Quadrature GPS Receiver Front-End in 0.13μm CMOS: The QLMV cell

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Global Positioning System

• A global navigation satellite system maintained by US government
  – Other systems: GLONASS (Russia), COMPASS (China), Galilieo (EU)

• 30 NAVSTAR satellites in orbit
  – First satellite launched in 1978

• Approved for civilian use in 1983

[www.blaugh.com]
Global Positioning System

- Requires line of sight to four or more GPS satellites (latitude, longitude and altitude)
- 50W transmitter power

- L1 signal - 1.57542 GHz (Civilian)
- L2 signal - 1.2276 GHz (Military)

[www.sparkfun.com]
GPS Receiver Architecture

- Emphasizes on low-power design
- IF frequency: 3 MHz

[Cheng et al. ISSCC’09]
Stacked Quadrature LNA-Mixer-VCO

VCO

MIXER

LNA

Vbias

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Mixer-LNA

- Advantages
  - Current reuse
  - 1/f noise is minimized
  - 2X conversion gain comparing the single-balanced mixer
  - Number of transistors is reduced to optimize LNA NF and RF loss
Mixer-LNA

- Noise Figure

![Graph showing Noise Figure vs VCO power]

1 mA, 9.352 dB

2 mA, 7.897 dB
Gate Modulated CMOS QVCO

- Low power supply voltage operation
- Low phase noise
- Added parasitic capacitance

<table>
<thead>
<tr>
<th>VCO Frequency</th>
<th>1.57 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Noise @ 1MHz</td>
<td>-114 dBc/Hz</td>
</tr>
</tbody>
</table>
QVCO Output

![Graph of QVCO Output]

- Voltage [V]
- Time [ns]
- I+  Q+  I-  Q-

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QVCO Phase Noise

1 MHz, -112.3 dBc/Hz
QLMV Cell Layout

- Area: ~1mm$^2$
## Data Comparison

<table>
<thead>
<tr>
<th></th>
<th>This Work</th>
<th>[1]</th>
<th>[4]</th>
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<tbody>
<tr>
<td><strong>Technology</strong></td>
<td>0.13µm CMOS</td>
<td>0.13µm CMOS</td>
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<tr>
<td><strong>RF frequency</strong></td>
<td></td>
<td>1.57542GHz</td>
<td></td>
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<tr>
<td><strong>Power (mW)</strong></td>
<td>2.14</td>
<td>1</td>
<td>5.4</td>
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<td><strong>Conversion Gain (dB)</strong></td>
<td>27.7</td>
<td>42.5</td>
<td>36</td>
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<tr>
<td><strong>Phase Noise @ 1MHz (dBc/Hz)</strong></td>
<td>-112.3</td>
<td>-110</td>
<td>-104</td>
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<td><strong>NF (dB)</strong></td>
<td>48</td>
<td>6.5</td>
<td>4.8</td>
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<tr>
<td><strong>P1dB (dBm)</strong></td>
<td>-68</td>
<td>-40</td>
<td>-31</td>
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<tr>
<td><strong>IIP3 (dBm)</strong></td>
<td>-57</td>
<td>-30</td>
<td>-19</td>
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<td><strong>S11 (dB)</strong></td>
<td>&lt;-30</td>
<td>&lt;-10</td>
<td>&lt;-10</td>
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<td><strong>Current (mA)</strong></td>
<td>2.14</td>
<td>1</td>
<td>4.5</td>
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<td><strong>Supply Voltage (V)</strong></td>
<td>1</td>
<td>1</td>
<td>1.2</td>
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<td><strong>Area (mm²)</strong></td>
<td>1.05</td>
<td>-</td>
<td>1.5</td>
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Questions?
References


