

Phase Coherence: Terminology

This application note gives illustrated definitions of the common terms used when referring to phase coherent signals, helping the reader better understand the features and capabilities of BNC's Multi-Channel Signal Generators (855B).

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1 Purpose

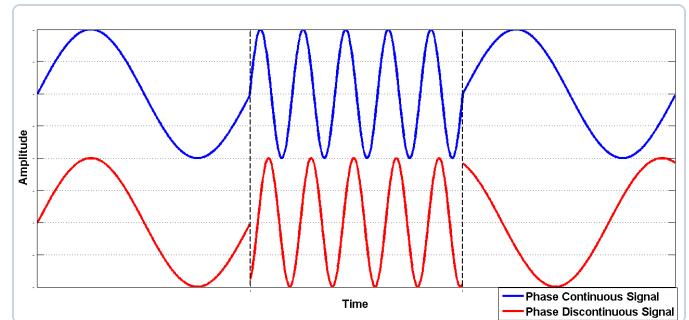
This application note defines common terms used when referring to Phase Coherent signals.

2 Introduction

When talking about signals and phase coherence, the vocabulary is sometimes used interchangeably, although each term has a very specific meaning. In this application note, we give illustrated definitions of the following terms: Phase Continuity, Phase Coherence, Phase Coherent Switching, Phase Memory and Phase Matched Outputs. This should help the reader better understand the features and capabilities of BNC's Multi-Channel Signal Generators (855B).

3 Phase Continuity

A signal is said to be phase continuous if, after switching its frequency, the phase of the signal is the same as before the switch occurred. This means that there is no discontinuity in the signal at the frequency switching point. Figure 1 compares a phase continuous signal with a phase discontinuous signal.



SCHEMATIC Figure 1. Phase continuity. The phase continuous signal (blue) shows no discontinuity at either frequency switch; the phase discontinuous signal (red) jumps in phase at each switch.

4 Single Channel Phase Coherence

As applied to single channel frequency synthesizers, phase coherence describes the relation of the frequency standard to the output frequency. If the output frequency accurately reproduces the relative frequency stability of the standard, the device is considered coherent.

5 Phase Coherence Between Two Channels

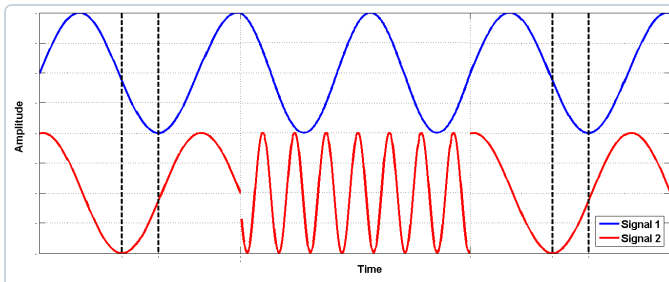
If the phase relationship of two signals remains constant, those two signals are considered to be phase coherent. This means that their relative phase stays constant over time.

A stricter definition only considers phase coherence between continuous wave (CW) signals of equal frequencies or when their frequencies are multiples of each other.

6 Phase Coherent Switching

When referring to the switching behavior of a signal, the term "phase coherence" defines the state of the signal's phase once the switching process is completed.

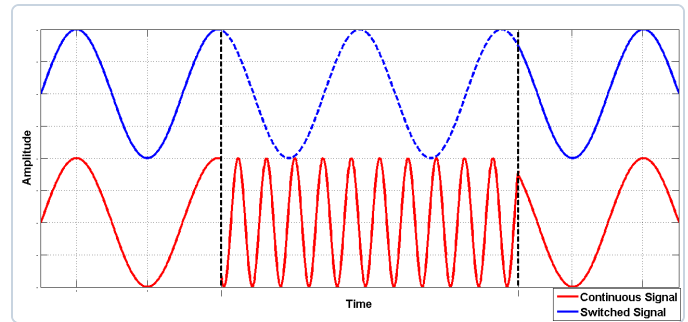
To illustrate this, consider two phase coherent signals, Signal 1 and Signal 2, at frequency f_1 with a relative phase ϕ . If Signal 2 is switched to frequency f_2 and then back to frequency f_1 , the relative phase between the two signals is ϕ again, provided they are phase coherently switched.



SCHEMATIC Figure 2. Phase coherent switching. While both signals are at f_1 their relative phase is maintained; when Signal 2 (red) is switched to f_2 and back, the phase discontinuity is on the switched signal only and the original relative phase returns.

7 Phase Memory

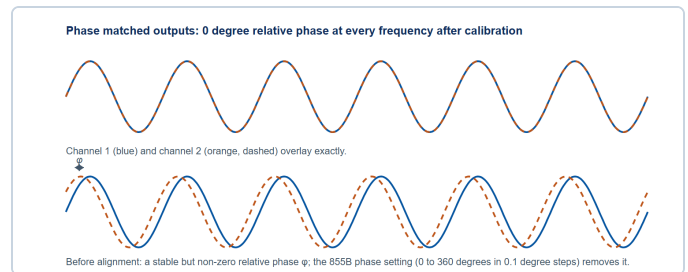
A signal is said to have phase memory if, when it is switched from frequency f_1 to frequency f_2 and then back to frequency f_1 , the signal's phase resumes at the position it would have had if it had run continuously at frequency f_1 . In other words, whenever the signal goes back to a previously set frequency, it behaves as if it had been running continuously at said frequency the whole time. Phase memory usually implies phase discontinuity, as Figure 3 shows.



SCHEMATIC Figure 3. Phase memory. The switched signal (blue) resumes, after returning to f_1 , the phase it would have had if it had run continuously (dashed), which produces a phase discontinuity at the switch back.

8 Phase Matched Outputs

A multi-channel Signal Generator is said to have phase matched outputs if the outputs are aligned to a calibrated 0 degree relative phase at all output frequencies. On the Model 855B each channel's phase is adjustable over 0 to 360 degrees in 0.1 degree steps, so the outputs can be aligned at any frequency, and with option PHS the phase mismatch at the outputs after a switch is 15 ps.



SCHEMATIC Figure 4. Phase matched outputs. After alignment the two channels overlay with 0 degree relative phase; before alignment they hold a stable but non-zero relative phase ϕ .

9 Conclusion

There is a well defined terminology for the different characteristics of phase coherent signals. The terms are sometimes used interchangeably, and the differences between the phenomena they describe matter when a specification is written.

The Model 855B holds the relative phase between its channels within 3 mrad at 5 GHz over 5 hours, and between synchronized modules within 5 mrad (Model 855B datasheet). With option PHS the generator adds phase coherent switching, phase memory and phase matched outputs, with a phase mismatch at the outputs of 15 ps.

