Ultra-Low Phase Noise, Multi-Channel Source with Phase Coherent Switching

APMS 超低相位噪声/相位同调切换的多通道源

Simulating and testing multi-antenna systems such as phased arrays or beamforming antennas requires a test system capable of providing multiple signals with deterministic frequency and amplitude with stable, user-adjustable phase relationship among those signals. AnaPico's APMS multi-channel signal generators provide a well-designed solution for these applications, packing unique phase coherent signal features in a compact design. The APMS40G-ULN-PHS is a compact, four channel, 40 GHz signal generator that fulfills the demanding requirements for many new test applications cost-effectively.

模拟和测试诸如相控阵或波束成形天线之类的多天线系统需要一种测试系统，该系统必须能够提供具有确定性频率和幅度的多个信号，并且这些信号之间具有稳定的，用户可调的相位关系。 AnaPico 的 APMS 多通道信号发生器为这些应用提供了精心设计的解决方案，以紧凑的设计封装了独特的相位相干信号功能。APMS40G-ULN-PHS 是一款紧凑的四通道 40 GHz 信号发生器，可以经济高效地满足许多新测试应用的苛刻要求。

TERMINOLOGY

When talking about signals and phase coherence, various terms are sometimes used interchangeably, although each term has a very specific meaning. Here are the important definitions used in this article.

术语

在谈论信号和相位相干性时，尽管每个术语都有非常具体的含义，但有时有时会互换使用各种术语。这是本文中使用的重要定义。

Phase continuity and discontinuity

A signal is phase continuous if, after switching frequency, the phase of the

signal is the same as before the switch occurred. If the phase changes after switching, the signal is phase discontinuous.
相连续性和不连续性
如果在切换频率之后，信号的相位与发生切换之前的信号相同，则该信号是相位连续的。如果切换后相位改变，则信号是相位不连续的。

Phase coherence between two channels
If the phase relationship between two signals remains constant, the signals are considered to be pha
两个通道之间的相位相干
如果两个信号之间的相位关系保持恒定，则认为这些信号是相位相干的。se coherent.

Phase coherent switching
Phase coherent switching defines the state of the signals' phase once frequency switching is complete. Two signals at frequency f and with relative phase φ are said to be phase coherently switched if the relative phase is again φ whenever they go back to frequency f.
相干切换
一旦频率切换完成，相位相干切换就定义了信号的相位状态。如果频率 f 且相对相位为 φ 的两个信号每当回到频率 f 时，如果相对相位再次变为 φ，则称相位相干切换。

Phase memory
A signal has phase memory if, when switched from frequency f1 to frequency f2 and back to frequency f1, the signal's phase is the same as if it had run continuously at f1.
相记忆
如果信号从频率 f1 切换到频率 f2，再回到频率 f1，则信号的相位与信号在 f1 连续运行时的相位相同，则该信号具有相位记忆功能。

Phase matched outputs
A multichannel signal generator has phase matched signals if the outputs have 0 degree relative phase at all output frequencies.
相位匹配输出
如果输出在所有输出频率上具有 0 度相对相位，则多通道信号发生器具有相位匹配信号。

APMS40G-ULN-PHS
AnaPico's APMS-ULN multi-channel synthesized signal generators are now available with frequency coverage to 40 GHz and with one to four channels in a compact 1U 19 in. rackmount enclosure. They provide tight stability, phase coherence and extremely fast tuning speeds, and each channel's frequency, phase, amplitude and modulation can be independently

programmed. Other features include a compact design, excellent phase noise, high output power, accurately leveled output and simplicity of control.

APMS40G-ULN-PHS

AnaPico 的 APMS-ULN 多通道合成信号发生器现已上市，频率覆盖范围高达 40 GHz，并在紧凑的 1U 19 英寸机架安装式机箱中具有 1-4 个通道。它们具有严格的稳定性，相位相干性和极快的调谐速度，并且每个通道的频率，相位，幅度和调制都可以独立编程。其他功能还包括紧凑的设计，出色的相位噪声，高输出功率，输出电平准确且控制简单。

The exceptionally low phase noise and high correlation of the independent channels yield outstanding phase coherence, both short- and long-term. The high stability synchronization circuit shared among all the channels of a single unit, with proprietary techniques for exact frequency synthesis, ensures little systematic phase drift between channels, even after hours or days of uninterrupted use. Some applications require more than four independent outputs maintaining phase stability over long time periods. The APMS-ULN offers a dedicated clock synchronization mode, using two ports on the rear panel to maintain phase coherence among a cascaded group of APMS-ULN sources. In this way, the unique features of the APMS can be scaled to virtually any number of channels.

独立通道异常低的相位噪声和高度相关性，无论是短期还是长期的，其均具有出色的相位相干性。单个单元所有通道之间共享的高稳定性同步电路，采用专有技术进行精确的频率合成，即使经过数小时或数天的不间断使用，也可确保通道之间的系统相位漂移很小。一些应用需要四个以上的独立输出，以在长时间内保持相位稳定性。 APMS-ULN 提供了专用的时钟同步模式，它使用后面板上的两个端口来维持一组级联的 APMS-ULN 源之间的相位一致性。这样，APMS 的独特功能可以扩展到几乎任何数量的通道。

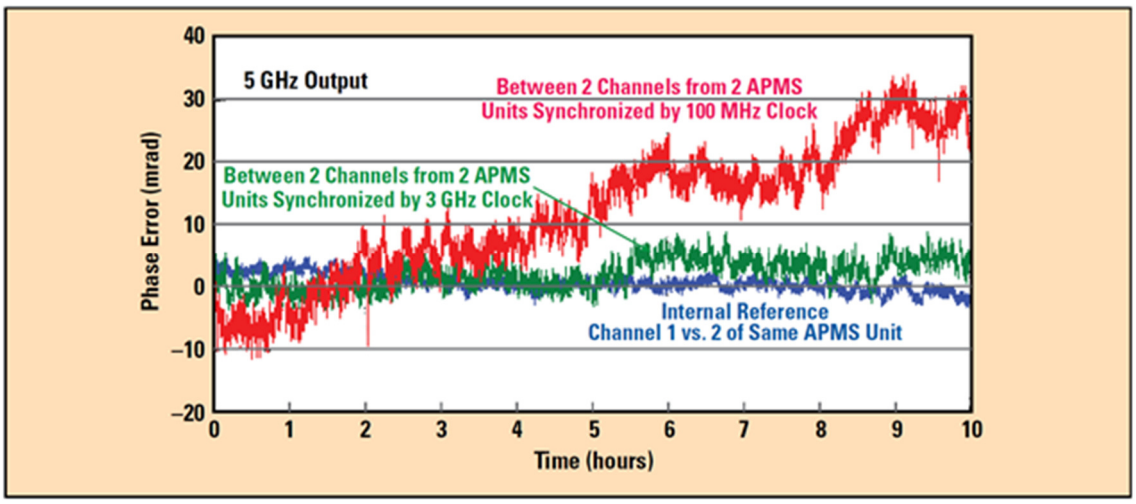

Figure 1: Phase stability measured over 10 hours. 在 10 小时内测得的相稳定性

To demonstrate the phase stability over time, *Figure 1* shows the measured phase difference between two 5 GHz output signals over 10 hours. The excellent phase stability between two individual channels of the APMS is shown by the blue trace. Similarly, the excellent stability when synchronizing two separate units is shown by the green trace. For comparison, phase locking two independent signal generators using an external, 100 MHz reference results in significant phase drift— several hundred milliradians— shown by the red trace. Synchronizing with a common 10 MHz reference yields even worse performance.
为了证明随时间变化的相位稳定性，图 1 显示在 10 个小时内两个 5 GHz 输出信号间测得的相位差。蓝色轨迹显示 APMS 的两个单独通道之间的出色相位稳定性。同样，绿色轨迹显示同步两个独立单元时的出色稳定性。为了进行比较，使用外部 100 MHz 参考信号锁相两个独立的信号发生器会导致明显的相位漂移（数百毫弧度），如红色轨迹所示。与常见的 10 MHz 参考同步会产生更差的性能。

In addition to the excellent channel-to-channel phase stability, the APMS supports both phase coherent switching and phase memory (see *Figure 2*).
除了出色的通道间相位稳定性外，APMS 还支持相位相干切换和相位存储器（见图 2）

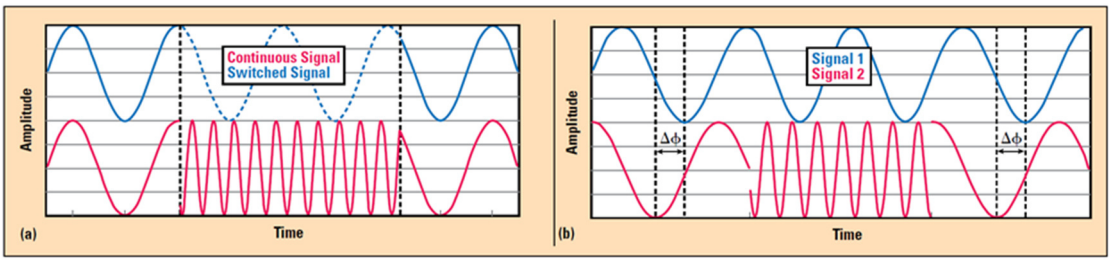

Figure 2: The signal generator has phase coherent switching (a) and phase memory (b).
信号发生器具有相位相干切换（a）和相位存储器（b）

Its channels can be synchronized to maintain a defined phase relationship at all times at any set frequency. As an example of phase coherent switching, consider two channels set to the same frequency f1, with a phase offset of φ degrees. After switching both channels to any other frequency and then back to the initial frequency f1, they will have the same phase offset φ. The APMS can also be programmed to phase match the outputs (φ = 0 degrees). Programming one channel does not affect the signal from the other channels; only the channel being programmed has a phase discontinuity. With phase memory, whenever a channel hops frequency, then goes back to a previous frequency, it behaves as if it had always been running at the first frequency. All these features can be extended beyond four channels by cascading and synchronizing multiple APMS units.
它的通道可以同步，在任何设置频率下始终保持定义的相位关系。作为相位相干切换的示例，考虑设置为相同频率 f1 且相位偏移为 1/3 度的两个通道。在将两个通道切换到任何其他频率，然后又回到初始频率 f1 之后，它们将具有相同的相位偏移 φ。还可以对 APMS 进行编程，使其与输出相位匹配（φ = 0 度）。对一个通道进行编

程不会影响其他通道的信号；只有被编程的通道具有相位不连续性。使用相位存储器，每当信道跳变频率，然后返回到先前的频率时，其行为就好像一直在第一个频率下运行一样。通过级联和同步多个 APMS 单元，可将所有这些功能扩展到 4 个通道之外。

Table 1 summarizes the key specifications of the APMS40G.
总结 APMS40G 的关键规格

TABLE 1
APMS40G SPECIFICATIONS

Parameter	Min	Typical	Max	Note
Frequency Range	300 kHz		40 GHz	
Frequency Resolution		< 1 mHz		
Phase Resolution		0.1°		
Output Power Range	−30 dBm −50 dBm		+25 dBm +23 dBm	Option PE4
Output Power Resolution		0.01 dB		
Output Power Accuracy			< 1 dB	
Switching Speed			500 µs 25 µs	Option FS
SSB Phase Noise at 10 GHz	−80 dBc/Hz −100 dBc/Hz −112 dBc/Hz −128 dBc/Hz			10 Hz Offset 10 Hz Offset Option LN 1 kHz Offset 100 kHz Offset
Modulation	Pulse, Phase and Amplitude			Option Mod

AnaPico's APMS multi-channel signal generators support the requirements of a wide range of applications, such as testing phased arrays, beamforming antennas, satellite payloads and the implementation of quantum computing. With a unique design, the signal generators provide outstanding channel-to-channel phase coherence and are scalable to virtually any number of channels. The PHS option adds phase coherent switching, phase memory and phase matching features.

AnaPico 的 APMS 多通道信号发生器可满足各种应用的需求，例如测试相控阵，波束成形天线，卫星有效载荷以及实施量子计算。 通过独特的设计，信号发生器可提供出色的通道间相位相干性，并可扩展至几乎任何数量的通道。
PHS 选件增加相位相干切换，相位存储和相位匹配功能。