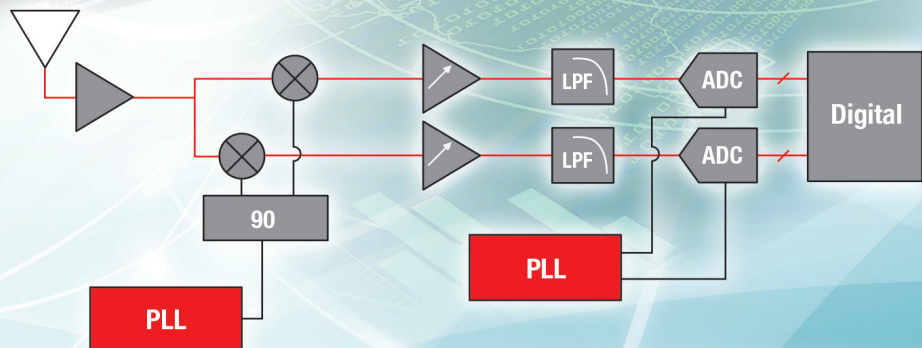


# Microwave PLL and Synthesizer

Best PLL for your solution



The central image is a composite graphic. At the top, a large satellite dish is shown against a blue sky. Below it, a hand in a white lab coat points towards several glowing labels: '5G', '3G', '4G', and 'MC-GSM'. To the left, a spectrum analyzer screen displays a signal trace with various parameters like 'Atten 20 dB', 'Center Freq', and 'Span'. At the bottom, a mobile phone is shown with an antenna. The background is a light blue grid with circuit-like patterns.



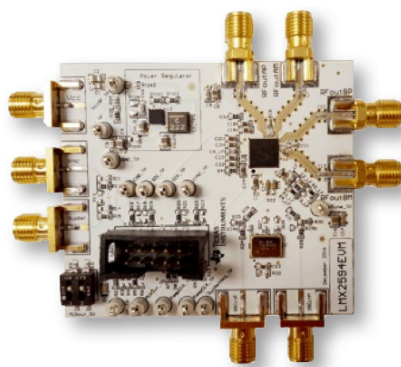
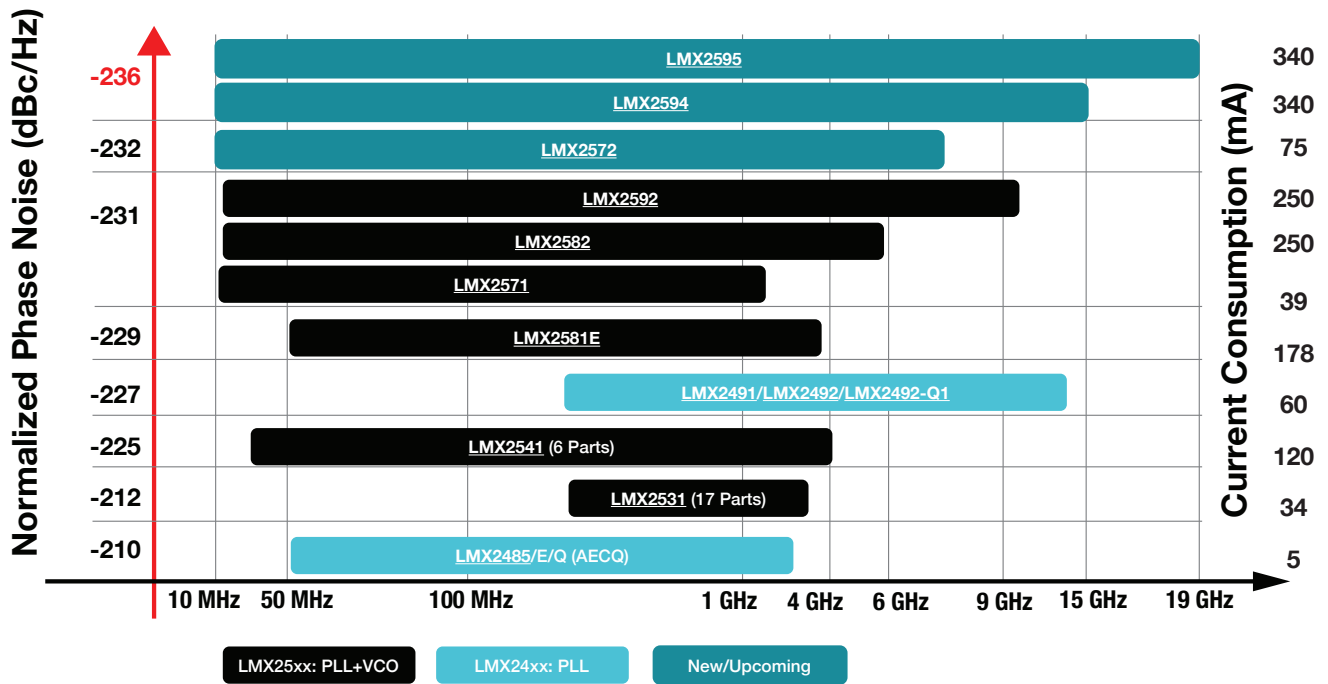
# Microwave PLL and synthesizer portfolio

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.

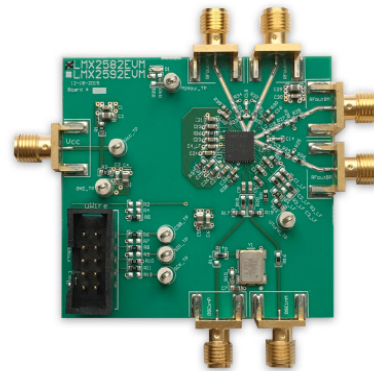
## Portfolio key features:

- 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)



[LMX2594 evaluation module.](#)



[LMX2582 evaluation module.](#)

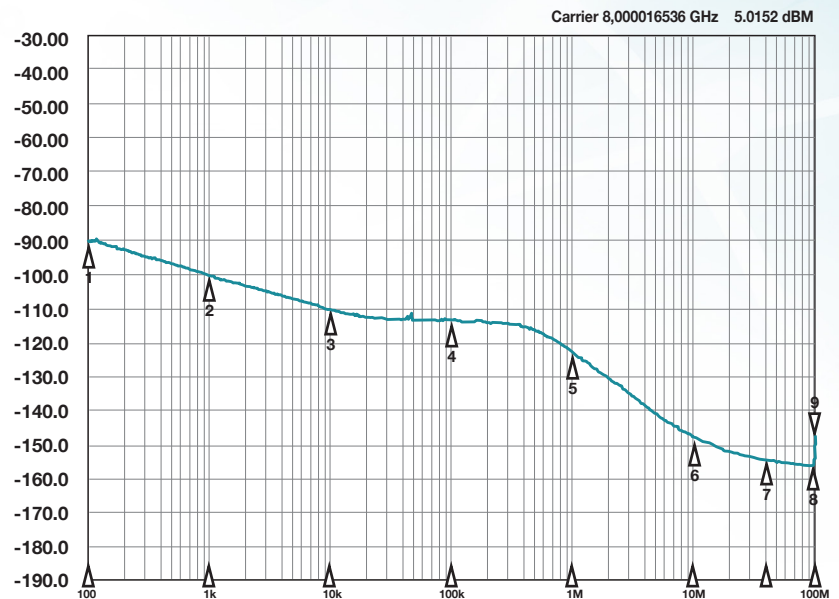
## Feature rich, high performance products for the most performance demanding applications

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.

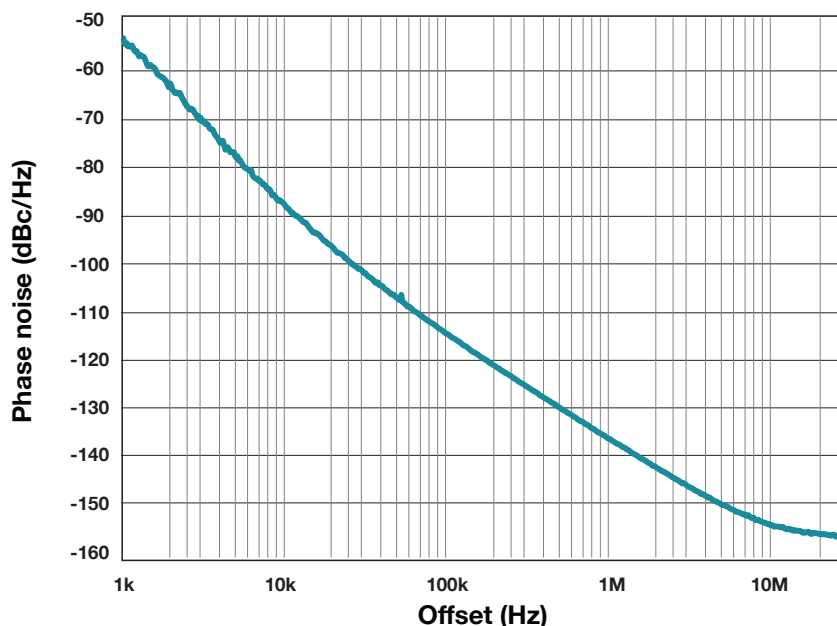
**LMX2594** make it easy to synchronize the output phase of multiple devices in a system even when the PLL is used in fractional mode. Once the output phases of the fractional PLLs are aligned, it is possible to adjust the phase of each device individually. This makes Multiple Input, Multiple Output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

1: 100Hz	-89.6207	dBc/Hz
2: 1kHz	-99.8161	dBc/Hz
3: 10kHz	-110.0678	dBc/Hz
4: 100kHz	-113.3698	dBc/Hz
5: 1MHz	-123.1377	dBc/Hz
6: 10MHz	-148.3220	dBc/Hz
7: 40Mz	-155.1546	dBc/Hz
8: 95Mz	-157.0743	dBc/Hz
> 9: 100Mz	-148.2153	dBc/Hz

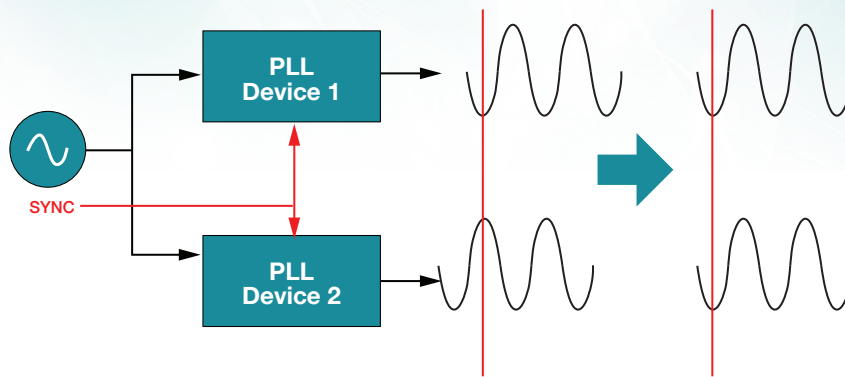
.....Noise.....  
 Analysis Range X: Band Marker  
 Analysis Range Y: Band Marker  
 Intg Noise: -55.5677 dBc/19.69 MHz  
 RMS Noise: 2.35576 mrad  
 134.975 mdeg  
 RMS Jitter: 46.866 fsec  
 Residual FM: 2.80979 kHz



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



Open loop 6 GHz VCO performance of **LMX2592**.



*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.*

TI Design	Description	Key Device
<a href="#">TIDA-00626</a>	9.8 GHz signal generator	<a href="#">LMX2592</a>
<a href="#">TIDA-01410</a>	Synchronizing multiple microwave PLLs	<a href="#">LMX2594</a>
<a href="#">TIDA-01021</a>	JESD204B implementation with LMX2594	<a href="#">LMX2594</a>
<a href="#">TIDA-00885</a>	Powering LMX2592 directly with a DC-DC converter	<a href="#">LMX2592</a>
<a href="#">TIDA-00886</a>	Low Power LMX2571 powered by single cell battery	<a href="#">LMX2571</a>
<a href="#">TIDA-01346</a>	Get better than 40 fs RMS jitter using TI’s microwave synthesizers	<a href="#">LMX2594</a>

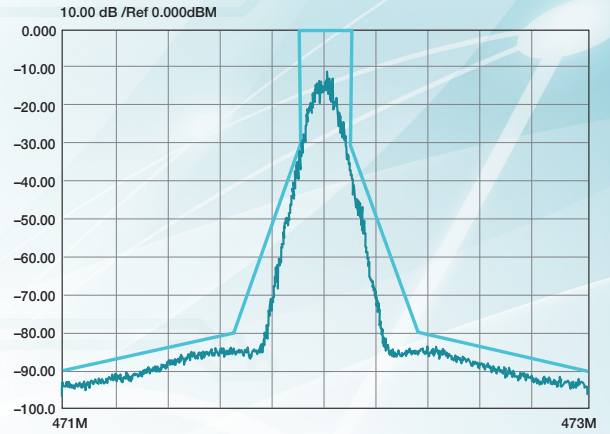
Device	Max F <sub>OUT</sub> (GHz)	PLL FOM	1/f Noise*	VCO Phase Noise	Key Features
<a href="#">LMX2594</a>	15	-236 dBc/Hz	-129 dBc/Hz	-126 dBc/Hz (1 MHz offset, 10.2 GHz carrier)	<ul style="list-style-type: none"> <li>✓ Phase sync and phase adjust</li> <li>✓ JESD204B support</li> <li>✓ Frequency ramp</li> <li>✓ Doubler free</li> </ul>
<a href="#">LMX2595</a>	19	-236 dBc/Hz	-129 dBc/Hz	-126 dBc/Hz (1 MHz offset, 10.2 GHz carrier)	<ul style="list-style-type: none"> <li>✓ Phase sync and phase adjust</li> <li>✓ JESD204B support</li> <li>✓ Frequency ramp</li> </ul>
<a href="#">LMX2592</a>	9.8	-231 dBc/Hz	-126 dBc/Hz	-134 dBc/Hz (1 MHz offset, 6 GHz carrier)	<ul style="list-style-type: none"> <li>✓ Phase adjust</li> </ul>

\*Normalized to 1 GHz carrier, 10 KHz offset

## 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.

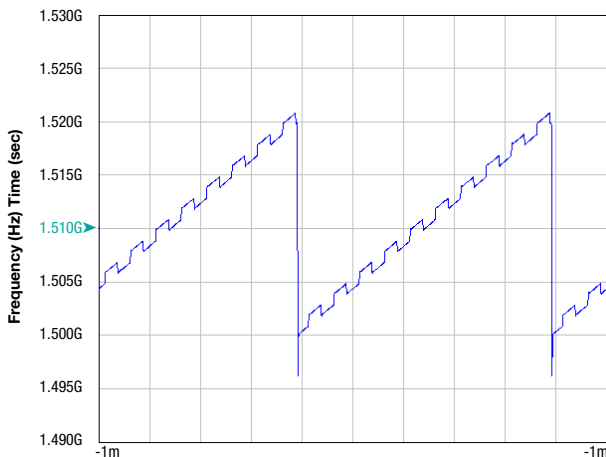


Direct carrier FSK modulation spectrum example.

Device	Current Consumption (mA)	Min V <sub>CC</sub> (V)	External VCO Supported	Internal VCO Supported	FSK Supported	PLL FOM (dBc/Hz)
<b>LMX2485E</b>	5	2.5	Yes	No	No	-210
<b>LMX2571</b> (Ext VCO option)	9	3.0	Yes	Yes	Yes	-231
<b>LMX2571</b>	39	3.0	Yes	Yes	Yes	-231
<b>LMX2572</b>	75	3.0	No	Yes	Yes	-231

## 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.



Sawtooth frequency ramping with FSK modulation superposition.

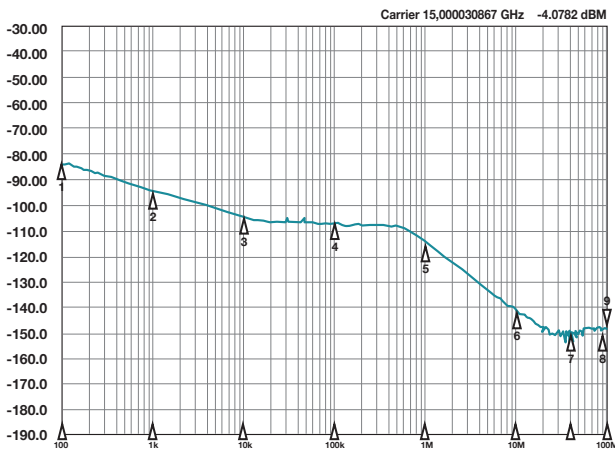
Device	Feedback Input Frequency Range (GHz)	PLL FOM	Charge Pump Supply (V)	Analog Supply (V)	Package
<b>LMX2492-Q1</b>	0.5 to 14	-227	3.15 to 5.25	3.15 to 3.45	QFN-24
<b>LMX2485Q-Q1</b>	0.5 to 3.1	-210	2.5 to 3.6	2.5 to 3.6	QFN-24



# TI's broad range of PLLs cover basestation standards from GSM to 5G and satellite communication bands

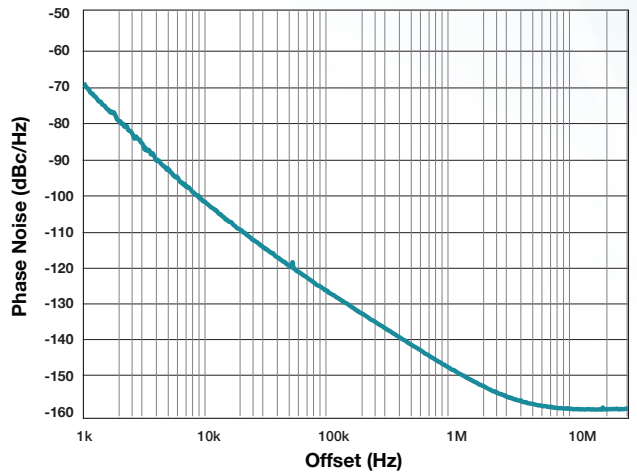
TI's *pin-compatible family* of PLLatinum Microwave Synthesizers are ideally suited for basestation (for every standard from GSM to 5G), wireless repeaters, microwave backhaul and satellite communication applications. All of these devices use a single 3.3-V supply and have integrated LDOs, thus simplifying 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.

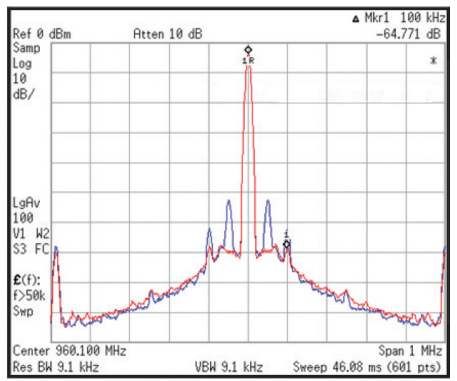


1: 100Hz	-84.0162	dBc/Hz
2: 1kHz	-94.4656	dBc/Hz
3: 10kHz	-104.7805	dBc/Hz
4: 100kHz	-107.5165	dBc/Hz
5: 1MHz	-114.7458	dBc/Hz
6: 10MHz	-141.7698	dBc/Hz
7: 40MHz	-150.1983	dBc/Hz
8: 95MHz	-148.5787	dBc/Hz
> 9: 100MHz	-147.6257	dBc/Hz

.....Noise.....  
 Analysis Range X: Band Marker  
 Analysis Range Y: Band Marker  
 Intg Noise: -48.5870 dBc/19.69 MHz  
 RMS Noise: 5.26219 mrad  
 301.501 mdeg  
 RMS Jitter: 55.833 fsec  
 Residual FM: 6.1638 kHz



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



**LMX2571** plot with SpurBGone removal of integer boundary spurs.

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

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

## Design resources and references

### 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](http://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](#).

The screenshot shows the PLLatinum Sim software interface with several callouts highlighting key features:

- Scalable feature for all user levels:** Located on the left side of the interface.
- Loop filter calculator:** Located in the top center of the interface.
- Spur and lock time calculator:** Located in the top right of the interface.
- Passive and active filter capability with 2nd, 3rd and 4th order filter:** Located in the center of the interface.
- Help available beside each function:** Located on the right side of the interface.
- Filter optimization routine for jitter, phase noise and many others criteria:** Located on the right side of the interface.
- Filter value selector for real world component values:** Located in the bottom right of the interface.
- Detailed loop calculations for advanced users:** Located in the bottom right of the interface.
- Closed loop phase noise calculations with each block contribution:** Located in the bottom left of the interface.

The interface includes a block diagram, a phase noise plot, and a table of poles and time constants.

Poles and Time Constants					
Design Target	Actual		Actual		
T2	1.5036e-6	1.551e-5	s	1.0251e1	kHz
T1	1.7337e-8	1.5356e-7	s	9.1759e3	kHz
T3	0	0	s	n/a	kHz
T4	0	0	s	n/a	kHz
A0	2.5379e-9	3.333e-7	F		
A1	4.4001e-17	5.1183e-14	aF		
A2	0	0	s <sup>-2</sup>		
A3	0	0	s <sup>-2</sup>		

PLLatinum simulator.

To learn more about TI's family of PLLs and microwave synthesizers, visit [ti.com/pll](http://ti.com/pll).

 **E2E Clocks & Timers Forum**  
Community [ti.com/e2eclocks](http://ti.com/e2eclocks)

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