AFILS

Induction Loop Systems with XL2 Analyzer

Exel Line: Minirator MR-PRO with XL2 Audio and Acoustic Analyzer

This application note describes the commissioning and verification of Inductive Loop Systems according the international standard IEC 60118-4.

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General

Audio-frequency induction loop systems (AFILS) improve the speech intelligibility for hearing aid users. The acoustic measured by a microphone are converted into a magnetic field, which will be transformed by the T-coil in the hearing aid for the user.

This minimizes listening problems of sound sources at a distance, with persons speaking behind protective windows and in environments with background noise. Vocal communication with a person wearing a hearing aid is often rather poor since acoustical noise and reverberation tend to mask the perceived signal. Wearing a hearing aid deprives the person of directional hearing. Communication is much easier at shorter acoustic distances.

An inductive loop system enables hearing aid users to understand the spoken messages.

Int. Symbol for Induction Loop Systems

The inductive loop system provides a magnetic field, which has to correspond to the specifications. The XL2 Audio and Acoustic Analyzer together with an induction loop sensor measures these magnetic fields very accurately and confirms that the specifications are achieved.

Induction loop systems are widely installed in churches, theatres and cinemas, for the benefit of hearing-impaired people. The use of induction loop systems has been even extended too many further applications, such as ticket offices, bank counters, drive-through services or elevators.

The following method provides repeatable and accurate results for most of the specialized amplification systems on the market. Other methods have been suggested, some using exotic test signals such as artificial speech, but obtaining accurate results has proven difficult.

Required Instruments

In order to measure inductive loop systems the following equipment is required:

- NTi Audio XL2 Audio and Acoustic Analyzer
- NTi Audio Minirator MR-PRO signal generator with suitable audio cables to insert test signals into the induction loop system.
- Calibrated receiver for inductive loop systems with a flat frequency response, such as the Ampetronic CMR-3, input sensitivity: 0 dBu RMS = 400 mA/m, the A-weighting filter of the CMR-3 should be switched off, see www.ampetronic.co.uk.
- Induction receivers to listen to the system to detect any artefacts. These receivers are available from various suppliers, e.g. ILR3 of www.ampetronic.co.uk.

Calibration

Church with AFILS system installed

The reference magnetic field strength level of 0 dB is 400 mA/m. The XL2 Audio and Acoustic Analyzer displays this reference field strength as follows:

- RMS/THD: 400 mA/m = 0 dBu
- SLMmeter: 100 mA/m = 70 dBSPL (set the sensitivity in the XL2 calibration menu to 3,08 V/Pa)
- Conversion table:

field strength	Level dB	Level RMS	Level SPL
400 mA/m	0 dB	0 dBu	82 dBSPL
100 mA/m	-12 dB	-12 dBu	70 dBSPL
32 mA/m	-22 dB	-22 dBu	60 dBSPL
1.8 mA/m	-47 dB	-47 dBu	35 dBSPL

Technical Standards

AFILS main control

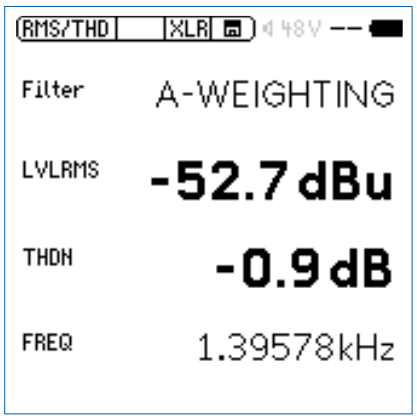
The international standard IEC 60118-4 (also known as SN, EN or BS 60118-4) specifies the following requirements (all referred to 400 mA/m):

- Average Field Strength -12 dBu +/- 3 dB (= 100 mA/m)
- Maximum Field Strength 0 dBu (= 400 mA/m)
- Frequency Response 100 - 5000 Hz +/- 3 dB
- Background Noise Level -22 dBu, A-weighted

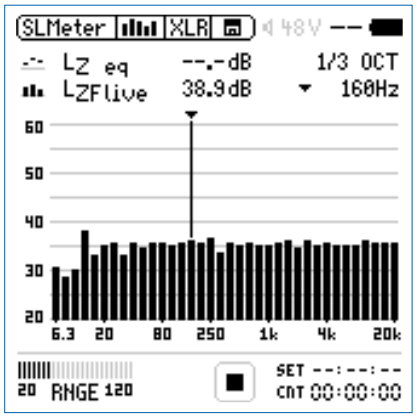
These specifications relate to the vertical component of the magnetic field. The T-coil in hearing aids is usually mounted vertically. Not all hearing aids comply with this standard which often causes complaints about loop systems. Exceptions must be made in certain situations where the head of the listener is not vertical (places of worship, hospitals and recovery areas as people may be kneel, prone or supine).

The area covered by the induction loop system is defined as the area where all the above specifications are met. All measurements should be repeated at a randomly distributed selection of points. The measurement height should be 1.2 m in seating areas and 1.7 m in standing areas. In special cases it may be necessary to use different heights depending on the listeners. The loop receiver should always be held in order to measure the vertical component of the magnetic field, e.g. with the CMR-3 receiver the long axis of the device needs to be vertically orientated.

Measuring the Background Noise Level



XL2 Screenshot Level RMS



XL2 Screenshot RTA

The background noise level has to be measured prior to planning the loop system for a room. In rooms with high level of magnetic noise it may not be possible to fit an inductive system. In this case the use of other systems such as FM or Infrared should be discussed with the hearing impaired. Ideally, the reference signal-to-noise ratio difference between the reference magnetic field strength level and the A-weighted magnetic background noise level should be minimum 22 dBu, best greater than 47 dBu.

Measurement:

- Switch off the induction loop system.
- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer and select the RMS/THD function with A-Weighting filter.
- Carry out the measurement at different representative positions, the background noise level shall be not greater than -22 dBu (LAF=60 dB).
- Repeat the measurements with any electrical equipment in the room (especially floor heating and lighting in the on and off position. If the lighting can be dimmed, the measurement needs to be repeated with various positions of the dimmer circuits.
- In case of any undesirable tonal noise can be observed by Measuring the LZlive value using the real time analyzer in the SLMeter menu, then the signal-to-noise ration shall be greater than 47 dBu.
- Monitor the background noise by listening to the system with the inductive receiver.
- Store the measurement results for documentation.

Measuring the Maximum Field Strength and Amplitude Characteristic

XL2 Screenshot Level RMS

The relation between field strength and the system input voltage shall be measured over the useful range (between the noise level and overload) for each the amplifier input.

Measurement:

- Switch on the induction loop system and warm up the system for 5 minutes prior taking the first measurements.
- Connect the Minirator to the inductive loop system and select a 1kHz sine wave.
- The output level of the Minirator and the induction loop system settings should be adjusted in order to obtain the maximum output without distortion, e.g. 1 dB below the maximum specified value. The output of the induction loop system can be checked with the XL2 Scope function to ensure the measured induction signal is not distorted.
- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer.
- Select the RMS/THD function with Z-Weighting filter (=flat) and measure the field strength.
- Carry out the measurement at different representative positions, the maximum field strength shall be 0 dBu (= 400mA/m) and shall not vary by more than ±3 dBu.
- Reduce the input level step by step and record the effects on the field strength at one typical location manually in a graph.
- Store the measurement results for documentation.

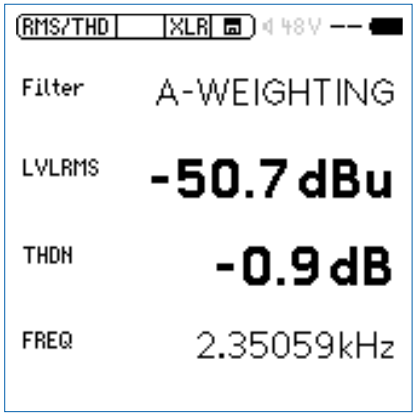
Exel Set for induction loop measurements

Application hints:

If a high background noise level is detected it may interfere with the maximum field strength measurement. The high-pass filter HP400 can be switched on to reduce the effects of 50/60Hz mains background noise. This will not influence the readings at 1 kHz.

If there are any overheating problems with the induction loop amplifier this measurement should be completed rapidly and the maximum level measurement can be restricted to one position. Reduce the level e.g. by 6 dB, check the other positions and correct the results accordingly.

Checking the Noise level with the Loop System



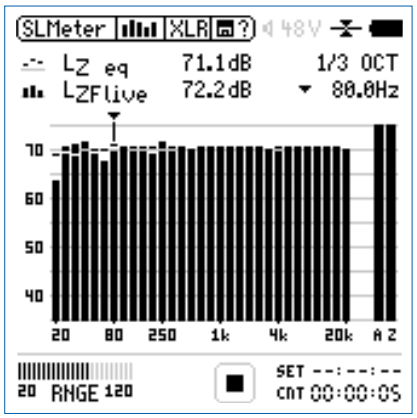
XL2 Screenshot Level RMS

Repeat the earlier background noise level measurement, this time with the induction loop system switched on.

Measurement:

- Set the volume controls to normal operation level. Any microphone inputs should be turned off.
- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer
- Select the RMS/THD function with A-Weighting filter.
- Carry out the measurement at different representative positions. Any differences should be documented. The background noise level shall be not greater than -22 dBu (LAF=60 dB).
- The results shall be the same or only very slightly higher (not more than 3 dBu) than the measurements made at induction loop system switched off.
- Store the measurement results for documentation.

Measuring the Frequency Response

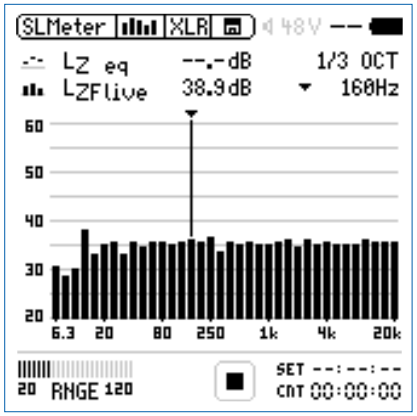


XL2 Screenshot RTA

Measurement:

- Connect the Minirator to the induction loop system and select the pink noise test signal. The level of the input signal shall be according the recommended system manufacturer specifications for this measurement.
- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer.
- Measure the LZeq parameter with the real time analyzer in the SLMeter menu.
- Obtain the average spectrum. The frequency response shall be within +/- 3 dB when referenced to the level at 1kHz over the frequency range 100 - 5000 Hz
- Carry out the measurement at different representative positions.
- Store the measurement results for documentation.

Checking Interference from other Loop Systems



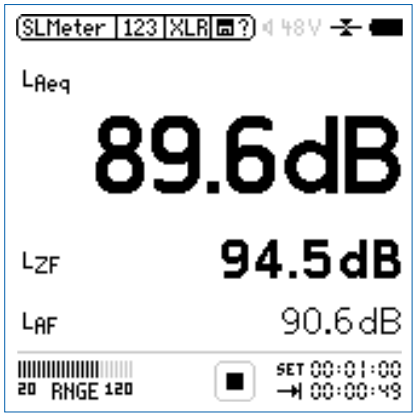
XL2 Screenshot RTA

When two rooms which are physically close have inductive systems fitted it is possible that there will be interference between these systems. In such cases a specification is required for the maximum allowable crosstalk. This specification is not included in the standard but a maximum crosstalk between two systems of -40 dBu @ 1 kHz (LAF=42 dB) has found to be acceptable. In critical cases, e.g. cinemas, -48 dBu (LAF=34 dB) has found to be acceptable.

Measurement:

- Switch off the induction loop system.
- Switch on the loops system in the rooms which may interfere and adjust this systems to obtain the maximum field strength.
- In the actual room under test, measure the level of the 1/3rd octave band at 1 kHz with the XL2 Audio and Acoustic Analyzer.
- Carry out the measurement at different representative positions especially near the wall separating the areas. Any differences should be documented. The max. crosstalk between two systems shall be -40dBu (LAF=42 dB).
- Store the measurement results for documentation.

Measure the long-term average field strength



XL2 Screenshot Sound Level Meter

The average field strength shall be measured during real operation.

Measurement:

- Switch on the induction loop system.
- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer
- Measure the wideband LAeq level of 60 seconds in the SLMeter menu.
- Store the measurement results for documentation.

System check

For the system check a small number of hearing-aid users should be available. It is important to check these hearing aid users for correct operation of their aids, and to ensure that they actually understand what they are supposed to be listening to.

The system check should include a test with the sound sources (talker, etc.) in their normal positions with respect to the system microphone(s) and with any other sources, such as a CD player.

Measurement:

- Connect the loop receiver to the XL2 Audio and Acoustic Analyzer and measure the level in the RMS/THD menu with Z-weighting.
- The maximum measured field strength shall be 400 mA/m, thus the level shall be maximum 0 dBu.
- Check the subjective level as perceived by the hearing aid users with the induction loop system on. With the loudspeakers off the perceived level for the hearing aid users should be the same as for unaided speech at a distance of 1m.
- Store the measurement results for documentation.

Information and a List of Possible Problems

The AFILS sign shall be placed in a prominent position close to the entrance of the area where an induction loop is installed. The sign shall be of sufficient size to be easily read and constructed of durable material. Please contact the local hearing organizations for the official sign in your country.

A plan indicating the specified magnetic field area should be placed beside the above sign or incorporated in it. The results should be analyzed and the areas where all the specifications are obtained should be marked on this plan. For small area induction loop systems e.g. window counters, a sign shall be placed in a prominent position where the hearing aid user is expected.

The following list includes some possible problems encountered when measuring induction loop systems. A possible source of the problem is given. This list does not cover all problems and their causes, just the most common ones.

This application note is written by Mr. David Ian Norman, member of IEC committee for the AFILS regulations, see www.david-norman.ch.Many thanks !

Problem	Possible cause	Possible remedy
Field Strength too low		
In whole area	Incorrect amplifier used	Change
In whole area	Loop positioned too high and height correction factor not taken into consideration.	Change loop position or amplifier
In loop centre	Metal in structure.	Use loop design that compensates the metal loss.
Field Strength too low in system check		
In whole area	AGC not present or incorrectly set up	Check, readjust or replace
In whole area	Level dependant on position of volume control for the loudspeaker system.	Reconnect the induction loop system to an output which is independent of the volume control.
Field strength irregular		
Low field strength in the centre of the loop	Metal in structure.	Use loop design that compensates the metal loss.
Low field strength in the centre the loop	Loop too wide	Maximum loop width for a vertical of distance of 1.2 m between loop height and receiver height (normal for seated audience and loop laid at floor height is about 15 m.
Poor frequency response		
Loss of high frequencies	Use of a voltage drive amplifier possibly in conjunction with a transformer).	Replace with a modern current drive amplifier.
Irregular frequency response	Equalizer used for the sound system affecting the loop response.	Connect loops drive amplifier to a path with no equalizer.
Irregular frequency response	Loop amplifier or electronics of the sound system defect.	Check and replace in necessary.
Loss of high frequencies in centre of the area covered	Metal in structure.	Use a loop design that correctly the compensates for the metal loss in the structure.
High Noise level (Loop system switched off)		
50/60 Hz mains harmonics	Mains interference source.	Check locality for large mains transformers, power lines and so on. If these cannot be moved it may be necessary to consider an alternative to an induction system.
50/60 Hz mains with high level harmonics	Interference from dimmers.	Check dimmers and wiring. Modern dimmers and correct wiring do not produce an interferences.
Interference from other loop systems	Incorrect loop system design	Redesign of loop system(s)
High Noise level (Loop system switched on)		
50/60 Hz mains harmonics	Sound system incorrectly installed.	Check grounding, cabling etc. of the sound system.
Wide band noise	Sound system noisy	Check and if necessary replace