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Title:
Amendment to CISPR 22: Clarification of its application to telecommunication system on the method of disturbance measurement at ports used for PLC (Power Line Communication)
(Titre) :

Introductory note
In CISPR 22, conducted disturbances of ITE are measured at the mains port and at the telecom port. PLC modems however use one port only for both purposes (mains power supply and telecom). This leads to the definition of the **Multi Purpose Port**[1] for PLC.

The current document is based on the principle that PLC equipment is required to meet the same radio protection limits as any other wire bound communication system. The interference potential at the multi purpose port is thus measured twice:

1) in its function as a power consumer (i.e. communication function disabled) using the familiar V-network and limits in tables 1 and 2 of CISPR 22 and;
2) in its function as telecom device using the T-network specified within this document and applying the limits in tables 3 and 4 of CISPR 22.

National committees are advised that this application of separate limits for the different functions is a new approach in CISPR/I and are asked to comment on this approach.

The test methods proposed are based on the principle that:

- A consumer appliance power supply is an unsymmetrical source of disturbance in which case a V-network (AMN) is suited to determine the interference potential.
- In contrast a telecom device is engineered to be a symmetrical source where the common mode signal, which is the cause for radiation, is much smaller than the differential mode signal. A T-ISN is suited to measure the common mode voltage, accounting for the conversion of differential to common mode due to a defined unbalance (LCL) representative of the appropriate network performance.

National committees are advised that this document includes some specific test methods and CISPR/I is looking for guidance as whether this work (which is specific to PLC) should be transferred to CISPR/A.

A Task Force of CISPR/I/ WG3 is mandated to determine the LCL function suitable for low voltage power distribution networks.

This CD is based on CISPR/I/33/INF (compilation of comments on CISPR/I/26/DC) and decisions at the CISPR/I WG3 meeting held on 27 - 28 June 2002 in Red Bank.

[1] not defined in CISPR 22:1997 but defined in this CD

Amendment to CISPR 22: Clarification of its application to telecommunication system on the method of disturbance measurement at ports used for PLC

Change the following paragraphs as follows (changes/additions underlined):

Add new paragraph 3.7 to read as follows

<u>3.7 Multi Purpose Port</u>

<u>A port, connecting to low voltage distribution networks supporting data transfer and telecommunications, which combines the functions of the telecommunication port and the mains port.</u>

Change paragraph 5 to read as follows:

5 Limits for conducted disturbance at mains <u>ports, multi purpose ports</u> and telecommunication ports

The equipment under test (EUT) shall meet the limits in tables 1 and 3 or 2 and 4, as applicable<u>. Multi purpose ports have to be measured twice:</u>

<u>a) with the communication functions inactive using an AMN in conjunction with the limits of tables 1 or 2 and</u>

<u>b) with the communication functions active using a T-ISN in conjunction with the limits of tables 3 or 4.</u>

<u>Meeting the limits shall include</u> the average limit and the quasi-peak limit when using, respectively, an average detector receiver and quasi-peak detector receiver and measured in accordance with the methods described in clause 9. Either the voltage limits or the current limits in table 3 or 4, as applicable, shall be met except for the measurement method of C.1.3 where both limits shall be met. If the average limit is met when using a quasi-peak detector receiver, the EUT shall be deemed to meet both limits and measurement with the average detector receiver is unnecessary.

If the reading of the measuring receiver shows fluctuations close to the limit, the reading shall be observed for at least 15 s at each measurement frequency; the higher reading shall be recorded with the exception of any brief isolated high reading, which shall be ignored.

Change Headline of paragraph 5.1 to read as follows:

<u>Limits of disturbance voltage of mains terminals and multi purpose ports with communication functions inactive.</u>

Change Headline of table 1, paragraph 5.1 to read as follows:

Table 1 – Limits for conducted disturbance at the mains ports<u> and at multi purpose ports with communication functions inactive </u>of class A ITE.

Change Headline of table 2, paragraph 5.1 to read as follows:

Table 2 – Limits for conducted disturbance at the mains ports<u> and at multi purpose ports with communication functions inactive </u>of class B ITE.

Change Headline of paragraph 5.2 to read as follows:

5.2 Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports <u>and multi purpose ports with communications functions active.</u>

Change Headline of table 3, paragraph 5.2 to read as follows:

Table 3 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports <u>and multi purpose ports with communications functions active</u> in the frequency range 0,15 MHz to 30 MHz for class A equipment.

Change Headline of table 4, paragraph 5.2 to read as follows:

Table 4 – Limits of conducted common mode (asymmetric mode) disturbance at telecommunication ports <u>and multi purpose ports with communications functions active</u> in the frequency range 0,15 MHz to 30 MHz for class B equipment.

Change Headline of paragraph 9 to read as follows:

9 Method of measurement of conducted disturbance at mains<u> ports, multi purpose ports</u> and telecommunication ports

Change the last sentence of 9.4 to read as follows:

A telecommunication port or a multi purpose port is connected by its signal cable to a T-ISN

Change the headline and the first paragraph of 9.5 to read as follows:
9.5 Measurement of disturbances at telecommunication ports and multi purpose ports

The purpose of these tests is to measure the common mode disturbance emitted at the telecommunication ports and multi purpose ports of an EUT.

Change the last sentence of paragraph 9.5.1.1 to read as follows:
9.5.1.1 Alternative 1
…
In cases of dispute the method of conformance in 9.5.1.2 takes precedence for telecommunication ports intended to be connected to category 3 and category 5 cables (see ISO/IEC 11801) or for multi purpose ports connected to low voltage distribution networks.

Add to paragraph 9.5.1.2 following the last sentence:
9.5.1.2 Alternative 2
…
For multi purpose ports intended to be connected to low voltage distribution networks the measurement is made using a T-ISN with an LCL as defined in c) 4) of 9.5.2.

Add to paragraph 9.5.2 an option c)4) to specify a T-shaped ISN for PLC equipment:
9.5.2 Impedance stabilisation network (ISN)
…
c)4) T-ISN for method of conformance alternative 2, multi purpose ports for low voltage distribution networks

The longitudinal conversion loss (LCL) shall be:

- 150 kHz to 30 MHz: 36 dB +/- 3dB

Change the headline of 9.5.3 to read as follows:
9.5.3 Measurement at telecommunication ports and multi purpose ports

Add a new paragraph 9.5.3.6:
Measurement at multi purpose ports intended for connection to low voltage distribution networks

The measurement method of C.1.5 shall be used.

Contributions of AE equipment to the measured levels of EUT mains disturbances shall be minimised. Therefore, PLT terminal adapter or PLC network simulator transmissions shall be adjusted to the minimum levels necessary to exercise the normal PLT transmission functions of the EUT. Bonding to the metal reference plane, or insulation from it, shall duplicate normal usage.
EUT mains supply ports that are NOT used for PLC shall not be measured for disturbances in the way illustrated above but shall be measured, and shall comply with the relevant mains disturbance limits, using an AMN as specified in clause 9.2.
The terminals of the T-ISN will be, in general, at mains potential. For operator safety they shall be insulated or otherwise made inaccessible.

Change first sentence of paragraph C.1 in Annex C to read as follows:
These test methods and test set-ups are used for multi purpose ports (C.1.5) or for cases where ISNs specified in 9.5.2 are not applicable.

Add C.1.5 to paragraph C.1 of Annex C to read as follows:
C.1.5 shall be applied to low voltage power distribution networks.

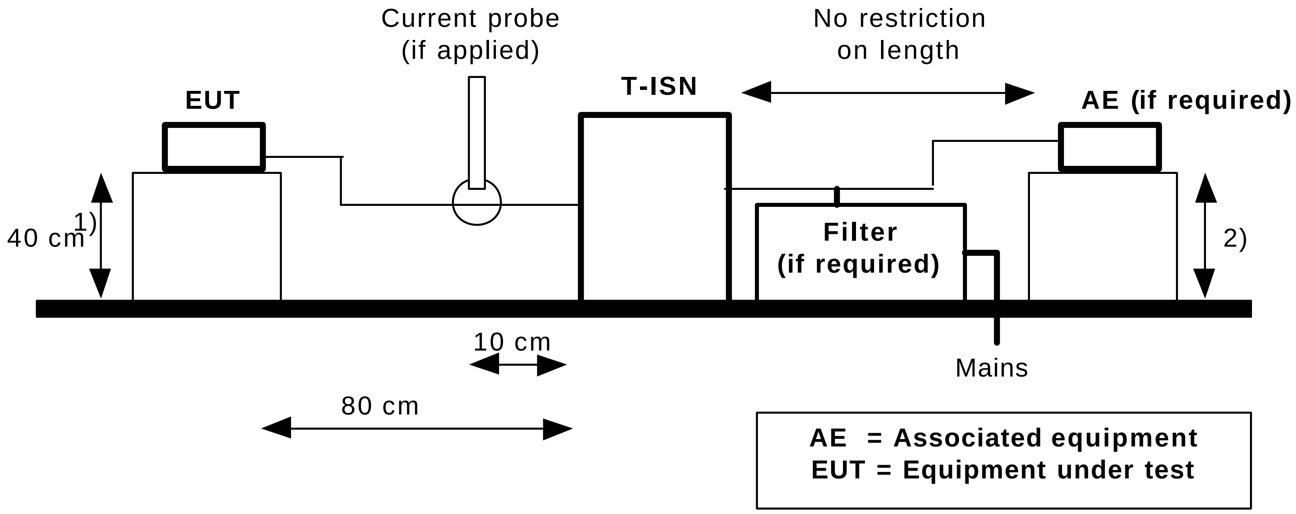
Add title and text of subclause C.1.5 to read as follows:

C.1.5 Using T-ISN

- Connect T-ISN directly to reference groundplane.
- If voltage measurement is used, measure voltage at the measurement port of the T-ISN, correct the reading by adding the voltage division factor of the T-ISN, and compare to the voltage limit.

- If current measurement is used, measure current with the current probe and compare to the current limit.
- It is not necessary to apply both, the voltage and the current limit if a T-ISN is used.
- A 50 O load has to be connected to the measurement port of the T-ISN during the current measurement.

Add figure C.5 to look as follows:



1) Distance to the reference groundplate (vertical or horizontal)
2) Distance to the reference groundplate is not critical

Figure C.5: Compliance test set-up

Add the following paragraph after figure C5.

To ensure that at any test frequency unwanted signals existing on the supply mains do not affect the measurement, an additional RF low-pass filter may be required, inserted between the T-ISN to AE connection and the supply mains. The recommended attenuation of this filter is at least 40 dB over the frequency range from 150 kHz to 30 MHz for both the differential-mode and the common-mode voltages. With this filter inserted, the impedance requirements given below shall be met. The components forming this filter shall be enclosed in a metallic screen directly connected to the reference earth of the measuring system. The voltage drop of the RF low-pass filter shall comply with clause 5.1.8 of CISPR 16-1:99.

The differential-mode impedance presented by the RF low-pass filter to the T-ISN and to the AE, from 1.6 to 30 MHz, has to be at least 20 times the differential-mode impedance of the EUT in transmit mode or the AE in receive mode, whichever is the largest.

The T-ISN shall have the following properties:

a) The common mode termination impedance in the frequency range 0,15 MHz to 30 MHz shall be 150 O ± 20 O, phase angle $0^0 \pm 20^0$.

b) The T-ISN shall provide sufficient isolation against disturbances from an AE. The attenuation of the T-ISN, for common mode current or voltage disturbances originating from the AE, shall be such that the measured level of these disturbances at the measuring receiver input shall be at least 10 dB below the relevant disturbance limit.

The required isolation is at least:

- 150 kHz to 1,5 MHz > 35 dB to 55 dB, increasing linearly with the logarithm of the frequency
- 1,5 MHz to 30 MHz > 55 dB.

Note – Isolation means the decoupling of common mode disturbance originating in an AE and subsequently appearing at the EUT port of the T-ISN.

c) The T-ISN implements an LCL of 36 dB ± 3 dB in the whole frequency range.

NOTE 1 – The above specification of LCL versus the frequency (c) is an approximate representation of the LCL between phase and neutral of typical mains networks as installed in representative environments. Such specifications are under continuing study and open to future modification.
NOTE 2 – The LCL is defined in accordance with the ITU-T Recommendation G.117: 1996.

d) The attenuation distortion or other deterioration of the signal quality in the wanted signal frequency band caused by the presence of the T-ISN shall not significantly affect the normal operation of the EUT.
e) If a voltage port on the T-ISN is available then the accuracy of the voltage division factor shall be within ±1,0 dB. The voltage division factor is the difference between the voltage appearing across the common mode impedance presented to the EUT by the T-ISN and the resulting voltage appearing across a receiver input attached to the measuring port of the ISN, expressed in decibels. For example, for a 150 O common mode impedance and a 50 O receiver input, the voltage division factor is given by 20 $\log_{10}$ (50/150) = -9,5 dB

Change title of figure C.5 to read as follows:

Figure C.6 – Calibration fixture

Add Figure D.5 with note to annex D as follows:

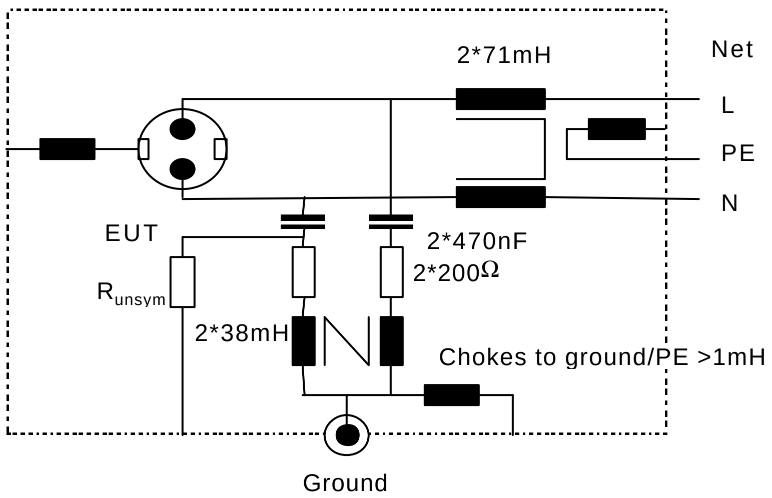


Figure D.5 T-ISN for use with power distribution networks

Note: By calibrating the resistor Runsym, the desired LCL can be achieved. This calibrating is necessary due to tolerances within the characteristics of the used chokes. The method for calibrating the ISN is to adjust the resistor while measuring the LCL of the ISN with the same method as used for the power network. If the desired LCL is reached, the value of Runsym is frozen.

Annex A
(informative)

Justification of LCL figure quoted

A.1 Documented data on LCL measurements for national committees to make an informed decision on the proposed LCL value

A measurement campaign is being performed in various countries, in order to determine the LCL of real electricity networks.
Figure A.1 shows results obtained up to the date for in-home electricity networks. The basic theory of LCL measurements can be found in the ITU-T Recommendations G.117 (02.96) and O.9 (03.99). The practical measurements are carried out according to the method described by Ian P. Macfarlane in IEEE Transactions on electromagnetic compatibility, Vol. 41, No. 1, February 1999. This method is by no means new. It was first described by Macfarlane in 1988 to CISPR Subcommittee G Working Group 2. It was developed to assist that WG's consideration of measuring methods at balanced signal ports of Information Technology Equipment for a revision of CISPR Publication 22. Since then it is considered a well proven method by the EMC community. According to the experience of the contributors to this paper, the Macfarlane methodology is also well suited to LCL measurement on low voltage distribution networks.

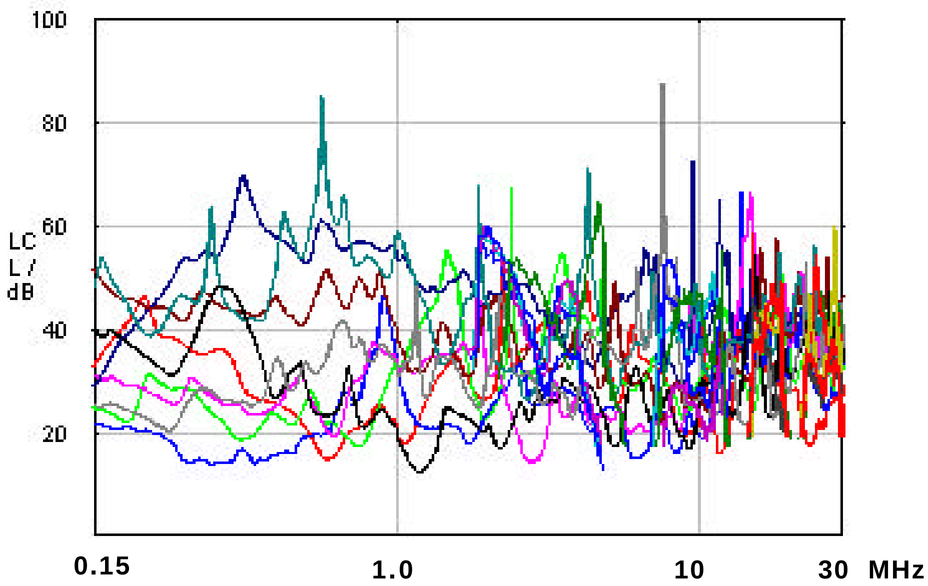


Figure A. 1. LCL - In-home electricity networks phase-neutral

Some measurements were also made on access lines. Their number is somewhat smaller and not sufficient for statistical analysis. Considering the available data it appears that the LCL of access lines is somewhat higher than the LCL on in-home lines.

A.2 Test method and apparatus used for measurements presented in A.1

A.2.1 The test adapter and formulas used.

The test method described below Figure A.2 shall allow any expert to collect additional data under comparable test conditions

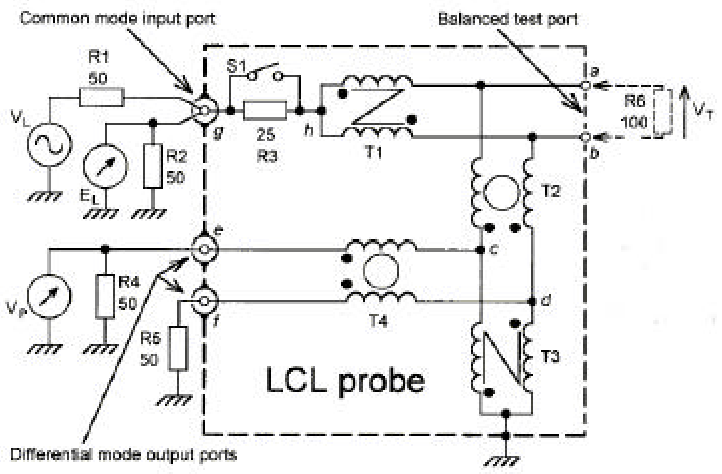


Figure A.2 Universal LCL measurement adapter according to Macfarlane IEEE Trans. on EMC, Vol. 41, No. 1, pp 3-14.

The measurements were made by connecting the terminals a/b of the balanced test port via safety capacitors of 100 nF each to the phase respectively to the neutral of low voltage distribution networks. The differential mode impedance is 100 O (R4 + R5). The common mode generator impedance is 100 O/4 = 25 O. For this purpose EL is maintained constant and the switch S1 is open. LCL is calculated as follows:

LCL = 20 log (EL / VT) or

LCL = 20 log (EL / 2 VP)

A.2.2 An example of a test equipment set-up

The measurements can be performed with 4-port test equipment like a network analyser or with a spectrum analyser-tracking generator combination. If both the generator output impedance and the analyser input impedance is 50 O, the impedance requirements of R1 through R3 of the LCL test adapter are met by simply connecting the measuring equipment to the probe. Other equipment needed is an amplifier if the output of the test-generator is not sufficiently high and surge limiters to protect the input.

Additionally, commercially available adapters, which are designed for telephone line measurements, need to be modified for use with the mains supply voltage. At the test-terminals 'a' and 'b' of the LCL test adapter two safety capacitors (Cy) have to be added. In order to keep the measuring uncertainty low at 150 kHz, the value of the capacitor should be not smaller than 100 nF.

Due to the modification of the LCL adapter with the capacitors, the 'self' LCL of the adapter shall be measured and calibrated and the adapter must be re-calibrated according to the procedures described in Macfarlane IEEE Trans. On EMC, Vol. 41, No 1,pp 3-14. The self-LCL should be at any frequency at least 10 dB higher than the actual LCL values to be measured.

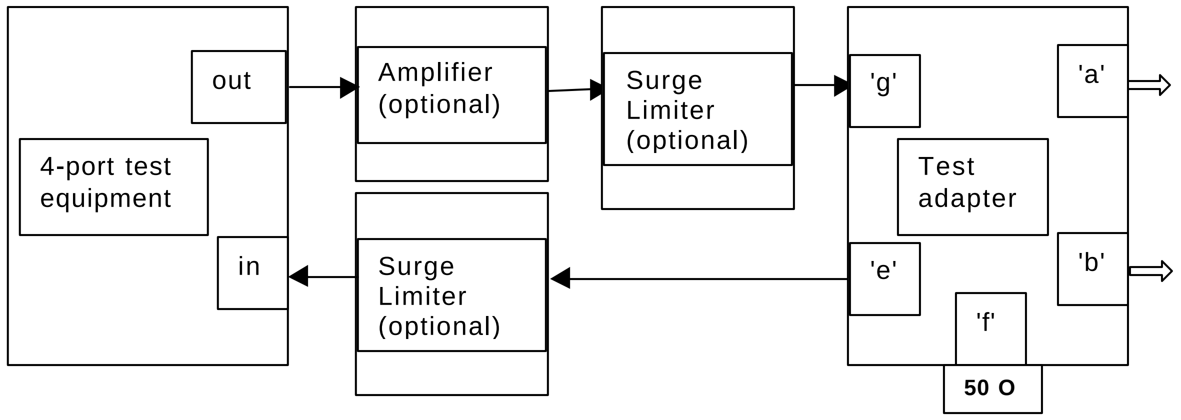


Figure A. 3 The measurement equipment set-up

The reference of the measuring set-up is ground. A virtual connection to the Ground is made by means of the large capacitance between a metal plane on which the measuring equipment - inclusive the test adapter - is placed and the environment. A trolley covered with e.g. copper or aluminium foil is a perfect measuring station. The surface of the metal plane should be at least 1 m^2. For safety reasons, the metal plate - and the measuring equipment on the metal plate - must be grounded. The safety ground point shall be isolated form the test set-up for frequencies above 150 kHz by means of common mode chokes in the ground wire. The value of the coil is at least 280 µH. This inductance value is taken form IEC61000-4-6, where it is used for the construction of CDN's. CDN's also can be used for the isolation of measurement set-equipment, e.g. a CDN M3 for the equipment power supply. An AMN with the earth connection switched 'on' also can be used.

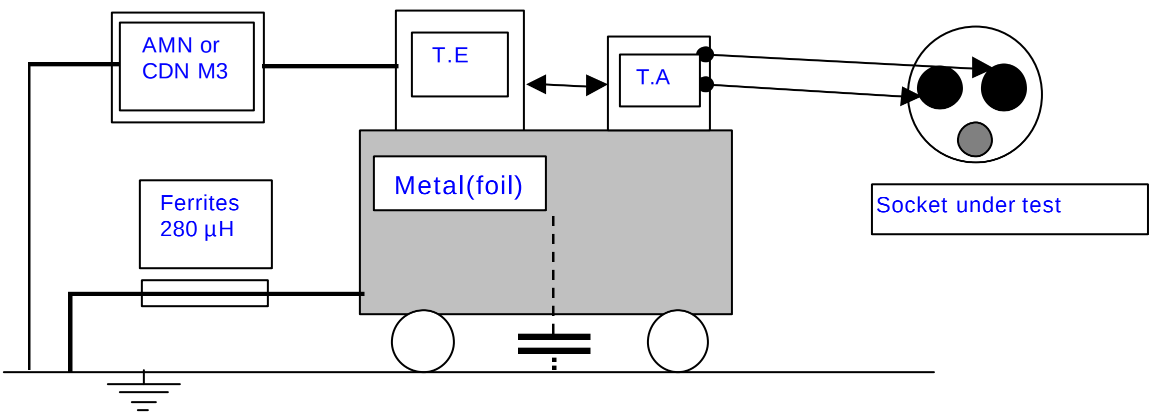


Figure A.4 The measurement equipment layout

T.E. = test equipment, connected to metal foil
T.A. = test adapter, bonded to metal foil
AMN = artificial mains network, earth coil switched 'on'
CDN-M3, defined in IEC 61000-4-6
Ferrite's on safety earth connection, value defined in IEC 61000-4-6

Note: If battery powered equipment is used, the AMN or the CDN-M3 are not present.

A.2.3 The test procedure

In this description of the test procedure it is assumed that there is only one voltage measuring device available, e.g. the input of a network analyser. This means that the voltage measurements at the ports 'g' and 'e' of the test adapter - see figure A.2 - can't be done simultaneously. If two voltage measuring devices are available, then the measuring procedure is slightly simpler. On the other hand, with two separate voltage measuring devices the tracking with the source can be a problem.

1. Connect the output of the voltage source to port 'g' of the test adapter. A coaxial T-piece is needed on port 'g'
2. Connect the input of the voltage measuring device also to port 'g' of the test adapter. Ports 'e' and ' f' are terminated with 50O. Record the injected voltage EL.
3. Connect the input of the voltage measuring device to port 'e' of the test adapter. T-piece port 'g' and port ' f' are terminated with 50O. Record the voltage VP.
4. Calculate LCL according to: LCL = 20 log (EL / 2 VP)

As an alternative, using modern spectrum analysers which keep VL constant versus frequency: If one closes S1 and one calculates LCL = 20 log VL / 4 VP there is no need to calibrate EL.

Note: The noise voltage at test adapter terminal 'e' with the test generator switched 'off' should be sufficiently low in order to get a minimum average signal to noise ratio of 10 dB. If this requirement is not met, the optional amplifier must be used.

A.3 Statistical Analysis of LCL-Measurement

The limit-value of LCL was derived by statistical analysis of all available LCL-measurement-results. The following analysis method was used:

The frequencies at which the sample values were either individually measured or selected out of frequency sweep measurements were chosen at random.
The limit value of LCL was chosen in such a way that 80% of the sample-values of LCL were equal or superior to the limit-value of LCL.

The result of this analysis showed a LCL-limit value of 36 dB.