LAPLACE INSTRUMENTS LTD

RF300 LARGE LOOP ANTENNA

USER GUIDE

Serial Number 9072

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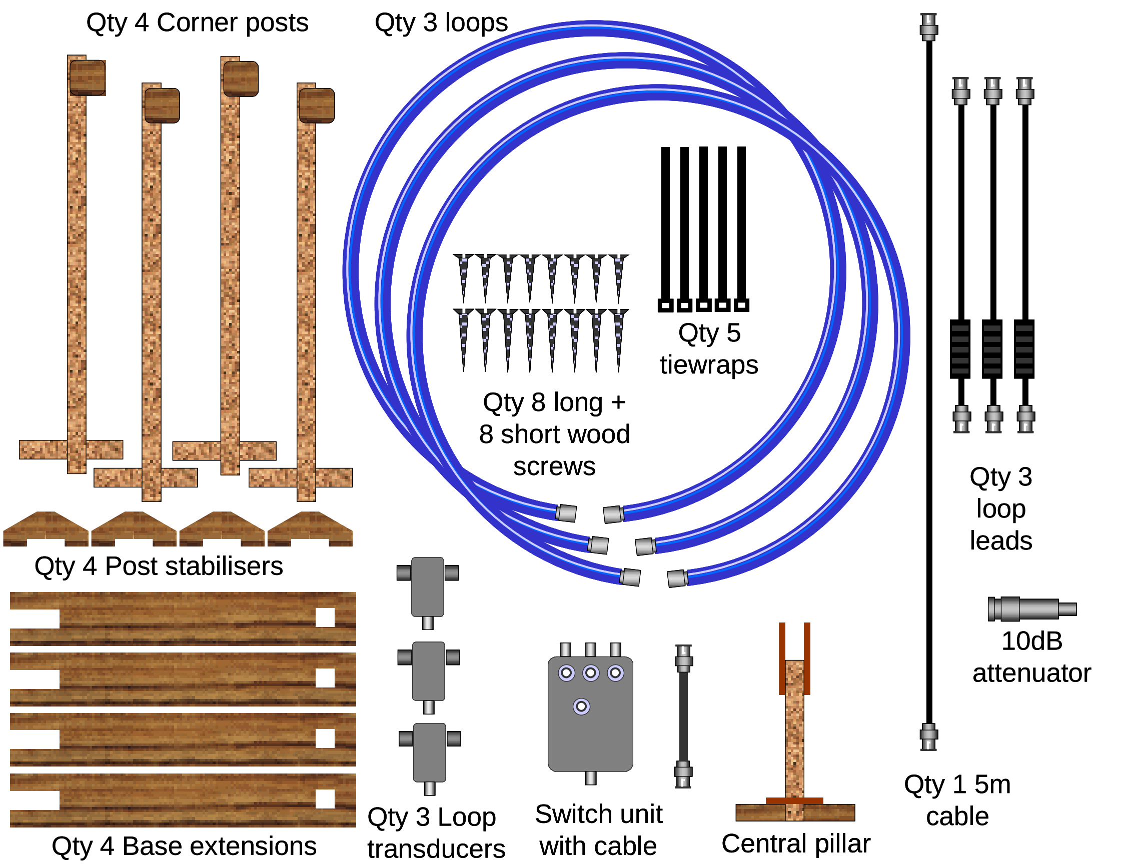
Introduction

The RF300 large loop antenna has been developed to meet the requirements of EN55015, section 9.9.1, which refers to CISPR16-1-4, section 4.6.1. This specifies the limits for magnetic field induced current for luminaires with lamp operating frequencies in excess of 100Hz.
Construction of the RF300 is as detailed in annex C of EN55016. This antenna is fully compliant with the standard and details of the calibration factors are included in this manual. These antenna factors should be added to the results to obtain correct measurements that can be compared directly with the limits.

Test setup and limits should be conducted as required by EN55015, section 4.4.

Packing List

On receipt of the RF300, check the contents of the packages against the diagram shown in fig 1.



Identify each component and check for shortages.

See also list overleaf.

Qty	Item
3	Large loops fitted with connectors at each end
4	Corner posts
4	Base extensions
4	Post stabilisers
1	Central pillar
1	Switch unit
1	Short co-ax patch cable fitted with BNC connectors
3	Loop transducers
5	Tiewraps
8	1¾ x 8 wood screws
8	1” x 8 wood screws
1	5m BNC - BNC lead
3	2m BNC-BNC lead fitted with ferrite absorbers
1	10dB in-line BNC attenuator

Assembly

1. Establish an appropriate area to erect the RF300. This needs to be a clear area at least 4m square with a flat floor and a ceiling height of at least 3m.

2. In the centre of this area, stand the central pillar and fit the base extensions as shown in fig 2.

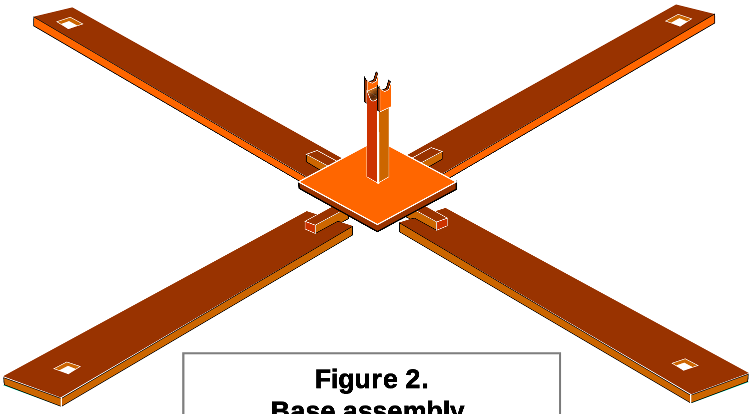


Figure 2.
Base assembly.
Set centre and base extensions

3.Attach corner post stabilisers with 2 short brass screws as shown in fig 3a and then slot the corner posts into the square hole at the end of each base. Secure each with the long brass wood screws as shown in fig 3b.

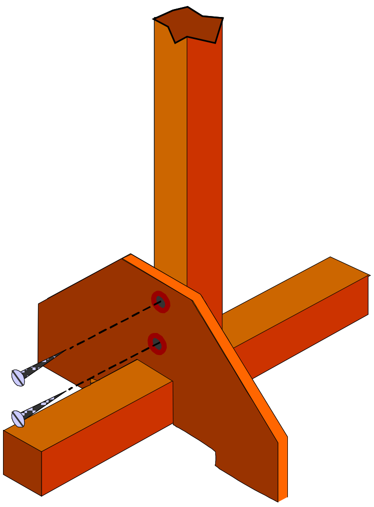


Figure 3a
Screw post stabilisers to post bases

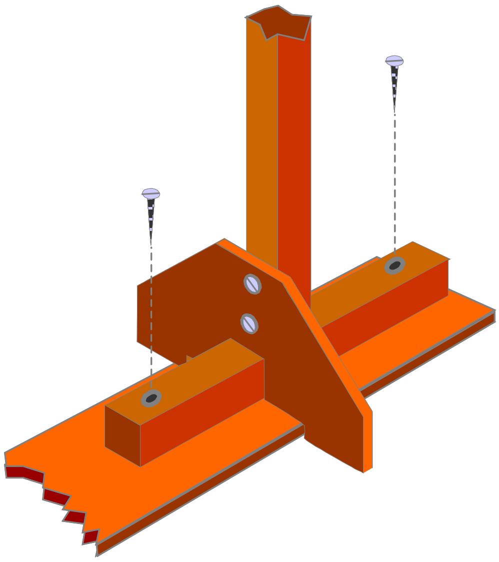


Figure 3b
Secure posts to base extensions

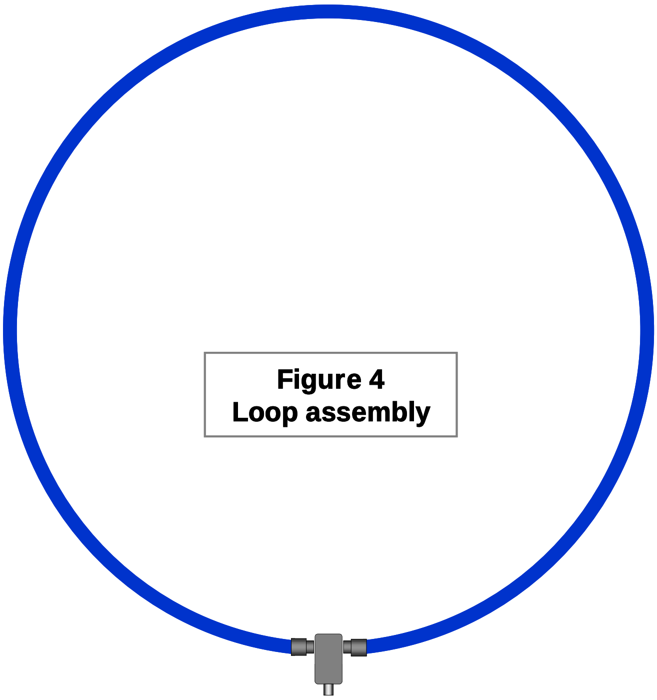


Figure 4
Loop assembly

4. Prepare the 3 loops. The configuration of these loops is as shown in fig 4 and fig 5. The connectors on each end of the loop are mated with the sockets either side of each loop transducer. The retaining ring on each connector needs to be screwed firmly to the socket but take care. These rings will bind and be difficult to turn unless the loop is aligned properly. Force is not necessary, simple jiggle the loop into alignment and the ring will turn easily.

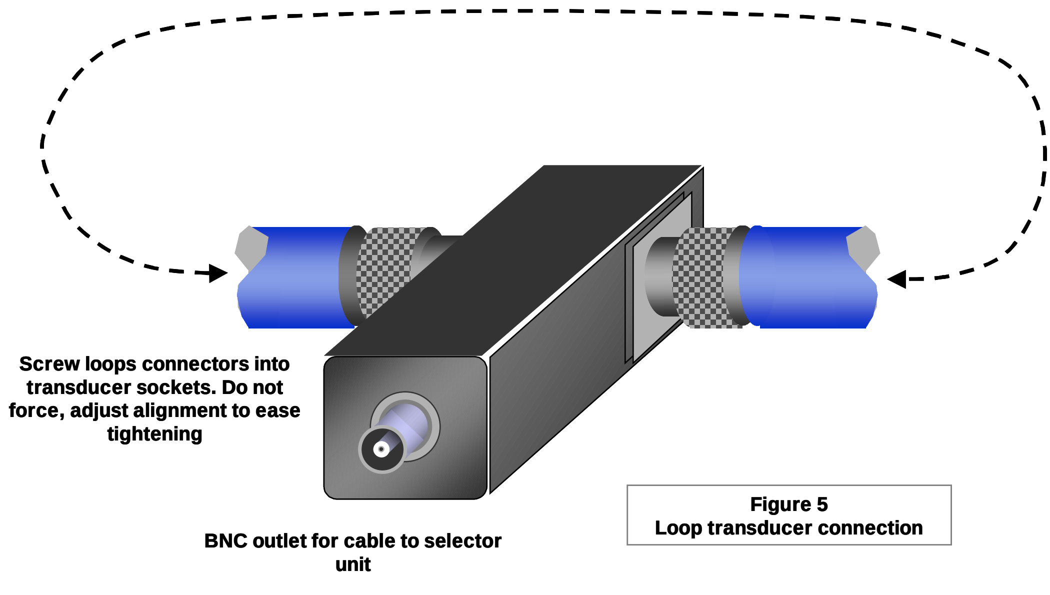


Figure 5
Loop transducer connection

5. The first loop to mount is the horizontal loop. To mount the loops, at least two people are required. Do not try to do this single handed....it will only end in tears. Mount the loop in the recesses at the top of each corner post with the loop transducer close to (within 5 cm) of a corner post. See fig 6.
Slight ‘drooping’ of the loop between the posts has no effect on the performance of the antenna.

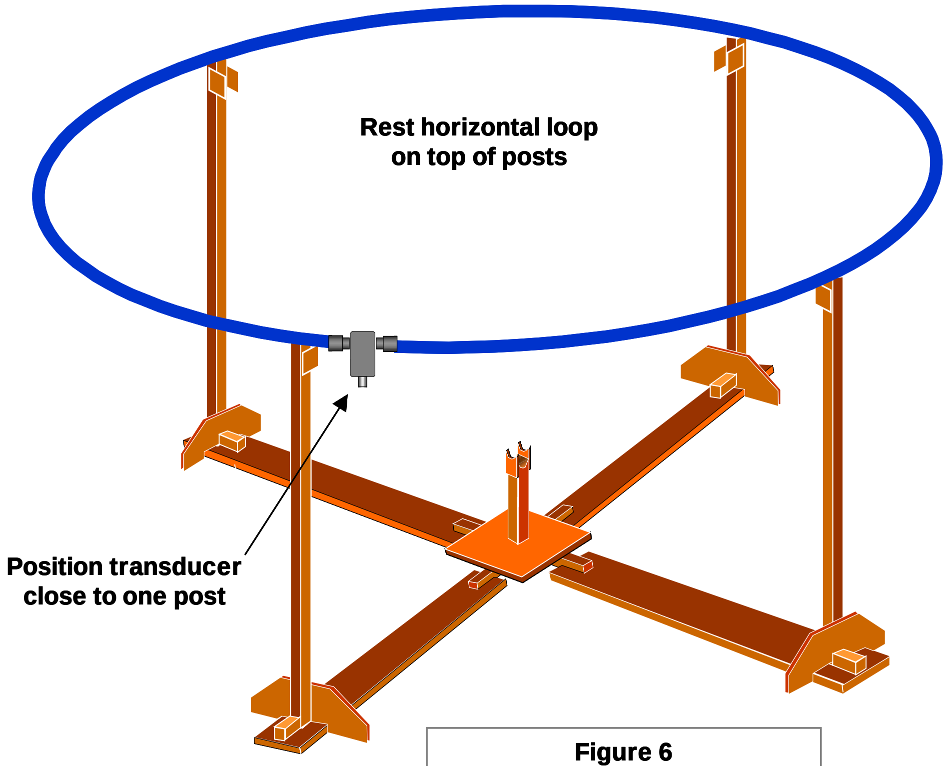


Figure 6
Mounting of horizontal loop

6. The second loop is now fitted. Figs 7, 8, 9 show the details.

This loop is fitted inside the first (horizontal) loop, orientated so that it fits in the lower ‘slot’ in the central pillar (fig 9) and is held between the ‘ears’ on the corner posts (fig 8). Arrange the loop so that the transducer is within 20 cm of the central pillar.
For the moment, the loop will sag and generally not hold its shape. This will be resolved later.

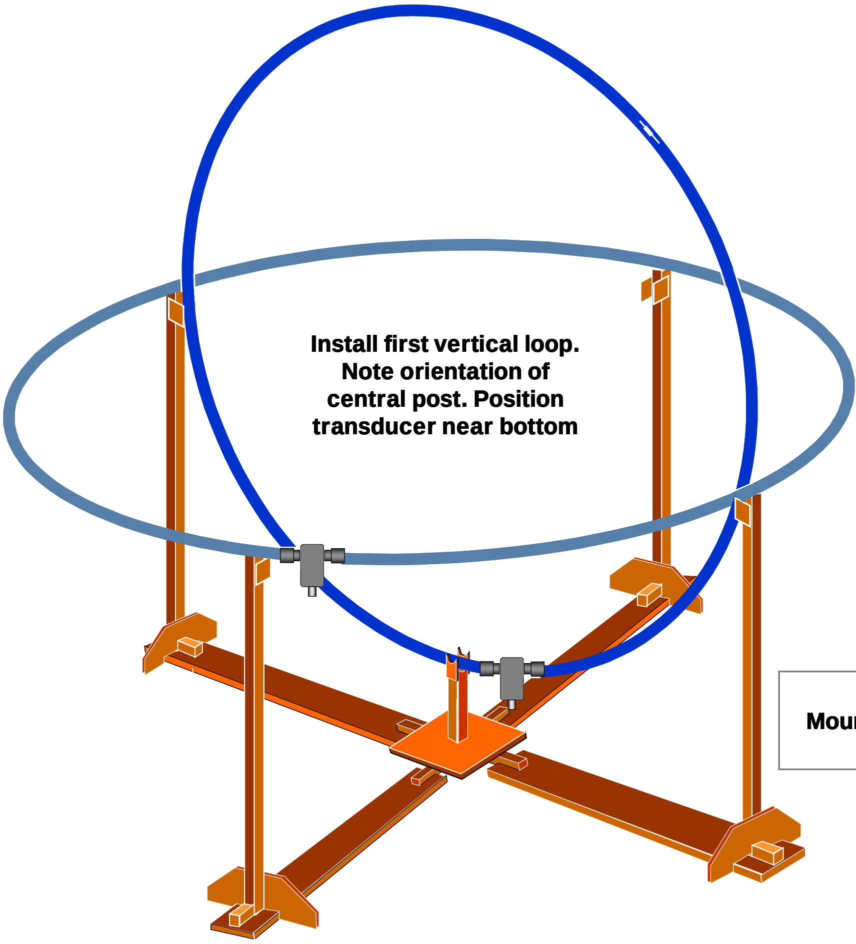


Figure 7
Mounting of second loop

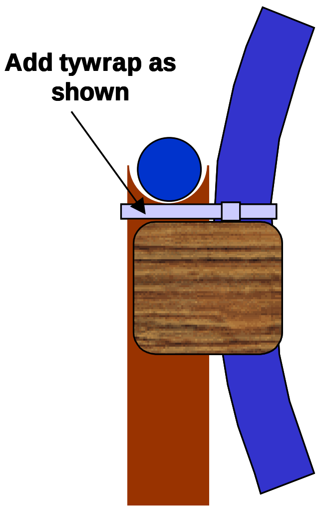


Figure 8
Attachment of loops to posts

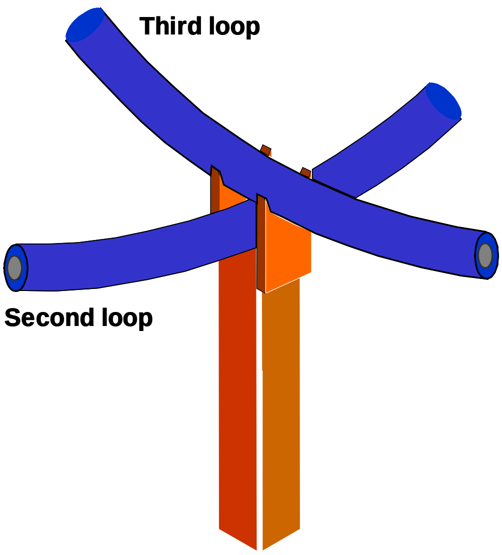


Figure 9
Central post configuration

7. The final loop is now fitted INSIDE the other two. See fig 10.
This fits in the upper slot in the central pillar, between the corner post 'ears' and under the other vertical loop at the top. Again arrange the loop so the transducer is close to the central pillar.

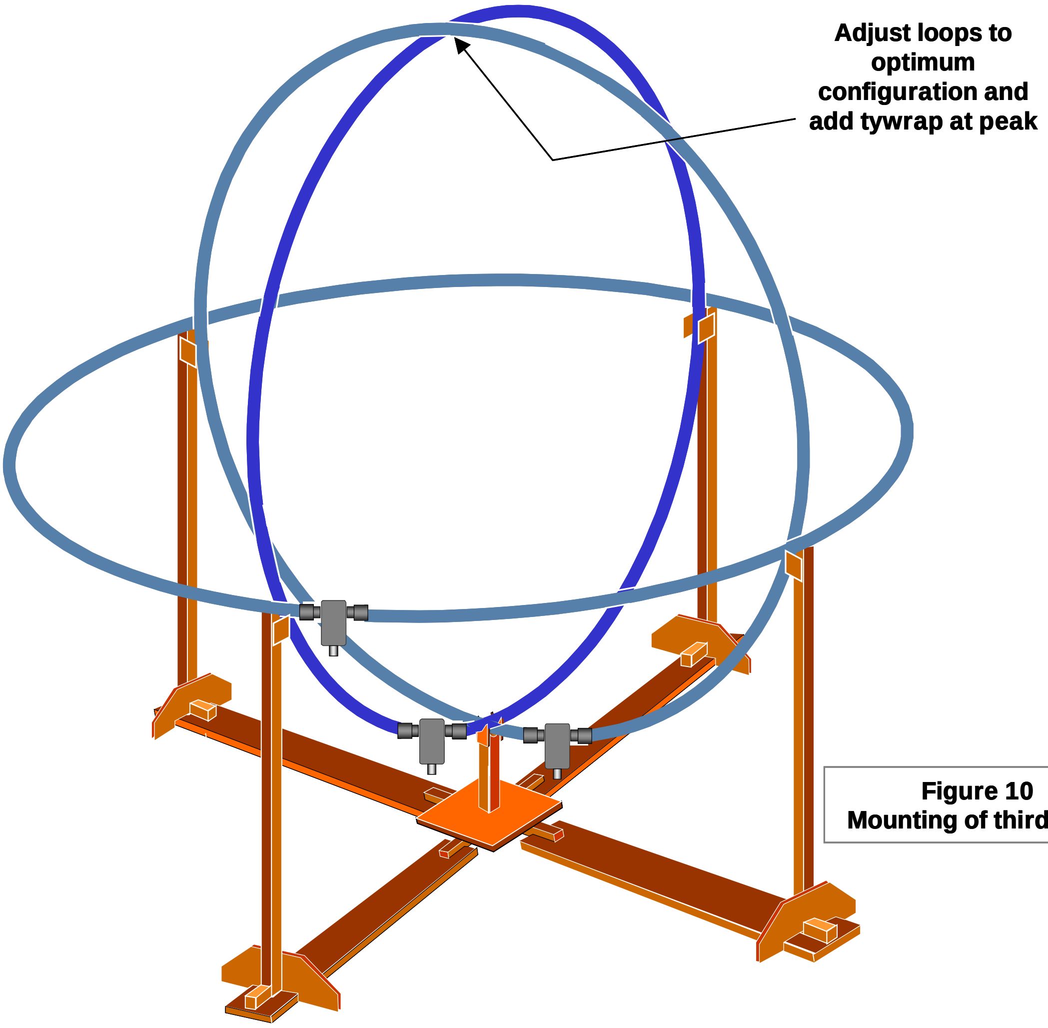


Figure 10
Mounting of third loop

8. The loops can now be adjusted for best shape and position. Generally the vertical loops will tend to sag into the lower half of the antenna. These are held up in position by using the tiewraps as shown in fig 8 on each corner post to take some on the weight of the loop. The top of the vertical loops can be adjusted for best shape and the two loops fastened together with the fifth tiewrap. With care, the tiewraps can be adjusted to produce reasonable circles for each loop.
Note that the exact shape is not critical. Deviation from perfect circles is inevitable but this has no significant effect on antenna performance. EN55015 states in section 7.2 that even the position of the UUT in the antenna is not critical.

9. Within the loop, construct a wooden stand or table to suit the products to be tested. This is not included with the RF300 because it needs to be matched to individual customers requirements. The stand should hold the product roughly central within the loop.

10. Connect the loop transducers to the switch unit as shown in fig 11. The 3 transducer cables are identified by having thick RF absorber filters along their length. Fit the cables so that these filters are nearest to the switch unit.
The switch unit is intended for floor mounting, or may be mounted on a suitable table if preferred. The short co-ax cable acts as a patch cable to switch each input, one at a time, to the output.
The output from the switch unit is connected direct to the analyser or receiver.

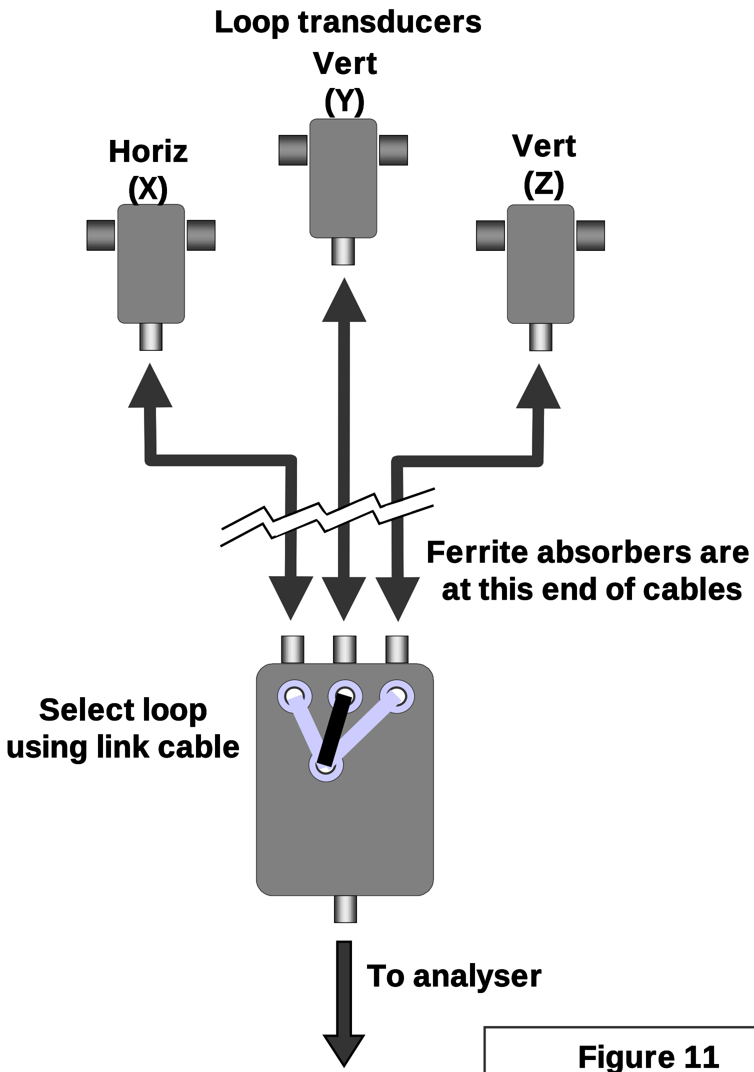


Figure 11
Connections to selector unit

Calibration loop

The RF300C calibration loop is manufactured to comply with CISPR16.

Full details of the use of this loop are provided in this standard.

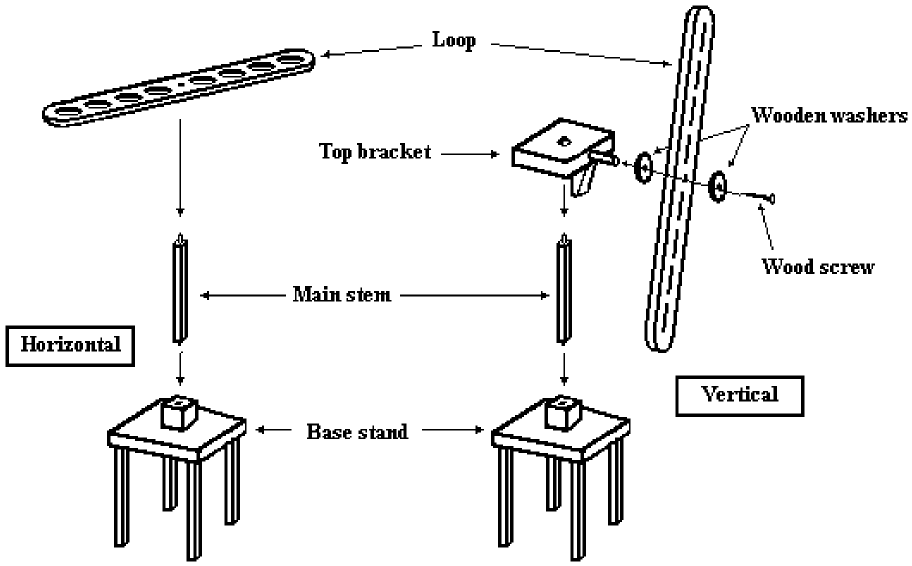


Fig 12
Assembly of calibration loop

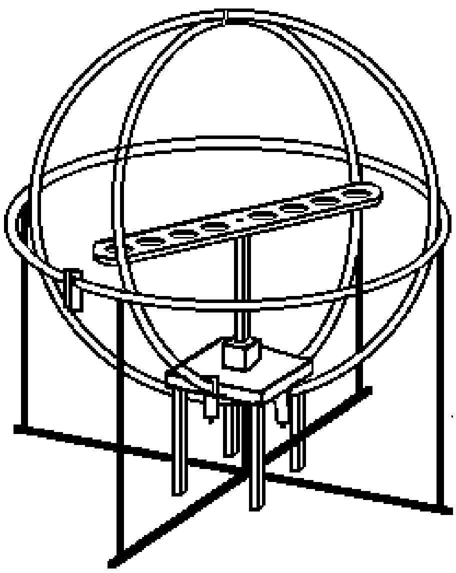


Diagram shows setup for calibration of horzontal loop.

Fig 13
Using the calibration loop

Calibration data

See appendix A

The calibration data for each loop is virtually identical. The following details therefore apply to all three axes, although full data for each axis is given in the appendix.

For reference, the 'ideal' curve is shown in graph 1. This is taken directly from EN55016, annex C, Figure C8.

The antenna factor data for the RF300 are also given.

This 'antenna factor' correction data effectively converts the output from the RF300 (measured in dBuV) directly to dBuA.
The data can be used with any analyser or receiver capable of EMC measurements.
The estimated measurement uncertainty is 3dB.

For a detailed explanation of the calibration of the RF300 and discussion of changes to CISPR15 (EN55015) and CISPR16, see appendix B

<u>If using the SA1002 or SA3000 analyser:</u>

The RF300 is listed under the normal **Inputs** menu. Just select this device and the software automatically applies the appropriate correction factors so that the trace reads correctly in dBuA and can be compared directly with the EN55015 limits.

Further details are given overleaf.

Operation

Details of the measurements and limits are given in EN55015, section 4.4. A copy of this should be consulted if performing compliance tests.

The UUT should be mounted on a wooden frame or table in the centre of the antenna. The position is not critical.

Connecting cables to the EUT should leave the volume enclosed by the loops in such a way as to be kept away from the loops to avoid capacitive coupling. See Fig C6 in CISPR16.

Each axis (loop) should be measured in turn. Each should meet the requirements of the standard. The loops are individually selected by connecting the short patch lead to the appropriate input socket as shown in fig 11.

Measurement with the SA1002 or SA3000 and EMCEngineer Windows software.

1. Select the **RF300** item under the input menu. The vertical scale will indicate units of dBuA. (If this item is not available, you need a later version of the software. Contact your supplier)

2 Under the **limits** menu, select the **EN55015** .... **2m loop antenna** limit line.

3. Connect the switch unit to the analyser input.

4. With the UUT switched off, check the background signal level. At frequencies below 1MHz, the background can be very strong. If strong signals do exist, check that the analyser is not in compression by changing the input attenuator setting on the analyser and comparing scans. Apart from the base line, the traces should overlay. If this happens then it is OK to use the analyser with that attenuator setting. If not, increase the attenuation and try again.

5. If the background is strong, it is advisable to either find a ‘quieter’ location or screen the room.

6. Switch the UUT on. Check the levels of signal over the background levels using the techniques used for conventional radiated testing as described in the user guide.
The levels displayed are fully compensated for the RF300 characteristics and can be compared directly with the limit lines.

7. ALWAYS check for compression (overload) when taking measurements. The amplitude of the reading on the screen cannot be used directly as a guide for compression because the readings have been adjusted for the RF300 characteristics.
If it is suspected that the signals are too strong even with the attenuator switched in, install the 10dB attenuator in the input lead to the switch unit. This additional

attenuator can be automatically compensated for in the software by adjusting the pre-amp settings on the screen.

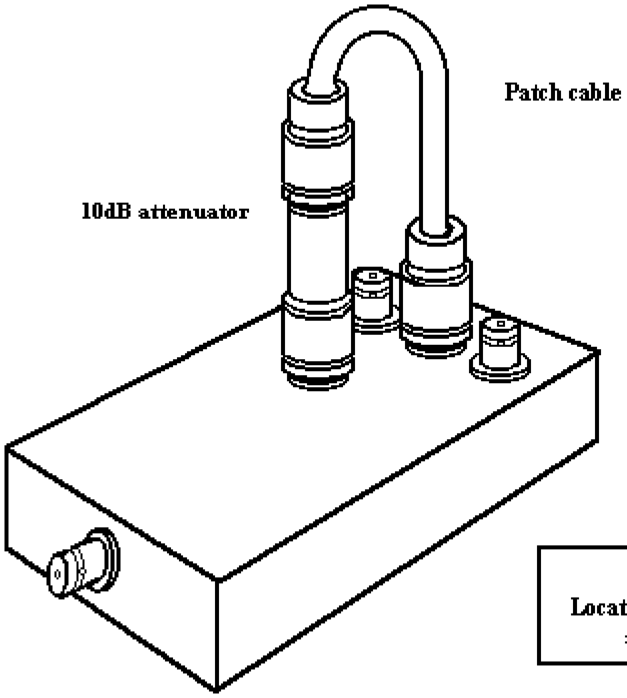


Fig 12
Location of additional attenuator

8. If the background and the product is ‘quiet’, and especially at frequencies above 20MHz, use 0dB attenuation.

APPENDIX A

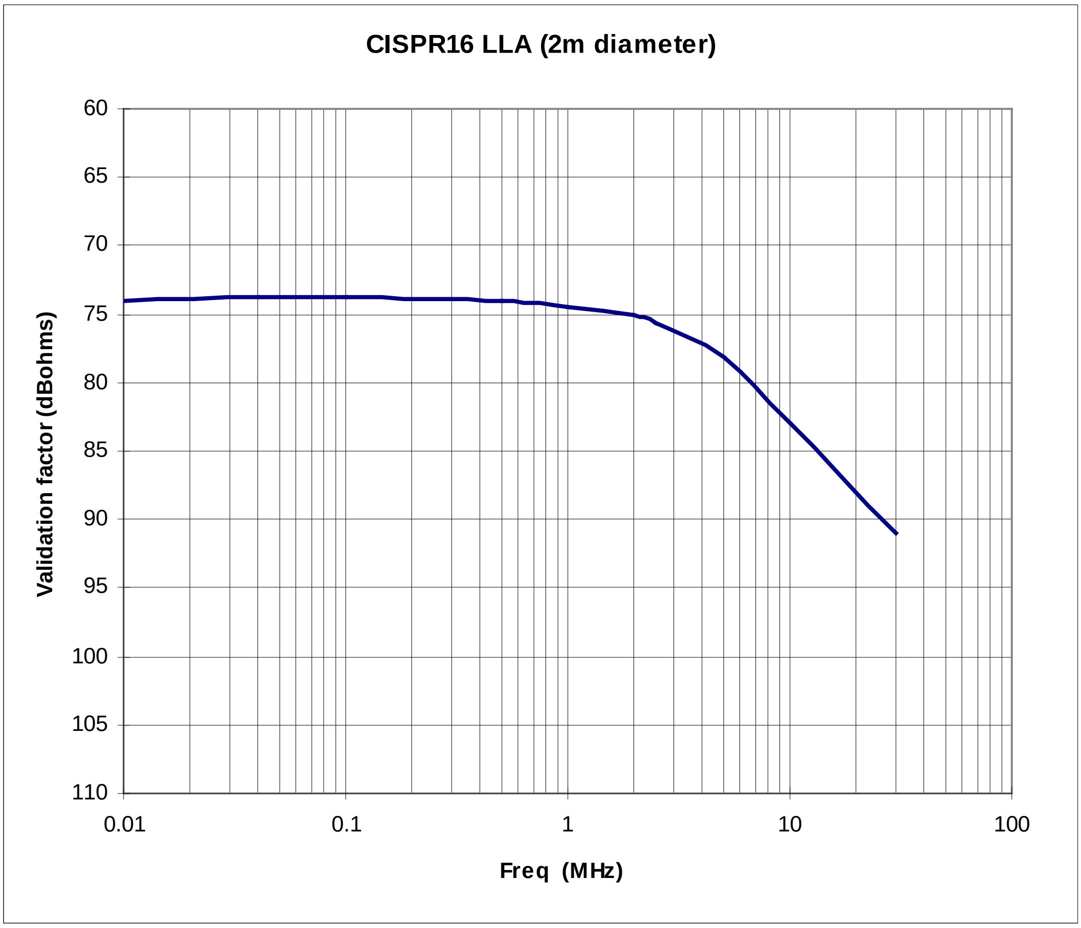
CALIBRATION DATA

1. CISPR16 ‘ideal’ plot

2. Calibration data.

3. RF300 actual sensitivity plots and RF300 correction plot (Antenna Factor)

EN55015 Standard antenna response



Calibration data

Freq.	Calibration			Freq.						EN		
MHz	9072A	9072B	9072C	MHz	Average	Max	Min	Range	Freq	55015	Freq	A.F
0.01	37.68	37.68	36.68	0.01	37.35	37.68	36.68	1.00	0.01	46	0.01	8.65
0.04	48.68	47.68	48.68	0.04	48.35	48.68	47.68	1.00	0.04	46.5	0.04	-1.85
0.10	55.68	55.68	55.68	0.10	55.68	55.68	55.68	0.00	0.10	46.5	0.10	-9.18
0.20	62.68	62.68	62.68	0.20	62.68	62.68	62.68	0.00	0.20	46.5	0.20	-16.18
0.50	69.68	69.68	69.68	0.50	69.68	69.68	69.68	0.00	0.50	46	0.50	-23.68
1.00	71.68	71.68	71.68	1.00	71.68	71.68	71.68	0.00	1.00	45.5	1.00	-26.18
2.50	71.68	71.68	71.68	2.50	71.68	71.68	71.68	0.00	2.50	44	2.50	-27.68
5.00	67.68	67.68	67.68	5.00	67.68	67.68	67.68	0.00	5.00	41	5.00	-26.68
10.00	62.68	62.68	62.68	10.00	62.68	62.68	62.68	0.00	10.00	37.5	10.00	-25.18
15.00	60.68	59.68	59.68	15.00	60.01	60.68	59.68	1.00	15.00	35	15.00	-25.01
20.00	55.68	55.68	55.68	20.00	55.68	55.68	55.68	0.00	20.00	32.5	20.00	-23.18
25.00	55.68	55.68	55.68	25.00	55.68	55.68	55.68	0.00	25.00	30.5	25.00	-25.18
30.00	52.68	52.68	53.68	30.00	53.01	53.68	52.68	1.00	30.00	28	30.00	-25.01

Calibration sources

Laplace Instruments Ltd, RF300C calibration loop to CISPR16, annex C5.

Laplace Instruments Ltd, SA1002 Spectrum analyser s/n 1010
Calibration: Laplace: 16.03.2009

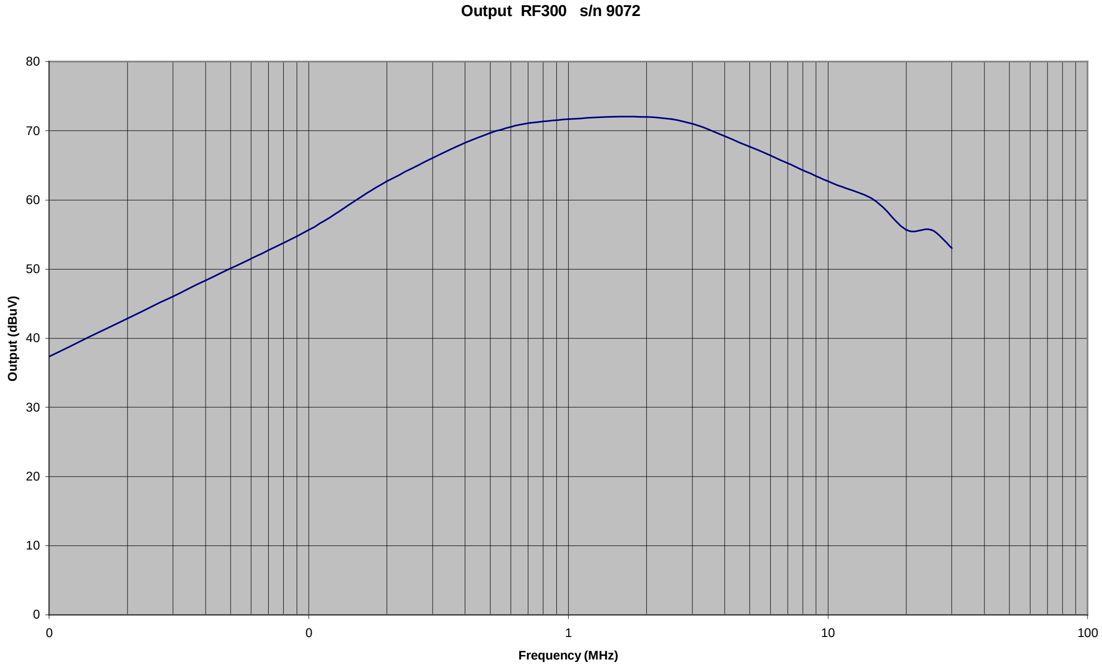
Marconi TF2016A signal generator, s/n 118032/004
Calibration: Checked against Marconi TF2019A, s/n 118449-169

Advantest R4131D calibrated by Schaffner, 20.11.02 and checked against Marconi TF2019A, s/n 118449-169

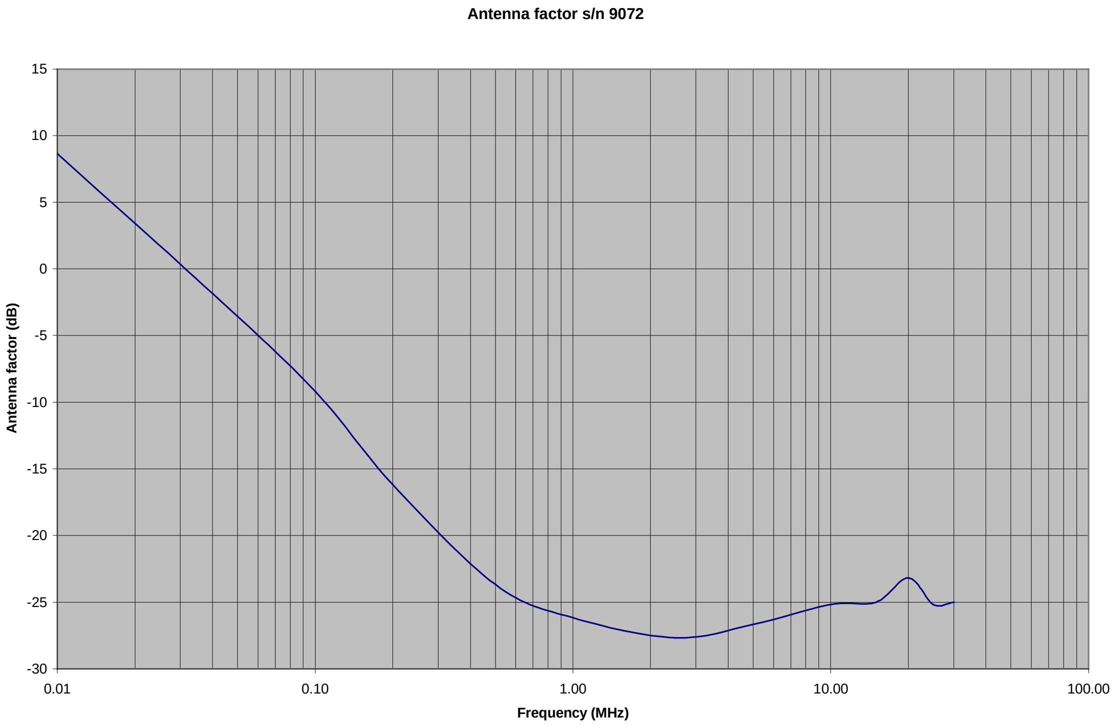
Marconi TF2019A, serial number 118449-169, calibrated by Industrial Calibration Ltd, 22.06.07

Actual output plots for the loops

Output



Antenna factor



Appendix B

Technical Report	Laplace Instruments Ltd	January 2010

RF300 Large loop antenna, an analysis of changes to the standards

These changes are due to the amendments to CISPR15 and CISPR16

The latest versions are now …..
CISPR15:2006 + A2:2009 and
CISPR16-1-4:2007 + A1:2008

The key changes related to LLAs are:

1. Sections related to the construction and specification of LLAs are moved from CISPR15 to CISPR16. Note that in the new CISPR15, the requirements for the LLA are referred to Section 4.7.1 in the new CISPR16, which does not exist! It seems that the reference should be to Section 4.6.1. The same error is repeated in CISPR16 which again refers in Annex C to the non-existent section 4.7.
2. The definition of the calibration data has been re-defined.

Note 1.
The details of the LLA were given in Annex B of CISPR15. These are now transferred to Annex C of CISPR16. Most of the content has remained the same, but Table 1 summarises the changes.

Previous CISPR15	New CISPR16	Notes	Significant changes
Annex B	Annex C	Description, construction and validation of LAS	Both annexes combined into one.
Annex C			
Clause B1	Clause C1	Introduction	Loop antenna named LAS (Loop Antenna System
Clause B2	Clause C2	Construction of LAS	Additional requirements for cables and connectors.
	Clause C3	Construction of loop	Information previously included with diagrams now included in text. Note low R for inner conductor is required.
Clause B3	-----	Positioning of the LAS	Requirement for minimum distance to nearby objects,…… not included in new CISPR16
Clause B4	Clause C4	Validation	New definition for validation factor. (see below).
Figure B1	Figure C1	General view	None
Figure B2	Figure C2	Position of slits	None
	Figure C3	Construction of slits	None
	Figure C5	Metal box for current probe	None
Figure B3	Figure C4	Example slit construction	None
Figure B4	Figure C8	Validation factor	Converted from dBuA to dB(Ω). See below.
	Figure C7	Positions of calibration loop	None
	Figure C9	Construction of calibration loop	None
Figure C1	Figure C11	Sensitivity vs diameter	None
Figure C2	Figure C10	Conversion factors between loop current and magnetic field strength at a distance.	Factors for magnetic field with electric field added. Factors for distance 30m removed.

Note 2
CISPR15 gave the verification data as a plot of loop current in dBuA vs frequency for the standard test signal (1V, open circuit voltage with a source impedance of 50ohm). This seems to be a straightforward method, especially as the limits are quoted in dBuA, so it's a direct correlation between the calibration loop and the limits.

CISPR16 is essentially the same information, but presented differently. It specifies the relationship between the source voltage (1V, as specified above) and the output current in the loop as measured by the current probe. Note that the current probe has a transfer characteristic of 1V/A. The relationship between volts and current is ohms, hence the use of dB(ohms) as the 'validation factor'.

The result is therefore a conversion factor scaled in dB(Ω) to convert current to voltage,
CISPR16 defines the validation factor dB(Ω) = 20*log(Vs/Ii) where Vs is the source voltage and Ii is the loop current.
Vs = 1V = 1,000,000uV

Under 'old' CISPR15, for Ii @ 100KHz = 46dBuA = 200uA
So the new CISPR16 value is 20*log(1000000/200) = 74 dB(Ω)
and
Old CISPR15 for Ii @ 30MHz = 29dBuA = 29uA
So the new CISPR16 value is 20*log(1000000/29) = 91 dB(Ω)

These calculations confirm the relationship between the CISPR15 plot and the CISPR16 validation factor.

The plots in the standards assume a current probe with a 1V/A transfer function. Such probes are 'active' but provide a flat frequency response. The RF300 uses passive probes which have a non-flat frequency response. This is not important if the probe is 'inside' the calibration loop and has a linear transfer function with amplitude. These factors hold true for the probe that is used. So the RF300 antenna uses an antenna factor correction to produce a calibration that agrees with the validation factor. This antenna factor is supplied with each antenna, and is equivalent to the correction factors as supplied with all EMC antennas, test cells, LISNs and other types of transducer.

Using the antenna factor data with the RF300 enables the output to be compared directly with the limits as specified in EN55015.