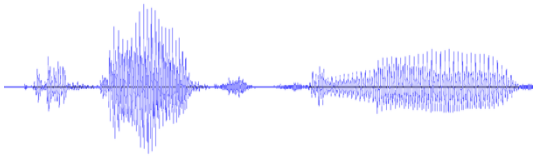
link22 Shield™
Acoustic Performance

link22 Shield is a soundproofed, sound masking box for storage of mobile phones and other smart mobile devices creating a secure meeting environment. The goal is to prevent any device inside Shield to eavesdrop on conversations between persons in the room. This is done by a combination of passive sound isolation and active generation of masking sounds.

Results from independent testing show that link22 Shield effectively prevents eavesdropping and is resistant to methods for advanced signal analysis.

WHAT IS SOUND?

Sound is vibrations in air or other mediums. The human ear and microphones are able to detect these vibrations.



These vibrations have two properties:

- Frequency (measured in Hertz) that measures the number of vibrations per second. For sound this can be referred to as *Pitch*.
- Amplitude that measures how strong the vibrations are. For sound this can be referred to as *Loudness* and can be measured in decibel (dB).

WHAT IS SPEECH?

Speech is sound that is detected and interpreted. For speech to be understood the following requirements must be met:

- The loudness must be high enough so that the listening device (e.g. ear) can detect it within the frequency range of normal speech (most information is in the range 125 – 6000 Hertz).
- To interpret the speech the listening device must be able to distinguish the speech sound over other sound sources.

To prevent speech from being heard one or both of the prerequisites above must be removed. link22 Shield addresses the first by sound isolation reducing loudness and the second by addition of masking sound sources drowning the speech.

SHIELD SOUND ISOLATION

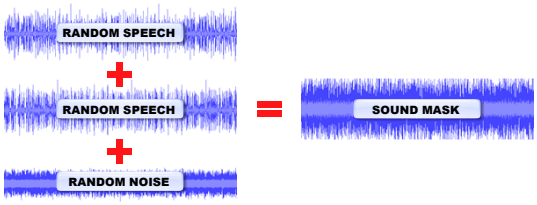
link22 Shield is designed to suppress speech sound from persons in the room to the inside. It also must suppress in the other direction in order to prevent the sound generated inside link22 Shield to disturb the meeting.

Sound can be transmitted through air as well as structures, e.g. vibrating walls, and link22 Shield is designed to reduce sound for both ways of transmission through:

- Reducing air leakage by seals and other measures.
- Vibration dampening by having an inside box mounted on silicon pads. The outer box is also designed to reduce vibrations through rubber feet, dampening material and rubber seals.

SHIELD SOUND MASKING

link22 Shield generates different disturbing sounds with the purpose of drowning speech originating from persons in the room. The different sounds are a combination of random (pink) noise and several synthetic voices.



Random speech is used since it affects the same frequency range that contain most of the

information from speakers in the meeting room.

The loudness of the masking sound is chosen to totally drown any speech that remains after the sound isolation while not high enough to disturb the surroundings.

link22 Shield uses hardware random sources based on electronic noise to generate true randomness.

INDEPENDENT TESTING

link22 Shield has been subject to testing in an independent acoustic laboratory and found to effectively prevent outside speech to be intelligible to devices inside of link22 Shield[1].

The laboratory measured how much of the speech remains after sound isolation and the loudness and characteristics of the masking sound. This measure can be expressed as the ratio between the loudness of the remaining speech and the masking sound.

This ratio is called Signal to Noise Ratio (SNR) and is measured in dB. Several researchers have investigated how speech intelligibility is reduced with lower SNR.

In a paper investigating speech privacy[2] the finding was that speech with an SNR lower than -16 dB is unintelligible by human listeners. The laboratory found the SNR[3] inside of link22 Shield to be -37.1 dB which prevents direct eavesdropping with a substantial margin.

A paper investigating an algorithm for a combined noise reduction and artificial speech recognition[4] shows that the very high noise environment in link22 Shield is outside the capabilities of this method with regards to successful speech reconstruction.

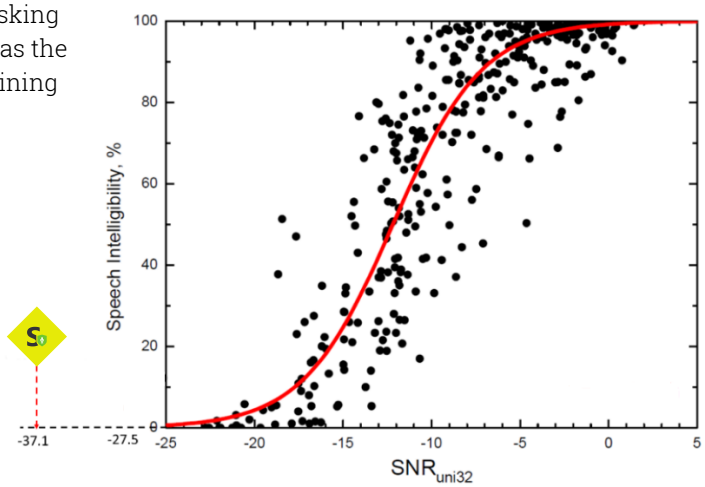


Figure 1: Graph showing reduction in speech intelligibility for different SNR levels extended to the low SNR in link22 Shield [1,2].

[1] Creo Dynamics AB, "Sound isolation and Acceptance criteria – link22 Shield", 2017.
[2] Bradley, J. S., and B. N. Gover. "A new system of speech privacy criteria in terms of Speech Privacy Class (SPC) values." Proceedings of 20th International Congress on Acoustics, ICA. 2010.
[3] SNR calculated for relevant speech frequencies 160 – 5000 Hz and a speaker at a distance of 1 meter screaming very loud (84 dB)
[4] Andrew L. Maas, Quoc V. Le, Tyler M. O'Neil, Oriol Vinyals, Patrick Nguyen and Andrew Y. Ng, "Recurrent Neural Networks for Noise Reduction in Robust ASR"