Phase and Timing-Accurate Multi-Channel Radar Signal Generation

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AnaPico launched its APVSG series of vector signal generators (VSG) in single- and multi-channel models two years ago. The main features of these models are:

- Wideband performance to 40 GHz and 500 MSa/s data processing capability supporting 400 MHz signal bandwidth
- 512 MSa internal memory with 32 bits per sample supporting sequential and waveform segment ID selective playbacks
- Fast frequency and amplitude switching ranges from less than a microsecond to a few microseconds depending on the frequency change range
- Phase coherence and phase-coherent switching
- Fast control port (FCP) for rapid modulation parameter setting and digital IQ data streaming up to 250 MSa/s.

The above feature combinations enable the flexible generation of versatile phase and timing-accurate, multi-channel radar signals. AnaPico has recently developed user-friendly and cost-efficient software to support the radar signal generation on the AnaPico multi-channel APVSGs.

PULSE DESCRIPTOR WORD

Engineers testing radar require the ability to generate multi-pulse streams with each pulse supporting dozens of parameters such as frequency, amplitude, phase, pulse width, time position and intrapulse modulation or chirping. ***Table 1*** summarizes the typical parameter set describing a single radar pulse, known as a pulse descriptor word (PDW). A list of PDWs will fully describe a radar pulse stream.

Multi-patch radar antenna arrays require additional parameters for full characterization. For these arrays, inter-channel phase coherence, which addresses relative phase stability becomes important. Phase-coherent switching, where the relative phase between channels is stored in memory and

TABLE 1
THE TYPICAL STRUCTURE OF A PDW

Parameter Name	Parameter Group
PDW Configuration	PDW Setting
PDW Start Time	
Fixed Carrier Frequency	Carrier & Output
Fixed Carrier Power	
Fixed Phase	
RF Output Control	
Segment ID	Waveform
Sequence ID	
Modulation State	
Frequency Offset	Offset
Amplitude Offset	
Phase Offset	
FM Frequency	FM/ΦM
FM Deviation	
ΦM Deviation	
AM Frequency	AM
AM Depth	
Chirp Rate	Chirp
Chirp Shape	
Pulse Delay	Pulse Mod.
Pulse Width	
Start Frequency	Sweep
Step Frequency	
Start Power	
Step Power	
Start Phase	
Step Phase	
Dwell Time	
Delay Time	
Number of Points	

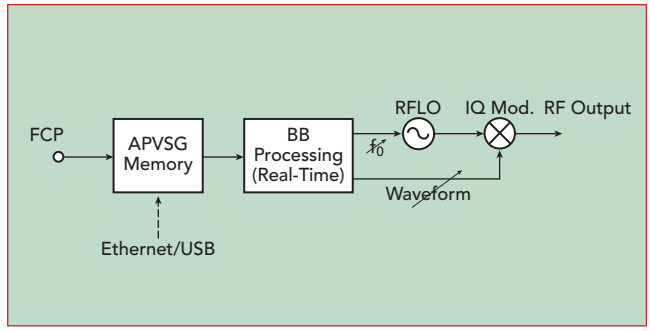

Fig. 1 Operation modes of the PDW list playback.

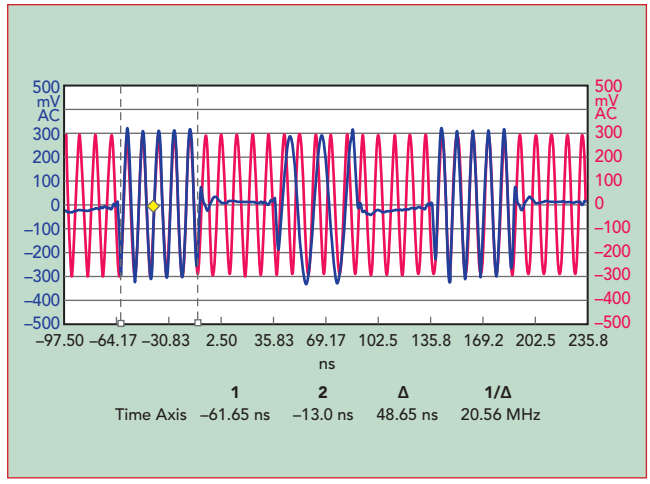

Fig. 2 Phase-coherent switching illustration.

inter-channel timing accuracy are also critical parameters.

SIGNAL GENERATION MODES

The AnaPico VSGs accommodate two different modes for generating the PDWs. These modes are implemented with circuitry within the VSG. ***Figure 1*** depicts the block diagram for the two PDW-related operation modes.

Mode 1: Sequential PDW Playback

In this mode, a list of PDWs, precompiled in a data format, can be uploaded into the APVSG internal memory through the Ethernet or USB communication port. During the playback, each PDW is translated to the corresponding modulation parameters, sequentially and in real-time. This generates a stream of modulated radar signals and accurately timed PDW sequences can be played back with the multi-channel APVSGs.

Mode 2: PDW Live-Streaming

In this mode, individual PDWs are fed into the APVSG internal memory sequentially and in real-time through the APVSG FCP for immediate playback as described in mode 1.

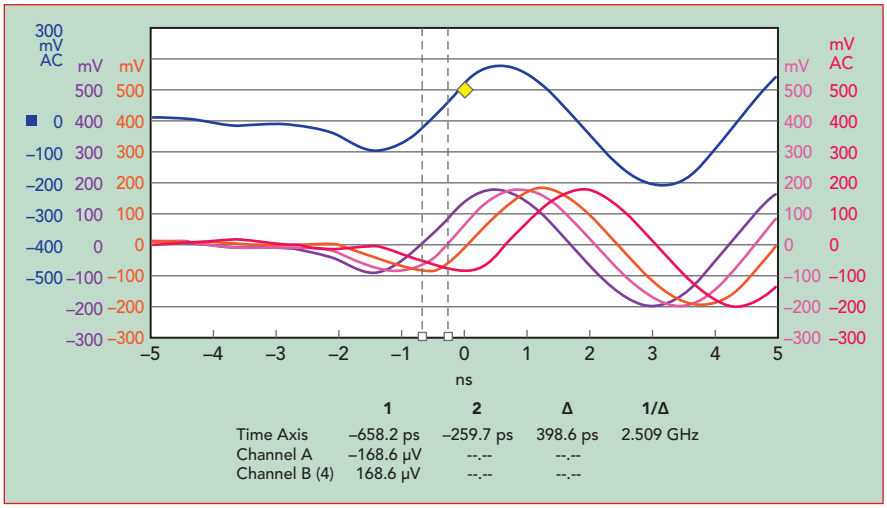

Fig. 3 Setting delays on identical chirping signals.

KEY FEATURES AND PERFORMANCE POINTS

To generate radar pulse sequences that approximate real sequences, a number of features and aspects are important. Fast switching is a key parameter. The VSG must support a pulse width ranging from less than a microsecond to a few microseconds. The frequency chirp rate is limited by the modulation bandwidth of 400 MHz. At a 1 µs pulse width, chirp rates of close to 400 MHz/µs can be produced with excellent signal quality. Phase coherence is another important capability. For a multi-channel VSG to implement the correct radar beam angle specification, phase coherence becomes the most relevant feature. The phase difference variation of the multi-channel APVSGs over hours of operation is 0.3 degrees RMS between two channels generating 5 GHz signals.

Deterministic phase differences between the channels are essential for sustaining the angle information during radar operation. For a given frequency and power setting, the phase difference between channels does not change, even when the supply power switches on and off. This is called phase-coherent switching and it is illustrated in ***Figure 2***. The red sinusoidal signal is the reference channel. The blue signal switches to a different frequency and there is a phase offset, but the blue signal maintains the same relative phase to the red signal when both return to the same frequency setting.

Multi-channel APVSGs support fine delays to +/- 1 ps RMS precision over the entire operating frequency range. This allows multiple radar signal streams to be generated with accurate timing. The capability in a VSG is known as timing-accurate multi-channel triggering. A unique delay mechanism enables this fine trigger delay adjustment. The effective resolution is a very small fraction, typically less than 1/2000, of the sample time. This equates to less than 1 ps with a physical sample time of 2 nsec. ***Figure 3*** illustrates the fine delay setting capability.

SUMMARY

AnaPico's multi-channel APVSG VSGs have a combination of features such as fast switching, phase coherence, phase-coherent switching and timing-accurate operation. These VSGs allow users to easily generate versatile and realistic pulse signals in radar and electronic warfare application scenarios. Multiple lists of PDWs can be replayed from the internal memories or live-streamed through the fast control ports.

VENDORVIEW

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