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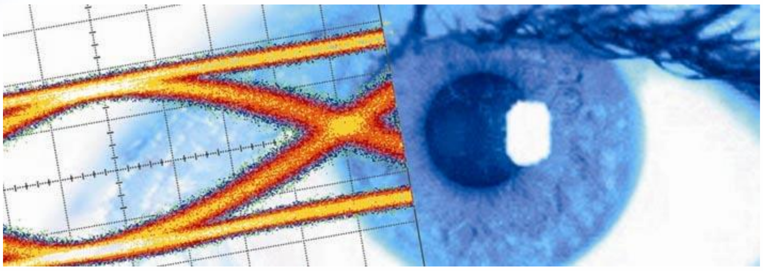


Datasheet

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.

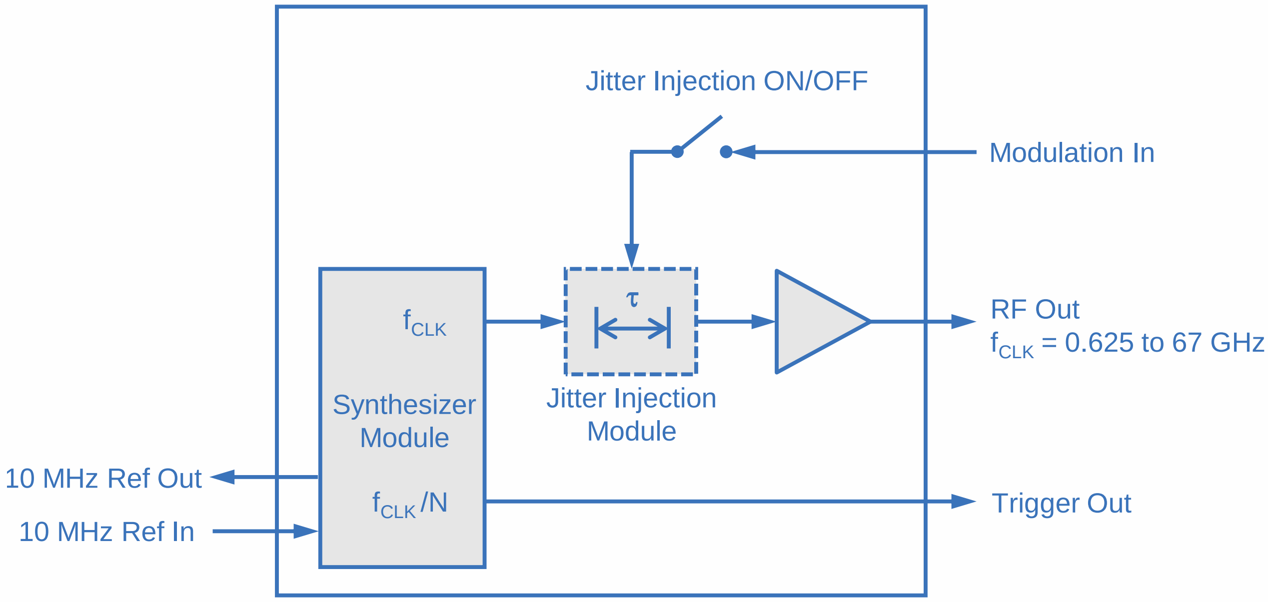
It features a wide frequency range **from 0.625 to 67 GHz (operational to 70 GHz) with a 1 kHz resolution** and a large output power (**typically 8 dBm up to 62 GHz and 4 dBm up to 67 GHz**). The output power can be adjusted in 0.1 dB steps.

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_{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

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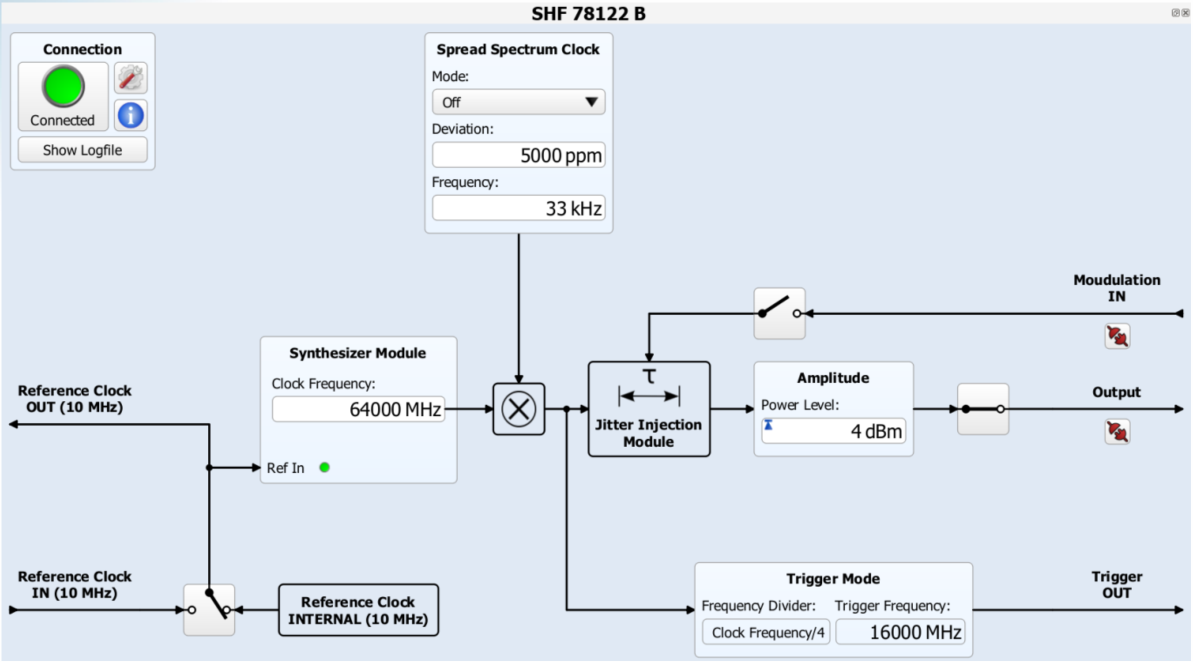
Operation of the Synthesized Signal Generator

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

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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	with 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} ≤ 38 GHz f_{CLK} ≤ 62 GHz f_{CLK} ≤ 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} ≥ 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			400 800	P_{out} ≥ -3 dBm P_{out} < -3 dBm For f_{CLK} ≥ 10 GHz; on scope display (not deconvolved)[1]
Output Impedance		Ω		50		
Connector						1.85 mm (V) female

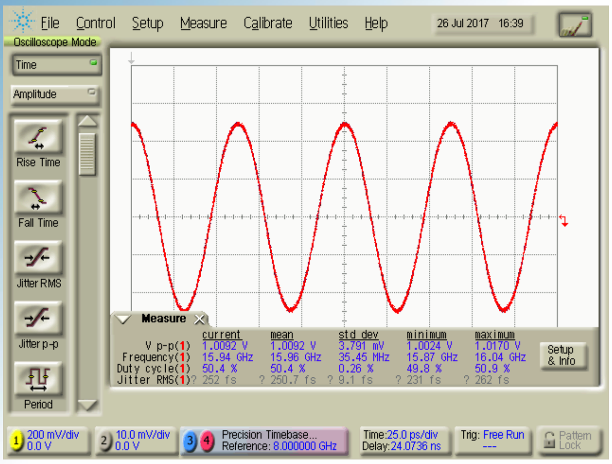
Parameter	Symbol	Unit	Min.	Typ.	Max.	Comment
Trigger Out						
Frequency		GHz	0.15625		21	
Output Amplitude		mVpp	400		1000	
Output Impedance		Ω		50		
Connector						2.92 mm (K) female

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

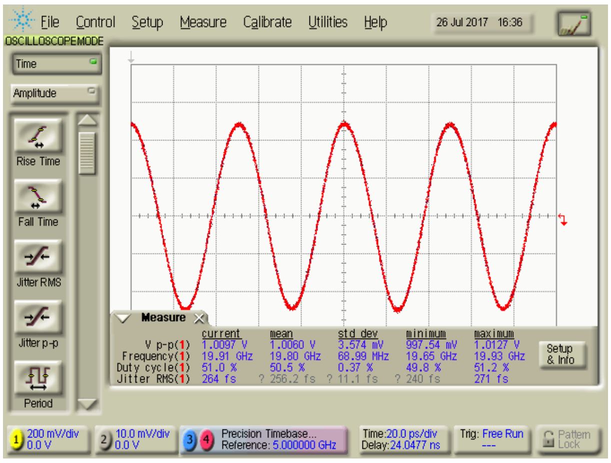
External Jitter Injection						
Modulation Frequency		MHz	0.5		1000	
Modulation Amplitude		mVpp	0		1200	
Jitter Amplitude		ps	0		50	Peak-to-peak
Input Impedance		Ω		50		
Connector						2.92 mm (K) female
Spread Spectrum Clocking						
Modulation Frequency		Hz	10		100 k	
Deviation		ppm	0		20,000	Up/down/center
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.

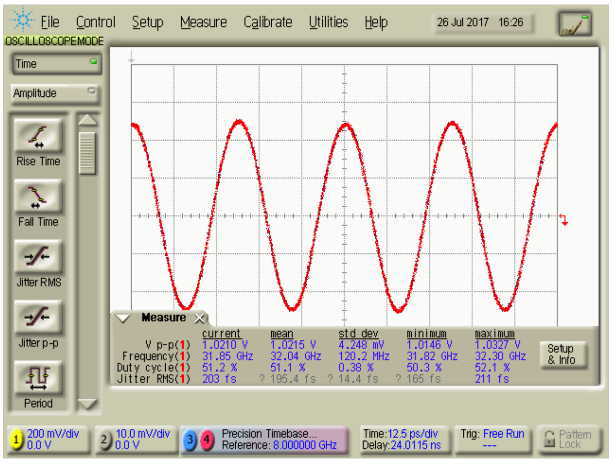
Typical Output Waveforms



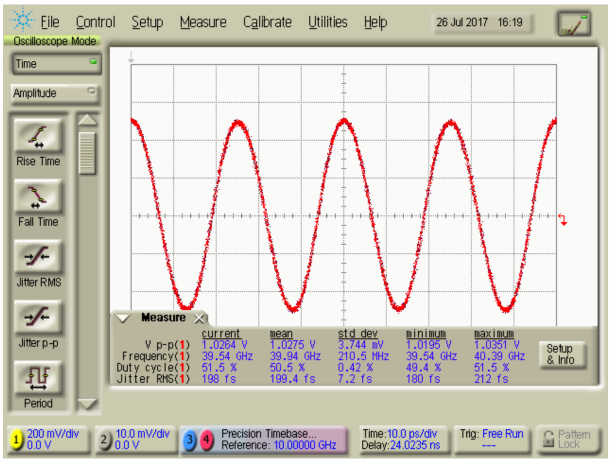
16 GHz clock output at 4 dBm



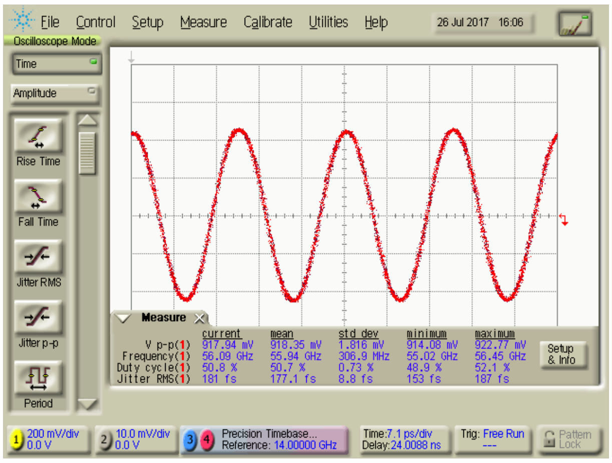
20 GHz clock output at 4 dBm



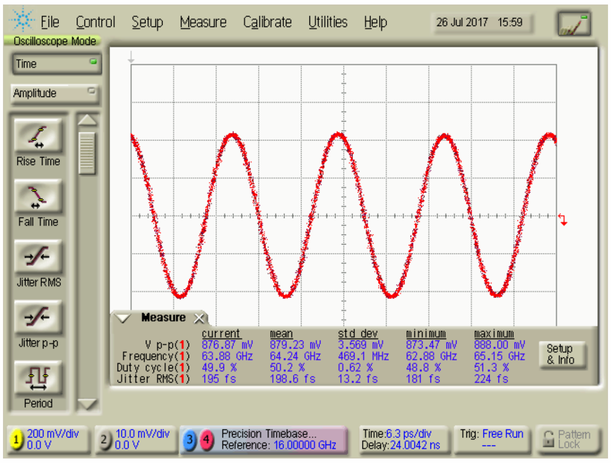
32 GHz clock output at 4 dBm



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:

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

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

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.

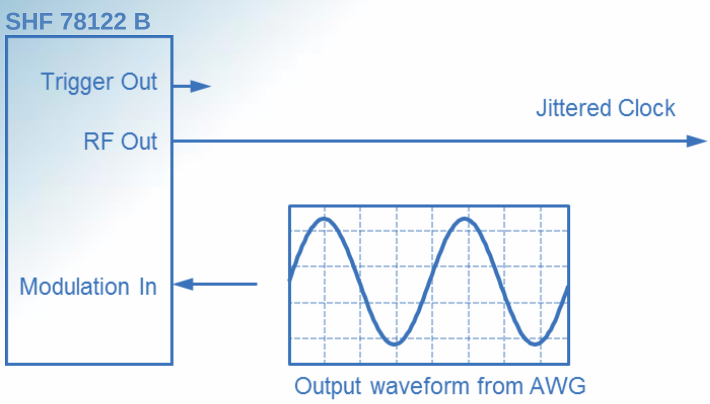
In combination with an SHF Bit Pattern Generator and an Error Analyzer, the SHF 78122 B enables a test solution for jitter tolerance tests as required by many telecommunication standards such as 100G Ethernet and 40 GBit/s OTN, FibreChannel, InfiniBand®, PCI Express®, and Serial ATA. For further details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

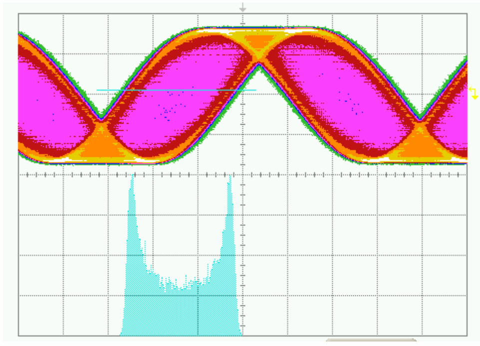
® *InfiniBand* is a registered trademark of the InfiniBand Trade Association. *PCI Express* is a registered trademark of Peripheral Component Interconnect Special Interest Group (PCI-SIG).

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



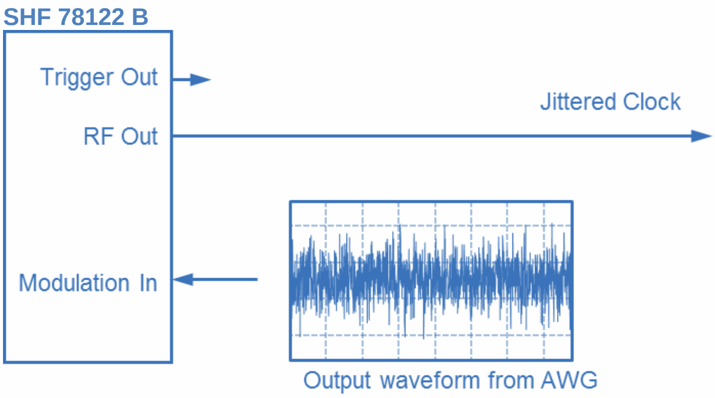


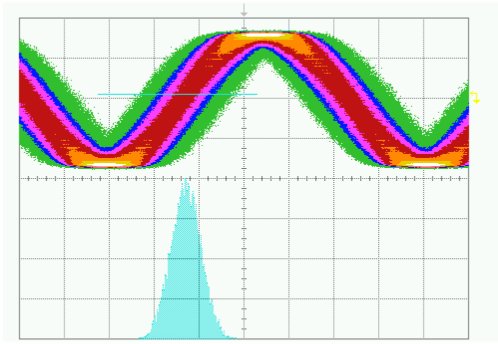
Sinusoidal jitter on 28 GHz clock.

AWG Setting

Waveform: Sine wave

Gaussian-Distributed Noise on Modulation Input



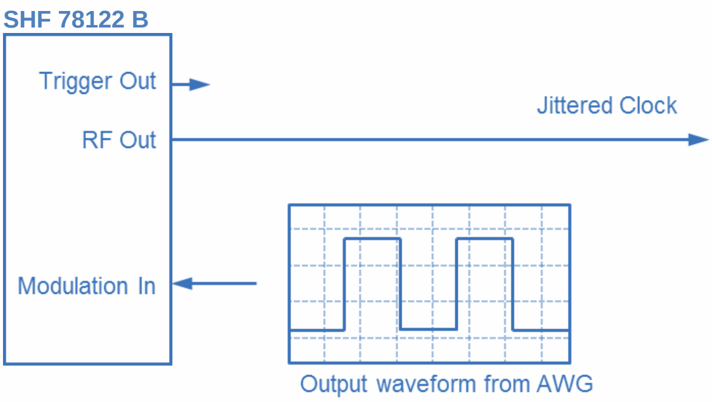


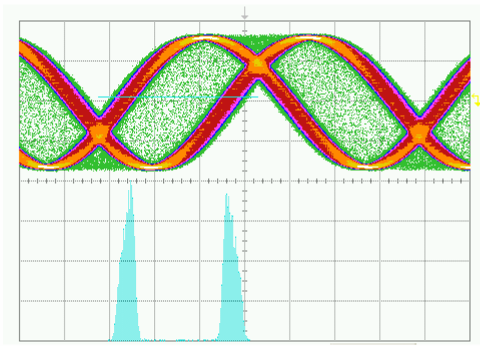
Random jitter on 28 GHz clock.

AWG Setting

Waveform: Noise

Square Waveform on Modulation Input





Peak-to-peak jitter on 28 GHz clock.

AWG Setting

Waveform: Square

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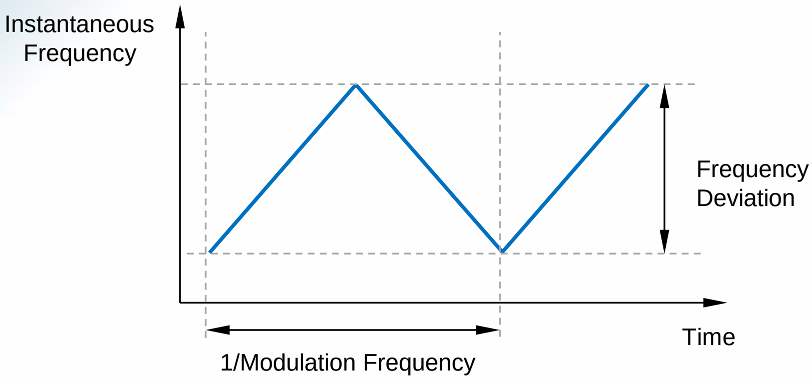
Spread Spectrum Clocking

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.



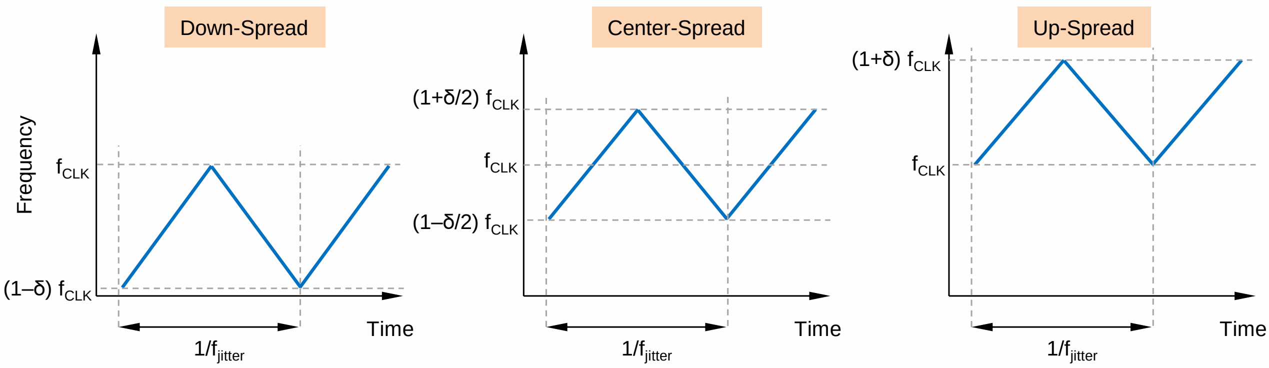
The principle of SSC is the periodic frequency modulation of a clock signal.

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.

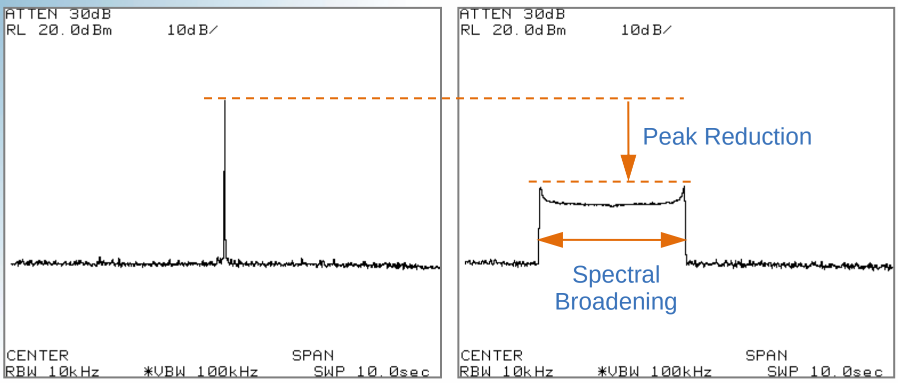
Depending on the relative position of the clock frequency and the frequency deviation, SSC can be classified into three types: down, center, and up-spread. The figure below illustrates the three configurations.



Three types of SSC.

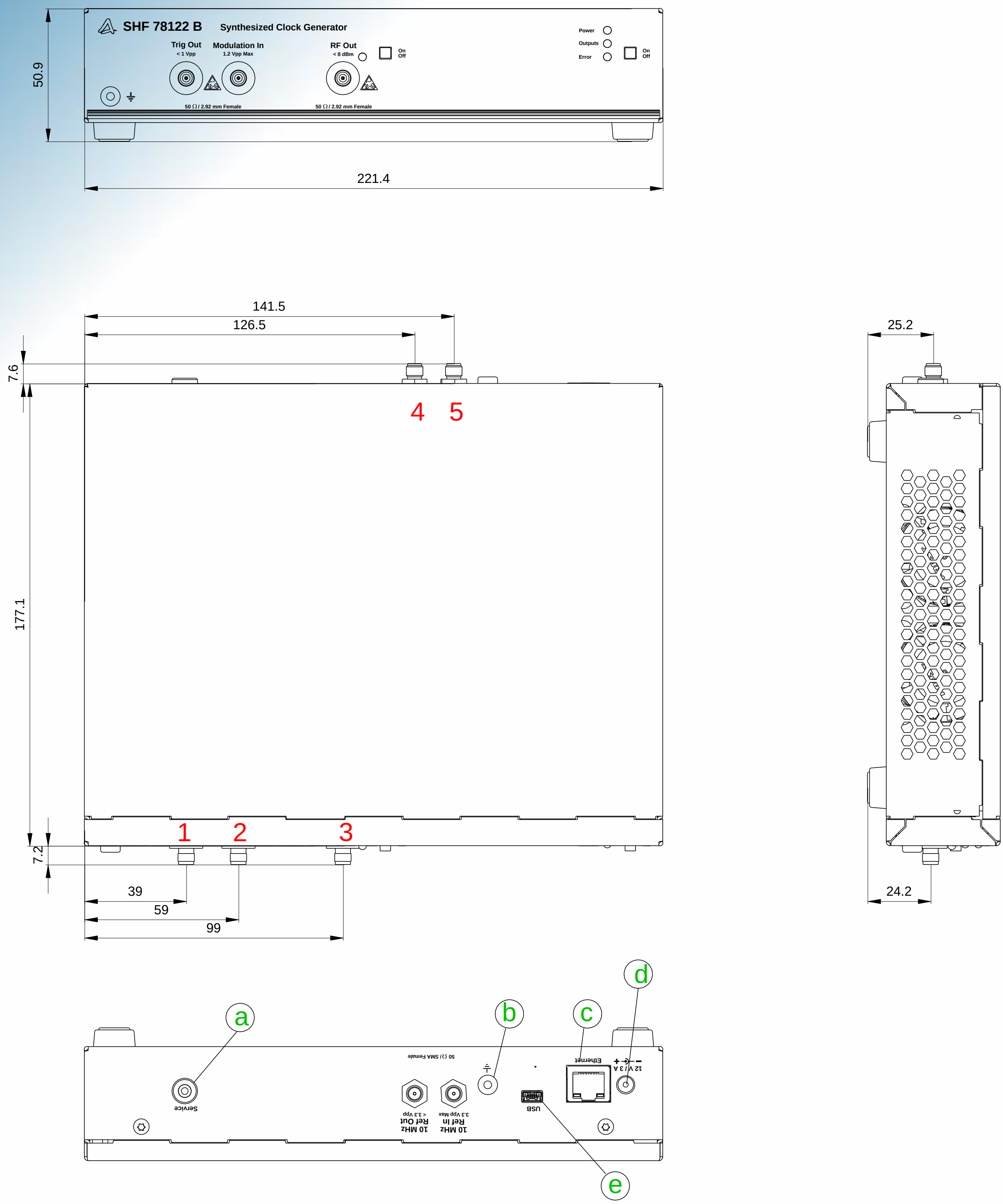
SSC effectively broadens the spectral peak of a clock signal so that the maximum of the power spectral density is reduced leading to less radiated emission. This is illustrated in the following spectra measured at the output of the SHF 78122 B for a 25 GHz clock with 30 kHz modulation frequency and 0.5% 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.

Without SSC With SSC



SHF 78122 B clock spectrum with and without SSC.

Mechanical Drawing



Pos.	Designation	Connector
1	Trigger Output	2.92 mm (K) Female
2	Modulation Input	2.92 mm (K) Female
3	RF Out	1.85 mm (V) Female
4	Ref Out	SMA Female
5	Ref In	SMA Female

Pos.	Designation
a	Service
b	GND
c	Ethernet
d	Power Supply
e	USB

All dimensions are specified in millimeters (mm).