Analysis of Cascode Structure for 60GHz Amplifier Design in 65nm CMOS

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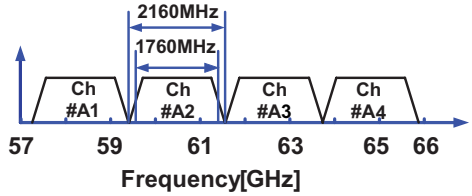
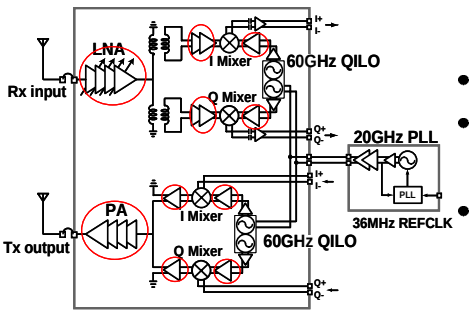
1 Background

- IEEE 802.15.3c specification
  - 9 GHz unlicensed bandwidth
  - 2.16 GHz/ch
  - Several Gbps data transfer
    - QPSK ⇒ 3.5 Gbps •16QAM ⇒ 7 Gbps

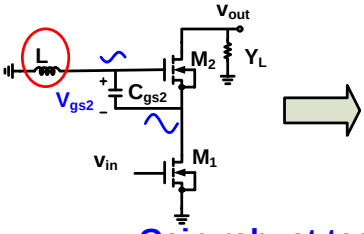




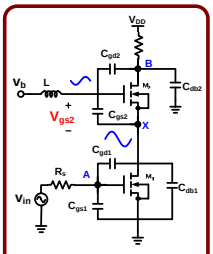
- High gain
- Good stability
- Low power consumption

2 Cascode structure at mmW frequency

- Cascode structure at mmW frequency, a reduction of the reverse isolation S_{12}.
  - ☺ Increase MSG
  - ☺ Large K
  - ☹ Larger parasitic capacitance



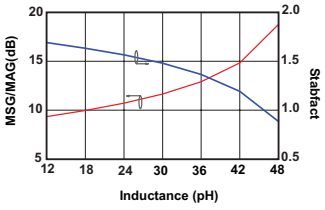
Gain robust technique



Parasitics

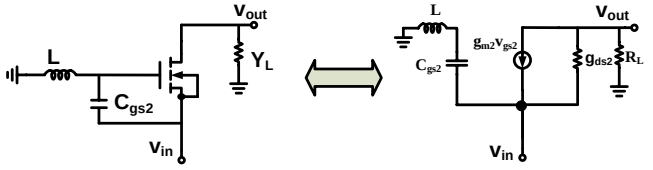
- A double zero and a double pole are added when using L
  - The pole frequency is much lower than the zero frequency.
  - At 60 GHz, only the poles have a significant effect.

3 Inductance optimization



–The trade-off between G_{max} and stability factor

–Inductance has to be optimized reasonably



$$A_v = -\frac{\frac{g_{m2}}{1-\omega^2 L C_{gs2}} + g_{ds2}}{Y_L + g_{ds2}} \Rightarrow L = \frac{1}{\omega^2 C_{gs2}}$$

Gain calculation

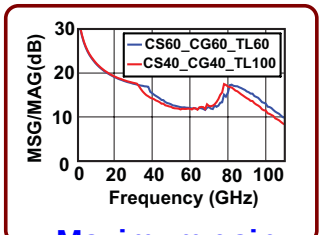
$$K = \frac{2g_{m2}(\frac{Y_L}{g_{ds2}}+1)+2(Y_L+g_{ds2})}{g_{m2}-g_{ds2}(1-\omega^2 L_{TL} C_{gs2})} - 1 > 1 \Rightarrow L = \frac{1-\frac{g_{m2}Y_L}{(2Y_L+g_{ds2})g_{ds2}}}{\omega^2 C_{gs2}}$$

Satability calculation

4 Measurement results

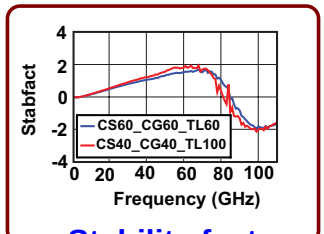
- Two cascode structure TEGs with difference sizes in 65 nm CMOS
- TLs which have about 0.3 pH per μm are utilized as inductance

- CS W_f = 20×2 μm (Nf = 20)
- CG W_f = 20×2 μm (Nf = 20)
- TL 100 μm



Maximum gain

- CS W_f = 30×2 μm (Nf = 20)
- CG W_f = 30×2 μm (Nf = 20)
- TL 60 μm



Stability factor

5 Conclusion

- The measurement results proved that the required inductance is inversely proportional to the transistor size
- The inductance can be optimized according to the theoretical equation