Microwave PLL and Synthesizer
Best PLL for your solution
TI’s broad portfolio of PLLatinum® microwave phase locked loop (PLL) and synthesizer (PLL with integrated VCO) family offers the best choice for a variety of applications ranging from performance demanding industrial RADAR, make and test equipment, MC-GSM/FDD/TDD wireless base stations and repeaters to low power applications like Land Mobile Radio, USB powered test equipment and wireless microphones. New high performance, high frequency synthesizers are designed targeting applications in the microwave and millimeter-wave (mm-wave) region including 5G base stations and wireless testers.

**Portfolio key features:**
- Synchronize multiple PLLs
- Remove integer boundary spurs with easy programming
- Generate SYSREF with fine delay adjustment for clocking JESD204B compliant data converters
- Generate frequency ramps
- Support for FSK modulation
- Integrated LDOs for easy power supply design

### RF PLL Portfolio (Ranked by PLL Phase Noise)

![RF PLL Portfolio Diagram](image)

- **Normalized Phase Noise (dBc/Hz)**
  - LMX2595
  - LMX2594
  - LMX2572
  - LMX2592
  - LMX2582
  - LMX2571
  - LMX2581
  - LMX2491/LMX2492/LMX2492-Q1
  - LMX2541 (6 Parts)
  - LMX2531 (17 Parts)
  - LMX2485/E/Q (AECQ)

- **Current Consumption (mA)**
  - 5
  - 10 MHz, 50 MHz, 100 MHz, 1 GHz, 4 GHz, 6 GHz, 9 GHz, 15 GHz, 19 GHz
  - 340
  - 340
  - 75
  - 250
  - 250
  - 39
  - 178
  - 60
  - 120
  - 34

**New/Upcoming**
- LMX2571
- LMX2581E
- LMX2541
- LMX2531
- LMX2485/E/Q (AECQ)

**Evaluation Modules**
- **LMX2594 evaluation module.**
- **LMX2582 evaluation module.**
Feature rich, high performance products for the most performance demanding applications

Texas Instruments PLL plus integrated VCO have Industry leading performance with a PLL figure of merit (1 Hz carrier, 1 Hz phase detector frequency) down to -236 dBc/Hz, flicker noise down to -129 dBc/Hz (1 GHz carrier, 10 kHz offset) and outstanding VCO phase noise. They are the best choice for applications that demand the highest performance. By integrating multiple VCOs going up to 15 GHz in LMX2594, TI sets a new benchmark for SiGe PLLs with integrated VCOs.

LMX2594 make it easy to synchronize the output phase of multiple devices in a system even when the PLL is used in fractional mode. Once the output phases of the fractional PLLs are aligned, it is possible to adjust the phase of each device individually. This makes Multiple Input, Multiple Output (MIMO) and beam-forming applications easier to implement.

Open loop 6 GHz VCO performance of LMX2592.

46.8 fs RMS jitter (100 Hz to 100 MHz) closed loop performance of LMX2594 at 8 GHz.
**TI Design**

<table>
<thead>
<tr>
<th>Description</th>
<th>Key Device</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.8 GHz signal generator</td>
<td>LMX2592</td>
</tr>
<tr>
<td>Synchronizing multiple microwave PLLs</td>
<td>LMX2594</td>
</tr>
<tr>
<td>JESD204B implementation with LMX2594</td>
<td>LMX2594</td>
</tr>
<tr>
<td>Powering LMX2592 directly with a DC-DC converter</td>
<td>LMX2592</td>
</tr>
<tr>
<td>Low Power LMX2571 powered by single cell battery</td>
<td>LMX2571</td>
</tr>
<tr>
<td>Get better than 40 fs RMS jitter using TI's microwave synthesizers</td>
<td>LMX2594</td>
</tr>
</tbody>
</table>

**Device Specifications**

<table>
<thead>
<tr>
<th>Device</th>
<th>Max $F_{off}$ (GHz)</th>
<th>PLL FOM</th>
<th>1/f Noise*</th>
<th>VCO Phase Noise</th>
<th>Key Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMX2594</td>
<td>15</td>
<td>-236 dBc/Hz</td>
<td>-129 dBc/Hz</td>
<td>-126 dBc/Hz (1 MHz offset, 10.2 GHz carrier)</td>
<td>✓ Phase sync and phase adjust&lt;br&gt; ✓ JESD204B support&lt;br&gt; ✓ Frequency ramp&lt;br&gt; ✓ Doubler free</td>
</tr>
<tr>
<td>LMX2595</td>
<td>19</td>
<td>-236 dBc/Hz</td>
<td>-129 dBc/Hz</td>
<td>-126 dBc/Hz (1 MHz offset, 10.2 GHz carrier)</td>
<td>✓ Phase sync and phase adjust&lt;br&gt; ✓ JESD204B support&lt;br&gt; ✓ Frequency ramp</td>
</tr>
<tr>
<td>LMX2592</td>
<td>9.8</td>
<td>-231 dBc/Hz</td>
<td>-126 dBc/Hz</td>
<td>-134 dBc/Hz (1 MHz offset, 6 GHz carrier)</td>
<td>✓ Phase adjust</td>
</tr>
</tbody>
</table>

*Normalized to 1 GHz carrier, 10 kHz offset

*LMX2572 and LMX2594 make it easier for users to implement “Beam Forming” in their applications and provides an easy way to align phase across multiple devices.*
Microwave PLLs for low power applications

TI’s low power microwave PLLs and synthesizers deliver key features and exceptional performance within the strictest power budgets for hand-held applications.

The LMX2571 and LMX2572 synthesizers are capable of performing direct carrier FSK modulation for simpler implementation of the digital transmission signal chain. This closed-loop, self-calibrated method is immune to errors due to process, voltage and temperature.

<table>
<thead>
<tr>
<th>Device</th>
<th>Current Consumption (mA)</th>
<th>Min ( V_{cc} ) (V)</th>
<th>External VCO Supported</th>
<th>Internal VCO Supported</th>
<th>FSK Supported</th>
<th>PLL FOM (dBc/Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMX2485E</td>
<td>5</td>
<td>2.5</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>-210</td>
</tr>
<tr>
<td>LMX2571 (Ext VCO option)</td>
<td>9</td>
<td>3.0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>-231</td>
</tr>
<tr>
<td>LMX2571</td>
<td>39</td>
<td>3.0</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>-231</td>
</tr>
<tr>
<td>LMX2572</td>
<td>75</td>
<td>3.0</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>-231</td>
</tr>
</tbody>
</table>

Automotive qualified microwave PLLs

LMX2492-Q1 automotive Grade-1 qualified PLL enables high performance automotive RADAR applications with its low PLL noise floor and provides an easy way to generate frequency ramps up to 8 segments. This feature also makes this PLL popular in Industrial Frequency-Modulated Continuous-Wave (FMCW) RADAR applications.

<table>
<thead>
<tr>
<th>Device</th>
<th>Feedback Input Frequency Range (GHz)</th>
<th>PLL FOM</th>
<th>Charge Pump Supply (V)</th>
<th>Analog Supply (V)</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td>LMX2492-Q1</td>
<td>0.5 to 14</td>
<td>-227</td>
<td>3.15 to 5.25</td>
<td>3.15 to 3.45</td>
<td>QFN-24</td>
</tr>
<tr>
<td>LMX2485Q-Q1</td>
<td>0.5 to 3.1</td>
<td>-210</td>
<td>2.5 to 3.6</td>
<td>2.5 to 3.6</td>
<td>QFN-24</td>
</tr>
</tbody>
</table>

Sawtooth frequency ramping with FSK modulation superposition.
TI’s broad range of PLLs cover basestation standards from GSM to 5G and satellite communication bands

TI’s *pin-compatible family* of PLLatinum Microwave Synthesizers are ideally suited for basestation (for every standard from GSM to 5G), wireless repeaters, microwave backhaul and satellite communication applications. All of these devices use a single 3.3-V supply and have integrated LDOs, thus simplifying the power supply connections. The family of devices have two high frequency differential outputs to reduce the device count for high density boards. The devices support high phase detector frequency to enable lower in-band phase noise.

The **LMX2582**, **LMX2594** and **LMX2572** have a programmable multiplier in the reference path, making it easy to remove Integer Boundary Spurs (IBS), hence allowing a higher number of channels to be available for wireless transmission.

**Device** | **Max Fout (GHz)** | **PLL FOM** | **Phase Detector Frequency** | **VCO Phase Noise** |
---|---|---|---|---|
LMX2594 | 15 | -236 dBc/Hz | 400 MHz | -126 dBc/Hz (1 MHz offset, 10.2 GHz carrier) |
LMX2572 | 6.6 | -232 dBc/Hz | 200 MHz | -127 dBc/Hz (1 MHz offset, 6.6 GHz carrier) |
LMX2582 | 5.5 | -231 dBc/Hz | 200 MHz | -144.5 dBc/Hz (1 MHz offset, 1.8 GHz carrier) |

**LMX2582** 1.8 GHz VCO meets the stringent MC-GSM requirements.

**LMX2594** enables mm-wave 5G with excellent closed loop performance at 15 GHz without an internal doubler.

**LMX2571** plot with SpurBGone removal of integer boundary spurs.
A fast, simple and accurate simulator for our PLL's

Simulating and optimizing a PLL from Texas Instruments has never been easier with the PLLatinum Sim software platform. A simple, easy-to-use interface allows the PLL designer to simulate all TI's devices in minutes. Simulation models are based on device measurements leading to accurate results. Device selection, loop filter design and optimization, closed loop phase noise, spur calculator and lock time are easy-to-use features that will help obtain the best performance for your application.

The filter optimizer is specifically designed to help find the perfect loop filter. The optimizer will quickly obtain a loop filter to minimize jitter. The fast and responsive closed loop phase noise simulation allows quick “what if” scenarios to make sure you are selecting the most desirable configuration.

Visit ti.com/pll today and download a standalone copy for your next PLL design. Also, take the opportunity to download TI's evaluation module control software Texas Instruments Clocks and Synthesizers (TICS) Pro Software.

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E2E Clocks & Timers Forum
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Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
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