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

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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.

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.

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.

Phase coherence between two channels—If the phase relationship between two signals remains constant, the signals are considered to be phase 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.

Phase memory—A signal has phase memory if, when switched from frequency f_1 to frequency f_2 and back to frequency f_1, the signal's phase is the same as if it had run continuously at f_1.

Phase matched outputs — A multi-channel signal generator has phase matched signals if the outputs have 0 degree relative phase at all output frequencies.

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.

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.

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.

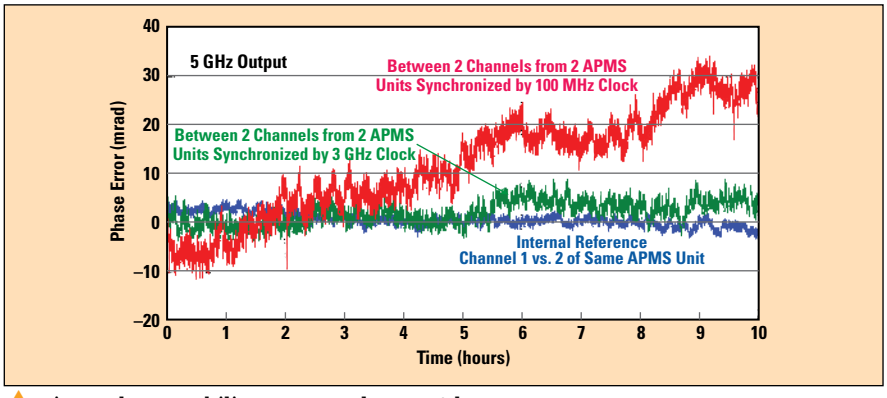

Fig. 1 Phase stability measured over 10 hours.

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

In addition to the excellent channel-to-channel phase stability, the APMS supports both phase coherent switching and phase memory (see ***Figure 2***). 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 f_1, with a phase offset of ϕ degrees. After switching both channels to any other frequency and then back to the initial frequency f_1, 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. ***Table 1*** summarizes the key specifications of the APMS40G.

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.

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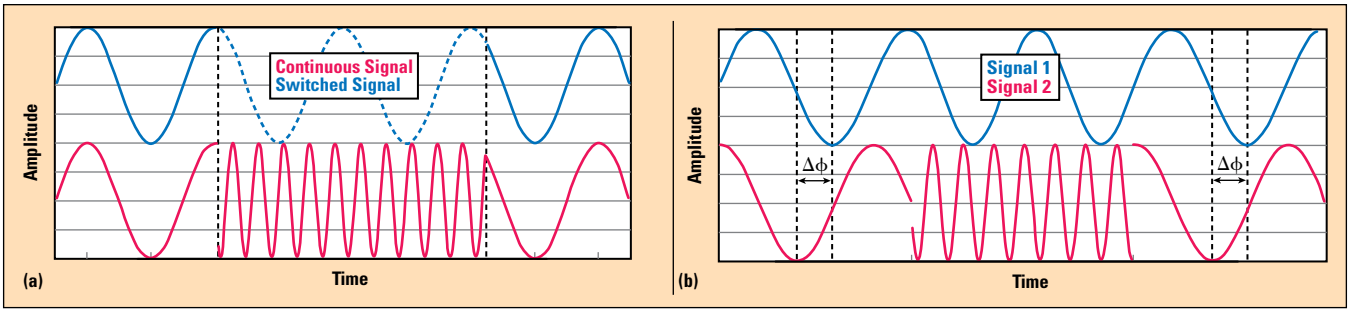

Fig. 2 The signal generator has phase coherent switching (a) and phase memory (b).