An 80-400 MHz 74 dB-DR Gm-C Low-Pass Filter With a Unique Auto-Tuning System

T. Gao, W. Li, N. Li, J. Y. Ren
State Key Laboratory of ASIC and System
Fudan University, China
January 26, 2011
Outline

- Design Specifications
- Filter Architecture
- Tuning Technique
- Measurement Results and Comparisons
Design Specifications

- Filter Type: 5th Order Chebyshev
- Ripple:< 1 dB
- Attenuation: >45 dB @ 2.3* $f_c$
- Voltage Gain: 0-30 dB
Programmable Gm-C filter Architecture

- 1 bit Gm Cell
- 5 bit DCCA

Programmable Gm

\[ f_c = 300 \text{ MHz} \]
Transconductor Structure

1bit Gm Cell
- Modified Nauta structure
- Six Inverters
- Controlled by ‘S’
- Transconductance can be switched between ‘$g_m$’ and ‘$g_m/2$’
Discrete Auto Tuning Technique

- Wide tuning range
- Low power Consumption
- Stable
- Clock needed

1 bit data: 0 or 1

Highest bit

Up to 20 MHz
Chip Photograph and Measurement

Tuning error versus reference frequency

<table>
<thead>
<tr>
<th>$f_r$ (MHz)</th>
<th>90</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>350</th>
<th>380</th>
</tr>
</thead>
<tbody>
<tr>
<td>$f_c$ (MHz)</td>
<td>93</td>
<td>103</td>
<td>206</td>
<td>315</td>
<td>358</td>
<td>362</td>
</tr>
<tr>
<td>Error</td>
<td>3.3%</td>
<td>3.0%</td>
<td>3.0%</td>
<td>5.0%</td>
<td>2.3%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

Active area: 0.13 mm$^2$

Tuning Range: 80 MHz- 400 MHz
Measurement Results

Measured @ 250 MHz Cut-off frequency

- Noise Figure: 14-18 dB
- Voltage Gain: 0-30 dB

Measured NF and Voltage Gain
Measurement Results

Two tone test @ 100 MHz

- Cut-off frequency: 250 MHz
- $\text{IIP3}=17.4$ dBm
Comparisons

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology (um)</td>
<td>0.13</td>
<td>0.13</td>
<td>0.13</td>
</tr>
<tr>
<td>Supply Voltage (V)</td>
<td>1.2</td>
<td>1.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Power (mW)</td>
<td>20.8</td>
<td>21</td>
<td>9</td>
</tr>
<tr>
<td>Bandwidth (MHz)</td>
<td>200</td>
<td>70-280</td>
<td>80-400</td>
</tr>
<tr>
<td>Active area (mm²)</td>
<td>0.28</td>
<td>0.12</td>
<td>0.13</td>
</tr>
<tr>
<td>Gain (dB)</td>
<td>0</td>
<td>0</td>
<td>0-30</td>
</tr>
<tr>
<td>DR</td>
<td>54.5</td>
<td>53</td>
<td>74/60</td>
</tr>
<tr>
<td>FoM</td>
<td>NaN</td>
<td>13.3</td>
<td>2.8</td>
</tr>
</tbody>
</table>


\[ FoM = \frac{\text{Power}}{pQ_{\text{max}} f_c DR^2} \]

The End

Q&A?