PHOTONICS
TECHNOLOGIES

Do you need to memorise and recreate various pulse sequences?

Much more than just an arbitrary waveform generator is required for today's atomic physics experiments.

VERSATILE FREQUENCY GENERATOR VFG 150

With the Versatile Frequency Generator VFG 150 Photonics Technologies offers a novel approach to phase-controlled, coherently driven experiments in atom, ion and condensed matter physics. Unlike arbitrary waveform generators, which are limited by their internal memory, the VFG 150 can emit infinitely long radiofrequency (rf) signal trains with very high complexity.

Key features:

- Phase-continuous and phase-coherent frequency switching modes, frequency range 1 - 150 MHz
- Standard waveforms: sine, the versatile modulation capabilities allow for easy implementation of special wave forms like Blackman, Gaussian or chirped pulses
- Infinitely-long random sequences, not limited by storage capacity, due to USB 2.0 computer interface with streaming capability

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- Frequency range: 1-150 MHz
- Waveforms: sine, arbitrary
- Frequency switching modes: phase-continuous, phase-coherent
- USB 2.0 computer interface with streaming capability
- Four additional digital outputs
- All I/O are galvanically isolated
- External reference: 10, 20 or 25 MHz
- Fixed trigger latency

Applications

The VFG 150 can be used as a frequency generator from 1 to 150 MHz with computer controlled modulation capabilities. It lends itself to applications which require precise control of radio frequency waveforms, e.g. in quantum control measurement and sensing, quantum computing and cold ion trapping.

Description

The VFG-150 has 4 digital outputs with a resolution of 5 ns and a minimal pulse width of 10 ns. It can be used as a pulse or a pattern generator. Streaming mode sequence transfer provides modulated waveforms at any wavelength. By programming the frequency, phase and amplitude of the VFG-150's sine waveform and the state of its outputs at any instant of time, a sequence can be defined.

The VFG-150 provides phase-coherent and phase-continuous switching. Phase-continuous mode means that phase information is not preserved when switching between different frequencies. In phase-coherent switching mode, phase information for many frequencies is preserved. In principle, an Arbitrary Waveform Generator (AWG) can provide these two modes as well. However, the available memory usually limits the application of an AWG for many applications. The VFG-150 places no memory restrictions on pulses and pulse sequences. The way it handles date and generates a desired waveform allows the user to create a pulse sequence of arbitrary length where each pulse has a desired frequency up to 150 MHz, amplitude, and phase.

VFG 150 OVERLEAF

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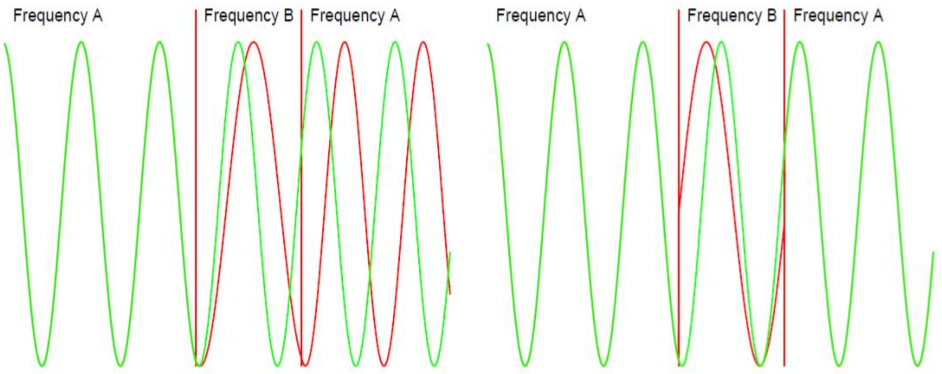

(a) Phase continuous frequency switching.   (b) Phase coherent frequency switching.

Specifications

Frequency range	**1 – 150 MHz**	
Frequency resolution	32 bit, better than 50 mHz resolution	
Frequency stability	Internal reference	Better than 10^{-4}
	External reference input	Accepts 10, 20 , and 25 MHz
Frequency switching modes	Phase continuous and phase coherent switching	
Frequency switching speed	Internal trigger	5 ns
	External trigger	Fixed latency of <100 ns from trigger pulse
Maximum sequence length	Unlimited	
Phase resolution	16 bit, better than 0.1 mrad	
Maximum amplitude	-4 dBm	
Amplitude resolution	16 bit, usable dynamic range is limited to ~8 bit	
Amplitdue stability	100 ppm/K	
Noise level	Better than -70 dB within 1 kHz band of carrier	
Dynamic range	Better than 50 dB	
Inputs	Trigger	5V CMOS, digital coupler isolated
	Reference frequency	-16 to +7 dBm at 50Ω, transformer isolated
	Computer control	USB 2.0
	Power	100 to 240 VAC, 1A max., 20W max.
Outputs	Synthesized waveform	Up to -4 dBm at 50Ω Transformer isolated
	Auxiliary digital outputs	4x 5 V TTL into 50Ω Each separate digital coupler isolated Minimum pulse width 10 ns.
Size	23 cm x 18 cm x 9.5 cm	
Weight	1.9 kg	

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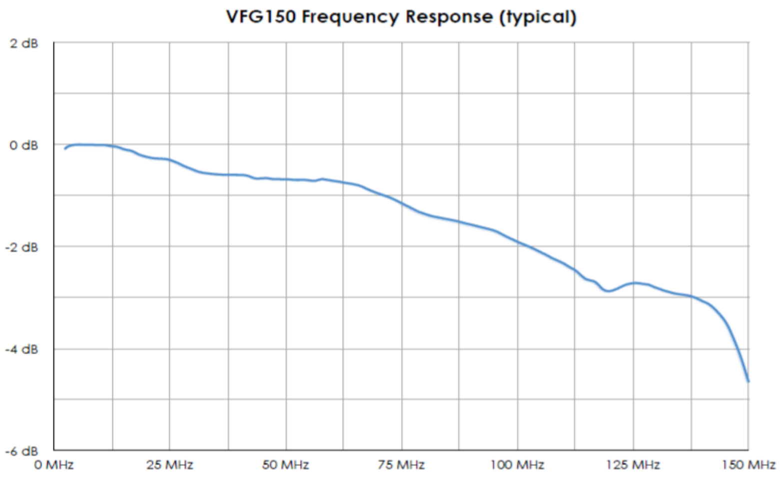

What is phase coherent frequency switching?

When switching the rf signal of a usual generator from a given frequency ω_1 to another frequency ω_2, the initial phase of the signal at frequency ω_2 is either random (a discontinuity in the rf signal's amplitude occurs), or the signal is switched between frequencies such that the rf amplitude goes on continuously. In the latter case, the initial phase of the rf signal at frequency ω_2 is determined by the signal's phase at frequency ω_1 at the time of switching. This mode is labelled "phase-continuous switching". In this mode phase-information of frequency ω_1 is not preserved when switching between different frequencies. Figure 1 shows an example of phase-continuous switching for the frequency cycle ω_1 -> ω_2 -> ω_1 (the frequency is switched at scaled times t=5 and t=10). Here, the green line indicates the phase the signal at ω_1 would have, if no switching to $\omega_2$had occurred. As one can see, this phase is not preserved when switching from ω_2 back to ω_1.

In "phase coherent switching" mode, phase information for arbitrary many frequencies is preserved. The equivalent circuit diagram is shown in figure 2. Each frequency is generated by a dedicated oscillator and phase shifter. Switching between different frequencies is done by just switching the desired oscillator to the output. Figure 3 shows an example of the switching cycle ω_1 -> ω_2 -> ω_1 in phase-coherent switching mode. When reverting from ω_2 back to ω_1, the rf signal's phase is the same the signal at frequency ω_1 would have, if one never had switched to a different frequency (here ω_2) in between.

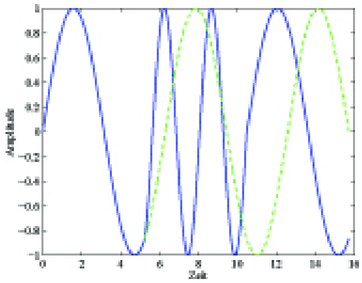

Figure 1:
Phase-continuous switching. The phase after switching back to initial frequency is different to the initial phase.

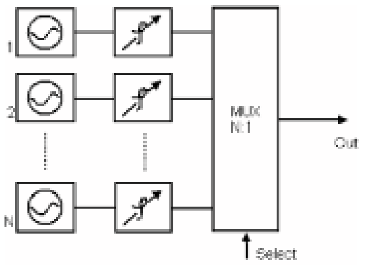

Figure 2:
Equivalent circuit diagram of phase-coherent switching.

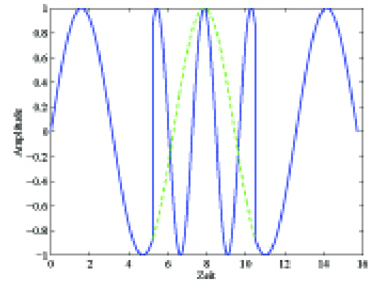

Figure 3:
Phase coherent switching. By switching between frequencies the phases of each one is preserved.

VFG 150 OVERLEAF

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Why not use an Arbitrary Waveform Generator?

An Arbitrary Waveform Generator (AWG) is designed to store a signal in memory that arbitrarily varies with time and to output this time series when triggered. Thus, phase-continuous as well as phase coherent switching is possible in principle using such a device. However, the available memory usually limits the usefulness of an AWG for many experimental applications.

This is illustrated here with an example:
One would like to generate a sequence of rf pulses with well defined frequency, amplitude, and phase around a centre frequency of 100 MHz, for instance, to modulate laser light with the help of an acousto-optic modulator. The parameters characterizing each pulse may also vary during each individual pulse, for instance the amplitude may have a desired envelope, or the frequency is swept, or the phase varies with time in a prescribed way.

If an AWG is used with the capability to generate an arbitrary waveform with a bandwidth ranging up to 100 MHz, at a sample rate of 1 GS/s, and can store up to 16 KB in memory, then one may generate a single pulse, or a sequence of pulses with negligible pauses between individual pulses, having a total length of 8 µs (at 16-bit resolution). Therefore, if the next pulse (or pulse sequence) needed in a given experiment is different from the previous one, this has to be loaded into the AWG's memory every 8 µs which is often not possible.

The VFG-150 places no such restrictions on pulses and pulse sequences. Its particular way of handling data and generating a desired waveform lets the user create (almost) any pulse sequence of arbitrary length where each pulse has a desired frequency (up to 150 MHz), amplitude, and phase (these parameters, of course, may vary during a given pulse).