Design of Radio Frequency Building Blocks (LH1b-09)

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Project Overview
A CMOS down-conversion mixer has been designed for Bluetooth receiver using LC resonant tank as the source coupled pair and folded structure techniques. The mixer has an NF3 intercept point of 3.15 dBm and consumes less than 7 mW power.

Background
A Down-Conversion Mixer:
• At the radio frequency front-end
• Perform frequency translation
• Should have high linearity

A Single Balanced Mixer:

Specification:
0.35μm CMOS technology process is used throughout the project. The mixer is designed for 2.4GHz Bluetooth application and the specification of the mixer is listed below.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Frequency</td>
<td>2.4</td>
<td>GHz</td>
</tr>
<tr>
<td>LO Frequency</td>
<td>2.4</td>
<td>GHz</td>
</tr>
<tr>
<td>NF3</td>
<td>3</td>
<td>dBm</td>
</tr>
<tr>
<td>Converter Gain</td>
<td>&gt;2</td>
<td>dB</td>
</tr>
<tr>
<td>Noise Figure</td>
<td>&gt;-20</td>
<td>dB</td>
</tr>
<tr>
<td>IS Power isolation</td>
<td>&gt;80</td>
<td>dB</td>
</tr>
<tr>
<td>VSWR</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Power Consumption</td>
<td>&lt;80</td>
<td>mW</td>
</tr>
</tbody>
</table>

Methodology
Planar Dipole:

Circuit Design:
- Simple to implement
- Low noise figure
- Lower linearity
- Requires differential input

And weighing the above advantages and disadvantages, the Gilbert cell is chosen to be the basic topology of the mixer. And the techniques listed below are used to improve the performance.

LC tank as Source-Coupled Pair:
- Reduce the current
- High impedances of resonant frequency
- High selectivity

Folded Structure:
- Increase of voltage headroom
- Lower supply voltage

Final Design
Here are the simulation results:

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO, RF, LO, RF</td>
<td>3.15 dBm</td>
</tr>
<tr>
<td>NF3, NF3</td>
<td>7 mW</td>
</tr>
<tr>
<td>IS, IS, IS</td>
<td>80 dB</td>
</tr>
<tr>
<td>Power Consumption</td>
<td>&lt;80 mW</td>
</tr>
</tbody>
</table>

Result
This is the schematics of the final product. The table below summarizes the component parameters.

RF Power Budget
Performance Summary
- Power
- Gain
- Linearity
- Noise Figure
- Sensitivity
- Linearity
- Intermodulation
- RF Power
- NF3
- LO Power
- LO Power
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