Production Noise Immunity **S21**

QC Version 5

Features

- Auto-detection of ambient noise
- Extension of Standard SPL task
- Supervises Rub&Buzz, Harmonics, Frequency Response, Average Level and Polarity
- Repeats invalid measurement automatically
- Intelligent merging of valid data
- Considers noise attenuation of test enclosure
- Finds dominant effect: defects or noise
- Running in normal rooms

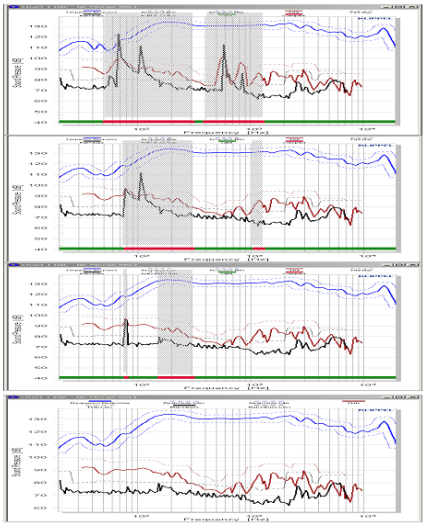
Benefits

- Reliable measurement in a noisy environments (rooms, cabins, box enclosures)
- Avoids FAIL assignment to good drivers
- Increases yield rate
- No need to change sequences or settings
- Exploits full sensitivity of meta-hearing technology
- Reduces test time
- Simple set-up (one parameter)

Defects such as rub and buzz, loose particles, air leakage, and other mechanical problems causes symptoms, which are 80 dB below the fundamental but still audible and not acceptable in the final application. Even moderate production noise during end-of-line testing (QC) can easily corrupt the measurement and cause wrong PASS/FAIL results. The Noise Immunity option of the Klippel QC system copes with this problem providing full noise immunity by using a new patent protected technology. The impact of ambient noise is reliably predicted using a second microphone. Corrupted measurements are repeated automatically and moreover the valid parts may be merged together giving the accurate result eventually in a minimal time.

Application:

- End-of-line testing
- Coping with production noise
- Testing of large audio components that cannot be tested in enclosures



Sequence of repeated test

Article Number: #4000-250

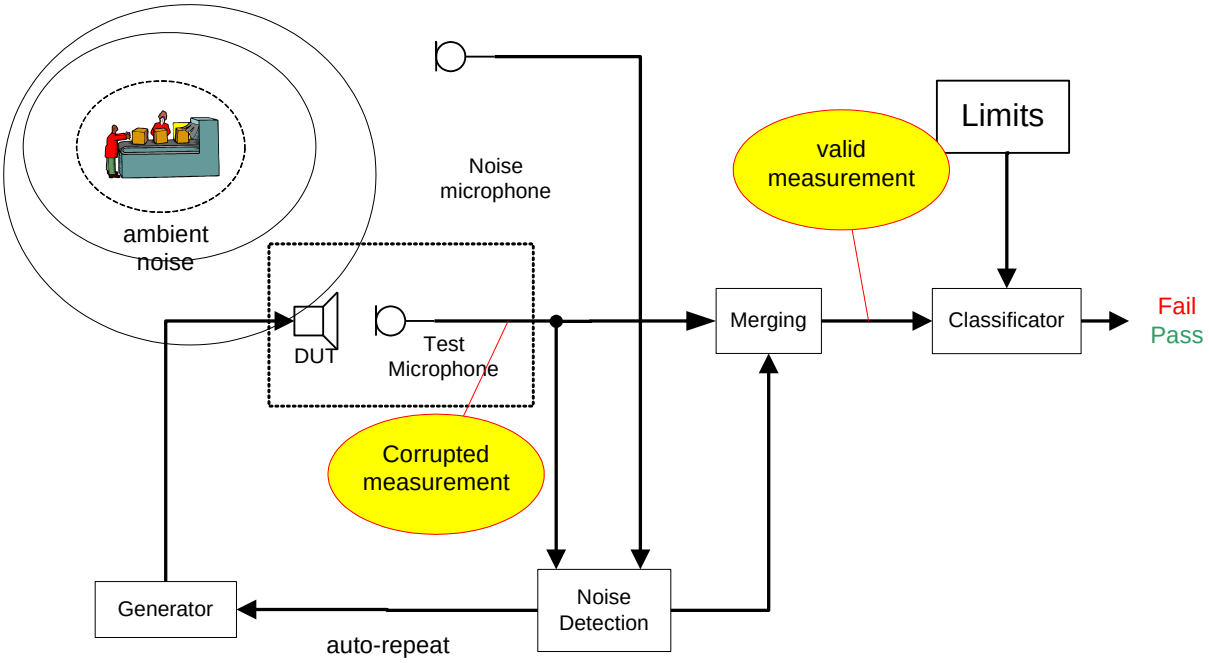
CONTENTS:

Klippel GmbH
Mendelssohnallee 30
01309 Dresden, Germany

www.klippel.de
info@klippel.de

TEL: +49-351-501 93 90
FAX: +49-351-501 939 10

Background / Theory



The test microphone is typically located in a (optional) test enclosure near to the sound source. Production noise is measured using a noise microphone in the far field (outside a test box). A noise detection algorithm is used to predict the impact of ambient noise at the test microphone position. If the predicted noise exceeds an automatically calculated limit, the measurement is considered as corrupted and needs to be repeated.

The following measures are susceptible to ambient noise and are supervised by the *Noise Immunity Options*:

- Frequency Response
- Level (average level)
- Polarity
- THD, 2^{nd} – 4^{th} harmonic distortion
- Rub&Buzz
- Leak Detection results (applies only if *ALD* module is used)

Using the new *Merging or Splicing Technology*, all valid parts of measurements are stored and accumulated until a complete valid result can be calculated. An active compensation of ambient noise is not possible due to the complex 3D nature of ambient noise.

Definitions

The following definitions are used in this specification:

Susceptible measure is a characteristic such as a single value (e.g. mean SPL) or a curve (e.g. Rub&Buzz) which may be corrupted by ambient noise

Noise measure is introduced for each susceptible measure (curve type only) that reflects the impact of ambient noise at the test microphone position

Test Microphone is usually located in the near field to measure the response and other characteristics of the test object

Noise microphone is a second microphone recording the noise signal located outside a test box in about 1m distance. Also other sensors may be used such as acceleration sensors.

General Features

The Production Noise Immunity (PNI) option is an add-on to the standard SPL-task.

License

The *Production Noise Immunity* (P*NI*) option requires a separate license. It is not part of the *Standard QC* package.

Activation

The P*NI* option can be enabled in section *Ambient Noise* on the property page tasks. When the license is installed, the option is enabled automatically.

Protected measures by Noise Immunity

The following measures are protected by the *Noise Immunity Options*:

- Frequency Response
- Level (average level)
- Polarity
- THD, 2nd – 4th harmonic distortion
- Rub&Buzz
- Leak Detection results (applies only if *ALD* module is used)

Frequency Response, Harmonics and Rub&Buzz and Leak Detection results are checked directly exploiting the ambient noise microphone signal.
Level and Polarity are checked based on the frequency response data. For those measures the frequencies of frequency response, which are required for calculation, are checked for noise corruption. If such frequencies are corrupted and the limit check failed, they are marked as Warning with '- *noise'* added.

Results of Noise Immunity

Noise corrupted measures, exceeding their limits, are marked as FAIL with '- *noise'* added. See also the Noise immunity Manual for details.

The overall verdict is PASS, if all measures passed the test and no measure was corrupted by noise:

PASS

Frequency Response	100%
Average Level	100%
Polarity	100%
THD	100%
2nd Harmonic	100%
3rd Harmonic	100%
Rub+Buzz	67%

The overall verdict is NOISE and the measurement is invalid if all failed measures were corrupted by noise (the maximal number of repeats are performed):

NOISE

Frequency Response	100%
Average Level	100%
Polarity	100%
THD - *Noise*	75%
2nd Harmonic	100%
3rd Harmonic	80%
Rub+Buzz - *Noise*	67%

The overall verdict is FAIL, if at least one measures failed which was not corrupted by noise (Frequency Response in the example) and no other measurement was corrupted by noise:

FAIL

	Cpk	Ppk
Frequency Response		
Average Level	Cpk	Ppk
Polarity		
THD		
2nd Harmonic		
3rd Harmonic		
Rub+Buzz		

The overall verdict is also FAIL, if at least one measures failed which was not corrupted by noise and other measures were corrupted by noise (gray color):

FAIL

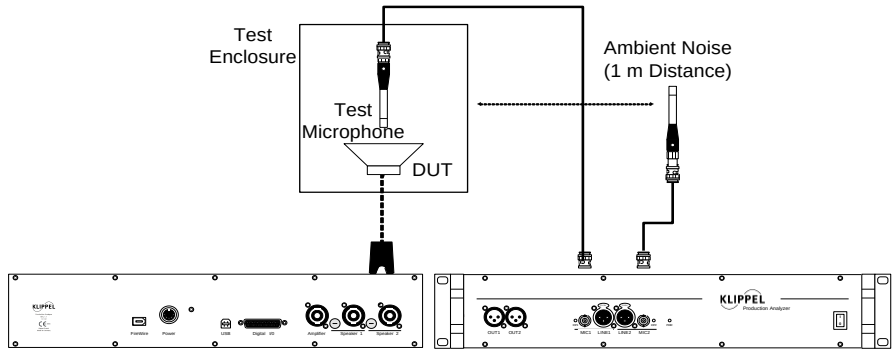
Frequency Response		
Average Level	Cpk	Ppk
Polarity		
THD - *Noise*		
2nd Harmonic - *Noise*		
3rd Harmonic - *Noise*		
Rub+Buzz - *Noise*		

Data compatibility

If upgraded to the *PNI* option by installing the *PNI* license, all old data (limits, reference DUTs) are kept and can be used as before.

Hardware Setup

Setup



- Test enclosure is optional
- Ambient noise microphone must be connected to MIC2
- Test Microphone can be connected to MIC1 (IEPE) or LINE1 (using external microphone power supply)

Microphones

All ICP powered microphones may be used with the *QC Test System*. For measurements in a closed box a low sensitivity microphone is required since sound pressure level exceeds 130 dB easily.
Also other IEPE compatible sensors such as acceleration sensors may be used.

Microphone Sensitivity

For optimal performance under free field conditions the ambient noise microphone should have at least 6dB lower noise floor than the near field microphone.
For selection of microphone, refer to spec sheet A4 - Microphones

If a test enclosure is used this limitation is not as critical depending on the actual noise damping.

Calibration

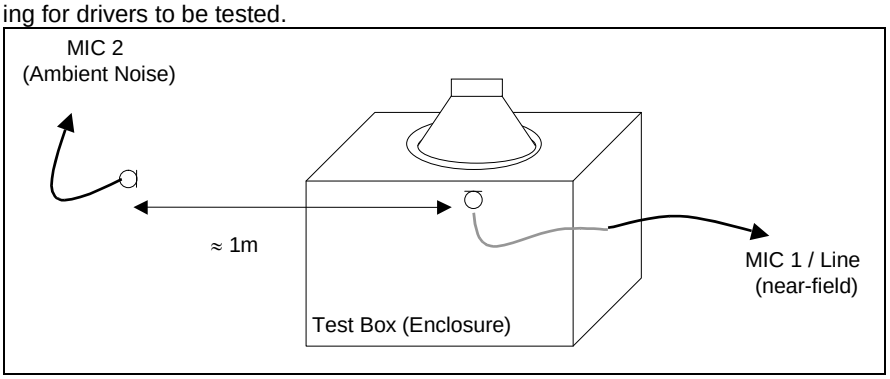
All used microphones must be calibrated carefully using a calibrator (e.g. pistonphone) or using the specification sheet data.

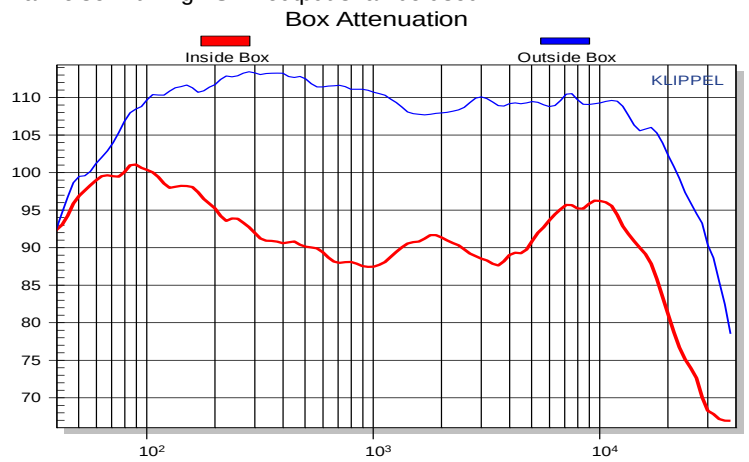
Acoustical Environment

To optimize the attenuation of the test enclosure, consider the following points:

- Avoid parallel walls (reduces standing waves inside the cavity).
- Allow sufficient box volume to reduce mechanical vibrations.
- Check the highest SPL level inside the box. At the very end of the *QC User Manual* helpful rules to estimate the max SPL are given. Also check section “Optimizing Performance”.
- Use appropriate high SPL microphones (available up to 155 dB).
- Consider providing an anechoic trap for low frequencies for testing woofers. This could be a section of the test box (0.5 m^3) or a port connected to the ambience filled with absorbing material.
- Cover the inner walls of the test box with a relatively thin layer of absorbing material (> 3 cm) to attenuate high frequencies.
- Avoid any mechanical gear inside the test box. Mount all equipment for closing the test box at the outside to avoid any parasitic vibration and resonances inside the box.
- Consider an insulation from the ground to decouple structure-borne noise
- Avoid any machines, generators, magnetizers, and fans close to the test box.

Setup

Number of repetitions	A maximal number of repetitions are to be specified. If all repeated tests are disturbed by ambient noise, a NOISE warning is shown. Please check in this case, if a continuous noise source is corrupting the test at one frequency.
Mode of repetition	Two modes of repetitions are provided: • All: A disturbed test will be repeated until a complete undisturbed test by ambient noise is done or the maximal number of repetitions is reached. In this mode the whole response is taken from the last repetition, no merging is applied. All activated measures are monitored by Noise Immunity. • Corrupted only: In case noise corruption is detected for certain frequencies, these frequencies will be dismissed and only valid parts of the response are stored. During repetition all missing frequencies are merged and accumulated if uncorrupted until the whole frequency range is valid. If the response violates a limit at uncorrupted frequencies the test is aborted and the measure is marked accordingly as FAIL. All measures, which are not tested completely at this moment (since they are still corrupted by noise), are marked as VOID. All activated measures are monitored by Noise Immunity. • All (Selected): Same as *All*, but user may select the measures, which are included in ambient noise immunity • Corrupted (Selected): Same as *Corrupted only*, but user may select the measures, which are included in ambient noise immunity
Microphone Position	The selection of the microphone position is part of the standard SPL task (without *PNI* option). However, it is described here in detail since it is relevant for noise immunity as well. Independent of the mode selected, the ambient noise microphone should be placed in direction of the most likely disturbance. Allow about 1 m distance from the test box or the test microphone (in case of free field conditions). The following options are available: • Free Air: There is no test enclosure is used. This setting can be used for evaluation and for particular setups, where no test enclosure can be applied. It is not recommended for testing driver and smaller systems. • Reverberant Room: Due to room modes the prediction of noise based on the 1/distance law cannot be applied reliably. To achieve ambient noise immunity, the noise level of the reference DUTs is amplified by 10dB before calculating the limit of the related measure. • Test Box: There is an average attenuation of 15dB over the full bandwidth assumed, when activating this mode. This setup should be used, if the attenuation of the test box is not known. This attenuation is typical for simple wooden test enclosures with an opening for drivers to be tested.  • Car: Typical damping of a car body is assumed. See the manual for detailed information. • Custom: It is recommended to measure the noise as a transfer function of inside and outside noise. A frequency dependent curve can be specified which will be used to predict the impact of the ambient noise at the measurement microphone position.

Shielding	If the microphone position is set to *custom*, the box attenuation curve is to be specified by the user. For instructions on the measurement of the noise attenuation, please see the manual of the *Noise Immunity Option*. The box damping may be interpreted as transfer function from noise sensor (microphone) to near field microphone. This frequency dependent function should be specified using the "Custom box attenuation" (see microphone position above). Note that the test object cannot be used as noise source in the normal test position. An external noise with high SPL output shall be used.  *Typical attenuation of a simple test enclosure (red curve: inside box, blue curve: outside)*
Show Noise Curves	The predicted noise curves for • Frequency Response • THD, 2nd – 4th harmonic distortion • Rub&Buzz can be displayed when activating the *Show Noise Curves* option in section DISPLAY on property page *Tasks*. Noise curves are always displayed in the same charts as the according measure curves. The color of the noise curves is automatically derived from the *measure curve color*. For normal use, this option should be switched off for a better overview of the results. It can be activated after a measurement to display the predicted noise curves of the latest measurement for diagnostics.

Noise Prediction

Automatic Prediction	The ambient noise is not only measured using a second microphone, it is *predicted* or transformed from the actual noise microphone position to the position of the measurement microphone. The predicted signal $p_{\text{predicted}}$ is calculated based on the measured signal p_{measured} considering the specified ambient noise attenuation *Damping* (defined by *Microphone Position*, see above) and a safety headroom, which is specific for the type of measure. $$p_{\text{predicted}} = p_{\text{measured}} - Damping + Headroom_{\text{safety}}$$ Note, that headroom is added to ensure robustness. The noise measure is amplified therefore for Rub&Buzz, Frequency Response: by 6dB Harmonics (THD and individual harmonics): by 10dB Due to this headroom the noise measure is higher than the actual measure, when bringing both microphones close together for a simple check of microphones.

Limits

Limit parameters	No additional limit parameters are needed to use ambient noise monitoring or ambient noise immunity. Since the noise signal is predicted to the measurement microphone position, the limit parameters for the noise signal are identical to those defined for the supervised measure.
Limit Calculation	Each measure has its own corresponding noise measure. The method of limit calculation for the noise measure is the same as defined for the actual susceptible measure.
Dominance Check of Defect and Noise	In case of a strong defect the measure will clearly violate its limit. But also the noise signal may violate its limit because the defect noise (e.g. a strong rubbing) is measured at the noise microphone (if measured in free air or the box damping is low). In this case a *Dominance Check* is done to decide, if the noise limit violation was caused by ambient noise or a strong defect. This check evaluates the magnitude of measure and noise in the frequency range, were the limit was violated. Details are shown on the Summary page in this case. If this check yields that a defect is the cause of the noise limit violation, the corresponding verdict is forced to FAIL instead of a Noise Corruption Warning.

Limitations

Warning "Sensitivity Lost"

The noise immunity option guarantees uncorrupted measurements. To ensure this feature, the predicted noise of a good (not disturbed) test of the reference units must be lower than the measure to be supervised for all frequencies.
Especially if the noise attenuation is low (free air condition, bad damping of test box), this is not always the case. To ensure noise immune testing, the limit of the susceptible measure is relaxed and the sensitivity of the test is therefore decreased.
If the system detects this case, a warning is issued when calculating limits in the *Summary* chart:

WARNING: Predicted Noise is higher than signal at test microphone

Show Details

You will lose up to 14 dB sensitivity using this setup. Use ambient noise microphone with lower noise floor or use a testbox or other means of shielding to prevent this.

Name	Value	Unit	Description
Measure	Rub+Buzz		Name of Measure
Loss	14.5	dB	Lost Sensitivity to garantee robust Noise Monitoring
Frequency	65.12	Hz	Frequency of maximal loss

Example of "Sensitivity Lost" Warning. Measure and frequency of the maximal loss can be checked using the data in the table below the warning.

In this case, it is recommended to

- Use a test box if possible
- Use a more sensitive microphone for the ambient noise. The level of the ambient noise is usually much lower and hence more sensitive microphones with lower noise floor can be used.
- Relax the limits of the susceptible measure to have this loss under control.
- Identify and remove permanent noise sources in the vicinity.

Noise inside test enclosure

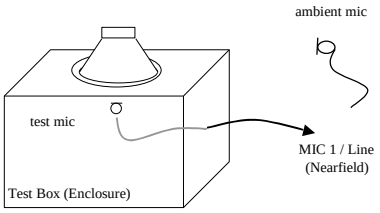
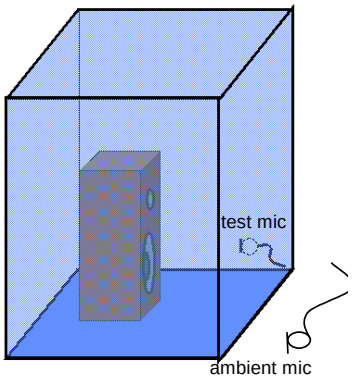
Avoid any parasitic vibration and rattling inside the test box. This noise is not monitored and cannot be detected by outside microphones. Carefully check the resonances inside the box before using it with the test object. You may use the *Manual Sweep* and increase the test voltage by about 3 dB or more to get some headroom for vibration diagnostics. This test highly depends on the test object type and should be done for each type. A check on a regular basis is also recommended.

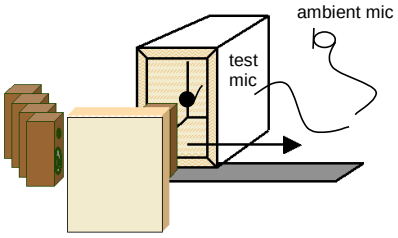
Noise free area

A minimal distance around the test box should be kept free from any noise source. The ambient noise microphone should be placed in direction of the most likely disturbance. Allow about 1 m distance between test box and ambient noise microphone.

Noise Micro-phone too close to DUT	Especially in free air conditions the noise microphone must be positioned carefully. Usually the measurement microphone must be located in the near field and on axis of the driver / system. The noise microphone should be located off axis and at much higher distance from the DUT. In rare cases of large multi-channel systems, this optimal setup cannot be realized. If the level recorded by the noise microphone is higher than at the measurement microphone, a warning is presented in the Summary chart: **WARNING: Noise Microphone is too close to DUT!**

Applications

Driver Testing	It is recommended to place the measurement microphone in a test enclosure and to operate the drive unit in a test frame firing into the box. The attenuation of ambient noise is limited by the cone of the loudspeaker system to 5 .. 20 dB rising to higher frequencies. This shielding is helpful but NOT sufficient to do reliable testing in a noisy production environment where high sound pressure peaks cannot be avoided. In conventional test systems ambient noise will be interpreted as a defect drive unit and will reduce the yield rate. Additional housing of the test station and transporting the drive units into a more silent test environment is expensive and not practical in most cases. The *PNI* option ensures that *Rub&Buzz* problems which occur at low levels (40 .. 80 dB below the fundamental) can reliably separated from ambient noise disturbances. Exploiting the extremely short measurement time of *Klippel QC,* repetitions do not degrade the overall measurement time too much.	 *Drive unit measured in a test enclosure*
Loudspeaker System in sealed test chamber	Completely sealed test enclosures are also very beneficial for testing smaller loudspeaker systems (e.g. for multimedia). Here the loudspeaker system and the test microphone are located inside the test enclosure. Although this shielding provides good attenuation (between 20-30 dB), high peak values of ambient noise corrupt conventional measurement techniques. The second ambient noise microphone and the algorithms used in *Noise Immunity* ensure full sensitivity for rub and buzz defects, loose parts and air leaks.	 *loudspeaker system measured in sealed test chamber*

System Testing in a semi-open box	The measurement of large loudspeaker systems (e.g. professional loudspeakers) requires large test enclosures, which are cost intensive and require production space. Placing the test object into the enclosure requires special means and time. The handling can be significantly simplified by using a semi-open test enclosure, which is placed close to the assembling line. This arrangement gives about 10..20 dB attenuation at higher frequencies. Conventional measurement techniques without ambient noise immunity are prone to invalid results and require high limit values, which reduces the sensitivity of the measurement.	 *Semi-open box system test on production belt*
System Testing in Free Air	If no large test enclosure and no means providing additional acoustical shielding are available the ambient noise immunity becomes more and more important to identify invalid measurements. It is important to place the test microphone as close as possible to the drive units. For testing large speakers using multiple drive units and for checking air leaks in the enclosure multiple microphones multiplexed by the measurement system are recommended. Performing a long test sequence required for complex systems (e.g. surround sound system) a repetition of a complete test is not efficient in case that a single test step failed due to ambient noise. The *NI* option only repeats the corrupted task and ensures a valid overall test.	 *Testing a 5.1 system under free air conditions*

Patents

Germany	102009033614
USA	12/819,455
China	201010228820.8

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

Klippel GmbH
Mendelssohnallee 30
01309 Dresden, Germany

www.klippel.de
info@klippel.de

TEL: +49-351-501 93 90
FAX: +49-351-501 939 10