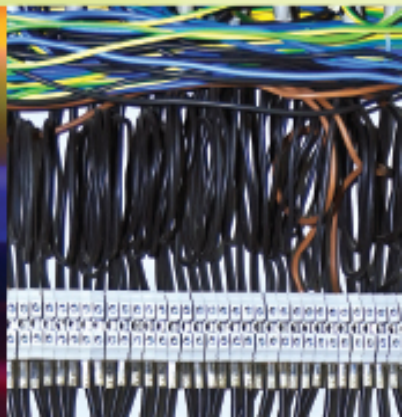
Bill Atkinson
Roger Lovegrove
Gary Gundry

Electrical Installation Designs

Fourth Edition

WILEY



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Chapter 14: Cables and Wiring Systems

Electrical Installation Designs

Fourth Edition

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About the Authors

Roger Lovegrove's extensive experience in the electrical contracting industry spans over 50 years. He served an apprenticeship, worked as an electrician and contracts engineer and then managed his own business for 18 years. Having left electrical contracting, he became a consultant specialising in inspecting, testing and surveying electrical installations. For a number of years he delivered lectures for ECA and IIE on various topics associated with *BS 7671*, the IEE Wiring Regulations. He is a Fellow of the IET and serves on the joint IET/BSI Wiring Regulations Committee. For many years an ECA member, he has served on the association's technical committee. Also, he has represented UK electrical contracting interests on International and European electrical installation standards working groups.

Gary Gundry is one of the UK's leading electrical safety trainers and presenters. Working at the Electrical Safety Council (ESC), he primarily produces technical guidance material for the electrical industry and safety literature for consumers. He also serves on one of the four committees responsible for the technical content of the Wiring Regulations (*BS 7671*); accordingly, he is able to speak authoritatively (to audiences of any number) on the requirements of the Seventeenth Edition of the Wiring Regulations.

Prior to working at the ESC, Gary was a Senior Engineer at NICEIC Training delivering bespoke training courses all over the United Kingdom, and before that he worked in the Standards division on, among other things, the NICEIC's Technical Manual.

Before joining the NICEIC in 1999, he was a Director and Qualified Supervisor of an electrical contracting business

enrolled as an NICEIC Approved Contractor.
Gary began his career as an apprentice with SEEBoard, and later joined Eastern Electricity.

Preface to the Fourth Edition

There are many books on electrical installation practice where the focus is on calculations and regulations. *Electrical Installation Designs* has been written from a different viewpoint. Typical projects are examined to produce designs that will fit current standards.

Most electrical contractors have an understanding of requirements related to their own regular everyday activities, where work is carried out using rule-of-thumb methods. Repetitive designs are used. Many installers claim that they are not designers and show concern that they are now required to certify the adequacy of an installation design.

In practice, problems only arise when an unusual project is undertaken or there is a change in regulations.

There is no harm in using a standardised design, rather in the way that an experienced cook uses a published recipe for a cake. *Electrical Installation Designs* is a book of recipes. The installer may select a design that corresponds as near as possible to the contract in hand and take up such technical and regulatory advice as is required. This will reduce the need for lengthy calculations and detailed study of *BS 7671*, *Requirements for Electrical Installations* (IET Wiring Regulations).

Most basic electrical installations may be completed by a competent person, with appropriate guidance to avoid serious problems and hazards.

Project chapters illustrate methods that could be used for particular types of installation ranging from a house to an industrial workshop. The ideas are by no means exclusive. Alternative solutions are always possible. In many instances carrying out detailed calculations and utilising different

circuitry will be more profitable. By their very nature, simplified examples of fictional projects can only produce generalised results.

The book contains special chapters on earthing, isolation and switching and overcurrent protection, which give a down to earth interpretation of the regulations.

Electrical installation students and non-electrical associates in the construction industry will appreciate the user-friendly approach. Nevertheless, this is not a do-it-yourself book for the untrained person. Warnings are therefore given where more specialised study is necessary. For example, readers are advised not to embark on installations in hazardous areas (such as petrol filling stations) without further training. Apart from moral implications and contractual risks, statutory requirements are such that incompetent work may carry criminal penalties.

Although the emphasis is on tried and tested methods, some new techniques are introduced. The most significant is the option for tree circuitry as an alternative to the ring final circuit. This is the first book to give designers the opportunity to compare the advantages of the tree system for both domestic and commercial installations. In recent years, consumer requirements have changed. It is essential that the industry keeps an open mind on changes in traditional wiring practice. Introduced in this fourth edition are new chapters on Residual Current Devices and, for those readers who require a basic understanding of circuit design, a chapter explaining the process for carrying out simple cable design calculations.

Amendments

The Institution of Electrical Engineers (IEE) joint wiring regulations committee amended *BS 7671*: *1992* (16th edition) in 1994, 1997 and 1999. In 2001, the standard was

renamed *BS 7671*: *2001* with further amendments, and minor amendments were made again in 2002.

In 2008, a complete review of the 16th edition saw the publication of the 17th edition: *BS 7671*: *2008*. The first amendment to the 17th edition was published in 2011 and came fully into force on 1 January 2012. This latest amendment also introduced the rebranded name of the IEE, namely the IET (Institution of Engineering and Technology). The most recent edition of *BS 7671* incorporates all alterations and additions to the European HD 384 series of standards.

As is often the case, many of the changes are of a minor nature in order to harmonise with other standards. However, significant changes were introduced in *BS 7671: 2008* (17th edition) with several other significant changes being introduced in its first amendment, in 2011. These are summarised in the following tables – Table A.1 summarises the changes introduced by *BS 7671*: *2008* (17th edition) and Table A.2 summarises the significant changes introduced by Amendment 1 to *BS 7671*: *2008*:

Table A.1 Summary of changes introduced by BS 7671: 2008 (17th edition).

BS 7671 reference	Subject	Summary of notable change/new content
General	Regulation numbering system	The 17th edition introduced the adoption of the IEC numbering system, in which the Regulation numbers are separated by a decimal point, rather than a hyphen as was previously the case.
Chapter 41	Protection against electric shock	Chapter was rewritten. Protection against direct contact – was replaced by basic protection. Protection against indirect contact – was replaced by fault protection. Introduction of term ‘Additional protection’. Socket-outlets with a rated current not exceeding 20 A and intended for general use by ordinary persons must be protected by 30 mA RCDs. Mobile equipment having a current rating of 32 A or less for use outdoors must also have 30 mA RCD protection.

BS 7671 reference	Subject	Summary of notable change/new content
Chapter 52	Selection and erection of wiring systems	For installations not under the supervision of a skilled or instructed person, such as domestic or similar installations, cables that are buried in a wall or partition at a depth of 50 mm or less and are not enclosed in earthed metallic covering (metallic armouring), earthed conduit, earthed trunking or have mechanical protection capable of resisting nails, screws or the like, are required to be protected by a 30 mA RCD as well as being installed in the so-called 'safe zones'. Similarly cables that are installed in metal framed walls require 30 mA RCD protection if not otherwise protected by earthed metallic covering, earthed conduit, earthed trunking or have mechanical protection capable of resisting nails, screws or the like, to be protected by a 30 mA RCD, unless the installation is under the control of skilled or instructed persons, such as office buildings and industrial premises.
Section 559	Luminaires and lighting	A new section applicable to all general lighting installations as appropriate to particular locations and structures. Requirements for fixed outdoor lighting, highway power supplies and street furniture are also included, which were previously in Part 6.
Part 6	Inspection and testing	Was previously Part 7.
Part 7	Special installations or locations	Was previously Part 6. 701 – Locations containing a bath or a shower. Zones 0, 1 and 2 as defined in the 16th edition were retained. Zone 3 was removed. All circuits supplying equipment in bathrooms and shower rooms are required to be protected by 30 mA RCDs. Supplementary bonding is no longer required, provided all of the following three conditions are met: • all final circuits of the location are protected by a 30 mA RCD; • all final circuits of the location meet the required disconnection times; • main bonding of services within the property is correctly installed.

BS 7671 reference	Subject	Summary of notable change/new content
		SELV (separated extra-low voltage) socket-outlets and shaver socket-outlets are permitted outside Zone 1 230 V socket-outlets are permitted, provided they are more than 3 metres horizontally from the boundary of zone 1. 708 – Electrical installations in caravan/camping parks and similar locations. Formerly caravans, motor caravans and caravan parks in the 16th edition.
		New Sections were added as follows: 709 – Marinas and similar locations; 711 – Exhibitions, shows and stands; 712 – Solar photovoltaic (PV) power supply systems; 717 – Mobile or transportable units; 721 – Electrical installations in caravans and motor caravans; 740 – Temporary electrical installations for structures, amusement devices and booths at fairgrounds, amusement parks and circuses.

Table A.2 Summary of changes introduced by Amendment 1 to BS 7671: 2008.

BS 7671 reference	Subject	Summary of notable change/new content
General	Regulation numbering system	In order to further implement changes to the requirements given in the International (IEC) and European (CENELEC) base documents, a number of the requirements contained in *BS 7671* are particular to the United Kingdom. Those Regulations are identified via a '10X' suffix. For example, *Regulation 522.6.100*.
General	References to ESQCR 2002	Amendments have been made throughout *BS 7671* to clarify the requirements of the *Electricity Safety, Quality and Continuity Regulations 2002* with regard to the suitability for use of Protective Multiple Earthing (PME).
Tables 41.2; 41.4; and 41.6	BS 88 fuses	Amended to reflect changes in product standards for cartridge fuses.
Table 41.5	Simplification of table	Scope of the table revised to cover only circuits at a nominal a.c. rms line-to-earth voltage (U_0) of 230 V.

BS 7671 reference	Subject	Summary of notable change/new content
Section 444	Measures against electromagnetic disturbances	New section added, *Measures against electromagnetic disturbances*.
514.10.1	Nominal voltages	Simplification of wording regarding enclosures within which nominal voltages exceeding 230 V to earth are present but may not be expected. Requirement relating to nominal voltage exceeding 230 V between simultaneously accessible enclosures has been deleted.
522.6.100	Cables in floor or ceiling voids	Clarification provided by adding indent relating to SELV and PELV circuits.
522.6.101	Cables in walls or partitions	Clarification provided by adding indent relating to SELV and PELV circuits.
522.6.103	Cables in partitions having metallic parts	Clarification provided by adding indent relating to SELV and PELV circuits.
526.3	Connections	Maintenance-free accessories complying with *BS 5733* recognised as an option for not needing to be accessible for inspection and maintenance.
Section 534	Surge protection devices	New section added, *Devices for protection against overvoltage*.
Section 710	Medical locations	New section added, *Medical locations*.
Section 729	Operating and maintenance gangways	New section added, *Operating and maintenance gangways*.
Appendix 4	Current-carrying capacity and voltage drop for cables	New clauses added: 5.5, *Rating factors for triple harmonic currents in four-core and five-core cables with four cores carrying current* and 5.6 *Harmonic currents in line conductors*. (New clauses based on text that was previously in Appendix 11).
		New clause added: 6.4, *Voltage drop in consumers' installations*. (Text was previously in Appendix 12).

BS 7671 reference	Subject	Summary of notable change/new content
Appendix 6	Model forms for certification and reporting	Introduction of Electrical Installation Condition Report to replace Periodic Inspection Report. New Schedule added: *Condition report inspection schedule for domestic and similar premises with up to 100 A supply*. New item added for other types of installation: *Examples of items requiring inspection for an electrical installation condition report*.
Appendix 16	Protection against overvoltage	New Appendix added: *Devices for protection against overvoltage*.

This book takes account of all amendments published since the 17th edition of the Wiring Regulations was first issued in 2008, including those introduced by Amendment 1, which was first issued in 2011 and which came into effect on 1 January 2012.

Roger Lovegrove and Gary Gundry

Acknowledgements

Gary Gundry would like to thank Roger Lovegrove for the opportunity to update this publication and for his encouragement and support during the reviewing and commenting stage of the project.

Gary would also like to thank his employer, The Electrical Safety Council (ESC), for granting permission to update this publication, and for allowing him to reproduce any copyright material, where applicable. In recognition of this, and as a gesture of good faith, he has requested his share of the royalties be sent directly to the Electrical and Electronics Industries Benevolent Association (EEIBA), for as long as he remains employed at the ESC. The EEIBA is a charity dedicated to helping those in hardship and distress who work or have worked in the Electrical and Electronics Industry.

Special thanks goes to Peter, Liz, Laura and their colleagues at Wiley for the book design concept and typesetting, and to the Institution of Engineering and Technology for its permission to reproduce some of the model certificates and associated forms shown in Appendix 6 of the Seventeenth Edition of the IET Wiring Regulations.

Gary would also like to express thanks to his mentors and family for their endless patience, support and encouragement along the way.

Finally, any views expressed within this publication are those of the authors' so they should not be associated with their employers, where applicable.

1

Introduction

This book contains designs for electrical installations that have been prepared with reference to the Wiring Regulations and includes interpretations of particular technicalities.

This is not a do-it-yourself book for the amateur or untrained person. It is a guidance manual for competent electrical designers and students of installation practice.

As far as possible, all information accords with the requirements of *BS 7671*: *2008*, incorporating Amendment 1, 2011 *Requirements for Electrical Installations*, the IET Wiring Regulations (17th edition), which is issued jointly by the British Standards Institution (BSI) and the Institution of Engineering and Technology (IET) as *BS 7671*. Relevant Regulation numbers and other references are shown in the margins. (Because of the space restrictions, the following abbreviations have been used: Ch. – Chapter; Sec. – Section; Defs – Definitions; App. – Appendix.) Reference is also made to various other British and European Standards and related Health and Safety documentation.

1.1 Layout of Chapters

Interspersed throughout the book are two types of chapters, giving information in different formats.

1. *Project chapters*: These may be compared with a selection of recipes for an experienced chef. The recipes give ideas for the design of typical electrical installations. Each project is dealt with on a stand-alone basis. Cross-references between these chapters are avoided,

wherever possible, and similar information may be found for more than one scheme.

2. *Topic chapters*: These supplement the project chapters with in-depth discussion of generalised technicalities. They also provide study information on regulatory subjects. It may be necessary to refer to these details to finalise a design with particular problems.

1.2 Wiring Regulations

Throughout this book the terms Wiring Regulations (or Regulations) refer to *BS 7671*:*2008 Requirements for Electrical Installations*, the IET Wiring Regulations, issued jointly by the BSI and the IET. The Standard therefore represents a code of acceptable safety for electrical installations to protect:

131.1

- persons;
- property; and
- livestock.

against electrical hazards, which are described as:

- electric shock;
- fire;
- burns;
- ignition of a potentially explosive atmosphere;
- undervoltages, overvoltages and electromagnetic effects;
- injury from mechanical movement of electrically actuated machinery;
- power supply interruptions or interruptions of safety services; and
- arcing or burning, excessive pressure or toxic gases.

114.1