

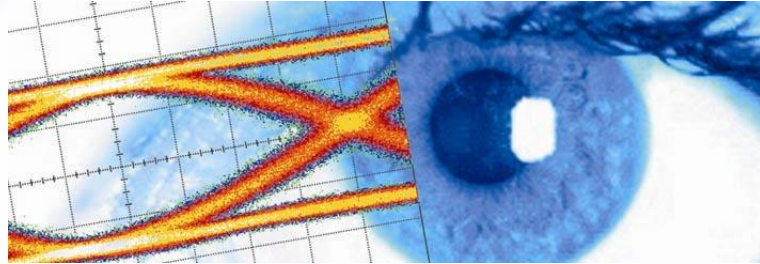


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Datasheet

SHF 78122 B

Synthesized Clock Generator





Description

The SHF 78122 B is a **synthesized signal generator for clock generation** that is designed to provide our BERT customers with a standalone compact clock source featuring wide frequency range, adjustable output power, low jitter and low harmonic levels.

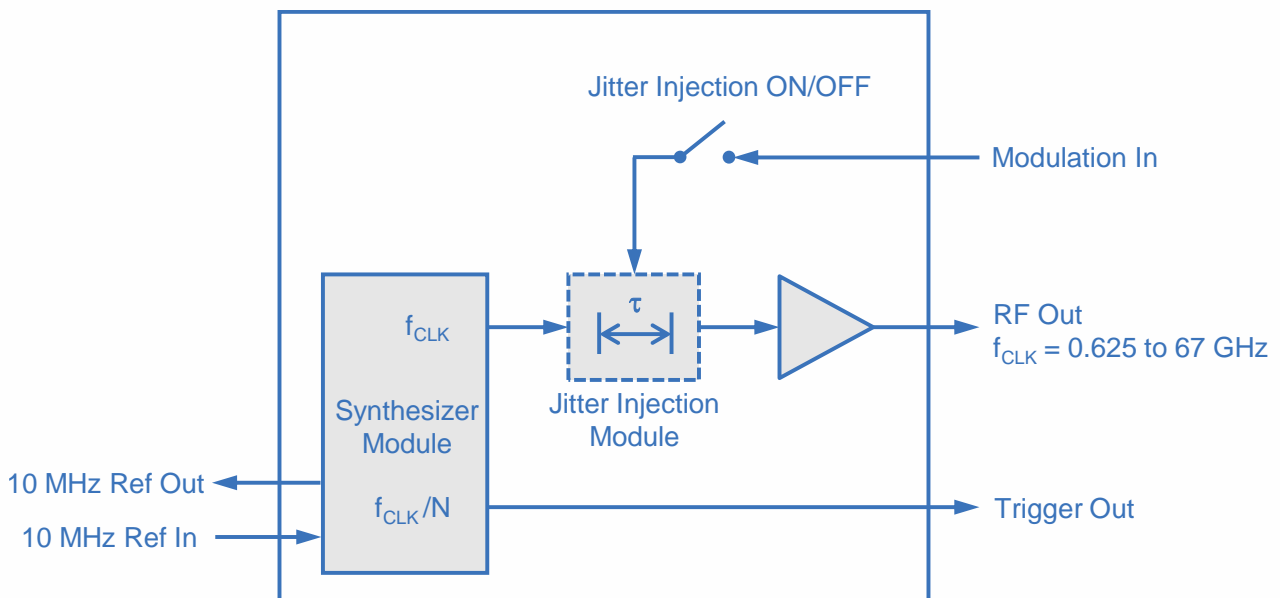
It features a wide frequency range **from 0.625 to 67 GHz (operational to 70 GHz) with a 1 kHz resolution** and a large output power (**typically 8 dBm up to 62 GHz and 4 dBm up to 67 GHz**). The output power can be adjusted in 0.1 dB steps.

For frequencies above 10 GHz, additional band-pass filtering ensures low harmonic levels. Up to 10 GHz, short rise time clock signals are generated resulting in an increased level of higher-order harmonics.

The **jitter injection** functionality is integrated for jitter stress test applications. Arbitrary jitter types may be applied to the clock signal by connecting an external signal source to the **modulation input**, enabling various test scenarios such as compliance testing.

An additional **trigger output** provides a trigger signal whose frequency can be switched to a quarter or half the output frequency.

Block Diagram



Features

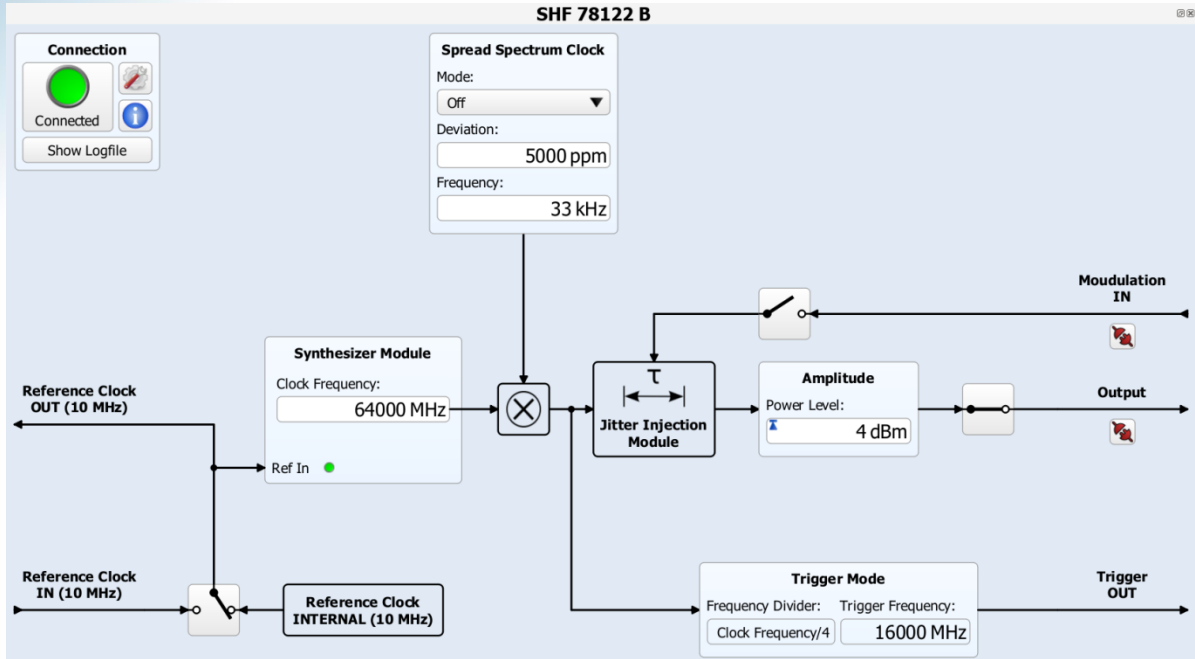
- Clock frequency ranges from $f_{\text{CLK}} = 0.625$ to 67 GHz (operational to 70 GHz) with 1 kHz resolution
- Output power adjustable from -10 to $+8$ dBm with 0.1 dB resolution
- External jitter injection using an external signal source such as SHF 19120 AWG
- Supports three spread-spectrum clocking (SSC) modes
- 10 MHz reference input and output for phase locking to other instruments
- Remote programming interface (Ethernet, USB) for automated measurements



Operation of the Synthesized Signal Generator

The SHF 78122 B is controlled over a standard Ethernet or USB connection by an external computer (not part of the delivery). Every system comes along with the intuitive, easy to use SHF Control Center. It provides the interface for changing the device parameters, see screenshot below.

Additionally, the instrument may be programmed remotely over the Ethernet connection for automated tests and measurements. Please refer to the *SHF BERT Programming Manual*.



SHF Control Center GUI



Specifications

| Parameter | Symbol | Unit | Min. | Typ. | Max. | Comment |
|--------------------------------|---------------|----------|-------------|---------------------------|-------|---|
| Clock Output (RF Out) | | | | | | |
| Operating Frequency | f_{CLK} | GHz | 0.625 | | 67 | |
| Frequency Resolution | | kHz | 1 | | | |
| Frequency Accuracy | | ppb | -1000 | | +1000 | Using internal reference |
| Frequency Stability | | ppb | -50 | | +50 | Ambient temperature 21°C |
| Frequency Stability Aging | | ppb | -500 | | +500 | per year |
| Minimum Output Power | $P_{out,min}$ | dBm | | | -10 | |
| Maximum Output Power | $P_{out,max}$ | dBm | 8 6 3 | 8 4 | | $f_{CLK} \leq 38$ GHz $f_{CLK} \leq 62$ GHz $f_{CLK} \leq 67$ GHz |
| Output Power Resolution | | dB | 0.1 | | | |
| Output Power Accuracy | | dB | -1 | | 1 | Ambient temperature 21°C |
| Output Power Temperature Drift | | dB/°C | | | 0.1 | |
| Harmonics/Spurious Signals | | dBc | | | -20 | For $f_{CLK} \geq 10$ GHz |
| Phase Noise | | dBc/Hz | | -90 -92 -85 -109 | | $f_{CLK} = 10$ GHz 1 kHz offset 10 kHz offset 100 kHz offset 1 MHz offset |
| Jitter (RMS) | J_{RMS} | fs | | | 400 | For $f_{CLK} \geq 10$ GHz; on scope display (not deconvolved) ¹ |
| Output Impedance | | Ω | | 50 | | |
| Connector | | | | | | 1.85 mm (V) female |

| Parameter | Symbol | Unit | Min. | Typ. | Max. | Comment |
|--------------------|--------|----------|---------|------|------|--------------------|
| Trigger Out | | | | | | |
| Frequency | | GHz | 0.15625 | | 21 | |
| Output Amplitude | | mVpp | 400 | | 1000 | |
| Output Impedance | | Ω | | 50 | | |
| Connector | | | | | | 2.92 mm (K) female |

¹ Measured with Agilent 86100A, 70 GHz sampling head and precision time base triggered by Trig Out signal.



| External Jitter Injection | | | | | | |
|---------------------------|--|----------|-----|----|------|--------------------|
| Modulation Frequency | | MHz | 0.5 | | 1000 | |
| Modulation Amplitude | | mVpp | 0 | | 1200 | |
| Jitter Amplitude | | ps | 0 | | 50 | Peak-to-peak |
| Input Impedance | | Ω | | 50 | | |
| Connector | | | | | | 2.92 mm (K) female |

| Spread Spectrum Clocking | | | | | | |
|--------------------------|--|-----|----|--|--------|----------------|
| Modulation Frequency | | Hz | 10 | | 100 k | |
| Deviation | | ppm | 0 | | 20,000 | Up/down/center |

| Ref In | | | | | | |
|---------------------|-----------|----------|-----|----|-----|------------|
| Reference Frequency | f_{ref} | MHz | | 10 | | |
| Amplitude | | Vpp | 0.2 | | 3.3 | |
| Input Impedance | | Ω | | 50 | | |
| Connector | | | | | | SMA female |

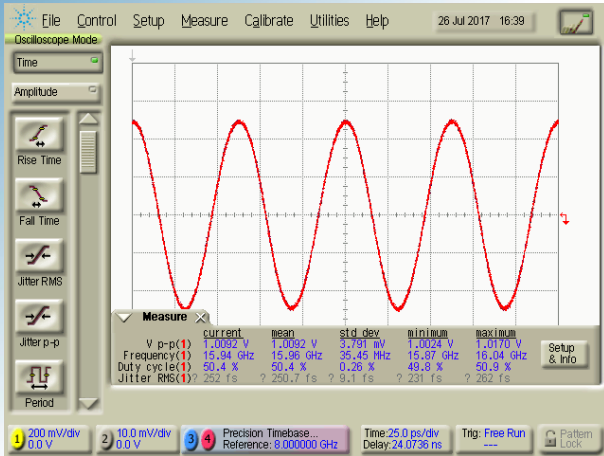
| Ref Out (using internal reference setting) ² | | | | | | |
|---|--|----------|-------|----|-------|--------------------------|
| Reference Frequency | | MHz | | 10 | | |
| Amplitude | | Vpp | | | 0.8 | |
| Output Impedance | | Ω | | 50 | | |
| Frequency Accuracy | | ppb | -1000 | | +1000 | |
| Frequency Stability | | ppb | -50 | | +50 | Ambient temperature 21°C |
| Frequency Stability Aging | | ppb | -500 | | +500 | per year |
| Connector | | | | | | SMA female |

| General | | | | | | |
|-----------------------|--|----|----|-------------|----|---|
| Power Consumption | | W | | | 25 | +12V switching power supply is included |
| Weight | | kg | | 1.6 1.85 | | without power supply with power supply |
| Operating Temperature | | °C | 10 | | 35 | Ambient temperature |

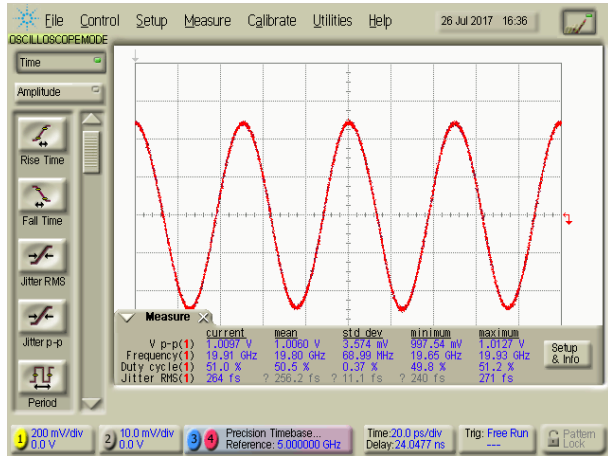
² The specifications in this datasheet are only valid if the internal reference is activated. If the external reference setting is activated the signal at Ref In is fed through to Ref Out. In this case the parameters frequency, stability and amplitude depend on the Ref In signal.



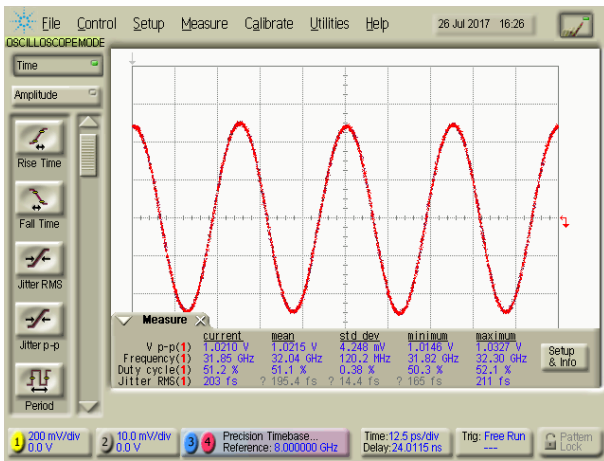
Typical Output Waveforms



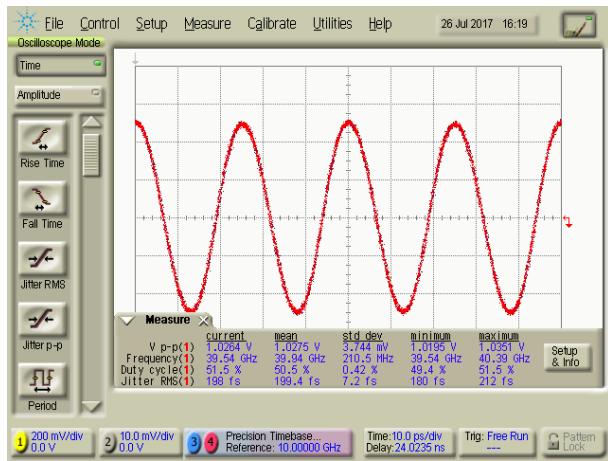
16 GHz clock output at 4 dBm



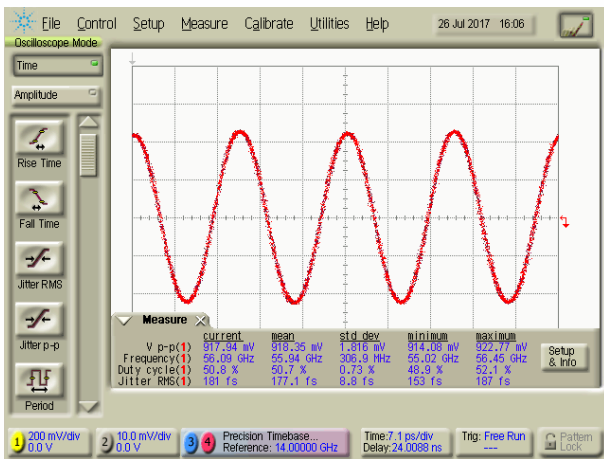
20 GHz clock output at 4 dBm



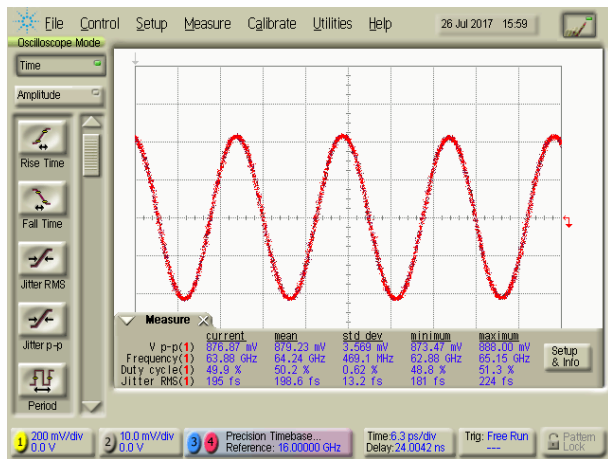
32 GHz clock output at 4 dBm



40 GHz clock output at 4 dBm



56 GHz clock output at 4 dBm



64 GHz clock output at 4 dBm

Note that for clock frequencies above 10 GHz, the signal is band-pass filtered to achieve low harmonics and a nearly pure sine wave. Below 10 GHz, however, the synthesized signals are amplified with subsequent amplitude clipping to shorten the rise time. In the frequency range below 10 GHz, this generates noticeable higher-order harmonics. The SHF 78122 B is optimized for clock source applications in combination with SHF BERT instruments, where a short rise time is preferred.



Output Amplitude

The output amplitude is factory-calibrated using a power meter. It can be varied from -10 to +8 dBm. By default, the amplitude is software-limited to +4 dBm to prevent damage on connected devices. If required the instrument can be configured to set the amplitude to the available hardware maximum. The typical hardware maximum is +8 dBm. The amplitude can be set in 0.1 dB steps.

For clock frequencies above 10 GHz, the amplitude value in dBm, P_{dBm} , can be converted from and to V_{pp} using the following equations which are valid in a 50 Ω system:

$$P_{dBm} = 20 \log_{10}(V_{pp}) + 4 \quad (\text{Eq. 1})$$

$$V_{pp} = 10^{(P_{dBm}-4)/20}. \quad (\text{Eq. 2})$$

Note that below 10 GHz, the measured V_{pp} will be slightly smaller than the value calculated from (Eq. 2) since the clock signals in that frequency range are square waves rather than single-tone sine waves.

External Jitter Injection

For additional flexibility, arbitrary jitter injection may be applied to the high-speed clock signal. Jitter is injected by connecting a signal source such as an arbitrary waveform generator to the external modulation input. The maximum jitter amplitude is 50 ps peak-to-peak with a modulation bandwidth of up to 1 GHz. As an example, the jitter amplitude of 50 ps corresponds to a relative jitter amplitude of 1.6 unit intervals (UI) at a bit rate of 32 Gbit/s.

The jitter amplitude needs to be calibrated by the user.

In combination with an SHF Bit Pattern Generator and an Error Analyzer, the SHF 78122 B enables a test solution for jitter tolerance tests as required by many telecommunication standards such as 100G Ethernet and 40 GBit/s OTN, FibreChannel, InfiniBand®, PCI Express®, and Serial ATA. For further details please refer to the SHF application note „Jitter Injection using the Multi-Channel BPG“, available online at www.shf-communication.com.

® *InfiniBand* is a registered trademark of the InfiniBand Trade Association. *PCI Express* is a registered trademark of Peripheral Component Interconnect Special Interest Group (PCI-SIG).

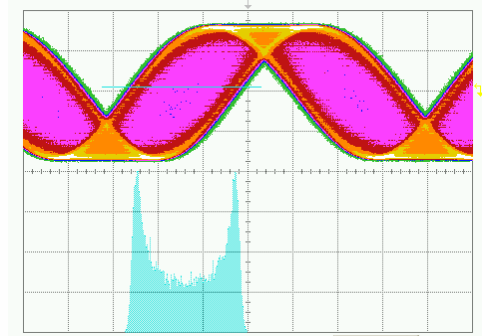
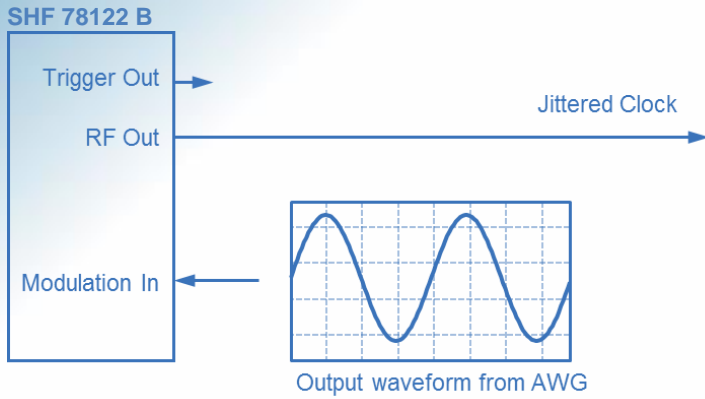
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Typical Jittered Signal Waveforms

The external modulation input can be driven by a signal source such as the SHF 19120 arbitrary waveform generators (AWG). The waveform characteristics of the AWG determine the jitter type of the SHF 78122 B.

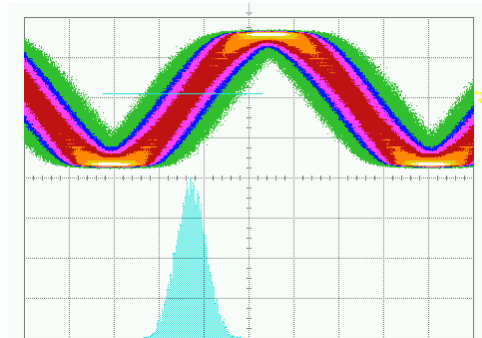
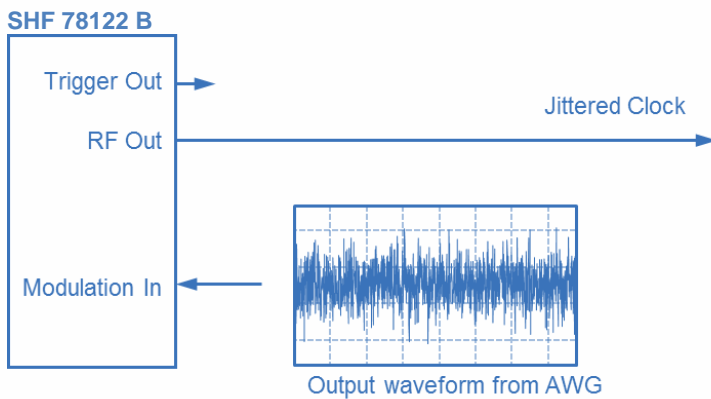
Sine Wave on Modulation Input



Sinusoidal jitter on 28 GHz clock.

AWG Setting
Waveform: Sine wave

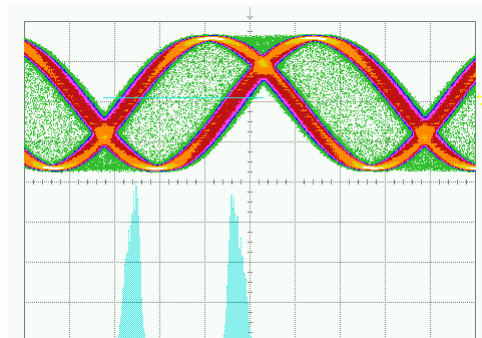
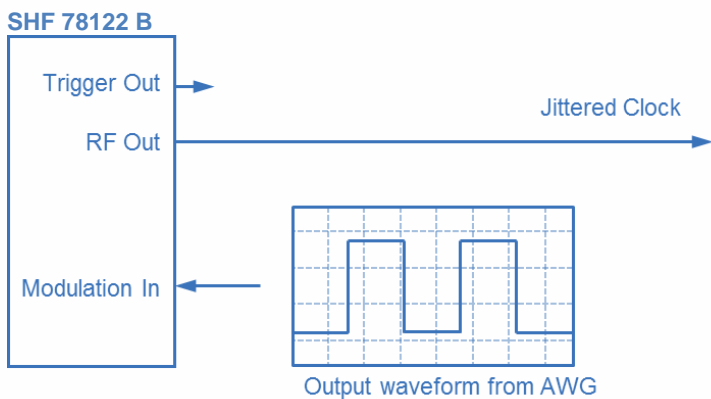
Gaussian-Distributed Noise on Modulation Input



Random jitter on 28 GHz clock.

AWG Setting
Waveform: Noise

Square Waveform on Modulation Input



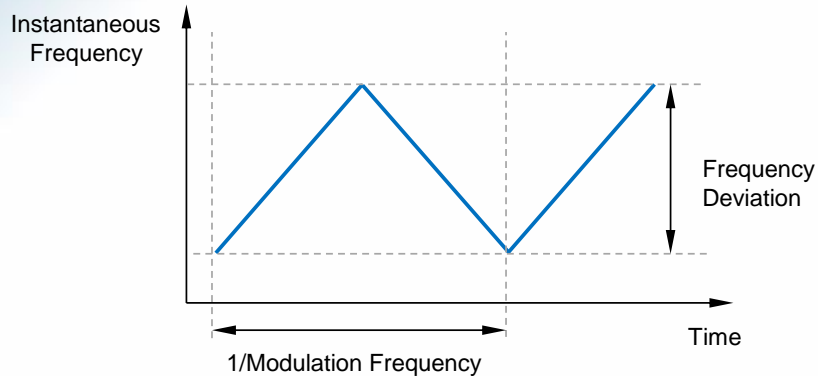
Peak-to-peak jitter on 28 GHz clock.

AWG Setting
Waveform: Square



Spread Spectrum Clocking

To meet the regulatory demands of electromagnetic interference several high-speed bus systems use a spread spectrum clocking (SSC) method. When SSC is enabled, the instantaneous frequency of the clock signal varies periodically with time by a small amount, i.e. the clock signal is frequency-modulated. The figure below illustrates the SSC frequency modulation with a triangular shape.



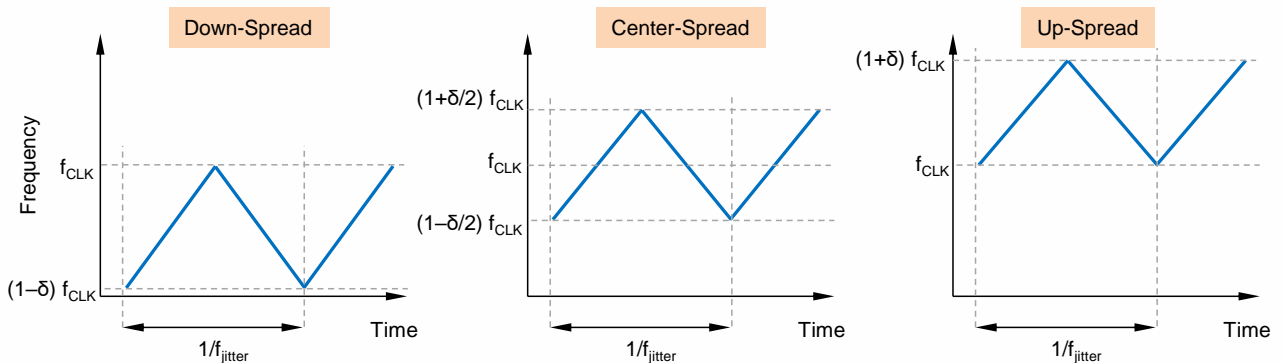
The principle of SSC is the periodic frequency modulation of a clock signal.

The key SSC parameters are the following:

- f_{CLK} original clock frequency without SSC
- δ relative frequency deviation (often given in percent or ppm, parts per million)
- f_{jitter} modulation frequency.

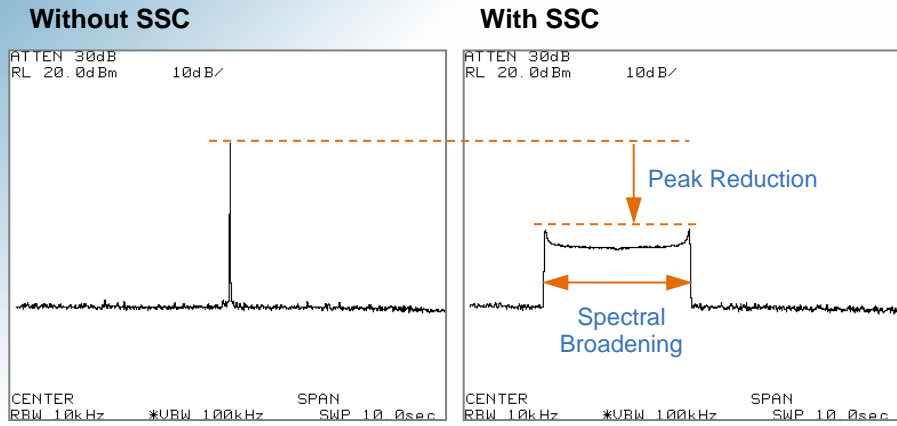
The parameters are directly accessible in the SHF Control Center software or through remote programming.

Depending on the relative position of the clock frequency and the frequency deviation, SSC can be classified into three types: down, center, and up-spread. The figure below illustrates the three configurations.



Three types of SSC.

SSC effectively broadens the spectral peak of a clock signal so that the maximum of the power spectral density is reduced leading to less radiated emission. This is illustrated in the following spectra measured at the output of the SHF 78122 B for a 25 GHz clock with 30 kHz modulation frequency and 0.5% deviation. Note that SSC does not reduce the total signal power of the clock. Rather, it redistributes the clock's spectral components as shown in the figure below.



SHF 78122 B clock spectrum with and without SSC.

