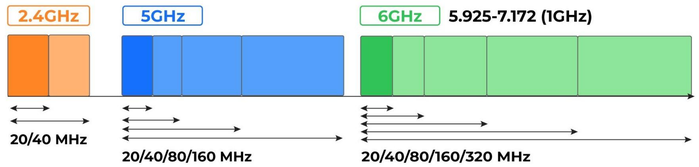
A 6GHZ 3RD ORDER SUBHARMONIC MIXER WITH >30DB FUNDAMENTAL CANCELLATION

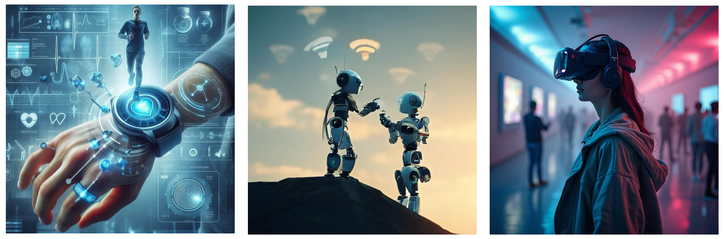
STUDENTS: AHMED R. ABOULSAAD, ZHUORAN WU, NOAH LEVY

Background

- The evolution of Wi-fi standards has enabled the use of higher frequency bands to enhance the throughput while mitigating the congestion at the 2.4GHz bands.



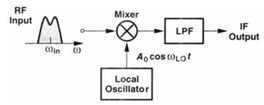
- Wi-Fi 6/6E (IEEE802.11ax) operate on 2.4GHz/5GHz and 6GHz bands. It uses 3 frequency bands, with bandwidths up to 320MHz at 6GHz compared to only 40 at 2.4GHz. Hence, the throughput can go up to 10Gbps.



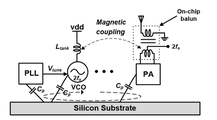
- This led to new applications such as ultra-high-speed streaming, smart wearables, machine communications, and AR/VR.

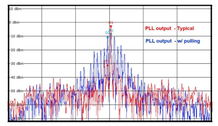
Motivation

- With the use of higher bands, the design of wireless receiver is facing some challenges, especially the core module in RX side - **Mixer**.



- Challenges associated with 6Ghz receivers:
  - Higher LO frequency will bring up higher phase noise.
  - LO Pulling (Coupling through the substrate and inductors).
  - LO distribution network jitter and power.



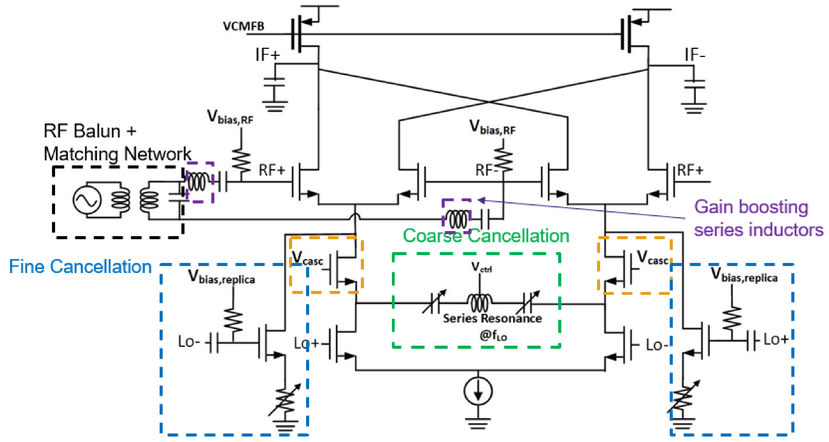


- Fortunately, the use of higher order Subharmonic Mixers (SHMs), which take the harmonics of the LO (2x, 3x, 4x, etc.) and mix with the RF input, can alleviate all these issues.

- However, traditional SHMS suffers from fundamental mixing and the drop of conversion gains.

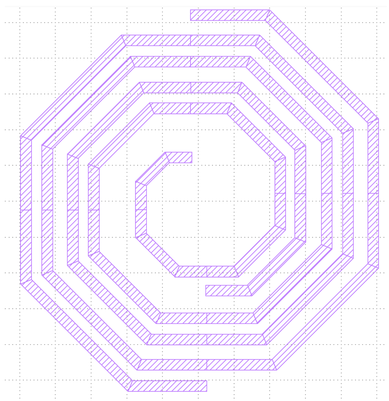
Proposed Circuit

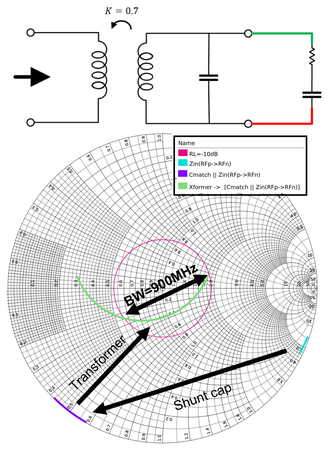
- Active 3rd order SHM. $f_{RF} = 5 \rightarrow 7GHz, \quad f_{LO} = 1.63 \rightarrow 2.3GHz, \quad f_{IF} = 100MHz$:
- Swapped LO and RF ports to cancel LO harmonics.
- Leverages differential pair non-linearities by switching LO using a square wave signal.
- Fundamental mixer output cancelled via tunable **coarse** and **fine** circuits.



Input Matching Network

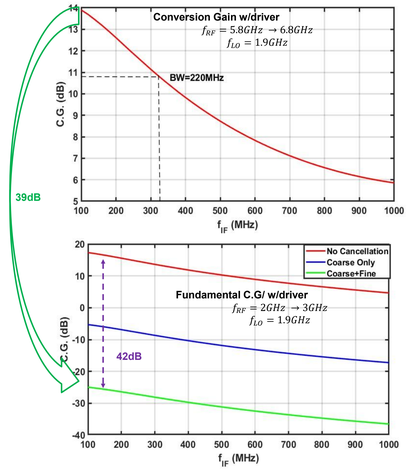
- Input matching network employs interdigitated transformer to transform single-ended 50Ω to differential signal
- Developed python script to export GDSII artwork for coupled inductors.

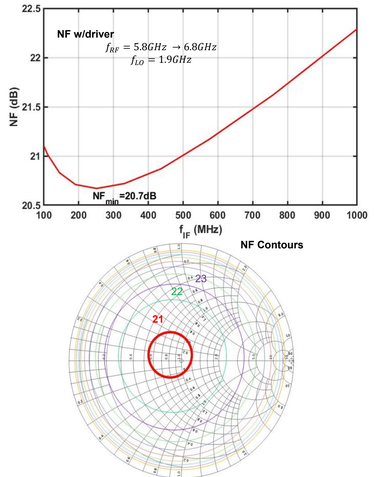


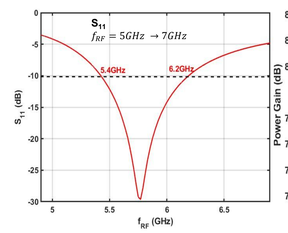


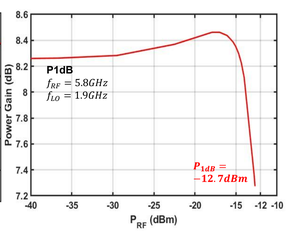
Simulation Results

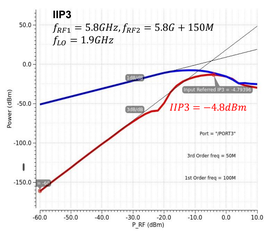
- Fundamental gain improved by 42dB by enabling coarse and fine cancellation.
- 3rd order conversion gain is 39dB higher than fundamental conversion gain in tuned condition.











Future Work and References

- Complete layout and perform post-layout verification of the design.
- Finish top-level simulation and send to fabrication.
- Perform post-silicon test in lab after the chip is fabricated.

[1] B. Razavi, RF Microelectronics, Prentice Hall, 2011.
[2] B. R. Jackson, F. Mazzilli and C. E. Saavedra, "A Frequency Tripler Using a Subharmonic Mixer and Fundamental Cancellation," in IEEE Transactions on Microwave Theory and Techniques, vol. 57, no. 5, pp. 1083–1090, May 2009
[3] H. -S. Lee, J. Myeong and B. -W. Min, "A 26GHz CMOS 3× Subharmonic Mixer With a Fundamental Frequency Rejection Technique," in IEEE Access, vol. 8, pp. 122986–122996, 2020.

ELECTRICAL & COMPUTER ENGINEERING
UNIVERSITY of WASHINGTON

ADVISERS: JACQUES C. RUDELL

SPONSOR: Apple Inc.