**DESCRIPTION**

IMEC’s divider-less All-Digital Phase Locked Loop (ADPLL) combines world’s lowest power consumption with state-of-the-art performance and small silicon area. The ADPLL supports industrial requirements for popular 2.4GHz and SubGHz IoT radio standards, such as Blue-tooth Low Energy (Bluetooth Smart), IEEE 802.15.4 (ZigBee, Thread) and others.

Analog PLLs are traditionally one of the major power consumers in a radio and can take up to 30% of the radio area. All-digital PLLs enable a smaller footprint, better control and testability, and improved scaling to advanced CMOS nodes. However, to-date, they have lagged behind in terms of performance as compared to analog solutions.

This new sub-sampling ADPLL features a small area (0.18mm² in 40nm CMOS), low-power consumption (0.67mW) and excellent performance for IoT radio applications with all spurs lower than -55dBc and jitter below 2ps, which is beyond state-of-the-art digital PLLs.

This dividerless fractional-N digital PLL features a power-efficient spur mitigation technique and a digital phase unwrap technique. Both approaches contribute to its state of the art performance.

Moreover, this digital PLL implements dynamic-element-matching (DEM), reset and retime techniques to further improve the linearity of the digital-to-time converter (DTC) and therefore achieves lower.

**KEY FEATURES**

Support uip 2.4GHz/subGHz IoT, e.g.,
- 2.4GHz
  - Bluetooth 4.0 (BLE), 4.2 and 5.0
  - IEEE802.15.4 (ZigBee, ISA100.11a, WirelessHART, Thread, 6LoWPAN)
- SubGHz:
  - IEEE802.15.4g (Wi-SUN), IEEE802.11ah (HaLow)

Ultra-low power (ULP) consumption

- < 0.7mW

Best-in-class performance

- Jitter < 2ps
- Spur < -55dBc (in-band)
- Spur < -70dBc (>2MHz)
- Settling time < 15μs

Features

- Extensive built-in self calibrations
- Advanced power-efficient spur mitigation
- Robust against freq. pulling/pushing with digital unwrap
APPLICATIONS
2.4GHz/SubGHz ULP IoT radios (Bluetooth 5, 802.15.4, 802.15.4g, 802.11ah) for
  • Smart watches and wearables
  • Smart phone accessories
  • Hearing aids and audio applications
  • Remote controllers
  • Home and commercial automation

MEASUREMENT RESULTS

SUBGHz SPECIFICATIONS

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range (GHz)</td>
<td>1.75-2.5</td>
</tr>
<tr>
<td>Freq. settling time (s)</td>
<td>&lt;15</td>
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<tr>
<td>Phase noise @ 1MHz (dBc/Hz)</td>
<td>&lt;-103</td>
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<tr>
<td>Integrated RMS jitter (ps)</td>
<td>&lt;2</td>
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<tr>
<td>Frac. spur &lt;55dBc (in-band)</td>
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<tr>
<td>Freq. modulation resolution</td>
<td>&lt;1 kHz</td>
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<tr>
<td>Power consumption (mW)</td>
<td>&lt;0.7</td>
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<tr>
<td>Area (mm²)</td>
<td>&lt;0.18</td>
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<tr>
<td>Nominal supply</td>
<td>1V</td>
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<tr>
<td>Technology</td>
<td>TSMC 40nm LP CMOS</td>
</tr>
</tbody>
</table>

STATE-OF-THE-ART PERFORMANCE

EVALUATION BOARDS

Imec provides evaluation boards on request to prospective customers and partners interested in licensing imec’s IC designs and IP.