A Progressive Mixing 20GHz ILFD with Wide Locking Range for Higher Division Ratios

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Outline

- Motivation
- Conventional ILFD
- Proposed ILFD
- Measurement Results
- Performance Comparison
- Conclusion
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High Frequency PLLs

- High Frequency PLLs are becoming more popular
- Static prescalers consume considerable power
  - 40% of PLL total power consumption [1].

[1] A. Musa et. al, JSSC 2011
High Speed Frequency Dividers

High speed frequency dividers and VCO are the most power hungry parts of modern high frequency PLLs.

- **Static Frequency Dividers:**
  - Wide locking range
  - Consume considerable power
  - Conventionally only divides by 2

- **Injection Locked Frequency Dividers (ILFDs)**
  - Limited locking range
  - Low power consumption
  - Can divide by higher than 2
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Conventional ILFD

Red arrows indicate desired injection
Blue arrows indicate harmful injection
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Proposed ILFD Configuration

• One oscillator
  – Direct division power consumption

• Reuse fundamental higher harmonics
  – Cascaded wider locking range

• Vertical configuration

• Extendable
Proposed $\div 4$ ILFD Schematic

Advantages of both approaches are combined by reusing higher harmonics that naturally exist in any osc.

Schematic of the Proposed Progressive Mixing ILFD
Proposed $\div 4$ ILFD Timing Waveform

Red arrows indicate desired injection
Blue arrows indicate harmful injection (NA)
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Sensitivity Curve $\div 4$ (Measured)

31.4% Locking range@20GHz
50% increase over conventional
Locking Range Vs Tuning (Measured)

42.7% Maximum Locking Range
~100% increase over conventional

Widest /4 locking range reported
Chip Micrograph

- **Chip Area:**
  - \( \div 4 \)
    - 750\(\mu\)m x 810\(\mu\)m
    - Divider
      - 52\(\mu\)m X 48\(\mu\)m
  
  - \( \div 8 \)
    - 750\(\mu\)m x 810\(\mu\)m
    - Divider
      - 66\(\mu\)m x 86\(\mu\)m
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## Comparison & Conclusion

<table>
<thead>
<tr>
<th>Division Ratio(s)</th>
<th>TEG 1</th>
<th>TEG 2</th>
<th>[3]</th>
<th>[2]</th>
<th>[5]</th>
<th>[6]</th>
</tr>
</thead>
<tbody>
<tr>
<td>2, 4</td>
<td>2, 4</td>
<td>4, 8</td>
<td>2, 4</td>
<td>2, 4</td>
<td>4</td>
<td>2, 4, 6, 8</td>
</tr>
</tbody>
</table>

| Power (mW)       | 3.9   | 7.1   | 3.0 | 12.4| 2.8 | 6.8 |

<table>
<thead>
<tr>
<th>Lock Range (GHz)</th>
<th>/2</th>
<th>/4</th>
<th>/8</th>
<th>/2</th>
<th>/4</th>
<th>/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5-16.1 (92%)</td>
<td>-</td>
<td>51.0-74.0 (34%)</td>
<td>82.0-94.1 (15%)</td>
<td>-</td>
<td>2.3-4.3 (56%)</td>
<td></td>
</tr>
<tr>
<td>13.4-21.3 (31%)</td>
<td>9.8-13.8 (32%)</td>
<td>82.5-89.0 (7.3%)</td>
<td>79.7-81.6 (2.4%)</td>
<td>70.0-71.6 (2.3%)</td>
<td>6.0-7.6 (22%)</td>
<td></td>
</tr>
<tr>
<td>20.9-24.7 (15%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>14.4-14.7 (1.7%)</td>
</tr>
</tbody>
</table>


An improvement by ~50% for divide-by-4 and ~780% for divide-by-8 at no increase in power is achieved.
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Conclusion

- A new injection locked frequency divider (ILFD) is proposed.
- The divider uses **progressive mixing** (multistep mixing) to allow injection at higher harmonics of the fundamental.
- The **widest locking range** has been achieved especially for higher division ratios.
  - $\div 2$ (93%)
  - $\div 4$ (43%)
  - $\div 8$ (17%)
Acknowledgement

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