Scottish Health Technical Memorandum 2035

(Part 3 of 3)

Validation and verification/
Operational management

Mains signalling

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Executive summary

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

Mains signalling is a method of communication to be compared with other systems such as:

a. radio transmission;

b. fixed wiring.

Every healthcare premises will have a low-voltage network (230 V) installed within its fabric. This network extends to every part of the building through the existence of socket-outlets. By utilising these conductors for specified communication signals, economies in data cabling provision may be possible.

While voice communication is used to exchange information, data signals can be sent/received for simple purposes such as calls for attention from patients, or for more complex applications such as monitoring/recording the output from medical equipment and for building management systems.

Historically, on the domestic scene, the simplest application of mains signalling equipment was in its use as a baby alarm or with simple intercoms. Electricity supply authorities have used their networks as a signalling medium since the 1930s to control functions such as tariff switching, load management and street lighting.

This part, ‘Validation and verification (V&V)/Operational management (OM)’ comprises two distinct sections. The V&V section details the requirements for testing and commissioning of mains signalling equipment, while the OM section provides information for day-to-day operation and maintenance.

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.

Management responsibilities in terms of compliance with statutory instruments are summarised in Chapter 2. An overview of the conditions of contract placement is given in Chapter 3. Tests required prior to delivery are indicated in Chapter 4. Chapters 5 and 6 contain guidance on installation, commissioning and site testing. General maintenance procedures, which include documentation and trouble-shooting, are described in Chapters 7 and 8. Chapter 9 contains definitions of selected staff functions. A glossary of terms, and References, are included in Chapters 10 and 11 respectively.

Contents

OPERATIONAL MANAGEMENT

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.

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 11, ‘References’.

Validation and verification

3. Functional overview

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.

Background

3.2 The conditions for placing the contract for mains communication equipment, the subsequent installation and commissioning for service are critical. While negotiating and wherever possible, the conditions of sale should be adhered to at all times.

NOTE: Assurances should be given by the manufacturer/supplier to provide all technical information for installation and commission.

Initial assessment

3.3 The prospective purchaser should provide a full specification of the requirements of the system to be supplied. This enables the manufacturer/ supplier to provide full design documentation for the ordered system, and ensures that clear instructions and installation guidance are made available at the earliest opportunity.

Contract development

3.4 To provide best possible practice in the commissioning of the equipment for mains signalling it is extremely important in the contractual conditions to supply all details for the equipment, installation and service. The equipment should comply with any relevant standards, for example BSI, IEC and CENELEC.

Signs and labels

3.5 All equipment should be correctly identified on delivery by labels displayed prominently on the equipment. The fact that mains signalling equipment is installed on the low-voltage network should be indicated by signs displayed prominently at suitable places, for example fuses or circuit breaker boards in locations such as wards, theatres or laboratories.

NOTE:

1. Operations such as isolating the circuit or removing a fuse could interrupt a mains signalling channel even when the power load that it supplied was not required.
2. BS 5378 covers aspects of safety signs and labels.

3.6 Similar notices should be displayed near to the point of connection, together with, if necessary, instructions for operating the equipment.

Safety instructions

3.7 All electrical safety precautions and standards should be available to all staff operating mains signalling equipment. In particular, the following information should be displayed on or adjacent to the equipment as specified in BS EN 50065:

"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."

NOTE: Refer to SHTM 2020; *Electrical safety code for low voltage systems (Escode – LV).*

4. Pre-delivery tests

4.1 Each major item of equipment should have been type tested and manufactured under an appropriate quality assurance procedure.

NOTE: It is recommended that equipment manufacturers are registered to BS EN ISO 9000, 'Quality Assurance'.

4.2 The type test results should be documented by certificates issued by an approved test house. Copies of these certificates should be submitted with the contractor's tender documentation.

4.3 Certificates relating to routine works tests are to be provided with each major item of electrical equipment and approved by the client's project manager before the items are installed.

NOTE: Further guidance on the information required at the different stages of the project is given in SHTM 2007; *Electrical services: supply and distribution* 'Validation and verification' and Scottish Hospital Technical Note 1, 'Post Commissioning Documentation for Health Buildings in Scotland'.

5. Installation and inspection

General

5.1 During installation work on the low-voltage network it is essential that due regard is given to the statutory requirements of the Electricity at Work Regulations 1989 and the guidance of SHTM 2020; *Electrical safety code for low voltage systems (Escode – LV).*

NOTE: All equipment delivered to site should be stored in a clean and dry environment.

5.2 Installations should also conform to BS 7671: 1992, 'Requirements for Electrical Installation', the IEE Wiring Regulations sixteenth edition (including all subsequent amendments).

5.3 In addition to normal good practice, special care should be taken to ensure that all signal coupling connections have the correct polarity.

NOTE: Connections to the wrong polarity will result in operation failure of the signalling system.

5.4 All necessary information should be provided to the installer concerning safe working conditions. This is particularly important for operating theatres, anaesthetising rooms, intensive care units and laboratories.

NOTE:

1. These are environments where vapours and gases may be present.
2. Refer to the relevant Health Building Note (HBN) and, Scottish Hospital Planning Note (SHPN) for further guidance on the requirements of special locations.

Pre-commissioning procedures

Test administration

5.5 The purpose of pre-commissioning tests is to ensure that all tests are carried out by the contractor before any system or equipment is handed over to the client.

NOTE: Further guidance on the information required at the different stages of the project is given in SHTM 2007; *Electrical services: supply and distribution* 'Validation and verification' and Scottish Hospital Technical Note 1, 'Post Commissioning Documentation for Health Buildings in Scotland'.

Test records of plant items

5.6 The original test records of all electrical equipment should be kept for future reference.

General inspection of equipment

5.7 Before the start of any pre-commissioning test, the equipment and its associated installation should be carefully inspected and checks made to ensure:

a. cleanliness and suitability of enclosure;

b. location, positioning, level and structural rigidity, and freedom from vibration;

c. that labels/numbers are correct to the approved contract drawing;

d. that there is adequate heating, ventilation and isolation from any adjacent heat source;

e. that provision is made for the cable entries and terminations;

f. that holding down bolts, clamps and cleats are connected;

g. that power and control cables are secured correctly;

h. that neatness of control wire looming is evident;

i. that all fuse links are of correct rating;

j. that all terminations are correctly numbered, permanently identified and correctly crimped;

k. that cable entries are secured against insect and vermin infestation;

l. that the electrical equipment is securely locked and materially secure from site theft or operational damage;

m. that an effective earth protective conductor is provided.

6. Commissioning and site testing

Commissioning

6.1 Commissioning of all mains signalling equipment and systems should be provided by the manufacturer/supplier. Results of measurements of the installed equipment, the actual settings of any adjustable components, the measured parameters of the operating frequency and amplitude of the transmitter and receiver signals, and the presence of disturbances within the operating frequency band should be recorded.

NOTE: The operating frequency band is specified in BS EN 50065.

6.2 The location and technical characteristics of any filters installed to limit the emission of the mains signals or to protect the signalling system from external disturbance should be carefully noted.

NOTE: If a filter has been installed to counter interference revealed during commissioning, the circumstances should be recorded.

6.3 Signals on the low-voltage network are usually attenuated (reduced in strength) by the losses in the conductors as well by the loading presented by the connected loads. Electromagnetic disturbances also occur on the mains. All of these effects are variable. As a result it cannot be assumed that reliable signalling at one time guarantees an equally good performance at all other times.

6.4 For these reasons the commissioning tests should be made with a test set or communications analyser that will enable the effect of changes in attenuation and signal strength to be simulated.

NOTE: The manufacturer/supplier should be advised of the load profiles of the building/site prior to making recommendations for changes in attenuation and signal strength.

6.5 Commissioning of equipment, as listed in the schedule of the contract document, must be accompanied by all the associated pre-commissioning data sheets. This should indicate full acceptance, or reservations in performance, by the engineer.

NOTE: The term “engineer” refers to the management’s technical representative in charge of the works or any person nominated to represent him/her.

Inspection of certificates

6.6 When the installation has reached practical completion in accordance with the contract, a handover certificate will be issued. This will certify the date on which the installation was taken over and the commencement of the maintenance/defects liability period.

Witnessing of tests

6.7 There should be a formal and contractual procedure arranged between the engineer and the contractor for all plant verification before acceptance can be agreed.

6.8 The verification should include a thorough inspection of the installation to assess the quality and accuracy of the work and to witness any tests specified in the contract. The engineer should witness all tests and inspections.

Retention

6.9 Minor defects or deficiencies relating to the work carried out by the contractor should be listed in the handover certificate and corrected as early as possible during the maintenance/liability period.

NOTE: Retention monies, as indicated in the contract document, should be paid at the end of the maintenance/liability period when all rectification of defects or deficiencies has been completed. This should also include items provided by nominated manufacturers/suppliers.

Wiring diagrams

6.10 Wiring diagrams, instruction manuals etc, should be given to the engineer supervising the work, preferably at the time of commissioning, but no later than at handover.

Contract requirements

6.11 All original forms of test record relate to the legal assurances as detailed in the contract document. Where a single level of performance is required, or interrelates to the overall reliability of the whole plant operation, the details of records required to ensure compliance should be negotiated with the contractor at the tender assessment stage.

NOTE: The "specification document" should give guidance and contain specific information on all final tests required. This should indicate the time required to validate the overall performance.

6.12 Due to the high cost of a rigorous verification programme, sufficient time should be identified within the project plan to allow for its execution.

NOTE:

1. Executive control and responsibility for achieving this should be effective.
2. Delays which can arise during the earlier phases of the construction programme must not be allowed to override this aspect of the contact.

Personnel

6.13 Good technical ability and integrity is required of staff carrying out the various test requirements. This should ensure that the results obtained are representative in establishing the effectiveness of the design and its operating provisions as stated or implied within the contract.

Witnessing of test documents

6.14 It is essential that the procedures for all tests have been agreed in advance between the engineer and the contractor. Any deviations should be fully recorded.

6.15 The document should be witnessed by both the engineer and the contractor. The time and date should be recorded and all observations noted.

6.16 If the results of a test do not conform to contract, they should be rejected, and a repeat or revised test demonstration negotiated.

Agreement to test

6.17 All the required commissioning tests should be conducted at the permanent installation. No equipment may be formally tested without the agreement and knowledge of the engineer.

6.18 Adequate safety precautions should be applied, as required by SHTM 2020; *Electrical safety code for low voltage systems (Escode – LV)* and any other relevant safety requirement. The following should be observed:

a. the tests should be carried out in accordance with normal good practice exercised in the electrical contracting industry;

b. all test equipment should be provided by the contractor, approved by the engineer and available on site for any planned test;

c. all instrumentation and metering should be accompanied by a recent test certificate of guaranteed accuracy;

d. all test results should be recorded on a mutually agreed test data sheet, and be dated and signed by the engineer and the contractor;

e. a register should be kept of names and signatures of all the engineer's and contractor's nominated representatives.

Operational management

7. General maintenance

7.1 Irrespective of the scale of operation, maintenance programmes are essential to ensure that all the electrical equipment is checked, inspected, tested, or replaced at the appropriate time. This will enhance the operational lifespan of the equipment.

7.2 Account should be taken of the dual function of mains signalling equipment, as an electronic system and as part of a communications network connected to the low voltage electricity mains.

7.3 All maintenance, testing and inspection of mains signalling equipment should be carried out in compliance with the requirements of the Electricity at Work Regulations 1989. This implies that only competent personnel have access to electrical equipment and systems.

7.4 Personnel working on mains signalling equipment should be fully aware of the operation and function of the signalling devices and also the implications of the interconnection of the signalling channel and the power distribution network.

7.5 Personnel whose work on the electrical power distribution system is not specifically related to mains signalling have to be aware that their actions may affect the signalling system.

NOTE: For example, changing the point from which a socket-outlet receives its supply could interrupt the function of mains signalling equipment. Starting or shutting down a stand-by generator could potentially affect the operation of the signalling process.

7.6 Although there are well-documented testing procedures and regulations, additional procedures may be introduced. Such procedures should take account of the need to check correct operation when the equipment would not otherwise be required to function, for instance, temperature control of heating systems during the summer.

NOTE: Refer to relevant British Standards in Chapter 11.

8. Maintenance procedures

General

8.1 The manufacturer/supplier of the mains signalling system should supply a full functional schedule with respect to the frequency of inspection of the equipment. The schedule will include full details to be followed by the range of staff responsible for the maintenance of the equipment.

System design

8.2 Where a system is complex and interacts with other electrical equipment, for example in energy management systems, a systematic maintenance programme should be provided in the design specification.

NOTE: Refer to SHTM 2005; *Building management system*.

Documentation

8.3 Full documentation for all staff categories should be supplied by the manufacturer/supplier of the mains signalling equipment. This should include details of on-site maintenance once the equipment is installed and made operational. The documentation should include full operating instructions giving specific information to enable the intended performance to be obtained. Systems diagrams should show the location of all components of the system and the staff required to carry out testing and maintenance.

8.4 Where appropriate and required, the manufacturer/supplier should provide demonstration of the equipment at the factory together with on-site training. Information on available training courses should also be provided.

Trouble-shooting

8.5 Should any equipment malfunction between maintenance periods, an investigation should be initiated immediately. Failure of the signalling system to transmit, receive or carry out control functions might render the total system inoperative.

8.6 The first thing to consider is whether the system has been installed and commissioned only recently and is under guarantee. If so, the manufacturer/ supplier should be contacted for advice and help.

NOTE: In a complex system, even when the commissioning has been conscientiously carried out, it may be impossible to exercise every possible combination of actions, or a previously undiscovered disturbance may be present.

8.7 If mains signalling equipment has operated satisfactorily for an appreciable time and then maloperates, circumstances surrounding the maloperation should be considered.

8.8 A maloperation may be a failure to operate when called upon to do so or, alternatively, it may be an unexpected and uncalled-for operation.

NOTE: Either case is covered by the requirement in paragraph 8.7 above that such an event should not give rise to a hazard to people or property.

8.9 Apart from the simplest systems, a mains signalling system is likely to incorporate sensors, transmitters, receivers, actuators and, possibly, logic controllers. A fault in any of these could cause maloperation of the mains signalling. Locating such a fault requires checking each component in the chain. If these components are found to be in order, other causes must be considered.

8.10 If the system consistently fails to operate, one should consider the possibility that an alteration to the mains wiring has caused the interruption or increased attenuation of the signal.

8.11 The mains distribution network wiring may give rise to neutral-to-earth connections that may not affect the operation of power equipment but can give rise to perturbations on the signalling system.

8.12 A possible cause of maloperation of mains signalling is electromagnetic interference (EMI), that is, interference caused by an unwanted signal. If there is an intermittent failure to operate, the installation of a new item of disturbance-causing apparatus may be responsible.

NOTE: Where EMI from a source outside the mains signalling system is suspected, reference may be made to SHTM 2014; *Abatement of electrical interference.*

8.13 Since the signals are coded it is unlikely that a source of disturbance other than a mains signal generator will cause unexpected operation. Such behaviour is more likely to be due to the reception of a valid signal either from another part of the same system or from a completely separate system using the same frequency and coding method. This case requires further investigation to see whether one or other signalling system should be modified or whether a decoupling filter would be appropriate.

Filters

8.14 The use of a filter to avoid interference between one mains signalling system and another may seem attractive. However, these devices are not without their disadvantages. They have to carry not only the signals but also the power component of the current, so that a current-carrying capacity of, say, 80 to 100 amperes may be required. This will add a significant expense. The filter not only has to attenuate the unwanted signal but must have sufficient impedance so as not to interfere with wanted signals on either side. This requires stringent requirements to be met over quite a wide frequency band.

9. Designated staff functions

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

9.2 **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.

9.3 **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.

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

9.5 **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.

9.6 **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)*).

9.7 **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).

9.8 **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).

10. 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.

$$Q = \frac{f_0}{\text{Band width}}$$

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

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