Chapter IV
RF Components
Active and Passive Mixers
Mixers translate modulated carriers from one frequency to another by multiplying the input by a square wave (a sum of odd harmonics).

In addition to generating sum and difference components, mixer will also generate unwanted spurs at multiples of the LO and Carrier frequencies.

Mixers also add noise, IMD products and LO leakage to the output spectrum.
Mixer Spurious Distortion Components

Mixer Spurious Trajectory Maps are often used to find optimum IF’s for a given mixer architecture.

A Mixer Spur table helps to provide systems engineers with knowledge of the $mf_{RF} \pm nf_{LO}$ rejection capability of a given mixer.
Input signal is split between upper and lower side-bands, not necessarily with equal gain or loss. Need to consider conversion gain or loss relationship versus frequency. Noise figure can be different for upper and lower sidebands. This may result in a slight difference between conversion loss and NF for a passive mixer.
Many Different Mixer Architectures

**Gilbert Cells**

- **AD8343**: Single-Ended
- **AD8342, AD8344**: Doubly-Balanced

**ADL5350**: Single-Ended Resistive FET

**Quad FET**: Doubly-Balanced
Single-Ended Passive Mixers

- Single-Ended Mixers share a common node for the RF and IF ports.
- The RF Envelope is Modulated by the switching action of a diode of FET junction at the rate of the applied oscillator.
- It is desirable to switch the RFIF node impedance between a short and open to provide maximum frequency conversion to the sum and difference frequencies.
- Sharp switching also has a positive impact on inter-modulation performance.
- Often an LO buffer is employed to ensure adequate On/Off switching of the RFIF node.
Single-Ended Mixer Implementation

Desired LO frequency | Recommended LO bias inductor (L4) |
--- | --- |
750 MHz | 24 nH |
1000 MHz | 18 nH |
1750 MHz | 3.8 nH |
2000 MHz | 2.7 nH |

<table>
<thead>
<tr>
<th>RF Frequency</th>
<th>L1</th>
<th>C1</th>
<th>L2</th>
<th>C2</th>
<th>L3</th>
<th>C3</th>
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</thead>
<tbody>
<tr>
<td>850 MHz</td>
<td>6.8 nH</td>
<td>4.7 pF</td>
<td>4.7 nH</td>
<td>5.6 pF</td>
<td>8.2 nH</td>
<td>100 pF</td>
</tr>
<tr>
<td>1950 MHz</td>
<td>1.7 nH</td>
<td>1.5 pF</td>
<td>1.7 nH</td>
<td>1.2 pF</td>
<td>3.5 nH</td>
<td>100 pF</td>
</tr>
</tbody>
</table>

**Step 1.** Tune the LO buffer supply inductor for minimum supply current.
**Step 2.** Tune the LO port input network for optimum return loss.
**Steps 3 and 4.** Design the RF and IF filter networks.
Passive Ring Mixers are the most popular type
- All Passive Mixers require Balun/Transformer structures on RF and LO ports in order to achieve good performance
- Balanced LO and RF drive results in improved even order spurious performance and improved LO to RF and LO to IF leakage
- Less popular balanced passive mixers include Star Mixers and Double-Doubly Balanced Mixers
Simple Active Mixers Using BJTs

Poor Isolation
Poor Linearity

Better Isolation
Poor Linearity
Better NF

Poor Isolation
Better Linearity
Poor NF

Better Isolation
Better Linearity
Better NF
Gilbert Cell Mixers

Several varieties. The AD8343 is very generic, requires some off-chip biasing and matching, but can be used over a broad range of frequencies. The AD8344 is optimized for 900MHz cellular applications and provides matched RF and LO ports. The AD8342 provides matched ports and is more broadband than the AD8344.
A Low Frequency to 500 MHz Active Mixer

- 3.7 dB Conversion Gain
- Integrated LO Drive
- Single Ended RL and LO Drive
- Differential IF Output
- +8 dBm IP1dB, 12 dB Noise Figure, +23 dBm IIP3
## Active vs Passive Mixers

<table>
<thead>
<tr>
<th></th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
</table>
| **Balanced Active Mixers** | • Provides Some Gain  
• Requires no balun/transformers  
• Good LO to RF Isolation  
• Requires low LO drive | • Tend to have higher NF than passive mixers  
• Tend to have lower input linearity than passive mixers  
• Requires DC Power |
| **Single-Ended Passive Mixers** | • Small and Low-Cost  
• Good Input Linearity  
• Low Noise  
• Low LO drive when includes integrated LO Buffer | • Poor LO to RF Isolation  
• Poor 2nd Order Distortion Performance  
• Requires Off-Chip Diplexer Networks to separate RF and IF ports |
| **Balanced Passive Mixers** | • Offers the best Input Linearity  
• Reasonably Low Noise  
• Good LO to RF Isolation | • Requires Strong LO Drive unless LO Buffer is included  
• Requires Off-Chip Baluns  
• May be size and cost prohibitive due to required magnetics |
# High Linearity Mixers

<table>
<thead>
<tr>
<th>Part No.</th>
<th>RF Freq (MHz)</th>
<th>IF Freq (MHz)</th>
<th>LO Freq (MHz)</th>
<th>Conversion Gain (dB)</th>
<th>IP3 (dBm)</th>
<th>P1dB (dBm)</th>
<th>NF (dB)</th>
<th>Package Type</th>
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</thead>
<tbody>
<tr>
<td>AD8342</td>
<td>dc to 500</td>
<td>dc to 400</td>
<td>LF to 850</td>
<td>4</td>
<td>24</td>
<td>9</td>
<td>11</td>
<td>16-lead CSP</td>
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<tr>
<td>AD8343</td>
<td>dc to 2500</td>
<td>dc to 2500</td>
<td>dc to 2500</td>
<td>7</td>
<td>16.5</td>
<td>2.8</td>
<td>14</td>
<td>14-lead TSSOP</td>
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<tr>
<td>AD8344</td>
<td>400 to 1200</td>
<td>70 to 400</td>
<td>470 to 1600</td>
<td>4</td>
<td>24</td>
<td>8</td>
<td>11</td>
<td>16-lead CSP</td>
</tr>
<tr>
<td>ADL5350</td>
<td>200 to 3000</td>
<td>LF to 3000</td>
<td>LF to 3000</td>
<td>-7</td>
<td>26</td>
<td>18</td>
<td>7</td>
<td>8-lead LFCSP</td>
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</tbody>
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