

AFILS

INDUCTION LOOP SYSTEMS WITH XL2 ANALYZER



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

XL2 Audio and Acoustic Analyzer and Minirator MR-PRO



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General

Audio-frequency induction loop systems (AFILS) improve the speech intelligibility for hearing aid users. The acoustic signal measured by a microphone is converted into a magnetic field, which is then converted back by the T-coil in the user's hearing aid. This reduces listening problems for sound sources at a distance, such as with a person speaking from behind a protective window or in an environment with background noise.

Vocal communication with a person wearing a hearing aid can be rather poor if background noise and reverberation masks the speech. Wearing a hearing aid also reduces the directional hearing ability of the person. Communication is much easier at shorter acoustic distances.

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

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 also been 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.



Int. Symbol for Induction Loop Systems

Required Instruments

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

- NTi Audio XL2 Audio and Acoustic Analyzer with firmware V2.60 or higher.
- 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 CMR3, input sensitivity: 0 dBu RMS = 400 mA/m, the A-weighting filter of the CMR3 should be switched off, see www.ampetronic.co.uk.
- Induction receivers for detecting artifacts in the system. These receivers are available from various suppliers, e.g. ILR3 of www.ampetronic.co.uk.



Calibration

The reference magnetic field strength level of 0 dB is 400 mA/m. The XL2 Audio and Acoustic Analyzer displays the reference field strength of 400 mA/m with the RMS/THD function as 0 dBu.

CONVERSION TABLE:

Field strength	Level dB	Level RMS
400 mA/m	0 dB	0 dBu
100 mA/m	-12 dB	-12 dBu
32 mA/m	-22 dB	-22 dBu
1.8 mA/m	-47 dB	-47 dBu



Church with AFILS system installed

TECHNICAL STANDARDS:

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 can cause 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 kneeling or recumbent).

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



AFILS main control

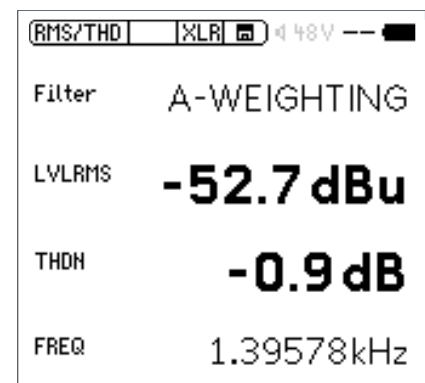
seating areas and 1.7 m in standing areas. In special cases it may be necessary to use different heights depending on the audience. The loop receiver should always be held in order to measure the vertical component of the magnetic field, e.g. with the CMR3 receiver the long axis of the device needs to be vertically orientated.

Measuring the Background Noise Level (IEC 60118-4, chapter 4.2)

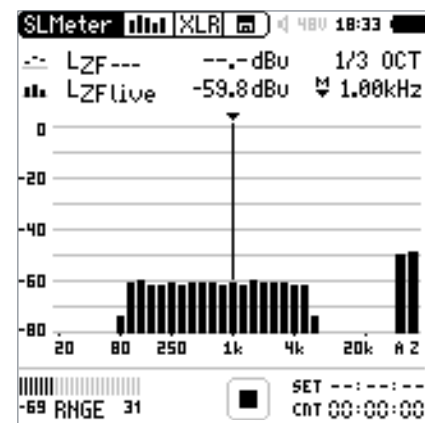
The background noise level has to be measured prior to planning the loop system for a room. In rooms with a high level of magnetic noise it may not be possible to fit an inductive system. In this case the use of other systems such as FM or infrared should be discussed with the hearing impaired. Ideally, 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 of 22 dB; best greater than 47 dB.

MEASUREMENT OF BACKGROUND NOISE:

- 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.
- Ensure that the 48V phantom power is switched off, as this may reduce your measurement accuracy. In case you use a sensor with automated sensor detection, then ASD will be displayed in the top menu line. In this case the phantom power is automatically switched off when the induction loop sensor is connected.
- Carry out the measurement at different representative positions. The magnetic noise level should be at least lower than -22 dBu.
- 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.



XL2 Screenshot Level RMS



XL2 Screenshot RTA

VERIFICATION OF TONAL NOISE:

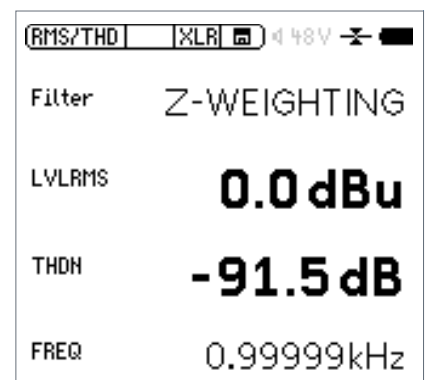
- Select the spectrum display in the SLMeter function.
- Select LZF filter weighting and the measurement unit dBu.
- Verify the magnetic noise spectrum. If the magnetic noise has significant undesirable tonal quality, then the magnetic noise level in the previous measurement should be at least lower 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

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

MEASUREMENT:

- Switch on the induction loop system and warm up the system for 5 minutes prior to taking the first measurements.
- Connect the Minirator to the inductive loop system and select a 1 kHz 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.
- Ensure that the 48V phantom power is switched off, as this may reduce your measurement accuracy. In case you use



XL2 Screenshot Level RMS

a sensor with automated sensor detection, then ASD will be displayed in the top menu line. In this case the phantom power is automatically switched off when the induction loop sensor is connected.

- 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 should be 0 dBu (= 400mA/m) and should 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.



XL2 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.

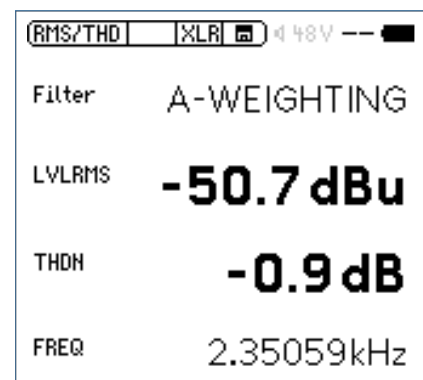
If there are any overheating problems with the induction loop amplifier this measurement should be completed rapidly and the maximum level measurement can be restricted to one position. Reduce the level e.g. by 6 dB, check the other positions and correct the results accordingly.

Checking the Noise Level with the Loop System

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 results should be the same or only very slightly higher (not more than 3 dBu) than the measurements made with



XL2 Screenshot Level RMS

the induction loop system switched off.

- Store the measurement results for documentation.

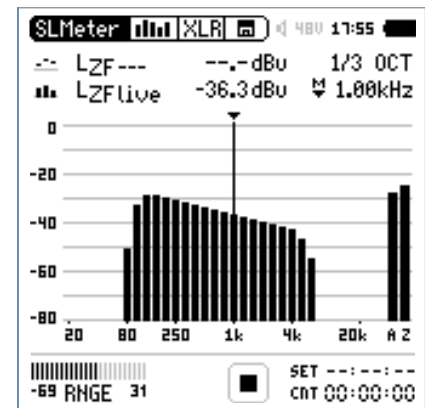
Measuring the Frequency Response (IEC 60118-4, chapter 6.6.3)

- Connect the Minirator to the induction loop system and select the pink noise test signal. The level of the input signal should be set according to 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 should be within ± 3 dB when referenced to the level at 1 kHz over the frequency range 100 - 5000 Hz
- Carry out the measurement at different representative positions.
- Store the measurement results for documentation.

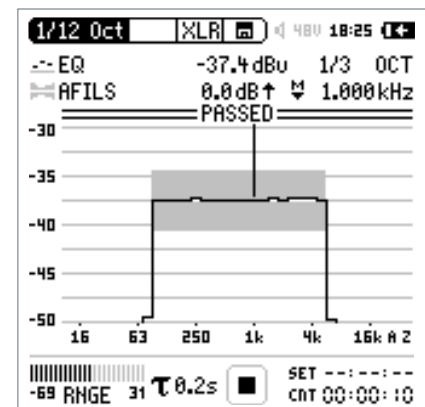
The Spectral Limits Option for the XL2 Analyzer defaults with a ± 3 dB tolerance band, thus you receive an instant PASSED/FAILED feedback during the verification of the magnetic spectrum throughout the room.

Checking Interference from other Loop Systems

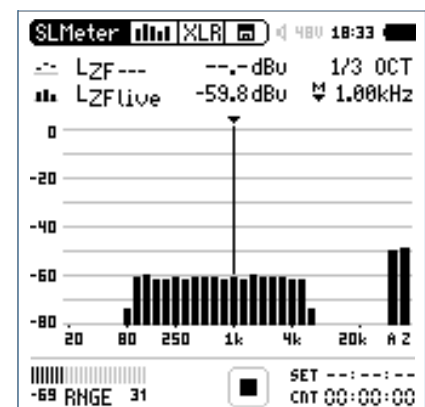
When two rooms which are physically close have inductive systems fitted it is possible that there will be interference between these systems. In such cases a specification is required for the maximum allowable crosstalk. This specification is not included in the standard but a maximum crosstalk between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



XL2 Screenshot RTA



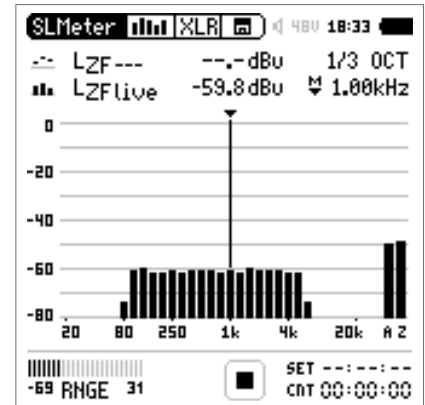
XL2 Screenshot with ± 3 dB tolerance



XL2 Screenshot RTA

MEASUREMENT:

- Switch off the induction loop system.
- Switch on the loop systems in the rooms which may interfere and adjust these systems to obtain the maximum field strength.
- Measure the level of the 1/3rd octave band at 1 kHz with the XL2 Audio and Acoustic Analyzer in the actual room under test.
- Select the spectrum display in the SLMeter function.
- Select LZF filter weighting and the measurement unit dBu.
- Carry out the measurement at different representative positions especially near the wall separating the areas. Any differences should be documented. The maximum crosstalk between two systems should be -40dBu.
- Store the measurement results for documentation.



XL2 Screenshot RTA

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 hearing 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 should be 400 mA/m. Thus the level should be a 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 should be placed in a prominent position close to the entrance of the area where an induction loop is installed. The sign should 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 should be placed in a position prominent to 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 center	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, re-adjust or replace
In whole area	Level dependent on position of volume control for the loud-speaker system.	Reconnect the induction loop system to an output which is independent of the volume control.
Field strength irregular		
Low field strength in loop center	Metal in structure.	Use loop design that compensates the metal loss.
Low field strength in loop center	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 with 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 if necessary.
Loss of high frequencies in loop center.	Metal in structure.	Use a loop design that correctly compensates for the metal loss in the structure.

Problem	Possible cause	Possible remedy
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 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 replace if necessary