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SERIES K: PROTECTION AGAINST INTERFERENCE

Method for measuring longitudinal conversion loss (9 kHz - 30 MHz)

Recommendation ITU-T K.86

ITU-T

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Method for measuring longitudinal conversion loss (9 kHz - 30 MHz)

Summary

With the liberalization in telecommunications, unbundling becomes commonplace in telecommunication networks. The unbundling of the access network increases the number of operators that may provide services within a common access network cable. In this context, unbalance is not only related to the transmission performance of the services, but also strongly related to electromagnetic compatibility (EMC) performance of the services. The longitudinal conversion loss (LCL) of telecommunication lines or telecommunication ports is a measure of the degree of unwanted transverse signal produced at the terminals of the network due to the presence of a longitudinal signal on the connecting leads.

Considering the frequency range of broadband services such as integrated services digital network (ISDN), asymmetric digital subscriber line (ADSL), ADSL2, ADSL2plus, very high-speed digital subscriber line (VDSL) and VDSL2, Recommendation ITU-T K.86 presents the method for measuring longitudinal conversion loss for the frequency range from 9 kHz to 30 MHz and presents the suggestion of the admissible value for the unbundling condition.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T K.86	2011-11-13	5

Keywords

LCL, longitudinal conversion loss, unbalance.

FOREWORD

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In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

Table of Contents

Recommendation ITU-T K.86

Method for measuring longitudinal conversion loss (9 kHz - 30 MHz)

1 Scope

This Recommendation specifies the method for measuring longitudinal conversion loss (9 kHz - 30 MHz) of the telecommunication cable and telecommunication port of the equipment used in analogue and digital communication systems by using the transmission measurement method; it also presents the suggestion of the admissible value for the unbundling condition.

This Recommendation is in agreement with the principles, the nomenclature and the definitions, addressed in [ITU-T O.9] and in [ITU-T G.117], which considers the transmission aspects of unbalance about earth.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T G.117] Recommendation ITU-T G.117 (1996), *Transmission aspects of unbalance about earth.*

[ITU-T G.961] Recommendation ITU-T G.961 (1993), *Digital transmission system on metallic local lines for ISDN basic rate access*.

[ITU-T G.992.1] Recommendation ITU-T G.992.1 (1999), *Asymmetric digital subscriber line (ADSL) transceivers.*

[ITU-T G.992.5] Recommendation ITU-T G.992.5 (2009), *Asymmetric digital subscriber line 2 (ADSL2) transceivers – Extended bandwidth ADSL2 (ADSL2plus).*

[ITU-T G.993.2] Recommendation ITU-T G.993.2 (2011), *Very high speed digital subscriber line transceivers 2 (VDSL2).*

[ITU-T O.9] Recommendation ITU-T O.9 (1999), *Measuring arrangement to assess the degree of unbalance about earth.*

3 Definitions

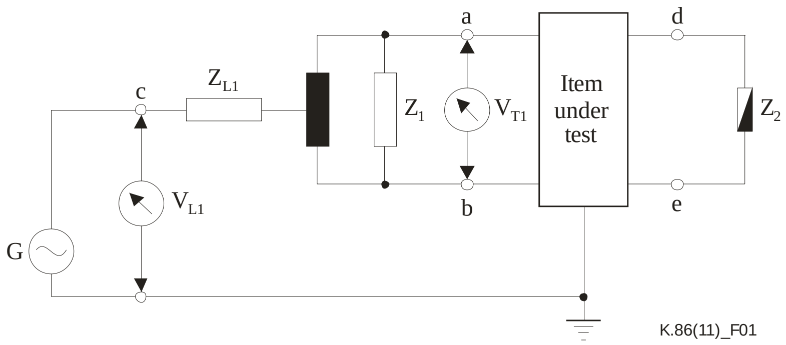
3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 longitudinal conversion loss (LCL) [ITU-T O.9]: The LCL of a one- or two-port network is a measure (a ratio expressed in dB) of the degree of unwanted transverse signal produced at the terminals of the network due to the presence of a longitudinal signal on the connecting leads. It is calculated as

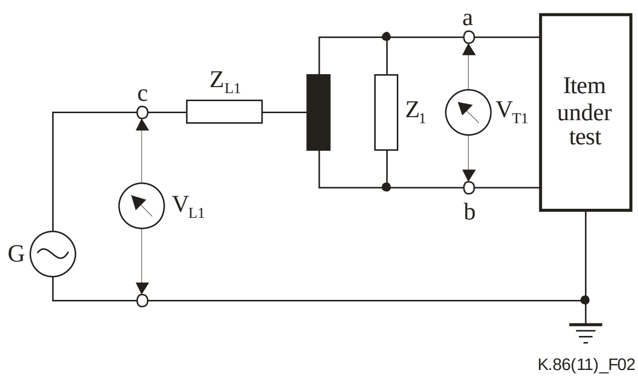
$$\text{Longitudinal conversion loss (LCL)} = 20 \text{ lg} \left| \frac{V_{L1}}{V_{T1}} \right| \text{ dB}$$

and measured as shown in Figure 1 and Figure 2. This technique is applicable to either the input or output terminals, e.g., transpose terminals a and b with d and e, respectively. (See clause 4.1.3 of [ITU-T G.117].)



G: Signal generator.

Figure 1 – Measurement of longitudinal conversion loss for a two-port network



G: Signal generator.

Figure 2 – Measurement of longitudinal conversion loss for a one-port network

Z_1 and Z_2 are the impedances connected in parallel to the input and/or output port, respectively, of the item under test. Z_1 and Z_2 are generally within ±25% of the nominal impedance of the port to which they are connected. If measurements are made via high-impedance input ports, an additional impedance Z_1 should be connected between points a and b. The longitudinal impedance Z_{L1} is nominally equal to $Z_1/4$. Different values, however, may be used. This may be necessary to more properly simulate operating conditions of the item under test.

3.2 Terms defined in this Recommendation

None.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADSL Asymmetric Digital Subscriber Line

EUT Equipment Under Test

ISDN Integrated Services Digital Network

LCL Longitudinal Conversion Loss

LCR Longitudinal Conversion Ratio

ONU Optical Network Unit

RFI Radio Frequency Interference

VDSL Very high-speed Digital Subscriber Line

VTU VDSL2 Transceiver Unit

VTU-O VTU at the ONU (or central office, exchange, etc., that is, operator end of the loop)

VTU-R VTU at the remote site (i.e., subscriber end of the loop)

5 Conventions

None.

6 Test methods and measuring arrangement

Longitudinal conversion loss (LCL) is measured using a network analyser by injecting a "common mode" signal between the pair and earth, and measuring the resulting "differential mode" signal between the wires in a pair.

6.1 Test equipment

For the measurement of LCL as shown in Figures 1 and 2, the test circuits shall be the combination of the following elements:

- a common mode signal injection circuit
- a common mode signal measurement
- transverse signal measurement
- balanced line termination.

The network analyser is the source for injecting a "common mode" signal between the pair and earth, and measuring the resulting "differential mode" signal between the wires in a pair.

A balun transformer as shown in Figure 3 combines the required elements listed above in a single package to interface directly with a network analyser. The inherent longitudinal conversion loss of the balun transformer within the frequency range from 9 kHz to 30 MHz should be 20 dB greater than the limit set for the item under test. Port 3 of the balun interfaces directly to the network analyser with matched impedance for measuring the transverse signal. Port 1 of the balun interfaces to the network analyser with matched impedance for injecting a longitudinal signal. Port 2 of the balun interfaces to the telecommunication cable or telecommunication port of the equipment under test (EUT) with transverse terminating impedance.

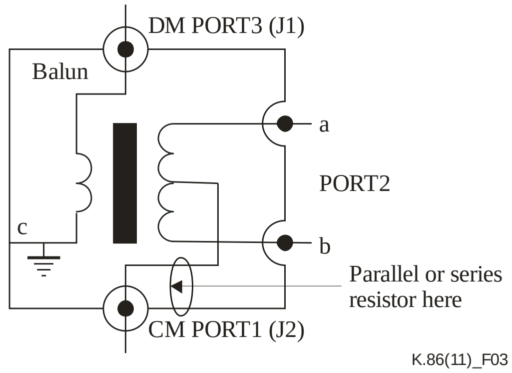


Figure 3 – Internal structure of the balun

A metal drum is necessary for the measurement of unscreened cable; it should be big enough to hold the length of unscreened cable in one layer for measurement.

6.2 Test methods and measuring arrangement for telecommunication ports

Generally the LCL of telecommunication ports such as the VDSL2 transceiver unit at the optical network unit (VTU-O) or VTU at the remote site (VTU-R) should be measured as a one-port network. Figure 4 shows the test methods and measuring arrangement for telecommunication ports with the equipment listed in clause 6.1.

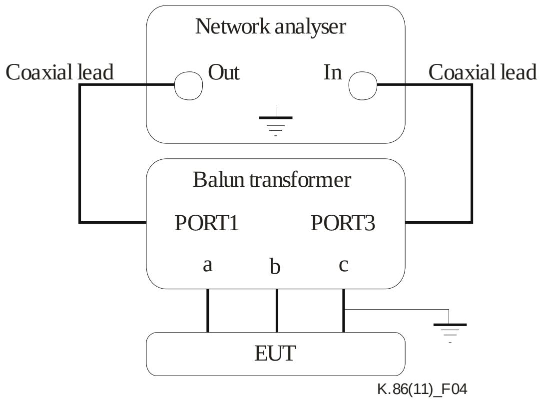


Figure 4 – Measuring arrangement for telecommunication ports

The transverse terminating impedance between terminals a and b should be referenced to the relevant ITU-T Recommendations as given in Table 1.

Table 1 – Impedance of telecommunication ports

Services	Frequency (Hz)	Impedance (ohms)	Reference
ISDN	80 8-800	150, 110	[ITU-T G.961]
ADSL	25-1104	100	[ITU-T G.992.1]
VDSL2	12 000 Up to 30 000	100	[ITU-T G.993.2]

6.3 Test methods and measuring arrangement for telecommunication cables

The LCL of the telecommunication cable should be measured as a two-port network. Figures 5 and 6 show the test methods and measuring arrangement for telecommunication cables with the equipment listed in clause 6.1.

The ends of the cable under test shall be prepared such that when connected to the terminals of the test equipment the twisting of the pairs/quads is maintained. The length of cable under test depends on the service for which the cable will be used. The length of cable for the Ethernet service should be 100 m ± 1 m. Appendix I provides a detailed description of the LCL test of shielded cables.

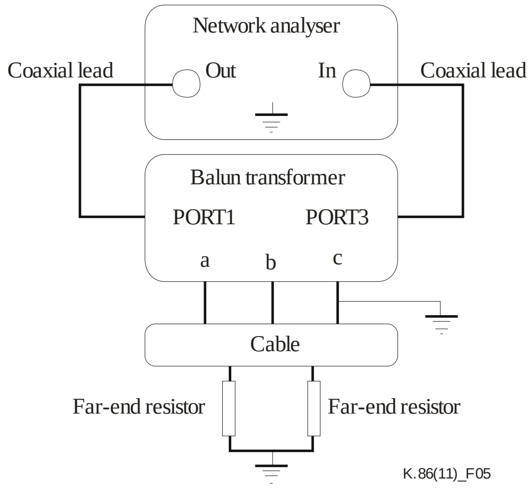


Figure 5 – Measuring arrangement for shielded telecommunication cables

Terminal C of the balun transformer in Figure 5 is connected to the outer shield of the test lead. The cable pair under test should be connected to the differential mode balun output terminals a and b. The far-end resistor network should be bonded together and connected to earth.

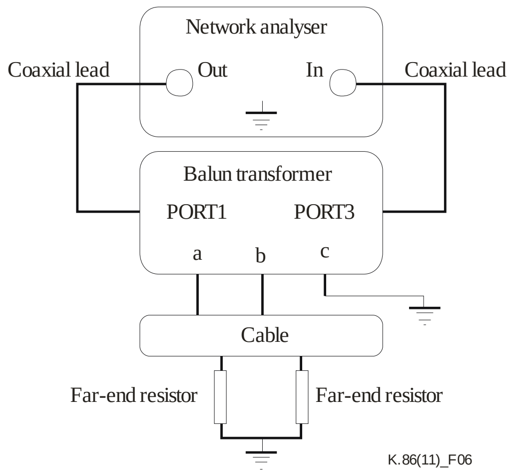


Figure 6 – Measuring arrangement for unshielded telecommunication cables

The cable in Figure 6 for the measuring arrangement shall be wound tightly around the metal drum in one layer. The distance between the windings should be at least the diameter of the cable. The metal drum shall be earthed by fixing the balun to the drum.

Far-end resistors are the impedances connected in parallel to the far ends of the telecommunication cable, respectively, of the item under test. Far-end resistors with precision better than 0.1% are generally within ±25% of the nominal impedance of the port to which they are connected.

7 Admissible longitudinal conversion loss value for the telecommunication port and cable

Cables for telecommunication purposes sometimes have to pass areas that have strong disturbing electromagnetic fields which may cause significant longitudinal signals along the cables. The disturbing effect may be caused by conversion from longitudinal mode to differential mode due to unbalance in the lines, the terminal, the switching equipment and any other equipment inserted in the longitudinal path.

Unbalance to earth is described in terms of longitudinal conversion loss (LCL). Admissible minimum LCL value for the telecommunication port measured in accordance with the above test method should be referenced to the relevant ITU-T Recommendations as given in Table 2.

Table 2 – Admissible minimum LCL values for the telecommunication port

Services	Frequency (Hz)	LCL	Reference
ISDN	80 8-800	44 dB 5 dB/decade decrease	[ITU-T G.961]
ADSL ADSL2(plus)	25-1104 25-2208	40 dB	[ITU-T G.992.1] [ITU-T G.992.5] (Note 1)
VDSL2	12 000	38 dB	[ITU-T G.993.2] (Note 2)
NOTE 1 – This value is defined in clause A.4.3.1 of [ITU-T G.992.1] as LCL at the U-C or U-R interface. NOTE 2 – This value is defined in [ITU-T G.993.2] and LCL may be increased to a value greater than 38 dB in a future revision of this Recommendation. The LCL beyond 12 MHz to 30 MHz is for further study.			

The admissible minimum LCL value for the telecommunication cable with the above test method should be better than the value of the telecommunication port defined in Table 2 in order to minimize the unwanted emissions and susceptibility to external radio frequency interference (RFI).

Appendix I

Loss conversion ratio test of the shielded telecommunication cable

(This appendix does not form an integral part of this Recommendation.)

The loss conversion ratio (LCR) is the negative value of LCL. Test configurations and test results are shown in this appendix.

I.1 Terms defined in this appendix

This appendix defines the following term:

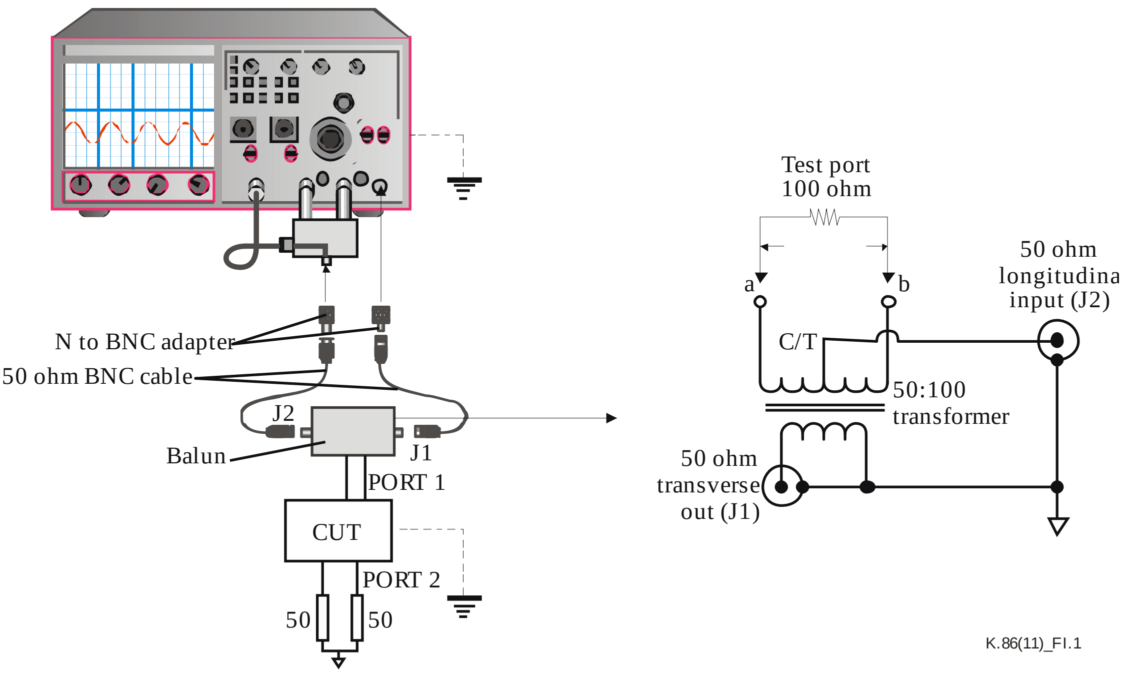
I.1.1 longitudinal conversion ratio (LCR): The LCR of a one- or two-port network is a measure (a ratio expressed in dB) of the degree of unwanted transverse signal produced at the terminals of the network due to the presence of a longitudinal signal on the connecting leads. It is calculated as

$$\text{Longitudinal conversion ratio (LCR)} = 20 \lg \left| \frac{V_{T1}}{V_{L1}} \right| \text{ dB}$$

and measured as shown in Figures 1 and 2.

I.2 Test configurations and calibration

The test configuration is shown in Figure I.1.



N: Type N connector.
BNC: Bayonet Neill-Concelman connector.

Figure I.1 – Test configuration

The inherent balance of the balun is shown in Figure I.2.

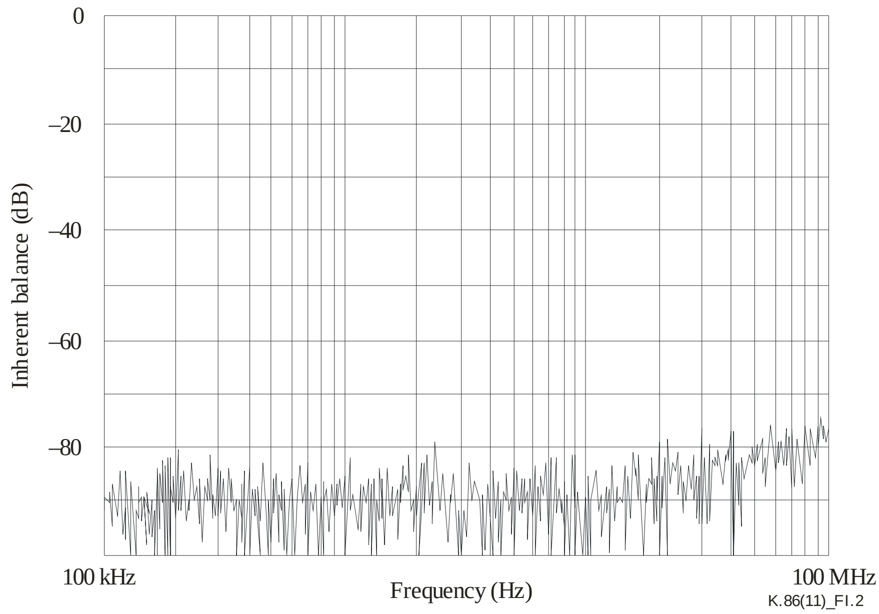


Figure I.2 – Inherent balance of the balun

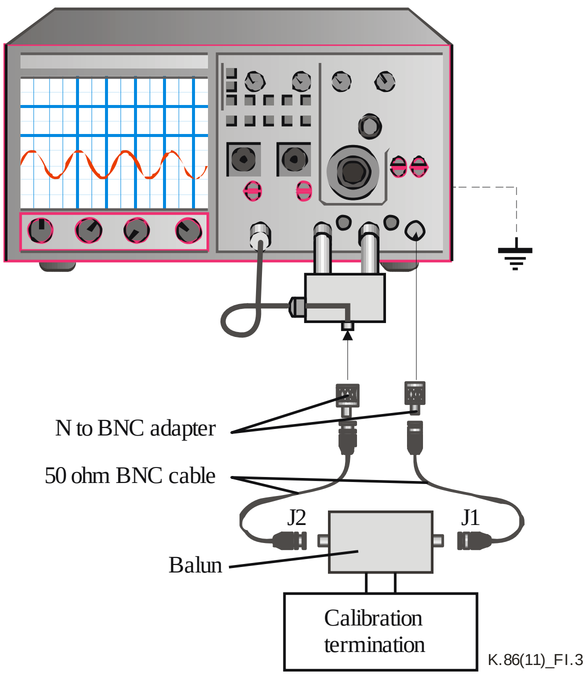
The calibration test configuration is shown in Figure I.3. A calibration termination shall be installed instead of the cable under test. Steps of the basic calibration procedure follow.

1) On the network analyser, set the frequency range and select the Thru (B/R or S21) Measurement. Adjust reference position to the top of the display if necessary.

2) Connect the network analyser output to J2 of the balun and input to J1. Insert the calibration termination to the balanced output terminals of the balun.

3) Perform a Thru Calibration. Set reference level and marker offset to 30 dB. Remove the calibration termination.

The above procedure has calibrated out the correction factor. The network analyser can now be read directly as the LCL value.



N: Type N connector.
BNC: Bayonet Neill-Concelman connector.

Figure I.3 – Calibration test configuration

I.3 LCR test result of the shielded telecommunication cable

Figures I.4 to I.6 show LCR test result values in the frequency range of 1 MHz to 35 MHz of different pairs of shielded telecommunication cables with different lengths.

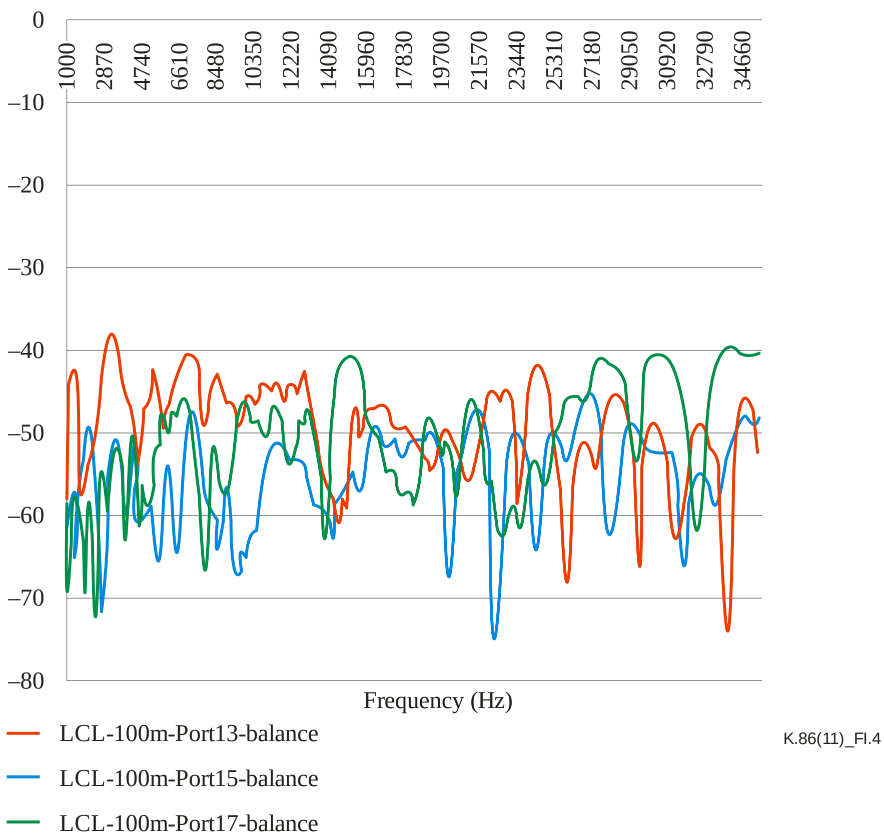


Figure I.4 – LCR value of a 100 metre shielded telecommunication cable

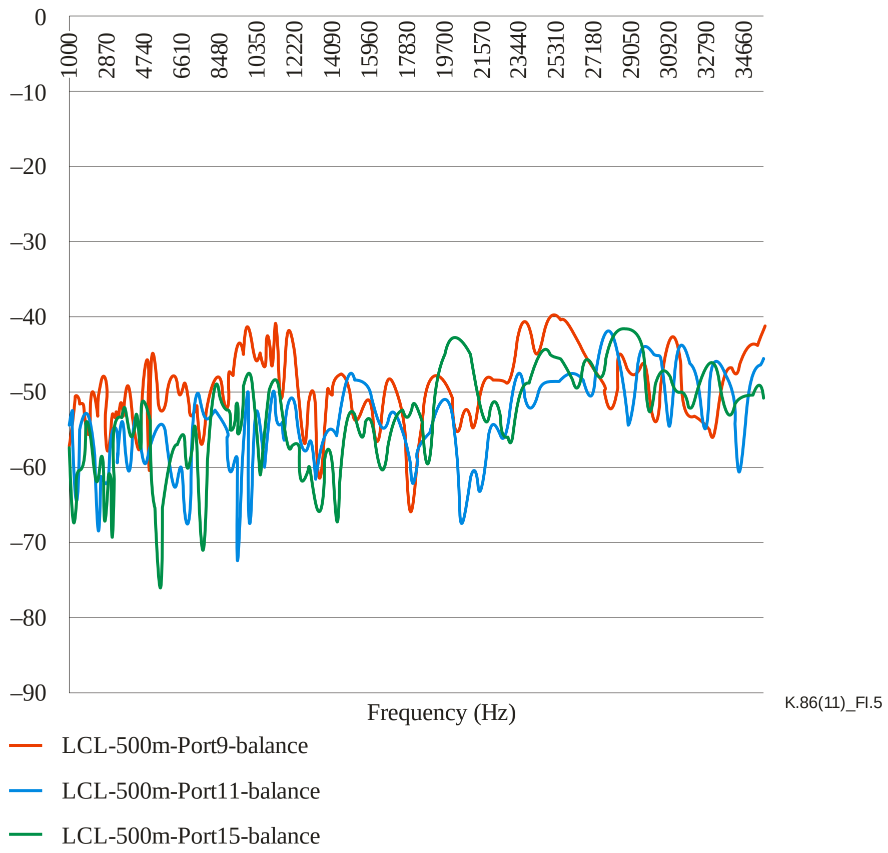


Figure I.5 – LCR value of a 500 metre shielded telecommunication cable

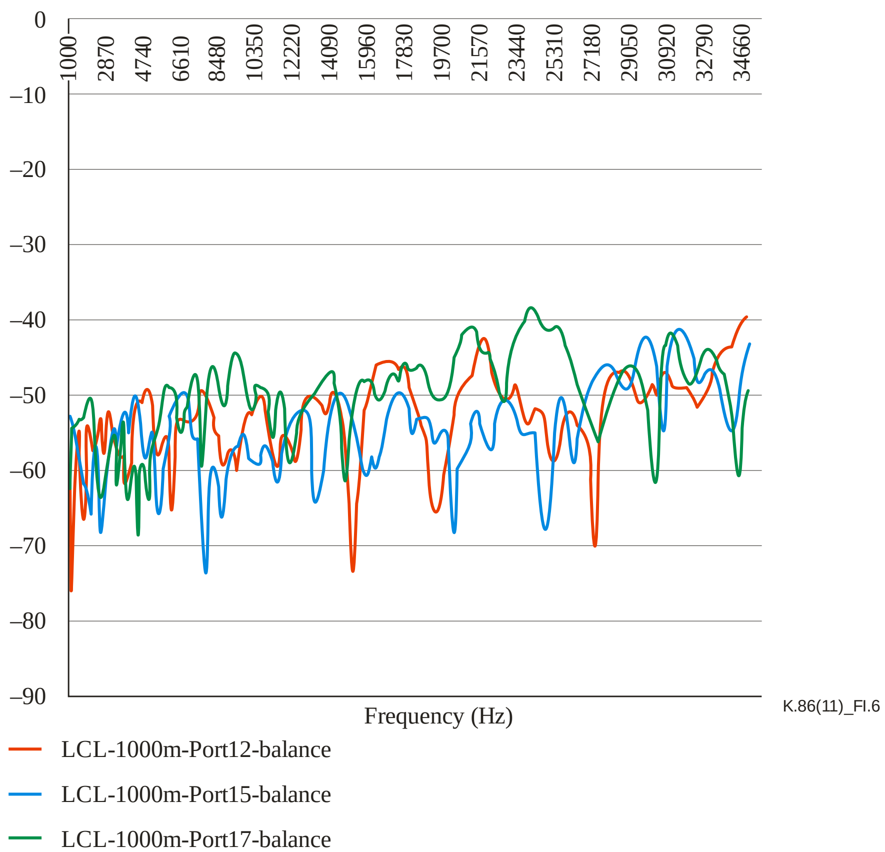


Figure I.6 – LCR value of a 1000 metre shielded telecommunication cable

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