Proposed cabling set-up for electromagnetic characterisation of cabling and EMC measurements on LAN systems

Feasibility study and results.

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Abstract. This article describes test result for electromagnetic characteristics on generic cabling and EMC measurements of equipment connected to generic cabling by use of a set-up proposed by standardisation committee JTC 1/SC 25/WG 3.

1. Introduction

In the Sydney meeting, Feb. 1996, of JTC 1/SC 25/WG 3, the work group responsible for the generic cabling standard ISO/IEC 11801, it was noticed that many test results of EMC properties of cabling was published. These results were all obtained for different configurations of the cabling. It was therefore decided to define a set-up of a complete cabling link which can be used for electromagnetic characterisation of cabling and for EMC measurements on LAN equipment.

In the London meeting, June 1996 of the work group, the set-up was defined. A liaison letter was written to committees responsible for EMC test methods, which asked them to take the set-up into consideration . This article describes results using the set-up for measurements.

2. Scope

The scope of this work was to evaluate the feasibility of the proposed cabling set-up. At first the properties of the set-up as a radiating element was evaluated. The radiated emission, compared to the emission of a dipole antenna, was measured and it was investigated if the relative gain was approximately constant over the frequency range. Secondly the properties of the set-up connected to IT equipment under test for EMC compliance was evaluated. At last the voltage developed at the cabling interface caused by an interfering field was measured, and based on the results, the coupling attenuation of the cabling link calculated.

3. Proposed generic cabling set-up

The proposed set-up is depicted in Fig. 1.

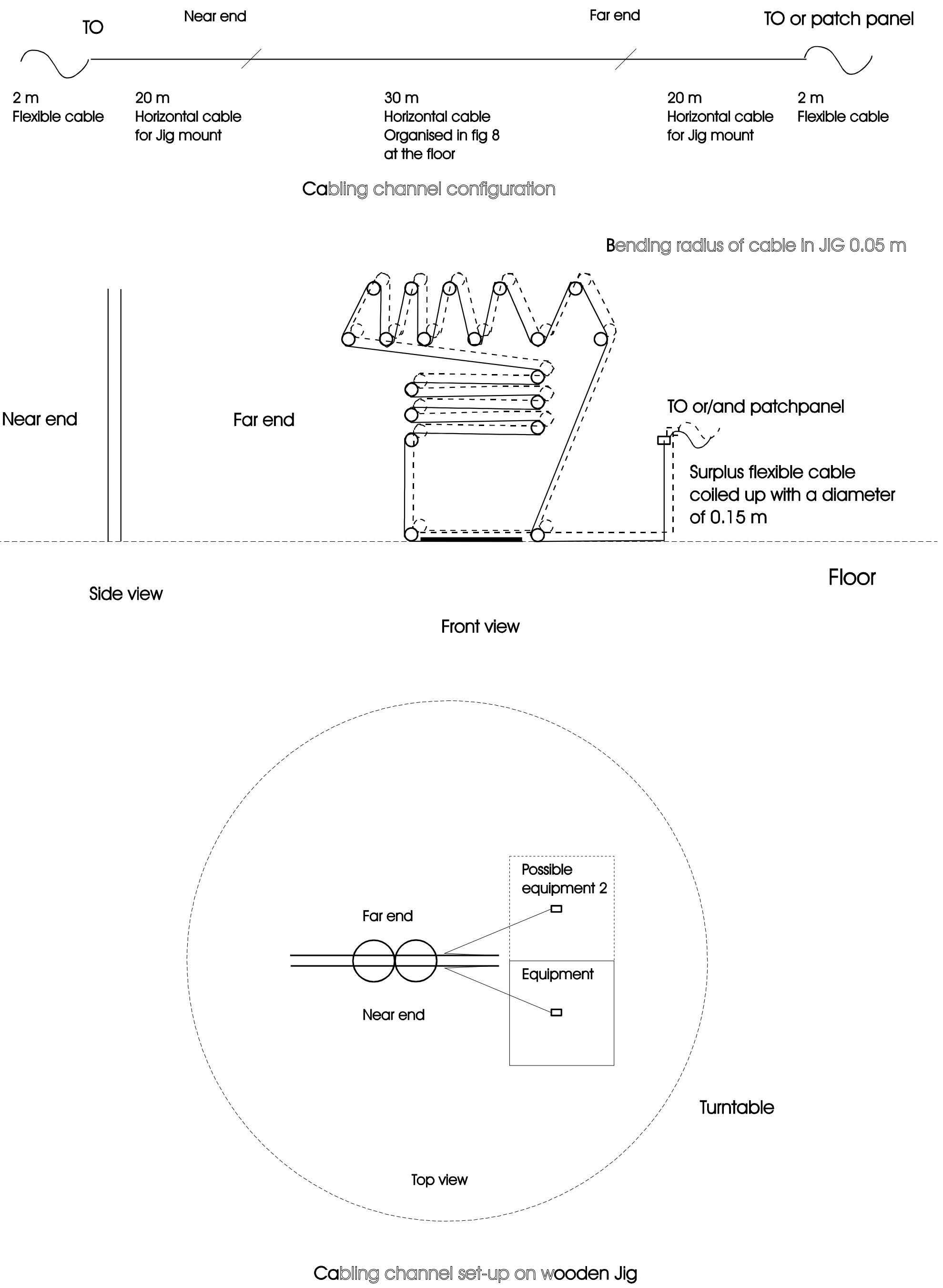

Fig. 1. Cabling set-up

A length of 70 m of horizontal cable is wound up on a wooden support as shown. One half of the cable is on one side, while the other half is on the other side. The distance between the two sides is 10 cm. At a height of about 80 cm above the floor, telecommunication outlets or patch panels are terminating the cable. From this points flexible cables are connected to the equipment under test. If none or only one equipment is placed inside the test chamber, then cables under the floor provides the signals for making the equipment operate. The reason for only using 70 instead of 90 m horizontal cable in the set-up, is to allow for some attenuation in the feeding cable's.

A photography of the proposed set-up connected to a PC for test is shown at Fig. 2

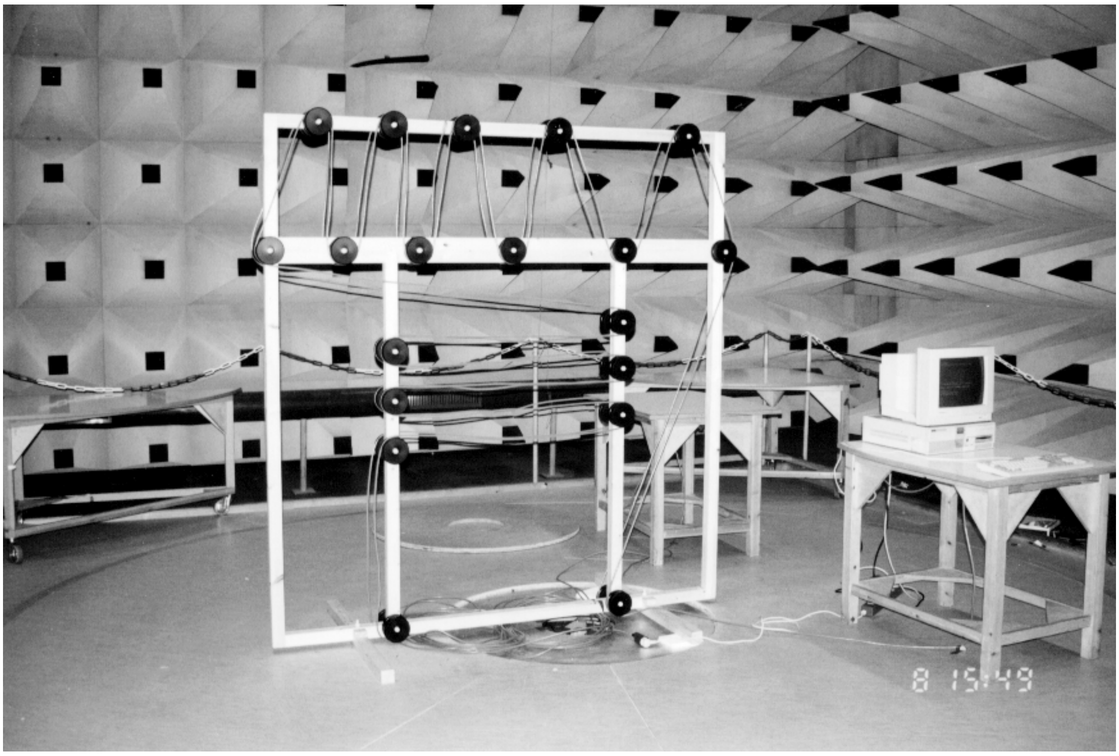

Fig. 2 Proposed cabling set-up connected to a PC for test.

4. Radiation properties of the set-up compared to an ideal dipole.

For the set-up to be usable for EMC tests, it has to acts as a broadband radiating element, when common mode currents are present at the cabling. If this is the case, the set-up will not suppress or enhance certain frequency ranges.

The radiation properties were measured and compared to radiation from a tuned test dipole. The measured relative gain for the set-up in respect to the dipole is shown in table 1.

Table 1. Relative gain of set-up

Frequency	40 MHz	95 MHz	200 MHz	500 MHz	1000 MHz
Relative gain	+3 dB	-5 dB	-8 dB	-4 dB	-5 dB

It is concluded that the relative gain of the cabling set-up is quite constant over the frequency range. This proves that the set-up is well suited for characterisation of EMC performance of equipment connected to it.

5. General radiated emission considerations

In order to observe the European EMC directive, electronic equipment and installations must not emit harmful electromagnetic noise or be subject to disturbances from electromagnetic noise. Conformance may be demonstrated by issuing a technical construction file or refer to compliance with harmonised standards. The harmonised standard for radiated emission of information technology equipment is EN 55022. The equipment has to fulfil requirements according to class A or class B. Radiated emissions are measured in the frequency range of 30 MHz to 1000 MHz. The class A limits are 40 dBμV/m from 30 MHz to 230 MHz and 47 dBμV/m from 230 MHz to 1000 MHz in a distance of 10 m, while class B limits are 10 dB lower. Class A equipment is intended for application in industrial areas while class B equipment is intended to be used in domestic areas.

6. Radiation properties of test PC running 100 Mb/s Ethernet

The radiated emission of a PC running 100 Mb/s Ethernet was tested according to the standard [1] and connected to the cabling set-up. In the standard the configuration of the equipment under test shall be worst case, but no exact directions for the layout of cabling is given. For the test reported here, the cable was extended 1 m horizontally form the PC and then guided to ground. For the test with the cabling set-up, the PC was connected to the set-up by the flexible cable in the set-up. The tests were performed by use of unscreened and screened cables (S-FTP).

For both tests it was seen that the direct radiation from the PC was higher than the radiation from the cabling. It was therefore hardly possible to see the influence of screening on the radiation pattern. The results for the PC connected to the cabling set-up is shown in Fig. 3 (unscreened link) and Fig. 4 (screened link).

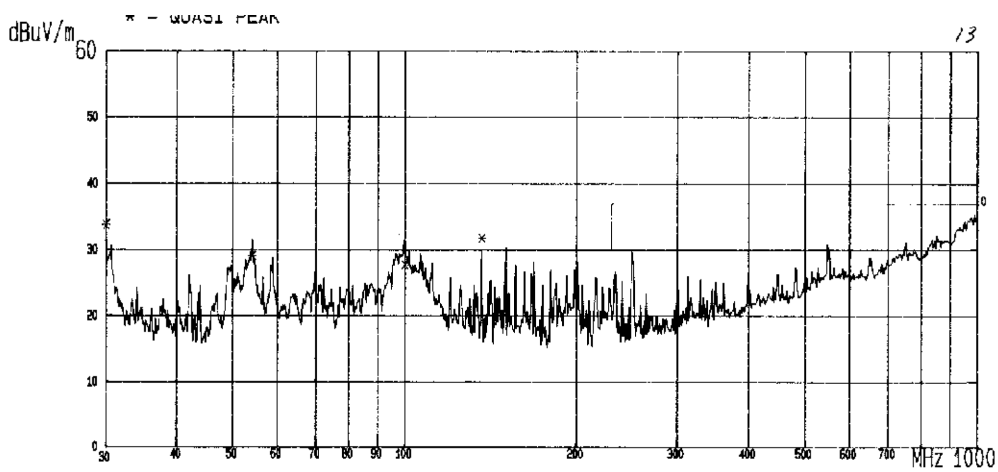

Fig. 3. Radiated emission. PC connected to UTP link.

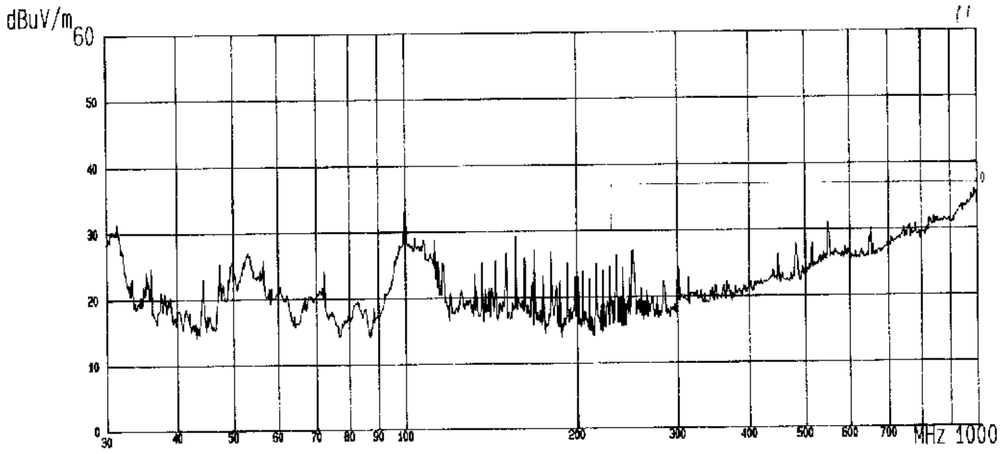

Fig. 4. Radiated emission. PC connected to S-FTP link.

7. Radiation properties of proposed cabling set-up conducting 100 Mb/s signals.

To investigate the direct radiation from the cabling link, measurements were performed using a set-up with the cabling fixture placed in the EMC test chamber and the active equipment placed outside. The communications signals were connected to the cabling under test by two well screened cables from the outside of the chamber.

The radiated emission from the 100 Base T signals were measured for the fixture mounted with unscreened and screened cabling.

The results for the unscreened cabling is shown in Fig. 5. The emissions are generally 6 dB below the class B limit. Also after correction for the attenuation of the feeding cable the class B limit is observed.

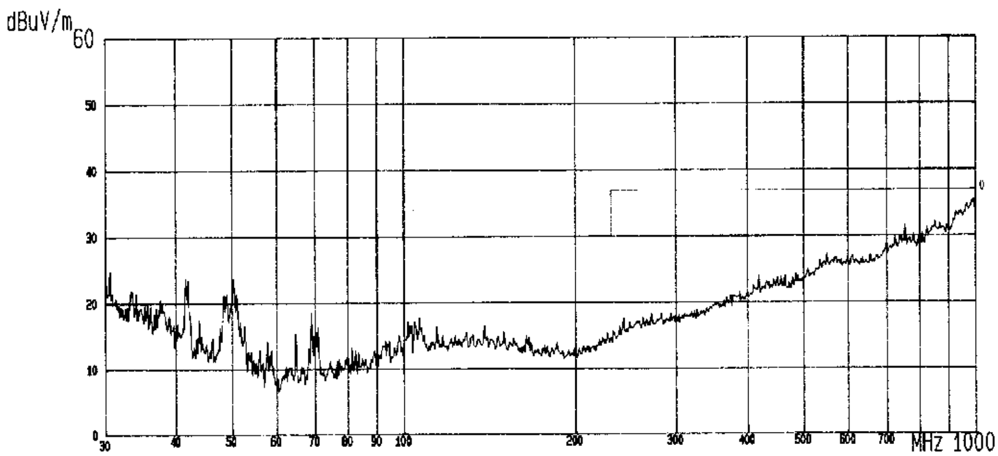

Fig. 5. Emissions from UTP cabling. Active equipment outside test chamber.

The results for screened (S-FTP) cabling showed that the emission were hardly noticeable over the noise floor of the measurement system.

These results show that EMC requirements for radiated emission is observed for a link mounted in the proposed fixture, carrying signals for 100 Base T LAN. The results also show that screening reduces the radiation considerably.

8. Immunity considerations

The harmonised generic immunity standard EN 50082 is used for reference for measurements performed in this report. Equipment and installations have to fulfil requirements of part 1 or part 2 of EN 50082. Radiated immunity is measured in the frequency range of 27 MHz to 500 MHz (part 1) and 80 MHz to 1000 MHz (part 2). The limits for radiated immunity are 3 V/m (part 1) and 10 V/m (part 2). Part 1 is for residential, commercial and light industry while part 2 is for industrial environment.

9. Received signal from cabling set-up exposed to a field of 3 V/m

Immunity is normally measured by exposing the equipment under test with the specified field. The equipment shall have suitable cables connected to the signal ports. In this work is was decided to measure the differential voltage collected by the cabling set-up from the exposed field. Using this information it can be evaluated if the voltage level is dangerous for the different architectures and the benefit of screened cabling can be quantified. During the measurements great precautions were taken to assure that common mode signals did not mask the measured differential mode signals.

The results for unscreened and screened cable (S-FTP) is shown in Fig. 6 - 7. The graphs show results for all four pairs in the cable.

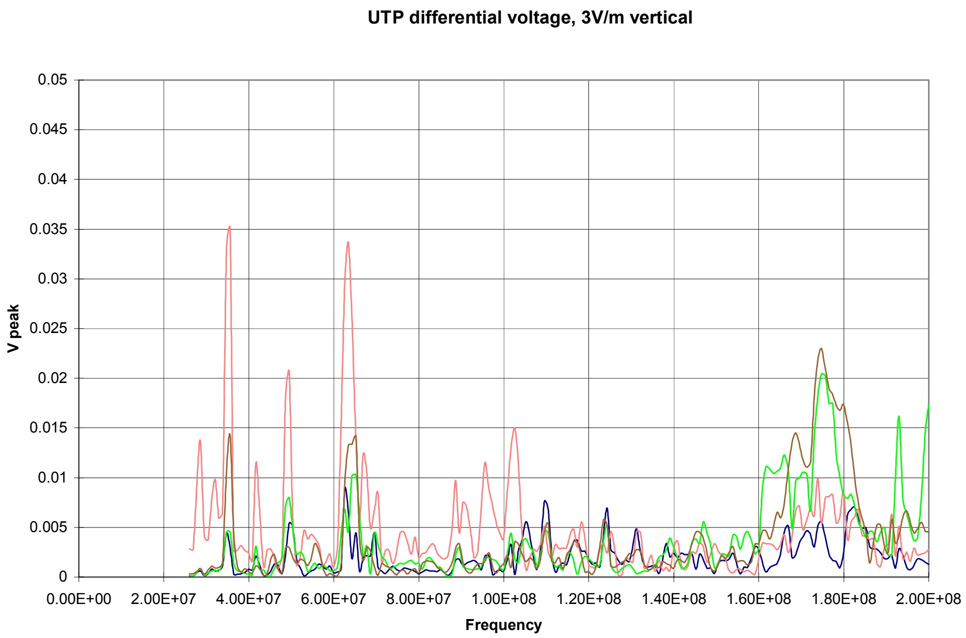

Fig. 6. Voltage at cabling interface, UTP cabling (vertical polarisation)

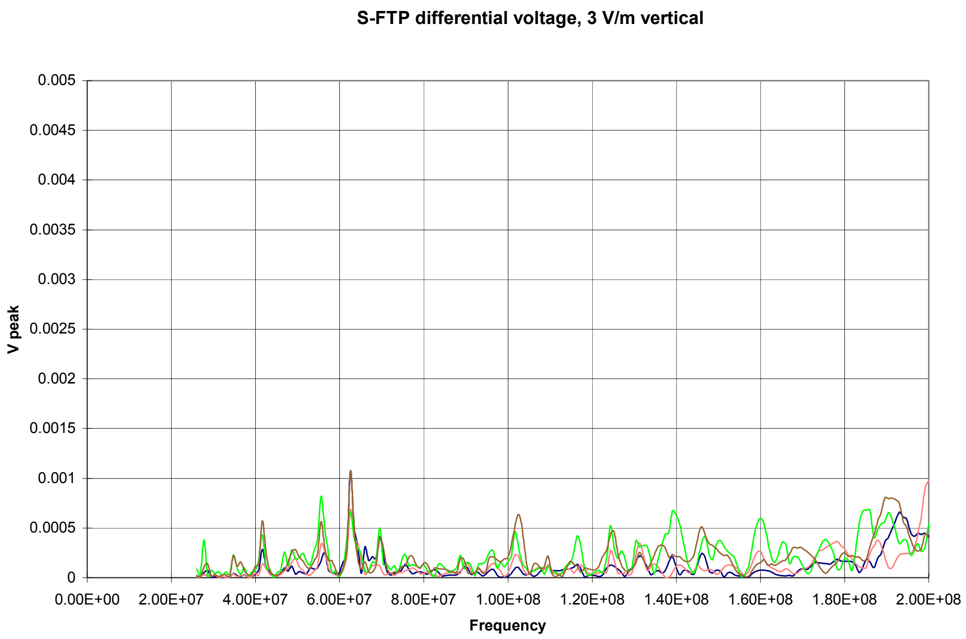

Fig. 7. Voltage at cabling interface, S-FTP cabling (vertical polarisation)

Note: Different scale on Y axis!

For the UTP cabling the maximum voltage was around 15 mVp with peaks up to 35 mVp. For the S-FTP cabling the maximum voltage was around 0.5 mVp with peaks up to 1.1 mVp. In the tested frequency range the screening attenuation of the screened link is then about 30 times or 30 dB.

10. Coupling attenuation properties based on the immunity measurements

The results of the measured voltage due to the radio frequency field can be used to determine the coupling attenuation of the cabling link.
Coupling attenuation is defined as the conducted power in a system with respect to the radiated power. Coupling attenuation is normally measured using the absorbing clamp method, which is standardised in [4] for determining screening attenuation of coaxial cables in the frequency range of 30 MHz to 1000 MHz. The definition for coupling attenuation can be used for balanced cabling as well as for coaxial cabling. For balanced cabling systems the coupling attenuation is the added attenuation of the radiated field due to balance and screening. The test method is now being developed as a standard for all cables by a CENELEC committee, TC 46X/WG 3.

Base on the results in section 9 the coupling attenuation was calculated. An exposed field of 3 V/m is equivalent to a power density of 13.8 dBm which gives a power flux of 16.8 dBm through the 2 m^2 area of the set-up. The measured differential voltage was converted to power and related to the power flux. The coupling attenuation measured in this way was found to be worse than coupling attenuation measured at the horizontal cable by the absorbing clamp method.

This was expected as the link balance and screening is deteriorated by the connectors and flexible cables. The deterioration was about 10 dB for the unscreened cabling and 20 B for the screened cabling.

11. Conclusion

The gain of the proposed set-up, as a radiating element, has been found to be quite constant over the frequency range of 26 MHz to 1000 MHz, with no dominant polarisation and directional characteristic. The configuration is therefore well suited for set-up of a cabling link for EMC tests of equipment and for characterisation of coupling attenuation.

The performed radiation measurements on a PC connected to the cabling link set-up show that the direct radiation from this particular PC enclosure, almost completely masks the radiation from the cabling set-up. The difference between the coupling attenuation performance of UTP and S-FTP cabling can therefore hardly be seen in these measurements.

The radiation measurements performed with the PC outside the test chamber shows that the radiation from the S-FTP cabling is less that of the UTP cabling. UTP cabling in this set-up, however, satisfies the class B limit carrying 100 MB/s Ethernet signals.

The immunity tests shows that the coupling attenuation of the UTP cabling is less that that of the S-FTP cabling. At the cabling interface up to 35 mV peak exists when the cabling is subject to a field of 3 V/m for UTP cabling and 1.1 mV for S-FTP cabling.

It is also shown that it is possible to measure coupling attenuation characteristics of the cabling set-up by applying a field to the set-up and measure the picked up power.

References

[1] EN 55022, Limits and methods of measurements of radio disturbance characteristics of information equipment.

[2] EN 50082-1, Electromagnetic compatibility - Generic immunity standard Part 1: Residential, commercial and light industry.

[3] EN 50082-2, Electromagnetic compatibility - Generic immunity standard Part 2: Industrial environment.

[4] IEC 1196, Radio-frequency cables.