Guidance on the specification and access protocols is detailed in Chapter 8. Chapter 9 outlines some pre-contractual matters.

Chapter 10 contains definitions of selected staff functions. A glossary of terms, and References, are included in Chapters 11 and 12 respectively.

Contents

Executive summary

1. Scope *page 6*
1.1 General

2. Management responsibilities *page 8*
2.2 Statutory requirements
2.3 Functional guidance

3. Basic concepts of mains signalling systems *page 10*
3.1 General
3.2 Development of mains signalling techniques
3.8 Fundamentals of mains signalling systems
3.12 Mains signalling regulations
3.15 Frequency bands for mains signalling
3.21 Modulation systems for mains signalling
3.22 Transmitter signal voltages

4. Application of mains signalling *page 16*
4.1 General
4.2 Basic applications
4.8 More complex applications

5. Power systems in buildings – factors affecting mains signalling *page 18*

6. Features of components of a mains signalling system *page 21*
6.1 Electromagnetic compatibility
6.6 Safety

7. Connections between signalling and power systems *page 23*
7.1 Coupling and propagation methods
7.8 Decoupling filters

8. Assessment of a mains signalling manufacturer/supplier *page 25*

8.1 Specifying the system

8.2 Details to be considered

8.15 Points to note in discussion with manufacturers/suppliers

8.21 Access protocol

8.26 Other factors affecting compatibility

9. Pre-contract studies *page 30*

9.1 General

9.6 Other matters

10. Designated staff functions *page 31*

11. Definitions *page 32*

References *page 35*

Figures *page 39*

1. Scope

General

1.1 Healthcare premises need to send and receive information of many kinds in order to fulfil their function.

> **NOTE:** Throughout this document, healthcare premises will include social services premises covered by the Registered Establishments (Scotland) Act 1998 in Scotland.

1.2 Voice communication is used to exchange information both of an administrative nature and in relation to patient care.

1.3 Data signals have to be sent and received for simple purposes such as calls for attention from patients, or for more complex applications such as monitoring and recording the output from medical equipment and for building management systems.

> **NOTE:**
>
> 1. Mains signalling installations operate in the frequency range 3 kHz to 148.5 kHz. This range makes mains signalling unsuitable for computer local area network applications operating at speeds upwards of 10 MHz.
>
> 2. Refer also to SHTM 2005; *Building management systems*.

1.4 Mains signalling is a method of communication to be compared with:

a. infra-red;

b. radio;

c. fixed wiring (twisted pair).

1.5 It has many advantages and some disadvantages, both technical and economic, which need to be considered when choosing a communication system for a particular purpose.

1.6 Except for the simplest applications, such as intercoms, mains signalling systems need to be carefully designed for use on the network on which they are to operate. The purpose of this guidance is to enhance the information available to the designer/purchaser of systems and equipment.

1.7 The scope of this Scottish Health Technical Memorandum is limited to mains signalling on the low-voltage installations associated with a single site. It considers signalling on the public mains only as a matter of background information.

NOTE:

1. In this context, “low-voltage” implies the 230 V mains voltage.
2. A single site can comprise more than one building.

1.8 Where a building is occupied by more than one user of mains signalling equipment, an agreement has to be reached regarding the adaptation of either separate frequencies or specific allocated times.

2. Management responsibilities

2.1 It is incumbent on management to ensure that their electrical installations (including mains signalling systems) comply with all the statutory regulations applicable to communications on their premises. Other functional guidance in terms of standards and codes of practice should be noted.

Statutory requirements

2.2 Safety regulations are as laid down in the:

a. Health and Safety at Work etc Act 1974;
b. Electricity at Work Regulations 1989;
c. Electricity Supply Regulations 1988;
d. Management of Health and Safety at Work Regulations 1999;
e. Provision and Use of Work Equipment Regulations 1998;
f. Manual Handling Operations Regulations 1992;
g. Workplace (Health, Safety and Welfare) Regulations 1992;
h. Personal Protective Equipment at Work (PPE) Regulations 1992;
i. Health and Safety (Display Screen Equipment) Regulations 1992;
j. Supply of Machinery (Safety) Regulations 1992;
k. Low Voltage Electrical Equipment (Safety) Regulations 1989;
l. Construction (Design and Management) Regulations 1994;
m. Electromagnetic Compatibility Regulations 1992.

NOTE: Where there is a requirement to address any of the above, care should be taken to ensure that all amendments following the date of issue are included.

Functional guidance

2.3 Guidance is as laid down in:

a. British Standards and Codes of Practice;

b. Health and Safety Executive guidance;

c. NHS Model Engineering Specifications – NHS Estates;

d. Scottish Hospital Planning Notes and Health Building Notes;

e. Building Standards (Scotland) Regulations 1990;

f. Scottish Health Technical Memoranda and NHS in Scotland Firecode.

For further details please refer to Chapter 12, ‘References’.

3. Basic concepts of mains signalling systems

General

3.1 For the purposes of this SHTM, "mains signalling" is defined as a transmission method by which information or control signals are superimposed on the low-voltage (230 V) mains power supply system.

NOTE:

1. The terms "mains signalling" and "mains communication" are used interchangeably in this SHTM. The term "mains signalling" has been used commonly in the UK but "mains communication" is used in the titles of some international committees.
2. Throughout this document, the term low-voltage network is used to mean the low-voltage (230 V) mains power distribution supply system.

Development of mains signalling techniques

3.2 The use of the low-voltage electricity supply network to transmit and receive signals is not a recent technique. Electricity supply undertakings in many countries use "ripple control" for such applications as:

a. tariff switching;

b. load control or street lighting control.

3.3 In these systems a voltage is applied, usually in the frequency range 100 Hz –2 kHz, which is superimposed on the low-voltage network to carry out these functions.

NOTE:

1. These applications started during the 1930s.
2. Refer to Chapter 11 for definitions.

3.4 A disadvantage of the early systems was the large amount of power needed to generate and inject the signals. It was also necessary to choose frequencies away from the harmonics of 50 Hz.

3.5 In the UK, time switching was introduced for tariff control (e.g. Economy 7). Although there were some instances of use of ripple control, time switching gained supremacy. In addition, photocells, which can respond to local conditions, became increasingly used for street lighting control.

4.9 As an example, the introduction of a building management system (BMS) in a large building offers an attractive application for mains signalling because its use makes it unnecessary to install new wiring to carry the necessary signals between:

a. sensors;

b. transmitters;

c. receivers;

d. actuators; and

e. to logic units.

NOTE:

1. Refer to SHTM 2005; *Building management systems*.
2. Mains signalling techniques should not be considered for control equipment that could become a hazard to people or property if it inadvertently operates or fails to operate in any way.

4.10 If extensions or changes are needed at a later date, the mains communication allows this to be done more readily than if dedicated wiring had been used.

5. Power systems in buildings – factors affecting mains signalling

5.1 The electrical power distribution system in buildings is installed primarily to provide power to a wide range of loads. Although large sites may receive their supply from the public supply network at high voltage (for example 11 kV) the majority of loads in healthcare premises require a supply at low voltage (230 V). As a result, each site has one or more low-voltage networks. According to the load to be supplied, these may be single phase (phase, neutral and earth) or 3-phase.

5.2 The load needs to be balanced reasonably equally between the three phases. A great deal of the low-voltage load is single phase. To limit the potential difference between adjacent load points or socket-outlets the single phase supplies in a given room are usually connected to the same phase.

5.3 If a mains signalling transmitter connected in one room is required to operate receivers in another room, these receivers could well be connected to a different phase. However, capacitance and mutual inductance between the cable cores may be sufficient to transfer the signal adequately, but the designer should be prepared for the necessity of using a coupling circuit.

5.4 The load characteristics that are important to the supply of power are mainly:

a. power demand;

b. power factor;

c. waveform distortion;

d. load fluctuation.

NOTE: Refer to SHTM 2007; *Electrical services: supply and distribution*.

5.5 The important characteristics of a load in relation to mains signalling are the impedance at frequencies between 95 kHz and 148.5 kHz, and whether it is:

a. capacitive;

b. resistive; or

c. inductive.

5.6 This impedance determines the current drawn at the signalling frequency and hence affects the attenuation of the signal. For example, a radio interference suppression capacitor, that draws little current at 50 Hz may present a very low impedance to the mains signal.

5.7 Faulty operation of a low-voltage network that may not be apparent in its normal use may block the signals. For instance, a stray connection between neutral and earth, in the absence of a residual current device (RCD), can persist undetected for years but could prevent some mains signalling systems from operating.

NOTE: Such stray connections are potentially dangerous. The need to locate and remove them is an advantage rather than a disadvantage of mains signalling.

5.8 Finding the voltage drop in a distribution network at 50 Hz is a routine calculation since the source impedance, cable and wiring impedance and load characteristics are readily available. A similar calculation is much more difficult at signal frequency, and the attenuation (loss of signal) is dependent on uncertain and variable quantities.

NOTE: The signal attenuation will change from time to time as loads are added to or removed from the system.

5.9 By way of example, the attenuation as a function of frequency has been measured on several different networks and for different loading conditions.

5.10 The measurements of attenuation against frequency shown in Figures 2, 3, 4, 5, 6 and 7 were taken between two specific points during a time period of approximately half an hour, with the reference signal transmission in phase 1 and both the transmitter and receiver supplied from the 230 V power line.

NOTE: Figures 2, 3, 4, and 5 show the attenuation against frequency for an industrial building (day and night), a hospital building and a residential building respectively.

5.11 Across-phase transmission, denoted by A, means that the transmitter and receiver each used a different phase of a three-phase system. The designation O (opposite-phase) indicates that the transmitter and receiver used different 230 V split, single-phase power lines.

5.12 For these measurements the receiver position was fixed and the transmitter was moved to obtain the results for across-phase or opposite-phase transmission.

5.13 Figure 2 shows attenuation measured in an industrial building during normal working hours. In-phase attenuation as a function of frequency over a short distance (denoted by IS) is relatively flat and is less than 5dB over most of the frequency range. This known, physically short, communication path of 10 metres is relatively free of electrical loads between the transmission and reception points. Curve IS indicates what minimum attenuation might be expected. Over long distances, however, attenuation is approximately 25 dB for frequencies below 60 kHz and increases to approximately 50 dB at 200 kHz.

5.14 Comparison of the in-phase attenuation, curve I, with the across-phase curves A1 and A2, shows that the across-phase transmission did not always result in greater attenuation than for in-phase transmissions, although the latter is often the case.

5.15 Disturbing effects, whether from system loads or other mains signals, may require the use of an isolation or decoupling filter. The characteristics of such filters are discussed in Chapter 7.

6. Features of components of a mains signalling system

Electromagnetic compatibility

6.1 Mains signalling equipment taking its power supplies from the mains is exposed to the same range of electrical disturbances as other apparatus fed in this way and has to be immune to the same disturbances.

6.2 Immunity standards have not yet been agreed internationally. The reason is significant disagreement not over the required immunity levels but over a difficulty in establishing a standard test circuit in which the effect of a transmitter and receiver operating together can be tested.

6.3 Two immunity classes are proposed for differing environments; these are:

a. residential, commercial and light industrial;

b. heavy industrial (where a higher immunity standard is required).

6.4 Well-established techniques exist for making electronic equipment immune to electromagnetic disturbance, and reputable manufacturers/ suppliers should not have difficulty in achieving the necessary performance.

6.5 It is of course necessary for the designer of a mains signalling system to make it immune to the mains signals that are likely to impinge upon it.

Safety

6.6 Mains signalling equipment connected to the system is no more hazardous than any other electronic equipment and has to comply with the same safety standards such as BS EN 60065: 1998. This should be certified by the manufacturer affixing the CE mark.

6.7 The safety precautions needed in the application of mains signalling for the control of loads are similar to those needed for any remote control system and have regard to any possible faulty operation.

6.8 BS EN 50065-1 requires guidance on the proper use and warning on improper use to be included in the installation and operating instructions supplied with each item of equipment.

6.9 BS EN 50065-1 also states that where appropriate a notice shall be attached securely to each product giving the substance of the following warning:

"MAINS SIGNALLING MUST NOT BE USED TO CONTROL EQUIPMENT THAT COULD BECOME A HAZARD TO PEOPLE OR PROPERTY IF IT INADVERTENTLY OPERATES OR FAILS TO OPERATE IN ANY WAY".

7. Connections between signalling and power systems

Coupling and propagation methods

7.1 Coupling between the signalling and power systems may be either:

a. parallel; or

b. series.

7.2 Propagation on the power system is as shown in Figure 1 and may be in:

a. the differential; or

b. common mode.

7.3 In the differential propagation mode the signal is injected between one of the phases of the power system and its neutral.

7.4 In common mode propagation the signal is applied between phase-and-neutral together and earth.

7.5 The advantage of the common mode connection is that there is effectively no signal potential between phase and neutral and the signal is, therefore not shunted by power factor correction capacitors (for example, as in fluorescent luminaires).

7.6 The disadvantage of the common mode connection is that the signal current flows through the tripping circuit of the protective residual current devices (RCDs). Tests have shown that, depending on the individual design of an RCD, the tripping sensitivity may be increased, decreased or unaffected.

7.7 To avoid hazards arising from inexpert installers, common mode propagation is prohibited in the residential environment. It may be used in industrial and commercial environments (including hospitals) under the responsibility of the installer or estate manager, and must comply with any local regulations.

Decoupling filters

7.8 The aim in developing standards for mains signalling has been to avoid the need for filters to separate different users on the same low-voltage network.

7.9 If a decoupling filter is found to be necessary it may be used:

a. to delimit the transmission area of wanted signals to the area in which the mains communication system operates;

b. to reduce unwanted signals coming from the other side of the mains port;

c. to allow simultaneous communication on both sides of the filter;

d. to set a suitable impedance to the mains power ports;

e. to provide a return path for the signal when needed (for example common mode propagation).

NOTE: An international standard for decoupling filters is under development.

7.10 If a filter has too low an input impedance on either side it will short out the signals. To avoid this the draft standard proposes that the input impedance should not be less than 10 ohm on the electricity supplier's side when tested from 3 kHz-95 kHz and not less than 10 ohm on the consumer's side when tested from 95 kHz-148.5 kHz.

8. Assessment of a mains signalling manufacturer/ supplier

Specifying the system

8.1 For a manufacturer/supplier to be able to recommend a suitable system it is important that the designer is able to specify their requirements clearly in respect of the various features affecting the operation of the mains signalling system. The following points need to be considered.

Details to be considered

What is the nature of the premises?

8.2 Healthcare premises include small residential establishments. Other premises are similar to commercial buildings, such as offices, whilst large hospitals have extensive power installations with a large variety of specialised loads in which a mains signalling installation will require careful design.

8.3 Most commercial and similar sites use three-phase supplies on which there is no resistive signal path between one phase and another. Many mains signalling installations can couple data adequately between phases, for instance through the capacitance between the cable cores, without special data linking arrangements. However, designers should consider the possible need to provide equipment to enable signals injected on one phase to be received on the others.

Are the premises served by more than one supply transformer?

8.4 **Mains signals will not normally pass from secondary to primary of a supply transformer**. Coupling between separate networks is possible by suitably designed data links.

NOTE: It is not permitted to couple signals to the electricity supplier's side of a distribution transformer.

Over what distances are signals required to travel on the mains wiring?

8.5 The communication range is dependent on many parameters and is difficult to predict accurately. Designers should provide manufacturers/suppliers with information such as the existence of apparatus presenting a capacitive load to the system (for example rectifiers or filters).

> **NOTE:** Equipment manufacturers/suppliers should be able to offer a system that will operate satisfactorily under all but the most extreme conditions.

What is the purpose of the proposed installation?

8.6 Many of the design features in this section will be influenced by the nature and complexity of the tasks to be carried out and the consequences of faulty operation or non-operation in response to a given signal or a disturbance mimicking a signal.

Is there a mains communication system (other than intercoms) already operating on the site?

8.7 There is no single nationally or internationally agreed protocol for mains signalling. As a result it cannot be expected that equipment, for example sensors and transmitters, produced by one manufacturer will operate equipment, for example receivers and actuators, produced by other manufacturers.

8.8 Equally, it cannot be assumed without investigation that a mains signalling system from one manufacturer will not interfere with the signals from another manufacturer's system.

> **NOTE:** Systems complying with BS EN 50065-1 and operating in the frequency band 125 kHz–140 kHz where an access protocol is specified should not interfere with each other.

What is the functional configuration of the required system?

8.9 Consideration needs to be given to the number and placing of the sensors, transmitters, receivers, actuators and logic units required in the system.

What signalling rate is required and what error rate is tolerable?

8.10 The signalling rate to be specified should be sufficient for the applications. Signalling errors can be minimised by the use of "error correcting codes" or "redundant messaging". However, the highest rate of signalling is not necessarily compatible with the lowest error rate, and it is wise to specify only what is actually required to obtain a reliable and economic system.

> **NOTE:** Mains signalling installations operate in the frequency range 3 kHz to 148.5 kHz. This range makes mains signalling unsuitable for applications such as computer local area networks operating at speeds of about 10 MHz.

What response time is required?

8.11 The required response time may set a different requirement from other aspects of system performance. For example, if a button or switch is activated the operator tends to look for the expected response almost immediately and, if it does not happen, he/she may repeat the operation. However, for automatic operation, for example heating control, it may well be that a delay of as much as a minute between command and response would be acceptable, provided that it was correctly executed when it occurred.

What response is required to a power failure?

8.12 The effect of an interruption to the mains supply needs to be considered at the design stage. In most cases the signal path would not be broken, and if the controlled equipment is driven from the same mains and has no uninterruptible power supply it is not necessary to maintain the control signals. If the power failure is partial, due to a blown fuse or circuit breaker trip, the system may be capable of partial operation, and such failure mode operation should be preplanned.

8.13 It is important to consider the state to which the equipment returns; that is, should the equipment return to the position that it was in when the power failed, or is it to take up an "on" or "off" state after restoration of power?

Is a standby generator installed?

8.14 A standby generator may not be capable of supplying power to all the equipment on the site. Connection of the generator will change the source impedance of the system and so alter the attenuation of the signals as they travel through the mains. It may also change the disturbance level on the system. This will mean that the system configuration will be different under emergency and normal conditions. The need for control of the different loads under the two conditions has to be fully taken into account in designing the control system.

> **NOTE:** Refer to SHTM 2011; *Emergency electrical services*.

Points to note in discussion with manufacturers/suppliers

8.15 Most manufacturers/suppliers use the frequency band 125 kHz to 140 kHz and the access protocol specified in BS EN 50065-1. This has been found to be effective in allowing different signalling systems of this type to work on the same mains network.

8.16 Although information should be obtained from several prospective manufacturers/suppliers, it is sensible for an initial installation to use a single reputable source or to choose a technology that supports a certification scheme.

8.17 Most manufacturers/suppliers have a certification scheme covering the technology and the application language.

8.18 Caution should be taken in relation to equipment designed for markets outside Europe because the standards may be different.

8.19 It is helpful if the chosen system uses the same signalling protocol for mains signalling and signalling on other media, for instance twisted pair wiring. This gives an alternative to mains communication for particular parts of the system if difficulties are encountered.

8.20 If reliability is important, a system using "half duplex" transmission, in which the signal can be acknowledged and verified, should be considered. This may not be available on some cheaper systems using one-way or "simplex" transmission, in which verification of the correctness of the received signal is not possible.

NOTE: The need to acknowledge the signal and possibly to retransmit is likely to reduce the possible signalling rate.

Access protocol

8.21 The access protocol specified in BS EN 50065-1 for the band 125–140 kHz is required to allow several systems to operate on the same low-voltage network.

8.22 Under this protocol all systems use the frequency 132.5 kHz to indicate that a transmission is in progress.

NOTE:

1. A transmission is considered as a series of signals in which there is no gap greater than 80 milliseconds without signal transmission. This allows a sequence of transmission, repetition and answer-back signals to occupy up to 1 second.
2. It will be seen that the requirements of the protocol set an upper limit to the signalling rate and a lower limit to the response time.

8.23 No transmitter or group of transmitters may transmit continuously for a period exceeding 1 second, and after each transmission shall not transmit again for 125 milliseconds.

8.24 Every device capable of transmitting is required to be equipped with a signal detector to indicate when the band is in use: band-in-use is the condition when any signal of at least 80 dB (μV) rms anywhere in the frequency range 131.5–133.5 kHz and having lasted for at least 4 milliseconds is present at the device's main input terminals and across the conductors used by the device's own transmitter.

8.25 Every device capable of transmitting may transmit only if its band-in-use signal detector has shown that the band has not been in use for a period randomly chosen on each occasion and uniformly distributed between 85 milliseconds and 115 milliseconds with at least seven possible values in that range.

Other factors affecting compatibility

8.26 The above access protocol ensures that two signalling systems can each work on the same low-voltage network, but is not enough to enable parts (for example a transmitter) from one manufacturer to operate parts (for example a receiver or actuator) from another manufacturer. For this to be possible the two systems must use the same signalling protocol and they must also attribute the same action to the same message.

9. Pre-contract studies

General

9.1 Since the conditions on a network in which a mains signalling system is to be installed are uncertain, it is necessary to find whether there are any obstacles to its use and whether they can be overcome.

9.2 Reputable manufacturers/suppliers have test sets or communication analysers which can simulate signalling transmitters and receivers to allow the reliability of signalling to be investigated. According to its design the test equipment is likely to allow the effect of increasing or reducing the signal level or of increasing the network attenuation to be investigated.

9.3 According to their business practice a manufacturer/supplier may lend, hire or sell a communications analyser or undertake to study the system and make a recommendation.

9.4 Tests have to be made under different supply conditions, for example with and without a standby generator operating.

9.5 Individual tests are also required under a given supply condition (loads will probably vary uncontrollably) to enable signalling error rate to be determined.

Other matters

9.6 Matters similar to those relating to contracts for other specialist apparatus must, of course, be agreed. These could include:

a. agreements on responsibility for installation;

b. commissioning;

c. acceptance testing;

d. provision of documentation;

e. provision of maintenance and other services.

10. Designated staff functions

10.1 Only trained authorised and competent persons should be appointed by management to control the operation and maintenance of mains signalling.

10.2 **Management**: the owner, occupier, employer, general manager, chief executive or other person who is accountable for the premises and is responsible for issuing or implementing a general policy statement under the HSW Act 1974.

10.3 **Designated person (electrical)**: an individual who has overall authority and responsibility for the premises containing the electrical supply and distribution system within the premises and has a duty under the HSW Act 1974 to prepare and issue a general policy statement on health and safety at work, including the organisation and arrangements for carrying out that policy. This person should not be the authorising engineer.

10.4 **Duty holder**: a person on whom the Electricity at Work Regulations 1989 impose a duty in connection with safety.

10.5 **Employer**: any person or body who:

a. employs one or more individuals under a contract of employment or apprenticeship;

b. provides training under the schemes to which the Health and Safety (Training for Employment) Regulations 1990 apply.

10.6 **Authorising engineer (low voltage)**: a Chartered Engineer or Incorporated Electrical Engineer with appropriate experience and possessing the necessary degree of independence from local management who is appointed in writing by management to implement, administer and monitor the safety arrangements for the low voltage electrical supply and distribution systems of that organisation to ensure compliance with the Electricity at Work Regulations 1989, and to assess the suitability and appointment of candidates in writing to be authorised persons (see SHTM 2020; *Electrical safety code for low voltage systems (Escode – LV)*).

10.7 **Authorised person (LV – electrical)**: an individual possessing adequate technical knowledge and having received appropriate training, appointed in writing by the authorising engineer to be responsible for the practical implementation and operation of management's safety policy and procedures on defined electrical systems (see SHTM 2020).

10.8 **Competent person (LV – electrical)**: an individual who, in the opinion of an authorised person, has sufficient technical knowledge and experience to prevent danger while carrying out work on defined electrical systems (see SHTM 2020).

11. Definitions

Department: an abbreviation of the generic term “UK Health Departments”, Scottish Executive Health Department.

System: a system in which all the electrical equipment is, or may be, electrically connected to a common source of electrical energy, including such source and such equipment.

Injury: death or personal injury from electrical shock, electrical burn, electrical explosion or arcing, or from fire or explosion initiated by electrical energy.

Danger: a risk of injury.

Low voltage (LV): the existence of a potential difference (rms value for a.c.) not exceeding 1000 volts a.c. or 1500 volts d.c. between circuit conductors or 600 volts a.c. or 900 volts d.c. between circuit conductors and earth.

Mains signalling: a means of transmitting information or control signals by superimposing them on the low-voltage (230 volts) mains power supply conductors.

Public supply mains: the electrical supply network that is operated by the electricity companies.

Electrical/electronic equipment: includes anything used, intended to be used or installed for use to generate, provide, transmit, transform, conduct, distribute, control, measure or use electrical energy.

Equipment: abbreviation of electrical/electronic equipment.

Ripple control: a method of controlling electricity consumption tariffs and electrical loading by the superposition of signal voltages on the low-voltage distribution system, usually in the frequency range from 175 Hz to 2 kHz.

Electromagnetic compatibility (EMC): capability of electronic equipment or systems to be operated with a defined margin of safety, in the intended operational environment, at designed levels of efficiency, without degradation due to interference.

Electromagnetic interference (EMI): any undesirable electromagnetic signals causing a malfunction in equipment.

Attenuation: a reduction in the strength of a signal.

Distribution line carrier (DLC): another name for low-voltage mains signalling.

Access protocol: the standard format and relative timing of the pulses forming the various components of the signal.

Power line carrier (PLC): another name for mains signalling; originally applied to the transmission of signals on high-voltage overhead lines but now used more generally.

Building management system (BMS): a system comprising electronic equipment and software with the prime function of controlling and monitoring the operation of building services within a building, including heating, air-conditioning, lighting, and other energy-using areas.

Data: a representation of information or instruction in a formalised manner suitable for communication, interpretation, or processing by humans or a computer.

CE mark: a European Commission logo indicating that the equipment/device meets all the relevant European Directives and satisfies the requirements essential for it to be fit for its intended purpose.

Type 1 equipment: electricity suppliers' equipment.

Type 2 equipment: consumers' equipment.

Simplex transmission: transmission over a circuit capable of transmitting in one direction only.

Half-duplex transmission: transmission over a circuit capable of transmitting in either direction, but in only one direction at a time.

Full-duplex transmission: method of transmission where each end can simultaneously transmit and receive. Note: this refers to a communication system or equipment capable of transmission simultaneously in two directions.

Rated current: the maximum power frequency current which the manufacturer declares the decoupling filter to be suitable for carrying continuously.

Rated voltage: The maximum voltage (for three-phase supply, the voltage between phases) for which the decoupling filter is still properly used.

Q factor: known as the quality factor, and defined as the ratio of the central resonant frequency, f_o, to the –3 dB bandwidth, BW.

$$Q = \frac{f_0}{\text{Bandwidth}}$$

$$Q = \frac{f_0}{f_{max} - f_{min}}$$

Carrier (wave): a high-frequency signal the modulation of which carries signals of lower frequencies representing the information to be conveyed.

Error correction: a detected error in a received signal will cause the information to be rejected and call for a retransmission.

NOTE: More sophisticated methods based on error-correcting codes may be used.

Error detection: a coding system in which the data is accompanied by error-check bits which, if not received correctly, will cause detectable inconsistencies in the received signal and initiate the error-correction procedure.

Error rate: the number of signals having errors on reception expressed as a proportion of the total number sent.

Phase modulation: a method of transmitting digital signals by using a carrier wave the phase of which is advanced or retarded with reference to a standard to indicate a digital 1 or 0.

Selective addressing: inclusion of data in a signal that will cause it to activate only certain receivers.

Signalling rate: the number of signal units sent and received in a suitable period (for example per second).

References

NOTE:
Where there is a requirement to address a listed reference, care should be taken to ensure that all amendments following the date of issue are included.

Publication ID	*Title*	*Publisher*	*Date*	*Notes*
Acts and Regulations				
	The Building (Scotland) Act	HMSO	1959	
	Clean Air Act	HMSO	1993	
	Electricity Act	HMSO	1989	
	Health and Safety at Work etc Act	HMSO	1974	
	Registered Establishments (Scotland) Act	HMSO	1998	
	Telecommunications Act	HMSO	1984	
	The Water (Scotland) Act	HMSO	1980	
SI 3146	The Active Implantable Medical Devices Regulations	HMSO	1992	
SI 2179 & 187	The Building Standards (Scotland) Regulations (as amended)	HMSO	1990	
	The Building Standards (Scotland) Regulations: Technical Standards Guidance	HMSO	1998	
SI 1460	Chemicals (Hazard Information and Packaging for Supply) Regulations (CHIP2)	HMSO	1997	
SI 3140	Construction (Design and Management) Regulations	HMSO	1994	
SI 437	Control of Substances Hazardous to Health Regulations (COSHH)	HMSO	1999	
SI 635	Electricity at Work Regulations	HMSO	1989	
SI 1057	Electricity Supply Regulations (as amended)	HMSO	1988 (amd 1994)	
SI 2372	Electromagnetic Compatibility Regulations (as amended)	HMSO	1992	
SI 2451	Gas Safety (Installation and Use) Regulations	HMSO	1998	
SI 917	Health & Safety (First Aid) Regulations	HMSO	1981	
SI 682	Health & Safety (Information for Employees) Regulations	HMSO	1989	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
SI 2792	Health and Safety (Display Screen Equipment) Regulations	HMSO	1992	
SI 341	Health and Safety (Safety Signs and Signals) Regulations	HMSO	1996	
SI 1380	Health and Safety (Training for Employment) Regulations	HMSO	1990	
SI 2307	Lifting Operations and Lifting Equipment Regulations (LOLER)	HMSO	1998	
SI 728	Low Voltage Electrical Equipment (Safety) Regulations	HMSO	1989	
SI 3242	Management of Health and Safety at Work Regulations	HMSO	1999	
SI 2793	Manual Handling Operations Regulations	HMSO	1992	
SI 3017	The Medical Devices Regulations	HMSO	1994	
SI 1790	Noise at Work Regulations	HMSO	1989	
SI 3139	Personal Protective Equipment (EC Directive) Regulations (as amended)	HMSO	1992	
SI 2966	Personal Protective Equipment at Work (PPE) Regulations	HMSO	1992	
SI 128	Pressure Systems Safety Regulations (PSSR)	HMSO	2000	
SI 2306	Provision and Use of Work Equipment Regulations (PUWER)	HMSO	1998	
SI 3163	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR)	HMSO	1995	
SI 3004	Workplace (Health, Safety and Welfare) Regulations	HMSO	1992	
British Standards				
BS 800	**Specification for limits and methods of measurement of radio interference characteristics of household electrical appliances, portable tools and similar electrical apparatus**	BSI Standards	1988	Amd 6275, 6/90 ; Amd 6578, 6/91
BS 4737	**Intruder alarm systems**	BSI Standards		
BS 5378-1	**Safety Signs and Colours. Specification for colour and design**	BSI Standards	1980	
BS 5445	**Components of automatic fire detection systems**	BSI Standards		
BS 6238	**Code of practice for performance monitoring of computer-based systems**	BSI Standards	1982 (1993)	

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
BS 7671	**Requirements for Electrical Installations. IEE Wiring Regulations**	BSI Standards	1992	(Amd 8356, 01/95)
BS 7807	**Code of practice for design, installation and servicing of integrated systems incorporating detection and alarm systems and/or security systems for buildings other than dwellings**	BSI Standards	1995	
BS EN 55011	**Specification for limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical (ISM) radio-frequency equipment**	BSI Standards	1991	
BS EN 55015	**Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment**	BSI Standards	1993	
BS EN 50065	**Specification for signalling on low-voltage electrical installations in the frequency range 3 kHz to 148.5 kHz**	BSI Standards	1992	
BS EN 50065–1	**General requirements, frequency bands and electromagnetic disturbances**	BSI Standards	1992	
BS EN 60065	**Safety requirements, audio, video and similar electronic apparatus**	BSI Standards	1998	
BS EN 60529	**Specification for degrees of protection provided by enclosures (IP code)**	BSI Standards	1992	
BS EN ISO 9000	**Quality management and quality assurance standards**	BSI Standards		
IEC Publication 417	**Graphs symbols for use on equipment**	IEC		
IEC 27, 148, 164, 416 and 617	**Letter symbols, signs, abbreviations and graphical symbols**	BSI Standards		
IEC Publication 50	**International electrotechnical vocabulary**	BSI Standards		
Scottish Health Technical Guidance				
SHTM 2005	Building management systems	P&EFEx	2001	CD-ROM
SHTM 2007	Electrical services supply and distribution	P&EFEx	2001	CD-ROM
SHTM 2011	Emergency electrical services	P&EFEx	2001	CD-ROM
SHTM 2014	Abatement of electrical interference	P&EFEx	2001	CD-ROM
SHTM 2015	Bedhead services	P&EFEx	2001	CD-ROM

Publication ID	***Title***	***Publisher***	***Date***	***Notes***
SHTM 2020	Electrical safety code for low voltage systems (Escode – LV)	P&EFEx	2001	CD-ROM
SHPN 1	Health service building in Scotland	HMSO	1991	
SHPN 2	Hospital briefing and operational policy	HMSO	1993	
SHPN 48	Telecommunications	HMSO		
SHTN 1	Post commissioning documentation for health buildings in Scotland	HMSO	1993	
SHTN 2	Domestic hot and cold water systems for Scottish Health Care Premises	P&EFEx	2001	CD-ROM
SHTN 4	General Purposes Estates and Functions Model Safety Permit-to-Work Systems	EEF	1997	
	NHS in Scotland – PROCODE	P&EFEx	2001	Version 1.1
MEL 46; 56	Management Executive Letters	Scottish Office	1993	
NHS in Scotland Firecode				
SHTM 81	Fire precautions in new hospitals	P&EFEx	1999	CD-ROM
SHTM 82	Alarm and detection systems	P&EFEx	1999	CD-ROM
SHTM 83	Fire safety in healthcare premises: general fire precautions	P&EFEx	1999	CD-ROM
SHTM 84	Fire safety in NHS residential care properties	P&EFEx	1999	CD-ROM
SHTM 85	Fire precautions in existing hospitals	P&EFEx	1999	CD-ROM
SHTM 86	Fire risk assessment in hospitals	P&EFEx	1999	CD-ROM
SHTM 87	Textiles and furniture	P&EFEx	1999	CD-ROM
SFPN 3	Escape bed lifts	P&EFEx	1999	CD-ROM
SFPN 4	Hospital main kitchens	P&EFEx	1999	CD-ROM
SFPN 5	Commercial enterprises on hospital premises	P&EFEx	1999	CD-ROM
SFPN 6	Arson prevention and control in NHS healthcare premises	P&EFEx	1999	CD-ROM
SFPN 7	Fire precautions in patient hotels	P&EFEx	1999	CD-ROM
SFPN 10	Laboratories on hospital premises	P&EFEx	1999	CD-ROM
UK Health Technical Guidance				
EH 40	HSE Occupational Exposure limits	HSE	Annual	
MES	Model Engineering Specifications	NHS Estates	1997	As required

Figures

Figure 1: Coupling and propagation methods

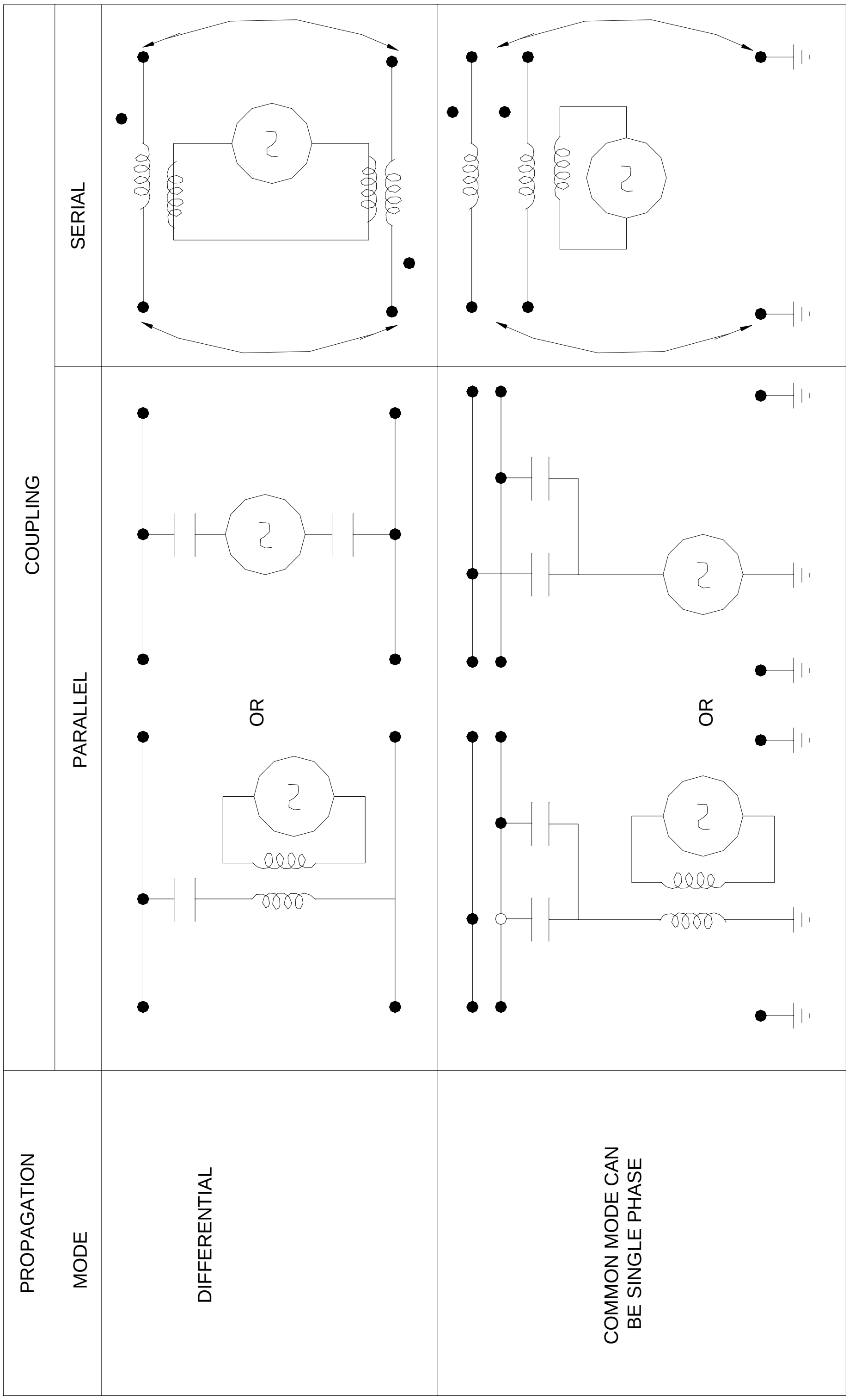
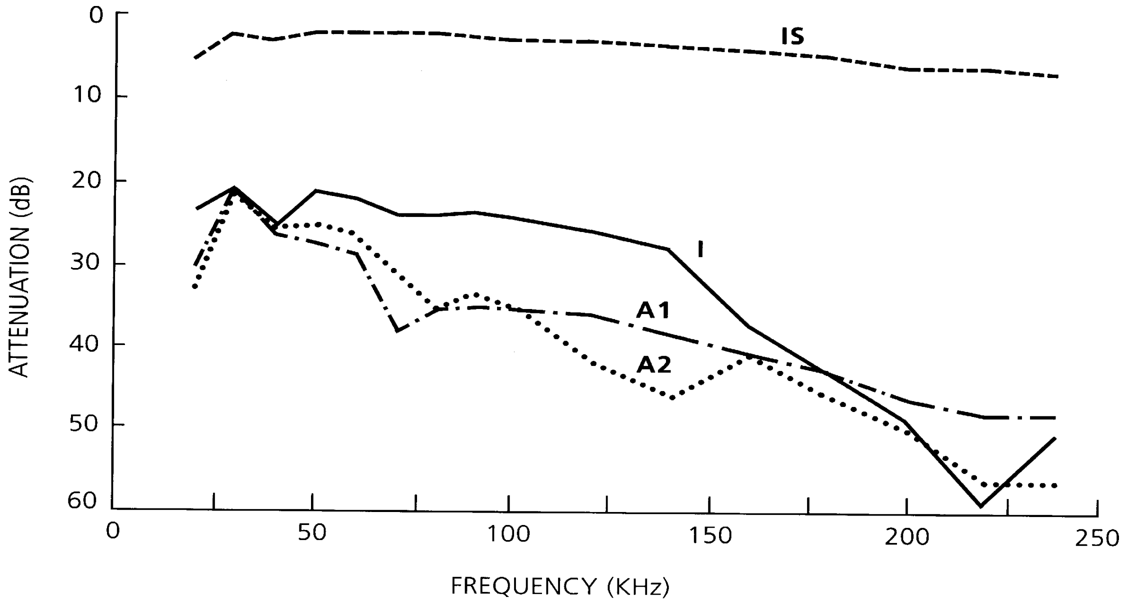
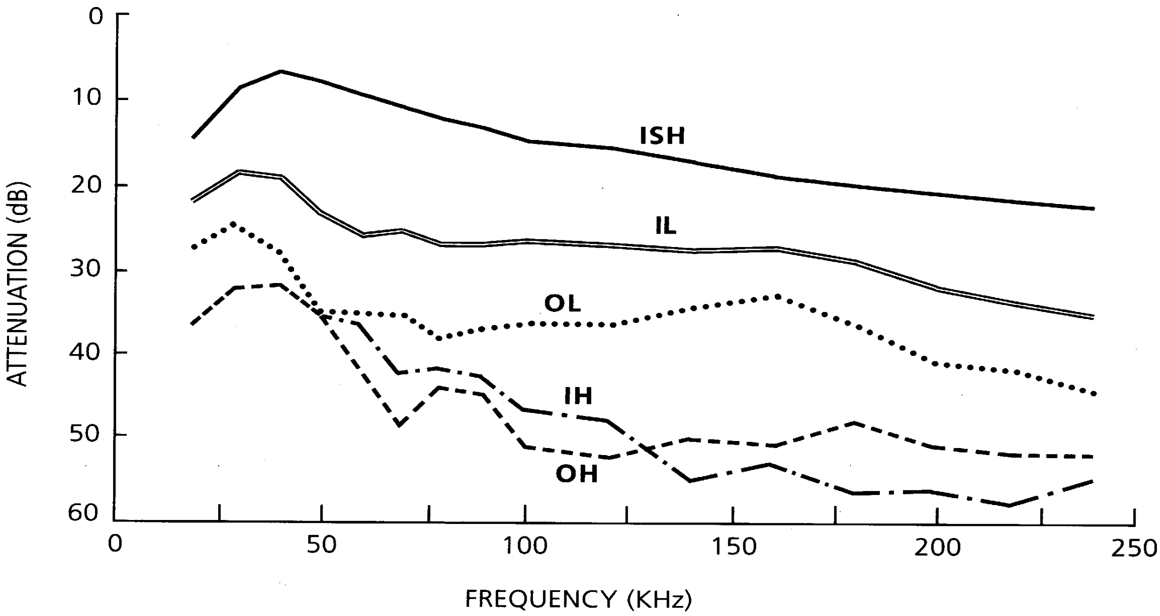


Figure 2: Attenuation versus frequency (industrial building, daytime)



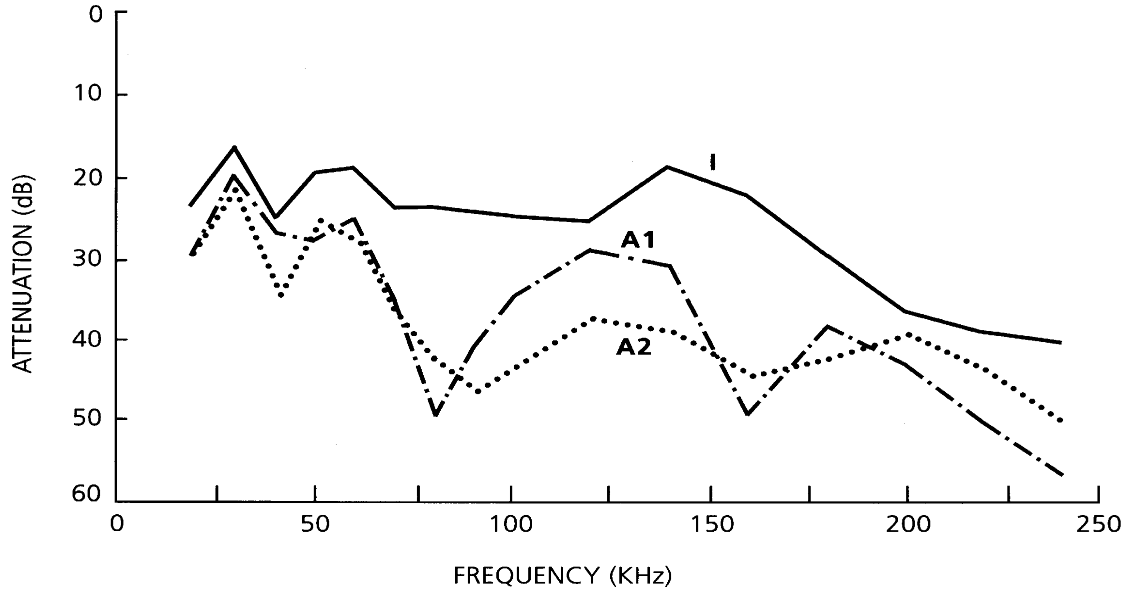
IS – short distance, in-phase channel
I – long (unknown distance), in-phase channel
A1 & A2 – across-phase channels

Figure 3: Attenuation versus frequency (residential building)



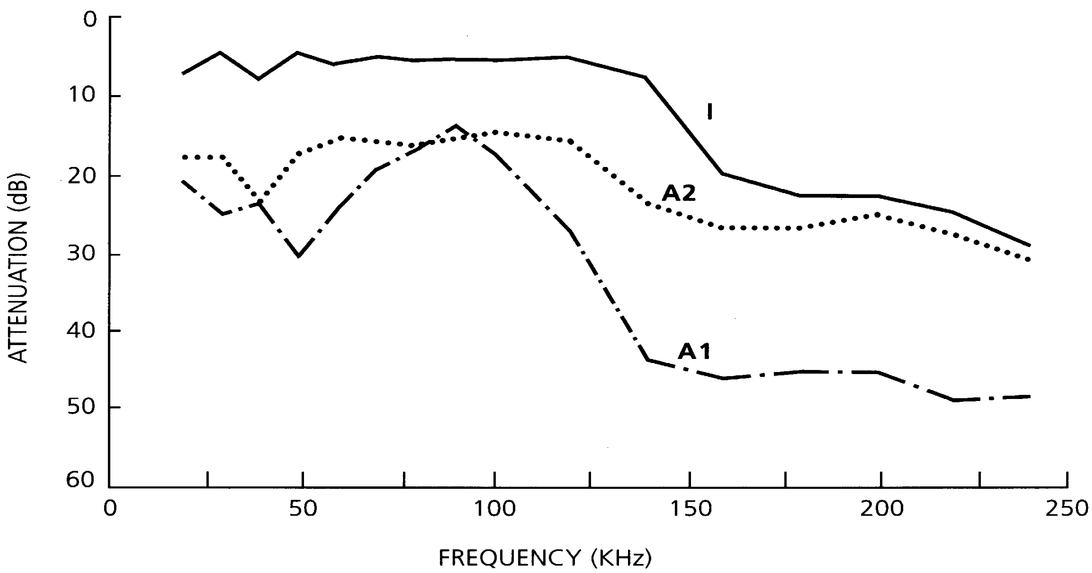
IL – low-rise, in-phase channel
OL – low-rise, opposite-phase channel
ISH – high-rise, short in-phase channel
IH – high-rise, in-phase channel
OH – high-rise, opposite-phase channel

Figure 4: Attenuation versus frequency (industrial building, night-time)



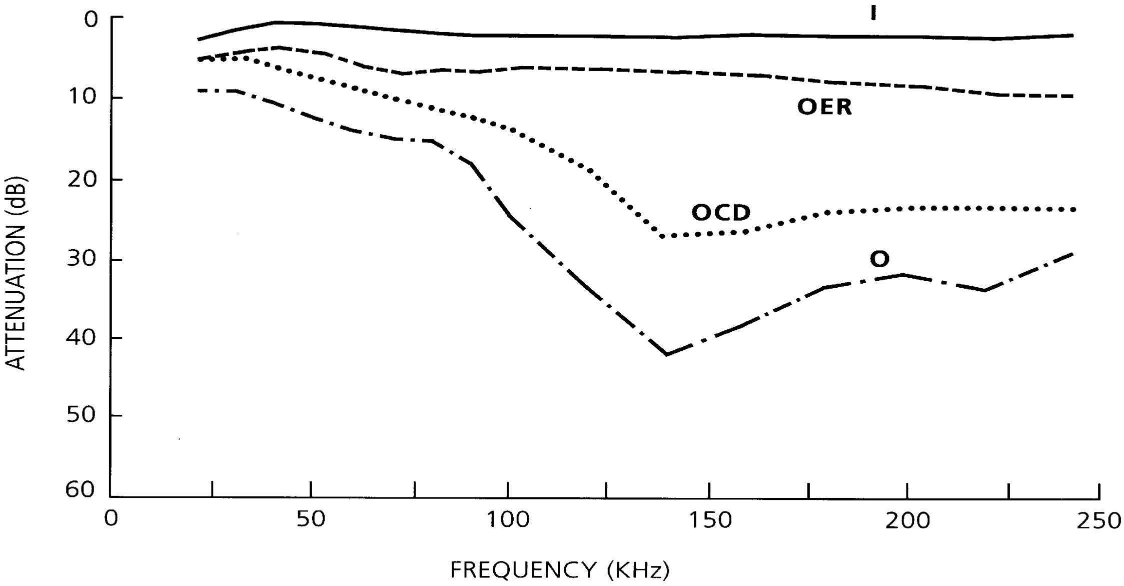
I – long (unknown distance), in-phase channel
A1 & A2 – across-phase channels

Figure 5: Attenuation versus frequency (typical hospital)



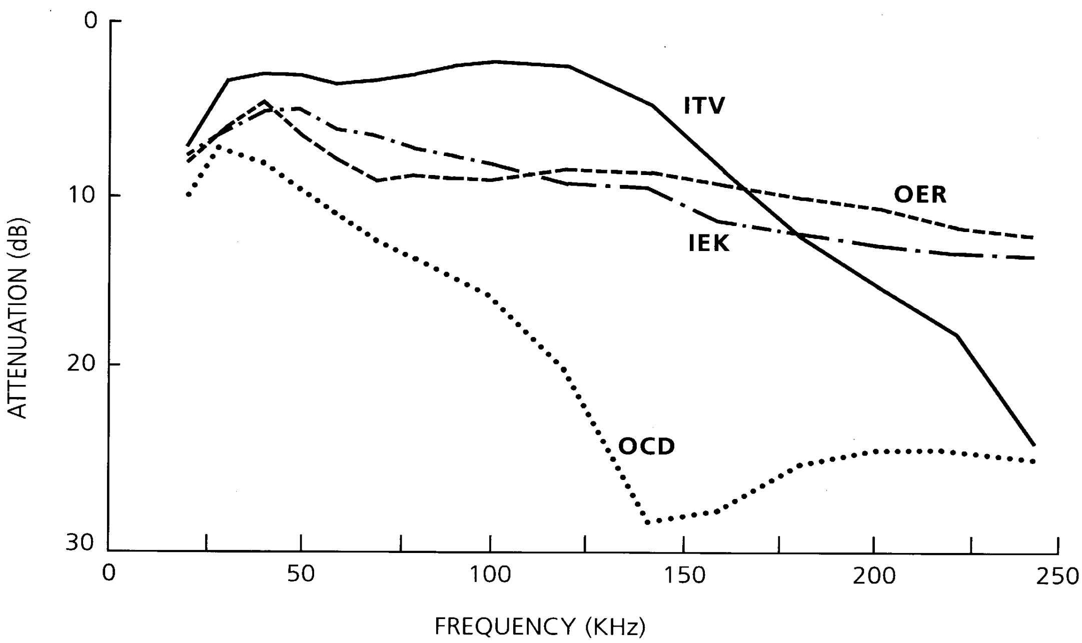
I – long (unknown distance), in-phase channel
A1 & A2 – across-phase channels

Figure 6: Attenuation versus frequency (single-family house)



I & O – in-phase and opposite-phase channels (no specific load applied)
OER & OCD – see Figure 7 (shown here for reference only)

Figure 7: Attenuation versus frequency (single-family house, known loads applied)



I & O – in-phase and opposite-phase channels with loads as follows:
TV: television receiver
EK: electric kettle
ER: electric cooker
CD: clothes dryer