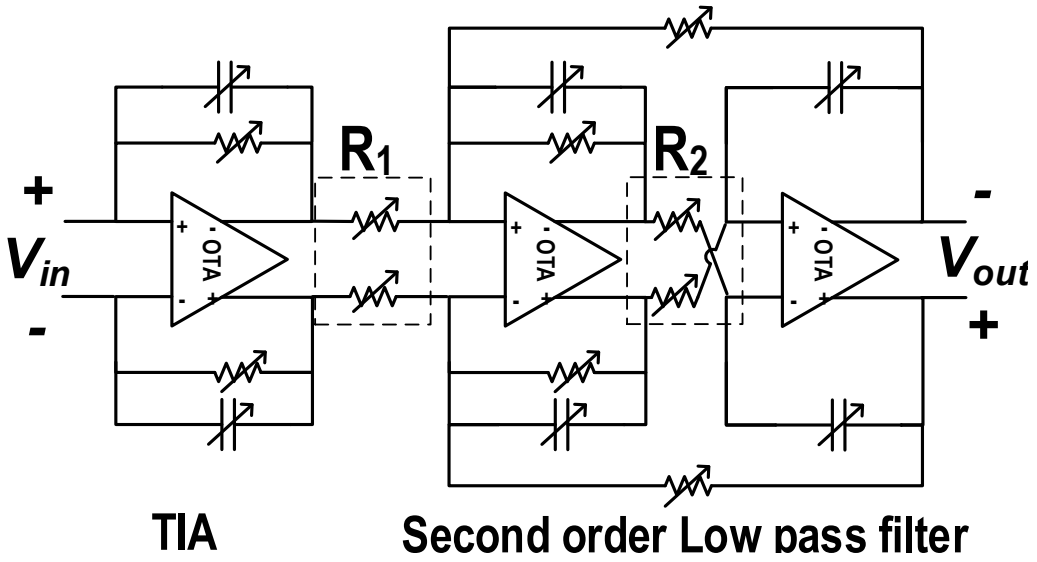
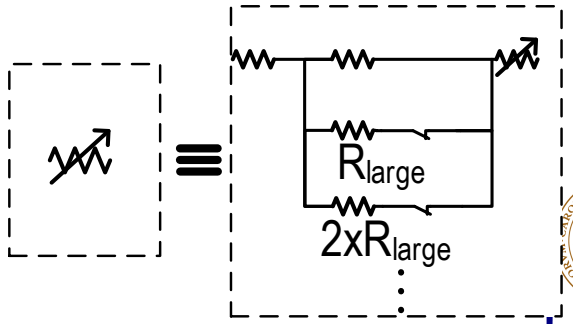
Channel select filter

- TIA is incorporated.
- Tunable gain at the TIA

- High sheet resistance poly resistors
- It can be shown that:
  - R_1 for fine amp. tuning
  - R_2 for fine phase tuning

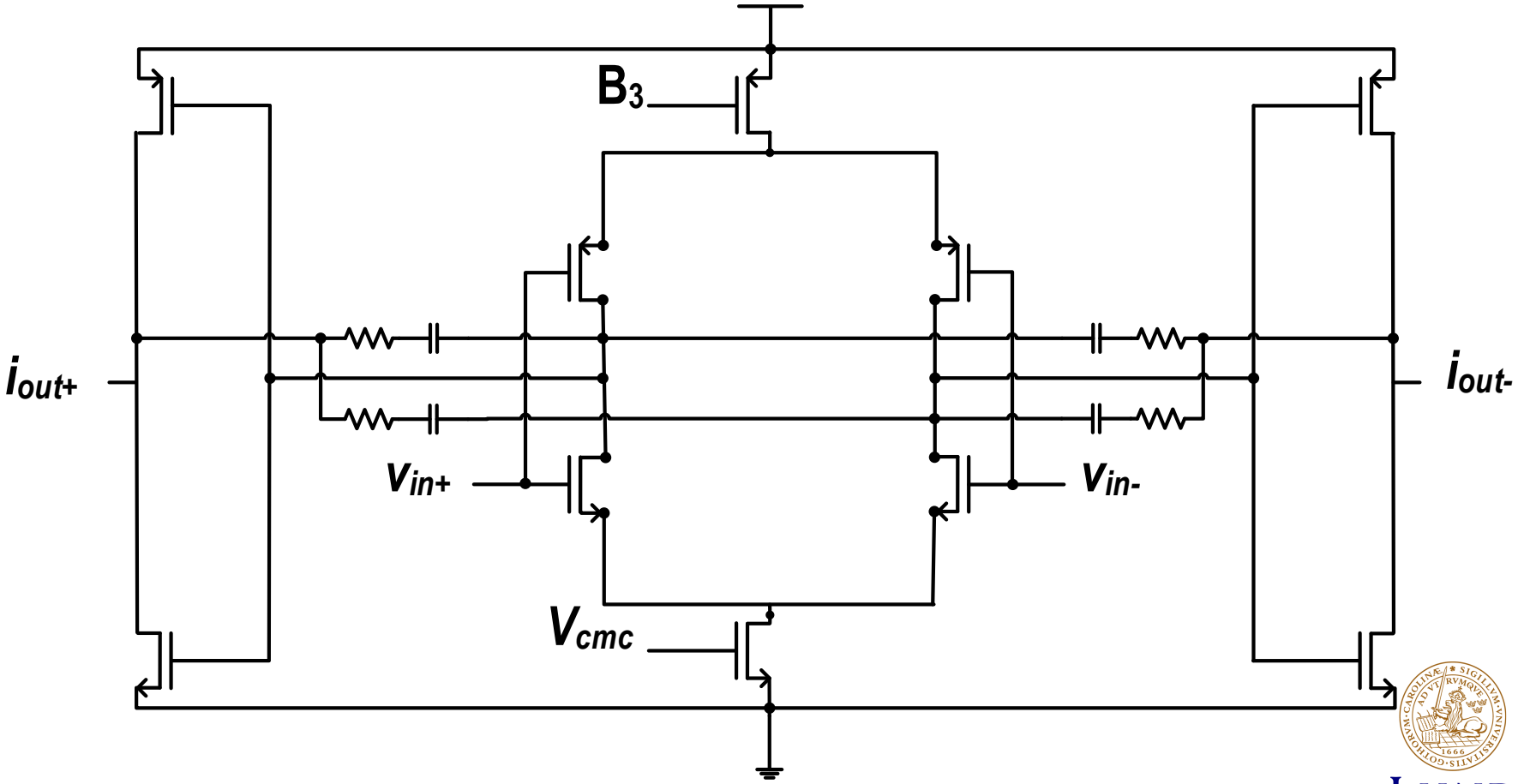




Fine tuning in resistors R_1, R_2

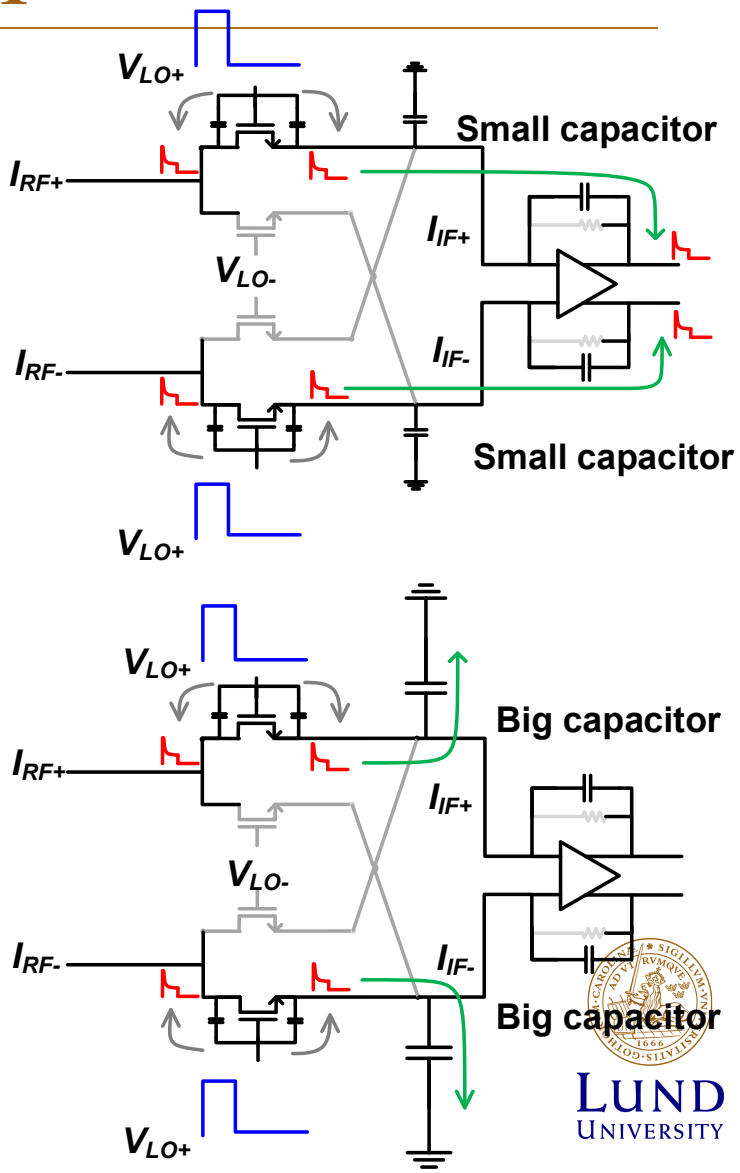
Two stage OTA

- Push-pull stages → improved linearity



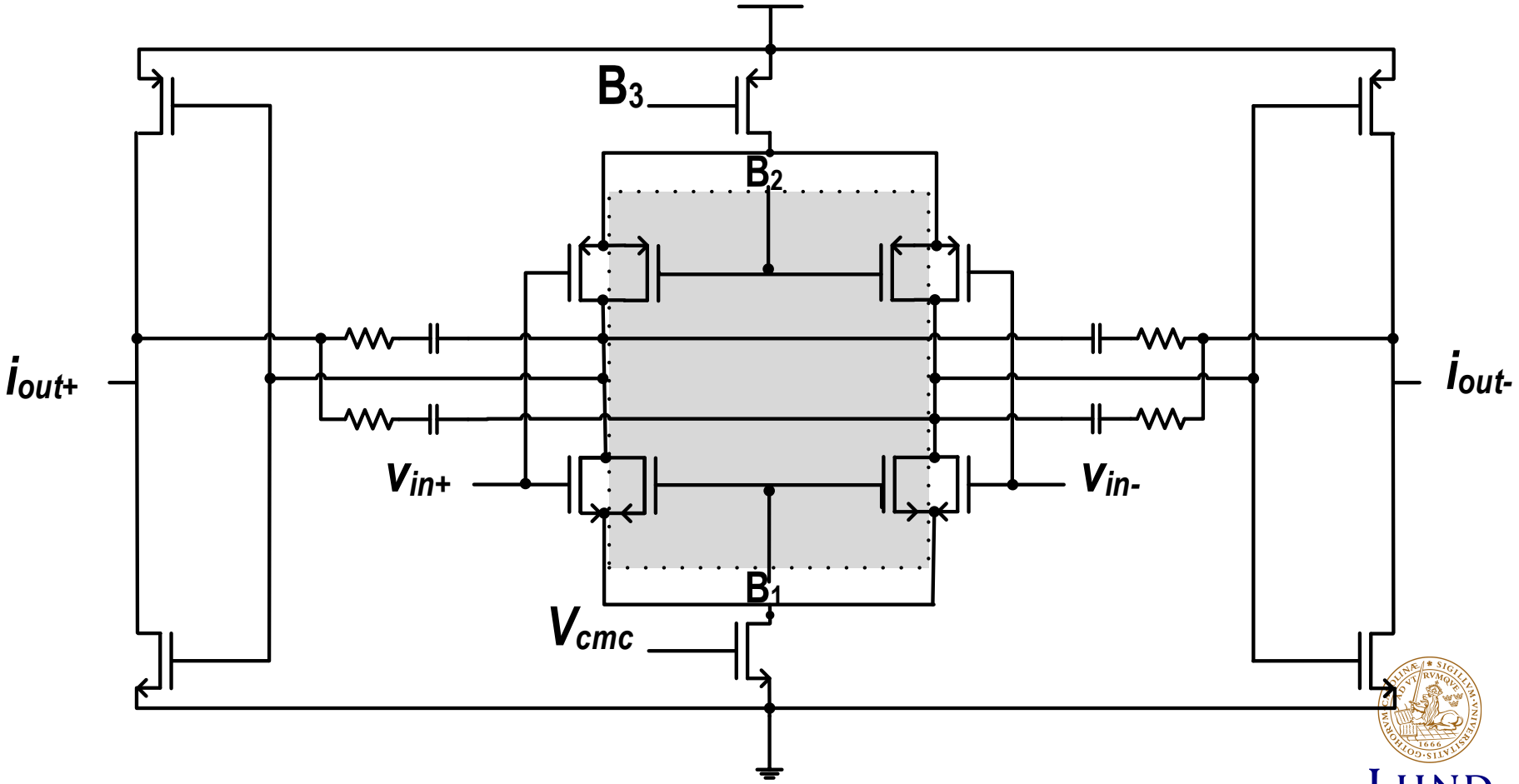
Common mode latch up

- LO CM signals are fed through directly to TIA output.
- The OTA saturates to VDD or GND at startup.
- Need large mixer capacitor.
- Large capacitor → in-band linearity is heavily degraded.



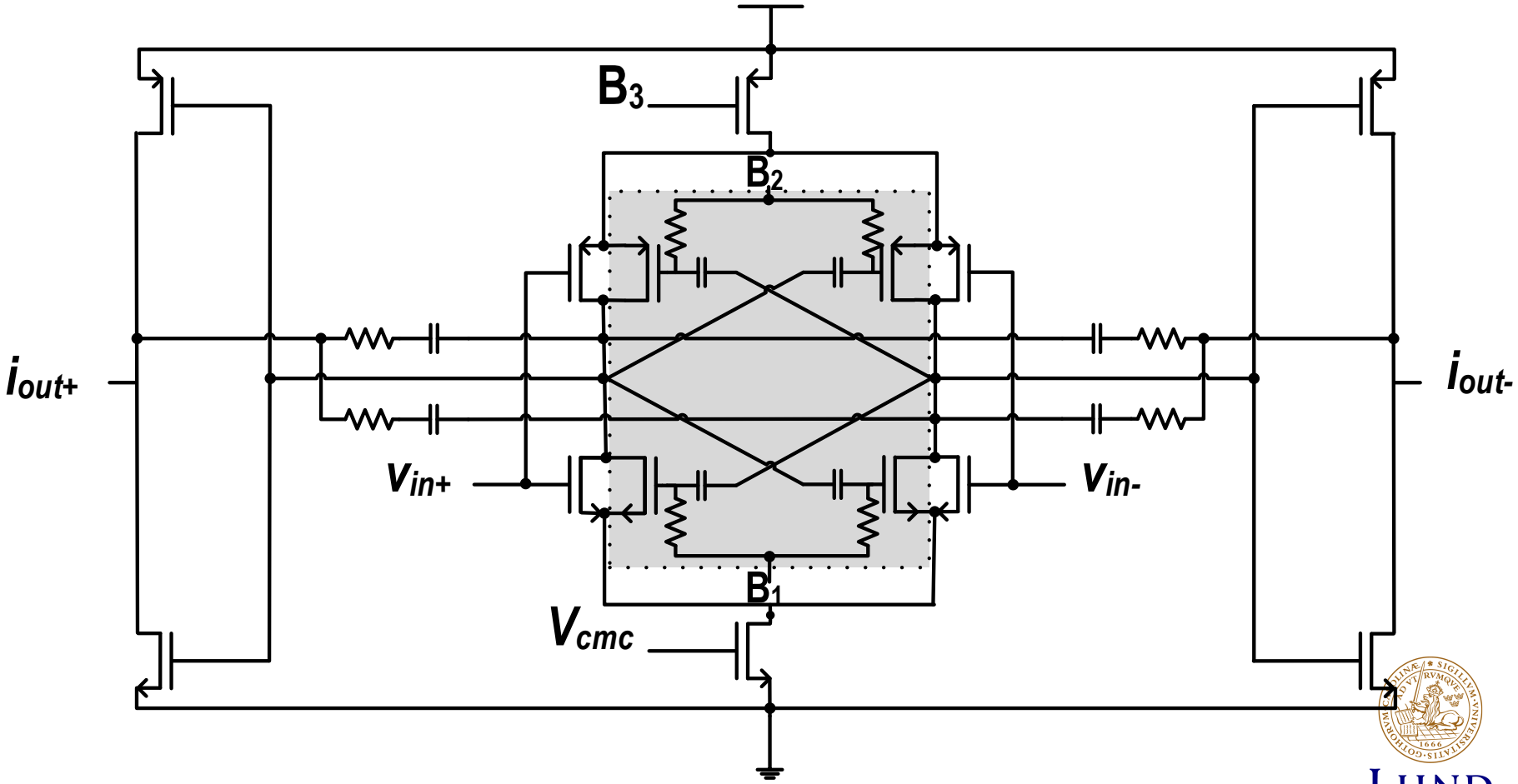
Two stage OTA

- Bias in weak inversion (around ±200mV+Vcm) to prevent latch up.



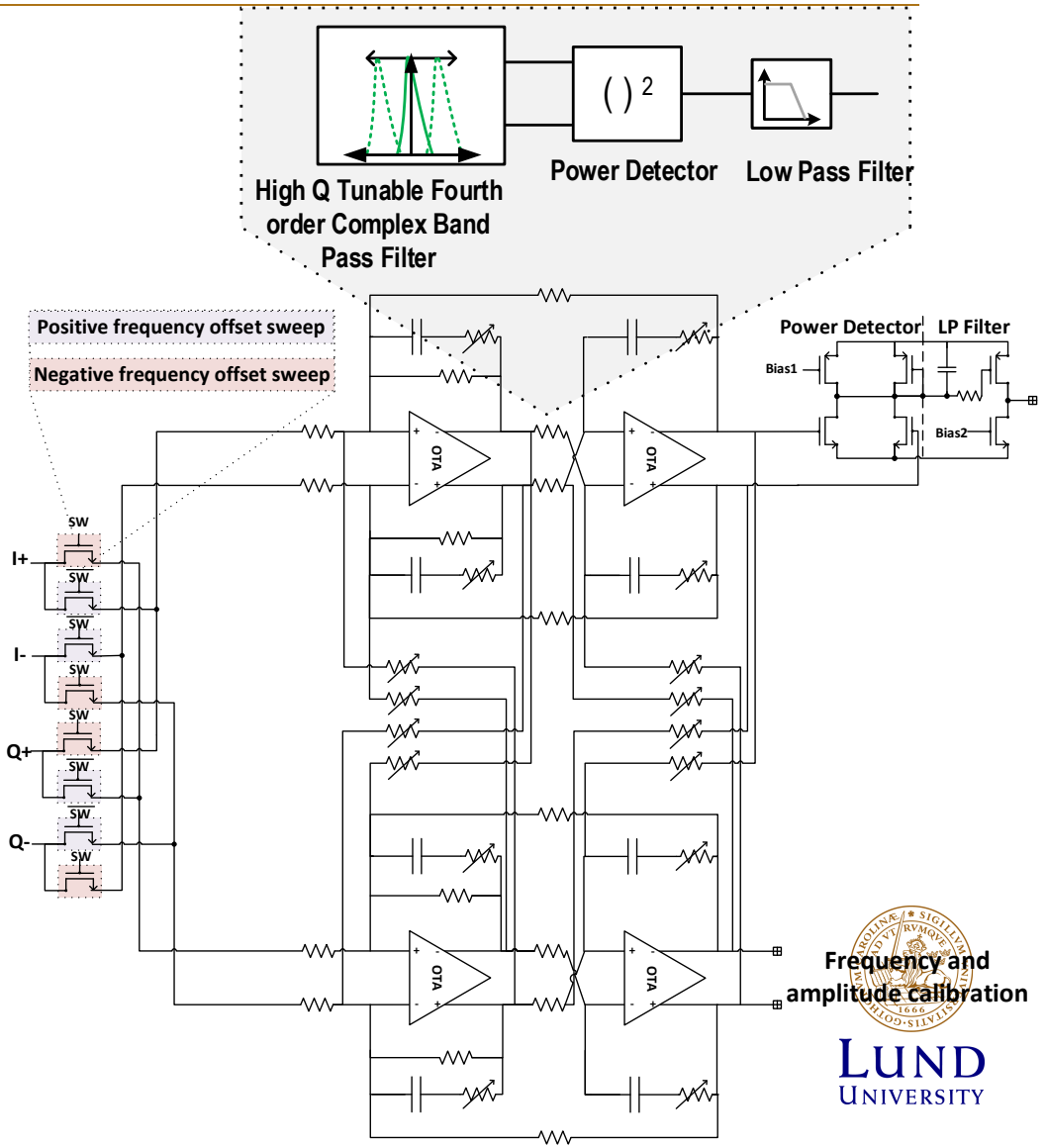
Two stage OTA

- DS to further linearize the OTA, feedback → small devices



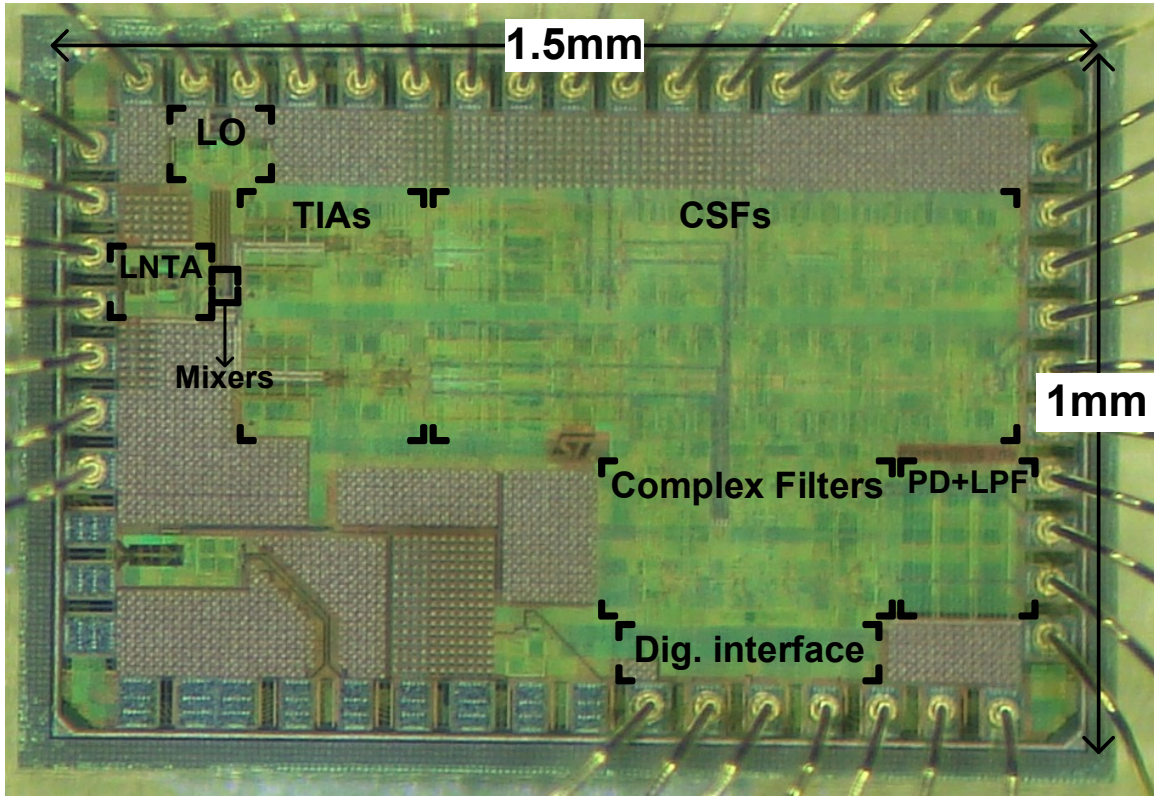
Spectrum sensor

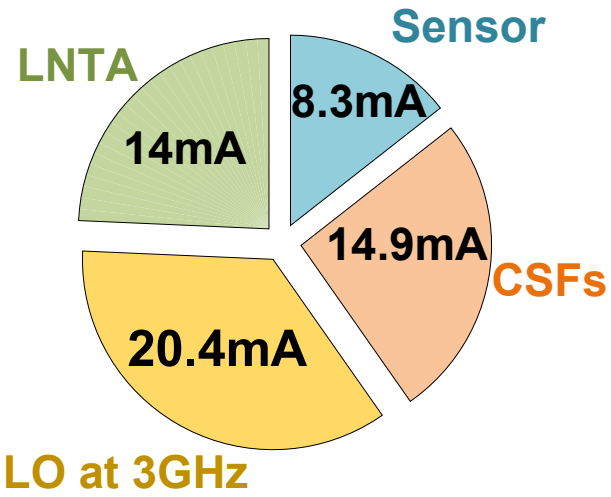
- Input switches for negative/positive frequency sweeps and to enable calibration
- DC output → easy to digitize
- Input switches are open for calibration
- Filter output for one time characterization



Measurements

- ST-65nm CMOS process
- NC off reduces LNTA current to 5.6mA
- LO reduces to 7.6mA at 750MHz





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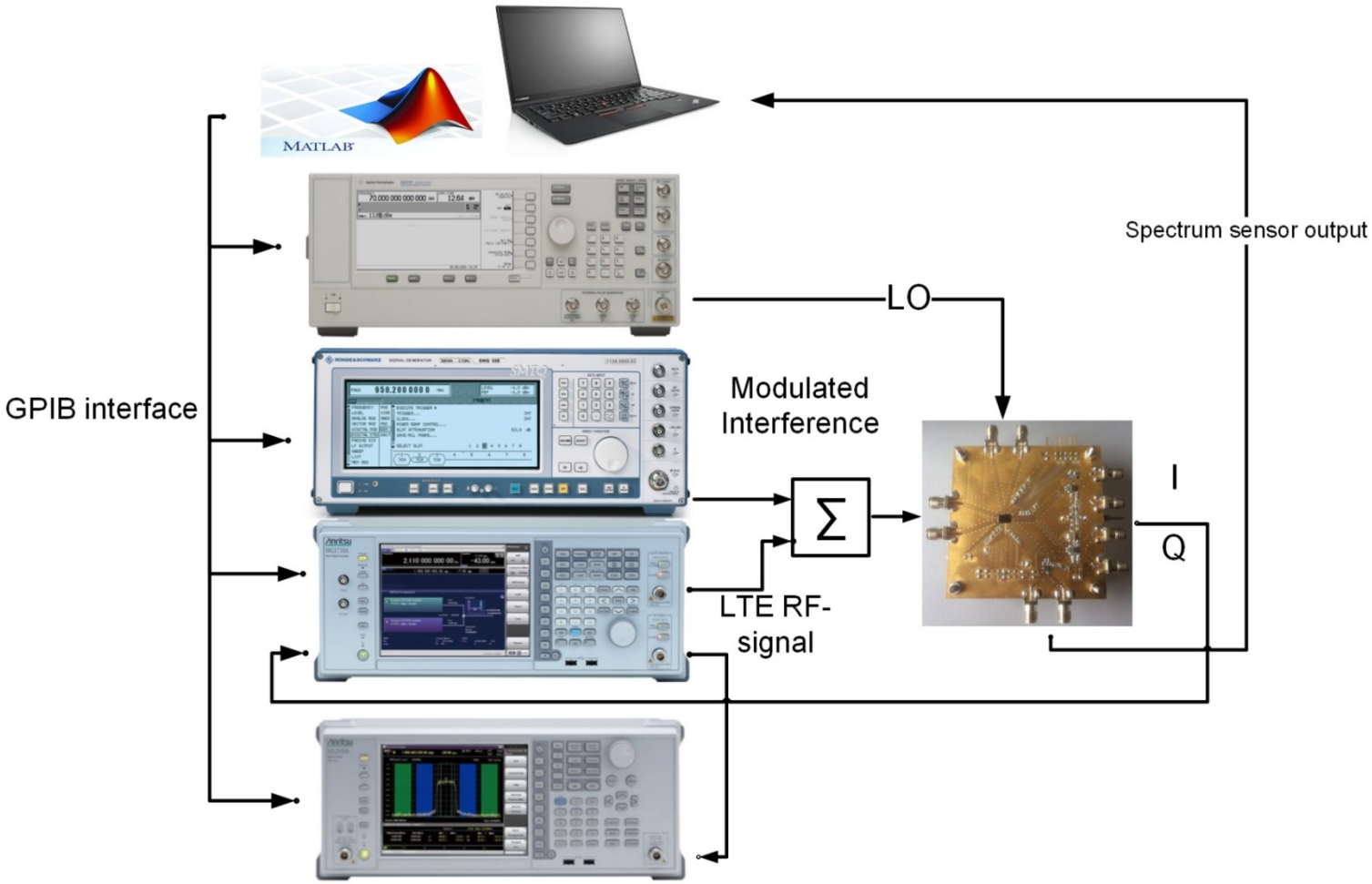
Measurement Setup



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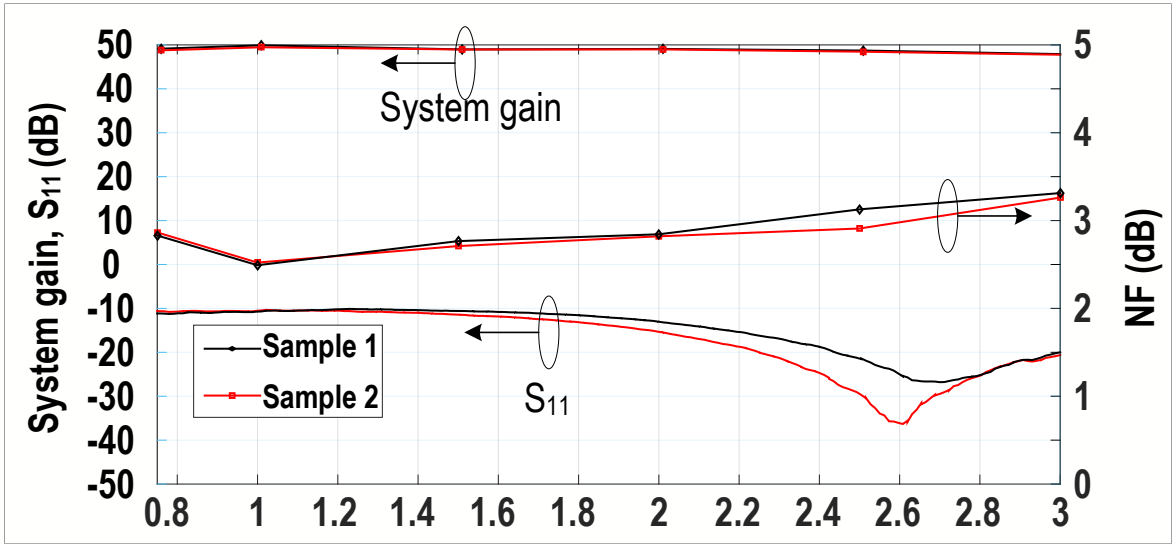
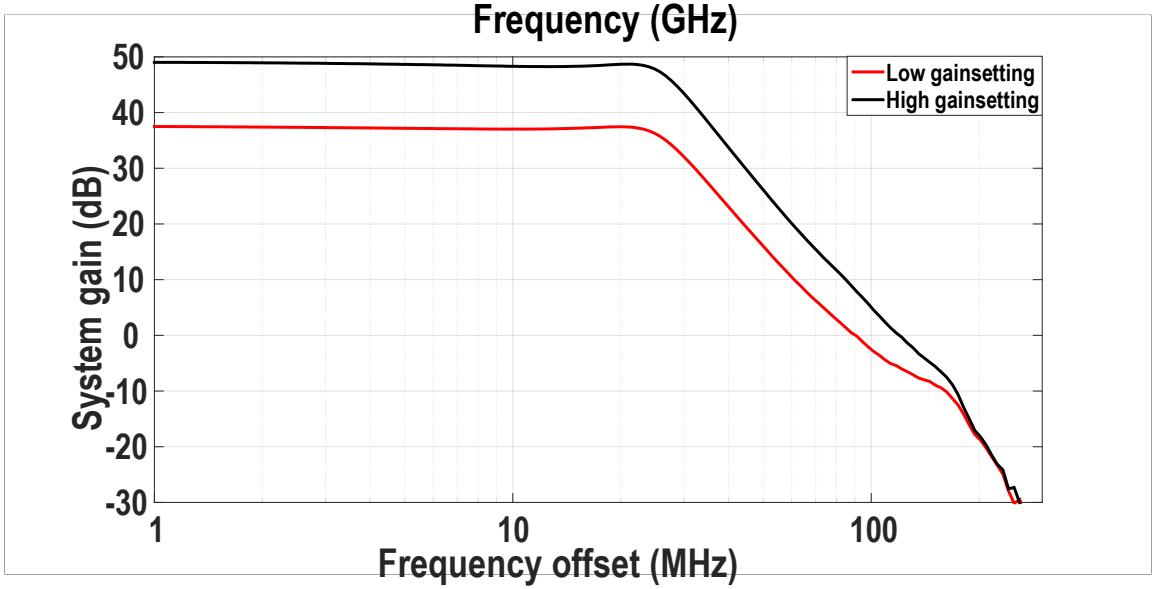
NF, gain, and S_{11}





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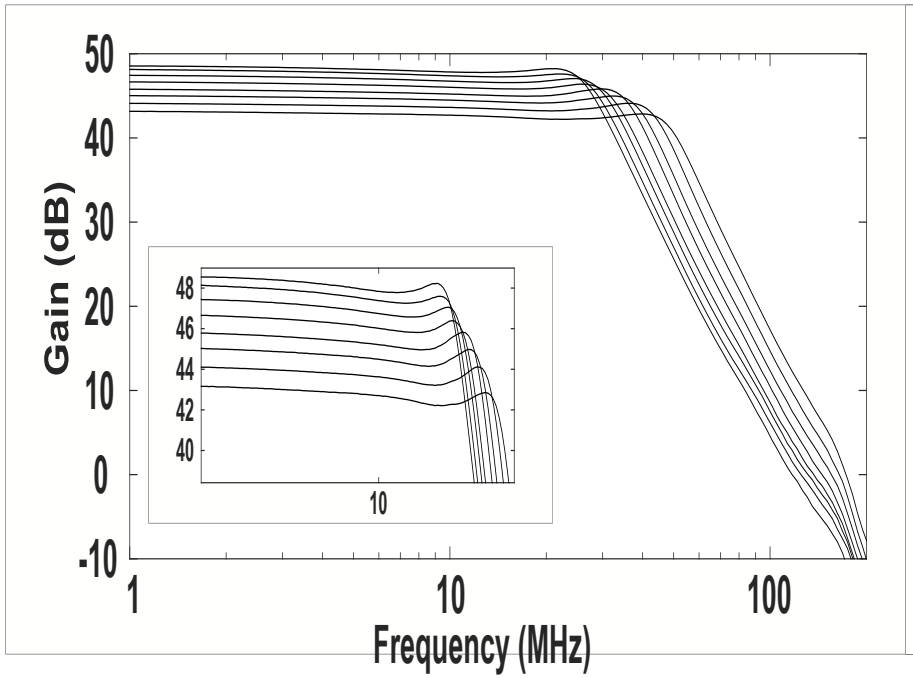
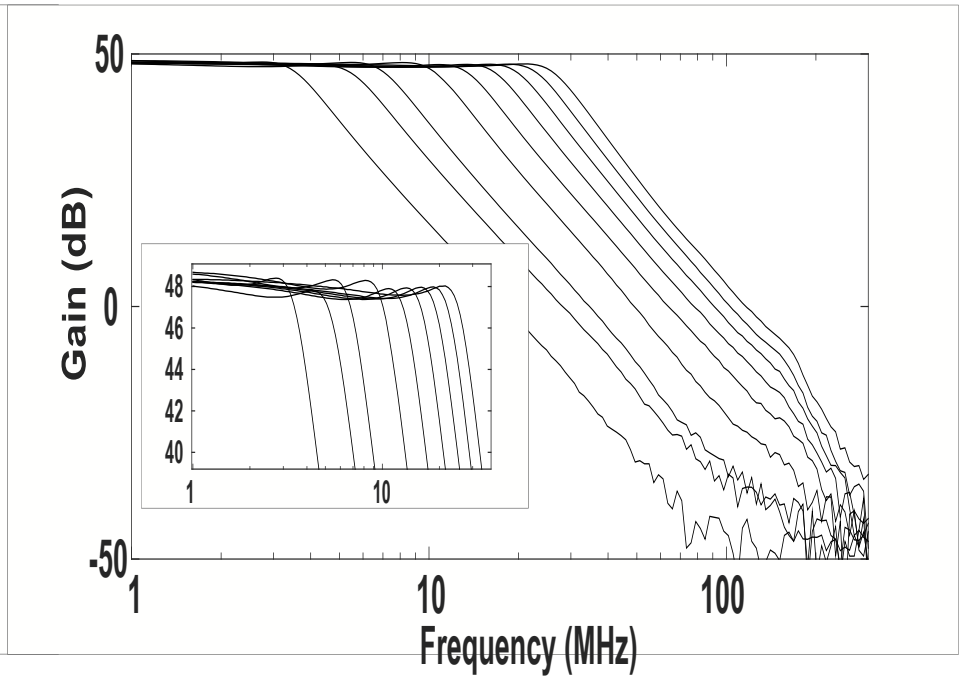
NF, gain, and S_{11}





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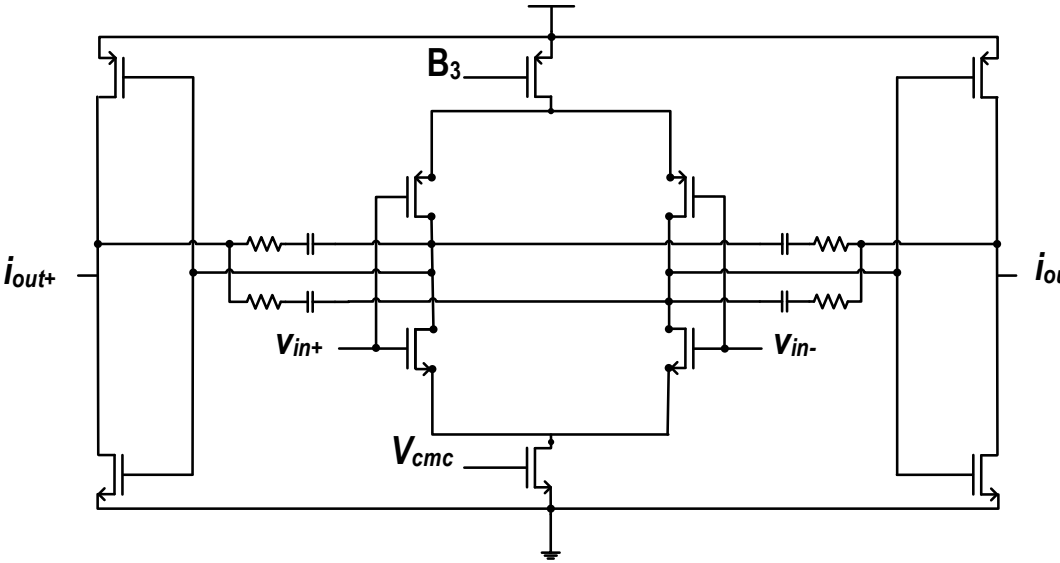
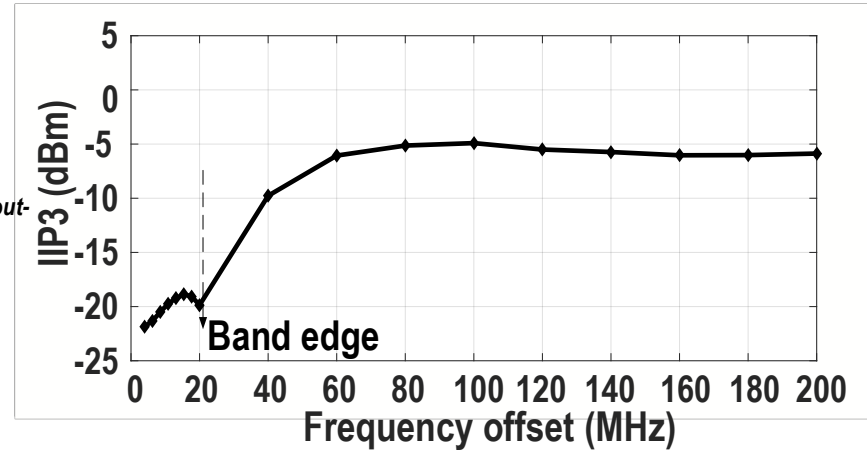
OTA linearization

- Linearity in-band and at band-edge is limited by the BB.





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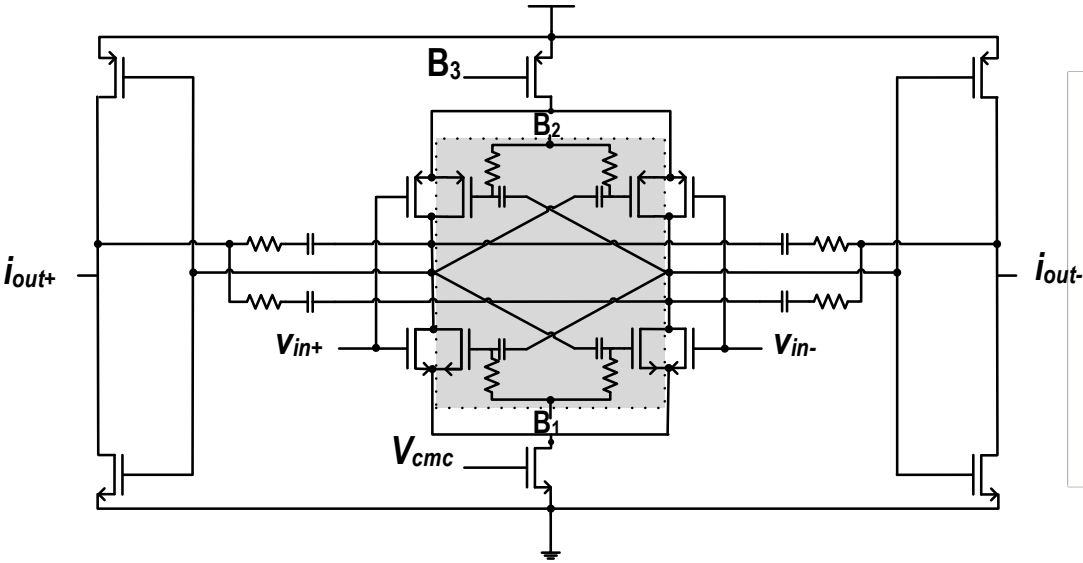
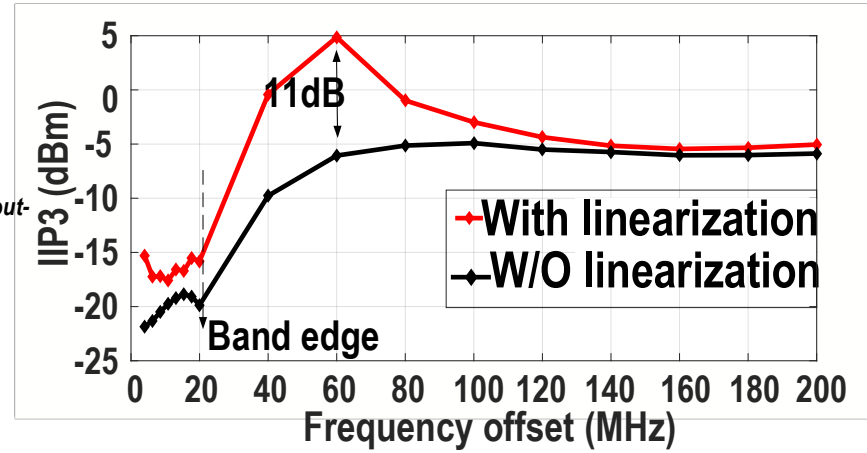
OTA linearization

- Improvement in in-band and band-edge





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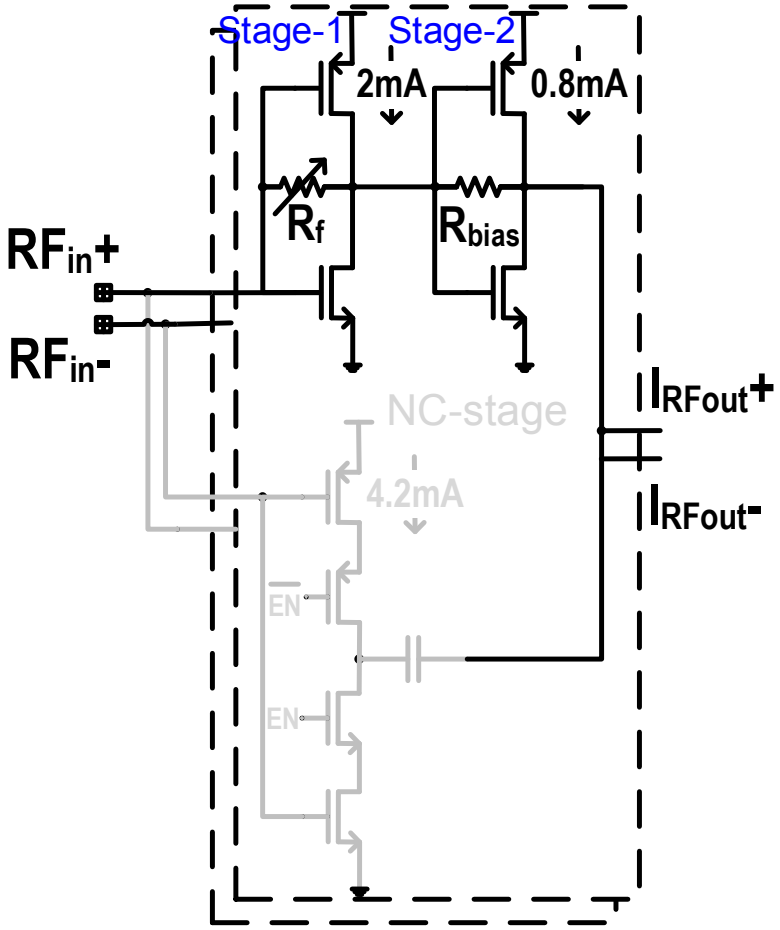
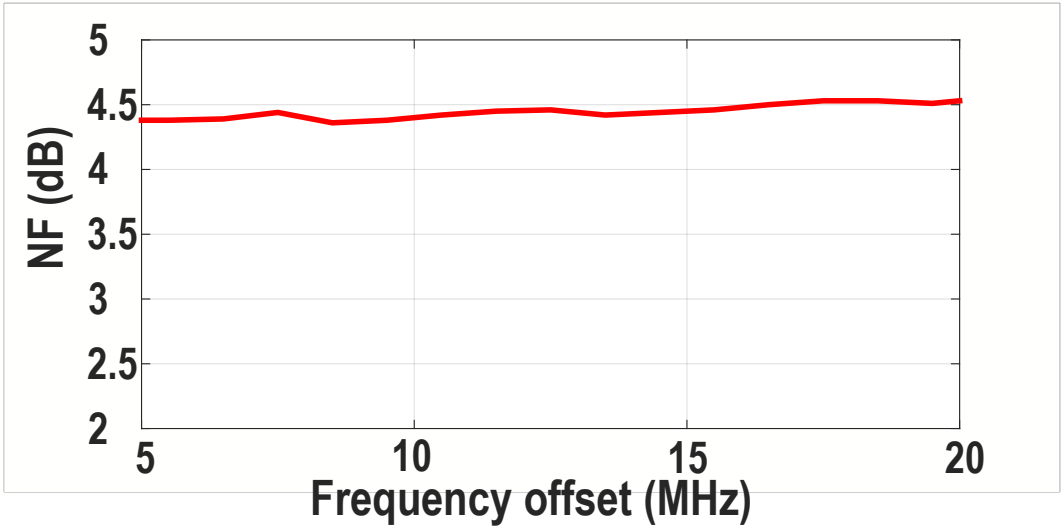
NC-LNTA

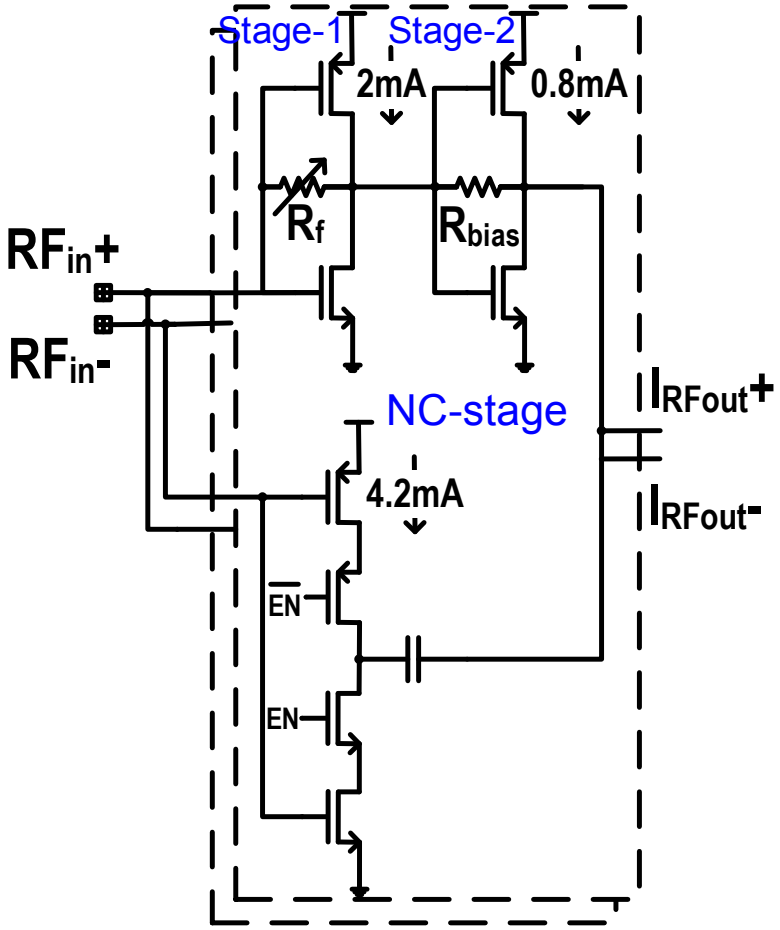
- Low power consumption → moderate NF

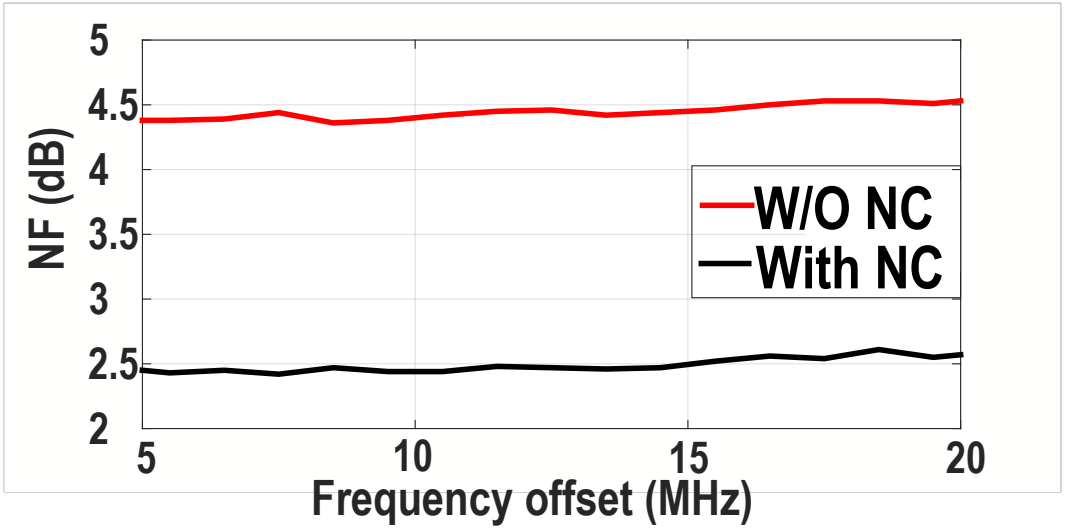




NC-LNTA

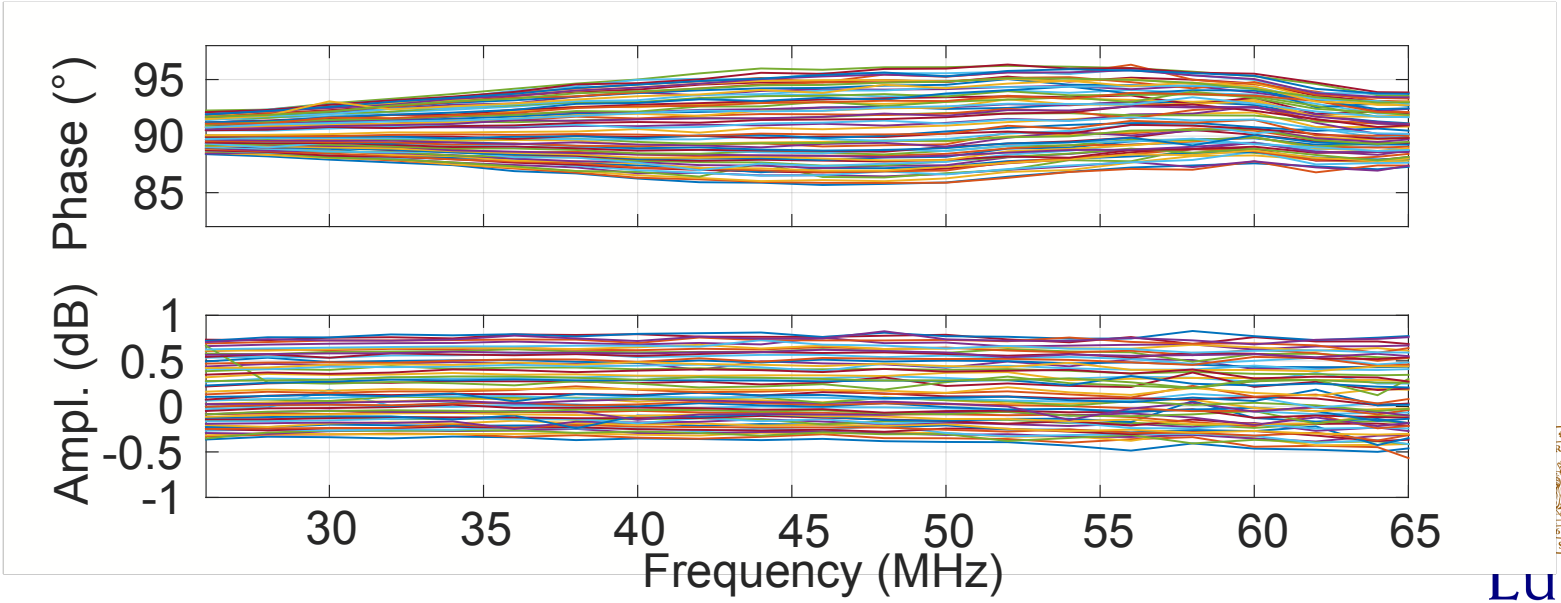
- Low NF → current is more than double





I Q mismatch

- Four port VNA (ZVA-67) was used
- Fine tuning at band-edge:
  - Less than 0.017dB amplitude and 0.15˚ phase resolution
  - IRR → better than 55dB



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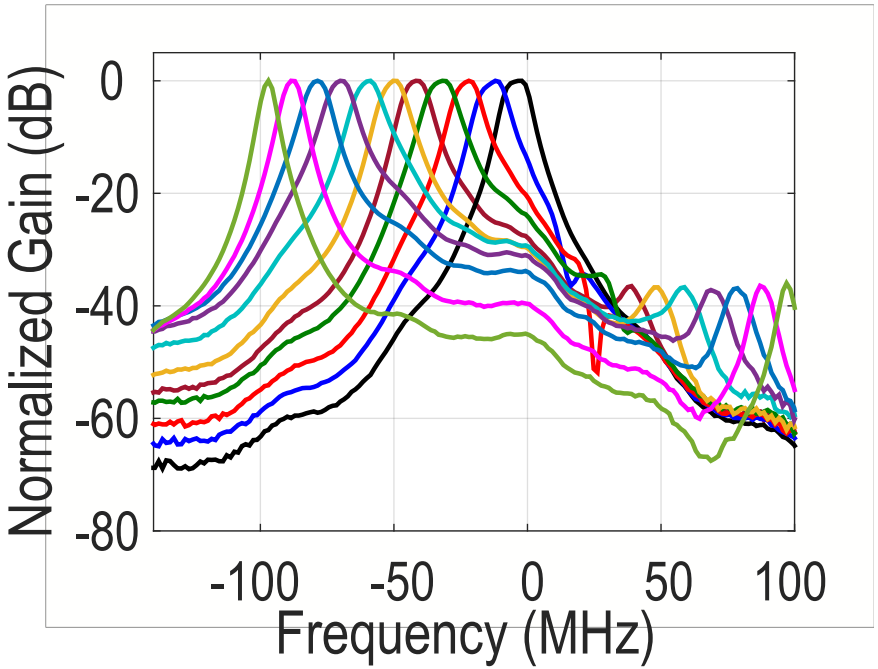
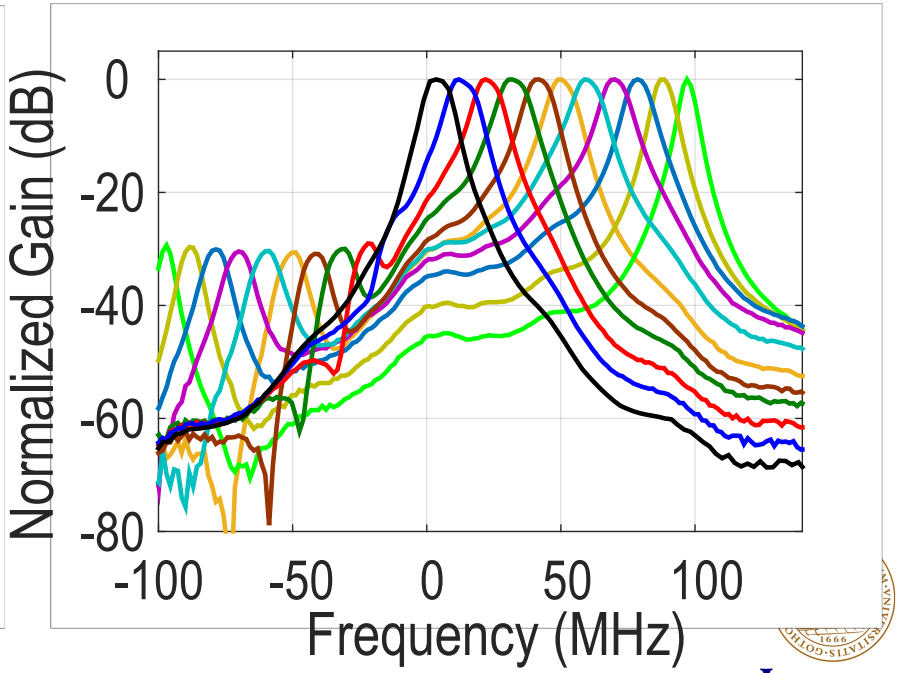
Spectrum sensor

- Normalized frequency response
- Scans up to ±100MHz offset!
-





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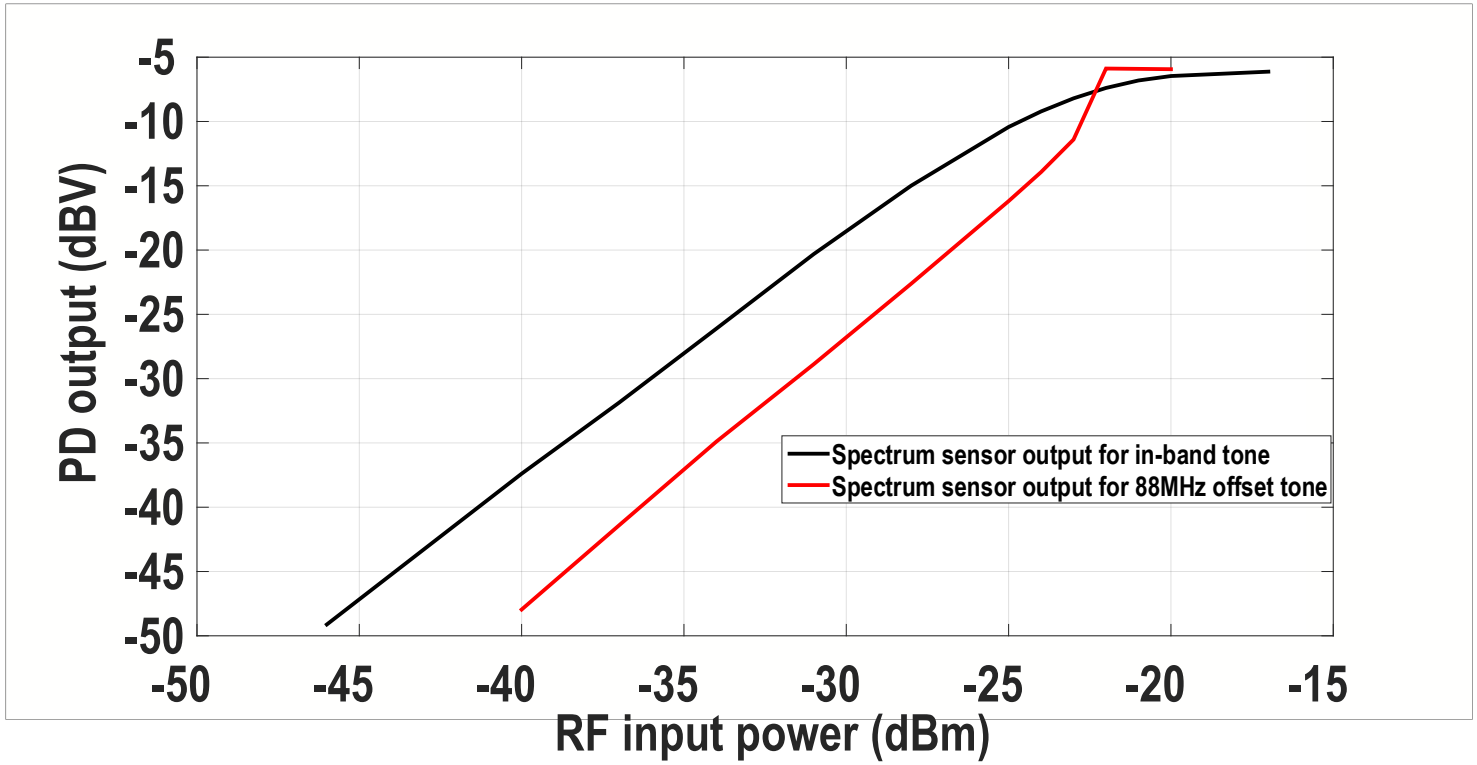
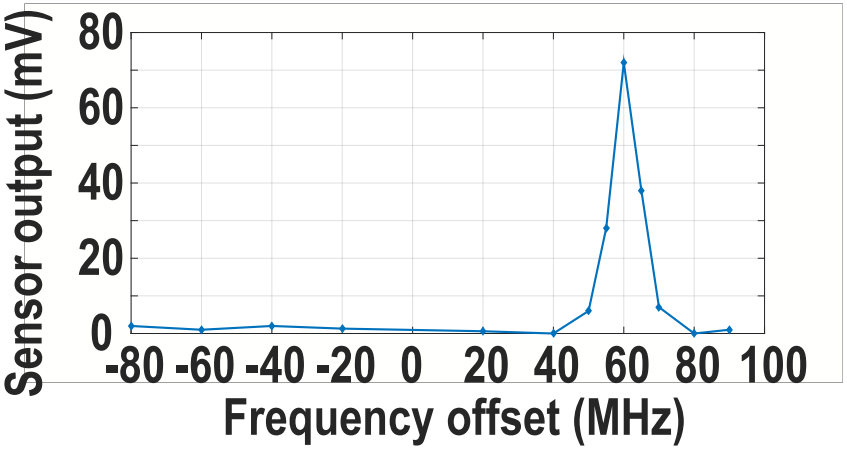
Spectrum sensor

- Can detect in-band signals up to -25dBm.
- Out-of-band (BB BW is 25MHz) can detect up to -22dBm



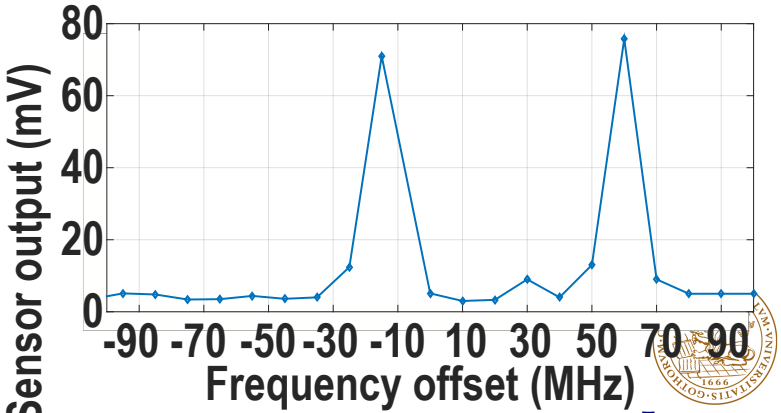
Spectrum sensor

- Spectrum sensor listening to one frequency (60MHz)



(a)

- Two tones are applied (-15MHz, and 60MHz) and spectrum is swept



(b)

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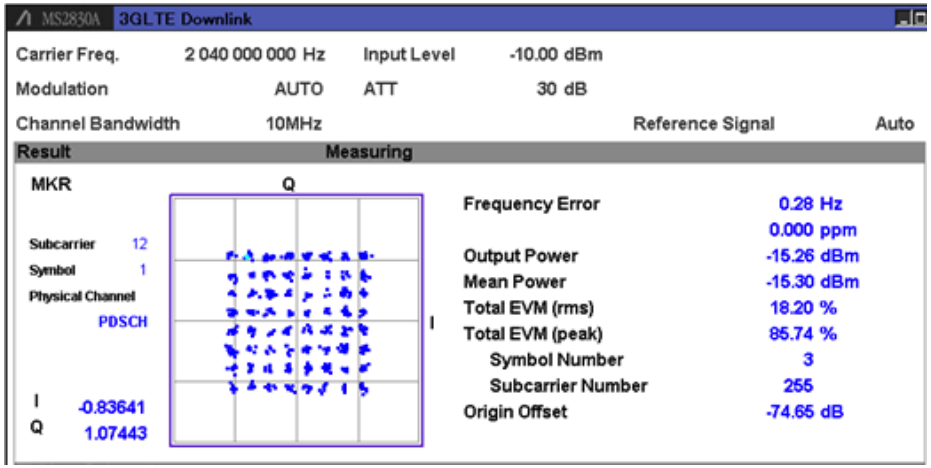
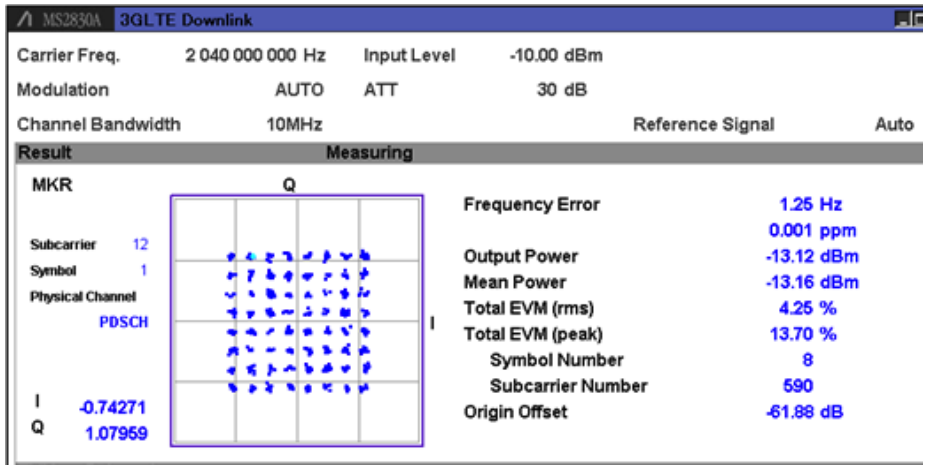
LTE signals- out-of-band blocker

- -24dBm blocker at 100MHz and -60dBm 64-QAM at 40MHz (band-edge)



Mixer capacitor=4pF

EVM=18.2%



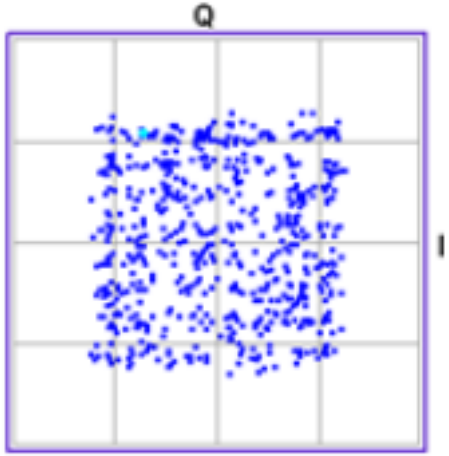
Mixer capacitor=24pF

EVM=4.2%

LTE signals- out-of-band blocker

- Blocker moved to 80MHz

Mixer capacitor=4pF

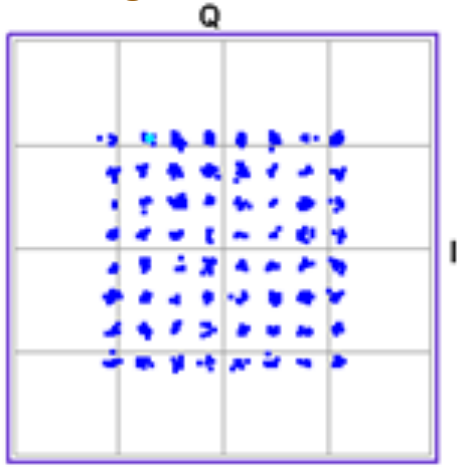


EVM=50.9%

Mixer capacitor=24pF

EVM=38.6%

BB gain back-off



EVM=4.5%

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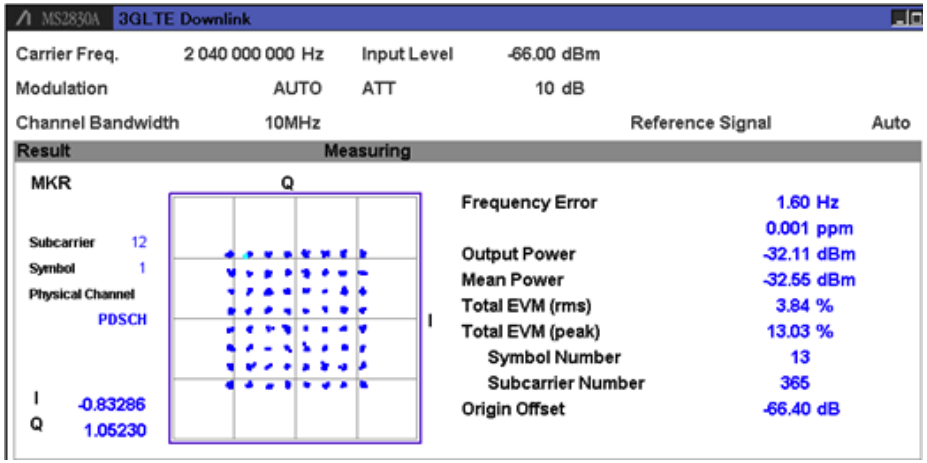
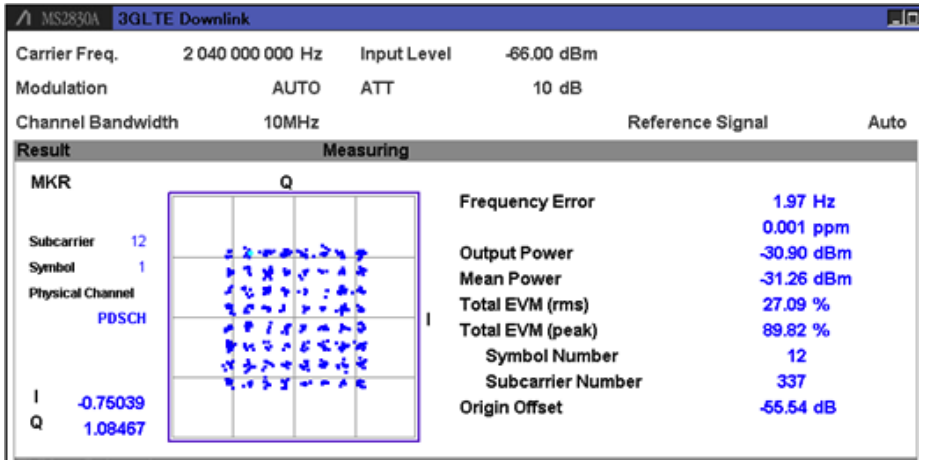
LTE signals- in-gap blocker

- So far large mixer capacitor always helps
- IMD limited performance
- Strong in-gap→-24dBm, and carrier at -54dBm
- RF+BB gains reduced



Mixer capacitor=4pF →EVM=3.8%



Mixer capacitor=24pF →EVM=27.0%

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Conclusion

- A wide-band RX-FE supporting LTE CA scenarios is presented.
- Low NF thanks to noise canceling-LNTA, and improved linearity thanks to linearized OTA.
- Fully integrated spectrum sensor
- LTE signals used to show the usefulness of spectrum sensing in tuning RX-FE.

Acknowledgment

Swedish Foundation for Strategic Research

Anritsu

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