International Telecommunication Union

ITU-T

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

K.76
(08/2022)

SERIES K: PROTECTION AGAINST INTERFERENCE

Electromagnetic compatibility requirements for DC power ports of telecommunication network equipment in frequencies below 150 kHz

Recommendation ITU-T K.76

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Summary

Recommendation ITU-T K.76 specifies conducted emissions requirements for DC power ports of telecommunication network equipment in frequencies below 150 kHz. Furthermore, an immunity requirement specific to power ports of telecommunication network equipment with analogue voice interfaces is also defined.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
1.0	ITU-T K.76	2008-07-07	5	11.1002/1000/9413
2.0	ITU-T K.76	2022-08-13	5	11.1002/1000/15037

Keywords

Below 150 kHz, conducted emissions, conducted immunity, electromagnetic compatibility, low frequency, performance criteria.

* To access the Recommendation, type the URL http://handle.itu.int/ in the address field of your web browser, followed by the Recommendation's unique ID. For example, http://handle.itu.int/11.1002/1000/11830-en.

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Introduction

This Recommendation complements the electromagnetic compatibility requirements for telecommunication network equipment contained in [ITU-T K.136] and [ITU-T K.137] by specifying requirements in frequencies below 150 kHz.

Telecommunication network equipment can produce disturbances to other equipment or can be susceptible to the electromagnetic phenomena in the frequencies below 150 kHz.

A necessity to analyse these frequencies was highlighted considering the influence that very low frequency disturbances have on analogue voice communication.

Recommendation ITU-T K.76

Electromagnetic compatibility requirements for DC power ports of telecommunication network equipment in the frequencies below 150 kHz

1 Scope

This Recommendation considers continuous electromagnetic phenomena applicable on direct current (DC) power ports of telecommunication network equipment in frequencies below 150 kHz. Electromagnetic phenomena above 150 kHz are covered by other specific product family Recommendations such as [ITU-T K.136] and [ITU-T K.137]. Impulsive low frequency phenomena are considered in other K-series Recommendations.

Both the emissions and the immunity requirements in frequencies below 150 kHz are taken into consideration in this Recommendation.

This Recommendation defines test set-ups, measurement methods, emission limits and immunity test levels for power ports of telecommunication network equipment.

This Recommendation applies to all types of telecommunication network equipment. Due to the nature of the interference, the immunity test is applicable only to equipment having an analogue voice interface that could be influenced by disturbing signals in the voice frequency range.

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 K.136] Recommendation ITU-T K.136 (2018), *Electromagnetic compatibility requirements for radio telecommunication equipment*.

[ITU-T K.137] Recommendation ITU-T K.137 (2022), *Electromagnetic compatibility requirements and measurement methods for wireline telecommunication network equipment*.

[IEC CISPR 16-1-1] IEC CISPR 16-1-1:2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*.

[IEC CISPR 16-1-2] IEC CISPR 16-1-2:2014 + AMD1:2017, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*.

[IEC CISPR 16-2-1] IEC CISPR 16-2-1:2014 + AMD1:2017, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*.

[IEC CISPR 32] IEC CISPR 32:2015 + AMD1:2019, *Electromagnetic compatibility of multimedia equipment – Emission requirements*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following term defined elsewhere:

3.1.1 continuous disturbance [b-IEC 60050-161], (161-02-11): Electromagnetic disturbance the effect of which on a particular device or equipment cannot be resolved into a succession of distinct effects.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 fully populated equipment: Equipment designed to provide housing ('slots') for a number of different functional modules (line cards, etc.), configured such that the full capacity (i.e., all 'slots') is populated with modules in a manner representative of intended use.

3.2.2 nominal current: The DC current consumption of a fully populated equipment powered at the nominal DC voltage when the equipment is operated in a manner representative of intended use.

3.2.3 nominal voltage: The value of the voltage that designates the type of supply declared by the manufacturer.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

ADN Artificial Direct current Network

DC Direct Current

DSU Data Service Unit

EUT Equipment Under Test

ISDN Integrated Services Digital Network

LAN Local Area Network

NM Normal-Mode

RMS Root Mean Square

SW Switching Equipment

5 Conventions

None.

6 Emission on DC power port in frequencies below 150 kHz

The electromagnetic emissions at low frequency in telecommunication network equipment are mainly due to the power units. Considering the wavelength of the disturbances in these frequencies, the radiated emissions are impractical (several hundred meters of cable length should be used) and therefore only conducted emission requirements are defined. Experience has been reported from telecommunication installations that emissions at low frequency from power ports can cause trouble in telecommunication installations (see Appendix I).

6.1 Equipment configuration

During the measurements, the telecommunication network equipment shall be powered at nominal voltage, operated at rated load conditions and have achieved a steady state (such that any transients on the current consumption associated with equipment power-up can be neglected).

If the power consumption of the equipment changes significantly from one operational state to another, the equipment shall be tested in each operational state to determine the highest value of emission.

The equipment shall be configured in a manner representative of intended use and exercised accordingly.

Detailed equipment test conditions, for different types of products, are reported in [ITU-T K.136] and [ITU-T K.137].

6.2 Emission requirements

The emissions from DC power ports are divided into the following two frequency ranges:

– Range 1: from 25 Hz to 20 kHz (narrow-band noise).

– Range 2: from 20 kHz to 150 kHz.

6.2.1 Emissions in range 1

6.2.1.1 Limits

The maximum level of noise emitted into the DC power supply system of the telecommunication network equipment is shown in Figure 1.

The values shown in Figure 1 refer to the bandwidths given in Table 1.

Table 1 – Resolution bandwidths versus frequency range

Frequency range	Resolution bandwidth
25 Hz to 10 kHz	10 Hz
> 10 kHz to 20 kHz	200 Hz or 300 Hz

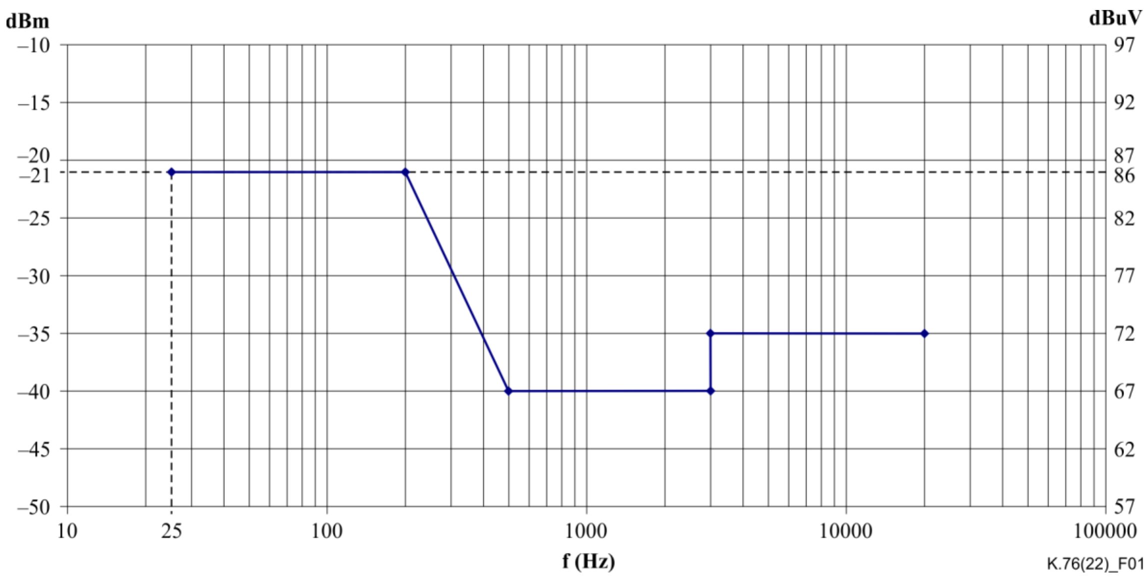


Figure 1 – Maximum levels of narrow-band noise

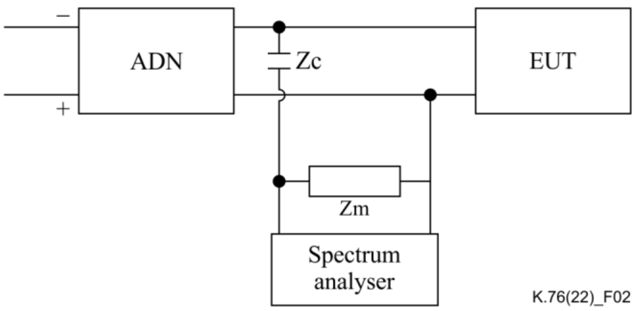
6.2.1.2 Measurement methods

The equipment under test (EUT) shall be connected to the DC power supply through an artificial network to provide defined impedance across the EUT at the point of measurement and to provide isolation from the noise on the DC power supply lines. This artificial network is referred to hereafter as the artificial DC network (ADN) and is displayed in Figure 3.

The measurement shall be made with a spectrum analyser or a receiver having the bandwidths shown in Table 1 for the relevant frequency range.

The measurement circuit shall be as shown in Figure 2. The measurement circuit shall be verified as described in Annex A.

The measurement shall be performed at three values of the powering voltage: the minimum, nominal and maximum of the normal service voltage range.



Z_m = 50 Ω (internal instrument impedance)
Z_c << Z_m at all measured frequencies.

Figure 2 – Measuring circuit for emitted narrow-band noise

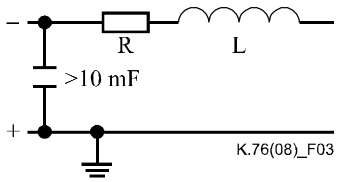


Figure 3 – Artificial DC network

Note that the ADN can be designed for telecommunication network equipment considering the nominal value of the DC voltage. Values for the resistance, R, and inductance, L, shown in Figure 3 are as follows:

$$R \le \frac{1}{I_m}$$

where:

I_m is the nominal current drawn at the nominal DC operating voltage

L = 15 μH +/–10% @ 10 kHz

6.2.2 Emissions in range 2

6.2.2.1 Limits

The maximum level of noise re-injected into the DC power supply system of the telecommunication network equipment is shown in Table 2.

Table 2 – Noise emission limits on DC power ports

Frequency range	**Limit [dBμV]**
	Quasi-peak
20 kHz to 150 kHz	79

6.2.2.2 Measurement methods

The measurement shall be made with a spectrum analyser or a receiver in line with the requirements of [IEC CISPR 16-1-1].

The measuring methods shall be those specified for the mains interface in [IEC CISPR 32] or [IEC CISPR 16-2-1].

The EUT shall be connected to the DC power supply through an artificial network to provide defined impedance across the EUT at the point of measurement and to provide isolation from the noise on the DC power supply lines.

The artificial network to be used is the 9 kHz to 150 kHz: (50 Ω // 50 μH + 5 Ω) artificial mains V-network described in [IEC CISPR 16-1-2].

7 Immunity requirements

Telecommunication network equipment with analogue voice interfaces can be sensitive to low frequency noise present on the DC power port, as this noise can be transferred to the analogue voice interface, where it presents itself as an audible noise that disturbs the voice conversation. Therefore, immunity requirements are only defined for DC power port and only in the frequency range 25 Hz to 20 kHz.

7.1 Test level

The telecommunication network equipment shall meet its specified performance criteria when the narrow-band noise is injected at the DC input port.

The root mean square (RMS) value of the injected noise current shall generally be 5% of the DC current level drawn by the equipment, but the injected noise voltage shall not exceed the level shown in Figure 4.

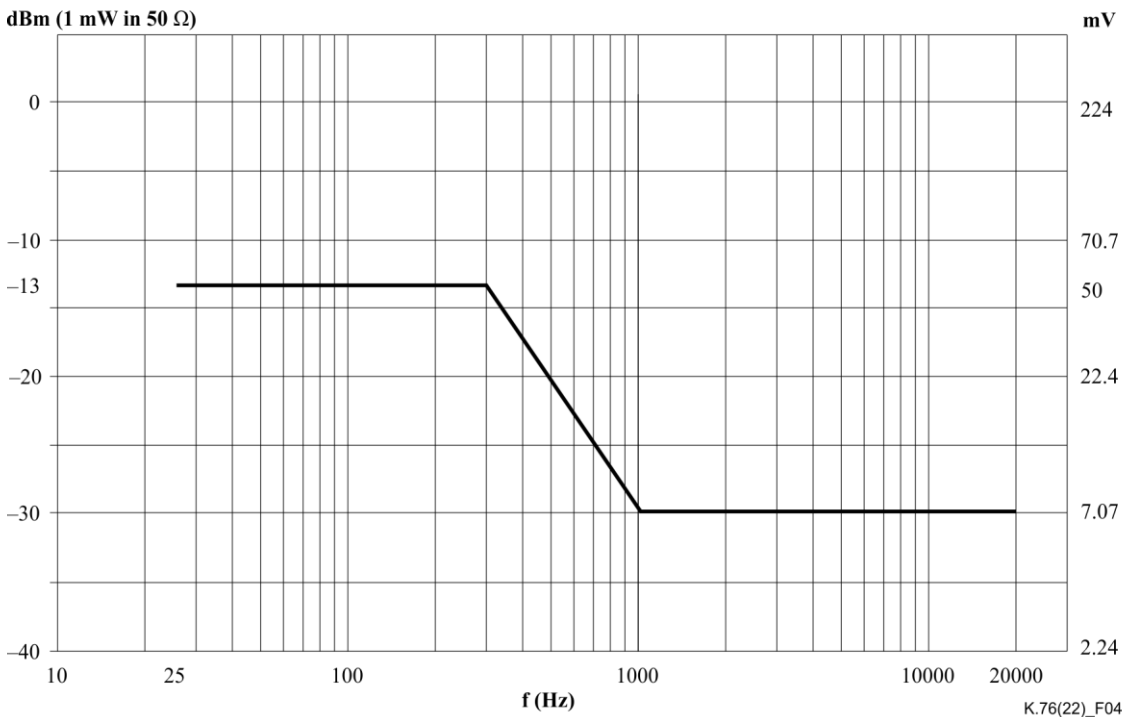


Figure 4 – Immunity level of narrow-band noise at DC power port

7.2 Test set-up

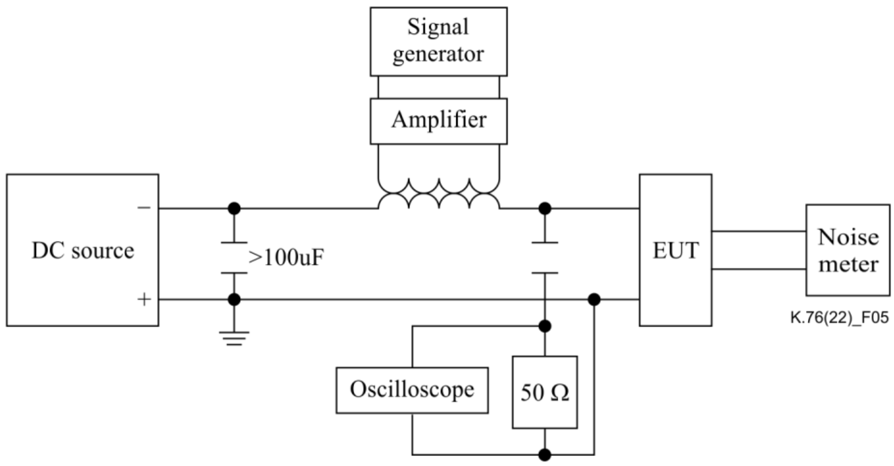
During the measurement, the telecommunication network equipment shall be powered at the nominal voltage and operated at rated load conditions.

The equipment shall be configured in a manner representative of intended use and exercised accordingly.

Detailed equipment test conditions for different type of products are reported in [ITU-T K.136] and [ITU-T K.137].

7.3 Method of measurement

The interference signal is injected into the DC power line using the circuit reported in Figure 5.



NOTE 1 – Z_c << 50 Ω at all measured frequencies.

NOTE 2 – The oscilloscope can be replaced by a spectrum analyser.

NOTE 3 – The 50 Ω shall be the input impedance of the measurement instrument (oscilloscope or spectrum analyser).

Figure 5 – Test arrangement for immunity test

Where the frequency is swept incrementally, the step size shall not exceed 1% of the preceding frequency value. The dwell time at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 1 s.

The generator shall be calibrated initially over the whole frequency range by connecting the transformer to a 0.5 Ω resistor and checking the voltage over the 0.5 Ω resistor.

Calibration procedure:

1) Set the signal generator to the lowest test frequency.
2) Increase the applied signal until the oscilloscope indicates the voltage level corresponding to the maximum required power level specified for the limit.
3) Record the setting of the signal source.
4) Scan to test the required frequency range and record the signal source setting needed to maintain the required power level. The frequency step size shall not exceed 1% of the preceding frequency value.

Compliance is achieved when the specified performance criteria are met when either of the following conditions is reached:

– The maximum noise voltage value (i.e., as presented on Figure 4); or
– The RMS of the injected noise current reaches 5% of the DC current level drawn by the equipment.

The level of the disturbance signal shall be controlled with a spectrum analyser having the bandwidths shown in Table 1 for the relevant frequency ranges.

7.4 Performance criteria

During the test, the telecommunication network equipment has to fulfil performance criterion A reported below.

Special requirements for analogue voice frequency signal ports are as follows.

The performance of the equipment shall be verified by measuring the audio signal break-through (demodulated 1 kHz) on the signal port during continuous exposure, in both signal path directions, covering both analogue-to-digital conversion, and digital-to-analogue conversion.

The connection must be maintained throughout testing:

a) During a sweep over the entire frequency range, the noise level measured at each two-wire analogue port at 600 Ω (ignoring the normal impedance of the port for practical reasons) must be less than −40 dBm.
b) The measurement shall be done selectively with a bandwidth ≤ 100 Hz at 1 kHz.

Performance criterion A

The telecommunication network equipment shall continue to operate as intended. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, then either of these may be derived from the product description and documentation, and what the user may reasonably expect from the equipment, if used as intended.

Annex A

Verification of measurement network defined in clause 6.2.1.2

(This annex forms an integral part of this Recommendation.)

The measurement test bench defined in clause 6.2.1.2 shall be verified to determine whether an attenuation is introduced by the decoupling capacitor Zc. The verification of the test bench shall be done on a 50 Ohm system as described in Figure A1.

The verification shall be performed connecting a signal generator at the port of the measurement network where the EUT will be connected as described in Figure A.1. Then, the signal generator shall be set to generate a test voltage of X dBµV in the frequency range 20 Hz to 20 kHz and the reading on the measurement receiver shall be of X dBµV ± 2% in the entire frequency range. If the reading of the measurement receiver is outside the tolerance of ±2% in respect to the generator signal, then the attenuation (i.e., insertion loss) of the network shall be determined with the following formula:

$$IL = X - Y$$

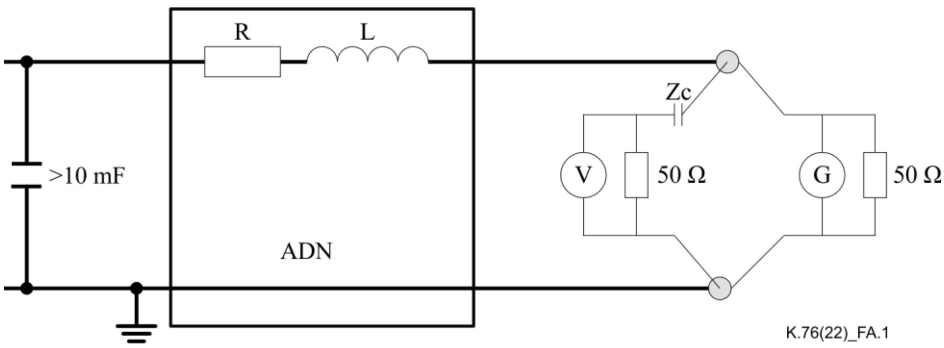
Where:

IL: Insertion loss

X: Voltage level at the generator port (in dBµV)

Y: Voltage level at the measurement receiver port (in dBµV)

The attenuation of the network shall be considered in the emission of the EUT measurements and the IL values shall be added to the EUT measured values to determine the compliance with the limits of Figure 1.



Zc << 50 Ω
V: Measuring equipment
G: Generator for frequency range 20 Hz – 20 KHz

Figure A.1 – Test bench for verification of Zc insertion losses

Appendix I

Example of disturbances at low frequency

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

This appendix reports some examples of interference due to a signal at a frequency below 150 kHz in a telecommunication installation.

– The first example is noise generated by a power rectifier that injects noise into the DC distribution, and this noise can generate disturbance on an audio signal in the terminal equipment.

– The second example shows how the noise generated by a lighting system can induce disturbances in a telecommunication network.

I.1 Audible noise caused by disturbance from rectifier

The example of the audible noise caused by interference from a rectifier is shown in Figure I.1. The common-mode noise produced by the rectifier propagates to equipment B on the DC power feeding cable, then it propagates toward the subscriber line through equipment B. Common-mode noise on the telecommunication cable connected to equipment A is induced by magnetic or capacitive coupling. The common-mode noise becomes normal-mode noise by the imbalance of equipment A. By detecting the envelope of the noise, this normal-mode noise is converted to audible noise at the terminal in equipment A, then it propagates to the terminal equipment and is recognized as acoustic noise.

Measurement results demonstrate that the main spectrum component of the noise is around 50 kHz and its envelope has an audible frequency component.

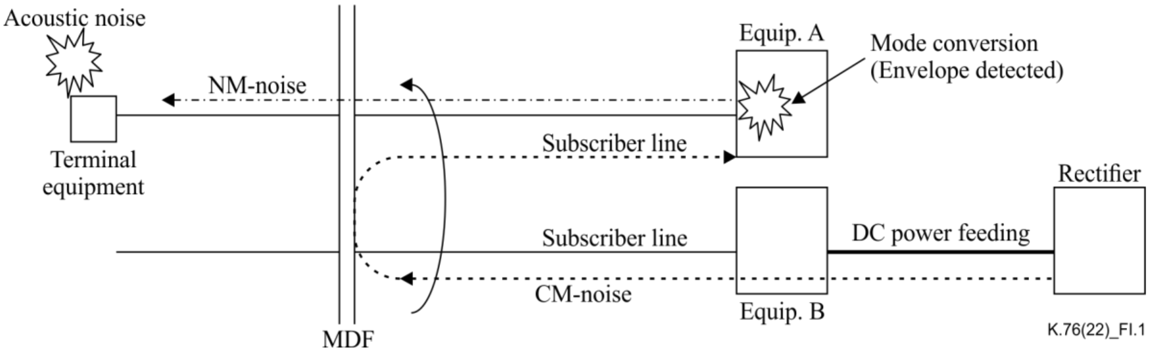


Figure I.1 – Configuration of trouble caused by interference from rectifier

I.2 Audible noise in telephone services provided from a central office

Figure I.2 illustrates an example of the trouble caused by power electronics apparatus. Noise is generated in a fluorescent light using inverter technology. The noise propagates through the power line connected to the fluorescent light and flows into the telecommunication cable via telecommunication terminal equipment.

In this case, the main spectrum component of the noise is around 80 kHz. Now the noise is not only converted into audible noise at the terminal equipment, but also at the switching equipment. Furthermore, similar disturbance occurs in a lot of terminal equipment, which is connected to different pairs in the same cable, because the noise is induced in the lines of the cable by electromagnetic or capacitive coupling.

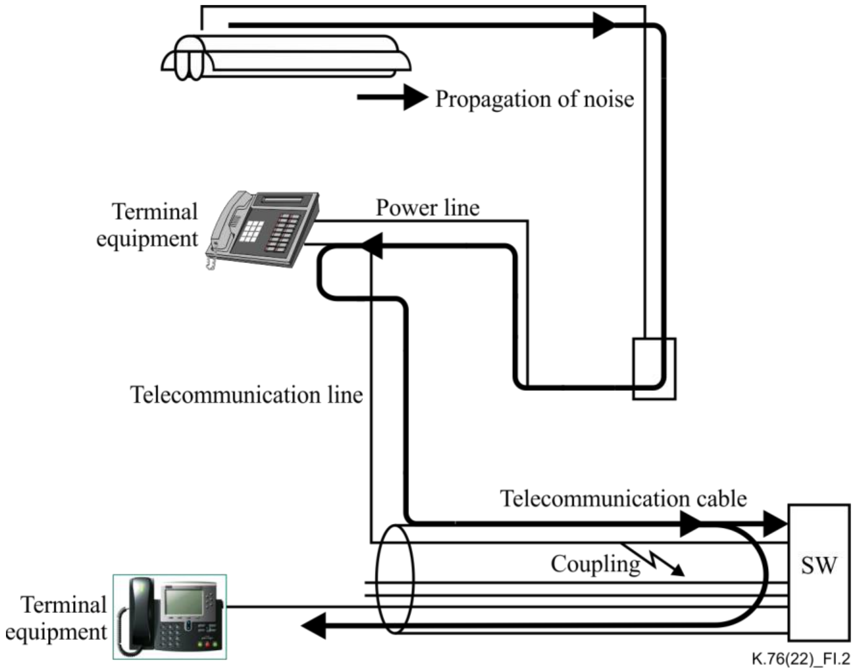


Figure I.2 – Propagation of noise from fluorescent light

I.3 Trouble in LAN system

Figure I.3 shows the configuration of a local area network (LAN) installed in a ski venue where disturbance caused by a ski lift occurred. A router is connected to the integrated services digital network (ISDN) that is provided from a telecommunication centre via a data service unit (DSU). The router stops functioning when the lift is running.

In this case, the noise is produced by the lift motor. Then the noise flows into a power line and propagates into the router. The measured voltage between the neutral line and earthing electrode shows a magnitude of the noise of about 100 V peak-to-peak with a main spectrum component of about 50 kHz, and a burst frequency of about 5 kHz.

From this measurement, it is found that this noise creates a disturbance in the router's power line and causes the malfunction.

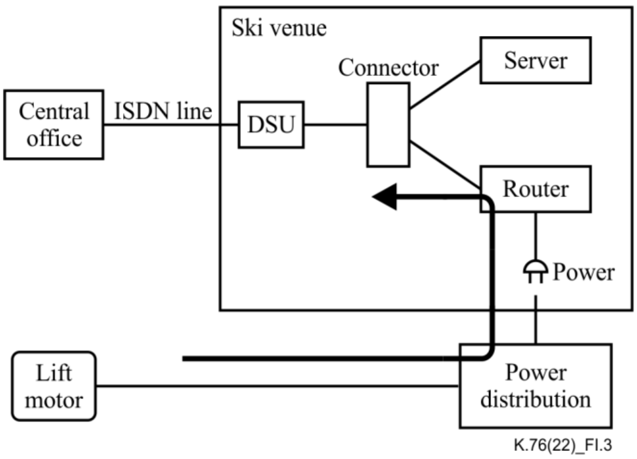


Figure I.3 – LAN configuration

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Printed in Switzerland
Geneva, 2022