11 October 2004

Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

RE: ISO/IEC JTC 1/SC 31 position regarding BPL as identified in FCC ET Docket No. 04-37

Dear Madam or Sir,

Please accept this letter as the position of ISO/IEC JTC 1/SC 31's and suggested guidance regarding Broadband over Power Line (BPL) as identified in the FCC ET Docket No. 04-37 of February 2004.

ISO/IEC JTC 1/SC 31 is the committee within ISO/IEC JTC 1 addressing Automatic Identification and Data Capture Techniques. Within SC 31 is Working Group 4 (WG4) whose responsibility is Radio Frequency Identification (RFID) for item management applications where data is collected by means of radio waves.

Broadband over Power Line makes use of the band 9 kHz to 30 MHz. This band is also used for inductive RFID systems, as identified in ISO/IEC 18000, Part 2 and 3 as well as within anti-theft systems using electronic article surveillance (EAS).

A technical report (see http://www.savehf.org/lib/isplc2003/isplc2003a7-1.pdf) shows interferences from BPL up to 340 MHz, so RFID systems operating at 433 MHz, as identified in ISO/IEC 18000-7, may also be affected.

Implementation of these types of RFID systems began to appear in the U.S. in the mid-70s. Today, there are numerous U.S. and European suppliers of such RFID systems and thousands of end user organizations having implemented the technology.

A cornerstone of such RFID systems is that they do not interfere with primary radio users in the 9 kHz to 30 MHz band nor in the 433 MHz band. They accomplish this by transmitting at field strength levels that are relatively low. To cover the read range required by the users' applications the receivers must be very sensitive. Consequently, for the indoor use of RF equipment a relative strong coupling exists between the receiving antennas of these systems and the main building wiring.

RFID systems can be found at the point of purchase, at entrances and exists of the building, within the backroom, and on the store's shelves. Therefore it is difficult if not impossible to identify how these systems might be positioned with regard to the power wiring of the building.

RFID systems have to comply with the conductive - and radiated emission limits provided in Section 15.207 and 15.209. For BPL the same radiated emission limits are applicable. No conductive measurements are necessary.

Normally, disturbances caused by individual electrical apparatus, lighting etc. will exhibit a statistical spread throughout the frequency bands affected. The higher interference level from BPL systems has a considerably more flat continuous spectrum. The interference becomes harmful to RFID systems in an environment where a large number of identical systems are all emitting the same spectrum.

One solution to overcome the interference could be decreasing the read distance, but this again can conflict with the application requirements of the retailers who need certain read ranges.

Likewise, canceling the interference is quite difficult since there is no single source, but a distributed transmitter consisting of all the power lines running throughout a building. Increasing the levels will have a very detrimental effect on RFID systems and may make operation in some existing locations impossible.

Additionally, several ISO standards are written around these inductive technologies operating in the bands below 30 MHz, such as ISO 11784/5 ISO 14225, ISO/IEC 14443, ISO 15693, ISO 18000-2, ISO 18000-3 and for the Airline Industry IATA RPC 1740. Several ISO standards are written or are in development using the 433 MHz technology, including ISO 17363.

Germany proposed radiated emission limits (See attached “Draft Order issued as a replacement for NB 30”) related to the current injected (conducted) in the power line with a level of the CISPR 22 Class B limits (Same as FCC Section 15.207).

Within the ETSI/CENELEC JWG a report (see attached JWG11-07) has been submitted on measurements of BPL. The results show that if injected into the power line with a CISPR 22 Class B current level the radiated emission limits are in line with the NB30.

ISO/IEC JTC1/SC31 endorses the radiation limits of the NB30 and urges the FCC to implement these limits in the rules concerning Broadband over Power Line. The radiated limits of Part 15.209 are much more relaxed and thus potentially harmful for RFID systems.

ISO/IEC JTC1/SC 31 recognizes that broadband over power line could support broadband data communication, however many alternatives are rapidly becoming available, such as many forms of wireless local loop e.g. WLL, WIFI, UMTS, HiperLAN, ZIGBEE, Satellite, etc. and also fibre.

As described above, the issues under discussion have potentially serious implications for the RFID community. We hope that this letter has broadened the FCC’s understanding of the issues and that FCC will seek for a sensible set of emission limits. ISO/IEC JTC 1/SC 31 is aware that, once decided, any emission limit will be almost impossible to change, because of the installed infrastructure. It is therefore quite important that emission limits are set at sensible levels.

ISO/IEC JTC 1/SC 31 seeks assurances that wideband data transmission networks along the power line will not be permitted with very relaxed radiating limits adversely impacting the operation of existing radio communications systems. In this respect we note, that the Protection Requirements of FCC part 47 Section 15.5 (b) states “Operation of an intentional, unintentional, or incidental radiator is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator”.

The understanding is that systems, including BPL, may not cause harmful interference.

If we can provide further information, please feel free to contact us at your leisure.

Regards,

Alan Haberman
Chairman
ISO/IEC JTC 1/SC 31

1. ------IND- **2003 0013 D-- EN-** ------ 20030204 --- --- PROJET

Draft Order issued as a replacement for NB 30

As at 13.12.02

Order on the protection of receivers and transmitters used for security purposes [German designation: VSiFunk]

On the basis of Section 8(10) of the Act on the electromagnetic compatibility of equipment dated 18 September 1998 (Federal Law Gazette I 1998 p. 2882), most recently amended by ....(Federal Law Gazette I ...... p. .....), the Federal Ministry of Economic Affairs and Employment, in collaboration with the Federal Ministry of the Interior, the Federal Ministry of Defence and the Federal Ministry of Transport, Construction and Housing, orders:

Contents

Section 1 Purpose and are of application

On the basis of Section 8(10) of the Act on the electromagnetic compatibility of equipment, this Order regulates the details concerning the implementation of measures from the Regulatory Authority for Telecommunications and Post aimed at protecting radio receivers and radio transmitters used for security purposes in the 9 kHz to 3 GHz frequency range from electromagnetic incompatibilities arising through the use of the frequencies in telecommunications installations or telecommunications networks.

Section 2 Terms and definitions

For the purposes of this Order,

1. an undesired emission

   is an emission or induction or an energy flow brought about by a combination of emission and induction, from a telecommunications installation or a telecommunications network, which may cause electromagnetic incompatibility in radio receivers or radio transmitters used for security purposes,

2. the operator

   is the natural or legal person who has the legal and actual control of the totality of the functions of a telecommunications installation or a telecommunications network,

3. the frequency range to be protected

   is the frequency range in accordance with Annex 1 in which a radio receiver or radio transmitter used for security purposes is operated.

Section 3 Protection of radio receivers or radio transmitters

(1) In order to protect radio receivers and radio transmitters used for security purposes from undesired emissions from telecommunications installations and networks, the limits of the interference-field strengths in accordance with Annex 2 shall not be exceeded by these in the frequency range to be protected.

(2) The values stipulated in Annex 2 are determined on the basis of harmonised standards, or, if these are not available, on the basis of the applicable harmonised EMC standards, or, if these are not available, in accordance with Reg TP 322 MV 05 Part 1 [Measurement Regulation from the Regulatory Authority for Telecommunications and Post] or a comparable measurement regulation.

(3) The interference-field strengths arising on channels in television cable networks in the event of the use of digital transmission methods, are determined on the basis of the applicable harmonised EMC standards, or, if these are not available, in accordance with Reg TP 322 MV 05 Part 2 [Measurement Regulation from the Regulatory Authority for Telecommunications and Post] or a comparable measurement regulation.

Section 4 Obligations of the operator

When putting into service and when operating telecommunications installations and networks, the operator shall ensure, at the operating site and along the cable run, at a distance of 3 metres from the telecommunications installation or telecommunications network or the connected cables, that the interference-field strength (peak value) does not exceed the values in the tables in Annex 2, taking account of the measurement methods prescribed in Section 3.

Section 5 Verification

The Regulatory Authority for Telecommunications and Post may undertake on-site verification of adherence to the limits stipulated in Section 3. The operators shall allow access, at the normal business times, to their telecommunications installations or to their telecommunications networks to all personnel of the Regulatory Authority for Telecommunications and Post undertaking the verification, and shall support all measures necessary for this. For the purpose of the verification, the Regulatory Authority for Telecommunications and Post may order that the operator feed special test signals into the telecommunications installation or the telecommunications network.

Section 6 Orders from the Regulatory Authority for Telecommunications and Post

The Regulatory Authority for Telecommunications and Post may:

1. require the operators to ensure, within an appropriate period of time, that their telecommunications installation or their telecommunications network adheres to the limits in accordance with Section 3,

2. order special measures with spatial, chronological or substantive stipulations for the operation of a telecommunications installation or a telecommunications network, or

3. prohibit operation in whole or in part.

Section 7 Administrative offences

An administrative offence within the meaning of Section 12(1) number 9 of the Act on the electromagnetic compatibility of equipment is committed by any person who intentionally or negligently:

1. operates a telecommunications installation or a telecommunications network contrary to Section 3, unless an order from the Regulatory Authority for Telecommunications and Post permits exceptions in accordance with Section 6(2),

2. fails to undertake the measures necessary for undertaking the verification contrary to Section 5,

3. fails to comply with the orders from the Regulatory Authority for Telecommunications and Post contrary to Section 6.

Section 8 Transitional provisions

The operators of a telecommunications installation or a telecommunications network are obliged to comply with the limit values specified in Section 3, with a transitional period up to 1 July 2003.

Section 9 Entry into force

This Order shall enter into force on the date following its promulgation.

Berlin, on 2003
The Federal Minister for Economic Affairs and Employment

Annex 1

List of the frequency ranges in which radio receivers and radio transmitters used for security purposes are operated.

1. Frequency ranges from 90 to 30000 kHz (as at 6 Dec. 2002)

Frequency range	Radio application
315 - 435 kHz	Aeronautical navigation radio
1606.5 - 1625 kHz	Authorities and organisations with security responsibilities
1635 - 1800 kHz	Authorities and organisations with security responsibilities
1890 - 2000 kHz	Authorities and organisations with security responsibilities
2045 - 2170 kHz	Authorities and organisations with security responsibilities
2180 - 2188 kHz	Maritime radio
2194 - 2498 kHz	Authorities and organisations with security responsibilities
2502 - 2850 kHz	Authorities and organisations with security responsibilities, military radio applications
3025 - 4063 kHz	Authorities and organisations with security responsibilities , military radio applications, aeronautical radio
4438 - 4650 kHz	Authorities and organisations with security responsibilities
4700 - 4995 kHz	Authorities and organisations with security responsibilities, aeronautical radio
5005 - 5480 kHz	Authorities and organisations with security responsibilities, aeronautical radio
5680 - 5730 kHz	Aeronautical radio
5730 - 5950 kHz	Authorities and organisations with security responsibilities
6685 - 6765 kHz	Aeronautical radio
6765 - 7000 kHz	Authorities and organisations with security responsibilities
7350 - 8195 kHz	Authorities and organisations with security responsibilities
8965 - 9400 kHz	Authorities and organisations with security responsibilities, aeronautical radio
10150 - 11175 kHz	Authorities and organisations with security responsibilities
11175 - 11275 kHz	Aeronautical radio
11400 - 11600 kHz	Authorities and organisations with security responsibilities
12050 - 12100 kHz	Authorities and organisations with security responsibilities
13200 - 13260 kHz	Aeronautical radio
13570 - 13600 kHz	Authorities and organisations with security responsibilities
13800 - 14000 kHz	Authorities and organisations with security responsibilities
14350 - 14990 kHz	Authorities and organisations with security responsibilities
15010 - 15100 kHz	Aeronautical radio
17970 - 18030 kHz	Aeronautical radio
18168 - 18780 kHz	Authorities and organisations with security responsibilities
19020 - 19680 kHz	Authorities and organisations with security responsibilities
20010 - 21000 kHz	Authorities and organisations with security responsibilities
22855 - 23000 kHz	Authorities and organisations with security responsibilities
23200 - 24890 kHz	Authorities and organisations with security responsibilities, aeronautical radio
25210 - 25550 kHz	Authorities and organisations with security responsibilities
26175 - 27500 kHz	Authorities and organisations with security responsibilities

2. Frequency ranges from 30 to 3000 MHz (as at 6 Dec. 2002)

Frequency range	Radio applications
30.3375 - 30.3625 MHz	Regional military applications
30.4375 - 30.4625 MHz	Regional military applications
30.5875 - 30.6125 MHz	Regional military applications
30.7375 - 30.7625 MHz	Regional military applications
31.7875 - 31.8125 MHz	Regional military applications
34.360 - 35.800 MHz	Authorities and organisations with security responsibilities
38.460 - 39.800 MHz	Authorities and organisations with security responsibilities
41.5875 - 41.6125 MHz	Regional military applications
43.5875 - 43.6125 MHz	Regional military applications
44.3875 - 44.4125 MHz	Regional military applications
45.2375 - 45.2625 MHz	Regional military applications
48,4375 - 48,4625 MHz	Regional military applications
48.6375 - 48.6625 MHz	Regional military applications
55.7875 - 55.8125 MHz	Regional military applications
56.2875 - 56.3125 MHz	Regional military applications
63.6375 - 63.6625 MHz	Regional military applications
63.9375 - 63.9625 MHz	Regional military applications
73 - 73.55 MHz	Regional military applications
74.215 - 77.475 MHz	Authorities and organisations with security responsibilities, aeronautical navigation radio
82.80 - 83.35 MHz	Regional military applications
84.015 - 87.255 MHz	Authorities and organisations with security responsibilities
108 - 137 MHz	Aeronautical navigation radio, aeronautical radio
138 - 144 MHz	Aeronautical radio
156 - 157.450 MHz	Maritime radio
160.600 - 160.975	Maritime radio
161.475 - 162.025 MHz	Maritime radio
165.200 - 165.700 MHz	Authorities and organisations with security responsibilities
167.560 - 169.380 MHz	Authorities and organisations with security responsibilities
169.800 - 170.300 MHz	Authorities and organisations with security responsibilities
172.160 - 173.980 MHz	Authorities and organisations with security responsibilities
240.25 - 270.25 MHz	Aeronautical radio
275.25 - 285.25 MHz	Aeronautical radio
290.25 - 301.25 MHz	Aeronautical radio
306.25 - 318.25 MHz	Aeronautical radio
328.6 - 345.25 MHz	Aeronautical navigation radio, aeronautical radio
355.25 - 399.9 MHz	Authorities and organisations with security responsibilities, aeronautical radio
443.600 - 444.9625 MHz	Authorities and organisations with security responsibilities
448.600 - 449.9625 MHz	Authorities and organisations with security responsibilities
960 - 1215 MHz	Aeronautical navigation radio
1250 - 1260 MHz	Aeronautical navigation radio
1340 - 1350 MHz	Aeronautical navigation radio
1544 - 1555 MHz	Emergency and security traffic via satellite, aeronautical radio via satellite
1559 - 1610 MHz	Aeronautical navigation radio, navigation radio via satellite
1690 - 1693 MHz	Authorities and organisations with security responsibilities
1782 - 1785 MHz	Authorities and organisations with security responsibilities
2700 - 2900 MHz	Aeronautical navigation radio

2351 - 2381 MHz Authorities and organisations with security responsibilities

Annex 2

1. Limit values for interference-field strength from telecommunications installations and telecommunications networks at security-relevant frequencies for the frequency range 9 kHz to 30 MHz

Table 2.1

Frequency f, MHz, in range	Limit value for interference-field strength (peak value) at 3 m distance dB(µV/m)		
0.009 to 1 greater than 1.000 to 30	$40-20 * \log_{10}$ (f/MHz) $40-8.8 * \log_{10}$ (f/MHz)		

2. Limit values for interference-field strength from telecommunications installations and telecommunications networks at security-relevant frequencies for the frequency range greater than 30 MHz and up to 3000 MHz

Table 2.2

Frequency f, MHz, in range	Limit value for interference-field strength (peak value) at 3 m distance dB(µV/m)		
greater than 30 to 1000 greater than 1000 to 3000	27 (1) 40 (2)		

(1) This corresponds to an equivalent radiated power of 20 dBpW
(2) This corresponds to an equivalent radiated power of 33 dBpW

Draft Order on the protection of receivers and transmitters used for security purposes [German designation: VSiFunk]

Explanatory statement

(as at: 12 December 2002)

A. General part

Purpose of the Order

The Act on the electromagnetic compatibility of equipment [German designation: EMVG] dated 18 September 1998 (Federal Law Gazette I 1998 p. 2882), most recently amended by ....(Federal Law Gazette I ...... p. .....), empowers the Federal Ministry of Economic Affairs and Employment, in collaboration with the Federal Ministry of the Interior, the Federal Ministry of Defence and the Federal Ministry of Transport, Construction and Housing to regulate details concerning the implementation of measures from the Regulatory Authority for Telecommunications and Post aimed at protecting radio receivers and radio transmitters used for security purposes in the 9 kHz to 3 GHz frequency range from electromagnetic incompatibilities arising through the use of the frequencies in telecommunications installations or telecommunications networks. The Order makes use of this right. The area of application of the Order thereby extends, in principle, to include the protection of radio *transmitters* used for security purposes from electromagnetic incompatibilities. It is, however, in fact only receivers that are affected, since the maximum interference-field strengths that can be anticipated are not liable, even if they considerably exceed the permitted limits, to impair the functioning of radio transmitters.

The Order replaces the regulations of Utilisation Provision 30 [German provision: NB 30] of the Order on the frequency range assignment plan [German designation: FreqBZPV] of 26 April 2001 (Federal Law Gazette I p. 778) on the free use of frequencies in and along cables. By contrast with NB 30, however, this Order contains only regulations for the protection of security-relevant radio operations. The FreqBZPV to be amended will, in future, no longer contain regulations for the free use of frequencies in and along cables. Such regulations are part of EMC legislation and therefore fall exclusively under the EMVG.

Necessity for the Order

Electromagnetic interference can be linked to the introduction and implementation of new telecommunications services carried in and along cables. It has proved necessary to provide special protection for radio receivers and radio transmitters used for security purposes against this type of interference to ensure that their proper use is neither obstructed nor prevented. By virtue of the authorisation in Section 8 of EMVG, these protection measures will take the legal form of an Order.

Contents of the Order

Costs

The administrative cost of monitoring adherence to the requirements relating to the telecommunications installation or the telecommunications network is reimbursed by means of fees and disbursements, which are regulated in the Cost Order relating to the Act.

No additional costs are incurred by the federal budget as a result of the Order.

B. Special part

Re Section 1 (Purpose and area of application)

The EMVG regulates electromagnetic compatibility between items of equipment. According to the definition under the Act, this includes installations and networks. Conformity with the essential requirements, that items of equipment must not interfere with other items of equipment and must be produced in such a way that they are themselves not subject to interference, can generally be demonstrated with the aid of harmonised standards. In the past, however, it was assumed that cables on and along which electrical signals are transmitted had been adequately screened against the surrounding field. Standards covering this area have therefore been unavailable hitherto. In recent years, it has increasingly transpired that, in high frequency ranges and where new technologies are in use, incompatibilities between cable and radio can occur. Since interference of this kind can have particularly serious consequences for services used for security purposes, it is absolutely essential to prescribe compulsory limit values and measures to be undertaken, irrespective of whether or not a harmonised standard will be available in future to cover this area of regulation.

Re Section 2 (Terms and definitions)

Number 1 defines the type of emission against which radio receivers or radio transmitters used for security purposes are to be protected. The undesired emission originates from installations and networks that emit undesired signals in such a way that the proper use of the devices to be protected is no longer guaranteed.

In **Number 2,** the term "operator" is adopted into the Order, with the same meaning as defined in Section 3 number 1 and 2 of the Telecommunications Act.

Number 3 defines which frequency ranges of radio receivers or radio transmitters used for security purposes have to be taken into account in order to achieve the objective of the Order.

Re Section 3 (Protection of radio receivers or radio transmitters)

The specification defines the maximum values of the permitted interference-field strength that allows unrestricted operation of the radio receivers and radio transmitters to be protected, and the measurement specifications to be used by the Regulatory Authority for Telecommunications and Post in order to prove the protection level. In order to avoid creating a possible barrier to trade within the meaning of Directive 98/34/EC as a result of the exclusive specification of a particular measurement regulation, the option is granted of applying an alternative regulation that brings about the same objective.

Re Section 4 (Obligations of the operator)

Responsibility is borne by the operator. The operator must require from the installation manufacturer that the installation adheres to the limit values, and the operator is further obliged to ensure, during operation and, in particular, when modifications or expansions are undertaken, that the proper state of the installation is maintained.

Re Section 5 (Verification)

This regulates the powers of the Regulatory Authority for Telecommunications and Post to verify the limit values defined in Section 3. For this verification, it requires the active organisational and technical assistance of the operator.

Re Section 6 (Administrative offences)

The regulation corresponds to the regulations of the Act and, in line with the regulations in Section 4, is directed against the operators of telecommunications installations and networks who intentionally or negligently operate telecommunications installations or networks contrary to the requirements of Sections 3, 5 or 7.

Re Section 7 (Orders from the Regulatory Authority for Telecommunications and Post)

This grants the Regulatory Authority for Telecommunications and Post discretionary powers to enforce adherence to the Order by means of necessary orders. This also relates to the necessary measures that operators of telecommunications installations and networks have to take in order to guarantee the protection of radio receivers or radio transmitters used for security purposes. A ban on operation may be imposed as the most severe measure. The principle of proportionality must be observed hereby.

Re Section 8 (Transitional provisions)

The transitional provisions provide the operators of a telecommunications installation or a telecommunications network that has been put into service before the specified deadline, a transitional period up to 1 July 2003. This date is identical to the date on which the corresponding regulation of NB 30 of FreqBZPV for the frequency range from 30 to 3000 MHz enters into force, and has therefore been known to the operators of telecommunications installations and networks for a considerable time. Outside of the security-relevant frequency ranges, the limit values of the Order are identical to those of NB 30, so additional burdens are not imposed on the operators of telecommunications installations and networks as a result of the specifications in the Order as compared with the regulations in NB 30 of FreqBZPV.

Re Section 9 (Entry into force)

This regulates the entry into force of the Order.

European Telecommunications Standards Institute
ERM EMC-ETSI/Cenelec JWG#11

2-3 September 2004

Sophia-Antipolis

Source:	Nedap N.V.
Title:	Comparison PLC-limits with CISPR 22
Date:	2004 - 08 - 10
Document for:	Technical Input
Agenda item:	3

Executive summary.

The equivalence of common mode current limits and field strength limits in low voltage mains networks with existing CISPR 22 limits has been studied, and verified with measurements.

From the results we conclude that the current proposals for EMC limits for PLC signals on mains networks will allow the use of an injection power density of - 50 dBm/Hz. This is 35 - 50 dB higher than the CISPR 22 class B limit.

In case of a Europe wide roll-out of PLC systems with this level of injection power density and a reasonable penetration rate of 10%, the manmade noise floor will rise to a level of 13 dB above the ITU Quiet Rural area level and 6 dB above the Residential area level.

Testing and certification of electric, electronic and radio equipment/installations including telecommunication systems

REPORT OF INJECTED COMMON MODE CURRENT MEASUREMENTS AND FIELD STRENGTH MEASUREMENTS IN A MAINS SUPPLY NETWORK

FCC listed	: 90828
Industry Canada	: IC3501
VCCI registered	: R-1518, C-1598

TNO Electronic Products & Services (EPS) B.V.
P.O. Box 15
9822 ZG Niekerk (NL)
Smidshornerweg 18
9822 TL Niekerk (NL)

Telephone: +31 594 505005
Telefax: +31 594 504804

E-mail: info@eps.tno.nl
Web: www.eps.tno.nl

Client information

Client name	:	dhr. Ir. T.W.H Fockens
Company	:	N.V. Nederlandsche Apparatenfabriek NEDAP short name NEDAP
Address	:	Parallelweg 2
postal code	:	NL-7141 DC
City	:	Groenlo
PO-box	:	6
Postal code	:	NL-7140 AA
City	:	Groenlo
Country	:	Netherlands
Telephone number	:	+31 0544 47 11 11
Telefax number	:	+31 0544 46 34 75

Assessment

Location	:	Molenweg 12, 7274 AA Geesteren, The Netherlands
Assessment started	:	May 6, 2004
Assessment completed	:	May 6, 2004

Measurements carried out by	:	J. Schuurmans, B.Sc.E.E.
Report written by	:	J. Schuurmans, B.Sc.E.E.
Report approved by	:	P. de Beer, laboratory manager TNO EPS (BV).

Table of contents

1 General information

1.1 Client description

Our client, Nedap is a supplier and manufacturer of surveillance systems, anti pilferage devices and RF-ID based products. Their technology makes extensive use of the RF spectrum, especially the part which may be polluted with emissions resulting from common mode currents in mains power supply systems.

1.2 Client request for measurements

Nedap have requested TNO EPS to perform measurements associated with injection of differential mode and measurements of common mode currents into to a mains power supply network.

2 Measurements

2.1 Purpose of the measurements

Purpose of the measurement is to measure common mode currents resulting from injection with differential mode currents at multiple places in a building installation of a mains power supply network

2.2 Measurement set up

The measurement set-up is shown in Figure 1. The tracking generator output of the Rohde & Schwarz spectrum analyzer of the type FSP3 drives an HP8447D amplifier, delivering about 14 dBm of power into the matching circuit. The matching circuit shows a power loss of 15 dB, so the net resulting available injected power, injected by the Mains Coupling Device into the mains, is about -1 dBm. The MCD is described in Annex 1. The source impedance for differential injection is 100 ohm. A piece of 1.7 m twin lead cable is placed between the MCD and the wall outlet of the network under test, representing the mains cable between mains powered device and the mains network.
A current probe of the type EZ-17, Rohde & Schwarz, converts the common mode current in the cable, where it is clamped on, into a voltage, which is measured by the spectrum analyzer. The current probe is place on the cabling of the network at a series of positions, numbered 1 to 27. At position 0 the probe is clamped on the twin lead cable between MCD and the injection point.

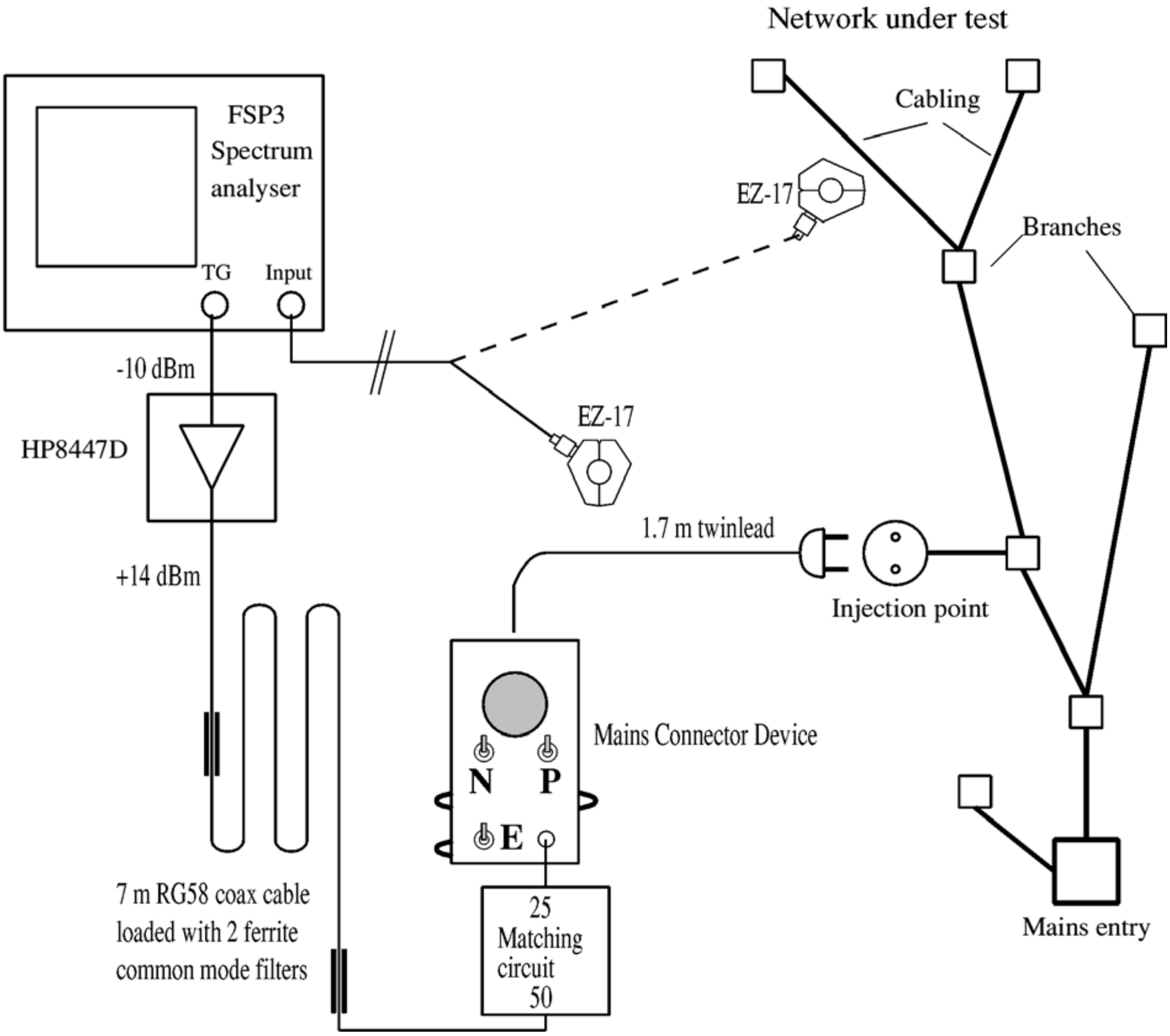

Figure 1 Measurement set -up

2.3 Measurement calibration

Note: The device used to inject currents, referred to as MCD throughout this document is described in detail in section 6.

The calibration of the measurement set-up is done as shown in Figure 2. The power from the MCD is injected in a LISN, type Schaffner NNB42. The voltage in each line, L and N, is measured by the spectrum analyzer. The input impedance for a differential voltage is 100 ohm, so an optimal impedance match with the source impedance has been achieved.

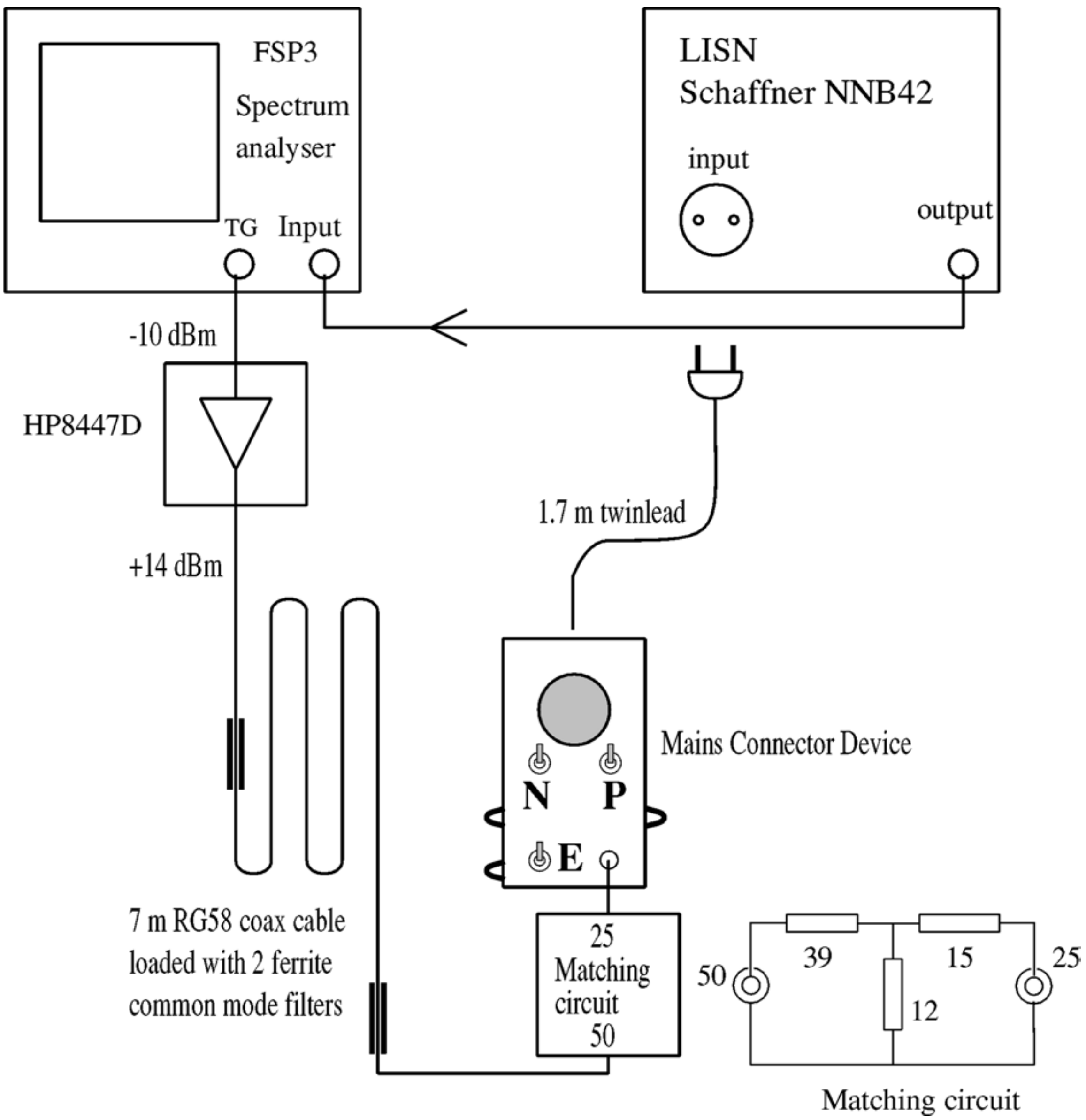

Figure 2 Calibration setup diagram

The frequency range in which is measured is 2 to 30 MHz, resulting in a data file with 501 frequency points. These data files are saved from the FSP3 and loaded in a laptop PC, running a calculation and plotting program. The voltages on both lines are measured, resulting in two sets of data, VL and VN. From both voltages the (linear) mean value is calculated, Vmean, and stored in dBµV.

Next Vmean is compared with CISPR 22-B values VCISPR from table 1: 56 dBµV for the frequency range 2 - 5 MHz and 60 dBµV in the range 5 - 30 MHz. [Here the values for the Quasi-peak detector are used. This means that comparing the results with the common mode current limit in the draft standard/draft technical specification also the value for the for the case of Quasi-peak detector has to be taken.] This results in the calibration variable Over-CISPR:

$$OverCISPR = V_{mean} - V_{CISPR}$$

The measurement result, $I_{common\ mode}$, is given by:

$$I_{common\ mode} = V_{sa} + K_{current\ probe} - OverCISPR + cable\_loss \text{ [dB}\mu\text{A]}$$

Herein is:

- V_{sa} the by the spectrum analyser measured voltage,
- $K_{current\ probe}$ the conversion number for the current probe, taken from the EZ-17 calibration report = -9.7 dB,
- *cable_loss* frequency dependent cable loss, calculated from measured cable loss at 30 MHz:
  $cable\_loss = cable\_loss@30MHz * f[\text{MHz}] / 30$ [dB]

2.4 The MCD (Mains Connector Device)

The Mains connector device is (MCD) is described in detail in Annex: The Mains Connector Device.

2.5 Sample measurement

A sample common mode current measurement (reading from the spectrum analyzer, with consecutive math) is calculated as follows:

f = 10 MHz
1. Calibration: f = 10 MHz
Measured voltage on L wire of LISN: 101.15 dBµV. N wire: 101.18 dBµV.
Mean voltage at LISN: 20*log((10^(101.15/20) +10^(101.18/20)/2 = 101.165 dBµV.
Limit value CISPR 22 B (QP) = 60 dBµV.
OverCISPR = 101.165 - 60 = 41.165 dB

2.5.1 Sample Current measurement

Measure voltage from current probe at measurement position 1: 47.09 dBµV.
K_current probe: -9.7 dB
OverCISPR: 41.165 dB
cable_loss: 0.43 dB (1.3 dB at 30 MHz)
Icommon mode = 47.09 - 9.7 - 41.165 + 0.43 = - 3.35 dBµA

The readings from the spectrum analyzer are stored. The results as presented in section 3 are then all calculated as described above.

2.5.2 Field strength measurement.

For the field strength measurement an active magnetic loop antenna (Chase, HLA6120) is connected to the spectrum analyser input instead of the current probe. The same cable has been used, and the frequency dependent losses in this cable is incorporated in the calculations.

$$H = V_{sa} + K_{loop} - Z_{free\ space} - OverCISPR + cable\_loss\ [\text{dB}\mu\text{A/m}]$$

Example calculation:
f = 10 MHz
Voltage indicated by spectrum analyser: 52.13 dBµV
K-factor magnetic loop antenna: 20.0 dB
Free space impedance: 51.5 dBohm
Magnetic field strength H = 52.13 + 20.0 - 51.5 - 41.165 + 0.43 = - 20.1 dBµA/m

(data taken from measurement documented in Figure 7 in Section 3.1.1)

Test measurement.
Figure 3 shows the result of a test measurement in the laboratory. Herein position 0 means the current probe clamped on the twin lead cable, and position 1 on the mains cable behind 1 branch from the injection point.An additional measurement was done by short circuiting the output of the MCD and measuring the current in the short. This was done directly at the MCD without the 1.7 m twin lead cable and after the twin lead cable. Comparing with the proposed common mode current limit this measurement shows that the calibration is correct.

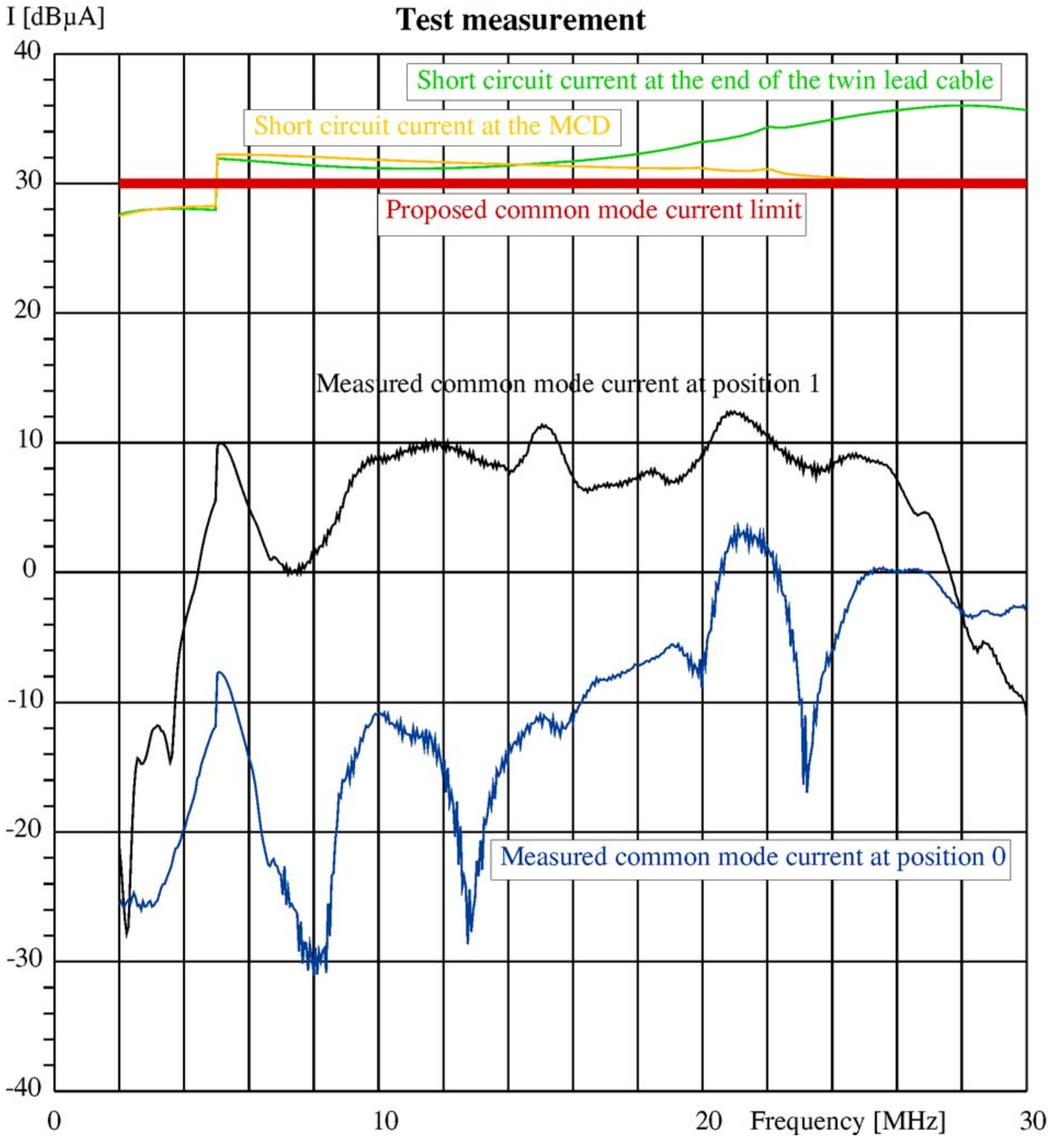

Figure 3 Test measurement

2.6 Measurement environment.

The measurements are performed in an old farmhouse. The favourable condition to do it herewas that nearly all cabling was mounted on the walls, instead of build in the walls, as is done inmodern houses. So it was possible to put a current probe on a cable at all wanted measurement positions. Not all cabling was in use, a part of the original cabling was disconnected because the danger of short circuits. A large part was 25 years ago replaced by modern VMVK cables. Another part of the cabling in the stables, still connected, consists of the predecessor of theVMVK cables.

Figure 4 shows a schematic view of the part of the mains network that was still connected, and used for the measurements. The network consists of three parts "(cable) groups", each group connected to one of the three phase inlet cable.

A fourth group is formed by a 3-phase cable running along the whole length of the south part of the stable.

There are two outlets used for injecting the measuring signal, injection point 1 and injection point 2. At the measuring positions 1 to 22 the current probe was clamped around the cable,while a measurement signal was injected at injection point 1. Some measuring positions were also used while injecting at position 2, indicated by 23 to 27.

Figure 4 shows a schematic layout of the farmhouse, indicating the positions used for field strength measurements.

The common mode currents are taken at the points given in the schematic representation of the network. The injection points (2) are indicated as well.

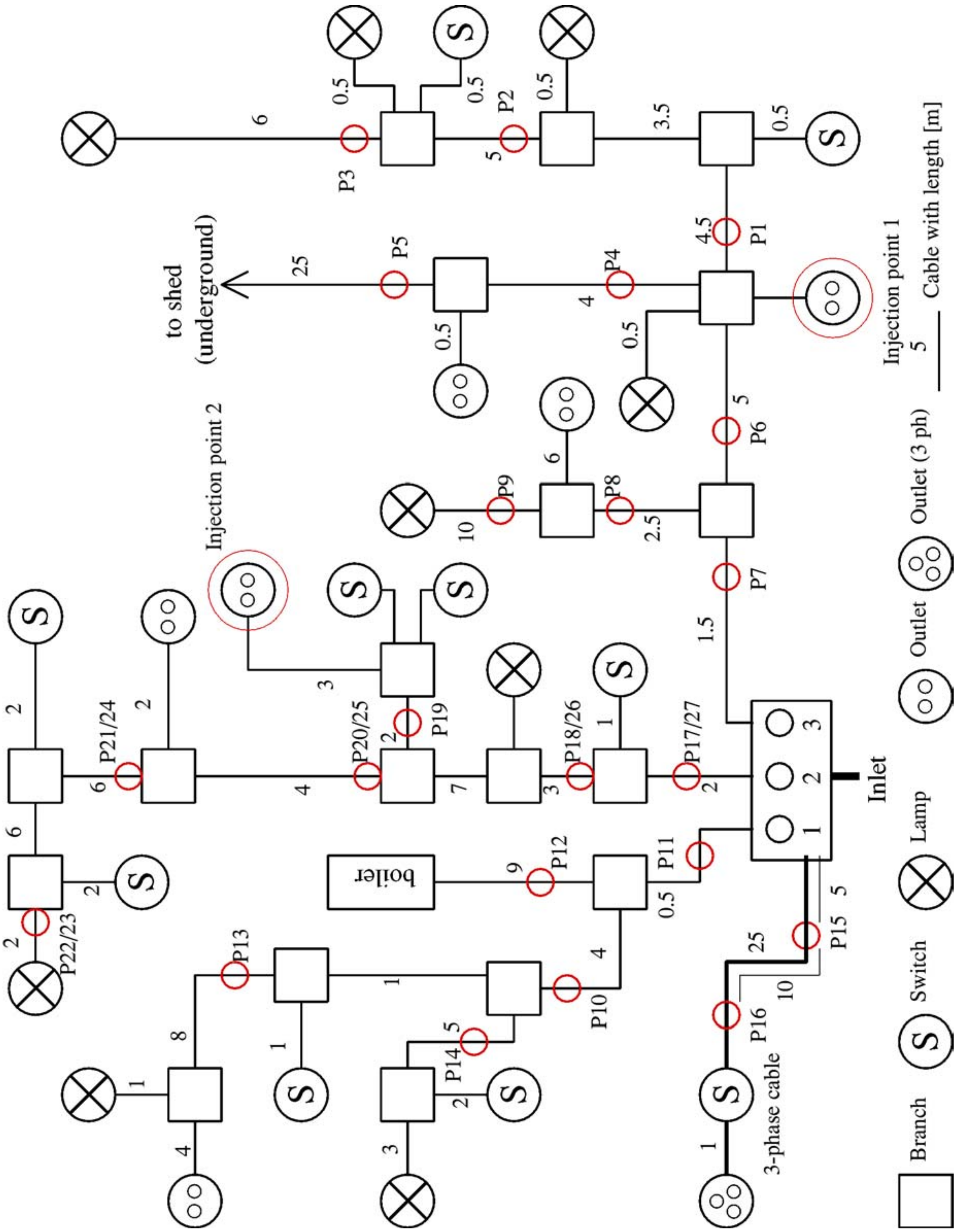

Figure 4 Network under test

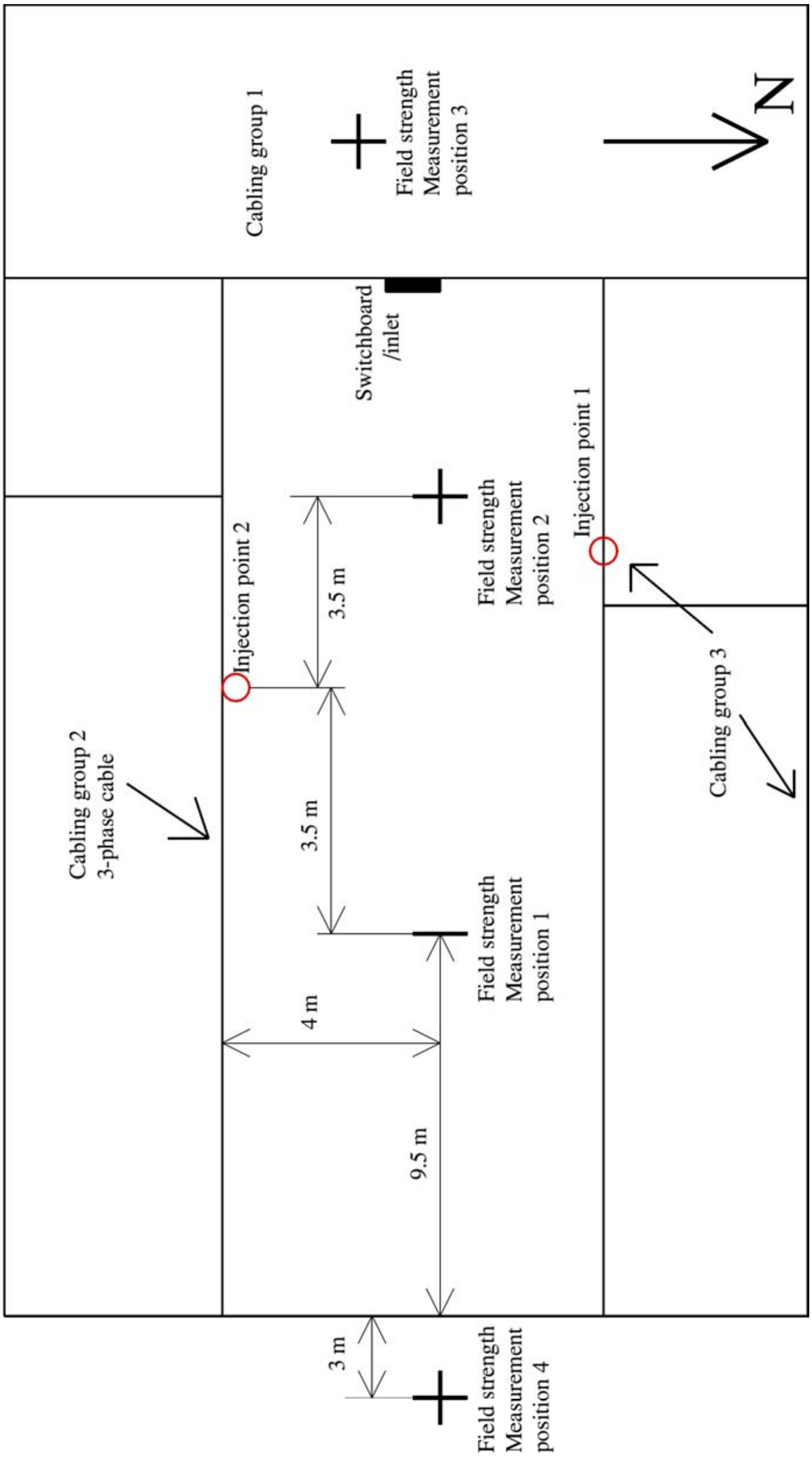

Figure 5 Schematic lay out of the farmhouse with measurement positions

3 Test Results

3.1 Common Mode current test results

The table below lists an overview of maximum currents found per position. The location of the position may be found in Figure 4 and Figure 5

Measurement position	Number of branching	Total cable Length [m]	Maximum value current [dBµA]
0	0	0.5	-3.2
1	1	1	12.0
2	3	8	11.0
3	4	13	15.5
4	1	1	11.5
5	2	5	7.4
6	1	5	3.7
7	2	7	5.6
8	2	8	3.7
9	3	10	-1.4
10	4	12	2.5
11	3	8	5.1
12	4	11	-0.9
13	6	13	-5.8
14	5	12	-12.7
15	3	12	-2.2
16	3	22	-7.3
17	3	8	-4.1
18	4	10	-3.1
19	6	20	-10.4
20	6	19	-12.8
21	7	23	-9.6
22	9	35	-11.9
23	5	21	4.0
24	3	6	10.8
25	2	5	12.1
26	3	15	13.5
27	4	16	11.4

3.1.1 Results of measurements on cable group 3, injection point 1.

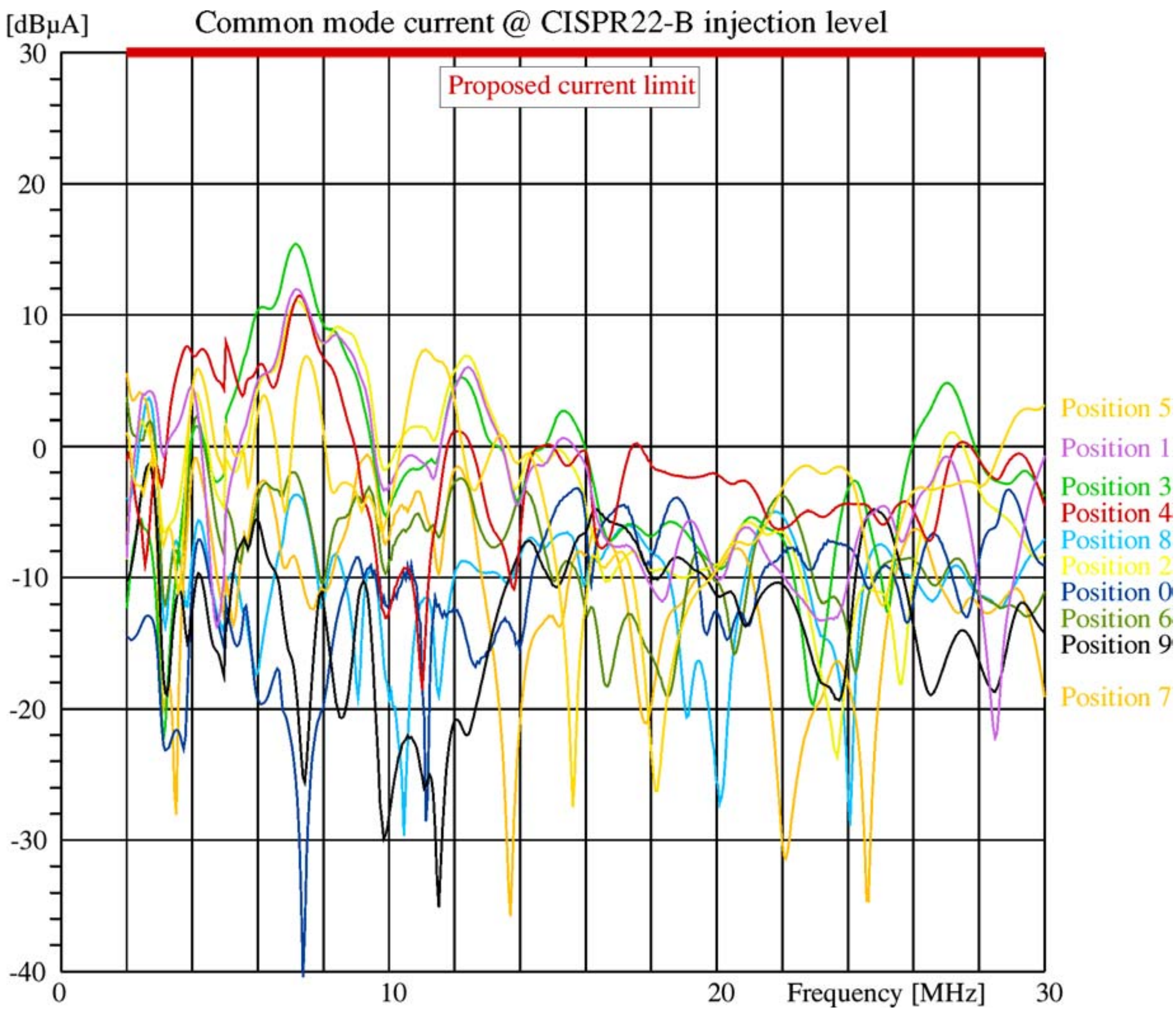

Figure 6 Overview of all common mode current measurement on cable group 3, while injecting at injection point 1, which is on cable group 3.

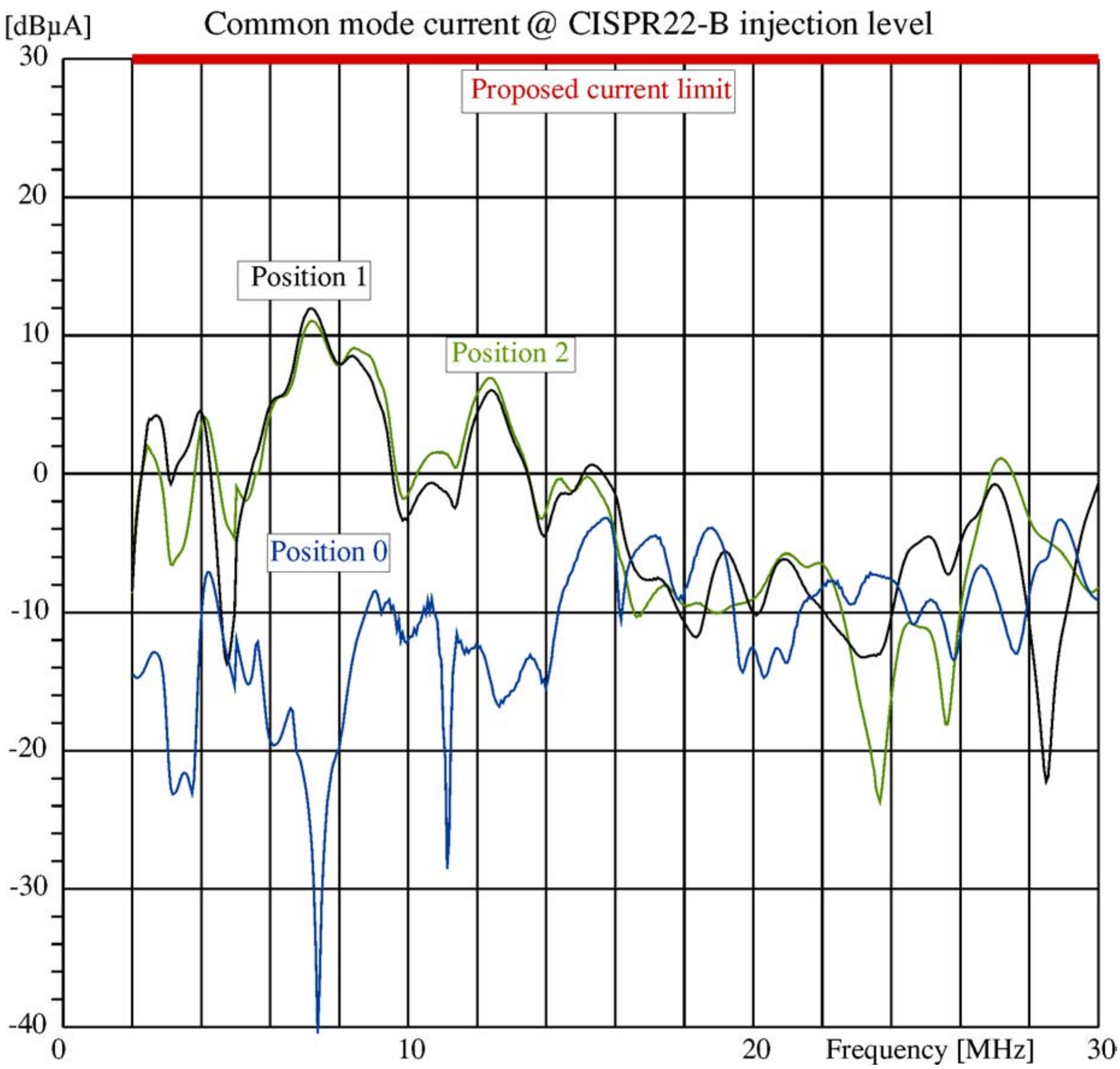

Figure 7 Injection point 1. CM current in twin lead cable to the injection point (position 0), and positions 1 and 2.

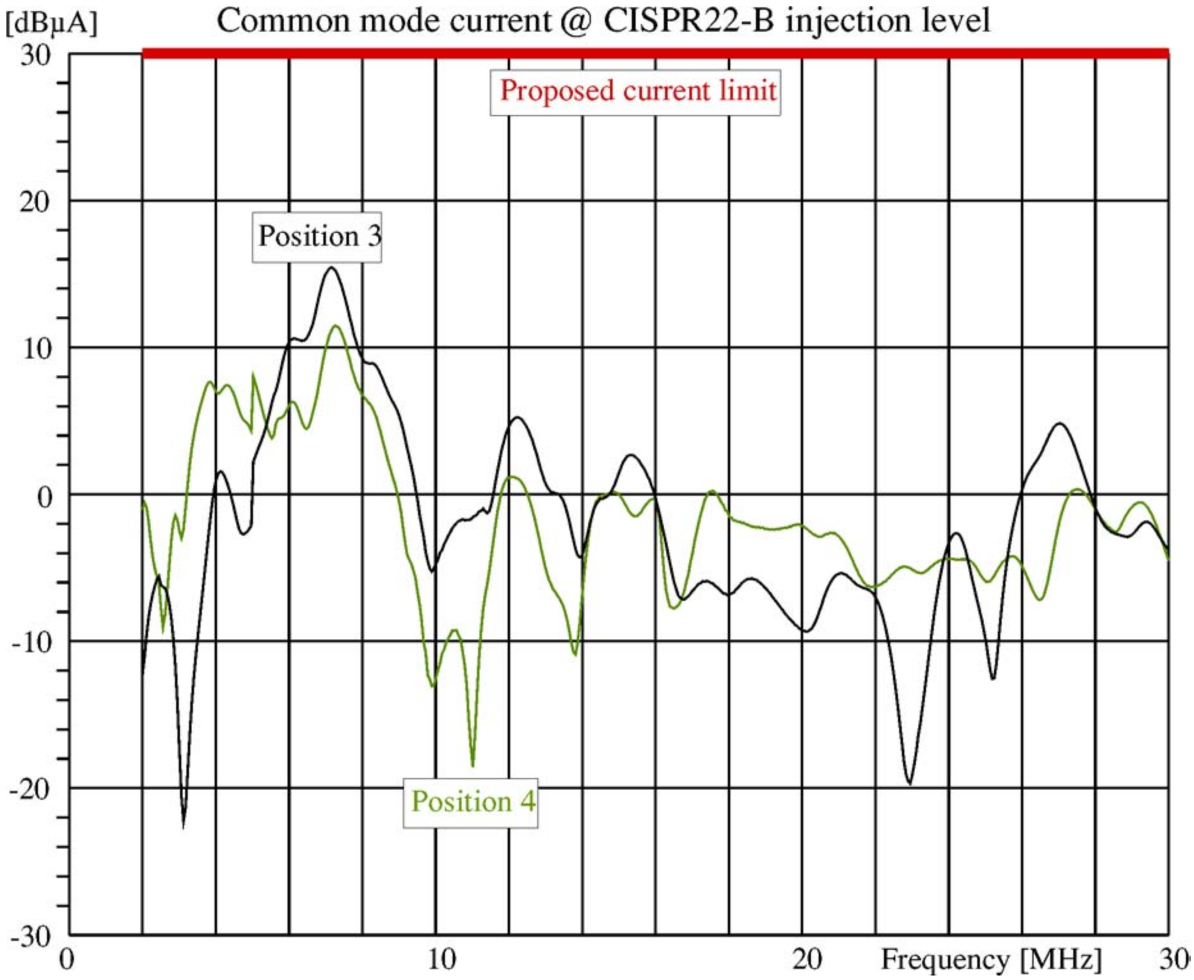

Figure 8 CM current at positions 3 and 4.

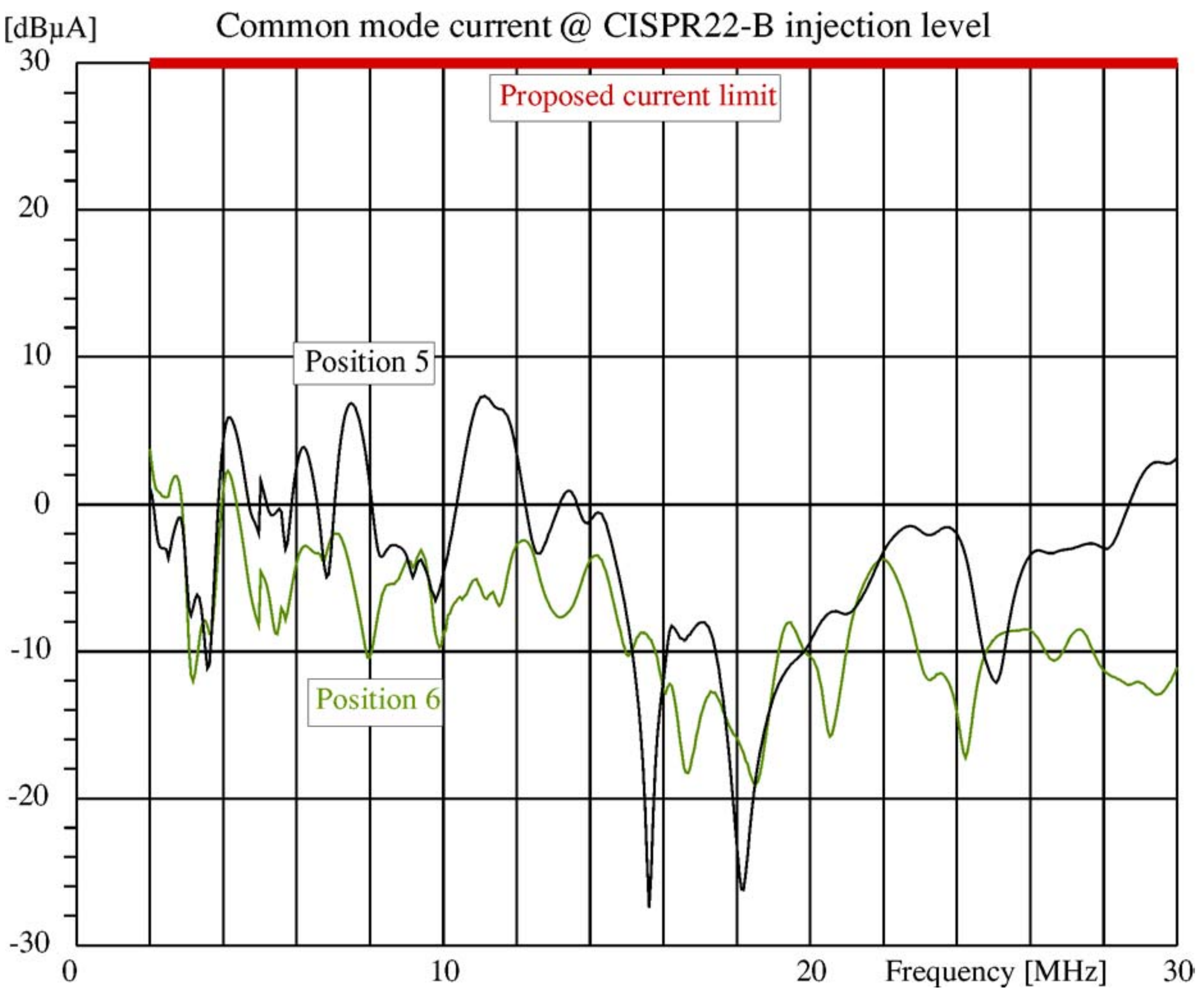

Figure 9 CM currents at positions 5 and 6.

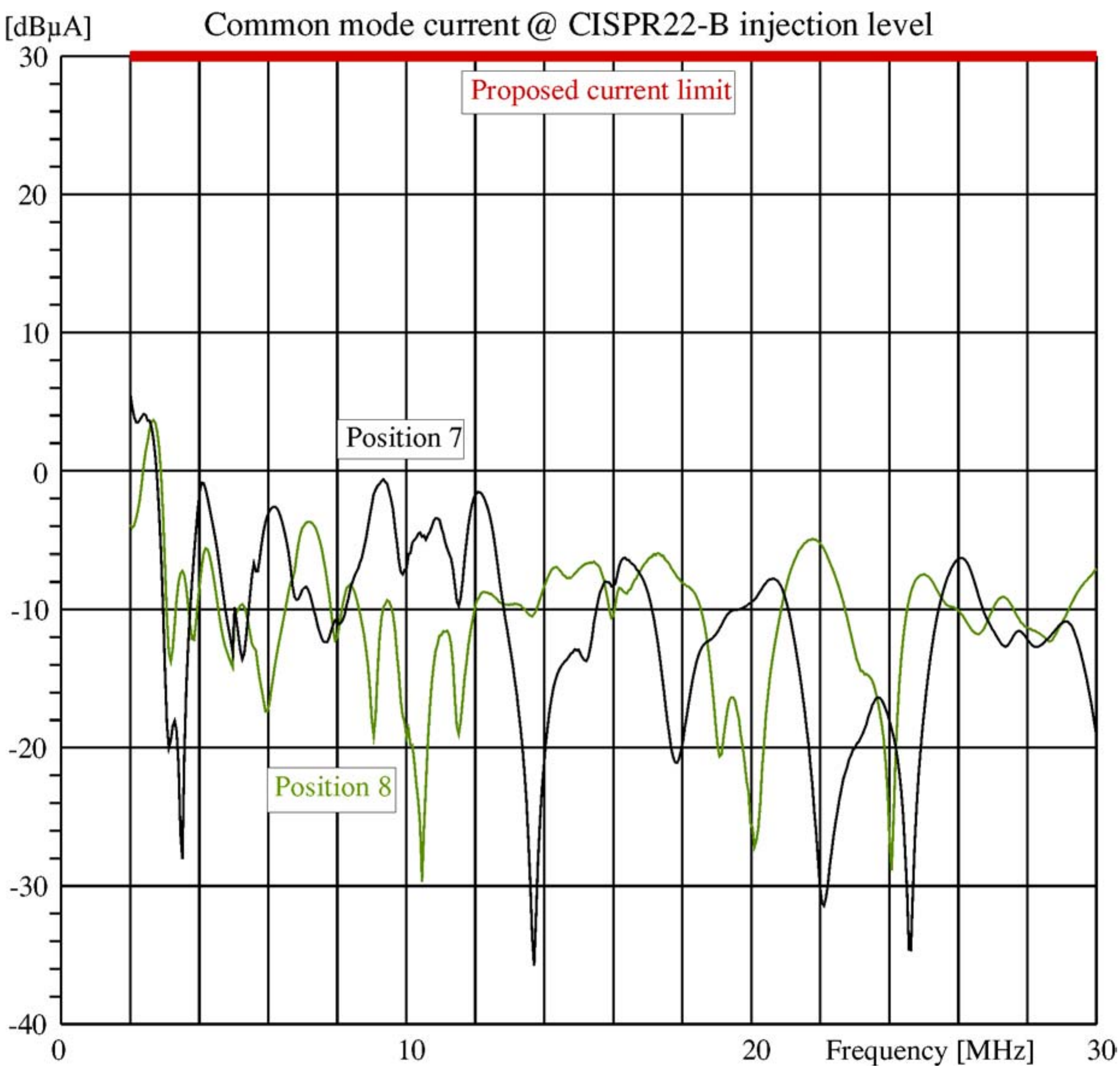

Figure 10 CM current at positions 7 and 8.

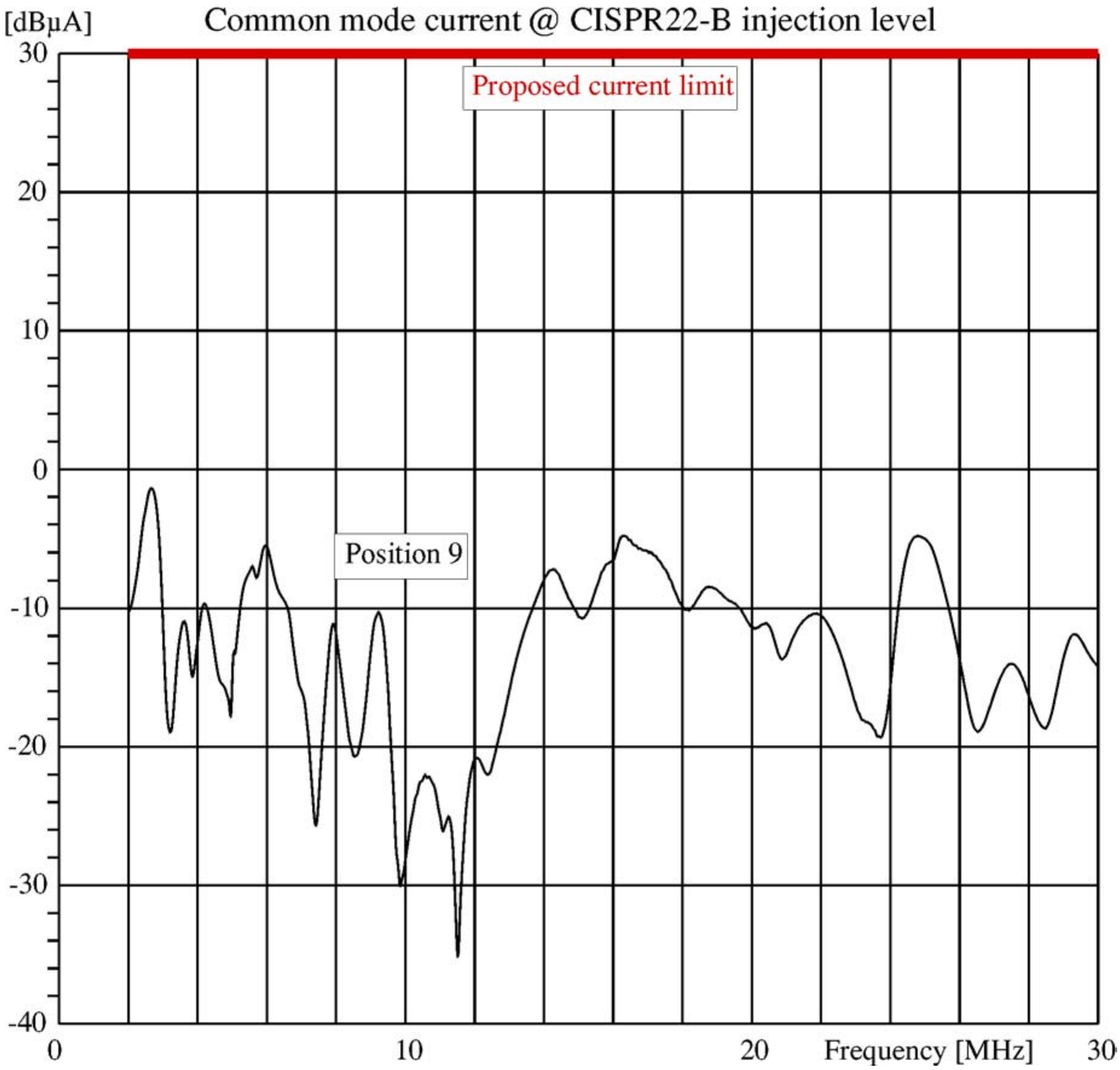

Figure 11 CM current at position 9.

3.1.2 Results of measuremens on cable group 1, injection point 1.

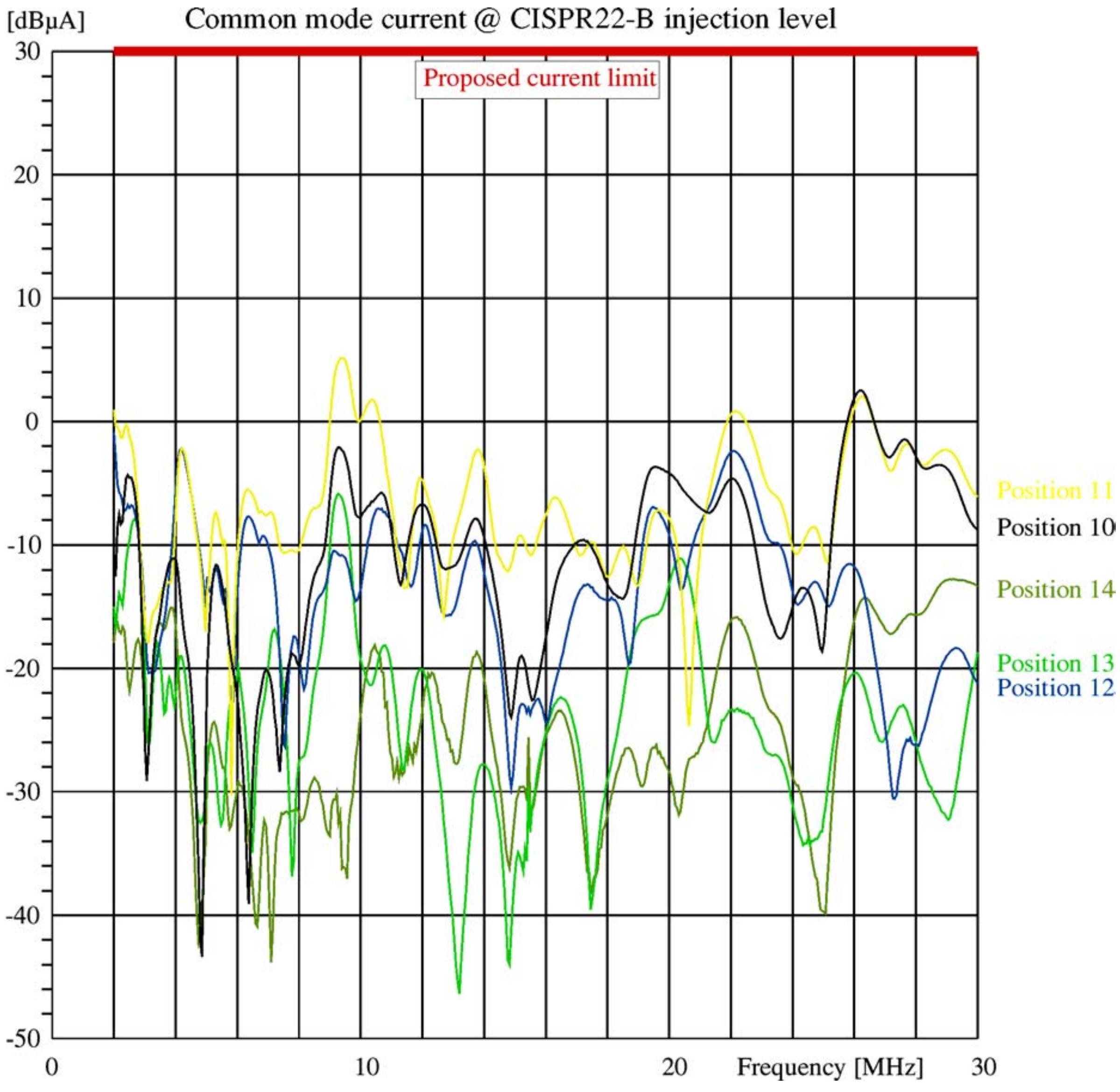

Figure 12 Overview of all CM current measurement on cable group 1, while injecting at injection point 1, which is on cable group 3.

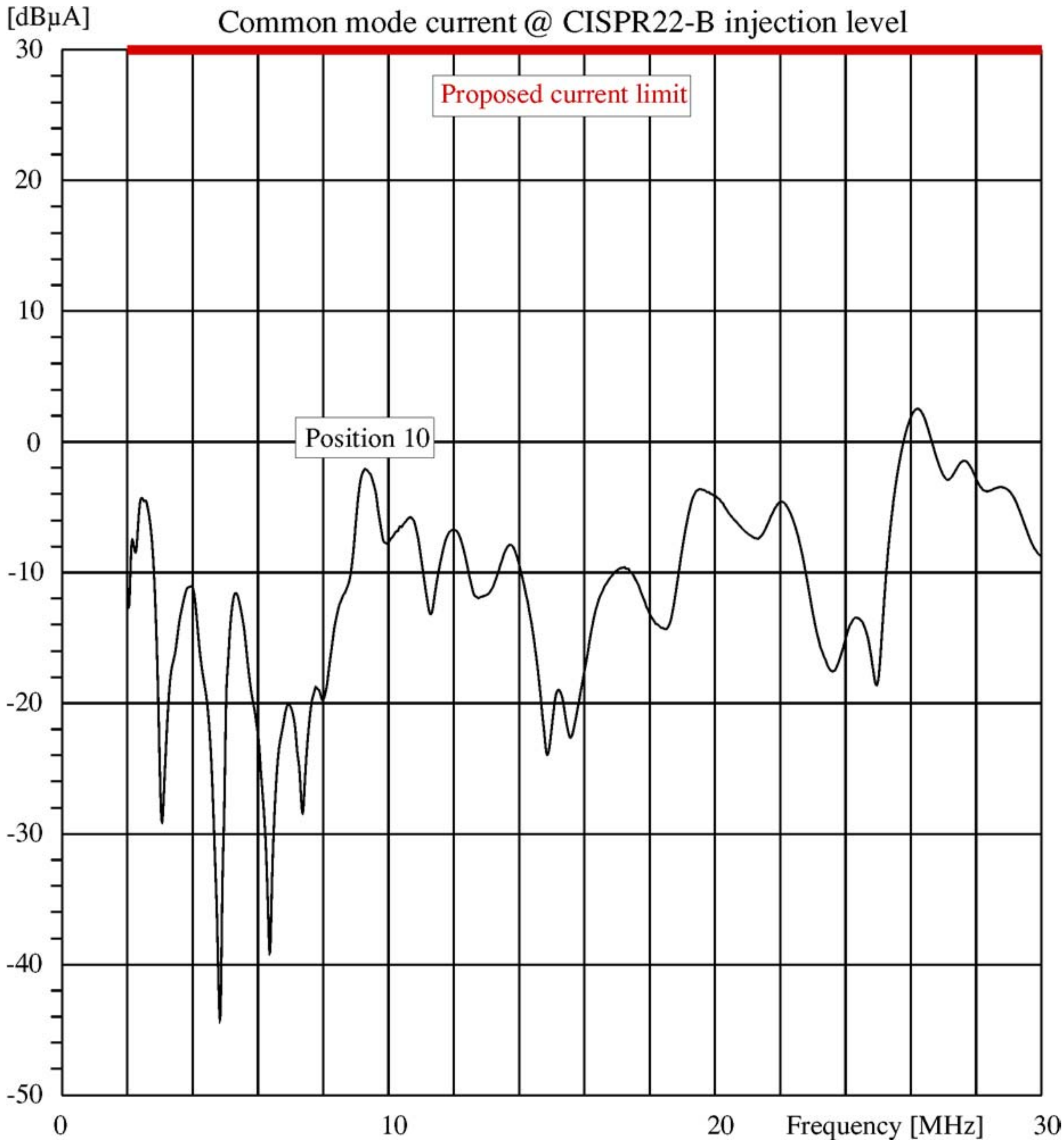

Figure 13 CM current at position 10.

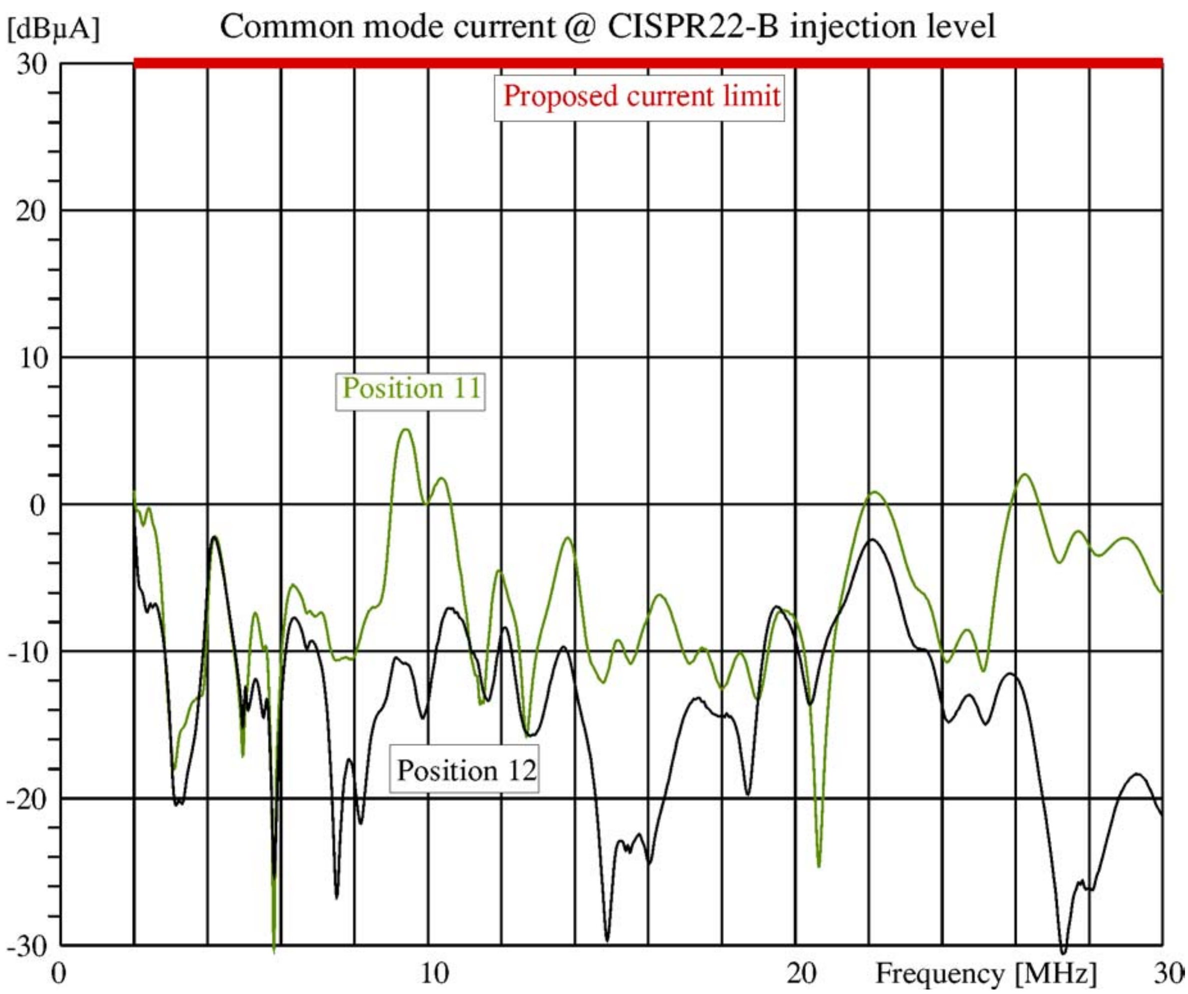

Figure 14 CM current at positions 11 and 12.

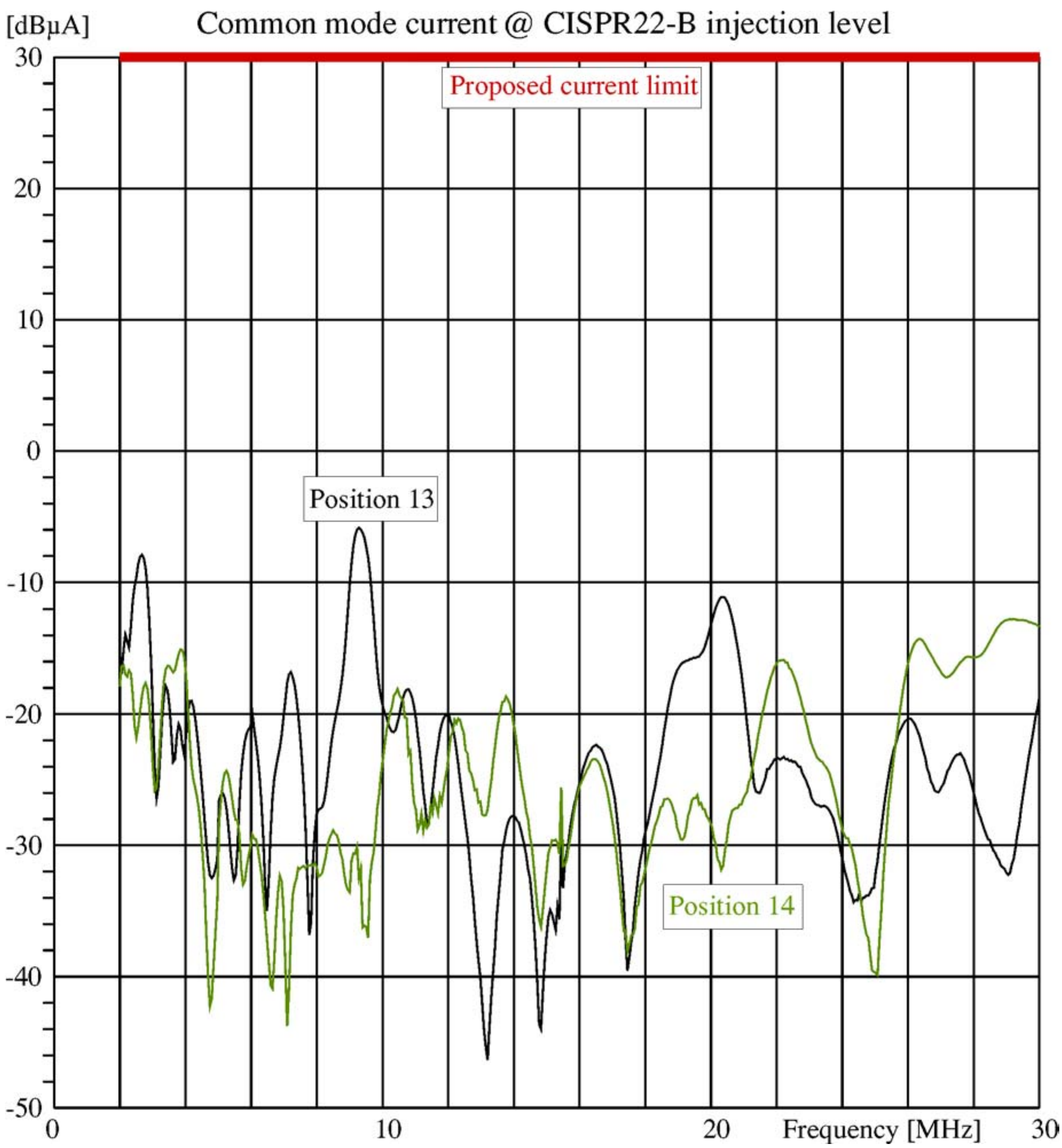

Figure 15 CM current at positions 13 and 14.

3.1.3 Results of measurements on 3 phase cable, injection point 1.

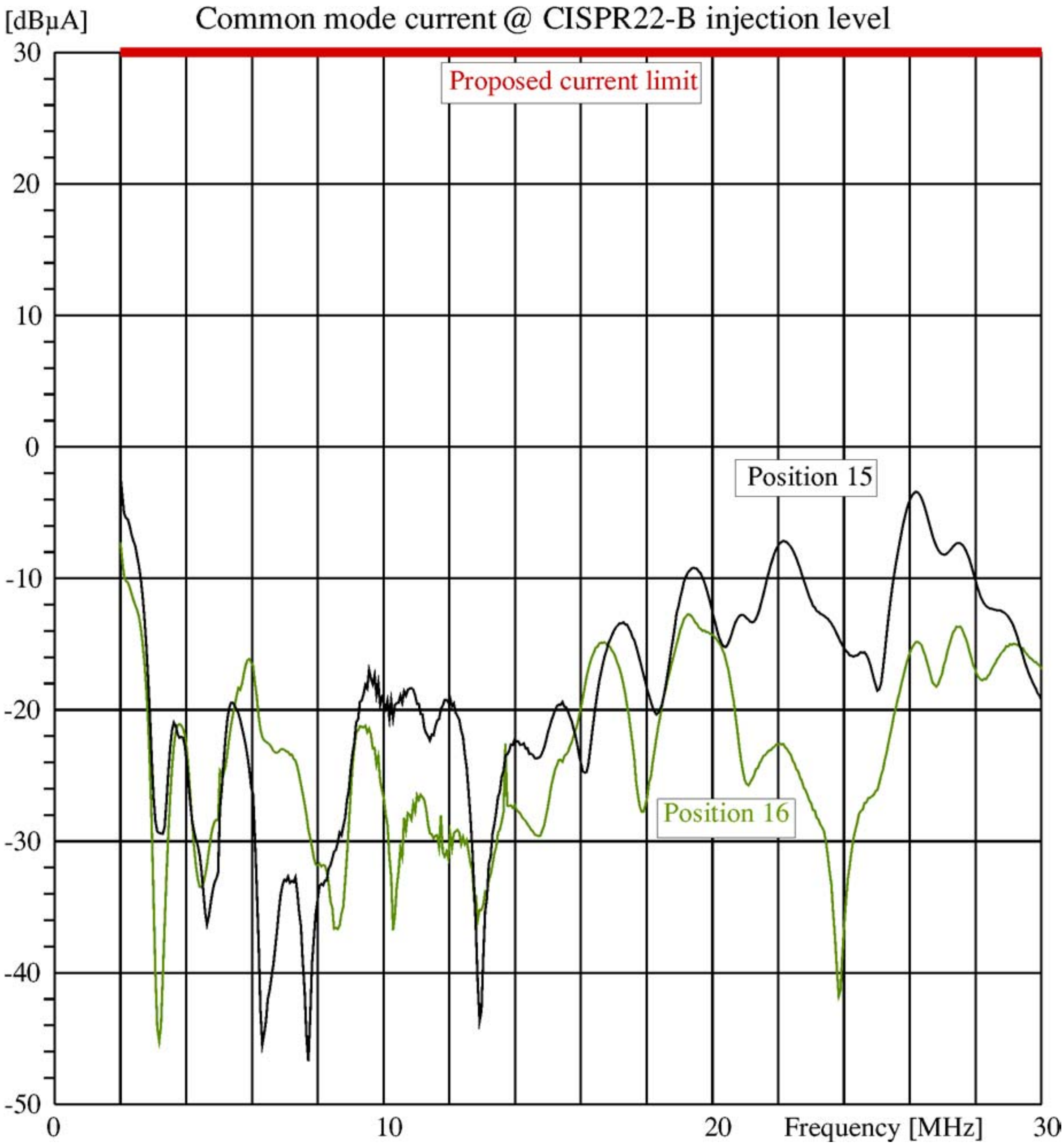

Figure 16 CM current at positions 15 and 16 on the 3-phase cable.

3.1.4 Results of measurements on cable group 2, injection point 1.

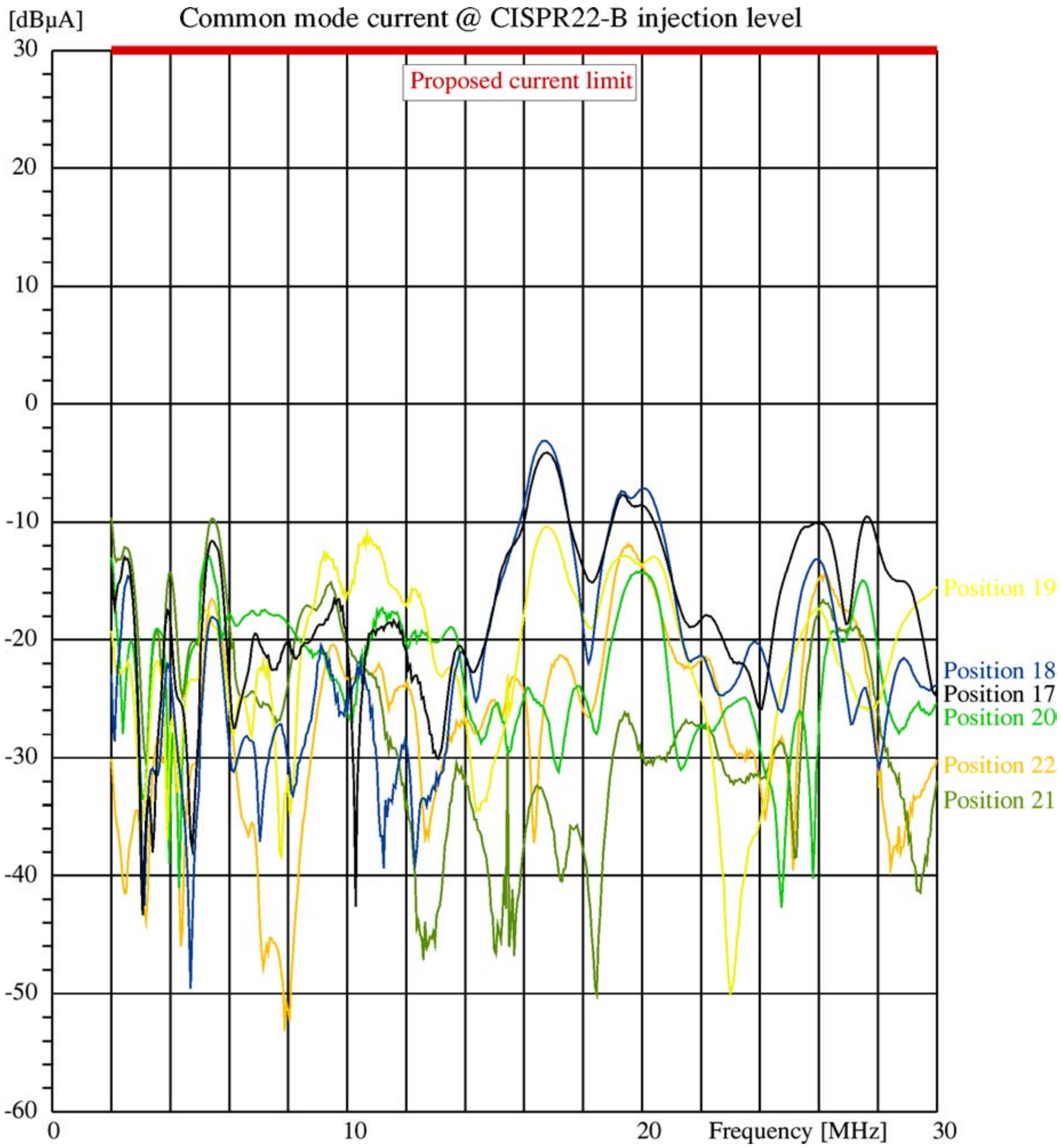

Figure 17 Overview of all CM current measurement on cable group 2, while injecting at injection point 1, which is on cable group 3.

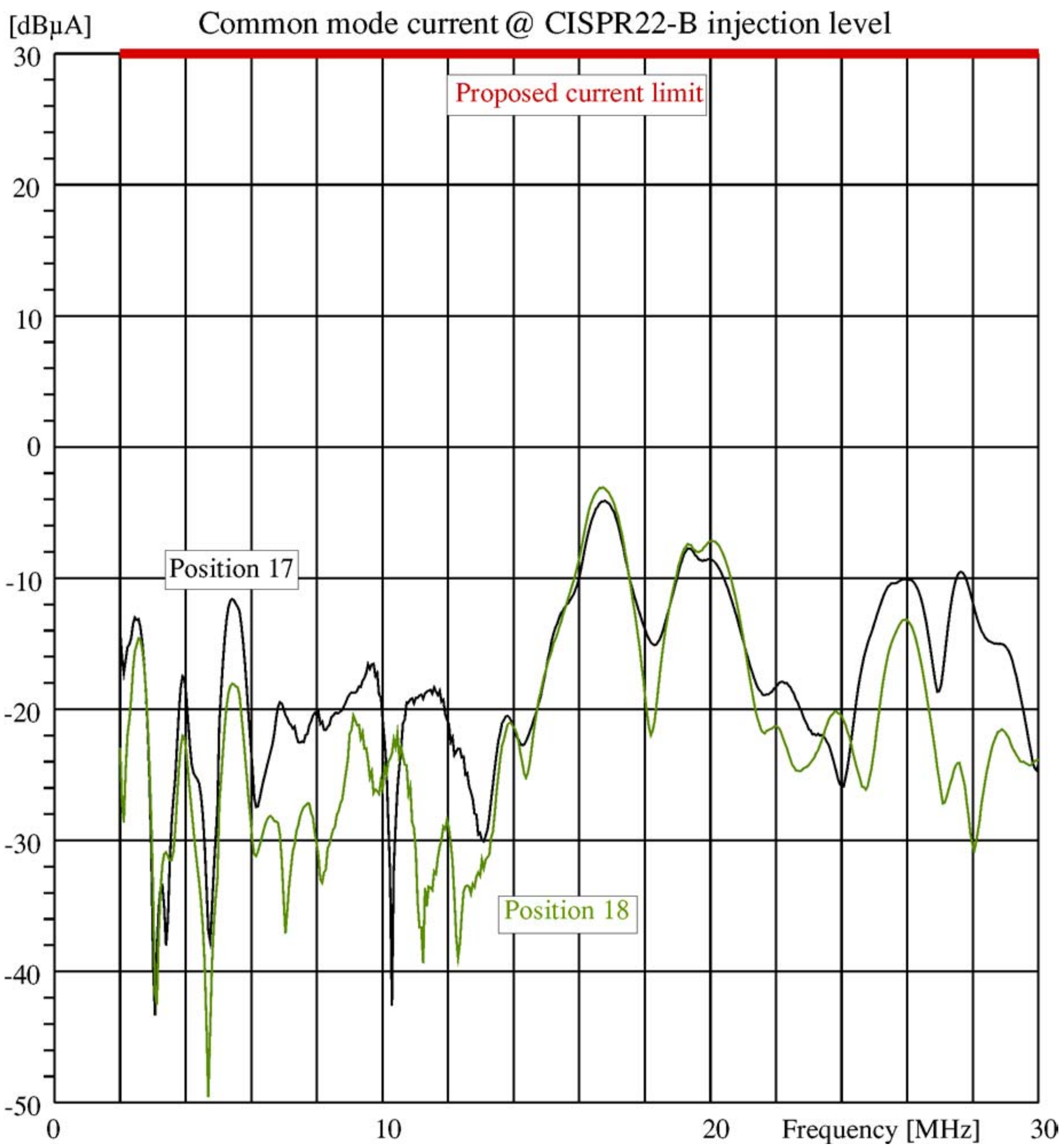

Figure 18 CM current at positions 17 and 18.

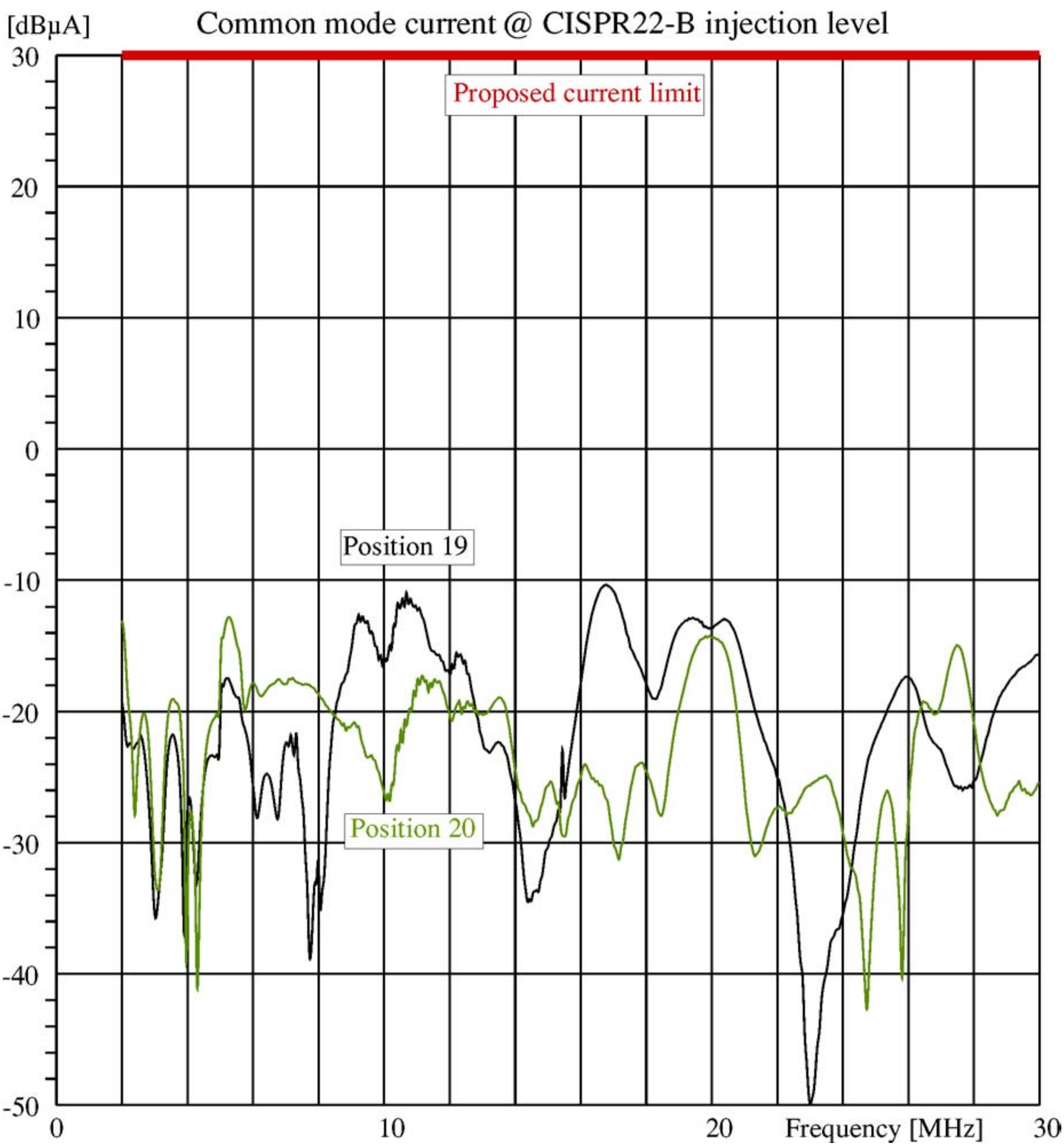

Figure 19 CM current at positions 19 and 20.

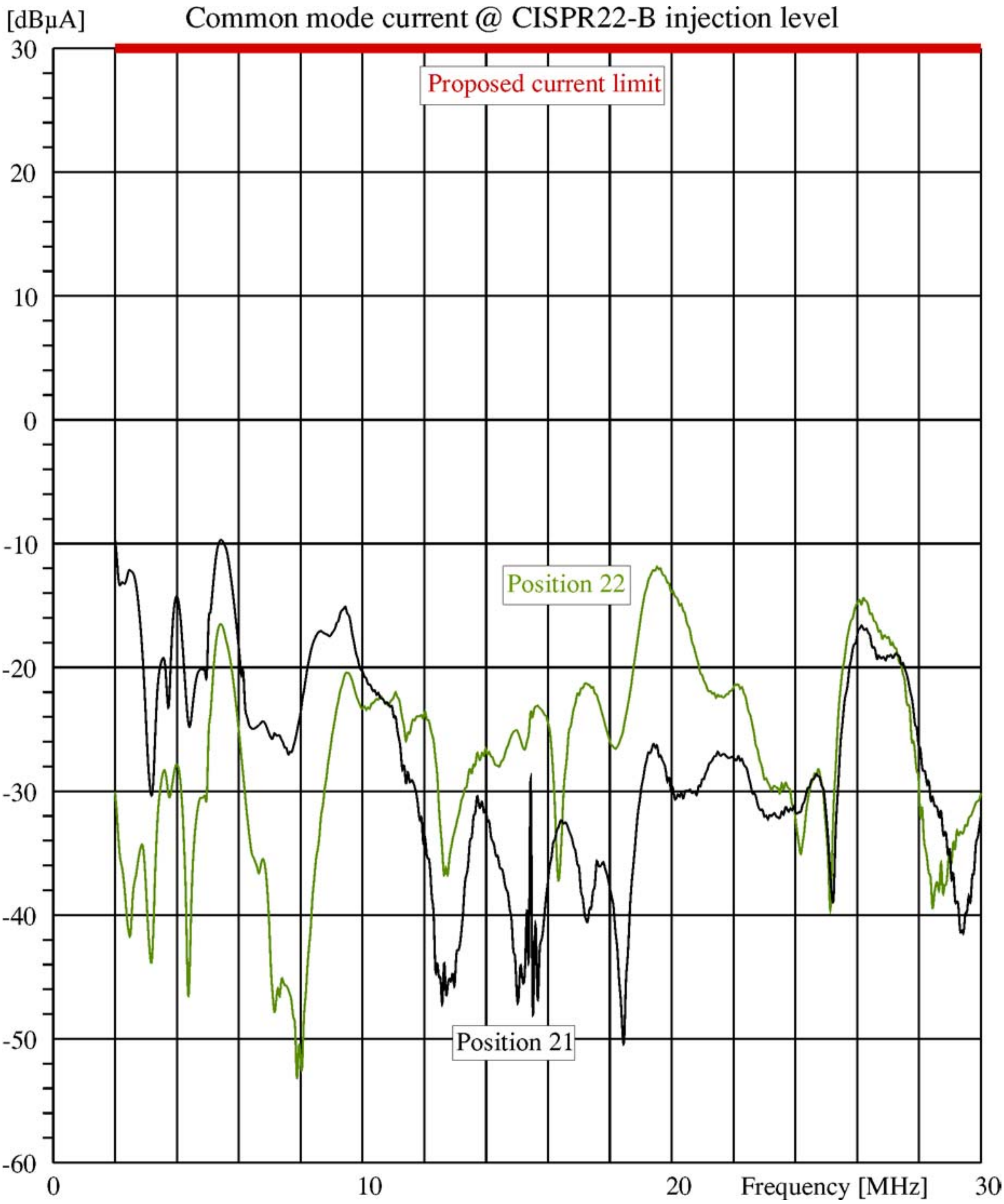

Figure 20 CM current at positions 21 and 22.

3.1.5 Results of measurements on cable group 2, injection point 2.

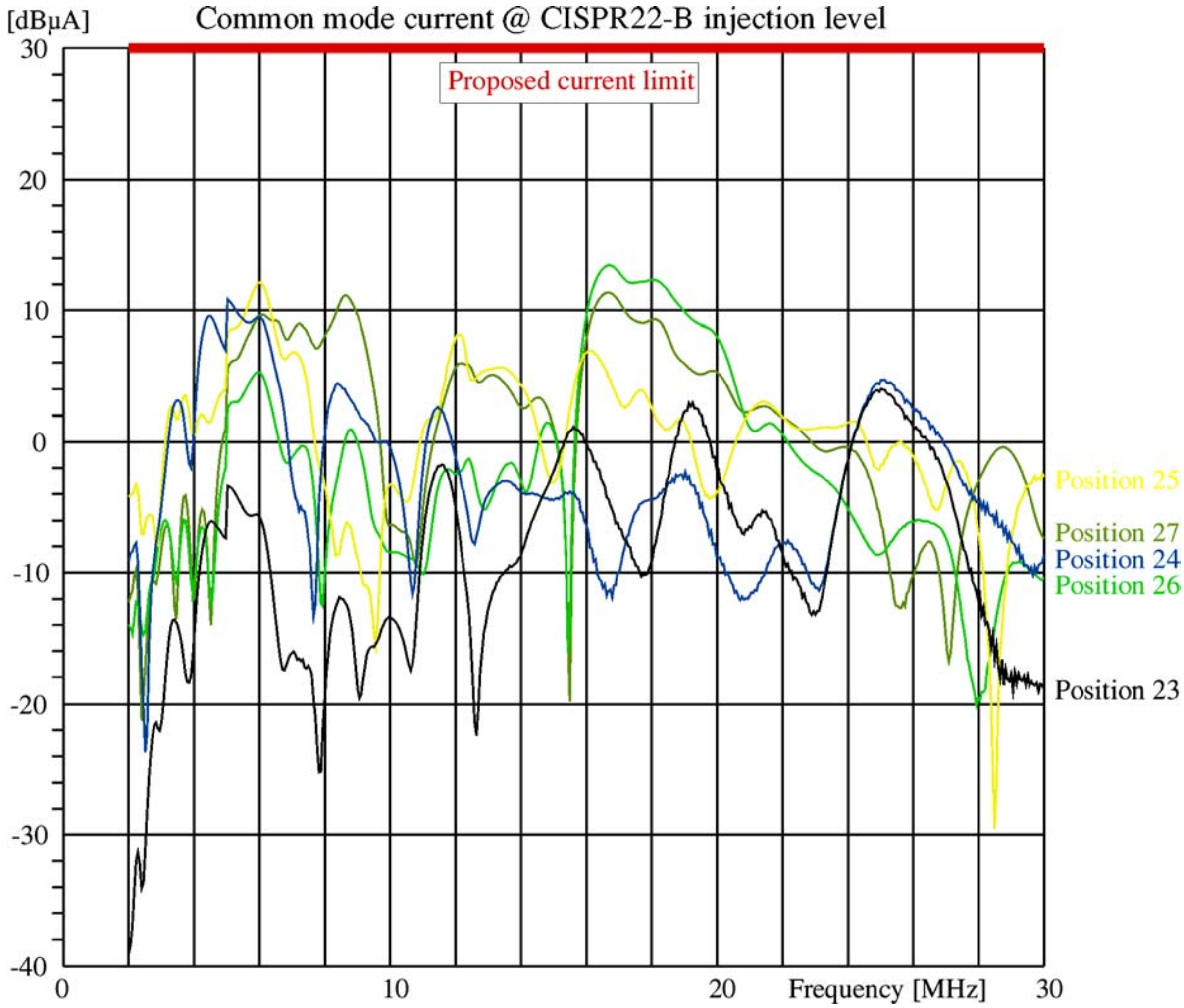

Figure 21 Overview of all CM current measurement on cable group 2, while injecting at injection point 2, which is on cable group 2.

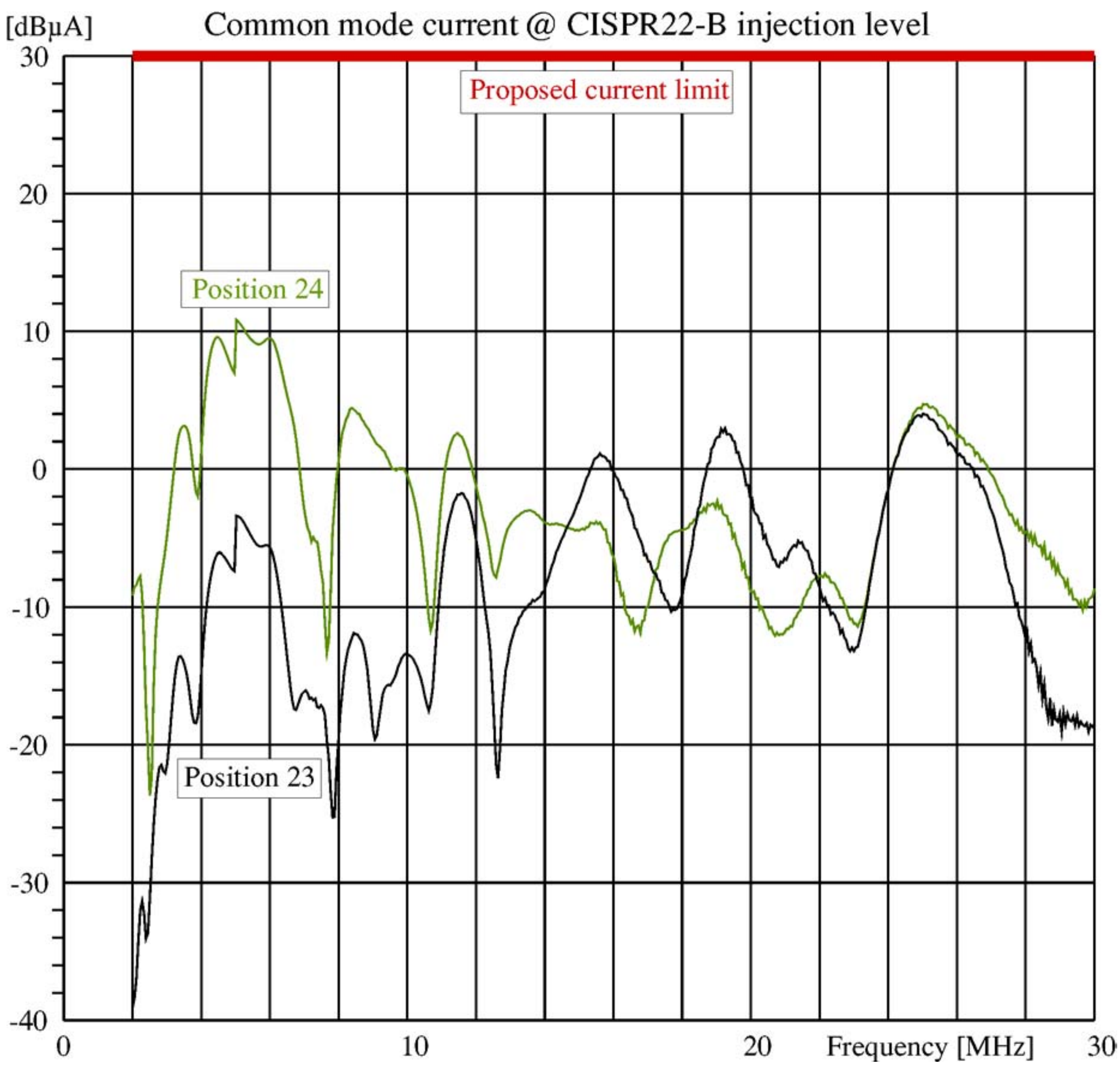

Figure 22 CM current at positions 23 and 24.

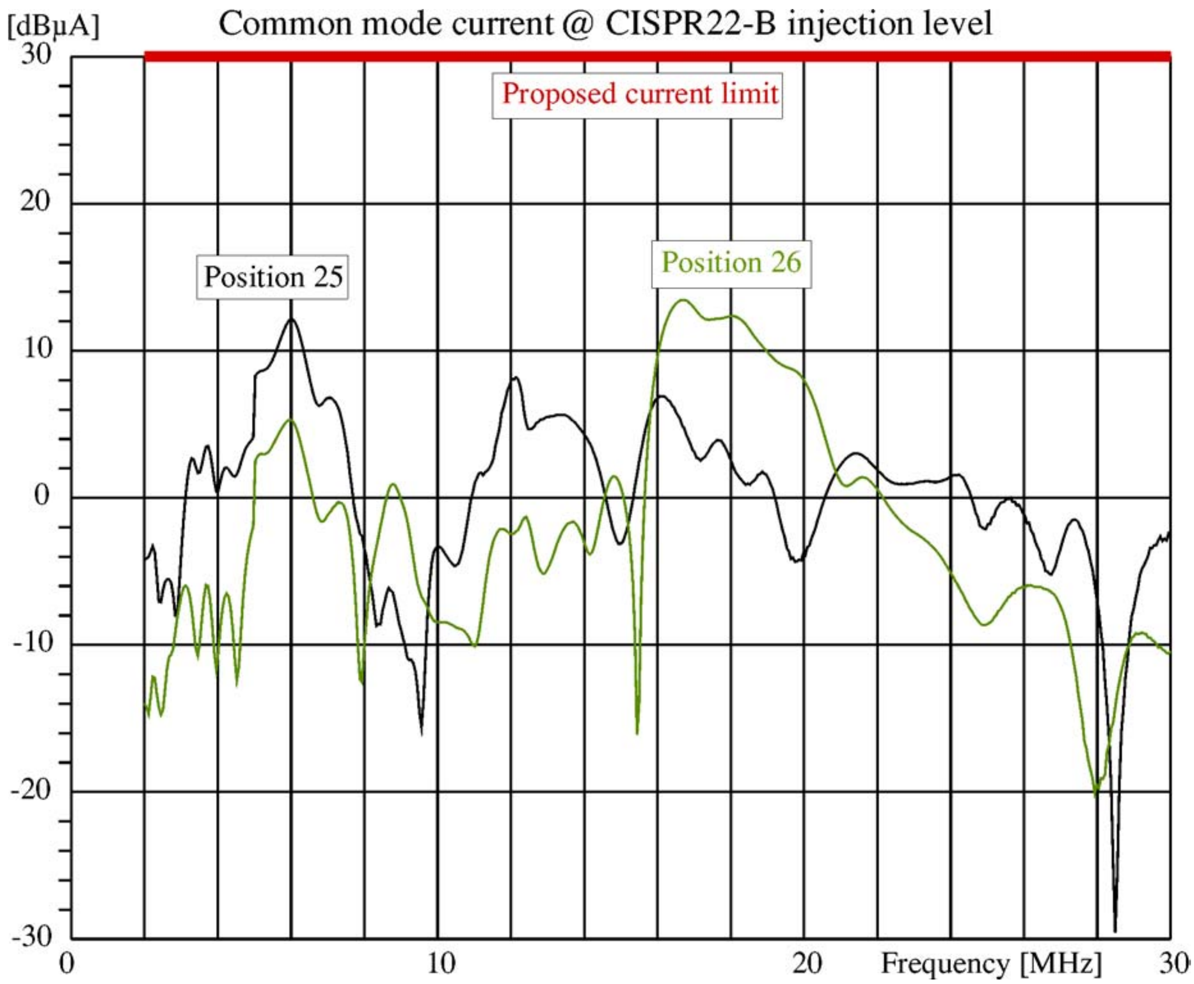

Figure 23 CM current at positions 25 and 26.

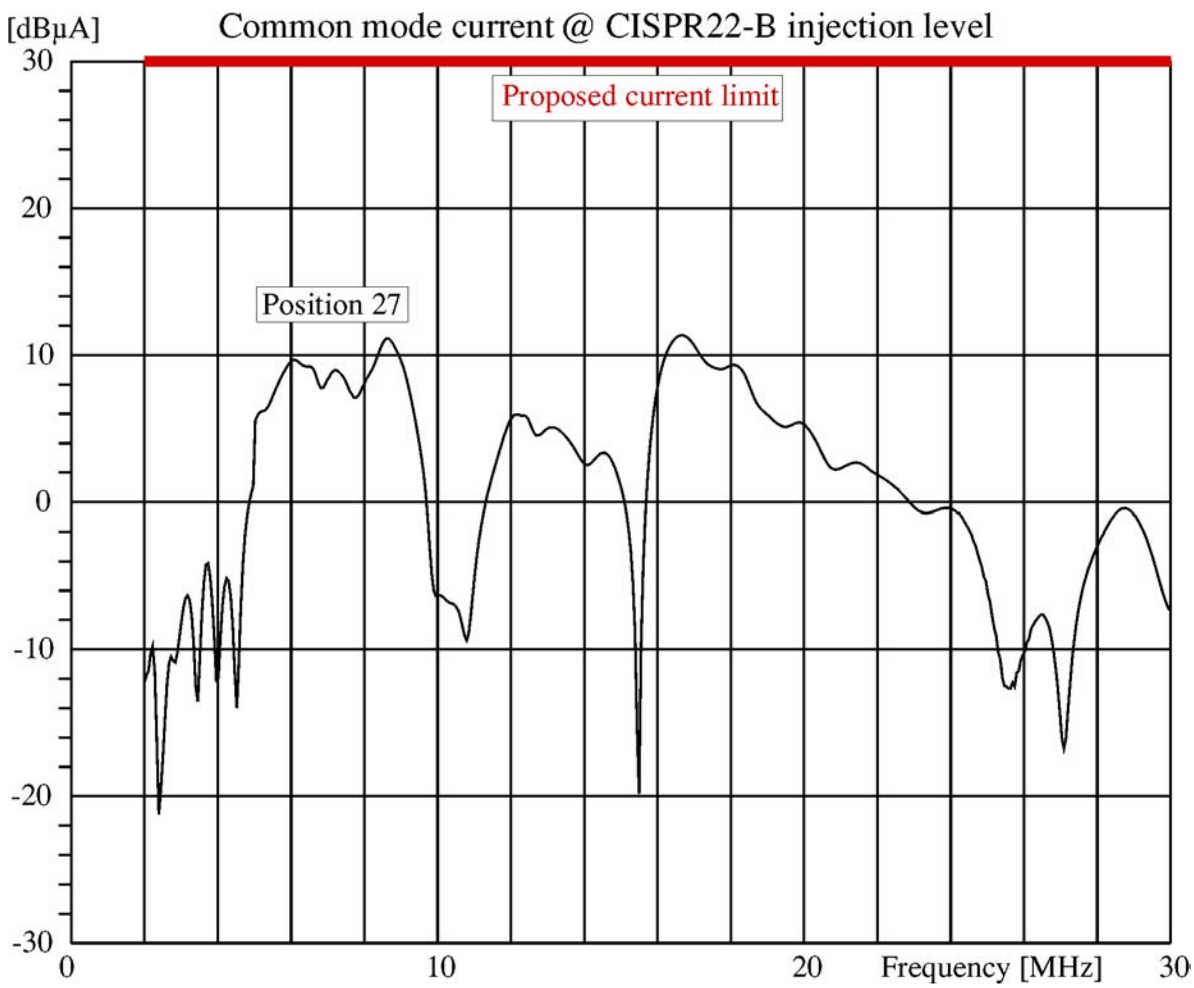

Figure 24 CM current at position 27.

3.2 Field strength measurement results

Using a loop antenna, field strength measurements are done at 4 locations in the building. Refer to the floor lay out of the building in Figure 5 for the location of the antenna during these measurements.

Measurement position	Injection point	Distance over cable [m]	Measurement distance loop antenna cable [m]	Maximum fieldstrength [dBµA]	At frequency [MHz]
1	2	3.5	4	-13.0	16.5
2	2	3.5	4	-16.4	8.7
3	2	10	3	-17.6	8.5
3	1	12	3	-27.6	15.8
4	1	37	3	-34.0	5.2
4	2	23	3	-27.8	8.7

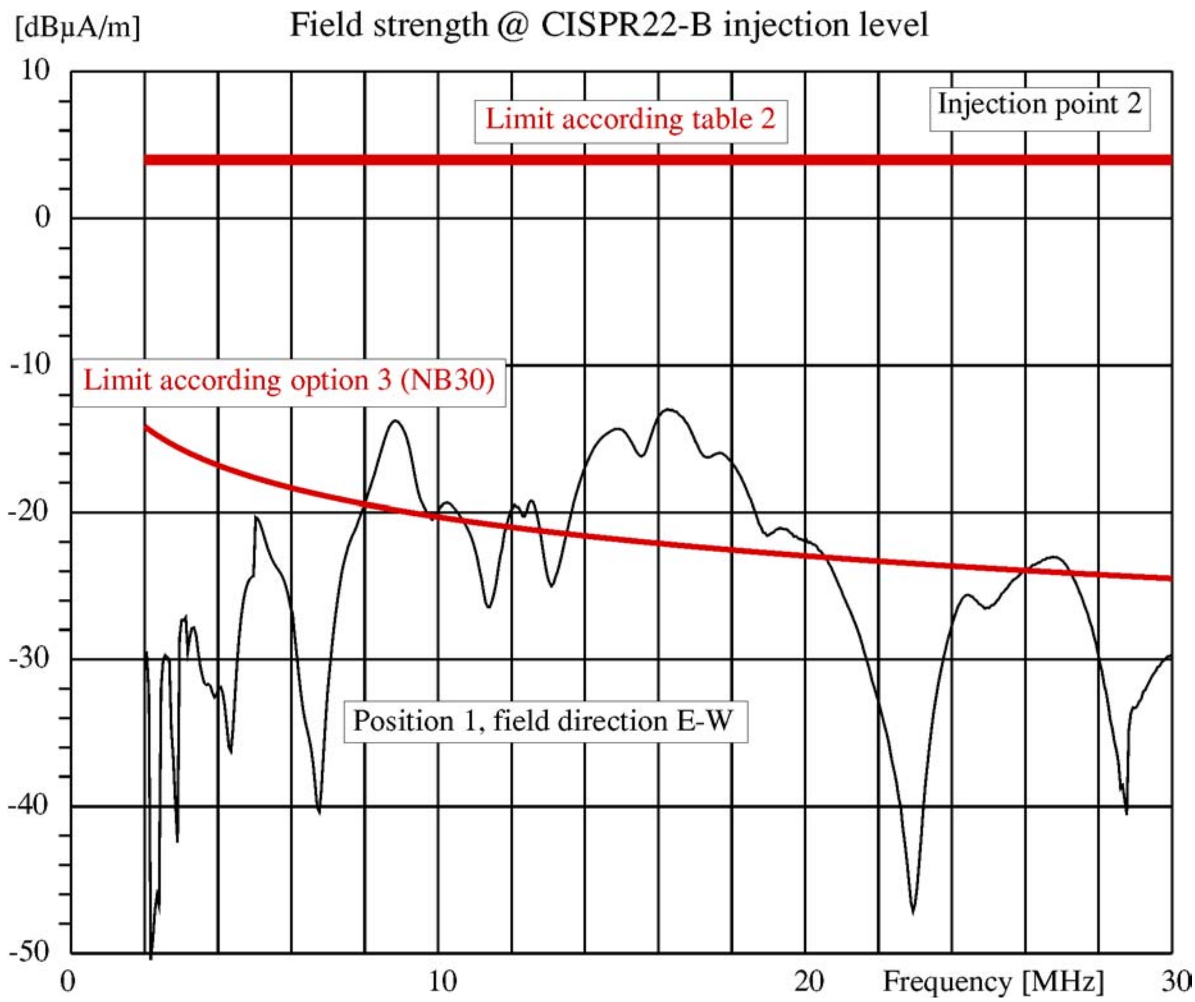

Figure 25 Field strength measurement at position 1.

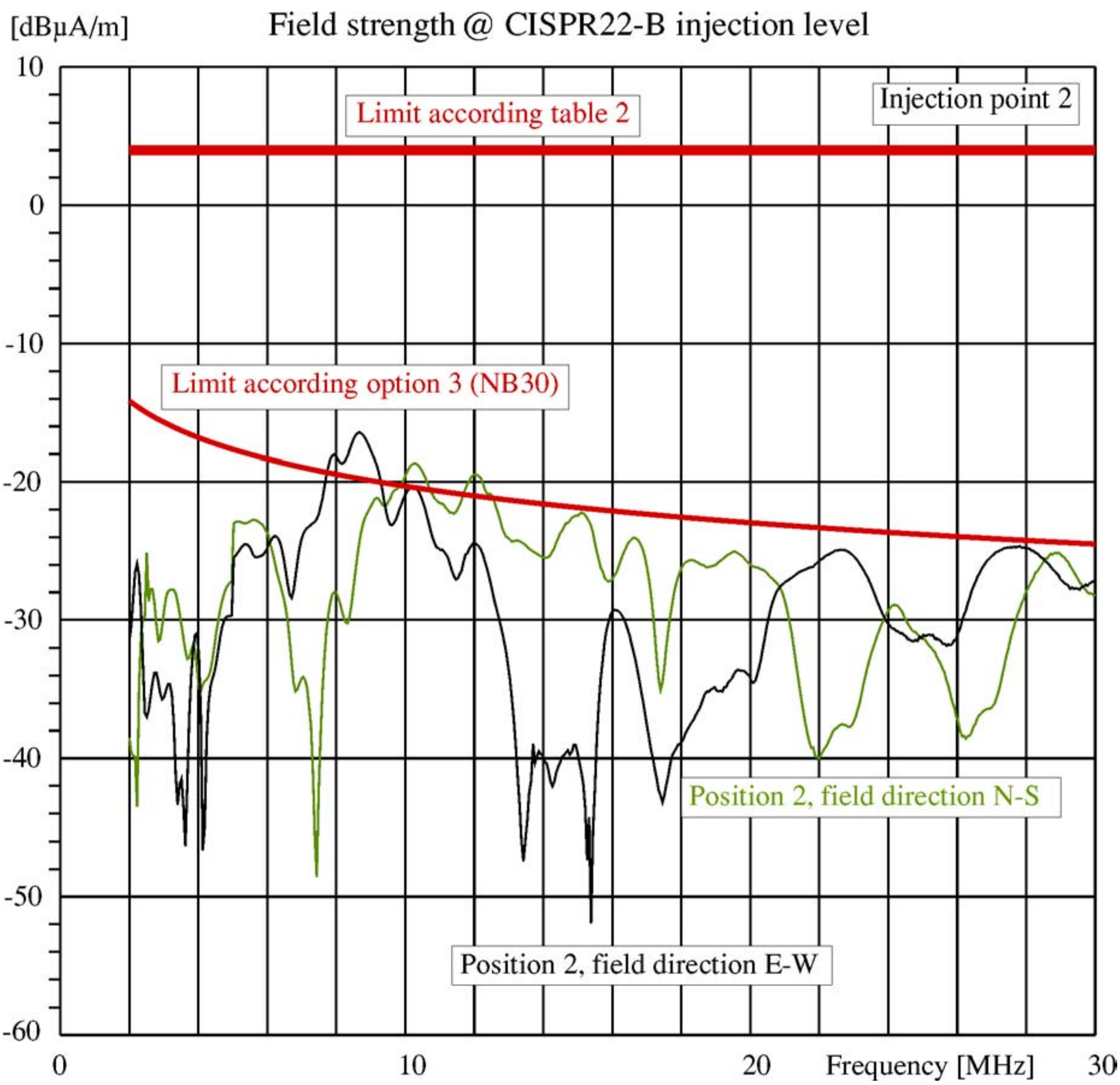

Figure 26 Field strength measurement at position 2.

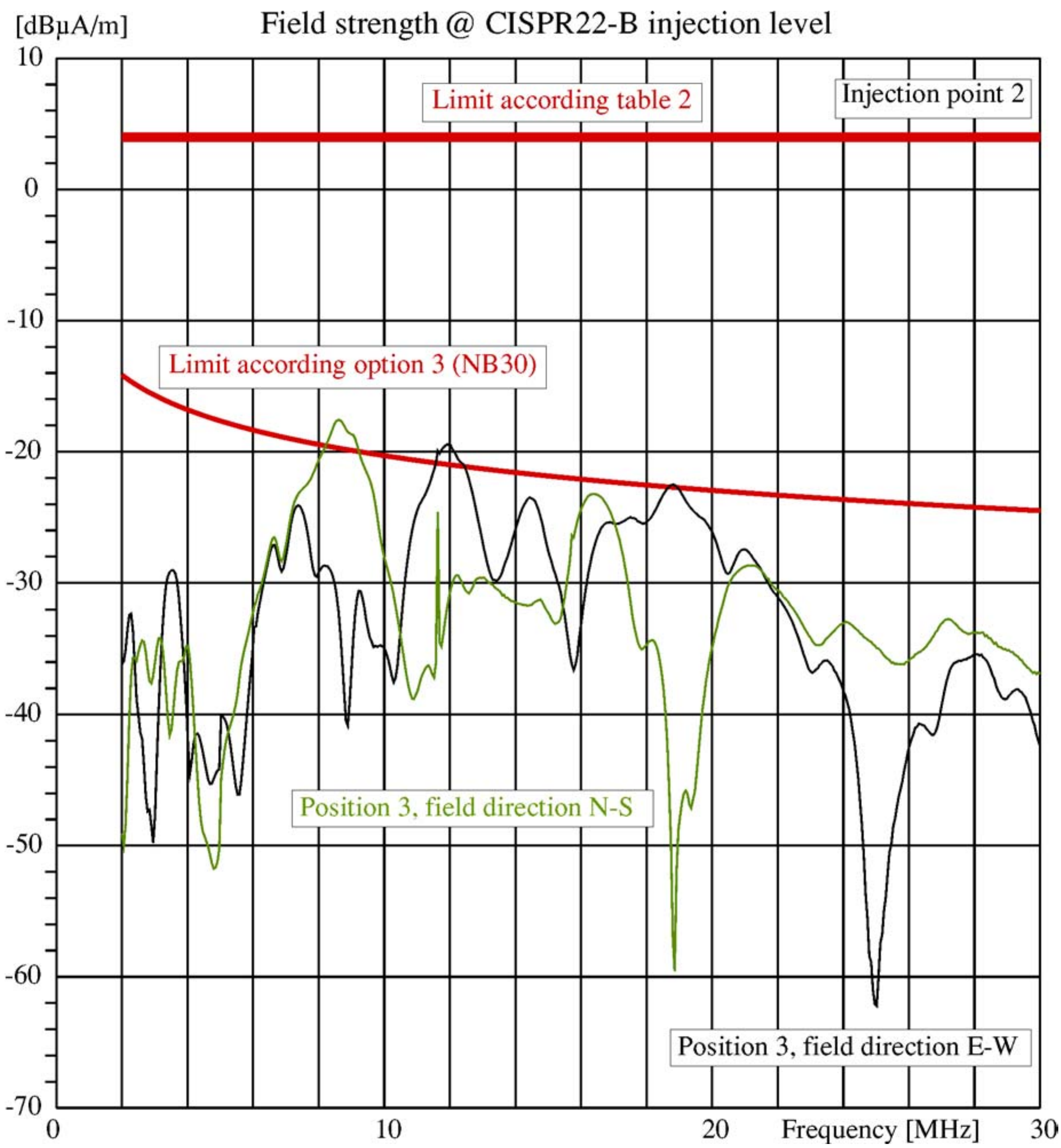

Figure 27 Field strength measurement at position 3, injection point 2.

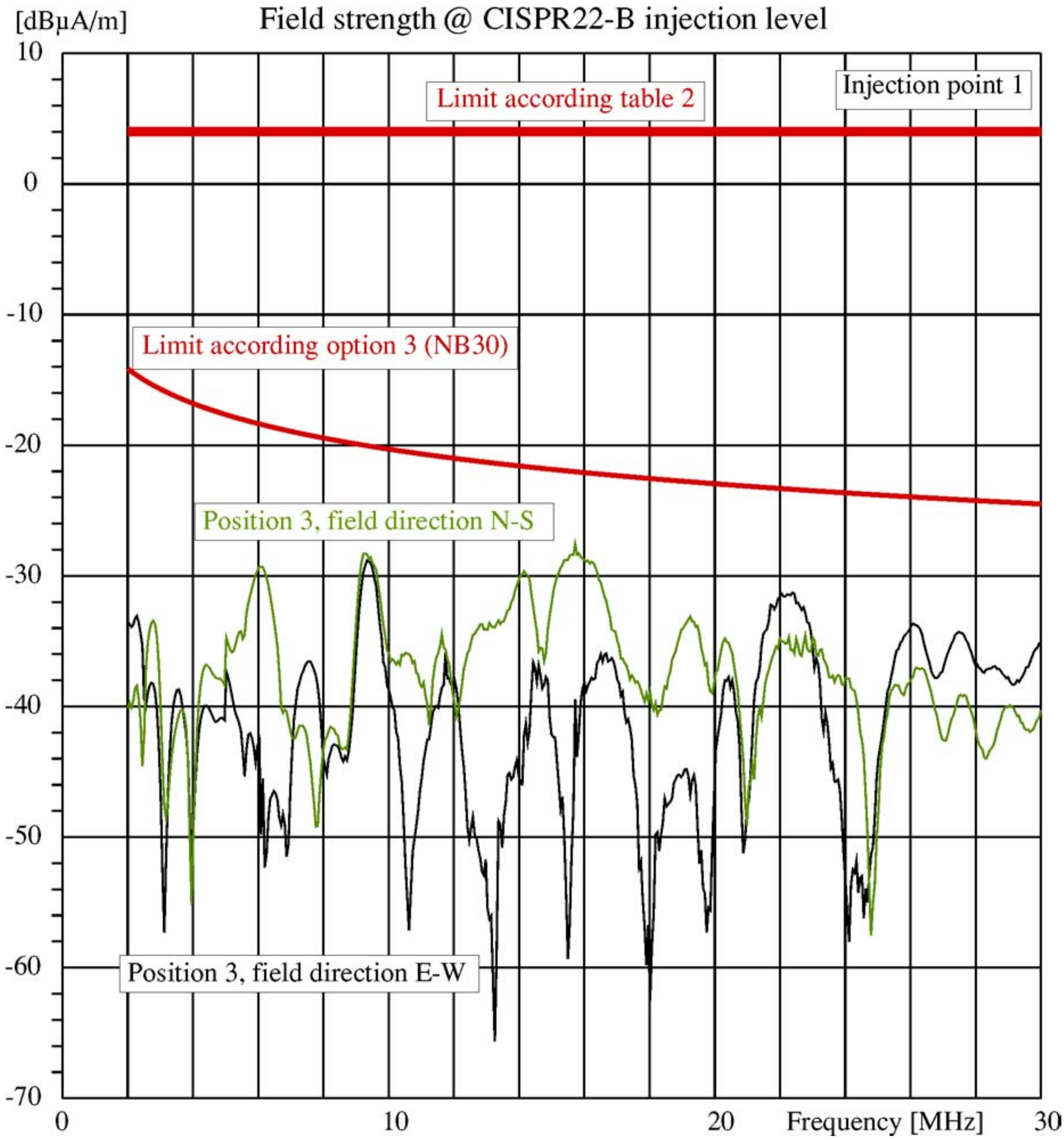

Figure 28 Field strength measurement at position 3, injection point 1.

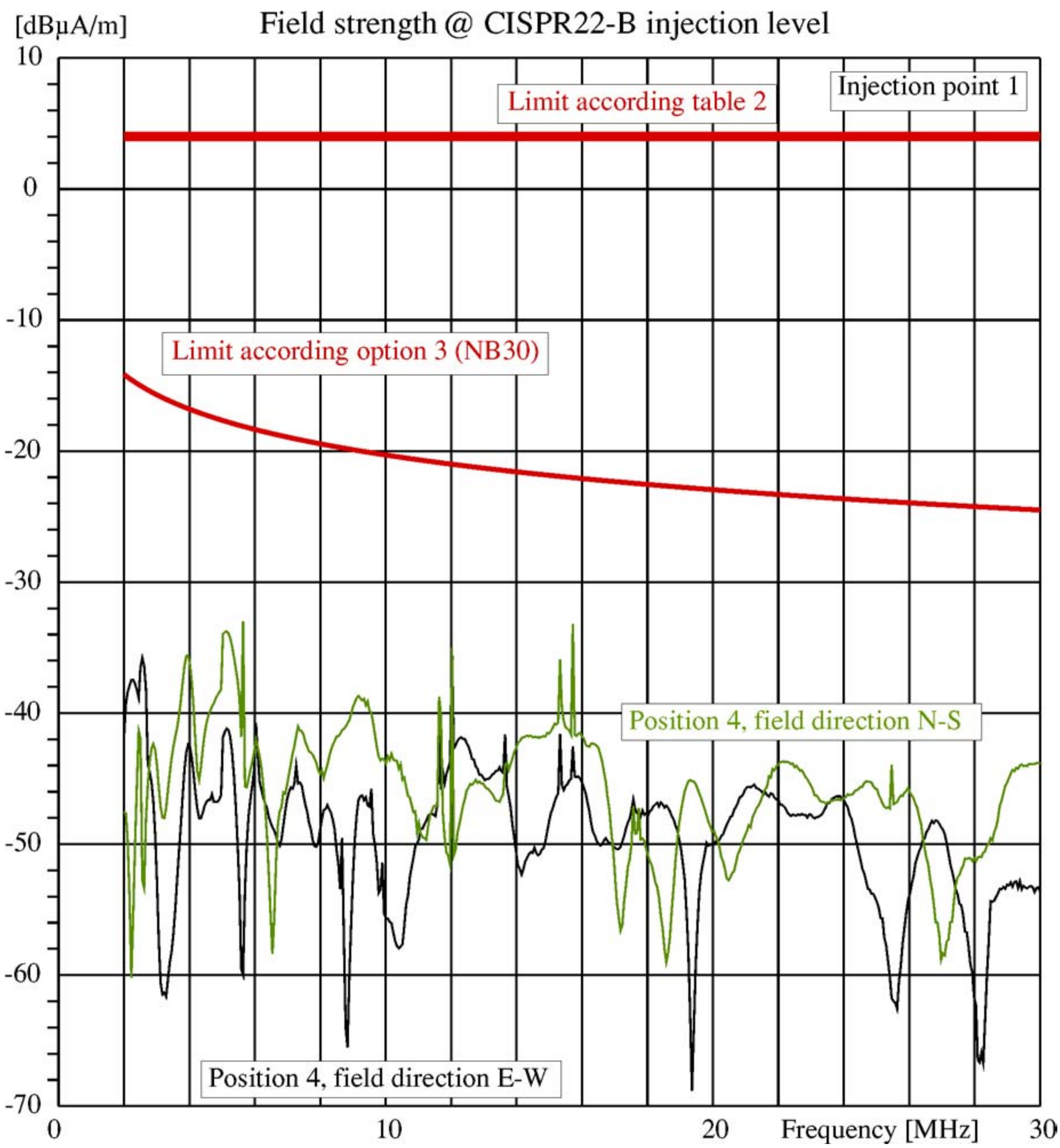

Figure 29 Field strength measurement at position 4, injection point 1.

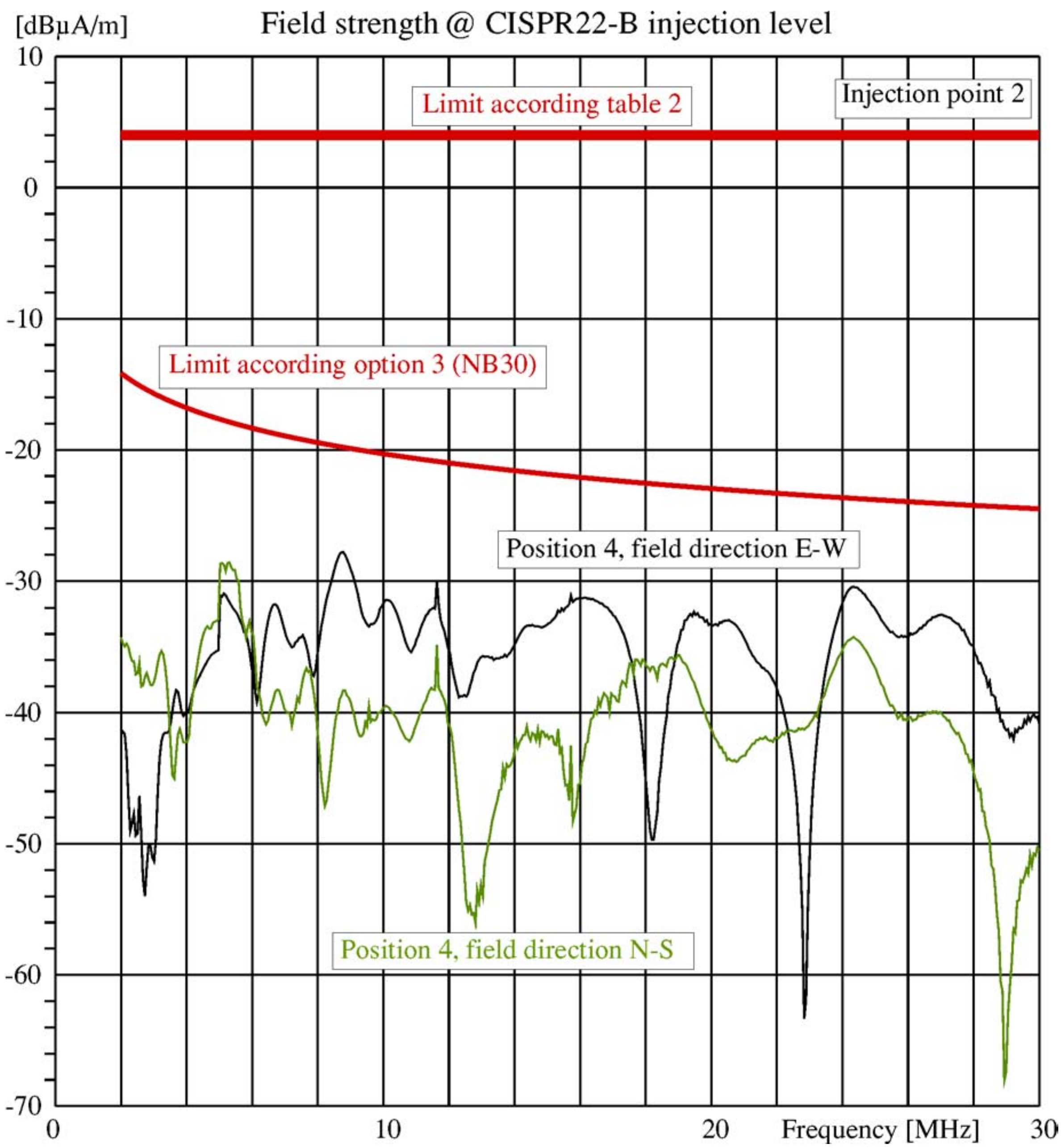

Figure 30 Field strength measurement at position 4, injection point 2.

4 Photographs

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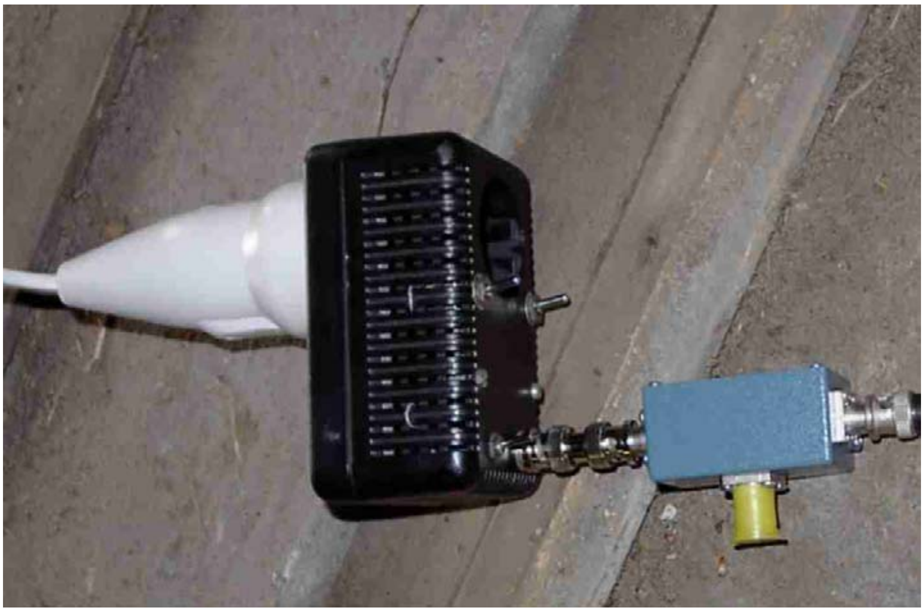
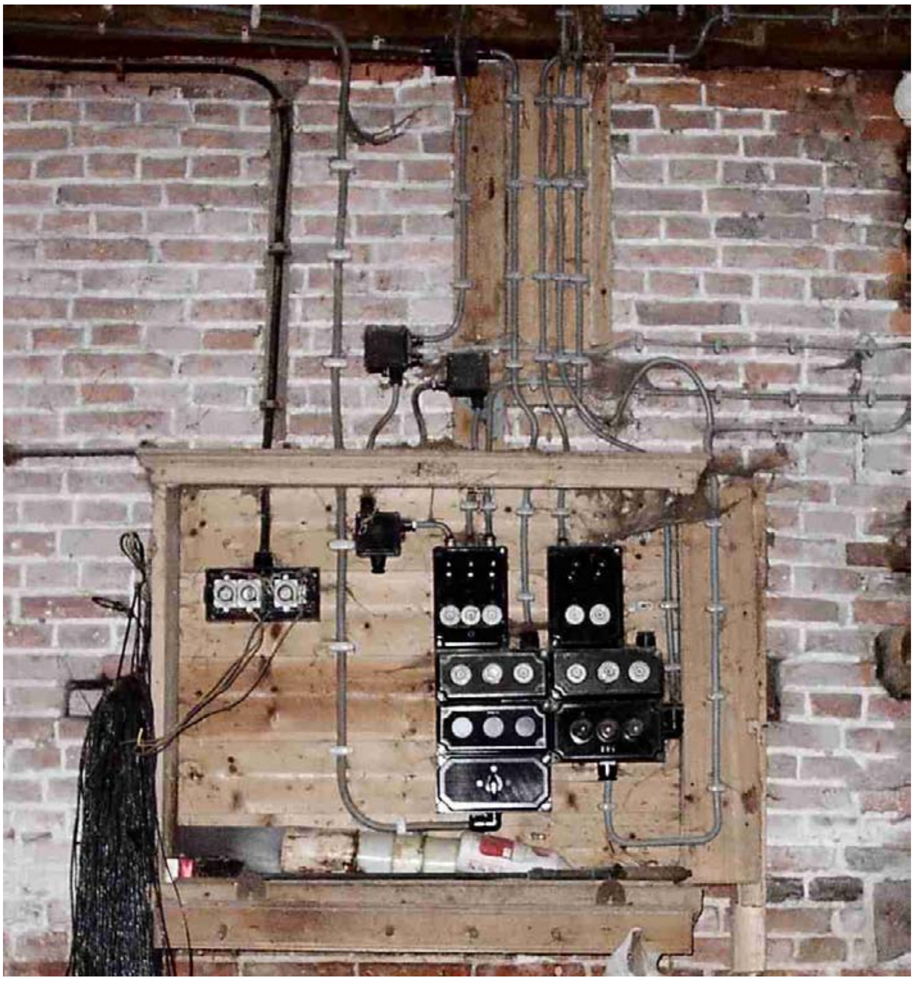
Photopgraph 1: Current probe connected to cable.



Photopgraph 2 Injection fixture and matching circuit

Photopgraph 3 FSP-3 spectrum analyzer with RF amplifier on top



Photopgraph 4 Building installation overview

Photopgraph 5 Loop Antenna setup (location 4).

Photopgraph 6 Building, rear

Photopgraph 7 Building, aspect
Antenna set up

-
-

5 List of utilized test equipment.

TNO Number	Description	Brand	Model	Serial No.
15453	Magnetic Loop antenna	Chase	HLA6120	1107
(x)	Spectrum Analyze with Tracking Generator	Rhode & Schwarz	FSP 3	10658
(xx)	RF Current Injection device	-	-	-
(xx)	Matching network	-	-	-
(xx)	HP8447D RF amplifier	Hewlett Packard	HP 8447D	2944A08623
-	Laptop computer	COMPAQ	EVO 600	-
(x)	LISN	Schaffner	NNB42	03/10038
(x)	Current clamp 100 MHz	Rhode & Schwarz	EZ-17	816.2063.02

(x) This measurement equipment is supplied by client. TNO declares that equipment used was accompanied with a valid calibration document.
(xx) The current injection device, matching device and RF amplifier are calibrated as part of the measurement procedure. The check of this calibration is witnessed.

6 Annex: The Mains Connector Device.

Purpose.
A dedicated device was made for injecting RF power into a mains network and measure RF voltages on that network. This document describes this device and gives calibration information.

Objective.
The objective of the device is to inject RF power into a mains network in a asymmetrical way, using the Neutral - Earth port or the Phase - Earth port, or in a symmetrical way using Neutral - Phase connection. In the latter case a choice can be made between a forced symmetry by connecting the Earth as a reference, or a floating symmetry. In practice it appeared that the effect of this is small. *The registered symmetrical measurements are all performed with S3 open.*
The original intended frequency range was 1.6 to 30 MHz, but using the transfer function, described below, measurements can be performed from 10 kHz to 50 MHz.

Description.
Figure A1-1 gives the circuit diagram. For injecting in the Phase line (P) switches S1 and S3 are closed, for Neutral line (N) S2 and S3, and for symmetrical injection S1 and S2, while S3 left open. By closing S3 in the last case the symmetry of the voltages on the Neutral and Phase wire can be forced. However in practice it appeared that the effect is little. *For the symmetrical measurements only those measuring values for S3 is open are registered.*

Figure A2 gives the principal circuit. The $transfer\ ratio$ is defined as:

$$transfer\ ratio = \frac{V_{load}}{E/2} = \frac{I \cdot |Z_p|}{E/2} = \frac{E/|Z| \cdot |Z_p|}{E/2} = 2 \cdot \frac{|Z_p|}{|Z|} \qquad (1)$$

with $|Z_p|$ the absolute value of the impedance of the parallel connection of L_p, the parallel selfinductance of balun transformer Tr2, and the (resistive) load on the output (= input impedance of the measuring receiver, 50 ohm).

$|Z|$ is the absolute value of the total loop impedance, in which the current I runs.
The values of C, R_{source}, and R_{load} are set by design, the values of L and R_{loss} are determined from a transmission measurement using a spectrum analyser with a tracking generator as network analyser.

The calculation of the loop impedance Z:

$$Z = \frac{1}{j\omega C} + j\omega L_s + Z_p + R_s + R_{loss} \qquad (2)$$

$$Z_p = \frac{R_L \cdot j\omega L_p}{R_L + j\omega L_p} \qquad (3)$$

$$Z = \frac{1}{j\omega C} + j\omega L_s + \frac{R_L \cdot j\omega L_p}{R_L + j\omega L_p} + R_s + R_{loss}$$

$$Z = \frac{R_L + j\omega L_p + j\omega L_s \cdot j\omega C (R_L + j\omega L_p) + j\omega C \cdot R_L \cdot j\omega L_p}{j\omega C (R_L + j\omega L_p)} + R_s + R_{loss}$$

$$Z = \frac{\omega^2 L_s C R_L + \omega^2 L_p C R_L - R_L + j\omega^3 L_s C L_p - j\omega L_p}{\omega C (\omega^2 L_p^2 + R_L^2)} \cdot \left(\omega L_p + jR_L\right) + R_s + R_{loss}$$

$$Z = \frac{\omega^3 L_p^2 C R_L + j\{\omega^4 L_s L_p^2 C - \omega^2 (L_p^2 - L_s C R_L^2 - L_p C R_L^2) - R_L^2\}}{\omega C (\omega^2 L_p^2 + R_L^2)} + R_s + R_{loss} \qquad (4)$$

To determine the absolute value of Z we divide Z in a real part $Re(Z)$ and in a complex part $Im(Z)$:

$$Re(Z) = \frac{\omega^3 L_p^2 C R_L}{\omega C\left(\omega^2 L_p^2 + R_L^2\right)} + R_s + R_{loss}$$

$$= \frac{\omega^2 L_p^2 R_L}{\omega^2 L_p^2 + R_L^2} + R_s + R_{loss} \tag{5}$$

$$Im(Z = \frac{\omega^4 L_s L_p^2 C - \omega^2\left(L_p^2 - L_s C R_L^2 - L_p C R_L^2\right) - R_L^2}{\omega C\left(\omega^2 L_p^2 + R_L^2\right)}$$

$$= \frac{\omega^4 L_s L_p^2 C - \omega^2\left(L_p^2 - (L_s + L_p) C R_L^2\right) - R_L^2}{\omega C\left(\omega^2 L_p^2 + R_L^2\right)} \tag{6}$$

Combining we get:

$$|Z| = \sqrt{(Re(Z))^2 + (Im(Z))^2} \tag{7}$$

In the same way we derive for Z_p:

$$Z_p = \frac{R_L \cdot j\omega L_p}{R_L + j\omega L_p} = \frac{j\omega L_p R_L (R_L - j\omega L_p)}{R_L^2 + \omega^2 L_p^2} = \frac{\omega^2 L_p^2 R_L + j\omega L_p R_L^2}{R_L^2 + \omega^2 L_p^2}$$

and

$$|Z_p| = \frac{1}{R_L^2 + \omega^2 L_p^2}\sqrt{\omega^4 L_p^4 R_L^2 + \omega^2 L_p^2 R_L^4} = \frac{\omega L_p R_L \sqrt{\omega^2 L_p^2 + R_L^2}}{R_L^2 + \omega^2 L_p^2} \tag{8}$$

The formulas (1), (5), (6), (7), and (8) are being inputted in a math program together with a list of frequencies and the component values. The result is displayed in figure A1-3 for asymmetrical coupling, and in figure A1-4 for symmetrical coupling.

The outcome has been compared with the measured transfer function, and in this way the values of L_s, L_p, en R_{loss} has been iterated to the indicated values. The resulting calculated curve is deviating less than 0,5 dB from the measured curve.
7

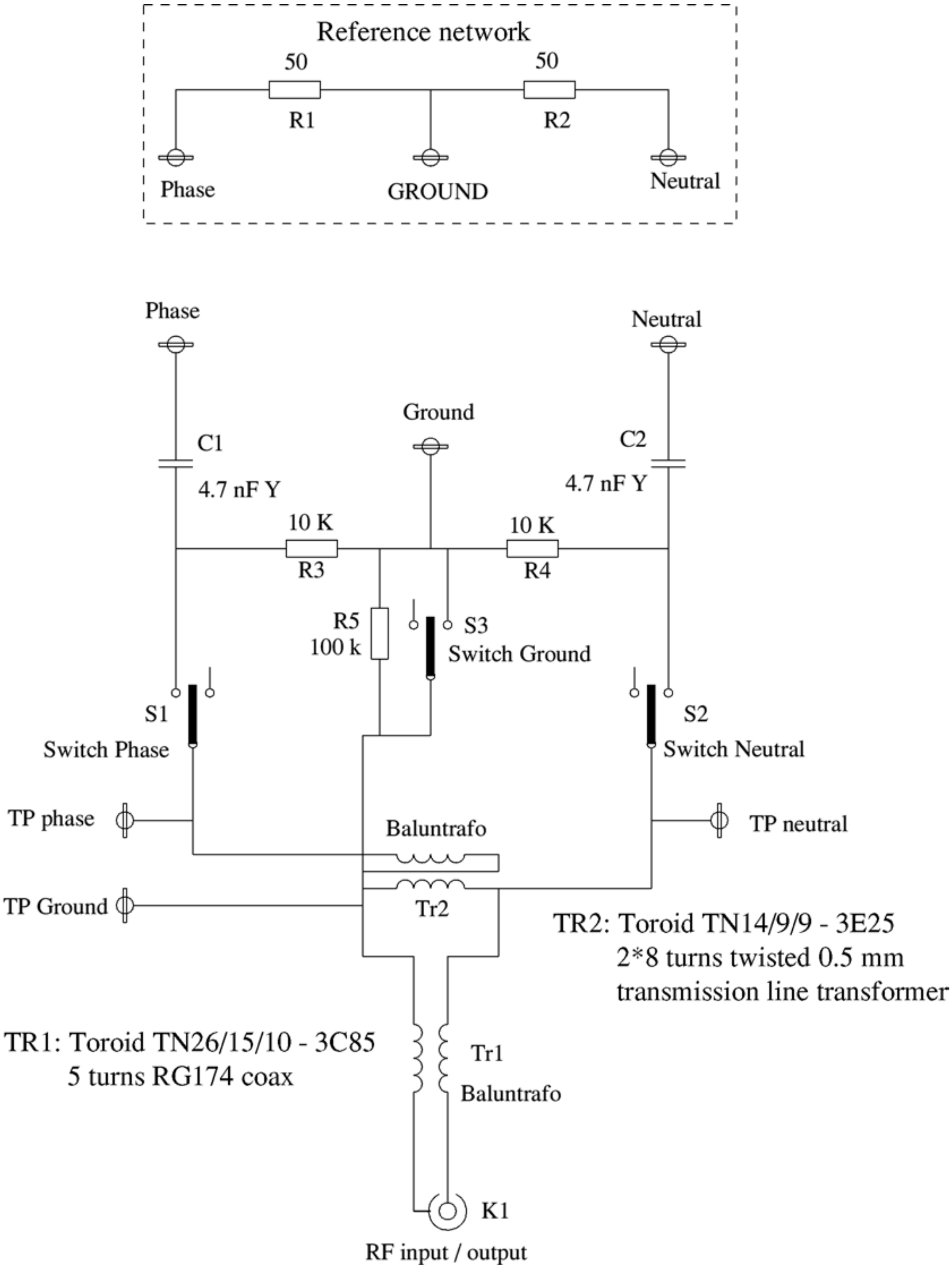


Figure A1-1. Circuit of the Mains Connector Device.

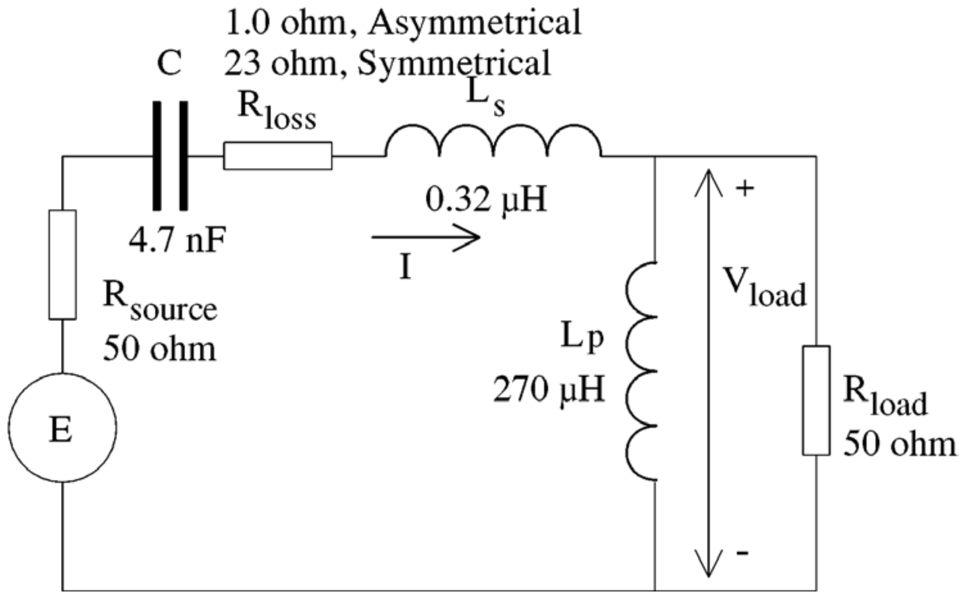


Figure A1-2. Principal schematic.

Now the transfer function is available in the form of a formula, the by the measuring receiver measured interference voltages at the connector of the MCD can be calculated back into mains disturbance voltages at the wall outlet where the MCD was inserted by software means.

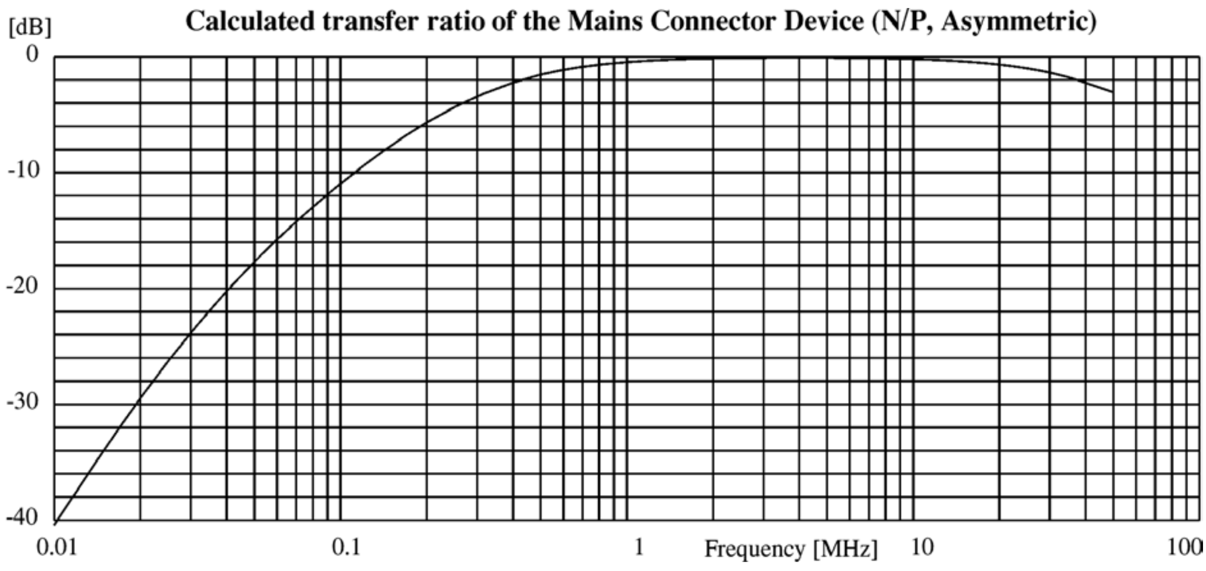
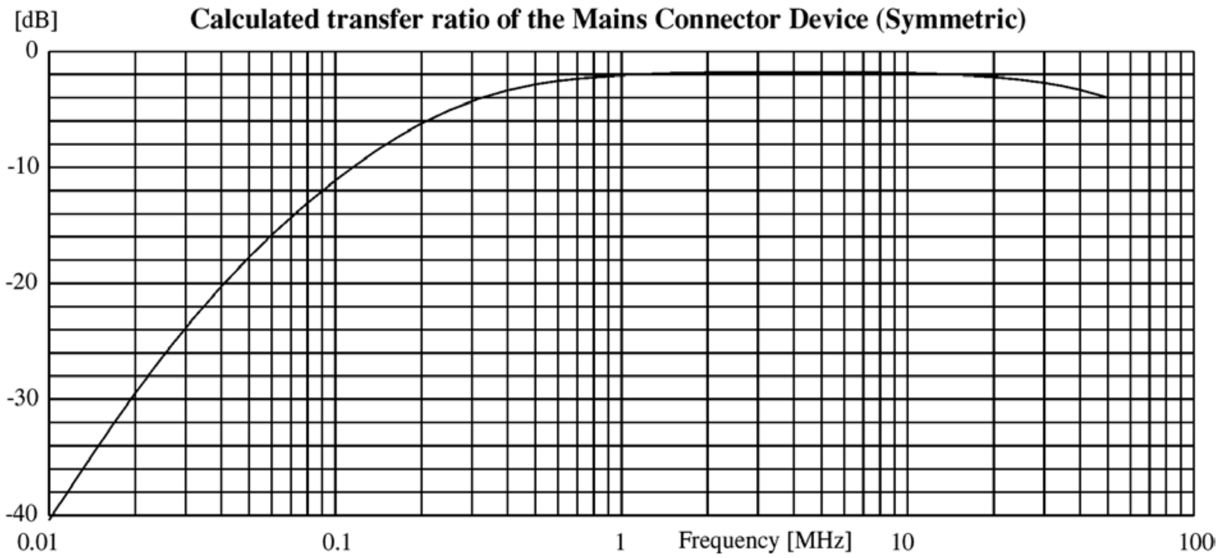


Figure A1-3. Transfer function for the case of asymmetric coupling.



1

Figure A1-4. Transfer function for the case of symmetric coupling.

Source impedance.
For the benefit of measurement of the impedance that the 230 V grid forms at the place where a signal is to be injected, and also for an assessment of the injected power, we need the magnitude of the source impedance of the combination of generator and MCD. Therefor we reverse the principal schematic of figure A1-2, see figure A1-5. The component values are based on the measurements of the transfer function in figure A1-2. For the symmetrical injection the effect of the balun transformer is taken care of by quadruple the impedance of the generator. Also the other component values are modified for the symmetrical injection, and mentioned between square brackets.

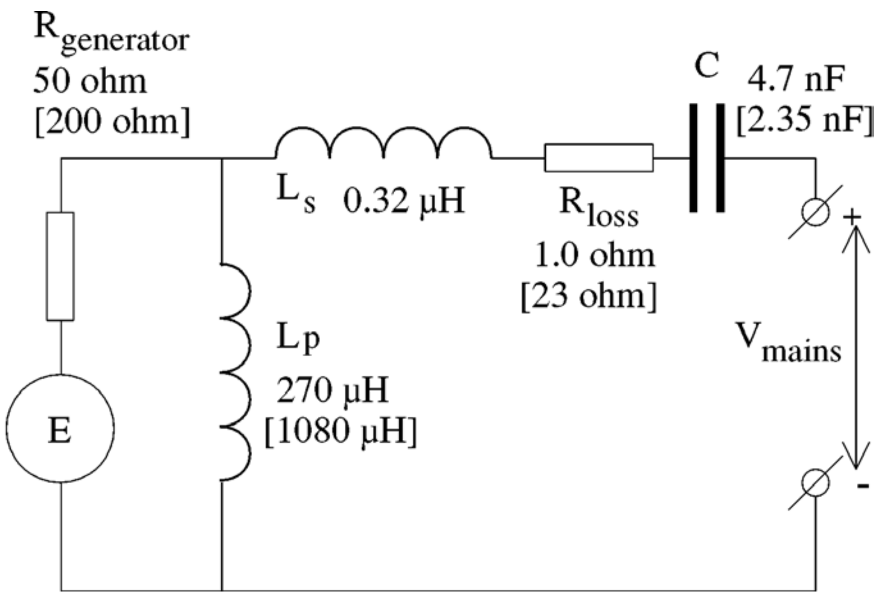


Figure A1-5. Principal schematic mains impedance measurement.

The source impedance follows from the modified formulas (2) en (3):

$$Z = \frac{1}{j\omega C} + j\omega L_s + Z_{pp} + R_{loss} \tag{9}$$

$$Z_{pp} = \frac{R_G \cdot j\omega L_p}{R_G + j\omega L_p} \tag{10}$$

According the same derivation we arrive at the magnitude of the soruce impedance Z_{ss}:

$$Re(Z_{ss}) = \frac{\omega^2 L_p^2 R_G}{\omega^2 L_p^2 + R_G^2} + R_{loss} \tag{11}$$

$$Im(Z_{ss}) = \frac{\omega^4 L_s L_p^2 C - \omega^2 \left(L_p^2 - (L_s + L_p) C R_G^2\right) - R_G^2}{\omega C \left(\omega^2 L_p^2 + R_G^2\right)} \tag{12}$$

$$\left|Z_{ss}\right| = \sqrt{(Re(Z_{ss}))^2 + (Im(Z_{ss}))^2} \tag{13}$$

Figure A1-6 gives the result of the calculation for the asymmetric injection, as well as in the neutral, as in the phase wire, and figure A1-7 shows the results for the symmetric injection.

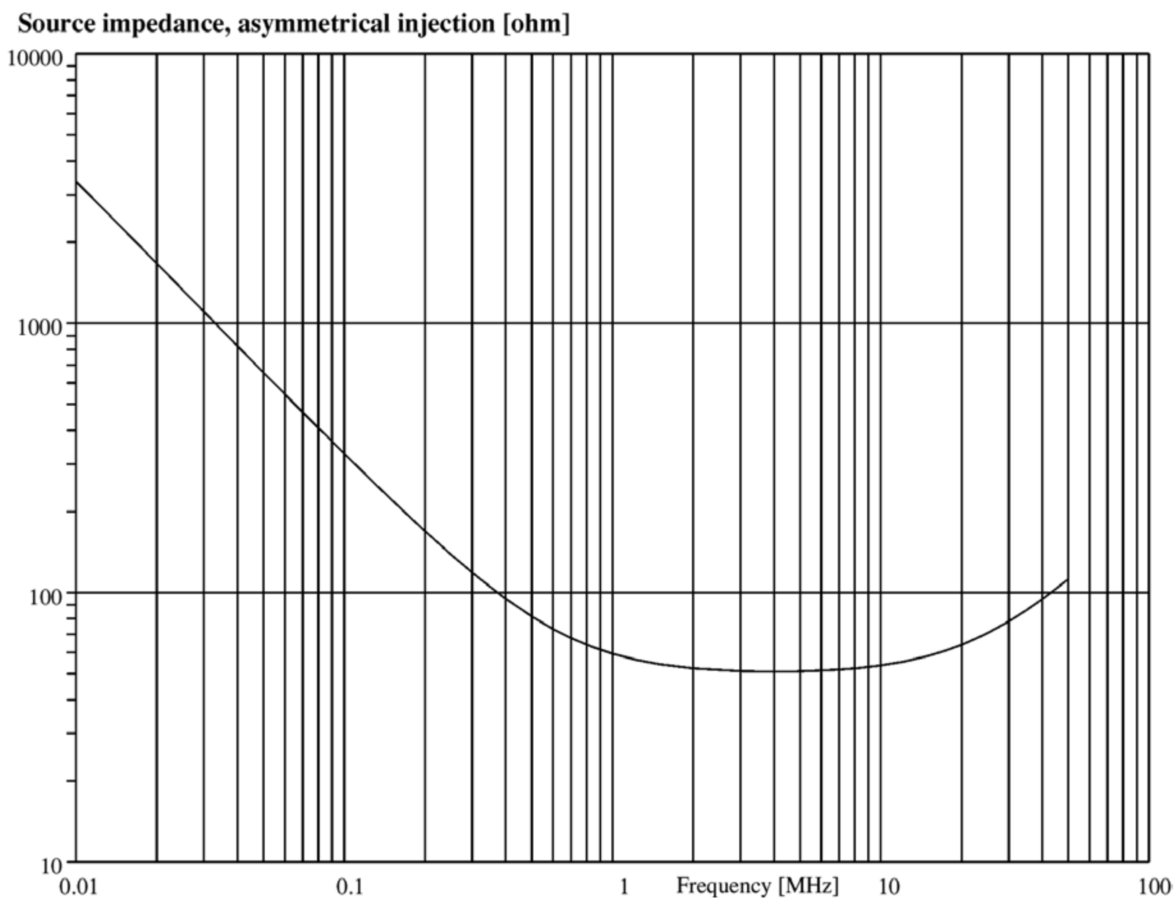


Figure A1-6. Source impedance for the case of asymmetric injection.

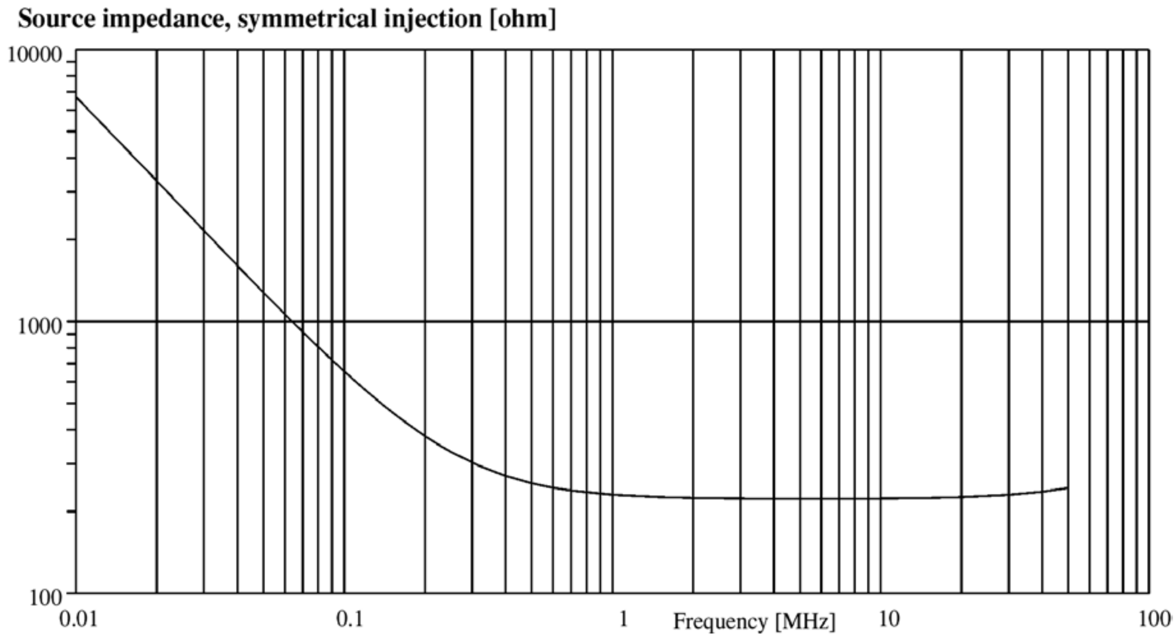


Figure A1-7. Source impedance for the case of symmetric injection.

Ir. T.W.H. Fockens Nedap R&D Date: 10/08/2004 JWG doc 11-07

Proposed EMC limits for PLC and existing CISPR 22 mains network limits: a study into network propagation effects and measurements thereof.

0. Executive summary.

The equivalence of common mode current limits and field strength limits in low voltage mains networks with existing CISPR 22 limits has been studied, and verified with measurements.
From the results we conclude that the current proposals for EMC limits for PLC signals on mains networks will allow the use of an injection power density of - 50 dBm/Hz. This is 35 - 50 dB higher than the CISPR 22 class B limit.
In case of a Europe wide roll-out of PLC systems with this level of injection power density and a reasonable penetration rate of 10%, the manmade noise floor will rise to a level of 13 dB above the ITU Quiet Rural area level and 6 dB above the Residential area level.

1. Existing EMC situation on LV mains networks in a non-industrial environment.

1.1. Power density.

In a residential and light business environment all mains connected apparatus has to comply with the conducted disturbance limit given in CISPR 22 B. For the relevant frequency range of 0.5 to 30 MHz the voltage limits as shown in table 1 apply, using an average detector.
From here the maximum available power density has been calculated.

CISPR 22 class B equipment, conducted mains disturbande limit, Average detector [1]).		
Frequency range:	0.5 - 5 MHz	5 - 30 MHz
Voltage limit on each line (L / N):	46 dBμV	50 dBμV
Available source power per line in 50 ohm load, 9 kHz bandwidth:	-61 dBm	-57 dBm
Power density per line:	-100.5 dBm/Hz	-96.5 dBm/Hz
Power density worse case; disturbance on each line, in phase:	-94.5 dBm/Hz	-90.5 dBm/Hz
[1]) *The average detector, or better the RMS detector, is relevant in relation to the cumulation effects.*		

Table 1. Calculation of power density generated by CISPR 22 sources.

1.2. Manmade noise levels.

Radiation from mains wiring is the main source for manmade noise in the frequency range up to 30 MHz. According to [1] the current manmade component of the noise floor in a Quiet Rural area by definition is determined by the ionospheric cumulation of disturbance from the current equipment. Calculations have shown that under the conditions of:

- An equipment density of 200 pieces/km^2 (av. 2 per person);
- A mean power density per apparatus: **-97 dBm/Hz**;
- An antenna gain of the LV mains network: -30 dBi;
- Reflection loss in the ionosphere: 6 dB,

a cumulated noise floor is produced, equal to the ITU manmade noise level for Quiet Rural areas (- 13.5 dBμV/m@9 kHz).

1.3. Antenna gain of LV mains networks.

Figure 1 refers to [2] and is showing an overview of measuring results concerning the antenna gain of LV mains networks. Also the FAFIRA Report no. 2 [3] gives useful information about measured antenna gain. Both sources show an average antenna gain of about -30 dBi for mains networks inside residential buildings, when injecting in a wall outlet. Interesting is to note that when injecting at the House Access Point (before the electricity meter) the antenna gain is about 20 dB lower than when injecting in a wall outlet.

From these antenna gain measurements we can conclude that the assumption of an antenna gain of -30 dBi for calculation of the cumulation effect in [1] was justified.

Annex F3 Results antenna gain measurements.

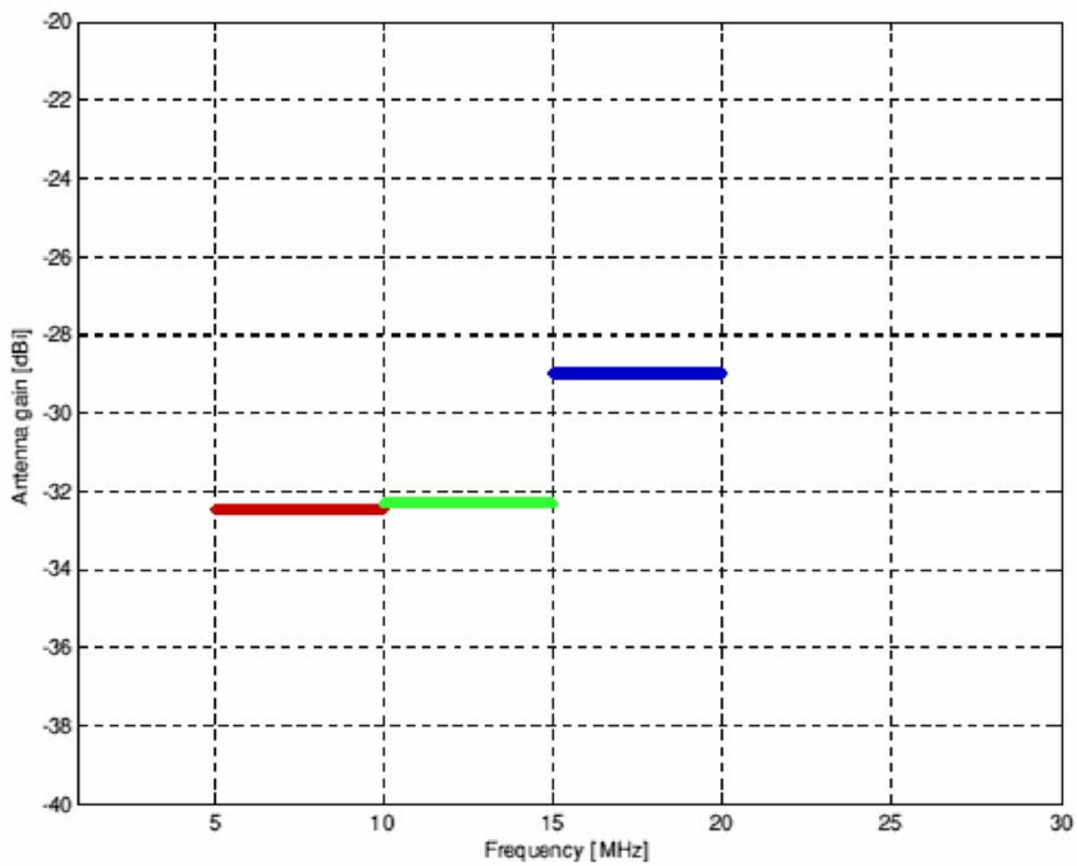


Figure 4b : Averaged results of indoor low voltage network antenna gain measurements in the frequency ranges 5 MHz-10 MHz, 10 MHz-15 MHz and 15 MHz-20 MHz. Total number of measurements: 113 measurements at 13 different houses in 3 frequency ranges.

Figure 1. Overview of results of antenna gain measurements by [2].

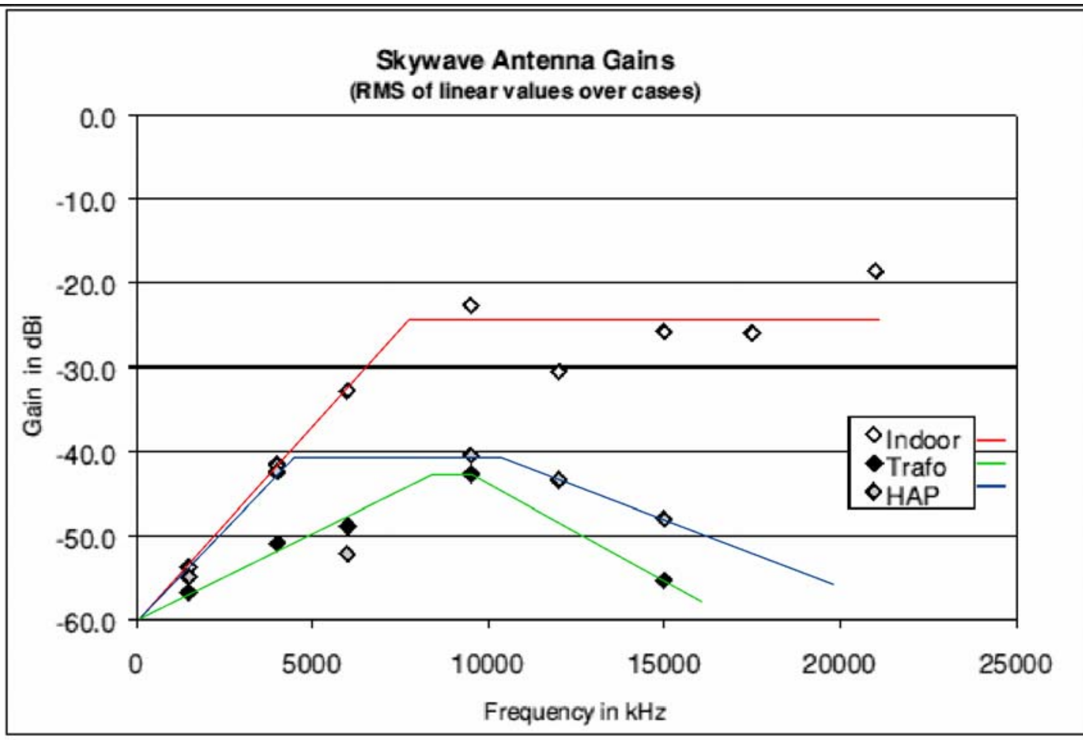


Figure 7 Average skywave antenna gains (RMS of values in linear units over all measured samples) vs frequency

HAP: House access point, before the electricity meter.
Note the difference between Indoor and HAP: ~ 20 dB.
Source: FAFIRA Report no. 2, trendlines by kf.

Figure 2. Antenna gain measurements by OFCOM and ASCOM.

1.4. Relevant phenomena inside the mains networks.

The CISPR conductive disturbance limits apply at the connection point between the apparatus and the network, e.g. the disturbance is measured with the mains connector connected to the LISN. At this position the power density calculation as shown in table 1 apply.

For assessing the common mode current at positions on the mains network, and so the field strength level, the following effects occurring in the network have to be taken into account:

1 spreading of available source power over several branches of the network;
2 dielectric losses in the cabling;
3 losses due to connected equipment;
4 losses by radiation.

1.4.1. Spreading of available source power over several branches of the network.

A LV in-house mains network is a wildly branched network. When at a certain point (a wall outlet) power is injected, this power is split up at each network node. Figure 3 shows this graphically.

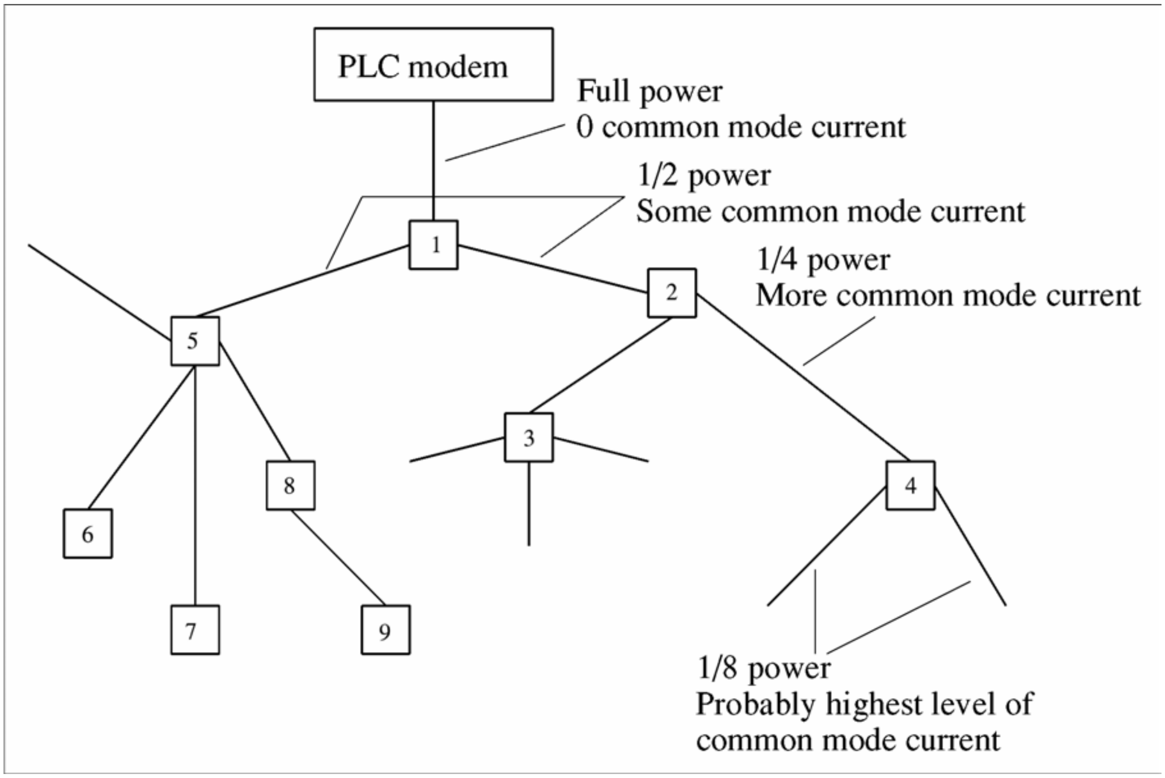


Figure 3. Distribution of available source power over a mains network.

It is reasonable to assume that a PLC modem will inject its signal power in symmetrical way. Not only because this is naturally the case when using a two-wire connecting (as we have seen by all in-house modems so far), but also because in that case the lowest level of common mode current will be measured. This enables the manufacturers of PLC modem to maximise the source power under the currently proposed regulations.

Figure 3 shows that, in case of symmetrical injection, by the cable between de PLC modem and node 1 the full available power is transferred, but that the common mode current is zero. After node 1, some common mode current becomes measurable, but the power is divided over two branches. So the relation between the maximum common mode current and the available source power is lost.

This relationship was assumed in [4] and was the basis of the proposed common mode current limit ("option 1") and the derived field strength limit ("option 2") in [5] from this current limit in the draft network standard, as well as in [6], the draft TS.

After the second branching, node 2 or node 5 in figure 3, more common mode current is measurable, but the available power density is still lower. After the third branching, our measurement (see par. 2.2) have shown, there is a certain probability that the highest common mode currents in the network will be found here. But this maximum in common mode current is far lower then assumed in [4] because of the spreading of available source power.

1.4.2. Dielectric losses in the wiring.

50 Hz cabling is not designed for radio frequencies, the isolation material, e.g. PVC, has a high loss factor for high frequencies.

1.4.3. Losses due to connected equipment.

Connected equipment dissipate energy directly (e.g. light bulbs, etc.), or cause a serious impedance mismatch (input EMC filters!), which also results in high voltage standing wave ratios and therefore extra losses in the wiring.

1.4.4. Losses by radiation.

Radiation means that energy is transferred from the network into space. So in any branch of the network this radiated energy is subtracted from the available energy. The measurements of the antenna gain show that this effect is real. However, we must assume that the amount of radiation loss is higher than indicated by the antenna gain measurement (abt. -30 dBi) because what is measured, is only that part of the radiation that left the building. We must assume that another part of the radiation is dissipated by material losses in the direct environment of the network cabling, different from the dielectric losses in the cables itself.

1.5. Conclusion:

These losses and spreading effects are part of the normal and already existing CISPR 22 practice. Together with the stochastic appearance of the original CISPR 22 related disturbance in the frequency ranges above 1 MHz they made it possible for the radio users to live with these limits (as measured at the connector of the DUT!) so far.

This means that, when translating an injected power limit of a PLC modem into a common mode network current of field strength limit, we must take into account the same effects.

The simple approach as used so far (in the draft TS and NS) results in a far too high common mode current limit, and does also result in a too high field strength limit.

2. The Nedap/TNO measurements in Geesteren.

2.1. Introduction.

Nedap has initiated a measurement of the common mode current distribution over an existing LV mains network.

Purpose: *Measure the transfer function from symmetrical injected power into common mode current and magnetic field strength in a real life mains network at a large number of positions, and scale the measuring results to an injection source power equivalent to CISPR 22 B.*

There was a unique opportunity to measure common mode current in an old farmhouse, where all the electricity cabling was mounted on the walls instead of hidden in the walls like in all modern houses.

The measurements were performed under supervision of TNO Electronic Products & Services (EPS) BV, a Dutch competent body, and reported in their report:

"Report of injected common mode current measurement and field strength measurements in a mains supply network", project number: 04050602.

This report is annexed to this document.

2.2. Results of the measurements.

The results of the measurement are in accordance with the effects in networks as described in this document. The measured common mode currents are 15 - 30 dB lower than the proposed limit, generally decreasing with frequency due to the already expected network losses.

The measured field strength levels follow roughly the NB30 curve. In combination with the measured current levels this means that the Biot-Savart approach is reasonably valid, but with the conclusion that the real common mode current levels. have to be used.

The measurements prove that the proposed common mode limit, as well as the proposed field strength limit, are 15 - 30 dB too high, depending on frequency.

This means that according the proposed limits, using a well defined measurement, PLC modem manufacturers are allowed to inject with a power density which is 15 - 30 dB higher than equivalent to CISPR 22 B.

3. Measurement requirements as laid down in the draft TS and NS:

4.1. Requirements:

"*In the case of rooms or buildings where both the network and its equipment are used, measurements shall be made outside those rooms or buildings*."

This means that in the house where a client is connected to an access PLC provider (necessarily having a PLC modem installed) no measurements will be carried out. So the most close measuring position to a PLC modem is in the house next door.

From the measured antenna gain at the HAP position being about 20 dB lower than at an indoor position (wall outlet) it can be concluded that the transmission loss from indoor first house to indoor second house will be twice this value, so *at least* more than 20 dB.

This results in the ability for the PLC modem manufacturers to use an injection level that is 20 - 30 dB higher than if has to be measured in the same house.

4. Allowably injection levels according the draft TS and NS.

Combining both forementioned aspects, the described and measured effects in real live mains networks, and the exclusion of measurement inside the home of a client, we can conclude that according [5] and [6] an injected power density level of about - 50 dBm/Hz (35 - 50 dB higher than CISPR 22 B) is allowed.

5. The effect on manmade noise levels.

A calculation of the increase in manmade noise level as the result of skywave cumulation of radiation of PLC noise from mains networks can be found in [1]. Assuming:

- PLC modem power density: -50 dBm/Hz
- Antenna gain LV mains networks: -30 dBi
- Reflection loss ionosphere: 6 dB

resulting in:

0.03 modem/km^2 ⇒ +0.5 dB increase over Quiet Rural noise level.
0.05 modem/km^2 ⇒ +0.5 dB increase over Rural noise level.
0.1 modem/km^2 ⇒ +0.5 dB increase over Residential noise level.

Combining this with a mean number of inhabitants in Europe of 110 / km^2 = 30 families/km^2. So a penetration rate of 10% results in a modem density of 3 modem/km^2. This will cause a noise floor increase of **13 dB above Quiet Rural**, and **6 dB above residential** area level.

6. References.

[1] EMC-analyse van PLC-netwerken, PowerPoint presentation. Ir. J.P. van Assche / Dr. H. Leonhard. Radio Communication Agency Netherlands. http://www.at-ez.nl/informatie/plc/plc_hme.html.

[2] ETSI/ERMEMC-JWG(03)09_04 Information on radiating properties of mains networks. Radio Communications Agency Netherlands, J.P. van Assche & J. Coenraads.

[3] FAFIRA Report no. 2. input doc SE35(01)22, OFCOM Switzerland and ASCOM, Switzerland.

[4] ETSI/ERMEMC-JWG(03)09_05 Equivalence of Limits. T. Morsman, BT.

[5] ETSI/ERMEMC-JWG(03)10_03r1 Product family emission standard for electronic communication networks.

[6] ETSI/ERMEMC-JWG(04)10_29 Draft Technical Specification for electromagnetic emissions from access powerline communications networks.