Speech Intelligibility

Measurement with XL2 Analyzer

The XL2 Analyzer measures the speech intelligibility according to the latest revision of standard IEC 60268-16:2011 (edition 4) and older editions. It includes ambient noise correction and automated averaging of measurements. The XL2 displays the measurement results as STI or as CIS results, accompanied by the individual levels and modulation indices of the seven octave bands.

STI and STIPA are the most established methods for measuring speech intelligibility. STIPA is an optimized version of STI dedicated for portable measurement instruments. This application note explains the principles behind these methods.

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Appendix

Introduction

Public address systems in building complexes have to inform members of the public about escape directions in case of emergency. Such public buildings include airports, railway stations, shopping centers and concert halls. However, if such announcements are misunderstood due to poor system quality, tragic consequences may result. Therefore, it is essential to design, install and properly verify the speech intelligibility of such sound reinforcement systems. In addition, common public announcement systems may have legal or contractual requirements regarding the level of speech intelligibility, such as in medical, industrial or commercial environments.

Standards

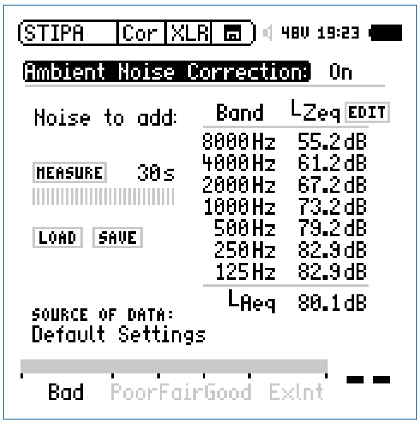
The standard ISO 7240-16 / - 19 requires the verification of electro-acoustic sound systems for emergency purposes. Realistic circumstances shall ascertain a measurable minimum level of speech intelligibility in case of an emergency. Therefore, speech intelligibility from a regulatory view is not a subjective measurement, but can be verified with several, more or less complex methods that have been standardized in IEC 60268-16.

International standards:	
ISO 7240	Fire detection and alarm systems, section 16 & 19
IEC 60268-16	Objective rating of speech intelligibility by speech transmission index

National regulatory bodies recommend or require maintaining a minimum speech intelligibility.

National standards:	
NFPA 72	National Fire Alarm Code (2010 edition)
BS 5839-8	Fire detection and alarm systems for buildings. Code of practice for the design, installation and servicing of voice alarm systems
VDE 0828-1	Electroacoustic Emergency Systems with application regulation described in standard DIN VDE 0833-4

Ambient Noise Correction



Measuring the speech intelligibility index under realistic environmental conditions is often not feasible; e.g., playing the test signal in a railway station at emergency levels during peak hours will irritate passengers. Additionally, at rush-hour the characteristics of ambient noise might be highly impulsive, while a pre-requisite for accurate STIPA measurements is a negligible impulsivity in the ambient noise. Under such circumstances the STIPA measurement should be shifted to a more suitable time of the day; e.g. night time.

Ambient noise affects the speech intelligibility. The ambient noise correction has to be applied in case the signal-noise ratio is lower than 15 dB in any octave band.

Measurement Sequence

- First measure the realistic ambient noise, e.g. during day time
- Secondly measure the speech intelligibility STIPA, e.g. at night

This sequence simplifies the STIPA measurement as follows: The XL2 immediately displays the STIPA result with ambient noise correction. The result provides a guideline if further measurements at the same location are required. For more details see the chapter "STIPA Measurement Hints" in this application note.

In case no ambient noise correction has been carried out on-site with the XL2 Analyzer, then you may post process your measurement data on the PC. The NTi Audio STIPA Reporting Tool combines the STIPA measurement taken at quiet conditions and the actual ambient noise caused by the public, e.g. during day-time. This emulates the expected STIPA value at real-life conditions.

Ambient Noise Correction of new PA-Systems

New announcement systems are commissioned e.g. at public areas prior the grand opening. Thus the actual ambient noise caused by the public is not available yet during the STIPA measurement. Here you may simulate the real-life condition with ambient noise data enabled by one of the following modes:

- Utilize a reference noise file, which might be applicable for the actual project. E.g. measure the ambient noise at another similar project and store this as reference noise file.
- Edit the actual noise data on the XL2 manually according your expectations.

Measure the actual ambient noise and verify the STI readings after the opening of the public area.

Recommended Ambient Noise

The following table lists the typically applicable ambient noise levels in accordance with the Austrian standard TRVB S 158 - 2006:

Area Type	Sound Level LAeq [dB]
Airport	
- check in, departure/arrival hall	59 - 72
- gates	54 - 64
- custom area	63 - 71
- passages	59 - 70
- waiting area departure	49 - 64
Aisles	
- with carpet	28 - 32
- quiet without carpet	45 - 55
- noise without carpet	66 - 76
Bus station	
- quiet	58 - 68
- noisy	63 - 73
Conference room	40 - 45
Concert halls, cinemas, theaters	60 - 75
Courtrooms	40 - 50
Exhibition hall	63 - 73
Hotels/Motels	
- service support areas	55 - 65
- sleeping room, TV off	28 - 35
- sleeping room, TV on	60 - 70
Libraries	
- reading area quiet	35 - 45
- reading area noisy	50 - 60
- reception	50 - 60
Manufacturing facilities	
- monitoring stations	70 - 75
- common manufacturing	80 - 85
- heavy industry	95 - >105
Markets	
- quiet	47 - 63
- noisy	63 - 80

Area Type	Sound Level LAeq [dB]
Offices	
- Single person office	40 - 50
- Open-plan office quiet	50 - 70
- Open-plan office noisy	70 - 85
Public Areas	50 - 64
Restaurant	
- quiet	55 - 65
- noisy	68 - 78
Railway	
- waiting area	54 - 65
- service area	60 - 66
- platform electric train	60 - 72
- platform diesel train	75 - 85
Restaurants	
- customer area	72 - 75
- kitchen	65 - 75
Schools	
- classrooms, quiet	56 - 68
- classrooms, noisy	64 - 72
Shops	
- quiet	50 - 60
- noisy	65 - 75
- shopping centre	70 - 75
Sport facilities	
- quiet	60 - 72
- noisy	72 - 82
- squash	60 - 80
- ice-skating hall	69 - 80
- swimming hall	72 - 79
- swimming area kids	81 - 87
- bowling	78 - 85

Averaging of STIPA Measurements

The standard IEC 60268-16 recommends averaging two or three subsequent results taken at the same measurement location.

The German Standard VDE 0833-4 requires performing minimum three subsequent measurements for one measurement position in case of STI < 0.63.

Consequently the XL2 Analyzer offers automated averaging STIPA results based on these standard requirements.

Qualification Scale "A+" to "U"

The STI value is shown as a letter of the qualification scale below, which informs about the typical STI requirements for dedicated applications.

Band	STI Range	Examples of typical uses
A+	> 0.76	recording studios
A	0.72 - 0.76	theatres, speech auditoria, parliaments, courts
B	0.68 - 0.72	theatres, speech auditoria, parliaments, courts
C	0.64 - 0.68	teleconference, theatres
D	0.60 - 0.64	class rooms, concert halls
E	0.56 - 0.60	concert halls, modern churches
F	0.52 - 0.56	PA in shopping malls, public offices, cathedrals
G	0.48 - 0.52	PA in shopping malls, public offices
H	0.44 - 0.48	PA in difficult acoustic environments
I	0.40 - 0.44	PA in very difficult spaces
J	0.36 - 0.40	not suitable for PA systems
U	< 0.36	not suitable for PA systems

Can I buy STIPA for my XL2 Analyzer?

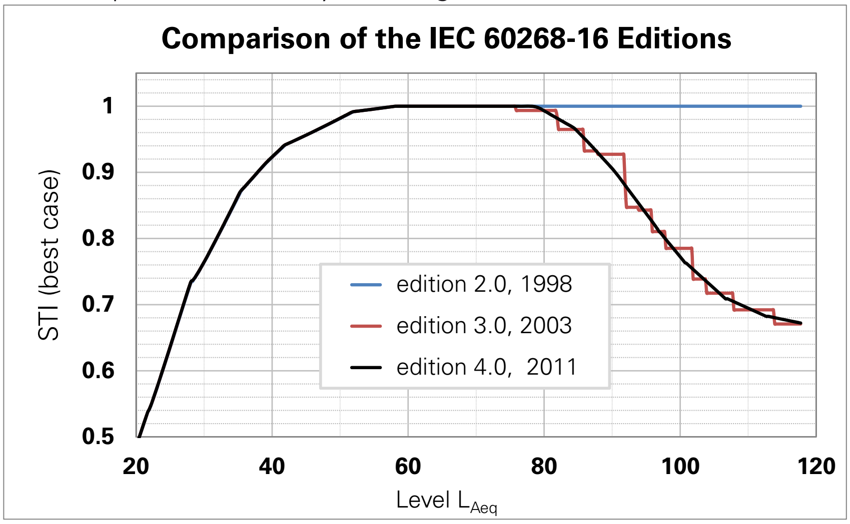
Yes, STIPA is an optional function for the XL2 Audio and Acoustic Analyzer. Any XL2 user may obtain a STIPA license. With the license key you may request the activation key for your XL2 Audio and Acoustic Analyzer. Enter your license key at

http://my.nti-audio.com.

Continuous level dependent auditory masking

The masking function developed through the various editions of the standard IEC60268-16 as follows:

ed2.0	old edition released in 1998 with fixed masking function
ed3.0	old edition released in 2003 with stepped level dependent auditory masking function
ed4.0	actual edition released in 2011 with continuous level dependent auditory masking function



Best intelligibility is achieved at message levels in the range of 70-80 dBSPL. At higher sound pressure levels the self-protection of the ear comes into action, which is reflected in a reduced intelligibility index, such as an STI of 1 at 70 dBSPL may be down to 0.7 STI at higher sound pressure level.

German Standard VDE 0833-4 Requirements

STI > 0.63	One single measurement is sufficient.
STI < 0.63	Perform three subsequent measurements for this measurement position.

- If the maximum result deviation of these three measurements is > 0.03 then further three measurements shall be performed.
- If the maximum result deviation of these measurements is > 0.05 then the cause of this instability shall be evaluated and removed.
- The arithmetic average of the performed three or six measurements has to be reported.

An STI > 0.63 ensures, that the speech intelligibility is higher than 0.5 with a confidence level of 95%.

STI Reporting Tool

The STI Reporting Tool creates measurement reports according to the IEC 60268-16 and VDE 0833 standards. Import the data directly from your XL2 including the ambient noise measurements. The corresponding speech intelligibility STI or CIS values are shown.

STIPA Summary Report

Report according to IEC 60268-16{ed4}, chapter 7.6.4 and DIN VDE 0833-4{2007-09}, appendix F.6

Project	Waiting Room
Comments	Measured in empty room with TalkBox
Standard	IEC 60268-16 ed4.0 2011

All	Arithmetic mean Iav		STI	0.58	
	Standard deviation σ		STI	0.06	
	Iav - σ		STI	0.52	G
1	**Position**		STI	0.58	E
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 1)			
	Noise File	XL2_V2x_RTA_APPEND_SLM_008 (MyLocation, 1)			
2	**Position**		STI	0.57	E
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 2)			
	Noise File	XL2_V2x_RTA_APPEND_SLM_008 (MyLocation, 2)			
3	**Position**		STI	0.60	D
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 3)			
	Noise File	XL2_V2x_RTA_APPEND_SLM_008 (MyLocation, 3)			
4	**Position**		STI	0.54	F
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 4)			
	Noise File	XL2_V2x_RTA_APPEND_SLM_008 (MyLocation, 1)			
5	**Position**		STI	0.52	F
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 5)			
	Noise File	XL2_V2x_RTA_APPEND_SLM_008 (MyLocation, 2)			
6	**Position**		STI	0.52	F
	STIPA File	AltbFlur_STIPA_000 (Altb_Flur, 6)			
	Noise File				

The STI Reporting Tool is free to download on the XL2 support website http://my.nti-audio.com for all registered users (enable all macros when opening the document).

Test Signal Source

Utilize the applicable STIPA signal source dedicated for your installation configuration:

NTi Audio TalkBox

NTi Audio TalkBox

The NTi Audio TalkBox is required for audio systems with voice microphones.

It simulates a person talking at a precise acoustic level, enabling the measurement of the complete signal chain including the microphone. It offers calibrated acoustic sound source emulating the speech levels of a person speaking in a normal and an emergency situation. The use of the NTi Audio TalkBox is advisable if:

- Regulations require a complete end-to-end system check including the microphone. This is the most realistic system check in any event.
- No input is available for an electrical test signal.
- The level of the test signal is not clearly defined.
- The characteristics of the speaker's acoustical environment are not negligible and flat.
- The characteristics, sensitivity and frequency response of the speaker's microphone is not known but needs to be considered.
- If for any other reason it is desirable to test the entire signal chain under real conditions.

The standard STIPA signal is based on a band-limited random noise of a male speech spectrum. The TalkBox is also capable of delivering white and pink noise and other special signals, and so is a very useful overall tool for system tuning and testing.

How to use the NTi Audio TalkBox?

- Place the NTi Audio TalkBox in front of the microphone at the typical position of the talking persons head.
- Select Track 1 for the STIPA test signal.
- Select Output Mode to Speaker; you should hear the STIPA test signal.

Minirator MR-PRO

Minirator MR-PRO

The Minirator MR-PRO is used for electrical signal injection into public address systems that commonly use alarm messages from a hard drive (systems without a microphone).

How to set the Minirator output level:

- Determine the LAeq of the voice signal, with a length of at least 40 s unless the signal is a recorded announcement of shorter duration.
- Then the measured level is corrected by an empirically derived factor of 3 dB in order to obtain an estimate of the real speech level which compensates the silent parts of the speech signal, e.g. the gaps between words (in accordance with IEC 60268-16:2011, Annex J4).
- Power on the STIPA test signal on the Minirator
- Increase the volume until the announcement level LAeq + 3 dB at the same measurement position is achieved.
- Perform the STI measurements with the XL2 Analyzer.

Test CD

The NTi Audio CD "STIPA V1.1", included in the package, can be used with a professional CD player. For details see the chapter "STIPA Measurement Hints"

i	Use only the original NTi Audio test signal for speech intelligibility measurements with the XL2. Other signals may not seamlessly loop, thus causing wrong measurement results! Compressed formats, like MP3 or similar, are strictly prohibited to be used.

STI Measurement Hints

Ambient Noise

The ambient noise has to be sufficiently static during the measurement. A signal-noise ratio of 15 dB or higher is recommended to achieve best speech intelligibility. Impulsive ambient noise during the measurement, such as speech, causes severe measurement errors. The STIPA result is usually too high.

Fluctuating noise is detected by measuring the direct STI in the absence of the test signal. Carry out these measurements at least at a representative set of locations. If the STI is too high (e.g. STI > 0.2), the measurement results are likely to be erroneous. Then the STIPA measurement should be carried out without this noise being present. Utilize the ambient noise correction for such instances.

At locations with varying conditions (e.g. public areas with few people and other areas with crowds) the worst-case STIPA results should be measured. Consult the local regulations (e.g. the NFPA code in the U.S.) for directives concerning measurement locations and number of required STIPA measurements under which circumstances.

STI Measurement

- The intelligibility index is measured in the range from 0 to 1, whereby 1 is perfect. The minimum intelligibility requirement including measurement uncertainty is typically 0.5. In areas occupied with persons knowing the alarm messages a minimum intelligibility of 0.45 STI can be assigned.
- The variation of STIPA test results should be not more than 0.03 STI at one test position. In case you find the deviations higher than 0.03 STI then verify and eliminate the causes for these discrepancies and repeat the measurement (e.g. mea-

sure STIPA during night time).

- Low STIPA readings can be caused by
  - Excessive sound reverberation, echoes or reflections
  - Poor speaker directivity or speaker coverage
  - Speaker level setting incorrect; e.g. low signal-to-noise ratio.

What to do if Impulsive Noise is permanently present?

In a 24/7 production environment or near a highway, impulsive noise may be permanently present and STIPA measurements should not be carried out. In such instances the onsite conditions have to be simulated in a laboratory for STIPA testing:

- The real noise spectrum should be measured e.g. with the XL2 Audio and Acoustic Analyzer SLM function, averaging over a sufficient period of time.
- A diffuse sound field of non-impulsive noise with same frequency shape and octave band levels as measured has to be generated in the laboratory.
- The real speaker - listener environment has to be acoustically reproduced as close as possible in the laboratory.
- Then the actual STIPA measurement can be carried out. No post processing is required.

This approach is also mandatory for systems that include automated gain control (AGC), if such systems cannot be tested in the original environment without annoying members of the public.

Measurement Configuration

Simulate the emergency situation as close as possible:

- Position the microphone at 1.0 - 1.2 meters above ground in sitting areas or 1.5 - 1.8 meters in standing areas (typical positions are not directly in front of the speakers).
- The person taking the measurements should be out of the acoustic field, so as not to affect the measurement results. For this purpose the measurement microphone can be mounted on a microphone stand and connected with the ASD-Cable to the XL2.
- An earlier draft of the VDE 0833 standard defines measurements to be carried in a grid from 6x6 and for very big areas like exhibition halls up to 12x12 meter. The measurement points have to represent the speech intelligibility of the area under test!

CD-Player

Only high-quality CD-Players should be used to reproduce the STPA test signal as only limited time-shifts (+/- 20 ppm) ensure reliable STIPA test results. Pitch control and shock protection should be disabled. We recommend that only professional CD-Players be used. Verify the time shift of the CD-Player with a 1 kHz test signal:

- Insert the NTi Audio Test CD into the CD-Player and start track 1, which is the 1 kHz test signal.
- Connect the XL2 directly to the audio output and measure the signal frequency in RMS/THD+N mode. The displayed frequency should be in the range from 0.99998 kHz to 1.00002 kHz

STIPA test signals from other test system manufacturers may sound similar but are not compatible. Only the NTi Audio STIPA test signal CD V1.1 or higher should be used in combination with the XL2 Analyzer.

Speech Intelligibility in Reverberant Spaces

Send the announcements via directed speakers to the public area. Any non-directed sound returns as reflections and reduces the speech intelligibility.

Who can and should conduct STI measurements?

Even though the background of the STIPA method is complex, the operation of STIPA using the XL2 Audio and Acoustic Analyzer is very simple. Operators with a basic acoustic knowledge can easily conduct these measurements. The instrument's internal storage ability also simplifies the measurements in larger buildings, where many measurements must be taken at many locations. The detailed access to the measured MTF (Modulation Transfer Function) matrix enables experts to post-process all measurement data.

Further Information:

For further information please visit www.nti-audio.com.

Detailed information on speech intelligibility measurements are contained in the IEC60268-16 (2011. edition 4.0) standard, which also describes the test procedures and the requirements in practice.

Appendix

Subjective analysis methods

Although frequency response, reverberation, distortion, signal-to-noise ratio or loudness are related to intelligibility, the conventional measurements of these parameters together only marginally relate to intelligibility. When added issues, such as directionality of drivers and the environment conditions are taken into consideration, the question is: How well a spoken message can be understood at different locations?

The fundamental approach to measuring intelligibility is to let a trained human speaker read a number of existing or synthetic words, whereas a representative number of listeners individually write down what they believe they understood. The statistical analysis of these notes results in a value representing the percentage of words being understood correctly. Standardized procedures according to this method are PB-words, CVC or SRT (Speech Reception Threshold). However, conducting such tests is rather time consuming and costly, and in some hazardous locations even impossible. Therefore, these methods are mainly used to verify alternate measurement methods.

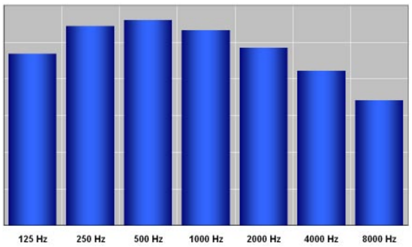


Figure 2: Average octave band spectrum of a male speaker

Technical Methods

As early as 1940, Bell Laboratories started to develop measurement technologies to determine the intelligibility of speech. Nowadays, highly-developed algorithms such as SII (Speech Intelligibility Index) and various forms of the STI (Speech Transmission Index) objectively quantify speech intelligibility measurement.

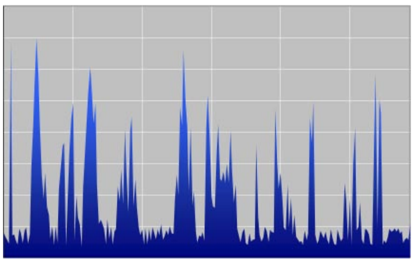


Figure 3: Envelope of a speech signal (250 Hz band).

These techniques consider many parameters which are important for intelligibility such as:

- Signal-to-noise ratio
- Psychoacoustic masking effects
- Sound pressure level
- Ambient noise level
- Reverberation time RT60
- Reflections
- Frequency response
- Distortion

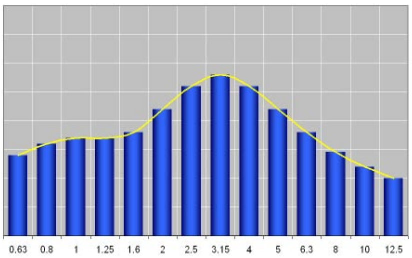


Figure 4: Frequency spectrum of the envelope (250 Hz band).

The basic principle of STI measurement consists of emitting synthesized test signals instead of a human speaker's voice. The speech intelligibility measurement acquires this signal and evaluates it as it would be perceived by the listener's ear. Extensive investigations have evolved the relationship between the alteration of speech characteristics and the resulting speech intelligibility. These findings are incorporated into the speech intelligibility meter that is able to display the intelligibility result as a single number between 0 (unintelligible) and 1 (excellent intelligibility).

Figure 1: Speech Intelligibility may be expressed by a single number value. Two scales are most commonly used: STI (Speech Transmission Index) and CIS (Common Intelligibility Scale)

Speech Model

First of all, measuring the speech intelligibility requires a model for speech signals. For instance, speech may be described as how a frequency spectrum evolves over time. Superimposition of spectra defines the long-term speech frequency spectrum. The intensity of each frequency modulates over time.

Time Modulation

Level of frequency components varies, i.e. is "modulated" by the speaker. Figure 3 shows the envelope of a speech signal in the 250 Hz octave band. The shape of the envelope is given by averaging the time evolution of the speech content.

Frequency Spectrum

The spectral analysis of a male voice averaged over a longer time results in a typical characteristic as shown in Figure 2.

Analyzing the spectra of time modulation intensity shows that a speaker modulates the speech spectra with frequencies in the range from 0.1 to 24 Hz. A set of modulation frequencies from 0.63Hz to 12.5Hz sufficiently represents these modulations.

Modulation Transfer Function (MTF)

High speech intelligibility requires that the spectral intensity modulation and the overall spectrum be preserved at the listeners ears. Therefore, the three core intelligibility measurement methods STI, RASTI and STIPA are based on measuring the MTFs (Modulation Transfer Functions) in 7 octave bands. For each octave band, one MTF quantifies the degree of preservation of the intensity modulations in this band. These functions quantify how much the intensity modulations are preserved in 7 octave bands, thereby covering the long-term speech spectrum.

Figure 5: Reverberation, ambient noise and reflection are responsible for degrading the modulation index.

Figure 6 shows the MTF of one octave band. This is derived from measuring the 1/3rd octave modulation frequencies, thus resulting in 14 frequencies between 0.63 and 12.5 Hz. Each modulation transfer function determines how well the modulations are preserved in the associated octave band.

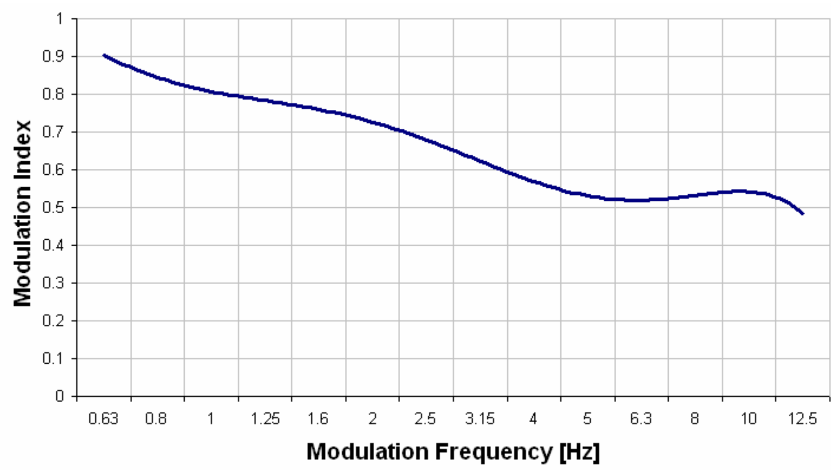


Figure 6: Modulation Transfer Function for one octave band

Based on the MTF results as well as sound pressure level, the hearing threshold of the octave band, frequency response and psycho acoustic effects (masking effects) it becomes possible to reliably determine the preservation of speech intelligibility from speaker to listener. The calculations are based on extensive and profound evaluations and comparisons with subjective methods.

Measuring the complete MTF – as required for STI – is rather time consuming. 14 * 7 = 98 individual measurements must be executed. Therefore, different approaches have been developed to reduce test duration and to enable speech intelligibility measurements with portable instruments.

STI - Speech Transmission Index

The STI result is based on the full set of 98 measurements. Since this approach requires a rather long test period, it is less frequently applied in practice. However, STI represents the most detailed method to measure the preservation of speech intelligibility during transmission and is mostly used if alternative approaches don't provide reliable results due to unfavorable environmental conditions.

	Modulation Frequencies													
Octave Bands	0.63 Hz	0.8 Hz	1 Hz	1.25 Hz	1.6 Hz	2 Hz	2.5 Hz	3.15 Hz	4 Hz	5 Hz	6,3 Hz	8 Hz	10 Hz	12.5 Hz
125 Hz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
250 Hz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
500 Hz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
1 kHz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2 kHz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4 kHz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
8 kHz	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Figure 7: STI considers all 14 modulation frequencies and all 7 octave bands resulting in 98 modulation index results.

In practice, the STI result is mostly calculated from the impulse response (MLSA) that has been acquired e.g. with a PC-based system. This approach is much quicker, but requires post-processing with spectral frequency weighting and lot of experience. The measurement assumes a linear behavior of the setup, i.e. there must be no non-linear processing or conditions, including compressors or limiters and close-to-zero wind speeds, which is a rather rare situation. Microphone and speakers are not allowed to be moved during measurement. As handheld instruments aren't fixed during measurement, it doesn't make sense to support MLS testing in handheld instruments.

RASTI - Room Acoustics Speech Transmission Index

Effective with the standard IEC60268-16, edition 4.0, 2011, is RASTI no longer a permitted method for speech intelligibility measurements.

RASTI has been developed for special cases, such as a human lecturer speaking into a small room without echo's, but not for electro-acoustic systems. In order to reduce the test time required for each STI measurement, a faster method called RASTI was developed. However, both the ability to comprehensively test and the resistance to outside interference are compromised. This leads to poor correlation between subjectively evaluated STI and RASTI. For a long period RASTI was the only method available for measuring the quality of speech transmission with a portable instrument, and has been extensively utilized to measure public announcement systems in the aviation industry, despite the compromises.

RASTI acquires only a few segments of a complete MTF table, and represents an extreme simplification of STI. Therefore, tight restrictions must be met to acquire reliable speech intelligibility results with RASTI. Furthermore, the RASTI result does not consider significant parameters such as the frequency response, echoes or frequency-dependent reverberation times. For a RASTI measurement, only two simultaneously-generated frequency bands are considered, i.e. the 500 Hz and the 2 kHz band which are then modulated with four and five frequencies respectively.

Octave Bands	Modulation Frequencies													
	0.63 Hz	0.8 Hz	1 Hz	1.25 Hz	1.6 Hz	2 Hz	2.5 Hz	3.15 Hz	4 Hz	5 Hz	6,3 Hz	8 Hz	10 Hz	12.5 Hz
125 Hz														
250 Hz														
500 Hz			✓			✓			✓			✓		
1 kHz														
2 kHz	✓			✓			✓			✓			✓	
4 kHz														
8 kHz														

RASTI uses 9 different modulation frequencies in 2 octave bands. The yellow marked octave bands and modulation frequency

RASTI is normally used only to quantify the intelligibility index of the channel between two persons.

STIPA - Speech Transmission Index for Public Address

A rising awareness of security issues, new technological developments and the shortcomings of RASTI triggered the speaker manufacturer Bose to develop a new method for speech intelligibility measurements of PA installations. The result of these efforts is STIPA, which allows quick and accurate tests with portable instruments.

STIPA applies a simplified procedure to calculate the MTF. But STIPA determines one MTF by analyzing all seven frequency bands, whereby each band is modulated with two frequencies.

Supposing that no severe impulsive ambient noise is present and that no massive non-linear distortions occur, the STIPA method provides results as accurate as the full STI method. If however impulsive ambient noise is present during the normal system operation hours, it is usually possible to mitigate the effects by also acquiring a measurement at a more favorable time e.g. under slightly different conditions in the area, or during the night time - and to calculate an unbiased overall measurement by using the results of both test cycles.

The old and already replaced revision IEC60268-16:2003 described a STIPA method where the 125 Hz band and 250 Hz band are combined and the yellow marked modulation frequencies are not considered.

Octave Bands	Modulation Frequencies 0.63 Hz	0.8 Hz	1 Hz	1.25 Hz	1.6 Hz	2 Hz	2.5 Hz	3.15 Hz	4 Hz	5 Hz	6,3 Hz	8 Hz	10 Hz	12.5 Hz
125 Hz / 250 Hz			✓							✓				
500 Hz	✓							✓						
1 kHz						✓							✓	
2 kHz				✓							✓			
4 kHz		✓							✓					
8 kHz							✓							✓

STIPA specified in old IEC60268-16:2003 standard (replaced by 2011 edition)

The handheld NTi Audio analyzers offered sufficient processing power for more precise speech intelligibility measurements than standardized. The NTi Audio STIPA method (verified by TNO) considers all 7 octave bands and all 14 modulation frequencies resulting in more accurate speech intelligibility results. This method is has been standardized in IEC60268-16:2011.

Octave Bands	Modulation Frequencies 0.63 Hz	0.8 Hz	1 Hz	1.25 Hz	1.6 Hz	2 Hz	2.5 Hz	3.15 Hz	4 Hz	5 Hz	6,3 Hz	8 Hz	10 Hz	12.5 Hz
125 Hz					✓							✓		
250 Hz			✓							✓				
500 Hz	✓							✓						
1 kHz						✓							✓	
2 kHz				✓							✓			
4 kHz		✓							✓					
8 kHz							✓							✓

NTi Audio STIPA Method (standardized in IEC60268-16:2011)

How does STIPA compare to STI

STI measured in public address systems can be very time consuming. A complete set of 98 measurements of modulation transfer functions (MTF) has to be obtained and summed. Due to the complex nature and the time required, almost no really useful STI measurement systems were available for years. With the appearance of MLS based systems, STI was more often obtained, as it can be calculated out of the transfer function, as long as the entire system is strictly linear and synchronous. Microphone and speaker are not allowed to move during the measurements, which prohibits employment of handheld instruments. Thus it doesn't make sense to support MLS measurements in handheld instruments. Alternatively by using the dedicated STIPA test signal, measurements can be accomplished with handheld instruments.

STIPA, a derivative of FULL STI, has been developed specifically to cope with the non-linear processing environment common to advanced sound systems, and to reduce the measurement time required to a practical level. The results of the STIPA measurement method and the Full STI methode correlate by approx. 99% at common evacuation installations. Typically, with FULL STI, the maximum deviation is about 0.02 STI. With STIPA the maximum deviation is approximately 0.03 STI for repeated measurements.

Calculation of % Alcons from STIPA Measurement

Alcons (%) = 10^((1-STI)/0.45)

The calculation of STIPA based on Alcon measurements is not reasonable due to the difference in the measurement principles.

STIPA Now

STIPA (Speech Transmission Index for Public Address systems) supports fast and accurate tests with portable instruments. Portable STIPA analyzers, e.g. NTi Audio's XL2 Audio and Acoustic Analyzer, are able to evaluate speech intelligibility within 15 seconds per room position and are thus well suited for wide-area measurements and high productivity.