A Comparison between Common-source and Cascode Topologies for 60GHz Amplifier Design in 65nm CMOS
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1 Background
- Issues of mmW amplifier design
  - Gain
  - Impedance matching
  - Stability factor
  - Linearity
  - Noise figure
  - Life time
  - Output power
  - Power consumption
- Topologies
  - Common source (CS)
  - Cascade (Cas.)
  - Gain-boost Cas.

2 NF and linearity calculation

Assume: \( g_{ds} \ll \omega(C_x + C_{gr2}) \)
So:
\[
Z_{x1} = -\frac{1}{j\omega(C_x + C_{gr})}, \quad Z_{x2} = -\frac{1 - \omega^2LC_{gr2}}{j\omega(C_x + C_{gr2} - \omega^2LC_{gr2}C_x)}
\]
\[
L = \frac{C_{gr2} + C_x}{\omega^2C_{gr2}C_x} \rightarrow |Z_{x1}| << |Z_{x2}|
\]
\[
I_{n\_out} = -\frac{I_{n2}}{1 + Z_xg_{m2}} \rightarrow I_{n\_out1} > I_{n\_out2}
\]

NF calculation

3 Verification method
- Measurement results of CS and Cas. transistor TEGs in 65nm CMOS process
- Transistor models based on the measurement data
- 1-stage amplifier with 50Ω matching using TL and MIM TL for simulation.

4 Comparison of CS and Cas. topologies

<table>
<thead>
<tr>
<th>Issues</th>
<th>CS</th>
<th>Cas. boost</th>
<th>CS @60GHz</th>
<th>Cas. boost @60GHz</th>
<th>Gain-boost Cas. @ 60GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max gain (dB)</td>
<td>△</td>
<td>△</td>
<td>9</td>
<td>9</td>
<td>11.7</td>
</tr>
<tr>
<td>Power consume (mW)</td>
<td>△</td>
<td>△</td>
<td>8.3</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>S12 (dB)</td>
<td>△</td>
<td>△</td>
<td>-13.4</td>
<td>-28</td>
<td>-32.8</td>
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<tr>
<td>Stability factor</td>
<td>△</td>
<td>△</td>
<td>0.44</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>OP2 (dBm)</td>
<td>△</td>
<td>△</td>
<td>5.2</td>
<td>4.3</td>
<td>6.4</td>
</tr>
<tr>
<td>IP3 (dBm)</td>
<td>△</td>
<td>△</td>
<td>11.1</td>
<td>3.5</td>
<td>3</td>
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<tr>
<td>OP3 (dBm)</td>
<td>△</td>
<td>△</td>
<td>9.1</td>
<td>-7.7</td>
<td>-7.9</td>
</tr>
<tr>
<td>Noise figure (dB)</td>
<td>△</td>
<td>△</td>
<td>10.5</td>
<td>3.4</td>
<td>1.5</td>
</tr>
<tr>
<td>Life time @ P1dB (Year)</td>
<td>△</td>
<td>△</td>
<td>0.077</td>
<td>0.2</td>
<td>0.3</td>
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<tr>
<td>Stability factor2</td>
<td>△</td>
<td>△</td>
<td>1.1</td>
<td>4</td>
<td>3.8</td>
</tr>
</tbody>
</table>

* Measurement results of Cas. TEGs **Simulation results of 1-stage amplifier with 50Ω matching

5 Conclusion
- A comparison between CS and Cas. topologies is carried out considering most of the issues of mmW amplifier design.
- Better NF and worse linearity of the gain-boost Cas. topology is verified by calculation and simulation.
- The comparison is useful for the design of mmW amplifiers, such as LNA and PA.