

Quick guide: Measurement of Speech-Intelligibility STI-PA according to DIN/IEC 60286-16



The picture above shows a complete measurement system for STI-PA

It contains:

- PC: typically a netbook for mobile measurements
- Measurement microphone incl. USB interface
- Active test loudspeaker with 10cm diaphragm
- Audio CD with STI-PA test signal

We recommend using a sound level calibrator for absolute sound level measurements.

Features:

- Conforms to IEC 60268-16:2003 and 2011 (ED 3.0 and ED 4.0)
- STI, STIPA, RASTI
- Very easy usage. Make your first STIPA measurement within 2 min.
- Measurement via modulated noise and room impulse response. (direct and indirect method)
- Background noise can be included via spectral values or .wav file. No spreadsheet calculation required.
- Auditory masking conforms to IEC 60268-16 ED 3.0 (2003) and ED 4.0 (2011)
- Displays modulation indices for each band
- Octave analyzer conforms to IEC 1260 class 0
- Speech level measurement according to IEC 60268-16:2011 Annex J.2
- Easy export of data



General hints

For correct 60268-16 measurements, please make sure:

- No frequency shifts or frequency multiplications
- No speech codecs e.g. LPC, CELP, RELP etc.
- The background noise must not contain tonal components
- The background noise must not contain impulsive components
- Echoes with a period of a multiple of the modulation frequencies are not allowed
- The background noise must be constant during the measurement period.
- Verify that the frequency pitch of the output test signal is less than 100ppm.



Configurations

We offer this solution in different configurations. Most widely you will use a netbook and our USB measurement microphone.



This setup above is the most comfortable version. Due to the USB microphone the system is automatically calibrated.

If you prefer a smaller version, you can use tablet PCs as well.



In addition, we offer solutions with ICP/IEPE interfaces.



Introduction

Speech-intelligibility is the key feature to human communication. For evacuation systems, telecommunication, announcement systems (e.g. train stations) or rooms for education, poor speech-intelligibility will degrade their function or even become a security issue.

In many countries there exist limits for the speech-intelligibility. For new public buildings a certification measurement is required and the speech-intelligibility results must be documented. In most cases this must be performed according to IEC 60849 or ISO 7240-16.

The first orginal measurements were based on statistical analysis of listening tests. In contrast, the STI-method specified in DIN/IEC 60268-16 is an *objective* method. It uses special test signals (modulated noise) that simulate human voice and computes the influence of a transmission channel which degrades the speech-intelligibility.

The speech intelligibility of a transmission channel depends on:

- the speech level
- frequency response of the channel
- non-linear distortions
- background noise level
- quality of the sound reproduction equipment
- echos (reflections with delay > 100ms)
- the reverberation time
- psychoacoustic effects (masking effects)

The STI method uses 7 octave bands in the range of 125Hz to 8000Hz. It computes a single value, that reflects the speech-intelligibility.

This value can be in the range of 0 to 1.0. A value of 0 is equivalent to a very poor speechintelligibility. 1.0 is an ideal channel with excellent speech transmission.



Installation

Execute "setup.exe" from the installation CD and follow the instructions.

Some versions are equipped with a USB key. The program will start only, if the key is connected to a USB port



This key does not require any driver and will be recognized by windows automatically.



First STI-PA Measurement

Start the program







The measurement-preset dialog can always be activated from the toolbar with the green button



From the measurement preset dialog select STIPA.





You can verify the calibration easily. The Input level SPL[F] must match the reference level. In this case this is 94dB. The signal from the calibrator must be clearly visible at 1000Hz.



If you get a different reading, you need to calibrate the system. Please refer to the general user manual for details.

Simply press the CAL button from the toolbar.

You can skip this step by pressing cancel, if you want to measure uncalibrated.

With the OK button you start the calibration.

Calibration		×
Reference level	94 dB	
	Cancel Gasua	e



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120 100 SPL[F] 94.1dB(Z) 94.0dB(A)										
🗖 STI-PA										
STI-PA STI: 0.32 CIS: 0.50 rating:poor	88.4 33.2 33.4 33.4 33.4 33.4 33.4 33.4 33									
125Hz 250Hz 500Hz 1000Hz 2000Hz 4000Hz RMS 43.6dB 43.6dB 26.4dB 82.3dB 30.0dB 23.6dB	Iz 8000Hz B 200 400 800 2k 4k 6k 8k 20									
MTI 0.502 0.502 0.514 0.084 0.336 0.336 M1 0.852 0.852 0.559 0.091 0.243 0.307 M2 0.151 0.151 0.489 0.018 0.244 0.190	16 0.192 1k 10k 17 0.122 Frequency [Hz] 0 0.022									
M2 0.101 0.101 0.105 0.010 0.244 0.150										
reset copy 1207s	opy to clipboard wav SNR Save RMS as Signal Save RMS as L0 2.5 3.0 3.5 4.0 4.5 5.									
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The calibration step is now complete.

Please put the audio CD with the STI-PA test signals into to the CD player und connect it with the loudspeaker. Please play the first track. You should hear the rhythmic STIPA-PA noise. You can use smartphones, MP3 player or any other audio source.

Place the measurement microphone ca. 50cm in front of the loudspeaker. Adjust the sound level (volume knob at the loudspeaker or CD player) to around 80dB(A).



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120 100 SPL[F] 85.0dB(Z) 78.7dB(A)									
🗆 STI-PA									
STI-PA STI: 0.95 CIS: 0.98 rating:excellent									
125Hz 250Hz 500Hz 1000Hz 2000Hz 4000Hz 8000Hz 200 400 800 2k 4k 8k RMS 84.1dB 84.1dB 75.5dB 75.0dB 60.0dB 49.4dB 55.3dB 200 400 800 2k 4k 8k 8k	201								
MTI 1.000 1.000 0.933 1.000 1.000 0.896 0.842 1k 10k 10k									
M2 0.977 0.977 0.926 0.975 1.021 0.939 0.889									
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reset	2 h#1								
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gender Save RMS as Signal © male STI:0.95									
CIS:0.98 Save RMS as Noise 1.0 2.5 3.0 3.5 4.0 4.5 Time [min] Time [min] Time [min] Time [min] Time [min] Time [min]	5.								
44100 8192 V 186ms A V Blackman									

Press reset in the STI-PA dialog to start a new measurement.

STI-	PA								×	
STI-PA STI: ?0.20? CIS: ?0.31? rating:bad										
	125Hz	250Hz	500Hz	1000Hz	2000Hz	4000	Hz 8	DOOHz		
RMS	51.0dB	51.0dB	31.9dB	33.2dB	34.7dB	33.8	idB 3	5.2dB		
MTI	0.171	0.171	0.352	0.192	0.172	0.2	08	0.104		
M1	0.240	0.240	0.552	0.115	0.168	0.1	.29	0.053		
M2	0.033	0.033	0.098	0.099	0.050	0.1	.07	0.070		
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The counter will be set to 0s and all intermediate results are reset. The counter should start again immediately.

A measurement will take around 20s. During the measurement do not move the microphone and avoid any noise.

After 15s the STI display will turn to green and you can read the measurement. In this simple test setup, the STI value must be better than 0.9



IEC 60286-16:2011 ED 4.0

The latest IEC 60286-16:2011 supports male speakers, only. This is the first track on the audio test CD.

Track 1 male IEC 60286-16:2011 ED 4.0

IEC 60286-16:2003 ED 3.0

Our software supports according IEC 60286-16:2003 two types of speakers: Male and female. The test CD contains both genders.

The test signal must match the settings in the program. By default we recommend using male test signals.

Track 2 male IEC 60286-16:2003 ED 3.0 Track 3 female IEC 60286-16:2003 ED 3.0

A real measurement consists of the following steps

- 1) Place the microphone
- 2) Start a new measurement with reset
- 3) Wait at least 15s. The STI display will turn to green.
- 4) You can save the measurement results either as a screenshot or as text data.

Measurement results as screenshot.



🖬 STI-PA 🛛 🔀										
STI-PA STI: 0.95 CIS: 0.98 rating:excellent										
	125Hz	250Hz	500Hz	1000Hz	2000Hz	400	0Hz	800	0Hz	
RMS	84.2dB	84.2dB	76.8dB	74.9dB	59.9dB	49.	6dB	55.	5dB	
MTI	1.000	1.000	1.000	0.992	0.992	0.	836	0.	865	
M1	0.992	0.992	1.002	1.004	0.990	0.	905	0.	952	
M2	0.998	0.998	1.025	0.966	0.966	0.	916	0.	888	
reset copy to clipboard 39s .wav SNR										
⊂ gender ⊙ mal ⊂ ferr	le nale			STI:	0.95		Sa	ive R Sigr	MS a hal	s
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If you use 'copy to clipboard', all measurement results are copied to the clipboard where you can do further analysis with e.g. Excel.

STI: 0.95 CIS: 0.98 rating:excellent MTI:1.000 1.000 0.975 0.999 0.838 0.865 M1: 0.990 0.992 1.003 0.993 0.905 0.953 M2: 0.995 1.011 0.957 0.969 0.917 0.885 RMS: 84.2 76.7 74.9 59.9 49.6 55.5 male

The program shows the following parameters:

Description	Parameter
Speech Transmission Index	STI
Common Intelligibility Scale	CIS
Level for each band	RMS
Modulation Transmission Index	MTI
Modulations indices	M1 M2

You can find all details for the parameters e.g. M1,M2, MTI in the official DIN60268-16 document.

There exist a simple relationship between STI and CIS.

CIS=1+log10(STI)

The speech index STI can be in the range from 0.0 to 1.0

STI Index	Commentary
0.0-0.3	unverständlich/bad
0.3-0.43	schwach/poor
0.43-0.6	angemessen/fair
0.6-0.75	gut/good
0.75-1.00	ausgezeichnet/excellent

According to DIN 60849 CIS (Common Intelligibility Scale) must be greater or equal to 0.7. This is equivalent to a STI (Speech Transmission Index) 0.5.



Practical measurement setup

The setup is very simple. The test signal is inserted to the emergency system with the test loudspeaker. At different positions in the building you measure the sound signal with the measurement microphone. Each measurement point will take around 20s.



The loudspeaker should be placed 50cm in front of the microphone. The sound level should be 66db(A).

You can also insert the test signal electrically, if you connect the output of the CD player and the input of the emergency system directly with a suitable cable.



Verify your measurement setup

Download http://www.dr-jordan-design.de/Download/STIPA_test.ZIP

This file contains different special STIPA test sequence with known STI reading. You should get the following results

30% STI-PA 0.38
40% STI-PA 0.44
50% STI-PA 0.50
60% STI-PA 0.56
70% STI-PA 0.62

You can easily hear the different modulation indices. A low modulation index signal is closer to pure noise. The rhythmical character decreases.



Level measurement for speech

For performing reproducible STI measurements, speech levels and noise levels should be carefully calibrated.

For determining the speech-to-noise ratio, a level measurement method is specified in the IEC 60268-16:2011 Annex J. The basic methods of measuring the real speech level are based on removing the silent parts of the speech signal, e.g. the gaps between words.

Display

You can easily get this special speech level measurement from the main STIPA dialog.

<u> </u>	STIPA 2011										
STIF	STIPA STI: 0.73 CIS: 0.86 rating:good(A)										
		125Hz	250Hz	500Hz	1000Hz	2000Hz	400	0Hz	8000H:	z	
RN	1S	35.6dB	39.6dB	41.5dB	39.4dB	42.6dB	54.	3dB	49.7dE	3	
M	TI	0.548	0.427	0.731	0.670	0.722	1.	000	0.63	1	
N	11	0.297	0.196	0.819	0.249	0.405	1.	109	0.16	1	
N	12	0.821	0.601	0.844	1.172	1.329	1.	754	1.298	3	
51°	pause Auditory masking © ED3.0 2003 copy to clipboard © ED4.0 2011 Copy to clipboard										
		0.00.040	. opooon								
C genu	© male STI:0.73										
Г	□ RASTI □ NTI-STIPA CIS:0.86						Save RMS as Noise				
	STI	IPA ED 3.0	2003	_			_				

In this window you get the normal A-weighted RMS reading, which is basically the energyequivalent average over the measurement time (here 51s).

The right value shows the speech level measurement according to 60268-16:2011 Annex J.2. The speech level is always higher than the normal RMS. For constant signals e.g. pink noise they are identical. For typical speech the speech level is around 3dB above the RMS. If the gaps or pauses are longer, the higher the speech level with respect to the RMS.

We recommend to average at least 40s for speech signals.



Test signals

The measurement signal contains 7 bandlimited modulated noise with the center frequencies 125Hz 250Hz 500Hz 1000Hz 2000HZ 4000Hz and 8000Hz.



The noise signal for each band is modulated by the amplitude. An ideal signal has an modulation index of 1.0. This is equivalent to an excellent STI value. Noise, Reverb, Echos, linear and non-linear distortion reduce the modulation index which leads to a poorer STI value. The analysis system measures the modulation factor for each band, and with a complex calculation one single value - the STI-result - is computed.



The picture above shows a spectral analysis of a IEC 60268-16:2011 STIPA signal. The seven octave bands can seen easily. Each band shows a decay of 3dB/octave, since pink noise is used as the base signal.





Filter response of our band-pass filters for the 1000Hz band

STIPA uses the following band and levels:

Center frequency [Hz]	125	250	500	1000	2000	4000	8000
Level [dB]	2.9	2.9	-0.8	-6.8	-12.8	-18.8	-24.8

0dB is the A weighted wideband level of the STIPA signal. After calibration, an octave analyzer measures e.g. -6.8dB for the 1000Hz band

STIPA uses 2 modulation frequencies with 180° phase shift between the 2 modulation frequencies for each band.

Center frequency [Hz]	125	250	500	1000	2000	4000	8000
Mod. Freq. 1 [Hz]	1.6	1	0.63	2	1.25	0.8	2.5
Mod. Freq. 2 [Hz]	8.0	5	3.15	10	6,25	4	12.5