Spectrum Analysis (SAN) S65

Module of the KLIPPEL ANALYZER SYSTEM (QC Ver. 6, dB-Lab Ver. 210)

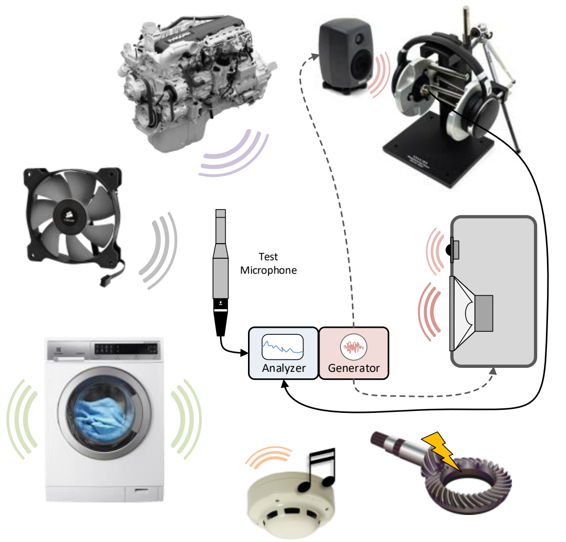
Document Revision 1.5

FEATURES

- Spectrum analysis of any noise source
- A-weighted sound pressure level
- Frequency response with white/pink noise or any other test signal (e.g. music)
- Incoherence (distortion)
- Phase and polarity

BENEFITS

- Simple, universal, flexible
- Use your favorite test signal
- Noise and vibration testing



DESCRIPTION

The Spectrum Analysis (SAN) is a versatile tool for the QC framework of the KLIPPEL Analyzer System dedicated to testing loudspeakers, audio systems as well as general noise and vibration testing of devices with no test stimulus input. A white or pink noise generator is provided to measure characteristics like spectrum, frequency response, A-weighted level and incoherence. You may use your own stimulus signal that can be imported from a wave file.

Even when no test signal can be applied, you may evaluate the spectrum and level of any sound or noise sources and apply PASS/FAIL limits.

Item number	4000-267

CONTENT

1 Overview

1.1 Principle

	The SAN Task provides two basic modes of operation: 1. Based on stimulus signal: A system is excited by a known excitation signal (white/pink noise, WAV) and the response is analyzed. This allows a deeper analysis such as amplitude and phase frequency response as well as distortion analysis. 2. Noise & vibration analysis: Spectral properties of any noise source that is not excited by the test system can be analyzed. Both methods provide PASS/FAIL limit check against shifted reference measurements or absolute limits.

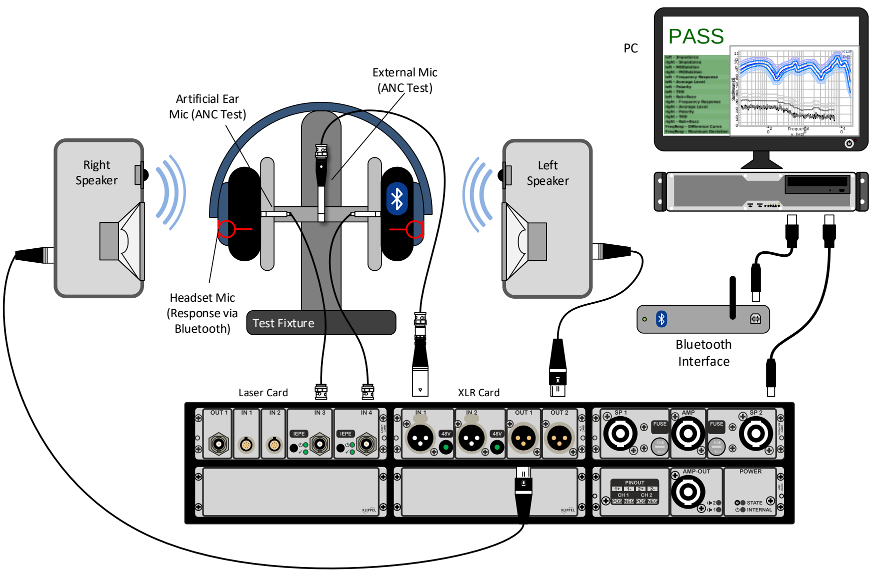
1.2 Results

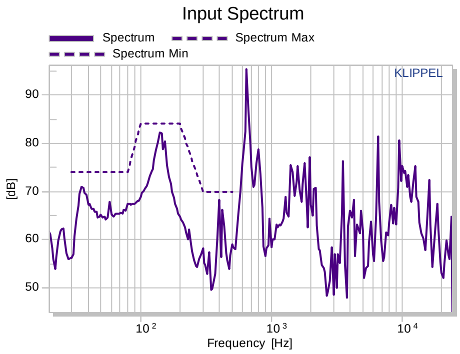
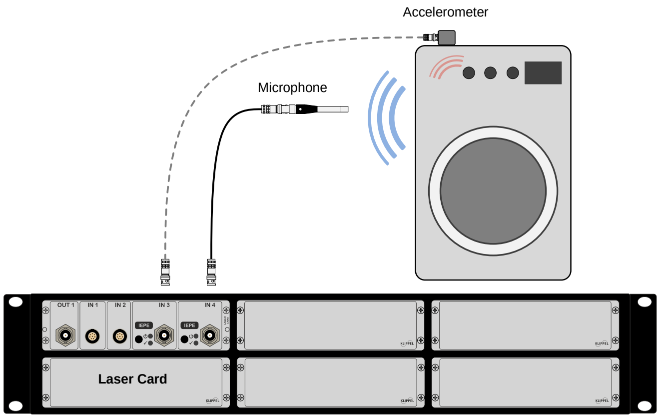
Noise & Vibration Analysis (Capture Only)	• Input FFT spectrum
	  ○ Magnitude
	  ○ Phase
	• Input level (opt. A-weighted)

Transfer Function (w. Stimulus)	• SPL frequency response
	• Transfer function
	  ○ Magnitude
	  ○ Polarity/phase
	• FFT spectrum
	  ○ Input
	  ○ Stimulus
	• Incoherence (distortion)

2 Examples

2.1 Examples

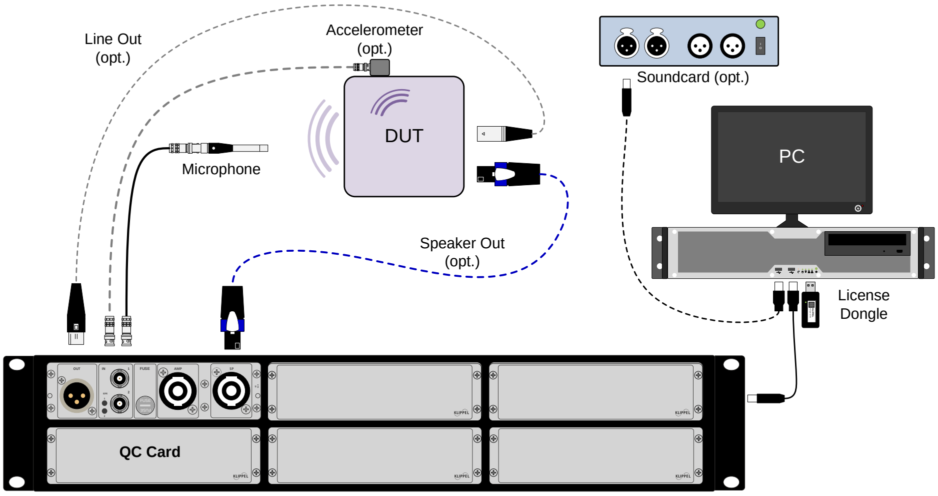
Digital Headset - ANC & Microphone Test	 For testing audio products with complex processing algorithms like Bluetooth® enabled headsets with active noise cancelation (ANC), a sinusoidal sweep (chirp) might not be the best choice as test stimulus. A broad-band, steady-state signal like pink or white noise is more suitable for reproducible test results of the ANC performance or the

	digital headset microphone response. In other cases, a standardized test signal (e.g. typical program material) shall be used. The SAN provides both an internal noise generator as well as custom wave file test signal import to meet those requirements. The response spectrum, frequency response, level and coherence can be measured for any signal with sufficient bandwidth. For attenuation tests, the free *Post-processing Task* to can be used to calculate the attenuation loss by the difference of two SAN tests results (e.g. ANC off vs. on) or two different test positions (outside/inside) and test the result against limits. Enhanced by the External Synchronization (SYN) add-on, any signal delay related to the wireless transmission and DSP is removed automatically. The stimulus signal may be used directly as a trigger. Even open loop scenarios with stimulus audio file export stored and recorded response import are handled seamlessly. Find more information in Application Note 73.
Noise & Vibration Test	In addition to testing the response to a defined test stimulus, the SAN can be used as a plain spectrum analyzer without generator in order to test the noise and vibration spectrum and (A-weighted) SPL of any noise source such as machines (motor, washing machine, …), fans or stand-alone sound sources (e.g. alarm device). Both radiated sound as well as structure-borne noise may be tested using microphones and vibration sensors.  

3 Requirements

3.1 Hardware

The schematic below shows a typical hardware setup for a general SAN test based on KA3 or a 3rd party audio interface. Optional signal paths are marked with dashed lines.



The following components are required:

- capture hardware
  - *KA3* - KLIPPEL Analyzer 3 (XLR/Laser/QC Card)
  - *PA* - KLIPPEL Production Analyzer
  - audio interface (soundcard)
- microphone for acoustic testing
- accelerometer for vibration testing
- playback hardware (opt. for stimulus playback)
  - *KA3* (XLR/QC/Amp Card, Speaker Card), *PA*, sound card or digital audio DUT (WDM, ASIO)
  - Power amplifier (KA3-Amp Card, QC Card, external amplifier)
- Klippel license dongle
- PC (see separate PC requirements)

3.2 Software

QC Framework	The SAN is included in • *QC Standard* (Item No. 4004-001) as well as • *QC Basic (Special Application)* (Item No. 4004-250) software version from QC release version 6.2. No additional setup or license is required.
RnD Framework	From release version 210.560, the SAN may be operated within the KLIPPEL RnD software release. A SAN operation template comes is included in the normal software setup. A SAN license is required for operation. **Note**: KLIPPEL Analyzer 3 (KA3) hardware is required to operate the SAN in the RnD software framework.

3.3 Further Requirements

Test Environment	The SAN does not support ambient noise detection. Therefore, any undesired ambient noise and vibration may affect the results without further notification. Especially for general noise and vibration testing it is recommended to use an insulated/decoupled test chamber to attenuate external disturbances. See also *AN-46 Test Enclosures for QC* for further reference.
Custom Test Signal	For valid estimation of the transfer function, the excitation signal should have a stationary and dense signal spectrum covering the measured frequency range of interest. Custom test signals must be provided in WAVE format.

4 Limits and Results

4.1 Setup Parameter Limits

Parameter	Symbol	Min.	Typ.	Max.	Unit
STIMULUS & ACQUISITION					
Min. Frequency1) - lower frequency limit of noise signal	f_{min}	0.1	20	96 k	Hz
Max. Frequency1) - upper frequency limit of noise signal	f_{max}	0.1	20 k	96 k	Hz
Time1) – excitation/measurement time	t	0.2	1	20 2)	s
Voltage3) – RMS stimulus voltage (line or amp output)	$\widetilde{U}_{\mathrm{stim}}$	>0	-	200	V
Stimulus Level3)4) – digital stimulus peak level rel. to full scale	L_{stim}	-∞	-	0	dBFS
PROCESSING					
Resolution – relative resolution of result curves (if empty, full resolution is used)	R	1	12	200	pts/oct
Smoothing – parts of octave for curve smoothing		1	-	99	pts/oct
Dynamic range5) – relative level threshold for wave stimulus	DR	3	60	200	dB
Window length3) – time segment length for incoherence estimation (Welch's method)	t_{win}	2.7	21.3	341.3	ms
Input Gain – input preamp gain	G_{pre}	-70	0	30	dB

4.2 Results

Measure	Symbol	Unit	QC Limits Applicable
Waveform			
Sound Pressure	$p(t)$	Pa	-
Displacement	$x(t)$	mm	-
Acceleration	$a(t)$	m/s²	-
Input Voltage	$u_{\mathrm{in}}(t)$	V	-
Stimulus Voltage	$u_{\mathrm{out}}(t)$	V	-
Spectrum Magnitude Level			
Sound Pressure	$L_p(f)$	dB (20 µPa)	✓
Displacement	$L_x(f)$	dB (1 pm)	✓
Acceleration	$L_a(f)$	dB (1 µm/s²)	✓

Input Voltage	$L_{U,\text{in}}(f)$	dB (1 V)	✓
Stimulus Voltage	$L_{U,\text{out}}(f)$	dB (1 V)	-
Transfer Function			
Sound Pressure - Magnitude (Level)	$\lvert\underline{H}_p(f)\rvert$	dB	✓
Displacement - Magnitude (Level)	$\lvert\underline{H}_x(f)\rvert$	dB	✓
Acceleration - Magnitude (Level)	$\lvert\underline{H}_a(f)\rvert$	dB	✓
Voltage - Magnitude (Level)	$\lvert\underline{H}_{U,\text{in}}(f)\rvert$	dB	✓
Transfer Function - Phase	$\varphi(f)$	°	✓[6)]
Frequency Response (IEC 60268-21)			
Sound Pressure Level	$FR_p(f) = SPL(f)$	dB (20 µPa)	✓
Displacement Level	$FR_x(f)$	dB (1 pm)	✓
Acceleration Level	$FR_a(f)$	dB (1 µm/s^2)	✓
Voltage Level	$FR_U(f)$	dB (1 V)	✓
Coherence			
Incoherence	$1 - C_{xy}(f)$	% or dB	✓
Level			
Sound Pressure Level	L_p	dB (20 µPa)	✓
Sound Pressure Level (A-weighted)	$L_{p,A}$	dB (A)	✓
Displacement Level	L_x	dB (1 pm)	✓
Acceleration Level	L_a	dB (1 µm/s^2)	✓
Input Voltage Level	$L_{U,\text{in}}$	dB (1 V)	✓

[1)] *Only available if internal noise generator is used*

[2)] *further restrictions apply at sample rates greater than 48 kHz and full resolution spectra*

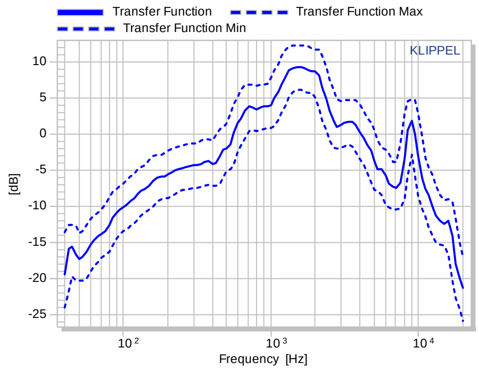
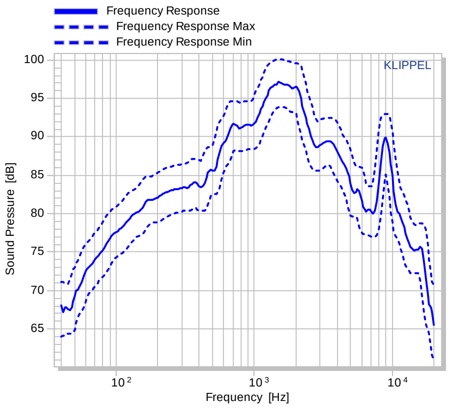
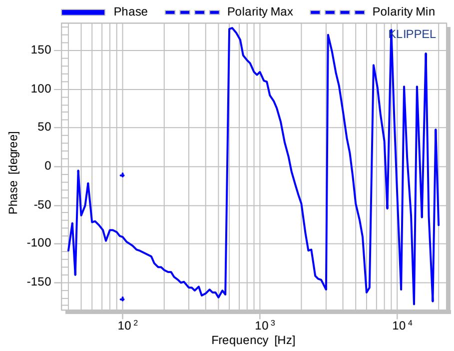
[3)] *Only available if stimulus signal is used*

[4)] *Only available if digital output device is used*

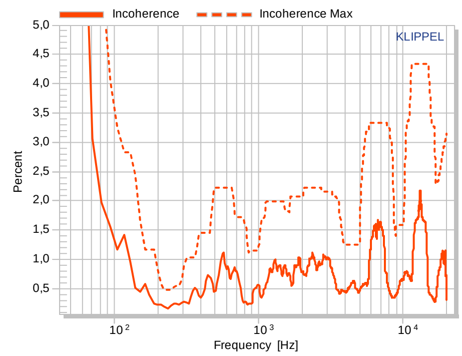
[5)] *Only available for WAVE file stimulus*

[6)] *Only at discrete frequencies for polarity check*

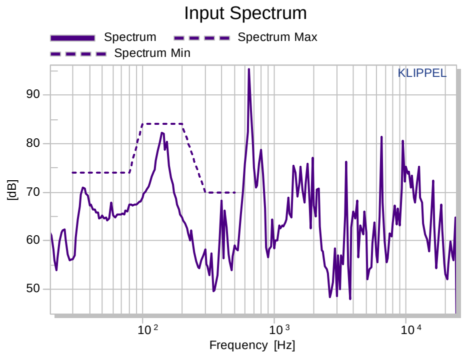
5 Output

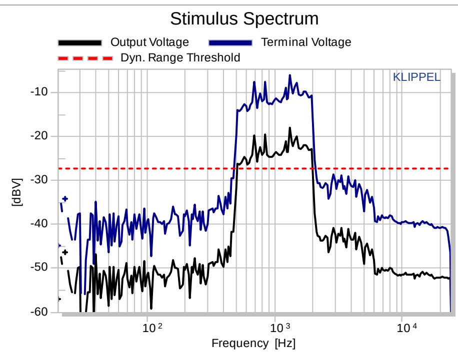
Transfer Function	The *Transfer Function* describes the linear, steady-state transfer behavior of the device under test (DUT). It is based on the measured input signal spectrum (e.g. sound pressure) divided by the excitation voltage spectrum (output or DUT input terminals). The full FFT spectra are taken into account (rectangular window) and the transfer function magnitude is displayed as a level in dB. The result is only available if the DUT has a signal input. Adjustable display resolution, smoothing as well as weighting (A-weighting or user defined) may be applied, optionally. The following limit calculation modes are provided: • Shifted • Statistics (standard deviation) • Absolute • “Best fit” alignment • Jitter may be applied 
Transfer Function (SPL Frequency Response)	The *SPL Frequency Response* (IEC 60268-21) is closely related to the *Transfer Function*, but normalized with RMS value of the excitation signal. The magnitude is displayed as a sound pressure level in dB SPL (re p_0 = 20 µPa) if a microphone input is used. The resulting curve is equivalent to the traditional SPL reading measured with a swept sinusoidal signal, if the excitation is dense and provides sufficient SNR at any frequency (e.g. pink noise). The following limit calculation modes are provided: see *Transfer Function* 
Polarity / Phase	The *Phase* is calculated from the complex *Transfer Function* and can be used for polarity check of a transducer or audio system at defined test frequencies. The following limit calculation modes are provided: • Shifted • Absolute • Automatic selection of test frequency 
Incoherence	The *Incoherence* is a measure for the linear dependency between the excitation signal and the DUT’s response. Thus, it describes any distortion and noise introduced by the DUT for arbitrary broad-band signals. It is based on the *Magnitude Squared Coherence* subtracted by one which is estimated by statistical signal processing (power spectral estimation, *Welch’s* method). The block length of the waveform segments can be adjusted; the individual FFT blocks are windowed with *Tukey* window (α = 0.5).

<table>
<tr><td></td><td>The Incoherence can be displayed in percent or as a relative level in dB. It cannot exceed 100 % (0 dB). A perfectly linear system yields an Incoherence of 0 % (-∞ dB). The frequency resolution is defined by the block length, but a relative target resolution can be enforced.

The following limit calculation modes are provided:
• Shifted
• Absolute
• Jitter may be applied</td><td>
</td></tr>
<tr><td>Input Spectrum</td><td>The Input Spectrum reflects the spectral properties of the measured sound event or the DUT's response to the applied stimulus signal. It is based on the FFT spectrum magnitude of the captured signal.

The resolution can be reduced to a fixed relative resolution (points per octave) and smoothing may be applied.

The following limit calculation modes are provided: see Transfer Function</td><td>
</td></tr>
<tr><td>Stimulus Spectrum</td><td>The stimulus spectrum is required to calculate the Transfer Function and it can be used to check the spectral properties of any custom wave file stimulus.

For custom stimulus, a dynamic range must be defined in order to take into account only excited frequencies for calculating a valid transfer function.</td><td>
</td></tr>
<tr><td>Level</td><td colspan="2">The input level is a single value result based on the total RMS of the measured input signal. In case of sound pressure it represents the Sound Pressure Level in the full available frequency band. A-weighting may be applied, optionally.

The following limit calculation modes are provided:
• Shifted
• Statistics (standard deviation)
• Absolute</td></tr>
</table>

6 References

6.1 Related Products	• QC Standard • QC Basic (Special Application Version) • QC SPL (Sound Pressure) Task • QC 3DL (Spectrogram 3D Limits) • QC Manual Sweep feature (included in QC software) • QC SYN Add-on (External Synchronization) • TRF Module (Transfer Function Analysis) • TFA Module (Time-Frequency Analysis) • LAA Module (Live Audio Analyzer)
6.2 Manuals	• QC User Manual • SAN User Manual • Hardware Manual
6.3 Application Notes	• AN 73 QC Headphone Testing • AN 76 QC Testing of Wireless Audio Devices Application notes can be downloaded from www.klippel.de.
6.4 Literature	• Random Data - Analysis and Measurement Procedures (Julius S. Bendat, Allan G. Piersol)
6.5 Standards	• ISO 1683 • IEC 60268-21 • IEC 61672

Find explanations for symbols at:
http://www.klippel.de/know-how/literature.html

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