

REPORT

REPORT ON A SURVEY OF LISN AND ABSORBING CLAMP USE

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ABSTRACT

The results are presented of a survey of LISN and Absorbing Clamp users working in testing for conformance to EMC standards to meet EU requirements on EMC. There are a wide range of test devices being used with a few being the most popular. Some of the variations in devices appear to be different manufacturers' versions of the same device. Most of the laboratories have their test devices calibrated at a UKAS Accredited Calibration Laboratory but there is, however, a significant spread in the results obtained and clearly room for improvement. There is also quite a spread in overall measurement uncertainty across the laboratories and there is clearly room for improvement in calibration methods and test methods. All would benefit from informed collective discussion on the assessment of uncertainty in both calibration and measurement environments.

There was not a great demand for a guidance document on the use of clamps and LISNs however some useful suggestions have been made for its content and presentation.

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Approved on behalf of the Managing Director, National Physical Laboratory
by Dr S Pollitt, Head of the Centre for Electromagnetic Metrology

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Report on a Survey on LISN and Absorbing Clamp Use

1 INTRODUCTION

The National Physical Laboratory and Schaffner-Chase EMC have carried out a survey of selected UKAS accredited laboratories using Line Impedance Stabilisation Networks (LISNs) and Absorbing Clamps in the assessment of compliance of electrical products with the EU Directive on Electromagnetic Compatibility. The questionnaire is appended to this report.

The objective of this survey was to assess the need for improved calibration facilities, measurement procedures and design of test devices which will reduce measurement uncertainty. This survey is part of a larger project supported by DTT's National Measurement System Policy Unit which will look closely at how these devices are used in typical configurations and seek to identify how improvements can be made in the design of the devices, in the measurement techniques used, and in the calibration procedures employed.

2 BACKGROUND

Survey questionnaires were sent to 24 selected UKAS Accredited Laboratories. It had been agreed at the onset of the work that work for the defence industry would be outside the scope of the survey. The laboratories chosen were representative of the EMC work in the UK. 17 replies have been received and are analysed in this report.

3 ANALYSIS OF SURVEY RESULTS

3.1 Choice of LISNs and absorbing clamps

The most widely used LISNs are the ESH2 Z-5 and the ESH3 Z-5 made by Rhode and Schwarz. Others made by Chase, EMCO and Schwarzbeck are also used: the details are given in Table I. The reasons for the choice of LISN ranged from, supplier reputation, cost, reliability to software and hardware compatibility.

In the case of Absorbing Clamps the models MDS-20 and MDS-21 made by R&S, Chase and Schwarzbeck and others were the most widely used. The details are given in Table II. The reason for purchase was often that these were the only devices available at the time, or quality, suitability and price. In some cases staff at the laboratory concerned had changed over the years and there was no history of why devices had been purchased.

Alternative models of LISN that had been used by the labs were ones included in the list in Table I used by other labs, with the exception of the TTI 1600 where no significant differences in performance were found. It was observed that the R&S automated devices were easier to use while the Chase device suffered from loose earthing bolts.

EMC standards to which laboratories test for conformance

LISN EMC Standards

All of the Laboratories test to EN 55022, nearly all to EN 55011, EN 55014, many to EN 55013 and EN 55015. There are a number of standards where only one laboratory tests for conformance. The details are given in Table III.

Absorbing Clamp EMC Standards

EN 55014 is the most commonly used standard against which products are tested with a few laboratories offering some other standards. The details are given in Table III.

3.3 Calibration of test instruments

All of the Laboratories except four had their LISNs and all but two had their Current Clamps calibrated by a UKAS accredited laboratory. These laboratories calibrated their own test devices as also did one of the laboratories using the UKAS accredited facilities.

The parameters calibrated in the case of their LISNs were Impedance, Insertion Loss and Isolation, although not all measured the isolation of the LISNs being calibrated. One laboratory measured the frequency variation of the insertion loss and the associated uncertainty. One or two labs measured additional parameters such as VSWR; all of the measured parameters are shown in Table V for both the LISNs and Absorbing Clamps. In the case of the Absorbing Clamps it was the Correction Factor that was calibrated by all laboratories with many of them also measuring the Directivity and Correction Factor for the second Maximum. One measured a full frequency swept calibration and another the impedance of the Clamp.

The uncertainties achieved in the UKAS accredited Labs and those carrying out their calibrations for the devices are shown in Table IV. In the case of the LISNs there appears to be a wide range of uncertainties obtained with very similar devices and a less obvious range in the overall measurement uncertainty. It is interesting to see that some laboratories attribute a significantly different uncertainty to their LISN when performing conducted emission tests. Many, but not all labs, correct for LISN loss when making conducted emission tests.

The uncertainties obtained for the calibration of the Absorbing Clamps is very similar for all the laboratories, with a wider range on the overall measurement uncertainty achieved. The disturbance power testing shows a similar level of uncertainty achieved by most labs with one or two achieving a rather lower level.

All of the laboratories were satisfied with the calibration uncertainties obtained but several remarked that a lower calibration uncertainty would give a lower overall uncertainty in the tests with a resulting greater confidence. There was only one test cited where a lower calibration uncertainty would help because in measurements on lamp dimmers the product is designed to comply by a specific margin. There were examples quoted where there was a lack of repeatability in the calibration of the devices and no correction factor and graphical

presentation of results for the Clamp in another case.

3.4 Measurement problems experienced with LISNs and absorbing clamps

Participants were asked to identify problems experienced with particular parts of the tests when using these devices.

3.4.1 LISNs

a) Test configuration and layout

When the LISN is mounted above the ground problems are experienced with the safety bonding. Mains input to the top of a 19" rack also causes problems. The layout required by EN55014 for the LISN introduces resonances. The LISN can only be connected to the ground plane by using a long cable. The Standard needs re-writing to allow placement of the LISN ground terminal as close as possible to the reference plane.

b) Choice of LISN versus EUT power supply (e.g. mains or 24V DC)

When the mains required is greater than 415 Volts.

c) Adaptors (e.g. UK or European mains adaptors)

Several people reported problems with connectors and one suggested a choice of connectors is required on the LISN. Dual sockets would be useful.

d) Other measurement conditions.

Earth bonding was mentioned as a problem area. It was also suggested that the test equipment needs protection from the connection surge.

3.4.2 Absorbing Clamps

a) Test configuration and layout

Problems usually only arise when the cable entry is more than 0.4 m from the floor.

b) The use or not of a screened room

Several of the laboratories use screened rooms and only experience problems when they are forced to work in unscreened rooms because of the test dimensions.

c) The way in which you connect a 6m length of mains cable to the EUT

Some laboratories usually extend the cable using IEC connectors, crimp connectors, chocolate block or hard wiring back to the EUT. One laboratory only uses the test for diagnostic purposes with a calibration for a 1.5 m length of cable. Another laboratory uses a tape joint streamlined to fit through the Clamp aperture to preserve cable impedance.

d) Other measurement conditions.

Sensitivity of the measurements to the route taken by the clamp coaxial cable was identified by one laboratory as a problem. Background noise was quoted as another problem.

Future developments in devices or test methods

The laboratories chosen were asked to identify improvements or developments in test methods or devices that they would like to see for both LISNs and Absorbing Clamps.

3.5.1 LISN

It was suggested that there should be standardisation between commercial and defence standards such as 59-41 and MIL STD 461D on the grounding methods prescribed. A need was identified for a high voltage LISN which would give more reliable results than a voltage probe or current clamp, as presently used. It was also suggested that a voltage probe be provided with the LISN.

There was a need identified for a limiter in the output to stop transients reaching sensitive receivers. Another need was identified for more portable LISNs, particularly those capable of handling high currents.

Absorbing Clamp

It was suggested that clamps could be used for cable evaluation prior to use on an OATS and that relevant limits should be derived. They could also be used to measure emissions from battery operated products. In the near-field of an antenna at a distance of less than a quarter of a wavelength clamps can be used to measure cable leakage in the range 30 to 100 MHz.

The devices could be improved by re-positioning of the top connector and the provision of a self correction procedure for transducer losses. A request was made to remove the requirement of the standard to extend cables to 6 m.

More work needs to be done on evaluating the relative merits of the use of clamps to measure currents and predict radiated fields, rather than measure the fields directly.

Significant and repeatable discrepancies found while using LISNs and absorbing clamps

Participants were asked to report any significant and repeatable discrepancies found when using LISNs and Absorbing Clamps. Very few discrepancies were reported and these are given below.

LISN

- a) The impedance presented by the LISN in the 1-30 MHz range varies with the grounding scheme used by the LISN and connection method used between the LISN and the EUT.

Absorbing Clamps

- a) Saturation problems arise for large current devices (normally low currents are used and saturation is not generally a key problem).

- b) Differences have been observed in the clamp measurements made in a screened room and an anechoic chamber.

3.7 Use of absorbing clamps to carry out other tests

Several respondents reported using Clamps to measure screening effectiveness and for pre-compliance testing.

3.8 Additional comments and observations

The following comments were provided by some of those who returned the questionnaire.

- a) One laboratory finds that the calibration results obtained for an Absorbing Clamp are not consistent and vary from one calibration laboratory to another.
- b) The clamp is very useful for obtaining an accurate frequency of cable emissions prior to measurements on the OATS.
- c) The directivity of the clamp makes it possible to detect the direction (and source) of RF current flow in faulty cables up to 1 GHz; smaller ones can be used at higher frequencies.

4 PROPOSED GUIDANCE DOCUMENT ON USE OF LISNs AND CLAMPS

The following suggestions and contributions have been received:

Content

- 1) Drawings of set-up and use.
- 2) Set-up for common tests. Highlight factors which affect the accuracy of measurements.
- 3) Uncertainties, idiosyncrasies and handling of unusual EUT configurations.
- 4) Contributions to calibration uncertainty budgets and typical values and distributions.
- 5) A detailed set-up and cable positioning guide to show how to obtain accurate and repeatable measurements with the absorbing clamp.
- 6) Summary of common methods. Breakdown of uncertainties for various uses. Explain loss of directivity at low frequencies.
- 7) Verification and calibration procedure for LISNs. Indicate how to increase equipment stability.
- 8) Propose a policy to bring about the standardisation of test methods.
- 9) Provide method of connection of the LISN to the ground plane for EN55014, 022 and 011.
- 10) Guidance is needed on the connection, grounding, use and calibration of the voltage probe.

- 1) Guidance is also needed on the calibration and associated uncertainties for Absorbing Clamps.

Format

- 1) Word 6 Document.
- 2) E-mail, Disk with Word 6 or hard copy.
- 3) Use plenty of diagrams.

Method of dissemination and to whom

- 1) E-mail.
- 2) To all UKAS accredited test labs.
- 3) EMCTLA, GEL 210/1 and UKAS accredited labs. A presentation of this report halfway through the project.
- 4) Sell through technical bookseller.
- 5) CD ROM or hard copy.
- 6) A NIS or EAL Guidance Document.

Manufacturer and type of LISN	Number of Laboratories
Belling Lee Y20172	1
Belling Lee	1
Chase 2853	1
Chase MN2050	1
Chase MN 2053	2
Chase>NNLK 8121	1
EMCO 3825	2
EMCO 3835/2	1
Fischer CC	1
MPE DS 23818	1
R&S	1
R&S ESH2 Z-5	9
R&S ESH3 Z-5	8
R&S ESH3 Z-6	1
RHH NNB 4/200	1
RHH NNB4/32T	1
Schwarzbeck NSLK 8126	1
Solar 7225-1	1
Solar 6338-57-TS-50-N	1
Thandar 1600	1
Own design and build	2

Table I: Types of LISN used

Make and Model of Current Clamp	Number of Laboratories
Chase MDS-21	2
R&S MDS-20	2
R&S MDS-21	5
Schwarzbeck MDS-21	2
Luthi MDS-20	2
MDS-20	2
MDS-21	3
MEB KEMZ 801	1
CEL 8110	1
Fisher F 201	1

Table II: Type of Absorbing Clamp used

No	LISN TEST STANDARDS																CLAMP TEST STANDARDS											
	EN 50065-1	EN 50081-1	EN 50081-2	EN 55011	EN 55013	EN 55014	EN 55015	En 55022	EN 60601-1-2	VCCI	VCC2 Class I	FCC	AS/NZS 3548	CFR 47	C 108.8.1	TRG 1068	ETS 300-339	ETS 300-386	ETS 300-445	ETS 300-683	BTNR 2511	CISPR 14	EN 50081-1/2	EN 55013	EN 55014	VDE 871	CISPR 14	
1																												
2				yes		yes		yes																		yes		
3				yes		yes		yes																		yes		
4	yes			yes	yes	yes	yes	yes																yes	yes			
5																						11&16						
6								yes																				16
7				yes	yes	yes		yes					yes	yes	yes	yes	yes	yes	yes	yes					yes			
8				yes		yes		yes																	yes			
9		yes	yes	yes	yes	yes		yes	yes	yes		yes	AS/NZ										yes	yes	yes			
10																												
11																												
12																												
13																												
14																												
15		yes		yes				yes																	yes	yes		
16				yes	yes	yes	yes	yes																	yes			
17								yes														25	83-2					
18																												
19								yes				yes						yes			yes	14						
20				yes	yes	yes		yes				yes													yes			yes
21					yes	yes	yes	yes				yes												yes	yes			
22																												
23					yes	yes		yes			yes	yes													yes			
24				yes	yes	yes	yes	yes				yes												yes	yes	yes		

Table III: EMC Standards to which laboratories test for conformance

No	Uncertainties for LISN Measurements					Uncertainties for Current Clamp Measurements			
	Calibration Uncertainty	Overall attributable e to LISN	Conducted Emission Testing	Insertion Loss Correction	Calibration Laboratory	Uncertainty in Correction Factor	Overall Measurement	Disturbance Power	Calibration Laboratory
	dB	dB	dB			dB	dB	dB	
	0.2, 9kHz to 1MHz	2.7							
1	0.4, 1 to 100MHz		0.3	yes	UKAS/self	2.0	4.69 to -3.92	2.0	UKAS/Self
	0.8	2.0				2.0			
2	0.3	3.2	0.8	9kHz to 30MHz	Self	0.8	2.0	0.8	UKAS
3	0.2 to < 1.0	2.5	1.9	no	UKAS	2.0	2.6	2.0	UKAS
4			0.2 to 0.3	yes	UKAS	2.0	3.0	not data	UKAS
5									
6	0.5	2.25	2.2	yes	Self	2.0	3.0	2.25	UKAS
7	not given	1.59	1.0	no	UKAS	2.0	1.62	1.0	UKAS
8	0.47 < 300kHz	2.0	0.95	yes	Self	+1.77 < 300kHz	3.38	1.77	Self
	0.95 > 300kHz					-1.86 > 300kHz		-1.86	
9	0.3	1.2	0.3	yes	UKAS	2.0	3.3	2.0	UKAS
10									
11									
12									
13									
14									
15	0.3	1.7	1.0	no	UKAS	2.0	3.0	2.0	UKAS
16	0.3	not given	2.2	no	UKAS	2.0	not given	2.9	UKAS
17	0.3	2.6	1.5	no	UKAS	2.0	4.1	2.0	UKAS
18									
19	0.1	1.69	0.3	yes	Self	none	none	none	none
20	0.8 to 1.4	not given	2.0 to 2.2	yes	UKAS	2.0	not given	2.8 to 2.9	UKAS
21	0.2	3	1	yes	UKAS	2.0	2.5	2.0	UKAS
22	0.3	1.26	0.5	yes < 150kHz	UKAS	2.0	2.65	2.0	UKAS
23	1.2	not given	man. spec.	yes	UKAS	1.0	man.spec...		UKAS
24	not given	2.38 to 1.74	1.6	yes	UKAS	not given	2.4	2.0	UKAS

Table IV: Calibration and Measurement uncertainties

Laboratory Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
LISN																						
Impedance	yes	yes	yes	yes		yes	yes	yes	yes						yes	yes	yes	yes	yes	yes	yes	yes
insertion Loss	yes	yes	yes	yes		yes	yes	yes	yes						yes	yes	yes	yes	yes	yes	yes	yes
Isolation	yes	yes	yes	yes		yes			yes						yes	yes			yes	yes	yes	yes
Other:	yes	yes					yes												yes			
DC resistance	yes																					
RF attenuation	yes																					
Decoupling	yes																					
High pass filter															yes							
VSWR																			yes			
Additional parameters																						
insertion loss plot & uncertainty							yes															
Absorbing clamps																						
Correction factor	yes	yes	yes	yes		yes	yes	yes	yes						yes	yes	yes		yes	yes		
Detectivity/Isolation		yes	yes	yes		yes	yes								yes		yes		yes	yes		
Correction factor on second max.		yes				yes		yes											yes			
Other:		yes																	yes			
Full swept calibration								yes														
Impedance															yes							
Fwd&Reverse attenuation																					yes	

Table V: Calibration parameters measured

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APPENDIX Questionnaire

Survey on the use of LINS's and Clamps

Survey of selected UKAS accredited laboratories using Line Impedance Stabilisation Networks (LISNs) and Absorbing Clamps, in the assessment of compliance of electrical products with the EU Directive on Electromagnetic Compatibility.

Objective To assess the need for improved calibration facilities, measurement procedures and design of test devices which will reduce measurement uncertainty.

- 1) What make and model do you routinely use?

LISN	Absorbing Clamp
------	-----------------

- 2) Why did you make this choice? Do you have objective reasons for using some models in preference to others?

LISN	Absorbing Clamp
------	-----------------

- 3) Please list other models which you have used for conformance testing.

LISN	Absorbing Clamp
------	-----------------

- 4) Please indicate any significant differences found in testing with these.

LISN	Absorbing Clamp
------	-----------------

- 5) Please list below the EMC Standards to which you test for conformance.

LISN	Absorbing Clamp
------	-----------------

- 6) Are your LISN(s) and Clamp(s) calibrated by a UKAS accredited calibration laboratory?

LISN	Absorbing Clamp
------	-----------------

- 7) Are your LISN(s) and Clamp(s) calibrated in your laboratory?
LISN Absorbing Clamp
- 8) Please indicate which parameters are calibrated.
LISN Absorbing Clamp
- | | |
|------------------|----------------------------------|
| Impedance | Correction Factor |
| Insertion Loss | Directivity/Isolation |
| Isolation | Correction Factor on 2nd maximum |
| Other parameters | Other parameters |
- 9) What calibration uncertainty is achieved for the LISN and Clamp? (It is assumed that the quoted uncertainty has been estimated as indicated in the UKAS document M3003, if not please give method used.)
Uncertainty achieved
LISN Absorbing Clamp
- 10) Is the calibration obtained satisfactory for your use? If you are not satisfied what improvements could you justify requesting?
LISN Absorbing Clamp
- 11) When using these test devices what overall uncertainty do you achieve in the test?
Please give below the uncertainty in dB.
LISN Absorbing Clamp
- 11a) What measurement uncertainty do you attribute to the LISN for conducted emissions testing?
Measurement uncertainty
- Do you also correct for the LISN loss?
LISN loss

11b) What measurement uncertainty do you attribute to the Clamp for conducted emissions testing?
Measurement Uncertainty

12) Do you need to achieve a lower overall uncertainty in these tests? Please give the level you require and the reasons for this?
LISN Absorbing Clamp

13) Do you experience problems when using the LISN associated with? (Please give details on a separate sheet if appropriate.)

- a) Test configuration and layout
- b) Choice of LISN versus EUT power supply (e.g. mains or 24V DC)
- c) Adaptors (e.g. UK or European mains adaptors)
- d) Other measurement conditions.

14) Do you experience problems when using the Clamp associated with? (Please give details on a separate sheet if appropriate.)

- a) Test configuration and layout
- b) The use or not of a screened room
- c) The way in which you connect a 6m length of mains cable to the EUT.
(Please state preferred method used.)
- d) Other measurement conditions.

15) A Guidance Document will be prepared by Chase and NPL for those using LISNs and Clamps in testing laboratories. It would be helpful to know what vital information you would expect to find in this and of what help would it be to you in your work?

Content

Format

Method of dissemination and to whom

16) What developments in devices or test methods would you wish to see in the future?
LISN Absorbing Clamp

- 17) Have you obtained any reliable and significant unexpected discrepancies while using LISNs and Absorbing Clamps?
Observations
- 18) Do you carry out other tests using the Absorbing Clamp such as "Screening Effectiveness", "Pre-Compliance Testing" etc?
Other Tests
- 19) Please provide any other comments or observations you may have.
Comments.