A Current Re-use Quadrature Front-End Receiver for ISM Band

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Introduction

- Stacked current reuse architecture for front-end
  - Low power, bias current re-use
  - No coupling required from stage to stage
- I and Q demodulation
  - Image rejection
- ISM Band 915 MHz
  - Intermediate frequency is 10 MHz
  - IF amplifier with LO leakage reduction
  - BPSK coding
- Applications:
  - Cordless phone
  - WSN nodes
  - ZigBee devices
Conventional Receiver Architecture

LNA

Mixer

IF

VCO
QLMV – Block level

QLMV Cell Stack

VCO

Mixer

LNA

IF
QLMV Cell (Top-Level)
LNA:

- Degenerated Common Source Amplifier
- Tested with balun as well as a direct input port
- $S_{11} : -18\,\text{dB} @ 900\,\text{MHz}$
- Inductor to decouple
  - Open circuit at high frequencies
- Tail current of 1.8mA.
- LNA NF (individual characterization) : 2.1 dB
QVCO:

• Gate-modulated architecture proposed by the paper
  • Less frequency pulling and increased phase noise
• Chose to implement a PVCO
• Phase Noise. - 115dBc (900Mhz – 940Mhz)
• Tunability: Vct - 500mV – 700mV. (for PLL or outside tuning)
• Bottom cap for increasing Q-factor and reducing feedthrough of LO
• Transistors sized up to reduce flicker noise
Mixer:

- Doubly balanced Gilbert mixer
- Mixer works in triode
  - Running in saturation needs external circuitry
    (adds noise)
IF Amplifier 2 (IF_2)

- New architecture – trans-impedance amplifier
- 40dB/dec roll off
- Power consumption: 1mW
IF Amplifier 1 (IF_1)

- Single pole trans-impedance amplifier
- Bandwidth – 15 MHz
- 20dB/dec roll-off
- Power: 300 μW
System Integration and Comparison

- RC polyphase filters for image rejection
  - Generates bandpass filter
- PLL for frequency control
- Baseband DSP processing

- Typical BER - $10^{-4}$
- Link Budget Analysis
  - 900MHz Protocols
Layout

- DRC and LVS clean
- Die area – 2.5mm²

LNA
VCO + mixer
IF Amplifier
<table>
<thead>
<tr>
<th></th>
<th>QLMV (IF_1)</th>
<th>QLMV (IF_2)</th>
<th>[1] GPS Rx</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_{11}$ (dB)</td>
<td>&lt; -10</td>
<td>&lt; -10</td>
<td>&lt; -10</td>
</tr>
<tr>
<td>IIP3 (dBm)</td>
<td>21.5</td>
<td>-55</td>
<td>-30</td>
</tr>
<tr>
<td>$P_{-1}dB$ (dBm)</td>
<td>-41.5</td>
<td>-65</td>
<td>-40</td>
</tr>
<tr>
<td>Conversion gain (dB)</td>
<td>46</td>
<td>42</td>
<td>42.5</td>
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<tr>
<td>Noise Figure (dB)</td>
<td>9.8</td>
<td>12</td>
<td>6.5</td>
</tr>
<tr>
<td>VCO Phase Noise (dBc/Hz)@1 Mhz</td>
<td>-116</td>
<td>-116</td>
<td>-110</td>
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<tr>
<td>VDD (V)</td>
<td>1.2</td>
<td>1.2</td>
<td>1</td>
</tr>
<tr>
<td>Current QLMV (mA)</td>
<td>1.8</td>
<td>1.8</td>
<td>1</td>
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<tr>
<td>Current IF Amp (mA)</td>
<td>1</td>
<td>1.8</td>
<td>1</td>
</tr>
</tbody>
</table>
References


Abdellah Chehri, Member, IEEE, Hussein Mouftah, Fellow, IEEE, Paul Fortier, Senior, IEEE, and Hasnaa, Aniss, Member, IEEE

R. van Langevelde I, M. van Elzakker I, D. van Goor, H. Termeer, J. Moss and A.J. Davie

[6] IEEE 802.15.4-2006 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group.

Thank You !!!
Phase Noise
VCO frequency control

- $V_{\text{control}}$ vs VCO frequency plot:
Noise figure for LMV cell
Noise figure
P1dB (-41 dB)
IIP3 = -21.493dB