ENGINEERING DESIGN STANDARD

EDS 08-2000

LV NETWORK DESIGN

Network(s): EPN, LPN, SPN

Summary: This standard provides guidelines for the design and development of the low voltage (LV) distribution networks to ensure they are safe, efficient and have regard for the environment.

Author: John Mason **Date:** 15/10/2025

Approved By: Paul Williams **Approved Date:** 17/10/2025

This document forms part of the Company's Integrated Business System and its requirements are mandatory throughout UK Power Networks. Departure from these requirements may only be taken with the written approval of the Director of Asset Management. If you have any queries about this document please contact the author or owner of the current issue.

Applicable To:

UK Power Networks

☒	Asset Management	☐	Information Systems
☐	Capital Programme	☐	Innovation
☒	Connections	☐	Legal
☐	Customer Services	☒	Network Operations
☐	DSO	☐	Procurement
☐	Finance / Income Management	☐	Strategy & Regulation
☐	Health & Safety	☒	Technical Training

External

☒	G81 Website	☒	Contractors
☒	ICPs/IDNOs	☐	Meter Operators

Revision Record

Version	6.0	Review Date	15/10/2030
Date	15/10/2025	Author	John Mason

Reason for update: Business feedback and alignment with other standards.

What has changed:

- Section 1 guidance on the application of this standard updated.
- Section 4.1 DCODE references corrected.
- Section 5.2 split-phase/two-phase note removed.
- Section 5.4 note added to clarify maximum (cumulative) volt drop for mains and services.
- Section 5.5 restructured and footnote added to clarify reduced EFLI values for new networks.
- Section 6.3.2 amended to consider impact on existing mains and services.
- Section 7.2.3 note amended to clarify reference to underground mains only.
- Section 7.4.1 revised to clarify additional earth electrode requirements (Figure 7-7).
- Section 7.5.1 reference to 1:500 drawing added as a document to include cable ID method.
- Section 7.5.2 revised to clarify burial depths and cable routes.
- Section 7.6 revised to include bunched phase and redundant conductors.
- Section 7.9.2 amended to illustrate un-energised spare ways (Figure 7-14).
- Section 7.10 amended to clarify fuse selection for new networks.
- Document reviewed.

Version	5.0	Review Date	06/08/2029
Date	06/08/2024	Author	John Mason

Reason for update: Document rewritten to provide further clarity, incorporate the requirements of EBB 08-0065 and align with updates to other LV design standards.

What has changed:

- Section 1 revised to include additional requirements (DCODE, OfGEM etc.) and provide guidance on the application of the standard.
- Section 3 revised and updated to include new abbreviations.
- Section 4 introduced to capture the statutory, industry, environmental and legal requirements.
- Section 5 revised to provide context to the section and include the latest EFLI/PSCC guidance.
- Section 6 introduced to provide guidance on network design, modelling tools and legacy networks.
- Section 6.2.1.1 includes the latest ADMD data from the Neighbourhood Green innovation project.
- Section 6.2.2 requirement added to assess load balance for alterations to existing networks.
- Section 7 introduced to cover cable & equipment requirements and include all relevant content from EBB 08-0065.
- Section 7.2 construction and connection to mains added from EBB 08-0065. Figure 7-3 added to include the requirement for a 185mm^2 main for overhead to underground diversions.
- Section 7.3 construction and connection of services added from EBB 08-0065.
- Section 7.4 earthing requirements added from EBB 08-0065. Figure 7-7 amended to include the requirement for an additional earth electrode at each LV overhead line cable termination.
- Section 7.5 revised to include cable identification (in accordance with DSR 01 018) and provide further guidance on the installation of cables and cable ducts.
- Section 7.6 revised to consolidate the bunching of phase and neutral conductors guidance.
- Section 7.7 revised to provide further guidance on fifth core and switched wire supplies.
- Section 7.8 revised to clarify the configuration of any link box spare way.
- Section 7.9 amended to include the requirement to consider available capacity from adjacent networks prior to the design of a new substation and refer to EDS 08-3000 for the maximum customers per substation.
- Section 7.9.2 substation spare way guidance amended and Figure 7-14 introduced.
- Section 7.10 added to provide guidance on the selection and assessment of fuses including the use of fuses in link boxes and PC400s.
- Section 8 introduced to capture connection arrangements (including reference to the relevant connection standards) and disconnection requirements.
- Section 9 introduced to capture asset replacement requirements.
- Appendix A tong test form removed.
- Document reviewed.

Version	4.3	Review Date	06/11/2028
Date	06/11/2023	Author	Stephen Tucker

Reason for update: New guidance on mains cable sizes and earthing.

What has changed:

- Section 6.5 new mains cable sizes content replaced with reference to EBB 08-0065.
- Section 6.11 earthing content replaced with reference to EBB 08-0065.
- Section 7.1 existing mains cable sizes content replaced with reference to EBB 08-0065.
- Section 10 reference to EBB 08-0065 added.

Version	4.2	Review Date	18/09/2028
Date	18/09/2023	Author	Stephen Tucker

Reason for update: References updated.

What has changed:

- Section 5 & 10 reference to EDS 08-4100 removed.
- Section 7.6 & 10 reference to EDS 07-0009 removed and replaced with material code.
- Section 6.4.7 London interconnected references updated to EDS 08-2001.

Version	4.1	Review Date	15/06/2025
Date	13/07/2020	Author	Stephen Tucker

Reason for update: Correction.

What has changed: Section 8 218-277kVA supplies standard cut-out size changed to 600A to align with EDS 08-2100.

Version	4.0	Review Date	15/06/2025
Date	15/06/2020	Author	Stephen Tucker

Reason for update: Periodic review to ensure alignment with current industry practice and other UK Power Networks design standards.

What has changed:

- Section 1 introduction revised to include losses.
- Section 1 reference to ENA EREC P5 included as the minimum design.
- Section 4.5 & 6.8 earth fault loop impedance values for substation supplies added to Table 4-3 & Table 6 1.
- Section 5 Table 5 1 aligned to EDS 08-2100.
- Section 6.2 energisation of spare LV ways clarified.
- Section 6.5 & 7.1 minimum cable sizes clarified.
- Section 6.6 installation and running arrangements of link boxes added.
- Section 6.9 padmount transformer cable restriction removed.
- Section 6.10 new LV network requirement clarified.
- Section 7.1 reference to the like-for-like replacement of link boxes included.
- Section 8.2 reference to EV requirements added.
- Section 8.3 legal consents streamlined.
- Appendix A tong test form amended.

Version	3.0	Review Date	20/12/2022
Date	13/11/2017	Author	Stephen Cuddihey

Reason for change: Re-alignment of LV design standards.

What has changed:

- Section 5 standard supply sizes for customer loads from EDS 08-2100 added.
- Section 7.7 fifth core added.
- Tong test form added.
- Document renumbered from EDS 08-0136 to EDS 08-2000.

Version	2.0	**Review Date**	01/06/2018
Date	09/03/2015	**Author**	Stephen Cuddihey
Reason for change: Periodic review and the opportunity to clarify some requirements of the standard and provide guidance on common issues. **What has changed:** • Structure has been revised and brought in line with the supporting LV standards. • Section 6.5 & 7.1 the impact of losses on network design has been considered. • Section 5 supply characteristics for LV are included. • Section 7.6 guidance on bunched phase and neutral cables is included. • Section 10.1 typical ADMDs are included.			
Version	1.0	**Review Date**	15/09/2011
Date	11/01/2011	**Author**	Ron Cordwell
First Issue. NBC_11_0005.			

Contents

Tables

Figures

1 Introduction

This standard provides the guidelines for the design and development of the low voltage (LV) distribution networks to ensure they are safe, efficient and have regard for the environment.

The network design requirements detailed in this standard are based on:

- General requirements (Section 4).
- The Distribution Code (DCODE)[1] requirements, in particular to:
    - Permit the development, maintenance, and operation of an efficient, coordinated, and economical system for the distribution of electricity.
    - Facilitate competition in electricity generation and supply.
    - Discharge the obligations on Distribution Network Operators (DNOs) from their licence conditions and other European regulations.
- The quality of supply performance targets for customer interruptions (CI) and customer minutes lost (CML) agreed with the Office of Gas and Electricity Markets (OfGEM) to improve the reliability and availability of the network.
- Licence Condition obligations[2] to ensure that losses on our distribution networks are kept as low as reasonably practicable. Opportunities exist when selecting distribution transformers, sizing conductors, designing, maintaining, and operating the network that can assist in the management of losses. Losses are cumulative year after year. Therefore, incorporating loss-inclusive design where the whole life-cycle cost of an asset is included into our processes, provides significant benefits to consumers, society and the environment.

As a minimum the LV distribution networks in all three regions shall be designed in accordance with the guidelines detailed in ENA EREC P5.

How to apply this standard...

Section 5 sets out the supply characteristics for LV distribution networks. Section 6 provides guidance on the LV network design approach including design requirements, modelling tools, and legacy networks. Section 7 details the cable and equipment requirements for the construction of the new LV network design. Refer to Section 8 for connection arrangements and Section 9 for asset replacement.

There are instances in this document where referral to Network Planning is advised. In the first instance this should be a review of the design proposal with the local Network Planning Engineer or Lead Network Planning Engineer and if further approval/authorisation is required it should be referred to the Network Planning Manager.

Where the term **shall** is used in this standard the requirement is mandatory and the term **should** is used to express a recommendation due to consideration of cost, time and effort.

[1] DCODE contains technical requirements relating to the connection to and use of electricity distribution systems, for existing and potential users. It sets out the procedures and principles that govern the DNO's relationship with all users of the distribution system.
[2] Condition 49. Electricity Distribution Losses Management Obligation and Distribution Losses Strategy.

2 Scope

This standard applies to the EPN, LPN and SPN distribution networks operating at low voltage i.e. 400/230V ac three-phase, 460/230V ac split-phase and 230V ac single-phase – 4 wire, 3 wire and 2 wire systems.

This standard is designed to be applied in conjunction with the relevant LV connection standard:

- EDS 08-1103 for supplies to multi-occupied buildings.
- EDS 08-2100 for supplies above 100A (69kVA).
- EDS 08-2101 for supplies up to 100A (69kVA).
- EDS 08-2102 for unmetered supplies (including street-lights and street furniture).
- EDS 08-5050 for supplies to electric vehicle chargers.

This standard does not apply to IDNO LV network design or connections, refer to EDS 08-1101.

3 Glossary and Abbreviations

Term	Definition
ABC	Aerial Bundled Conductor
ACB	Air Circuit Breaker
ADMD	After Diversity Maximum Demand
AONB	Area of Outstanding Natural Beauty
APA	Archaeological Priority Areas
CI	Customer Interruption. Refer to EDS 08-3000 for further details
CML	Customer Minute Lost. Refer to EDS 08-3000 for further details
CNE	Combined Neutral Earth
DCODE	The Distribution Code of licensed distribution network operators of Great Britain
DEFRA	Department for Environment, Food and Rural Affairs
DNO	Distribution Network Operator
DPlan	Distribution Planning. AmberTree HV and LV network modelling software
EFLI	Earth Fault Loop Impedance. The impedance of the earth fault current loop starting and ending at the point of earth fault
ESQCR	Electricity Safety, Quality and Continuity Regulations 2002
EVCP	Electric Vehicle Charging Point
Geospatial Analytics	UK Power Networks Geographical Information System (GIS)
GRP	Glass Reinforced Plastic
HV	High Voltage. Any voltage exceeding LV (as defined by The Electricity Safety Quality and Continuity Regulations 2002). In the context of this document, HV refers to 20kV, 11kV, 6.6kV, 3kV and 2kV
IDNO	Independent Distribution Network Operator
LV	Low Voltage. ‘A voltage exceeding 50V (rms) measured between phases (or phase to earth) but not exceeding 1000V phase to phase or 600V phase to earth’ (as defined by The Electricity Safety Quality and Continuity Regulations 2002)
MAGiC	Multi-Agency Geographic Information for the Countryside
Main	A low voltage underground cable or overhead line which connects a substation to either a pot-end earth, an overhead LV earth or to another substation
MDI	Maximum Demand Indicator. The peak load condition of a network demand
MSDB	Multi-Service Distribution Board
NetMap	UK Power Networks Geographical Information System (GIS)
OfGEM	Office of Gas and Electricity Markets
PME	Protective Multiple Earthing. A form of TN-C-S earthing. Refer to EDS 06-0017 for further information.
PME Enabled Networks (from ENA EREC G12)	A hybrid network where neutral-earth bonds are installed in accordance with the ESQCR. PME enabled networks enable a connected service to offer a PME earth terminal. PME enabled networks enable the retention of earths from SNE cables at service connections provided they meet the relevant criteria

Term	Definition
PNB	Protective Neutral Bonding. PNB is similar to PME except the neutral conductor is only earthed at one point which is usually located closer to the customer than the transformer and often connected at cut-out
Pot-end	A protective cover fixed over the end of a cable, to provide mechanical protection and prevent the ingress of water. Pot-ends are constructed from heat-shrink, resin or other, similar approved jointing materials and can be used on live or dead cables
PQ	Coefficients used in DPlan and WinDEBUT software calculations
PSCC	Prospective Short Circuit Current. The current that would flow in a circuit, in the event of a short circuit of negligible impedance. It is measured as the RMS (root mean square) value of the ac component. The actual fault current will therefore be less if the protective device has a current limiting feature or appreciable impedance
SAC	Special Areas of Conservation
Secondary Substation	A substation with an operating voltage of 20kV, 11kV, 6.6kV, 3kV or 2kV and may include transformation to 400V. Also termed 'Distribution Substation'
Service	A low voltage underground cable or overhead line, which connects a customer to a main or directly to a substation
SPA	Special Protection Areas
SSSI	Sites of Special Scientific Interest
SNE	Separate Neutral Earth
SPZ	Source Protection Zones
Supply Terminals	Outgoing terminals of the cut-out, LV way or ACB which forms the ownership boundary with the customer
TT	Terre Terre. A system in which earth function is provided by a local earth electrode provided by the customer. A DNO earth terminal is not provided at the customer's installation
WinDEBUT	EA Technology LV network modelling software
UK Power Networks	UK Power Networks consists of three electricity distribution networks: • Eastern Power Networks plc (EPN). • London Power Network plc (LPN). • South Eastern Power Networks plc (SPN).

4 General Requirements

4.1 Statutory Requirements

Distribution networks shall be designed with due regard to the statutory regulations detailed below:

- Electricity Act 1989 (Section 9).
- Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002.
- Health & Safety at Work Act 1974.
- Construction (Design and Management) Regulations 2015.

Distribution networks shall comply with the requirements of the Distribution Licence Conditions for each area within UK Power Networks, specifically:

- Condition 21 (compliance with DCODE).
- Condition 24 (distribution system planning standard and quality of service).
- The level of performance required by the Overall and Guaranteed standards agreed with OfGEM.

4.2 Industry Requirements

The following ENA engineering recommendations form the basis of network design:

- ENA EREC P5 – Design methods for LV underground networks for new housing developments.
- ENA EREC P23 – Guidance on Earth Fault Loop Impedance at Customers' Intake Supply Terminals.
- ENA EREC P25 – The short-circuit characteristics of single-phase and three-phase low voltage distribution networks.
- ENA EREC P28 – Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom.
- ENA EREC P29 – Planning limits for voltage unbalance in the UK for 132kV and below.
- ENA EREC G5 – Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom.
- ENA EREC G98 – Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019.
- ENA EREC G99 – Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019.

4.3 Environmental Requirements

All network design work shall be carried out with due regard to the environment in accordance with Schedule 9 of the Electricity Act 1989 and the following shall be considered:

- Landscape, habitats and wildlife.
- Archaeology and heritage.
- Rivers, watercourses and flood plains.
- Pollution prevention (water or land).
- Waste management.
- Noise, dust and odour.
- Ground contamination.

The environmental designations and requirements of Historic England, Natural England and the Environment Agency shall also be considered including:

- Areas of Outstanding Natural Beauty (AONB).
- Sites of Special Scientific Interest (SSSI).
- Special Areas of Conservation (SAC).
- Special Protection Areas (SPA).
- Ramsar sites (wetlands of international importance).
- Scheduled monuments and listed buildings.
- Archaeological Priority Areas (APA).
- Source Protection Zones (SPZ).

Designated sites are shown on internal mapping systems such as NetMap and Geospatial Analytics. The DEFRA website MAGiC (Multi-Agency Geographic Information for the Countryside) provides authoritative geographic information from across government and can be accessed in the public domain.

For further guidance, refer to the MAGiC Help Library and/or the suite of HSS environmental documents.

Failure to identify protected species or designated sites, or to comply with legal requirements may lead to offences that could result in prosecution.

4.4 Legal Requirements

4.4.1 Consents

Consents shall be acquired in accordance with AST 05 002 Property & Consent Acquisition Policy, any termination received on the network should be referred to the Property & Consent Department in the first instance.

4.4.2 Network Records

LV distribution networks and connections shall be recorded in NetMap. For guidance on the recording of LV networks, refer to EOS 09-0100.

5 Supply Characteristics

5.1 Overview

This section details the typical supply characteristics of LV distribution networks in the UK and includes the UK Power Networks requirements for all new LV distribution networks.

Particular reference shall be given to the characteristics that require compliance with the statutory (Section 4.1) and industry (Section 4.2) requirements.

5.2 Number of Phases

Typically, LV distribution networks are three-phase, but split-phase (or two-phase) systems may be encountered. For all new LV distribution networks:

- Mains shall be three-phase.
- Services shall be single-phase or three-phase as required.

5.3 Frequency

All LV distribution networks and services operate within 49.5Hz and 50.5Hz.

5.4 Voltage

The ESQCR statutory voltage limits for LV distribution networks are shown in Table 5-1.

New LV distribution networks (i.e. new radial networks or extensions to existing networks) shall be designed such that the voltage at the supply terminals is within the ESQCR statutory limits detailed in Table 5-1.

Note: Under normal running arrangements, the maximum (cumulative) volt drop of mains and services **shall not** exceed 6% of the declared voltage.

To ensure compliance with ESQCR, the voltage of a new LV distribution network shall be assessed using the network modelling tools detailed in Section 6.3.

Table 5-1 – ESQCR Statutory Voltage Limits

Supply	-6% Voltage Limit	Declared Voltage	+10% Voltage Limit
Single-phase	216	230	253
Three-phase	376	400	440
Split Phase	433	460	506

5.5 Earth Fault Loop Impedance (EFLI)

5.5.1 Existing LV Distribution Networks

Typical EFLI values encountered on existing LV distribution networks are shown in Table 5-2. These values may have been exceeded in some situations due to the design of the network and the higher value shall be declared to the customer.

For guidance on resolving existing EFLI issues, refer to ECS 06-0026.

Table 5-2 – ENA EREC P23 Typical EFLI Values for Existing LV Distribution Networks

Service	Earthing	EFLI
Up to 100A Single-phase	PME/PNB Earth Terminal	0.35Ω
	Cable Sheath/Continuous Earth Wire Earth Terminal	0.8Ω
Up to 200A Three-phase	PME/PNB Earth Terminal	0.35Ω
	Cable Sheath/Continuous Earth Wire Earth Terminal	0.8Ω
200 to 300A Three-phase	PME/PNB Earth Terminal	0.2Ω
	Cable Sheath/Continuous Earth Wire Earth Terminal	
Exceeding 300A Three-phase	PME/PNB Earth Terminal	0.15Ω
	Cable Sheath/Continuous Earth Wire Earth Terminal	
Direct from Substation	All	0.05Ω

5.5.2 New LV Distribution Networks

New LV distribution networks (i.e. new radial networks or extensions to existing networks) shall be designed such that the EFLI at the supply terminals does not exceed the values detailed in Table 5-3.

To ensure compliance, the EFLI of a new LV distribution network shall be assessed using the network modelling tools detailed in Section 6.3.

Table 5-3 – EFLI Values for New LV Distribution Networks

Service	Earth Fault Loop Impedance at the Supply Terminals	
	New Radial Networks[3]	Extensions to Existing Networks
Up to 100A Single-phase	0.25Ω	0.35Ω
Up to 200A Three-phase	0.25Ω	0.35Ω
200-300A Three-phase	0.2Ω	0.2Ω
Exceeding 300A Three-phase	0.15Ω	0.15Ω
Direct from Substation	0.02Ω	

[3] The reduced values of EFLI for new radial networks were introduced in 2011 to limit the degree of flicker caused by high instantaneous loads.

5.6 Fault Current

The declared fault current, or maximum prospective short circuit current (PSCC), for LV distribution networks is shown in Table 5-4 and Table 5-5.

For new LV radial distribution networks (i.e. new radial networks or extensions to existing networks), the fault current at the supply terminals shall **not** exceed the ENA EREC P25 PSCC values detailed in Table 5-4.

Table 5-4 – ENA EREC P25 PSCC Values

Supply Arrangement	Service	Radial Networks
Service from Passing LV Main	25A Single-phase	19.6kA
	100A Single-phase	19.6kA
	100A Three-phase	25.9kA
	200A Three-phase	25.9kA
	400A Three-phase	25.9kA
Direct from Network Substation	400A Three-phase	25.9kA
	600A Three-phase	25.9kA
	800A Three-phase	25.9kA
	1600A Three-phase	25.9kA
	2500A Three-phase	25.9kA

For new LV interconnected distribution networks (i.e. new networks that are interconnected by the parallelling of distribution substations), the fault current at the supply terminals shall **not** exceed the LV interconnected PSCC values detailed in Table 5-5.

Table 5-5 – LV Interconnected PSCC Values[4]

Supply Arrangement	Service	Interconnected Networks
Service from Passing LV Main	25A Single-phase	19.6kA
	100A Single-phase	19.6kA
	100A Three-phase	25.9kA
	200A Three-phase	34kA
	400A Three-phase	40kA
Direct from Network Substation	400A Three-phase	46kA
	600A Three-phase	46kA
	800A Three-phase	46kA
	1600A Three-phase	46kA
	2500A Three-phase	n/a

[4] The LV interconnected PSCC values are based on the parallelling of 2 x 1MVA transformers with a 5m service cable length.

6 Network Design

6.1 Overview

This section details the design approach for all new LV networks (including modifications to existing networks) and provides guidance on legacy networks. The design requirements and modelling tools shall be used to form the starting point of any new LV network design where the principle of underground mains and services in accordance with Section 7 shall apply.

Where additions or alterations are to be made to an existing network that does not comply with this standard, the opportunity should be taken to make the network compliant so far as is reasonable. In all cases, any changes should not increase the existing non-compliance or result in new non-compliance.

6.2 Design Requirements

6.2.1 Load Assessment

Typically, there are two design approaches used within the UK to determine the demand for the design of LV Networks, these are the ADMD and the PQ methods which are described in this section.

Note: It is the designer's responsibility to establish the most suitable method for a given scenario.

6.2.1.1 ADMD Method

The after diversity maximum demand (ADMD) method uses the concept of the coincidence of load between multiple users connected to the same main/transformer and was originally developed in the 1950s. The original dataset is a method dataset and was formulated from extensive site measurements.

This method has its limitations for multiple ADMD profiles connected to a common main and/or transformer where the time of peak loads do not coincide; for example, gas-heated housing and electrically heated flats (with off-peak tariffs i.e., E7). This method is a relatively simple linear forecast method and does not consider reduced diversity among small groups of connected customers.

The UK Power Networks Neighbourhood Green[5] innovation project, carried out during 2023/24, produced a revised ADMD dataset for properties with gas heating or a heat pump. A summary of the data is included in Table 6-1.

Note: ADMD values are intended to be applied to a transformer supplying an LV network or a main which forms part of an LV network and are not suitable for estimating individual customer maximum demand. BS 7671 and the associated guidance documents provide detailed guidance on calculating customer maximum demand.

[5] The Neighbourhood Green innovation project explored the future of normal domestic loads for future heating technologies and the resulting after diversity maximum demand (ADMD). A summary is available from https://innovation.ukpowernetworks.co.uk/projects/neighbourhood-green.

Table 6-1 – ADMD (source Neighbourhood Green Innovation Project)

Application	**Gas Heating (kVA)**				**Heat Pump (kVA)**			
No. of Properties	5	10	20	50+	5	10	20	50+
1-2 Bedrooms	1.35	1.11	0.95	0.82	2.66	2.36	2.16	2.05
3 Bedrooms	1.67	1.38	1.19	1.05	3.34	2.97	2.76	2.61
>3 Bedrooms	2.33	1.97	1.76	1.58	4.24	3.80	3.56	3.38

6.2.1.2 PQ Method

The PQ method originates from the 1970/80s and is a more complex method utilising statistical data for groups of customers. Pre-determined design coefficients ‘P’ and ‘Q’ are used to calculate the demand profile across 30-minute segments based on statistical distribution to give a load curve. A detailed explanation of this method is provided in ENA EREC P5.

6.2.2 Load Balance

For new LV networks, services shall be equally distributed across all phases to avoid the overload of a single-phase, reduce network losses and minimise neutral voltage rise in the event of a broken neutral.

For alterations to existing LV networks, an assessment may be required to establish the load balance of the existing network to ensure that the new connections maintain or improve load balance. Where required, load data can be accessed via:

- Data logging at the local secondary substation.
- MDI readings at the LV board.
- Service record cards (available from NetMap).

Where legacy single-phase or two-phase SNE cable networks are to be replaced with a modern three-phase CNE cable, particular care should be taken to balance load.

6.2.3 Power Quality

The power quality of LV distribution networks is directly impacted by the connection of disturbing loads often associated with low carbon technology industrial and commercial networks. Examples of disturbing loads include:

- Electric vehicles.
- Heat pumps.
- Electric motors.
- Variable speed drives.
- Welding equipment.
- Kilns and compressors.
- Embedded generation.
- Non-linear equipment.

For new LV networks (i.e. new networks or extensions to existing networks), the connection of disturbing loads shall comply with:

- ENA EREC P28 for voltage fluctuation.
- ENA EREC P29 for voltage unbalance.
- ENA EREC G5 for harmonics.

For further guidance on the connection of disturbing loads, refer to EDS 08-1901.

The addition of some low carbon loads (EVCPs and heat pumps) are notifiable to UK Power Networks by the installer in accordance with EDS 08-5050.

6.3 Modelling Tools

6.3.1 Overview

UK Power Networks uses the DPlan modelling tool which uses the PQ method. DPlan utilises actual kWh data and Elexon load profiles provided by electricity suppliers. EA Technology's WinDEBUT software is another PQ modelling tool and is the modern iteration of the DEBUT (Demand Estimation Based on Units and Time) software developed by the electricity council in the 1970/80s. This method uses standard demand curves and kWh data for different load profiles derived from various sources including ENA EREC P5, the Low Carbon London project and more recently has been updated with some Low Carbon Technology and generation profiles

All new LV networks and extensions to existing LV networks shall be designed using either DPlan or WinDEBUT and include the assessments detailed in Section 6.3.2.

Note: Connections designed in accordance with CON 08 120 using the small service self-service procedure are excluded.

6.3.2 Assessments

The following assessments shall be carried out using either DPlan or WinDebut (and any other supporting data/tools as required):

- Thermal assessment.
- Voltage drop (Section 5.4).
- Earth fault loop impedance (Section 5.5).
- Voltage dip associated with disturbing loads (Section 6.2.3).
- Fuse size (Section 7.10).
- Voltage rise associated with generation (ENA EREC G98/G99).

When assessing network extensions and new connections, consideration shall be given to the existing network mains and services to ensure that:

- Existing network mains and services, **compliant with this standard**, remain compliant.
- Existing network mains and services, **that do not comply with this standard**, are maintained (or improved where practicable).

Where required, network reinforcement or mains replacement shall be undertaken before (or at the time of) connection work, to prevent quality of supply issues relating to volt drop and/or earth loop impedance.

6.4 Legacy Networks

Various legacy LV underground systems may be encountered across the UK Power Networks distribution areas. These are as a result of previous practise and, unless agreed with Network Planning, shall **not** be extended or used for the design of new networks (except within the London interconnected network, refer to Section 6.4.8).

A summary of the legacy networks is included in this section together with actions that shall be taken should an opportunity arise.

6.4.1 Bunching of Phase and Neutral Conductors

The bunching of phase and neutral conductors was carried out in rural areas to resolve loop impedance issues on long low-voltage circuits. Where works are undertaken on networks with bunched phase and neutral conductors, the opportunity should be taken to reconfigure the network and remove the bunched conductors.

For further guidance on bunched conductors, refer to Section 7.6.

6.4.2 Fifth Core and Switched Wire Supplies

Legacy streetlights are often supplied by a dedicated lighting or 'fifth core' network controlled by a time switch at the local substation or LV pillar. Where work is required on this network, the opportunity shall be taken to remove any time switch and provide a direct supply to the existing fifth core within the passing LV main.

Note: The local authority shall be contacted to ensure all lighting columns are equipped with photocell technology.

For further guidance on fifth core and switched wire supplies, refer to Section 7.7.

6.4.3 Two-phase Cables Connected to a Normal Three-phase Network

This type of network creates a continuous neutral return current thereby increasing the volt drop both on the three-core cable and the upstream four-core cable where an out of balance persists. Where diversion, replacement or reinforcement of a two-phase cable is required, the opportunity should be taken to extend the network as three-phase where practicable.

Where it is not possible to extend the network as three-phase the redundant core of the new cable shall remain dead, be insulated from all other cores and be marked on the operational diagram.

6.4.4 Split-phase Networks

This system enables the utilisation of ex direct current three-core cables but is only connected to two phases of the HV network thus presenting an imbalanced load to the HV network. Where split-phase 460/230V networks are to be replaced or upgraded, the opportunity to convert to a three-phase network should be taken.

Note: Customers connected to the LV network shall be checked for any connected split-phase 460V equipment.

Where conversion to a three-phase network is not possible, split-phase transformers are available where only a two-phase HV network exists.

Where the network is to remain as split-phase, the redundant core of the new cable(s) shall remain dead, be insulated from all other cores and marked on the operational diagram.

6.4.5 Networks Fed from Scott Transformers

The Scott transformer network was developed to enable utilisation of ex direct current three-core cables whilst presenting a balanced three-phase load to the HV network. The majority of this type of network is located in the Croydon area. Where diversion/replacement of a three-core LV cable connected to this network is required, the redundant core of the new cable shall remain dead, be insulated from all other cores and marked on the operational diagram.

6.4.6 Phase/Anti-phase Systems

The phase/anti-phase system was developed to enable the best utilisation of ex direct current three-core cables, whilst presenting a balanced three-phase load to the HV network. The majority of this type of network is located in the Twickenham and Kew areas. Where diversion/replacement of a three-core cable connected to this network is required, the redundant core of the new cable shall remain dead, be insulated from all other cores and marked on the operational diagram.

For further guidance on phase/anti-phase systems, refer to Appendix A.

6.4.7 Three-wire Lines Connected to Three-phase Networks

Where three-wire overhead lines, connected to three-phase networks are to be replaced with ABC, the network should where possible be converted to three-phase and customers balanced over the three-phases. Where conversion to a three-phase network is not possible, the unused ABC core shall remain dead, be insulated from all other cores and marked on the operational diagram.

6.4.7.1 Networks fed from Diametric Transformers

A Diametric transformer has three LV windings with centre tapped neutrals, such that each winding provides two phases 180° apart. The LV pillar is split into three sections, one for each winding and has a phase/anti-phase output on two busbars in each section providing six phases in total. There is only a limited amount of LV network supplied in this way, located mainly in the Caterham area and no alterations shall be carried out on this network without prior consultation with Network Planning.

6.4.7.2 Extensions from Two-phase Mains

When a new underground three-phase CNE cable is to be connected to a two-phase (or split-phase) mains cable, only two of the new cable phase cores can be used. The redundant core shall remain dead, be insulated from all other cores and marked on the operational diagram. There is a high risk that the neutral core will be overloaded and damaged if the redundant core is utilised to supply load from the same phase as one of the other cores.

6.4.8 London Interconnected Network

Within the LPN network, there are a variety of system types associated with LV and 11/6.6kV networks. Areas of Central London continue to be supplied by interconnected LV networks with the associated 11/6.6kV feeders operating in discrete feeder groups. In effect, the

11/6.6kV and LV levels are integrated, and this precludes straightforward alterations to either, without affecting the integrity of the whole network.

The LV network is interconnected to both support the local load densities and provide support to LV customers under HV fault conditions. Therefore, any proposal to modify or extend central London networks shall be approved by Network Planning.

For further information on the London interconnected network, refer to EDS 08-2001.

7 Cable and Equipment Requirements

7.1 Overview

This section details the cable, plant and equipment requirements for the design of new LV networks and extensions to existing LV networks.

7.2 Mains

7.2.1 Overview

For the purpose of an LV network, a **Main** is defined as below. Figure 7-1 provides examples of mains and their configuration to form an LV network.

A low voltage underground cable or overhead line, which connects a substation to either a pot end, an overhead line earth or to another substation.

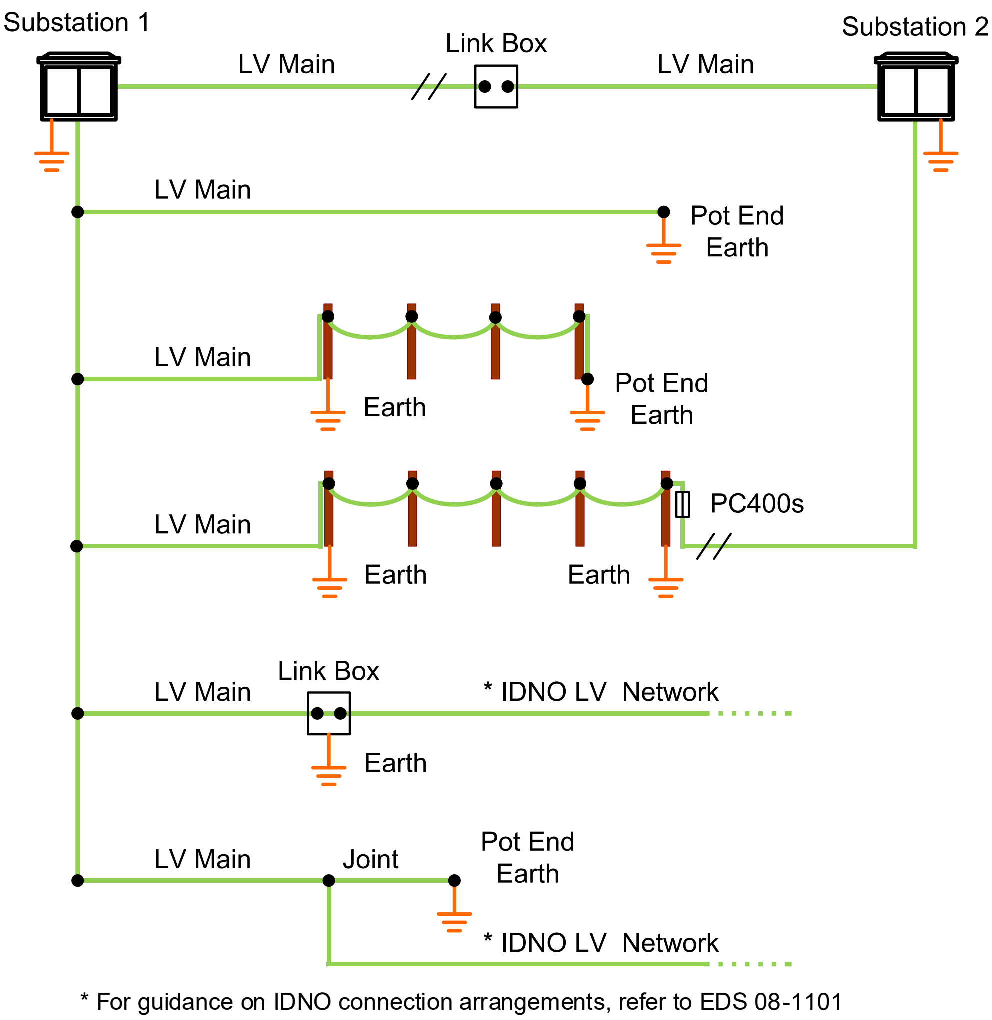


Figure 7-1 – Main Examples

7.2.2 Construction of Mains

The LV network shall be constructed using combined neutral and earth (CNE) cable to form a PME network earthed in accordance with Section 7.4.1.

Note: All existing distribution networks are considered to be PME even if they were originally constructed from separate neutral and earth (SNE) cables. ENA EREC G12/5 defines these networks as ‘hybrid’ and ‘PME enabled’ networks (refer to Section 3). Further guidance on the conversion of existing networks to PME is given in EDS 06-0016.

New mains or any main extension shall be designed using 300mm^2 aluminium cables.

The only exceptions are:

- An expected load on the main is above the rating or the volt drop exceeds the maximum limits of a 300mm^2 aluminium cable, where a 300mm^2 copper cable shall be used.
- A connection to an existing main of less than 0.1inch^2/70mm^2 is required, where a short taper (not exceeding 5 metres) of 95mm^2 aluminium cable may be used.
- An overhead to underground transition is required, where a 185mm^2 aluminium cable may be used. This shall be transitioned to 300mm^2 aluminium cable within 10 metres of the pole unless the main only supplies up to four 100A customers and there is no possibility of any future main extension – see Figure 7-2.
- An overhead to underground diversion of a single span which is, or can be shortened[6] to 30m or less, where a 185mm^2 aluminium cable may be used – see Figure 7-3.

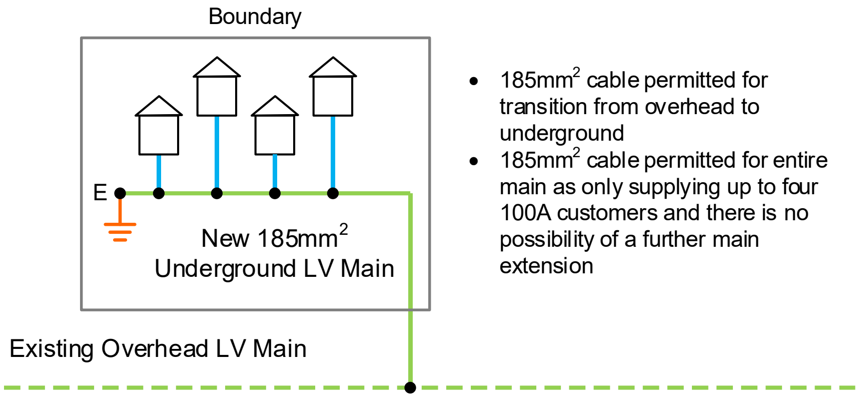


Figure 7-2 – Overhead to Underground Transition

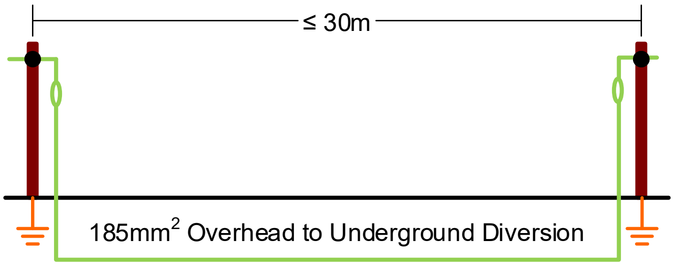


Figure 7-3 – Overhead to Underground Diversion

[6] Where an overhead to underground diversion is required but the existing span is greater than 30m, the span may be shortened with the installation of new terminal poles and stays.

7.2.3 Connection to Mains

In the past, services have been connected to cables of various types and sizes. Customer use has evolved over the years, and many of these cables are no longer suitable for use as mains due to their small conductor size. To provide clarity on the suitability of mains for the purposes of new service connections and extensions to existing LV networks, the minimum size of existing cable that shall be considered as a main are as follows:

- For underground networks – 0.06inch^2 copper, 0.1inch^2 aluminium or 70mm^2 aluminium.
- For overhead networks – 0.05inch^2 copper open wire, 35mm^2 copper or 50mm^2 ABC.

Note: For underground networks, LPN and SPN have typically considered 0.06inch^2 copper, 0.1inch^2 aluminium, and 70mm^2 aluminium to be the minimum main size whereas in EPN smaller cables have been used as mains. Therefore, as there is widespread use of 0.05inch^2 cable, this shall be considered the minimum main size in EPN.

New service connections or extensions to existing LV networks shall **not** be made to cables that are smaller than the above, or to networks where cables smaller than the above are located between the supplying substation and the proposed point of connection.

Note: LV unmetered supplies within the scope of EDS 08-2102 are excluded.

7.3 Services

7.3.1 Overview

For the purpose of LV connections, a **Service** is defined as below. Figure 7-4 provides examples of services and their connection to the LV network.

A low voltage underground cable or overhead line, which connects a customer to a main or directly to a substation as shown in Figure 7-4.

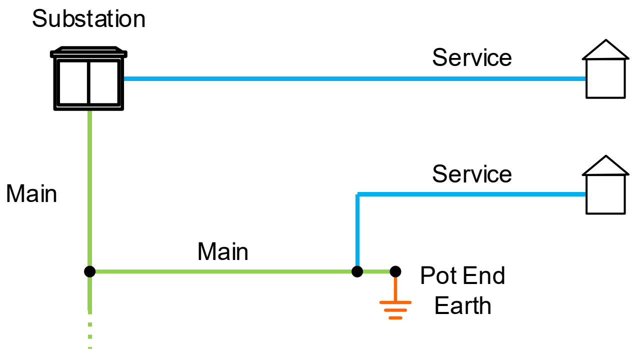


Figure 7-4 – Service Examples

7.3.2 Construction of Services

All services shall be provided in accordance with the appropriate customer connection standards (refer to Section 8). Where a service connection requires an extension of the existing main to comply with Section 5.4, the requirements of this section shall apply.

7.3.2.1 Services up to 100A

Where a service up to 100A requires an extension of the main, every opportunity shall be taken to lay the new main to a position where the service cable can be kept as short as possible as shown in Figure 7-5.

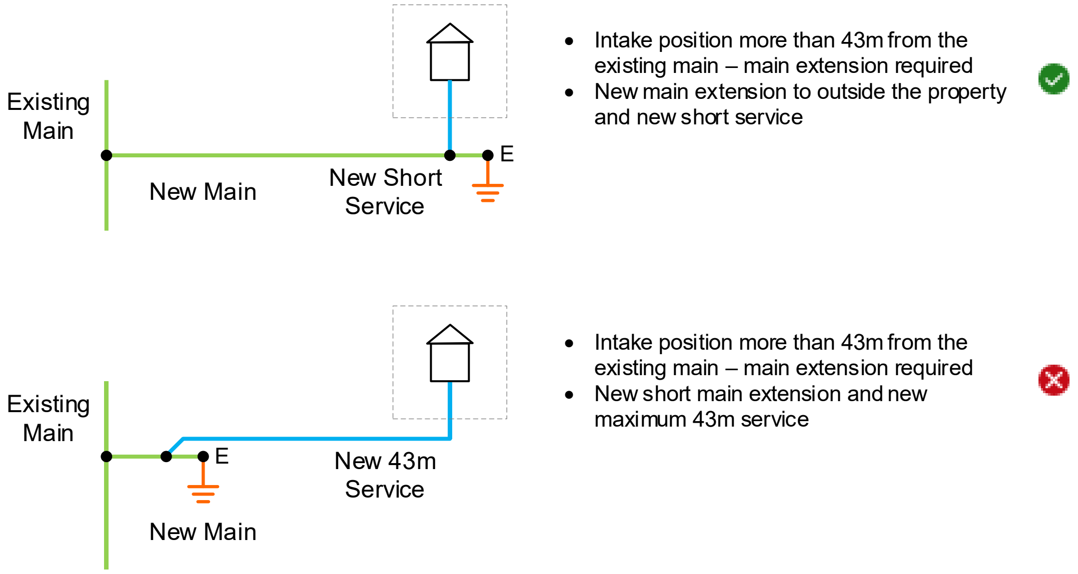


Figure 7-5 – ≤100A Main Extension

7.3.2.2 Services above 100A

Where a service above 100A requires an extension of the LV network, every opportunity shall be taken to lay the new main to a position where the service cable can be kept as short as possible as shown in Figure 7-6.

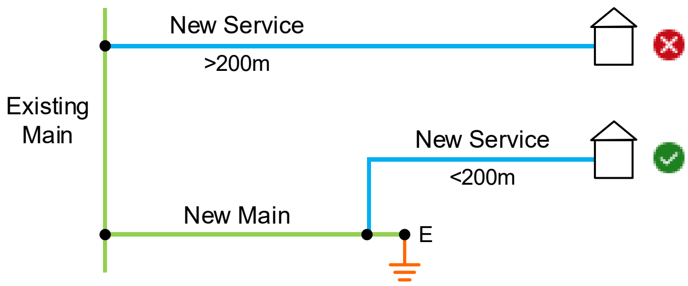


Figure 7-6 – >100A Main Extension

7.3.3 Direct Substation Services

Services direct from a substation shall be provided in accordance with EDS 08-2100 and constructed in accordance with ECS 13-0054.

7.3.4 Services to New Developments

Supplies to new developments should be planned to allow mains and services to be delivered without the need to install temporary pot-ends within the development site. Pot-ends can be difficult to locate once buried and may end up in the incorrect position (e.g. in the middle of a future carriageway, crossing a private garden etc.).

However temporary mains pot-ends may be used on development sites in the following circumstances:

- The development is at a stage where the road, kerb and property boundaries are clearly identified on site.
- The location of the pot-end is within 5 metres of the site boundary.
- The location of the pot-end work zone is clearly marked on both the plan and on site above ground to allow it to be easily located at a later date.
- The pot-end is removed at the earliest convenience.

Services shall **not** be pot-ended within a development site.

7.4 Earthing

7.4.1 Network Earthing

In addition to the transformer LV neutral earth electrode at the secondary substation, the neutral conductor shall be connected to another main (connecting to the same or different secondary substation), or an additional earth electrode in accordance with Figure 7-7 at the following locations:

- The pot end at the end of an LV underground main.
- The last pole of an LV overhead main.
- Every six poles/spans of an LV overhead main.
- At each LV overhead main cable termination.
- All cut-outs above 100A where practical (refer to Section 7.4.2).

Note: The additional earth electrode at the end of an LV underground main (i.e. end of main earth) shall be installed via a pot end joint in accordance with ECS 02-0415.

Where an existing LV network is supplying more than one customer but does not currently show as terminating at a pot end, or an open point at another substation, a link box or on the LV overhead network, an additional earth electrode shall be installed at the end of the main as shown in Figure 7-6. Where feasible, this shall be installed at a point downstream of the last customer connection.

All additional earth electrodes shall be separated by at least 2.5 metres from streetlights, street furniture, other LV earths and TT earths.

For further guidance on the earthing of LV networks, refer to EDS 06-0016.

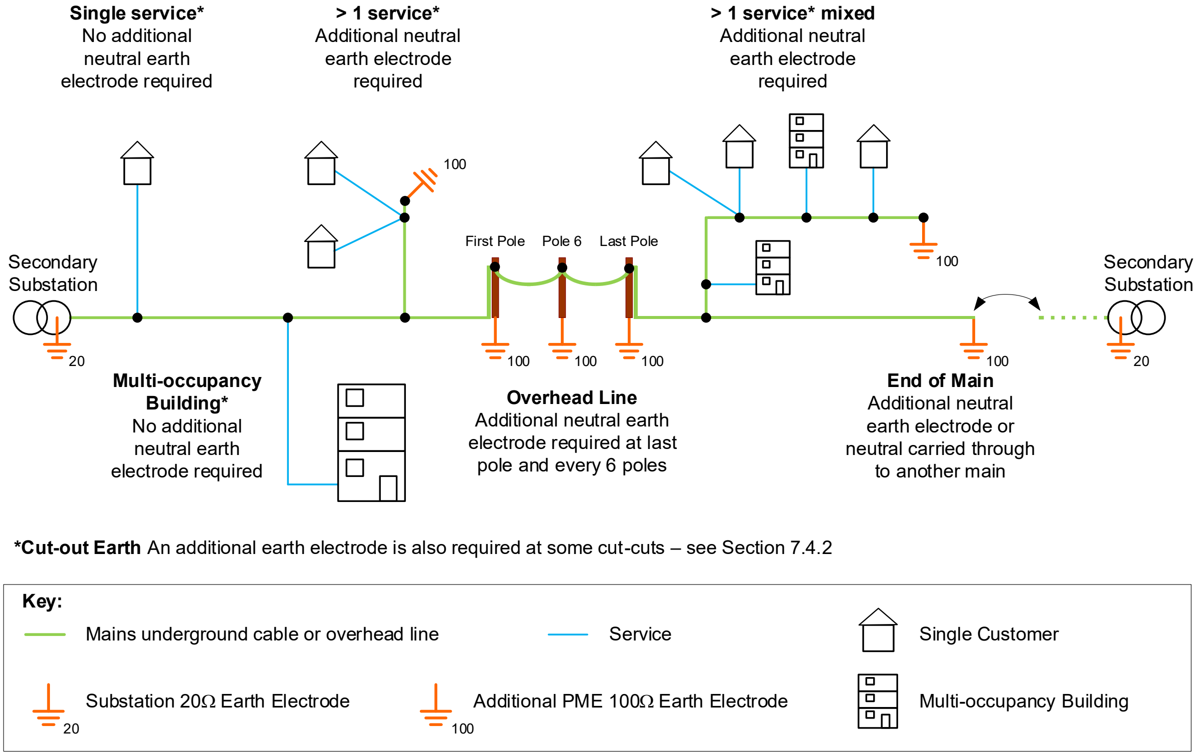


Figure 7-7 – End of Main Earth Electrodes

7.4.2 Cut-out Earth

Further guidance on cut-out earthing is provided in the relevant customer connection standard (refer to Section 8) and EDS 06-0017.

7.4.3 Earth Terminal

Further guidance on the provision of an earth terminal is provided in the relevant customer connection standard (refer to Section 8) and EDS 06-0017.

7.5 Cable Installation

7.5.1 Identification of Cables

For planned works, LV cable identification shall be considered at the design stage. Where practicable, the designer shall indicate the probable method of LV cable identification and incorporate it into the design (i.e. 1:500 drawing).

For further guidance, including the approved methods of identifying an LV cable, refer to DSR 01 018.

7.5.2 Installation of Cables

LV cables shall be installed in accordance with the requirements of ECS 02-0019.

For the design of LV networks, the preferred approach is the direct burial of cables or ducted (where required by Section 7.5.3) at the depths required by ECS 02-0019.

LV cable routes shall **not** be designed to pass beneath or within buildings.

7.5.3 Installation of Cable Ducts

LV cable ducts shall be installed accordance with the requirements of ECS 02-0019.

Where the required minimum depth can be achieved (refer to Section 7.5.2), LV cables shall be ducted in the following situations:

- Road crossings.
- Bridge crossings (within the bridge deck).
- Rail crossings.
- Town centre locations where future excavation may be difficult due to traffic management.
- Motorways and trunk roads.
- River, stream and canal crossings.
- Any other location (including specialist surfaces) where future excavation may be difficult and/or expensive.

Consideration shall always be given to the provision of additional, spare ducts during planned works to minimise future street works. For a list of approved ducts, refer to EAS 02-0000.

Note: The installation of a cable in a duct reduces its rating and a larger cable may be required to maintain the desired circuit rating. Refer to EDS 02-0040 and relevant cable specifications for further guidance.

7.6 Bunching of Conductors

The bunching of phase and/or neutral conductors is no longer acceptable.

For the design of new LV networks (i.e. new radial networks or extensions to existing networks), phase and/or neutral conductors shall **not** be bunched.

If works are undertaken on existing networks with bunched phase and/or neutral conductors, the opportunity should be taken to reconfigure the network and remove the bunched conductors.

Bunched networks shall only be used for the provision of new service connections where the service can be provided using un-bunched phase and neutral conductors.

Where circuits containing bunched phase and neutral conductors are found but not recorded on operational diagrams, they shall be noted and a system alteration notice submitted.

A warning notice (20021H, refer to EAS 07-0021) shall be fixed adjacent to the LV fuse way or aerial cable supplying the affected circuit and at all poles supporting conductors that have been bunched.

7.7 Fifth Core and Switched Wire Supplies

7.7.1 Overview

Formerly, a dedicated streetlighting network was supplied by a common fifth core within the distribution network cable and controlled by a time switch at the local substation or LV pillar. This configuration enabled automation of the streetlighting columns and established a single point of isolation for the streetlighting network.

Modern streetlighting networks (and LV mains cables) no longer utilise a fifth core. Each lighting column is connected directly to the distribution network using a standard unmetered single-phase supply (refer to EDS 08-2102) and is controlled by an individual photocell.

Where works are to be undertaken on dedicated streetlighting networks found to be utilising a fifth core and time switch supply, a suitable solution from this section shall be selected to directly supply and/or maintain the fifth core. These works include:

- Substation upgrade or replacement (Section 7.7.2).
- LV main reinforcement or repair (Section 7.7.3).
- Link box replacement (Section 7.7.4).
- Any other works that may render the dedicated lighting network non-operational.

Additionally, the local authority shall be contacted at the earliest opportunity and advised to equip all dedicated lighting devices with photocells to ensure correct operation.

Where the fifth core is found to be redundant, it shall be pot-ended and a solution from this section is not required.

To ensure a known point of isolation, the connection or jointing of the fifth core directly to an LV main is not permitted. Any fifth core found to be jointed directly to an LV main shall be removed and maintained using the solutions provided in this section. Any applied solution shall be affixed with appropriate labelling and marked on the operational diagram to indicate the additional point of isolation for the lighting network.

Note: Typically, the fifth core is consistently supplied by a common phase within an operational area. Where the solutions detailed in this section are applied, the common phase shall be identified, and the consistency maintained within the area.

7.7.2 Substation Upgrade or Replacement

Where a substation supplying a dedicated lighting network is to be upgraded or replaced, an approved 100A cut-out or MSDB shall be installed to replace any time switch and directly supply the fifth core of the lighting networks (up to 100A per network) as follows:

- 100A single-phase cut-out for a single lighting network.
- 100A three-phase cut-out for up to three lighting networks.
- Fused 10-Way MSDB for up to ten lighting networks.

The cut-out or MSDB shall be wall mounted internally to the substation and supplied via a 35mm^2 concentric service cable jointed on to an available LV main as close to the secondary substation as practicable and safe. A three-phase cut-out example is shown in Figure 7-8.

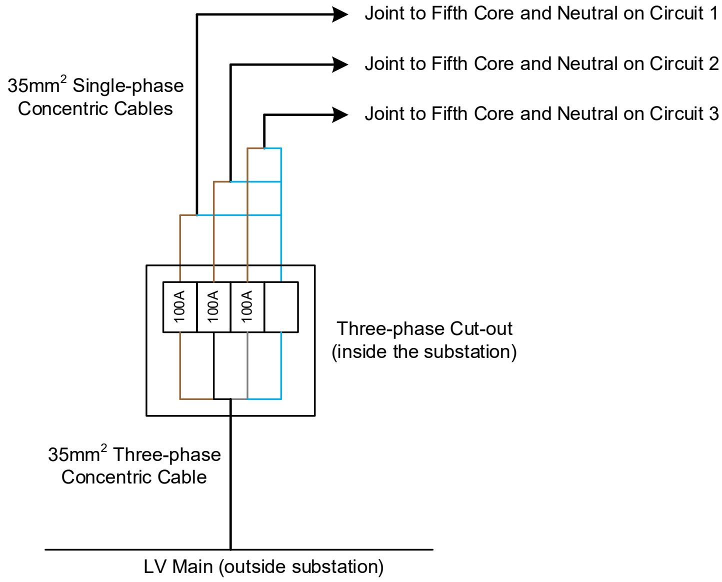


Figure 7-8 – Substation Solution Example

7.7.3 LV Mains Reinforcement or Repair

Where an LV main supplying a dedicated lighting network requires reinforcement or repair, the options detailed in this section shall be considered.

7.7.3.1 Reinforcement with Services

The option shown in Figure 7-9 shall be considered where reinforcement is required on the first leg out of the substation, and it is not feasible to transfer existing services to the new section of LV main.

An approved 100A cut-out shall be installed at the substation in accordance with Section 7.7.2. The cut-out shall be supplied via a 35mm^2 concentric service cable jointed on to the PILC 5c at the pot-end joint. The direct supply for the fifth core shall also be provided by a 35mm^2 concentric service jointed on to the existing PILC fifth core at the pot-end joint.

Note: The pot-end shall be installed in accordance with the LV earth separation requirements of Section 7.9.2.

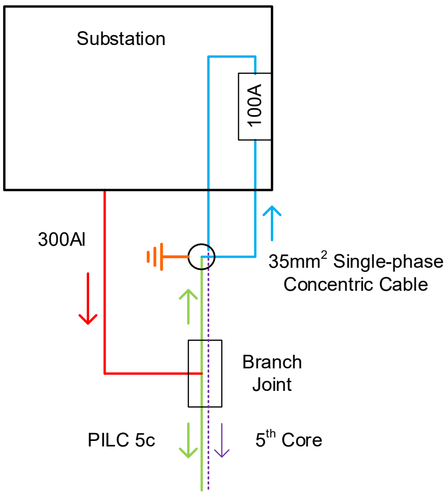


Figure 7-9 – Reinforcement with Services

7.7.3.2 Short Reinforcement without Services

The option shown in Figure 7-10 shall be considered where reinforcement is required on the first leg out of the substation, there are no existing services to be transferred to the new section of LV main and it is feasible to lay a service cable to maintain the fifth core.

An approved 100A cut-out shall be installed at the substation in accordance with Section 7.7.2. The cut-out shall be supplied via a 35mm^2 concentric service cable jointed onto the new 300Al. The direct supply for the fifth core shall also be provided by a 35mm^2 concentric service cable laid alongside the new 300Al and jointed on to the existing PILC fifth core at the straight joint.

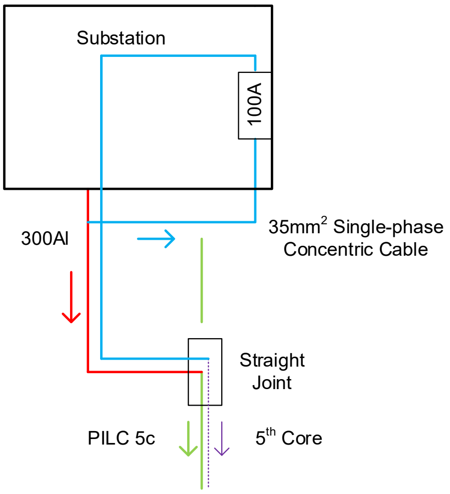


Figure 7-10 – Short Reinforcement without Services

7.7.3.3 Long Reinforcement without Services

The option shown in Figure 7-11 shall be considered where reinforcement is required on the first leg out of the substation, there are no existing services to be transferred to the new section of LV main and it is not feasible to lay a service cable to maintain the fifth core.

An approved 100A cut-out shall be installed in an approved GRP (refer to EAS 07-0000) on the distribution network. The cut-out shall be supplied via a 35mm^2 concentric service cable jointed onto the new 300Al at the straight joint. The direct supply for the fifth core shall also be provided by a 35mm^2 concentric service cable jointed on to the existing PILC fifth core at the straight joint.

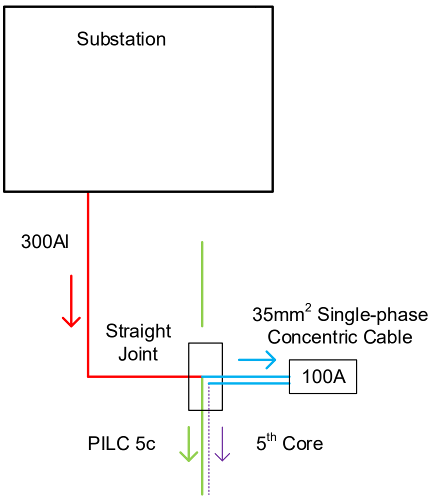


Figure 7-11 – Long Reinforcement without Services

7.7.3.4 Reinforcement or Repair

The option shown in Figure 7-12 shall be considered where reinforcement or repair is required.

The fifth core shall be maintained via a 35mm^2 concentric service cable laid alongside the new 300Al. The 35mm^2 concentric service cable shall be jointed on to the existing PILC fifth core and neutral at each straight joint.

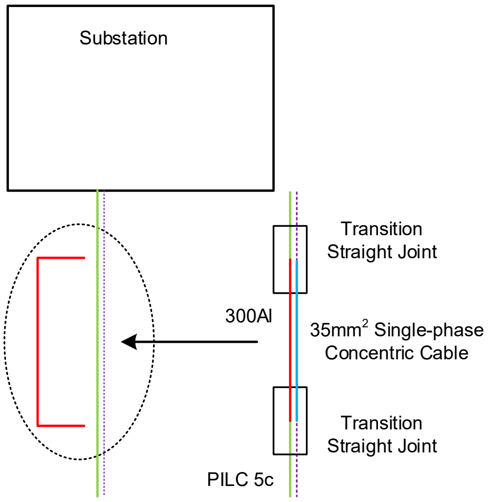


Figure 7-12 – Reinforcement or Repair

7.7.4 Link Box Replacement

This section refers to the replacement of a five-core enabled link box. For standard link box replacement, refer to Section 9.

Where a five-core enabled link box requires replacement, up to four approved 100A cut-outs shall be installed to maintain the fifth core of the lighting network(s) as follows:

- 2 x 100A cut-outs for two-way link box/single lighting network.
- 4 x 100A cut-outs for a four-way link box/double lighting network.

The approved 100A cut-outs shall be installed in an approved GRP (refer to EAS 07-0000) on the distribution network. The fifth core cable(s) supplied by the substation shall be terminated into the bottom of the first cut-out using a single-phase 35mm^2 concentric service cable which is jointed onto the LV main as close to the link box as practicable and safe. The remaining cut-out(s) shall be loop connected and supplied by the first cut-out using BS 7671 25mm^2 meter tails. The fifth core cables supplying the lighting network(s) shall be terminated into the bottom of the remaining cut-out(s) using a single-phase 35mm^2 concentric service cable which is jointed onto the LV main as close to the link box as practicable and safe. A four-way link box example is shown in Figure 7-13.

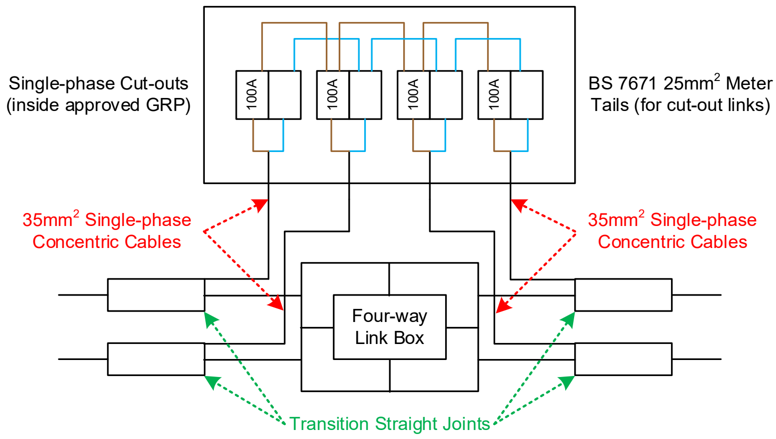


Figure 7-13 – Link Box Replacement

7.7.5 Overhead Supplies

Where equipment is supplied by a fifth core, refer to EDS 08-2102.

7.8 Link Boxes

Interconnection between adjacent LV networks for the purposes of network support shall be provided via a two or four-way LV link box as required. New LV link boxes shall only be installed with a minimum cable size of 300mm^2 aluminium.

Where a link box is installed with a spare way, the link box tail shall be pot-ended and left un-energised (i.e. links removed).

For the use of fuses in LV link boxes, refer to Section 7.10. The approved LV link boxes are specified in EAS 02-0000.

7.9 Substations

7.9.1 Overview

The requirement for a new substation will be largely dependent on the size of the development and/or any dedicated supply arrangements (ACB etc.) requested. Prior to the design of a new substation, available capacity from existing adjacent networks shall be considered to provide network support and allow for the flexible connection of customers.

Note: The number of customers per substation shall **not** exceed the values detailed in EDS 08-3000.

Where a new substation is required the number, position, capacity and timing of the substation shall consider the maximum power requirement of the development, the accessibility of the substation and the required land rights.

For secondary substation design requirements, refer to EDS 07-3101 and EDS 07-3102.

7.9.2 Spare Ways

During the installation of the new substation, the spare LV ways on transformer-mounted fuse cabinet or LV board shall be fitted with 300mm^2 aluminium cable of sufficient length to allow future LV joints without entering the substation as shown in Figure 7-14. The cable shall be pot-ended in accordance with the ECS 02-0415 and left un-energised (i.e. fuses left out).

Where the substation has separate HV and LV earths, any LV earth shall be installed a minimum of 8 metres from the substation HV earthing system as shown in Figure 7-14.

The location of the cables, pot ends and earths shall be marked on the project plan.

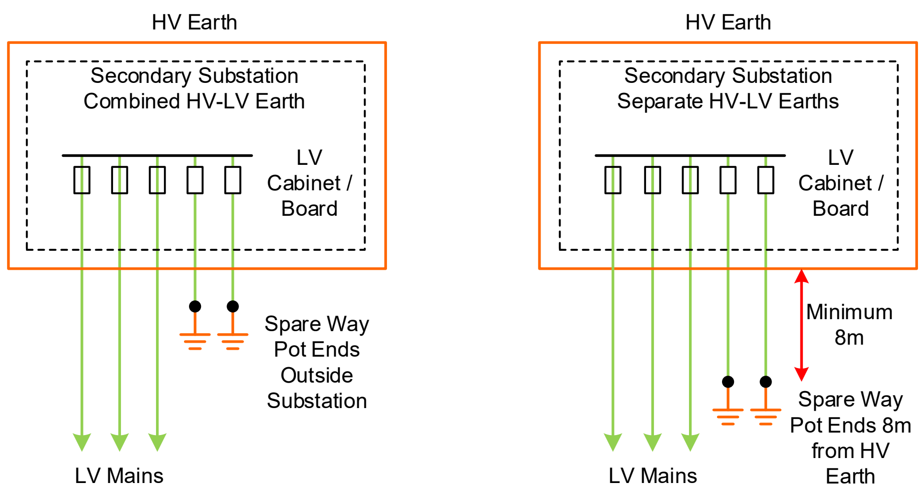


Figure 7-14 – Substation Spare Way Pot Ends

7.9.3 Network Support

For LV interconnection and backfeed requirements, Refer to EDS 08-3000.

Note: Backfeed support is not applicable to IDNO substations. Refer to EDS 08-1101 for further information.

7.9.4 Network Monitoring

For further guidance on LV network monitoring, refer to EDS 08-3001.

7.10 Fuses

For all new LV networks (i.e. new radial networks or extensions to existing networks), substation fuses shall be selected in accordance with EDS 05-4001[7] and assessed using the network modelling tools detailed in Section 6.3 to ensure that there is sufficient fault current for correct fuse operation.

Where an existing network has insufficient fault current to ensure correct fuse operation, one of the following options should be considered to resolve the issue:

[7] LV fuses selected and configured in accordance with EDS 05-4001 will ensure adequate cable protection as the design standard specifies fuses to align with LV cable ratings.

- Network reinforcement.
- Installation of smaller substation fuses with a suitable label.
- Installation of underground link box fuses (limited to one set of fuses per link box).
- Installation of overhead fuses (PC400).

Note: All options above shall be agreed and approved by Network Planning.

In all cases, the fuse size shall be notified to LV Network Control (where applicable) and recorded on the relevant operational diagrams such as NetMap/GeoView.

8 Connection Arrangements

8.1 Connections

Table 8-1 provides a summary of the LV service cables permissible on the network. The service cable shall be designed to meet the customer load. Refer to the relevant standard below for further information and the requirements including any caveats for each supply option.

- EDS 08-1103 for supplies to multi-occupied buildings.
- EDS 08-2100 for supplies above 100A (69kVA).
- EDS 08-2101 for supplies up to 100A (69kVA).
- EDS 08-2102 for unmetered supplies (including street-lights and street furniture).
- EDS 08-5050 for supplies to electric vehicle chargers.

Table 8-1 – LV Service Cable Sizes

Maximum Service Rating (A)	Cable Type
100	35mm² Single-phase Aluminium Split Concentric or Concentric
	35mm² Three-phase Aluminium Concentric
	35mm² Three-phase Aluminium Split Concentric
200	95mm² Three-phase Aluminium Waveform
	95mm² 4-core Three-phase Aluminium Waveform
315	185mm² Three-phase Aluminium Waveform
	185mm² 4-core Three-phase Aluminium Waveform
	Customer cables*
400	300mm² Three-phase Aluminium Waveform
	300mm² 4-core Three-phase Aluminium Waveform
	Customer cables*
500	300mm² Three-phase Copper Waveform
	Customer cables*
630	Customer cables*
800	Customer cables*
1600	Customer cables*
2000	Customer cables*
2500	Customer cables*
* Customer cables are connected to the LV board or ACB in the substation.	

8.2 Disconnections

The design requirements of service disconnections are covered in the appropriate customer connection standards (refer to Section 8).

Disconnected cables shall, where feasible and practical, be recovered. Where a dead cable must be abandoned in public land, this shall be marked on network records and recovered at a later opportunity should one arise.

9 Asset Replacement

LV underground and overhead line networks and associated equipment (such as LV pillars and link boxes) may require replacement for various reasons including overloading, voltage issues, condition based, end-of-life, changes to practice or diversions.

In all cases, consideration shall be given to network rationalisation and potential redesign if possible and practical rather than a like-for-like replacement. Where a non-standard LV network is to be replaced, consideration shall always be given to conversion to a three-phase system, refer to Section 6.4.

Network connectivity, the ability to transfer and support customers under outage, the introduction of more effective equipment and increased network efficiency should all be considered whenever possible. This may require increasing the capacity of the LV network rather than a like-for-like replacement, for example moving from a two-way to a four-way link box.

The capacity of the LV network shall **not** be de-rated by any replacement work.

When replacement is required:

- Underground cables shall be replaced in accordance with Section 7.2.2.
- Underground to overhead transitions shall be replaced in accordance with Section 7.2.2.
- Overhead lines should be considered for replacement with underground networks where reasonably practicable.
- Where the retention of overhead lines is unavoidable, conductors shall be replaced with ABC of the equivalent rating.
- LV pillars shall be replaced with link boxes ensuring that, as a minimum requirement, the LV network connectivity is maintained on a like-for-like basis.
- Link boxes shall be replaced on a like-for-like basis in accordance with the requirements of Section 7.8.

Note: These requirements should be considered during fault repairs, but only if feasible as network restoration remains the priority.

For guidance on mains, refer to Section 7.2.

For guidance on services, refer to Section 7.3.

10 References

10.1 UK Power Networks Standards

AST 05 002	Property & Consents - Consent Acquisition Policy
CON 08 120	ICP Small Service Self-Service (SSSS) Procedure
DSR 01 018	Identification of LV Cables
EAS 02-0000	Approved Equipment List – Cables and Joints
ECS 02-0019	Installation of Underground Cables LV to 132kV
EDS 02-0040	Current Ratings Guide for Distribution Cables
ECS 02-0415	LV Jointing Manual
EDS 05-4001	Fuse Ratings at Distribution Substations
ECS 06-0026	LV Supply Earthing Guide
EDS 06-0016	LV Network Earthing Design
EDS 06-0017	Customer LV Installation Earthing Design
EAS 07-0000	Approved Equipment List - Civils and Substations
EAS 07-0021	Operational Signs and Labels Material List
EDS 07-3101	Pre-design Requirements for Secondary Substations
EDS 07-3102	Secondary Substation Civil Design
EDS 08-1101	IDNO Networks
EDS 08-1103	Multi Occupied Building Supplies
EDS 08-1901	Guidance for the Connection of Customer's Disturbing Loads
EDS 08-2001	LV Interconnected Network Design
EDS 08-2100	LV Customer Supplies above 100A
EDS 08-2101	LV Customer Supplies up to 100A
EDS 08-2102	LV Customer Unmetered Supplies
EDS 08-3000	HV Network Design
EDS 08-3001	HV Network Remote Control and Monitoring
EDS 08-5050	Electric Vehicle Connections
EOS 09-0100	Site Recording of Cables, Plant and Equipment
ECS 13-0054	Connection of Large LV Services to Secondary Distribution Substations

10.2 Legislation

Electricity Act 1989

Electricity Safety, Quality and Continuity Regulations 2002

Health and Safety at Work etc Act 1974

Construction (Design and Management) Regulations 2015

10.3 National and International Standards[8]

BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
DCODE	The Distribution Code of licensed distribution network operators of Great Britain (https://dcode.org.uk/)
ENA EREC G5	Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom.
ENA EREC G98	Requirements for the Connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in Parallel with Public Low Voltage Distribution Networks on or after 27 April 2019
ENA EREC G12	Requirements for the application of Protective Multiple Earthing to Low Voltage Networks
ENA EREC G99	Requirements for the Connection of Generation Equipment in Parallel with Public Distribution Networks on or after 27 April 2019
ENA EREC P5	Design Methods for LV Underground Networks for New Housing Developments
ENA EREC P23	Guidance on Earth Fault Loop Impedance at Customers' Intake Supply Terminals
ENA EREC P25	The short-circuit characteristics of single-phase and three-phase low voltage distribution networks
ENA EREC P28	Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom
ENA EREC P29	Planning limits for voltage unbalance in the UK for 132kV and below
MAGiC	Multi-Agency Geographic Information for the Countryside (https://magic.defra.gov.uk/)

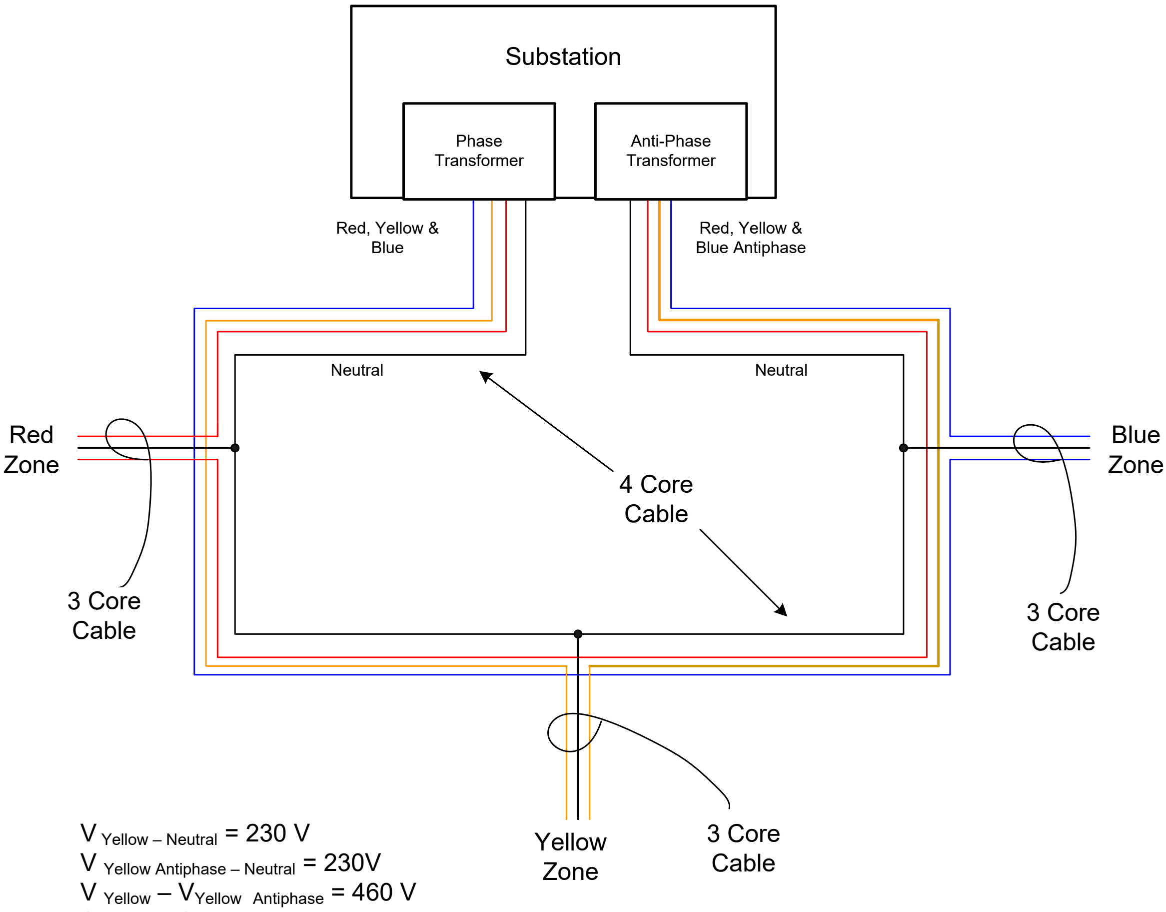
[8] ENA documents available from http://www.dcode.org.uk/annexes.html or www.energynetworks.org.

Appendix A - Phase/Anti-phase Systems

Substations supplying a phase/anti-phase system have two conventional Dy11 transformers, each of which supplies an LV feeder pillar or fuse board. The HV and LV connections on one of the transformers have however been adjusted such that each phase on the LV cables connecting to that transformer is electrically 180° apart from each corresponding phase on cables connecting to the other transformer.

The two transformers are permanently interconnected via the LV network as shown in Figure A-1 with three-core cables connected to the four-core cable ring. As can be seen, cables associated with any part of this network will be supplied from two different sources of supply and this shall be clearly defined on the risk assessment when any work on these cables is planned.

Provision of three-phase supplies from these substations shall be taken directly from the phase transformer LV pillar, and no attempt made to alter the phase/anti-phase network.



$V_{Yellow-Neutral} = 230$ V
$V_{Yellow\ Antiphase-Neutral} = 230$V
$V_{Yellow} - V_{Yellow\ Antiphase} = 460$ V
Similarly for Red and Blue Phases

Figure A-1 – Phase and Anti-phase System

Note: Legacy colours are used to define phases in the above diagram. On site, phases may be similarly coloured or different colours used or possibly numbered.