A New Transceiver Architecture for the 60-GHz Band

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Ali Parsa, Member, IEEE
Behzad Razavi, Fellow, IEEE

Presented by Jason Hill
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Outline

• Introduction
• Comparison of Architectures
• Receiver Design
• Transmitter Design
• Results
• Conclusion
Introduction

• 60-GHz transmitter and receiver
• Employs a 30-GHz LO and polyphase filter (PFF)
• 3 critical issues related to the LO
  – Generation
  – Division
  – Distribution
Comparison of Architectures

Generic Direct-Conversion Receiver
Comparison of Architectures

Direct-Conversion Receiver
with Frequency Doubler
Comparison of Architectures

Heterodyne Receiver with Frequency Multiplier and Divider
Comparison of Architectures

Half-RF Heterodyne Transceiver Architecture
Half-RF Receiver Spectra

[Diagram showing the RF Mixer Input, First LO, and RF Mixer Output frequencies.]
Elimination of Positive Frequency at RF
Proposed Receiver and its Spectra

![Diagram of proposed receiver and its spectra](image)
Effect of Mismatches

- Mismatches modeled as gain and phase imbalances ($\Delta A$ and $\Delta \theta$)
Effect of Mismatches

- Mismatches modeled as gain and phase imbalances ($\Delta A$ and $\Delta \theta$)

$$I_B + jQ_B = (1 + \alpha) \left[ \left( a + \frac{\Delta A}{A} \right) e^{j\Delta \theta + 1} \right] x_{BB}(t) + \left[ \left( 1 + \frac{\Delta A}{A} \right) e^{j\Delta \theta + 1} \right] x_{BB}^*(t)$$

$$\left| \frac{x_{BB}^*}{x_{BB}} \right| = \left| \frac{\left( 1 + \frac{\Delta A}{A} \right) e^{j\Delta \theta + 1} - 1}{\left( 1 + \frac{\Delta A}{A} \right) e^{j\Delta \theta + 1} + 1} \right|$$

This result is identical to the image-rejection ratio (IRR) of image reject receivers.
Schematic of LNA and PFF
Effect of Buffer Stage

- Voltage Gain (dB) vs Frequency (GHz)
- Noise Figure (NF) (dB) vs Frequency (GHz)
RF and IF Mixers and Oscillator
Receiver Floor Plan
Transmitter and its Spectra

- Baseband Inputs $[I_B, Q_B]$
- First LO
- IF Mixer Outputs $[I_{IF}, Q_{IF}]$
- Second LO
- RF Mixer Outputs $[I_{RF}, Q_{RF}]$
- Polyphase Output $[I_{PP}, Q_{PP}]$
- TX Output
Proposed Compact Transmitter
Schematic of Proposed Transmitter
Transmitter Floor Plan
Die Photographs

Receiver

Transmitter
# Results

## Comparison of Different Receivers

<table>
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<tr>
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<th>[3]</th>
<th>[15]</th>
<th>This Work</th>
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<tbody>
<tr>
<td>Frequency Range (GHz)</td>
<td>57-63</td>
<td>49-53</td>
<td>57-63</td>
<td>57-61</td>
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<tr>
<td>Noise Figure (dB)</td>
<td>10.4-11</td>
<td>6.9-8.3</td>
<td>6.1-6.35</td>
<td>5.7-7.1</td>
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<tr>
<td>Gain (dB)</td>
<td>9.5-12</td>
<td>26-31.5</td>
<td>-8.5-55</td>
<td>19.8-22</td>
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<tr>
<td>P_{1dB} (dBm)</td>
<td>-15.8</td>
<td>-25.5</td>
<td>-26</td>
<td>-27.5</td>
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<tr>
<td>LO Leakage to Input (dBm)</td>
<td>N/A</td>
<td>-47</td>
<td>&lt; -77</td>
<td>-65</td>
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<tr>
<td>I/Q Mismatch</td>
<td>N/A</td>
<td>6.5°/1.5dB</td>
<td>N/A</td>
<td>2.1°/1.1dB</td>
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<td>LO Phase Noise (dBc/Hz @ 1-MHz offset)</td>
<td>-86</td>
<td>-95</td>
<td>off-chip</td>
<td>-90</td>
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<td>Power Dissipation (mW)</td>
<td>77</td>
<td>80</td>
<td>24</td>
<td>36</td>
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<td>LNA</td>
<td>9</td>
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<td>Mixers</td>
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<td>Oscillator</td>
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<tr>
<td>Supply Voltage (V)</td>
<td>1.2</td>
<td>1.8</td>
<td>1.0</td>
<td>1.2</td>
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<td>Chip Area (mm²)</td>
<td>3.8</td>
<td>0.15</td>
<td>1.55</td>
<td>0.19</td>
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<td>CMOS Technology</td>
<td>0.13-μm</td>
<td>90-nm</td>
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## Comparison of Different Transmitters

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<td>Frequency Range (GHz)</td>
<td>57-67</td>
<td>60-64</td>
<td>59-63</td>
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<tr>
<td>Max Output Power (dBm)</td>
<td>-3</td>
<td>11</td>
<td>-7.2</td>
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<td>Output P$_{1dB}$ (dBm)</td>
<td>N/A</td>
<td>10</td>
<td>-8.6</td>
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<tr>
<td>I/Q Mismatch (dB)</td>
<td>N/A</td>
<td>N/A</td>
<td>-20</td>
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<tr>
<td>LO Phase Noise (dBc/Hz @ 1-MHz offset)</td>
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<td></td>
<td>-90</td>
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<tr>
<td>Power Consumption (mW)</td>
<td>98</td>
<td>133^*</td>
<td>78^*</td>
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<tr>
<td>Supply Voltage (V)</td>
<td>1.2</td>
<td>0.7</td>
<td>1.5</td>
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<tr>
<td>Chip Area (mm²)</td>
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Results
Conclusion

The half-RF architecture presented has shown several benefits

• Relaxes the LO related issues
• Compact
• Low-power
• $3f_{LO}$ suppression