D-Suite PED

Functional Technical Specification

ABOUT REPORT

Specification Title	D-Suite Power Electronic Devices Technical Specification.
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REPORT PROGRESS

Created By	Andrew Moon	
Reviewed By	Andrew Moon	
Approved By	Andrew Moon	

VERSION HISTORY

Date	Issue	Status
22/02/2024	1.0	Final Draft
26/03/2024	1.1	Updated branding for dissemination on the ENA SNP.

Index

Reference and Related Documents

D-Suite PED equipment shall comply with the requirements detailed in the Distribution Code, Electricity Safety Quality and Continuity Regulations 2002 (ESQCR), the Enquiry Documentation, this Specification, all relevant SPEN Specifications, ENA Technical Specifications, ENA Engineering Recommendations, British, European, or international standards listed in this document, in that order of precedence.

UK Safety Legislation

EU Recommendation 1999/519/EC	EU Council Recommendation of 12 July 1992 on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz)
EMC Regulations 2016	Electromagnetic Compatibility Regulations 2016
CEMFAW Regulations 2016	Control of Electromagnetic Fields at Work Regulations 2016
ESQCR	Electricity Safety, Quality and Continuity Regulations 2002
Electricity at Work Regulations 1989	
Provision and Use of Work Equipment Regulations 1998	
Health and Safety at Work Act 1974	
Pressure System Safety Regulations 2000	

SP Energy Networks Policies and Specifications

ASSET-02-002	EQUIPMENT APPROVALS PROCEDURE
EPS-03-033	Ratings and general requirements for plant and apparatus for connection to The Company's system
PROT-01-012	11kV Protection and Control Application Policy
TRAN-06-001	Approved Equipment Register - Transformers
INS 50.40.11	Prefabricated enclosures for distribution substations
INS 50.44.05	ACDC Auxiliary services
INS 46.99.00	Protection and Control Devices

Energy Networks Association Documents

ENA ER G5	Engineering Recommendation G5 Issue 5, 2020: Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom.
ENATS 12-11	Enclosed unfilled terminations of cables with rated voltages 12, 24 and 36 kV
ENATS 35-1	Distribution transformers Part 3 Schedules

ENATS 41-24	Guidelines for the Design, Installation, Testing and Maintenance of Main Earthing
ENATS 48-5	Environmental test requirements for protection and control equipment and systems
ENATS 50-18	Application of Ancillary Electrical Equipment
ENATS 50-19	Standard numbering for small wiring

International Electrotechnical Commission (IEC), EN Standards

NUMBER	TITLE
BS 2562	Specification for cable boxes for Transformers and Reactors Building
BS 4142	Methods for rating and assessing industrial and commercial sound
BS EN 50160	Voltage characteristics of electricity supplied by public electricity networks
BS EN 50180	Bushings above 1kV up to 36kV and from 250A to 3.15kA for liquid filled transformers.
BS 5499	Safety signs
BS EN 60071-1	Insulation co-ordination: Definitions, principles, and rules
BS EN 60071-2	Insulation co-ordination: Application guide
BS EN 60076-1	Power transformers. General
BS EN 60076-3	Power Transformers – Part 3: Insulation levels, dielectric tests and external clearances in air
BS EN 60076-10	Power Transformers – Part 10: Determination of Sound Levels
BS EN 60255	Measuring relays and protection equipment - Part 1: Common requirements
BS EN 60269-1	Low-voltage fuses. General requirements
BS EN 60269-2	Low-voltage fuses. Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application). Examples of standardized systems of fuses A to K.
BS EN 60529	Degrees of protection provided by enclosures
BS EN 60616	Terminal and Tapping Markings for Power Transformers
BS EN 60654	Industrial-process measurement and control equipment. Operating conditions
BS EN 60747-1	Semiconductor devices - Part 1: General
BS EN 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
BS EN 60947-7-1	Ancillary equipment - Terminal blocks for copper conductors
BS EN 61000-4-30	Testing and measurement techniques – Power quality measurement methods.
BS EN 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity for industrial environments

NUMBER	TITLE
BS EN 61000-6-3	Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments
BS EN 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments
BS EN 61000-6-5	Electromagnetic compatibility (EMC) – Part 6-5: Generic standards – Immunity for equipment used in power station and substation environment
IEC 61000-4-7	Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto
BS EN 61010	Safety requirements for electrical equipment for measurement, control and laboratory use
BS EN 61071	Capacitors for power electronics
BS EN 6121	Mechanical cable glands. Armour glands. Requirements and test methods.
BS EN 61810	Electromechanical elementary relays. General and safety requirements
BS EN 61850	Communication networks and systems for power utility automation
BS EN 61099	Synthetic organic esters for electrical purposes
BS EN 61869-2	Instrument transformers. Additional requirements for current transformers
BS EN 61869-3	Instrument transformers. Additional requirements for inductive voltage transformers
BS EN 61936-1	Power installations exceeding 1kV AC Common rules
BS EN 61968	Application integration at electric utilities – System interfaces for distribution management
BS EN 61970	Common Information Model (CIM) / Energy Management
BS EN 62477-1	Safety requirements for power electronic converter systems and equipment – Part 1: General
IEC 62477-2	Safety requirements for power electronic converter systems and equipment – Part 2: Power electronic converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC
BS EN 62927	Voltage sourced converter (VSC) valves for static synchronous compensator
BS 7671	Requirements for electrical installations
BS EN ISO 12944-2	Paints and varnishes. Corrosion protection of steel structures by protective paint systems. Classification of environments
BS EN ISO 3746	Acoustics - determination of sound power levels of noise sources using sound pressure - survey method using an enveloping measurement surface over a reflecting plane
BS EN ISO 9614	Acoustics – determination of sound power levels of noise sources using sound intensity
ICNIRP (1998)	For limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz)

NUMBER	TITLE
IEC/TS 60815-2	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions – Part 2: Ceramic and glass insulators for AC systems
IEC 62351	Industrial communication networks – Network and system security.
IEC 62443	Power systems management and associated information exchange – Data and communications security
ICNIRP (1998)	For limiting exposure to time varying electric, magnetic and electromagnetic fields (up to 300 GHz)

1. Introduction & General Requirements of D-Suite PED

Purpose

The purpose of this document is to outline the technical requirements of four LV **PED** solutions (**D-Suite PED**), namely, a Distribution:

1. Harmonic Filter (**D-HF**).
2. STATCOM (**D-STATCOM**).
3. Soft Open Point (**D-SOP**).
4. Smart Transformer (**D-ST**).

which will be designed, manufactured and trialled as part of the D-Suite project. D-Suite is SP Energy Networks' (SPEN) project, which has been funded through Ofgem's Strategic Innovation Fund (SIF) mechanism, which will procure and trial between 12 – 16 D-Suite PED.

This document covers the functional and technical requirements for the **D-HF, D-ST, D-SOP** and **D-ST**. These requirements have been specified based on the **Core Functionalities** of **each PED**, the requirements for connection to grid, and understanding of available data and potential communication structure.

Due to the innovative nature of the project, it is expected that some of the requirements may be subject to change or new requirements may be introduced for the final **PED** design. This shall be considered by any **PED Supplier(s)** which will provide the **PEDs**. The philosophy of D-Suite is to use power electronic modules as building blocks, to form each of the 4 D-Suite devices, so it is expected suppliers offer solutions with modularity in mind. The rating of each submodule is 30kVA, which can be combined to a maximum of 180kVA.

This should allow suppliers of offer solutions for all 4 D-Suite devices, although tenders offering at least 2 solutions will be considered. An example of a basic module of D-Suite is shown below, though suppliers are encouraged to submit their own designs if they provide a competitive technical advantage. This concept is a key requirement for D-Suite and *shall* be offered by tendering suppliers. More details are provided in Section 2.7.

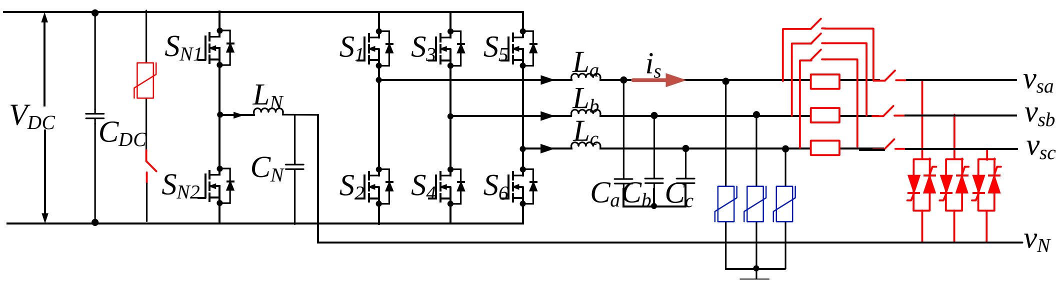


Figure 1. Basic D-Suite module using either Si IGBTs or SiC MOSFETs. These are to be used as building blocks, which will make up the D-Suite PED solutions.

It is envisaged that the D-Suite devices consists of a **PED** and a power **Network Level Control System** (**NLCS**). The **NLCS** is not part of this tender, the **D-Suite PED Supplier** is responsible to supplying the control interface, which can either be hardwired digital and analogue I/O or an

IEC 61850 interface. **D-Suite PED Suppliers** should outline design specifications for both options.

A detailed description of each D-Suite **PED** unit, which includes digitally controlled power electronics and hardware, which provide various network control functionalities is given below:

1. **Harmonic Filter** (**D-HF**): The harmonic filter is an advanced power-quality device designed to mitigate the detrimental effects of harmonics in distribution networks. The D-HF should be able to eliminate harmonics generated by non-linear loads and distorted voltage sources, or distorted grids, to reduce the total harmonic distortion (THD) on the 0.4 kV network.
2. **D-STATOM** (**D-STATCOM**): consists of a DC voltage source, inverter circuit, coupling transformer and a **PED** switching control module. This will be installed in street furniture or be pole mounted. The 0.4 kV feeder location will be determined by the optimum placement, specific to each feeder.
3. **Soft Open Point** (**D-SOP**): A 2 terminal version is installed as street furniture within an enclosure. A 3 terminal version is installed within a secondary substation and connected to the LV networks, of two neighbouring substations, local to the selected site. All versions are installed on the 0.4kV network.
4. **Smart Transformer** (**D-ST**): **D-ST** will be installed in the **Secondary Substations** and provide voltage conversion from (11kV) to **Low Voltage** (0.4kV). **D-ST** can control the power flow passing through itself and voltage at its terminals by adjusting the power electronics switching in response to set points received from the **NLCS**.

To achieve the objectives of D-Suite project, SPEN intends has identified D-Suite PED suppliers who can deliver fit-for-purpose D-Suite PED and the associated Network Level Control System interface and successfully integrate them into the existing distribution network:

- **D-Suite PED Supplier** shall design, manufacture and deliver two or more **D-Suite PED types (e.g., D-ST and D-SOP),** based on the requirements specified in Section 1 and Section 2.

- **NLCS Supplier** shall design, build and deliver the intelligent control system based on the requirements specified in Section 1. The interface requirements will be available at tender.

It is required that each **supplier** fully recognise all sections in this document to understand the interaction and interfaces required between different suppliers and also the equipment which they provide. It is possible that one supplier may have the technical capabilities to support the requirements for delivery of the scope of both the **PED Supplier** and the **NLCS Supplier**.

1.1. D-Suite PED Functional Specifications

Project suppliers(s) shall recognise, read and understand the "SPEN Network Overview" document which is a complementary document to this technical specification document and presents operation and planning requirements within SP Energy Networks.

1.2. D-Suite Concepts Overview

1.2.1. D-Suite Concept for D-HF

D-Suite D-HF aims to enhance **LV** networks operation by mitigating the detrimental effects of harmonics in distribution networks by actively detecting and counteracting harmonic currents generated by non-linear loads, such as electronic equipment. This is achieved by creating a much lower equivalent impedance compared with the source impedance at the harmonic frequencies to provide the attenuation required.

1.2.2. D-Suite Concept for D-ST

D-Suite D-ST aims to enhance **LV** networks operation by adding intelligent controls and automation functionalities to the **Secondary Substations**. A general concept of the **D-ST** is shown in Figure 2. **D-Suite** will trial **D-STs** in several schemes to demonstrate various functionalities including:

- *Phase Voltage Regulation* – The overall voltage profile of an **LV** feeder can be optimised by intelligently adjusting the phase voltage at the **Secondary Substation** in response to monitored voltage data points along the length of each **LV** feeder based on available smart meter data.
- *Power Flow Control* – STs have the capability to control power flow due to the inclusion of power electronics. This allows an **ST** to load share with nearby conventional transformers in real time for the purposes of reducing the thermal strain at peak times and maximising network capacity.
- *Reactive Power Control* – An **ST** can offer independent voltage regulations at the **LV** and **HV** terminals. Reactive power support and local voltage regulation at the **HV** terminal can be deployed to improve the voltage profile along the **HV** network. This function can be complementary to the conventional Automatic **Voltage Control** (AVC) scheme at the upstream **Primary Substations**.

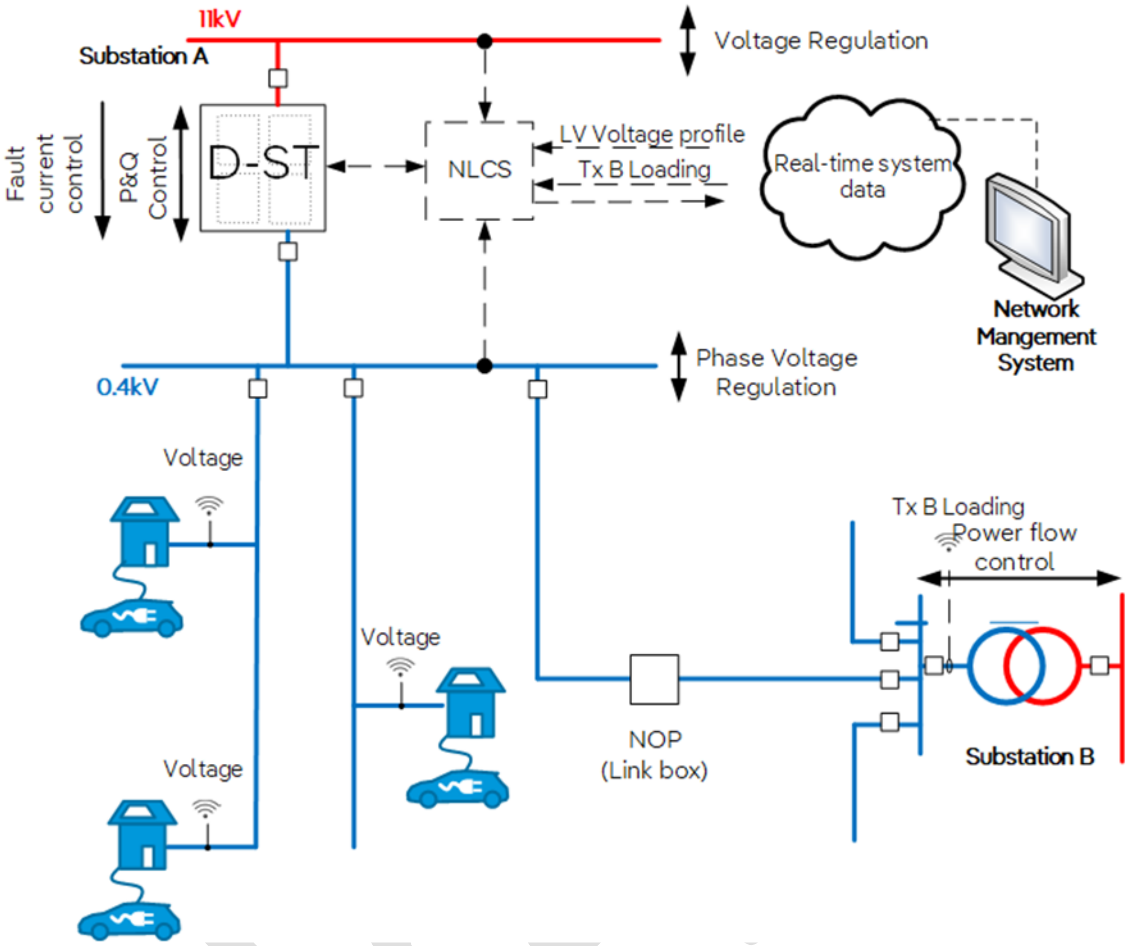


Figure 2 D-Suite control and operational D-ST concept.

There are also number of **Desirable Functionalities** which can be considered for the trial of the ST within D-Suite D-ST solution.

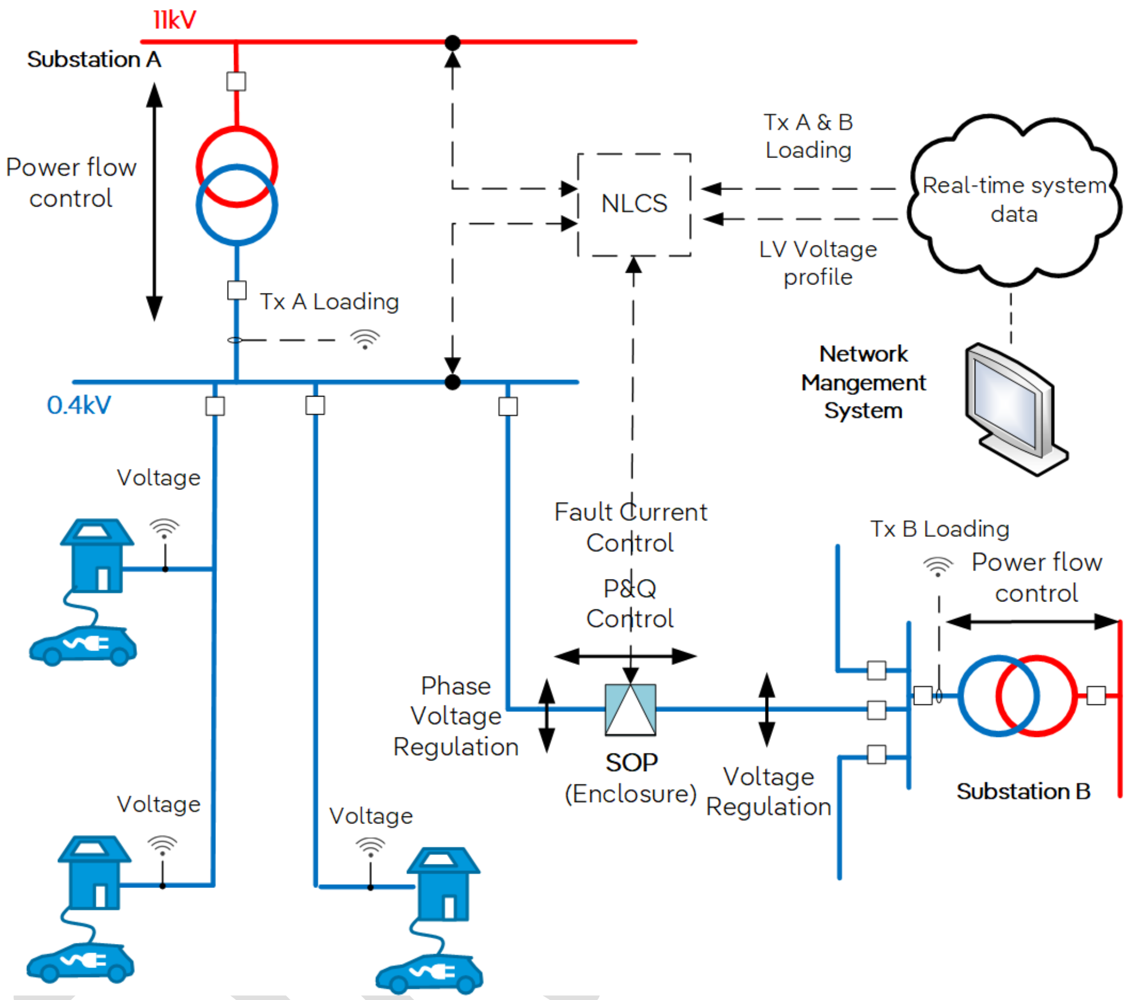
1.2.3. D-Suite Concept for D-STATCOM

***D-Suite D-STATCOM** aims to enhance **LV** networks operation by adding reactive power control at the point of connection. A general concept of the **D-STATCOM** is shown in*

. D-Suite will trial D-STATCOM in a number of schemes to demonstrate various functionalities including:

- *Reactive Power Control* – An STATCOM can offer independent voltage regulation and reactive power output, at the LV point of connection to improve the voltage profile along the feeders the D-STATCOM is connected to. This function can be complementary to the conventional Automatic Voltage Control (AVC) scheme at the upstream Primary Substations.

1.2.4. D-Suite Concept for D-SOP



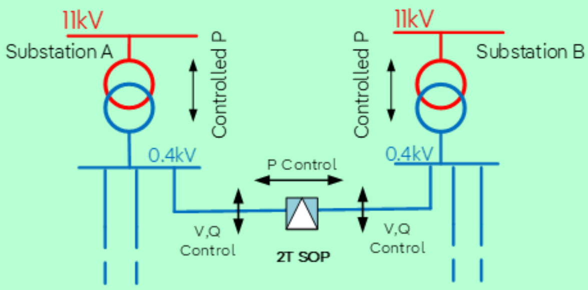
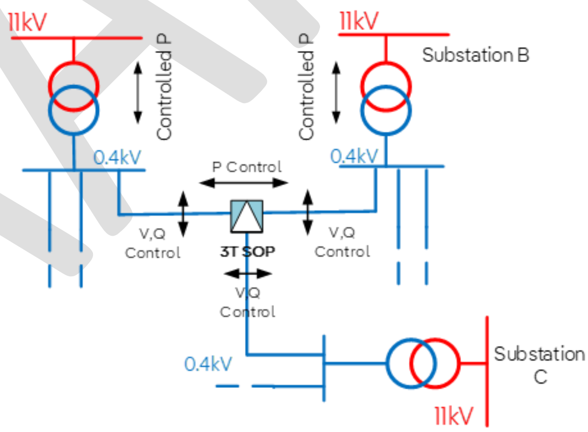
D-Suite control and operational D-SOP concept.

D-Suite will trial **D-SOP** in several schemes to demonstrate various functionalities including:

- *Phase Voltage Regulation* – The overall voltage profile of an **LV** feeder can be optimised by intelligently adjusting the phase voltage in real-time at any LV terminal, in response to monitored voltage data points along the length of each **LV** feeder.
- *Power Flow Control* – SOPs have the capability to control power flow due to the inclusion of power electronics. This allows an **SOP** to load share between conventional transformers, connected to the same feeder, in real time, for the purposes of reducing the thermal strain at peak times and maximising network capacity.
- *Reactive Power Control* – An **SOP** can offer independent voltage regulations and reactive power output, at the **LV** either side of the **SOP**. Reactive power support and local voltage regulation at either **LV** terminal can be deployed to improve the voltage profile along the feeders the SOP is connected to. This function can be complementary to the conventional Automatic **Voltage Control** (AVC) scheme at the upstream **Primary Substations**.

1.2.5. D-Suite Schemes

1.2.6. D-SOP Scheme

Scheme description	Scheme Diagram
Scheme 1 - The Two-Terminal (2T) SOP scheme aims to demonstrate the Voltage Control and capacity sharing functionalities of a 2T SOP between two secondary transformers. The Two-Terminal SOP shall be connected to the LV network via two link boxes. In normal operation, the link boxes shall have a normally open point between them. The link boxes shall act as a physical point of isolation and can also be reconfigured to bypass the SOP in the event that the SOP is disconnected.	
Scheme 2 - The Three-Terminal (3T) SOP scheme aims to demonstrate the Voltage Control and capacity sharing functionalities of a 3T SOP between three secondary transformers. The Three-Terminal SOP shall be connected to the LV network, via fused connections, to the LV board in a secondary substation or LV only substation. In normal operation each port of the SOP is connected to a different substation via separate LV feeders. The fuse carriers shall act as a physical point of isolation and can also be reconfigured to bypass the SOP in the event of the SOP being disconnected.	

1.2.7. D-ST Scheme

D-Suite D-ST will be trialled on several LV networks which can be different in terms of control functionalities and the type of customers supplied. Table 1 summarises the schemes which will be trialled in **D-Suite** project. The trial sites and locations for each scheme will be different. An initial candidate trial sites have been identified but the final sites for each scheme are yet to be confirmed.

Table 1. Summary of D-ST applicable network types.

<table>
<tr><th>Scheme description</th><th>Scheme diagram</th></tr>
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Scheme 1 - This scheme aims to demonstrate the Voltage Control and capacity sharing functionalities of a ST.

The Normally Open Point (NOP) between a conventional substation and the ST will be closed to create a solid interconnector between the two substations. The power flow control at the ST with the NOP closed will allow a controlled exchange of power between LV networks supplied by Substation A and Substation B.

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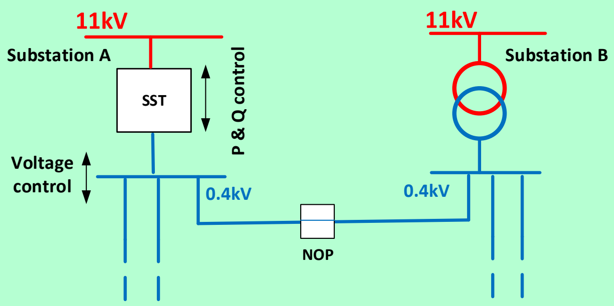

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Scheme 2 - This scheme provides further flexibility to that offered in Scheme 1. It aims to demonstrate the optimum LV Voltage Control and capacity sharing functionalities of the ST conventional transformers.

In this scheme, the ST will share the power with only one conventional transformer at a time which will be managed by the controlled remote switching of NOP-1 and NOP-2.

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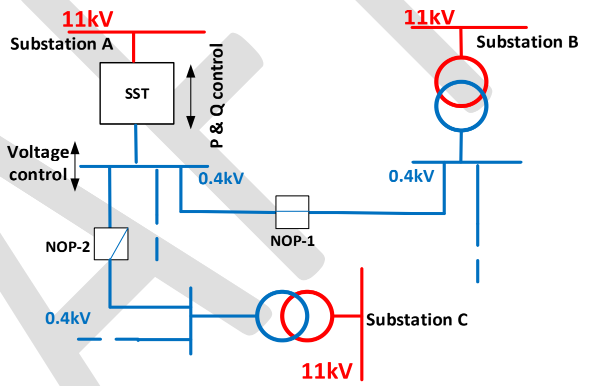

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Scheme 3 - This scheme provides a condition when two D-STs in neighbouring areas are operational.

Scheme 3 aims to demonstrate the optimum LV Voltage Control and capacity sharing functionalities of two STs with one conventional transformer.

In this scheme, the NOP between the three substations will be closed providing two solid interconnectors. The real-time Power Flow Control at STs will provide a controlled power exchange among the LV networks supplied by substations A, B, and C.

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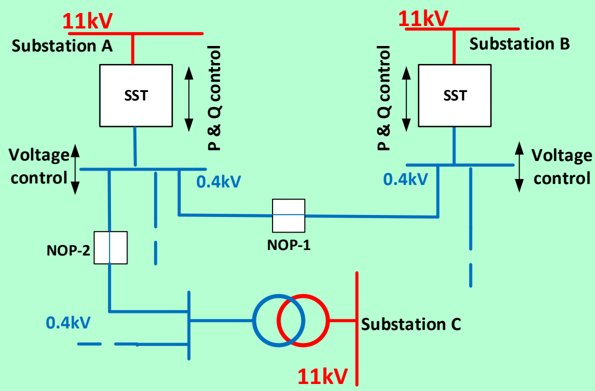

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1.3. Business as Usual (BaU) adoption vision

D-Suite provides an opportunity to demonstrate the performance and benefits of **PED** in different network conditions. SPEN aims to ensure the final D-Suite solutions, and in particular the modular design, can be deployed for BaU adoption. If successful, the solution can potentially be deployed in over 1800 LV networks by 2040 within SPEN to facilitate the growing integration of Low Carbon Technologies. The roll-out within UK is projected to be as high as 12,800 units deployed by 2040.

1.4. General Requirements

This section provides the general requirements of the D-Suite PED, which can be applicable to all **D-Suite PED**. The more detailed technical and functional specifications of **D-Suite PED** are given in Section 2.

1.4.1. D-HF Key Electrical Parameters

The PED's power rating is 5% of its full capacity so it can only process partial power caused by harmonics[3]. The turn ratio of the series transformer is selected as 1:20 so that the phase voltage on the secondary winding is 230V. Therefore, the DC-bus voltage of the PED is selected as 750V. 1200V Si IGBTs or 1200V SiC MOSFETs can be selected as the semiconductors of the PED. According to the IEC standards, total harmonic distortions (THD) should be compliant with the limitations.

Table 2. Design Specification of D-HF.

Series Interface Transformer		
HV Primary Terminal		3-Phase AC
Secondary Terminals		3 Phase AC and Neutral 4-Wire
Nominal Phase to Phase Primary Voltage (RMS)	V_p	0.4kV
Nominal Phase to Phase Secondary AC Voltage (RMS)	V_s	40V
Nominal Frequency	f	50Hz
Nominal Continuous Rating	P	24.2kVA
Vector Group		YYn0
LV system design fault level		25MVA
Harmonic Filter		
Rated AC Voltage (L-L)	V_s	400 V
Rated AC Current	I_s	17.5 A
Rated DC Voltage	V_{DC}	750 V
Output power range	S	30 kVA
Current Total Harmonic Distortion	THD	ER G5/5

1.4.2. D-STATCOM Key Electrical Parameters

There are two main types of D-STATCOMs, which are shown in Figure 3.2. Figure 3.2(a) is a series configuration, where the STATCOM is connected in series with the network. This helps regulate the voltage magnitude, compensate for line impedance, and improve system stability by injecting or absorbing reactive power in series. Figure 3.2(b) is a shunt configuration, where the STATCOM is connected in parallel with the power system at a specific location, typically at a bus or substation. This helps control the reactive power flow at the point of connection and is used for reactive power compensation in distribution systems.

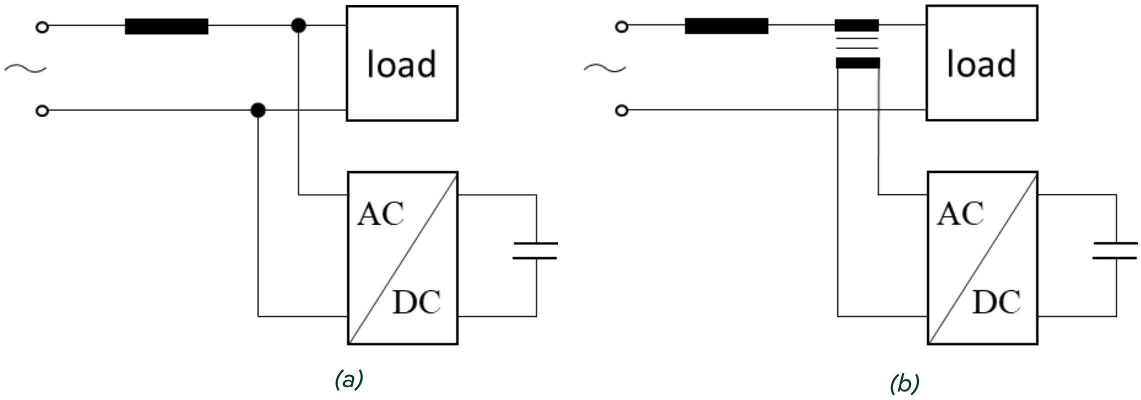


Figure 3. Simplified architecture of D-STATCOMs. (a) Series-connected D-STATCOMs. (b) Shunt-connected D-STATCOMs.

It is assumed that the voltage variation in the grid voltage is ΔV_s and the maximum value of ΔV_s is considered as 10% of the nominal grid voltage (V_s) in this report. Thus, for the shunt configuration it's recommended that the series transformer should be able to provide 10% of the rated voltage to counteract the maximum variation of the grid voltage. As for Figure 3 (b), it is crucial to design the power rating of PED based on the voltage regulation range and short-circuit power S_{SC}. According to the reactive power theory[2], $Q_c = \frac{\Delta V}{V} \times S_{sc}$ is selected. Thus, to compensate for the voltage despite a 10% voltage variation, the capacity of Q_c provided by the STATCOM should be at least $0.1S_{sc}$. The maximum design three phase short circuit currents in SP Energy Networks licence areas, at LV, are 35 kVA. The smallest submodule size is 30kVA.The detailed specifications have been given in Table 3. D-Statcom key parameters series and shunt configuration.

Table 3. D-Statcom key parameters series and shunt configuration.

Series Interface Transformer		
HV Primary Terminal		3-Phase AC
Secondary Terminals		3 Phase AC and Neutral 4-Wire
Nominal Phase to Phase Primary Voltage (RMS)	V_p	0.4kV
Nominal Phase to Phase Secondary AC Voltage (RMS)	V_s	40V
Nominal Frequency	f	50Hz

Nominal Continuous Rating	*P*	30 kVA
Vector Group		YYn0
LV system design fault level		25MVA
Series Connected D-STATCOM		
Rated AC Voltage (L-L)	V_s	0.4kV
Rated AC Current	I_s	35A
Rated DC Voltage	V_{DC}	750V
Output power range	*S*	30 kVA
Shunt Connected D-STATCOM		
Rated AC Voltage (L-L)	V_s	0.4kV
Rated AC Current	I_s	$\frac{0.1S_{sc}}{\sqrt{3}V_s}$A
Rated DC Voltage	V_{DC}	750V
Output power range	*S*	30 kVA (0-$0.1S_{sc}$ kVA)

1.4.3. 2T and 3T D-SOP Key Electrical Parameters

The power converter is capable of controlling power across its full range. The maximum power output is set as 180 kVA, as an example on how to choose other design specifications. Considering the 400 V line-to-line AC voltage, the DC-bus voltage of the PED is selected as 750V. Therefore, 1200V Si IGBTs or 1200V SiC MOSFETs can be selected as the semiconductors of the PED. Detailed specifications of PED are listed in Table 4.

Table 4 2T & 3T soft open points key parameters.

Rated AC Voltage (L-L)	V_s	0.4kV
Rated AC Current	I_s	260 A
Nominal Frequency All Terminals		50Hz
Rated DC Voltage	V_{DC}	750V
Output Power Range – 2T	S_{2T}	180 kVA
Output Power Range – 3T	S_{3T}	180 kVA
Power Factors All Terminal		0.0-1.0
HV system design fault level		250MVA
Output Voltage Control Range	$\frac{V_s}{V_{LV1}}$	100%

1.4.4. D-ST Key Electrical Parameters

The Low Frequency Transformer (LFT) is a 500 kVA 11kV/400V transformer. The power rating of D-ST PED is 5% of the LFT. Thus, the injected phase voltage V_{ser1} at the primary windings of the auxiliary transformer is 11.5 V. The turn ratio of the auxiliary transformer is 1:20 so the RMS value of the phase voltage V_{ser2} of the secondary windings is 230 V. The DC-bus voltage of the PED is selected as 750V. Therefore, 1200V Si IGBTs or 1200V SiC MOSFETs can be selected as the semiconductors of the PED. Detailed specifications of transformers and PED are listed in Table 5.

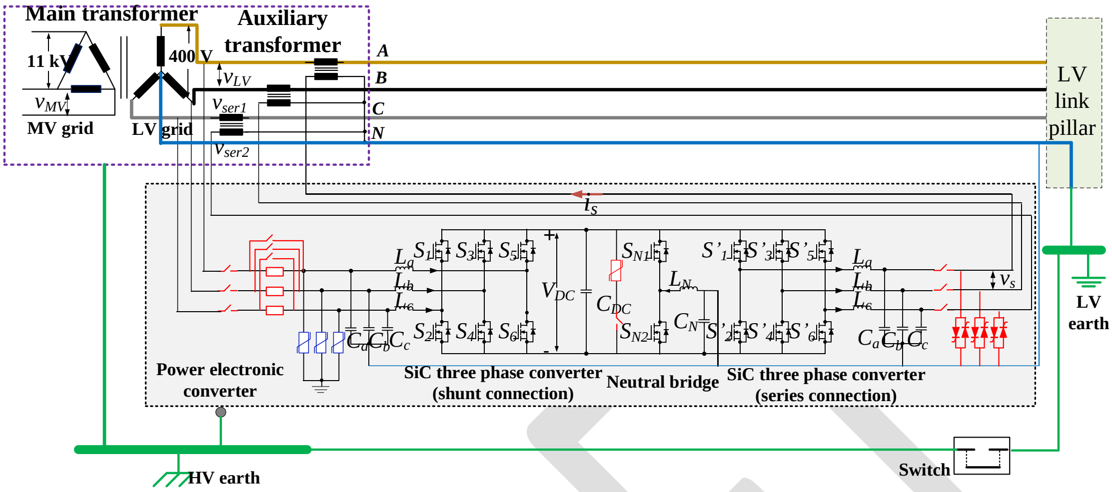


Figure 4. Concept Design of D-ST based on Type 1 of D-ST, utilising 2 D-Suite modules.

Table 5. Smart transformer key parameters.

Transformer	
HV Primary Terminal	3-Phase AC
Secondary Terminals	3 Phase AC and Neutral 4-Wire
Nominal Phase to Phase Primary Voltage (RMS)	11.0kV
Nominal Phase to Phase Secondary AC Voltage (RMS)	0.4kV
Nominal Frequency HV Primary Terminal	50Hz
Nominal Frequency LV AC Secondary Terminal	50Hz
Nominal Continuous Rating	500kVA
Vector Group	DYn11
HV system design fault level	250MVA
LV system design fault level	25MVA
PED Module	
Rated AC voltage (L-L)	400 V
Rated AC current	72 A
Rated DC voltage	750 V

Output power range	30 kVA
Power factor	0.0-1.0
Output voltage control range	5%
Rated AC voltage (L-L)	400 V
Rated AC current	72 A

1.4.5. Service Conditions

The **D-Suite PED** shall be suitable for operation within permanent brick-built enclosure and also preferably suitable for containerised and Glass Reinforced Plastic (GRP) enclosures which are classified as outdoor environment. The modules will be sized to fit through a 2m high doorway.

The **D-Suite PED** shall remain operational at its nominal ratings and deliver all its Core Functionalities for ambient temperature between -25°C and 40°C. The design shall allow for a maximum limit of 90% non-condensing humidity. Surfaces that can be touched must remain within +20 °C of ambient and are not to exceed 55 degrees as per IEC62477. Other thermal insulation material may be used to get over the hot spots around air vents. A cubicle anti-condensation heater will be included internally.

The **D-Suite PED** shall have a minimum degree of ingress protection of IP55 for outdoor application where specified in this document as defined in IEC 60529. When any doors are open, the degree of protection for persons against access to hazardous parts shall be at least to IP2X according to IEC 60529. The door shall have adequate weather resistant gaskets fitted to ensure a weatherproof seal. The ingress protection shall be maintained during the service life and SPEN reserve the right to request relevant evidence from the **PED Supplier**.

All cabinet doors will have a secure locking mechanism. Security socket button head screws can be used to deter access.

The enclosure doors shall have an interlock system that immediately shutdowns the device when the doors are opened.

The 2T **D-SOP and D-STATCOM** cabinet will be designed to prevent water sprayed from pavement cleaning activities from creating a hazard.

All the **D-Suite PED** equipment shall be suitable to operate in pollution class "d." (Heavy) as defined in IEC 60815.

1.4.6. Health and Safety Requirements

All the designs, tests, installations and commissioning of **ST** components shall comply with applicable Health and Safety requirements at the time of tendering. As a minimum the requirements specified in the following documents shall be met.

- The Electricity Safety Quality and Continuity Regulations 2002
- Scottish Power Safety Rules (Electrical and Mechanical) 5th Edition
- The Electricity at Work Regulation 1989

- SHE Standard 07, Model Distribution Safety Rules 2016
- The Health & Safety at Work Act 1974
- The Construction (Design & Management) Regulations 2015

The **Project suppliers** shall provide any additional safety documents and data sheets where required, in addition to those that will be specified by SPEN in the course of project delivery.

In addition, where the aforementioned documents do not provide health and safety compliance requirements, the following safety standards shall be complied with for design and testing of **D-Suite PED** after approval by SPEN:

- IEC 62477-1: Safety requirements for power electronic converter systems and equipment - Part 1: General.
- IEC 62477-2: Safety requirements for power semiconductor converter systems - Part 2: Power Electronic Converters from 1000 V AC or 1500 V DC up to 36 kV AC or 54 kV DC.
- BS EN 61010 Safety requirements for electrical equipment for measurement, control and laboratory use.

D-ST components shall not be flammable or provoke flames or fire after faults or from the breaking down of components. The flammability properties of materials used within **ST** shall be tested in accordance with IEC 62477-1.

1.4.7. Core functionalities

The **D-Suite PEDs** shall be capable of delivering the following **Core Functionalities**:

- *Voltage conversion* – shall provide a voltage conversion function similar to 11kV/0.4kV conventional transformers - **D-ST** only.
- *LV AC Phase Voltage Regulation* – shall have the capability to optimally control the voltage at the **Secondary LV AC Terminal** for each phase (Phase to Neutral) independently in response to voltages monitored at different locations along the **LV** network. - **D-SOP**, **D-STATCOM** and **D-ST**.
- *HV Voltage Control* – shall have the capability to regulate the voltage at the **HV Primary Terminal** by injecting or absorbing reactive power. - **D-ST** only.
- *Power Flow Control* – shall have the capability to optimally control power flow within a meshed network to share the network capacity with other STs and/or conventional transformer. - **D-SOP** and **D-ST.**
- *Bi-directional power flow* – shall be capable of allowing bi-directional power flow, within its operational envelope between **its terminals**. The sum through terminal shall be equal to zero, since no **D-Suite PED** contains energy storage - D-**SOP** and **D-ST**.
- *Load Balance* – shall have the capability to eliminate any load imbalance transfer between terminals **D-SOP**, **D-STATCOM** and **D-ST**.

Core Functionalities shall be delivered in Normal Operating Conditions regardless of whether the D-Suite **PED** operates within a Radial or Meshed LV Network.

1.4.8. Desirable Functionalities

The **D-Suite PED** shall be capable of delivering the following Desirable Functionalities:

- *Active Harmonic Filtering* – It is desirable that the **D-Suite PED** is capable of performing as an active harmonic filter to alleviate voltage harmonic distortion in the LV networks or HV networks to achieve compliance with individual harmonic order limits and Total Harmonic Distortion target.

1.4.9. Availability and Reliability

The **D-Suite PED** shall be highly reliable, available and robust to ensure the minimum impact on continuity and quality of supply to LV customers. ST is required to operate 365 days and 24 hours per day annually while not under maintenance. The following performance targets shall be required:

- Reliability > %99.9
- Forced Outage Rate < 3 outages per annum
- Availability > %99.9
- Scheduled Outage Rate < 2 outages per annum

Failure in any major components shall not have any impact on other network assets, monitoring equipment, protection system or any device interacting with ST beyond anticipated operational protection requirements.

D-Suite PED Suppliers shall provide the expected reliability and availability of the **D-Suite PED** main components in the tender response and the approach they have been calculated.

The service lifetime of the **D-Suite PED** shall be over 30 years with limited part replacements. The manufacturing partner shall provide expected D-Suite PED lifetime, annual maintenance and part replacement requirements in the tender response.

Project Partners shall indicate any potential obsolescence of the technology provided and if so at what point in the equipment lifetime it is anticipated that some components or systems will need to be upgraded.

1.4.10. Sound level

The sound power level of any **D-Suite PED** shall not exceed 56dBA as specified in ENA TS-35. The sound levels shall be tested in accordance with IEC 60076-10 and consider the full operation of all components of the **D-Suite PED** as a complete system. Octave bands of sound power shall be provided and adhered to.

The **PED Supplier** shall provide the guaranteed sound power levels with expected tolerances and any proposed method for sound level reduction.

1.4.11. Electromagnetic compatibility

The ST shall not cause Radio Frequency Interference (RFI) in the substation and radiated emission shall comply with CISPR/TR 18-2.

The electromagnetic interference level of the **D-Suite PED** shall comply with the requirements in IEC 61000-6-3 and ICNIRP Guidelines Exposure to Time-Varying Electric and Magnetic Fields.

All the auxiliary, control and protection equipment of ST shall be immune to electromagnetic interference in accordance with ENA TS 48-05 and the requirements specified in IEC 61000-6-5.

1.5. Warranty

The **Project suppliers** shall provide warranty for 4 years following successful commissioning of each PED Device. The warranty period will cover troubleshooting, replacements of all components due to equipment failure and required regular maintenance. A service maintenance agreement will be negotiated as part of the Best and Final Offer process.

1.6. Third party access

It is required that **PED suppliers** shall be able to have remote access to **PED** controllers for any diagnostic, firmware update and troubleshooting requirements. Any third-party access is required to be via a dedicated point to point VPN link into SPEN secure network and via terminating in a Jump Server before making a new connection onwards on to the relevant field equipment.

1.7. Auxiliary power

The **PED Suppliers** shall confirm the maximum level of auxiliary AC and DC power and its nominal voltage supply requirements. It is desirable that the primary source of auxiliary power will be from existing 11kV or 0.4kV network within the **Secondary Substation**.

The **PED Suppliers** shall confirm any backup auxiliary supply requirements in different operating conditions of each **D-Suite PED**.

1.8. Project location

D-Suite trial sites will be located within SP Manweb or SP Distribution licence areas, which include Central and South Scotland, Merseyside & North Wales in the UK. The **PED supplier** shall be responsible for delivery of the equipment to any trial site specified by SPEN.

A preliminarily list of potential trial sites for each license area has been prepared and reported in the D-Suite site selection report.

1.9. Packaging for shipment

All equipment shall be packed with appropriate protection to avoid any damage to the equipment during transit and storage. Suppliers shall provide long term storage requirements, in case SPEN is required to hold **PED** devices in storage.

The **PED Suppliers** shall deliver all the equipment, with a record of no damage, to the trial sites specified by SPEN prior to delivery.

Delivery Duty Paid (DDP) incoterms 2010 shall be applied to all deliverable equipment.

1.10. Drawings and Documentation

The **PED Suppliers** shall provide all appropriate operation, maintenance and health and safety documentations for all the equipment provided.

Operational clearances and physical layout of the equipment on **D-Suite** trial sites, with corresponding labels, shall be reflected in the final drawings and sketches provided by the **PED Suppliers**.

The **PED Suppliers** shall provide the sketches and drawings of all the wiring and connectivity of electrical and communication equipment up to and including the SPEN interface.

The **PED Suppliers** shall provide a complete troubleshooting and maintenance document based on the implemented system architecture including system shutdown, system safe isolation and system restoration.

All the documentations shall be provided in electronic formats approved by SPEN. As a guideline, drawings and sketches shall be provided in AutoCAD and PDF format with the software versions approved by SPEN. The reports shall be provided in Microsoft Word and PDF format with the software versions approved by SPEN.

The **PED Suppliers** may be also requested to provide a printed format of the documentation.

2. Technical & Functional Specifications

2.1. General Functionality Requirements

D-suite PED shall be able to provide **Core Functionalities** in both **Radial Network** and **Meshed Network** arrangements and fulfil the objectives of the scheme outlined in Section 1.

2.2. D-ST Topology

The focus of the **D-Suite** is demonstrating the performance of the **Core Functionalities** required by the network. As such any innovative approaches that provide these **Core Functionalities** in an efficient and reliable manner will be considered.

Topology using a conventional low frequency 50Hz (LF) transformer –This topology uses power electronics devices at the secondary side of conventional LF transformers (11kV/0.4kV). The power electronic devices can be added to the existing distribution transformers to deliver the **Core Functionalities** of **D-Suite D-ST**. **D-ST supplier** is required to provide the conventional transformer and the power electronic units.

D-Suite aims to trial the above topology buy using modular components to reduce cost and create the opportunity to compare their performance, inform cost benefit analysis and planning process for selecting the suitable topology.

The conventional transformer provided in Topology 1 shall be in full compliance with SPEN TRAN-03-02.

The **D-ST Supplier** shall provide the costing breakdown associated with the topology as specified within the pricing schedule.

2.3. Voltage Control Capabilities

It is required that **D-ST** shall deliver **Voltage Control** requirements in **Normal Operating Conditions** when **ST** operates within a **LV Radial Network** or **LV Meshed Network**.

2.3.1. Voltage Control Range

The **D-ST** shall have the capability of **Voltage Control** at the **Secondary AC Terminal** within the range of - 10% to +10% of nominal voltage (0.4kV) in response to **LV Voltage Set Points** for each phase received from a **NLCS**. This **Voltage Control** capability shall be achievable in all loading conditions (No-load to full load) when the primary nominal voltage (11kV) with -%15 to +%15 tolerance is applied to the **HV Primary Terminal**.

The **D-ST** shall be capable of controlling the voltage of each phase (phase-neutral) at the **Secondary AC Terminal** independently. The **Voltage Control** capability range at the **Secondary AC Terminal** (see above) shall be applicable to each phase independently.

The **D-ST** shall be capable of **Voltage Control** at **HV Primary Terminal** by injecting/absorbing reactive power from/to the 11kV network. The level of reactive power injection/absorption shall be optimally determined by the **D-ST** internal algorithm considering the **Power Capability of D-ST** and **HV Voltage Set Point** received form **NLCS.** The **HV** voltage capability is expected to be similar to STATCOM performance, as shown in Figure 5. The optimum dead band settings shall be determined by the **D-ST supplier** during the **D-ST** design phase.

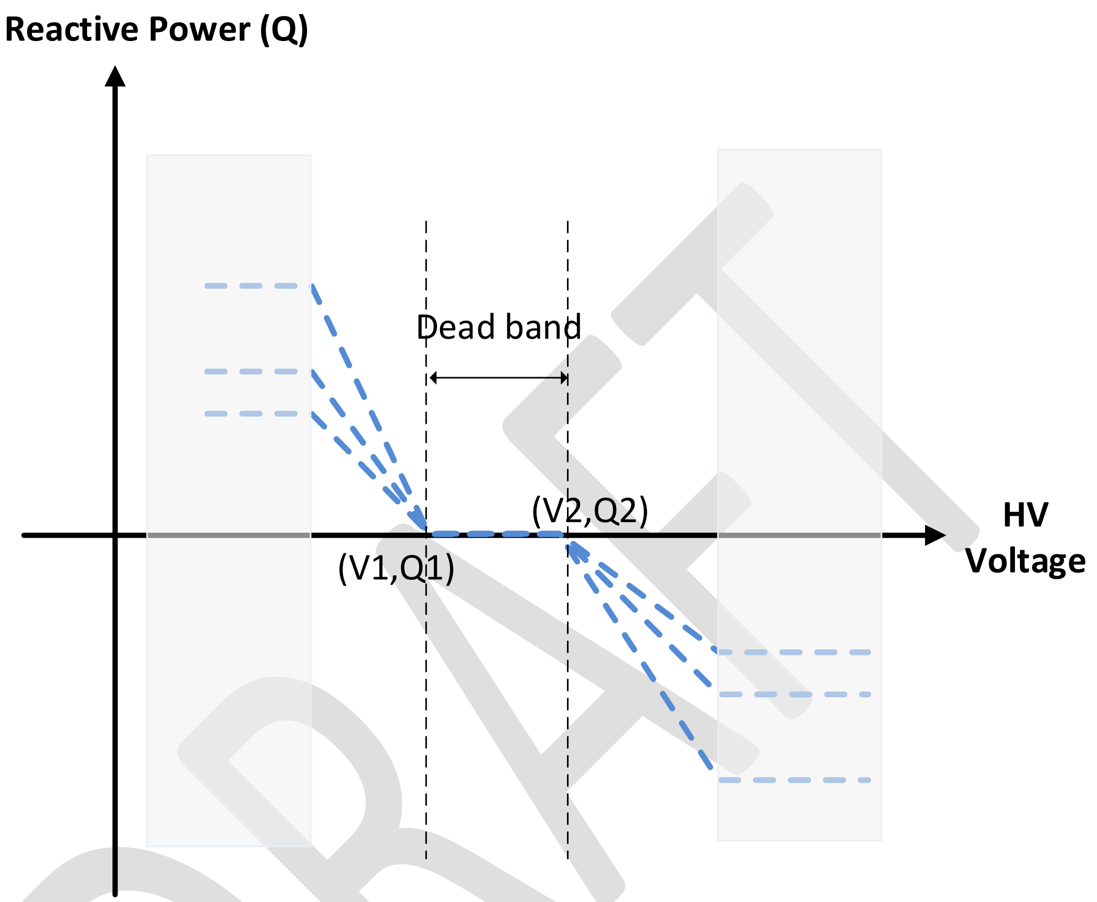


Figure 5 –Typical STATCOM voltage control performance

It is required that voltage regulation capability is independent at each **D-ST** terminal and not affected by the voltage set points at other terminals. For example, operating at particular **LV** AC voltage Set Points shall not limit the **Voltage Control** range capability at the **Primary AC Terminal.**

D-ST shall be capable of operating within full lead/lag power factor range (0 to 1.0) at both the **HV Primary Terminal** and the **Secondary AC Terminal** within the **Power Capability of D-ST**, as described in section **2.6**.

2.3.2. Response time

D-ST's **Response Time** for voltage regulation at the **Secondary AC Terminal** shall be less than 2.0 seconds upon receiving the **LV Voltage Set Point** from **NLCS**.

D-ST's **Response Time** for **D-ST** to perform optimal reactive power injection/absorption from the **Primary Terminal** shall be less than 2.0 seconds upon receiving the **HV Voltage Set Point** from **NLCS**.

It is desirable that **D-ST** is capable of performing voltage regulation at all terminals simultaneously and independently.

2.3.3. Accuracy & Granularity

The accuracy of the **Voltage Control** provided by **D-ST** shall be less than ± 0.5% of the nominal voltage at the **D-ST** terminals. This requirement shall be applicable for the controlled voltage at the **AC Secondary Terminal** and **DC Secondary Terminal**.

The accuracy of the reactive power injection /absorption from **HV Primary Terminal** shall be less than ± 0.5% of the **D-ST** nominal rating (500kVA).

The accuracy of **Voltage Control** shall remain within the specified limits in all loading conditions (from no-load to full-load) within **Power Capability of D-ST**.

D-ST shall be capable of applying a step change (coarse) and continuous change (fine) in voltage at the **D-ST** terminals. This should be configurable by the appropriate commands received from **NLCS**.

D-ST shall be capable of applying continuous voltage change or voltage step change (increase and decrease) between 1.0% to 2.5% of nominal voltage at the controlled terminal. **D-ST** shall consider a configurable minimum delay time (in seconds) between two subsequent step changes.

2.4. Power Flow Control Capabilities

Table 6. Summary of D-Suite PED Service Provisions

Type of Service	D-Suite PED
Real power transfer.	**D-SOP** and **D-ST**
Reactive power support.	**D-STATCOM, D-SOP** and **D-ST**
Voltage support and voltage equalisation.	**D-STATCOM, D-SOP** and **D-ST**
Power factor correction and improvement.	**D-STATCOM, D-SOP** and **D-ST**
Loss reduction	**D-SOP** and **D-ST**
Harmonic content improvement.	All **D-Suite PED**
Fault ride through.	All **D-Suite PED**

D-ST and **D-SOP** shall be capable of controlling active power supplied, to **LV AC Terminal,** in response to **Active Power Set Point**. The **D-ST**, **D-SOP** and **D-STATCOM** shall be capable of controlling reactive power, supplied to **LV AC Terminal,** in response to **Reactive Power Set Point** received from the **NLCS**.

D-ST and **D-SOP** shall be capable of controlling the active power and reactive power, in the complete full range and with any ratio between active power and reactive power within **Power Capability** of **D-ST or D-SOP**.

D-ST and **D-SOP** are required to have bi-directional **Power Flow Control** capability that allows controlling active power and reactive power in full range independently and in any direction, relative to their **AC Terminals.**

D-Suite PED Response Time for Power Flow Control shall be less than 2.0 seconds upon receiving Active Power Set Point (**D-ST** and **D-SOP**) and Reactive Power Set Point received from the **NLCS**.

The accuracy of the **Power Flow Control** provided by **D-STATCOM** and **D-SOP**, **D-ST** shall be less than ± 0.5% of the **Active Power Set Point** and **Reactive Power Set Point** received from **NLCS**.

2.5. Load Balance Capability D-ST

The aggregated load supplied by a transformer at the **Secondary Substation** may be unbalance due to uneven connection of customers to different phases or outage of faulted phase(s) in **LV** circuits. This unbalance load is usually transferred to the **HV** network and may cause additional losses in the **HV** network or impact on **HV** earth fault protection. **D-ST** shall be capable of eliminating any unbalance **LV** load that may be otherwise transferred to **HV Primary Terminal**.

2.6. Power Capability

The nominal continuous rating of **D-ST** types shall be 30kVA and the **D-SOP** 180 kVA with four quadrant operation capability as shown in Figure 6. Any limitation in the full four quadrant operation capability (A to G points in Figure 6) shall be declared in the tender response.

The D-ST and D-SOP shall be capable of supplying bi-directional active power and reactive power in the full range of loading conditions (No-load to nominal rating) regardless of the direction of active and reactive power and also the ratio between them.

D-ST and **D-SOP** shall be able to supply the demand variations in **LV** network immediately as they occur without compromising the **Core Functionalities** and supply quality requirements specified by ESQCR.

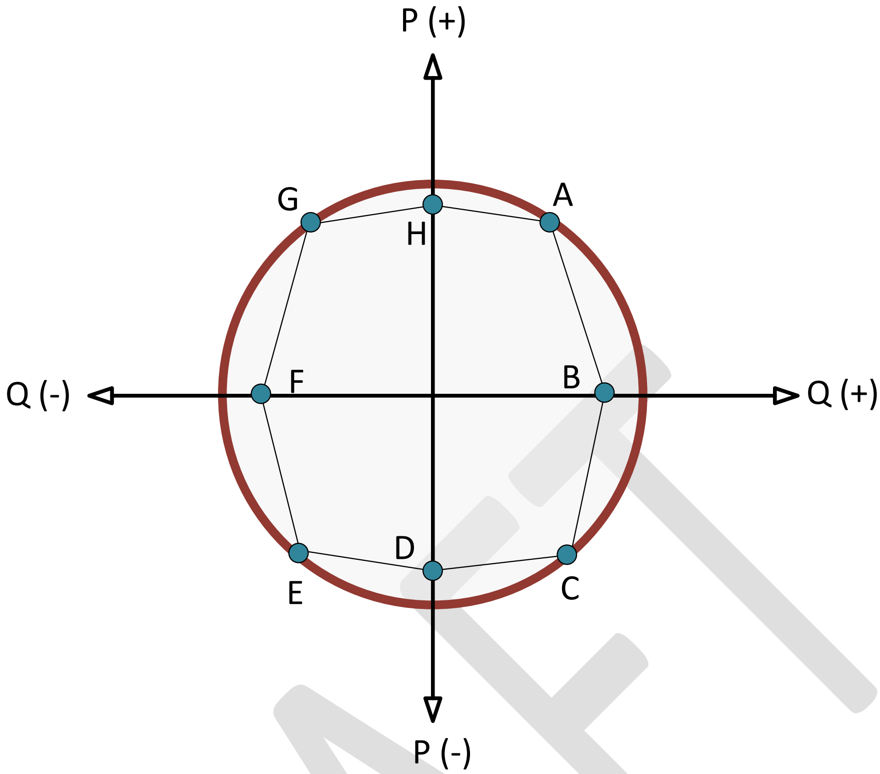


Figure 6 – Power capability of D-Suite PED.

D-Suite PED suppliers shall declare the power envelope capabilities, of their devices as shown in graphically in Figure 6 and numerically in Table 7.

Table 7. D-SOP and D-ST Power Capability Declaration.

Power Envelope Point	P (kW)	Q(kVAr)
A	-	-
B	-	-
C	-	-
D	-	-
E	-	-
F	-	-
G	-	-
H	-	-

2.7. Modular and Scalable Design of D-Suite Devices

2.7.1. Scalable Modular Approach

To facilitate modular design, multiple basic units can be combined to construct different D-Suite devices (i.e., **D-STATCOM**, **D-ST**, **D-HF** and **D-SOP**). The **D-ST** and **D-SOP** require two basic units while the **D-STATCOM** and **D-HF** require only one basic unit. The integrated software configuration of the basic unit allows for the enabling or disabling of functions such as current protection from thyristors.

To comply with LV networks, the power rating of the basic unit is designed with 400 V rated AC voltage and 750 V DC voltage. Thus, the voltage rating of power semiconductors can be chosen as the same parameters (i.e., 1200 V Si IGBT or 1200 V SiC MOSFET). The D-SOP requires fully rated power whereas the D-STATCOM, D-ST and D-HF only withstand 5% to 10% of the rated power. To ensure compatibility with all D-Suite devices and to optimise cost, the basic unit of PEDs shall be designed with one rating when submitting a modular design. The specifications of the basic unit of PEDs with maximum power 30 kVA are listed in Table 8 as an example.

Table 8. D-Suite base module specification.

Basic D-Suite Module Specification		
Rated AC Voltage (L-L)	V_s	0.4kV
Rated AC Current	I_s	43A
Rated DC Voltage	V_{DC}	750V
Output power range	S	0-30 kVA
Shunt Connected D-STATCOM		
Rated AC Voltage (L-L)	V_s	0.4kV
Rated AC Current	I_s	$\frac{0.1S_{SC}}{\sqrt{3}V_s}$A
Rated DC Voltage	V_{DC}	750V
Output power range	S	30 kVA

The D-Suite PED design shall be scalable and modular. The D-Suite PED shall be made up of between one (30kVA D-STATCOM) and twelve (180kVA 2T D-SOP) module 30kVA modules. The design should also be cable of connecting and scaling to a 3T D-SOP (18 modules at 180 kVA, though this is an optional requirement. An example of one 30kVA module is provided in Figure 7.

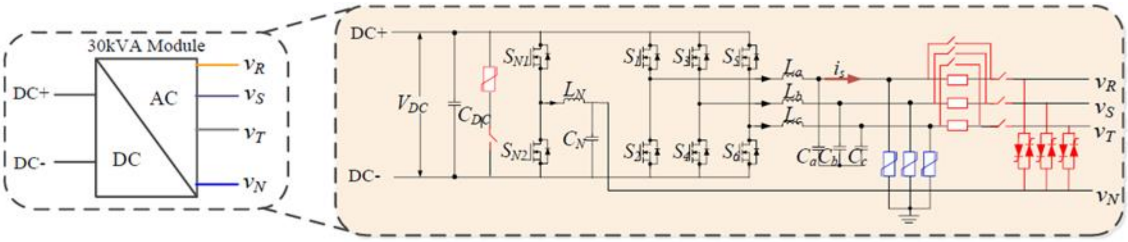


Figure 7. One D-Suite 30 kVA module, the smallest power electronic module, of which other D-Suite PED are made.

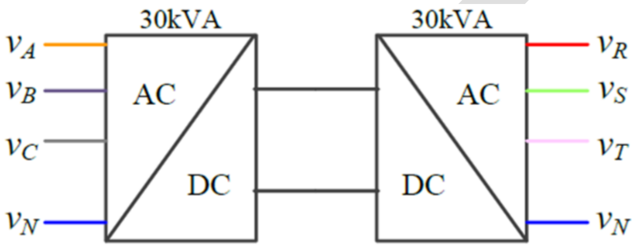


Figure 8. The smallest capacity D-SOP rated at 30kVA, comprising of two 30kVA modules, connected back-to-back.

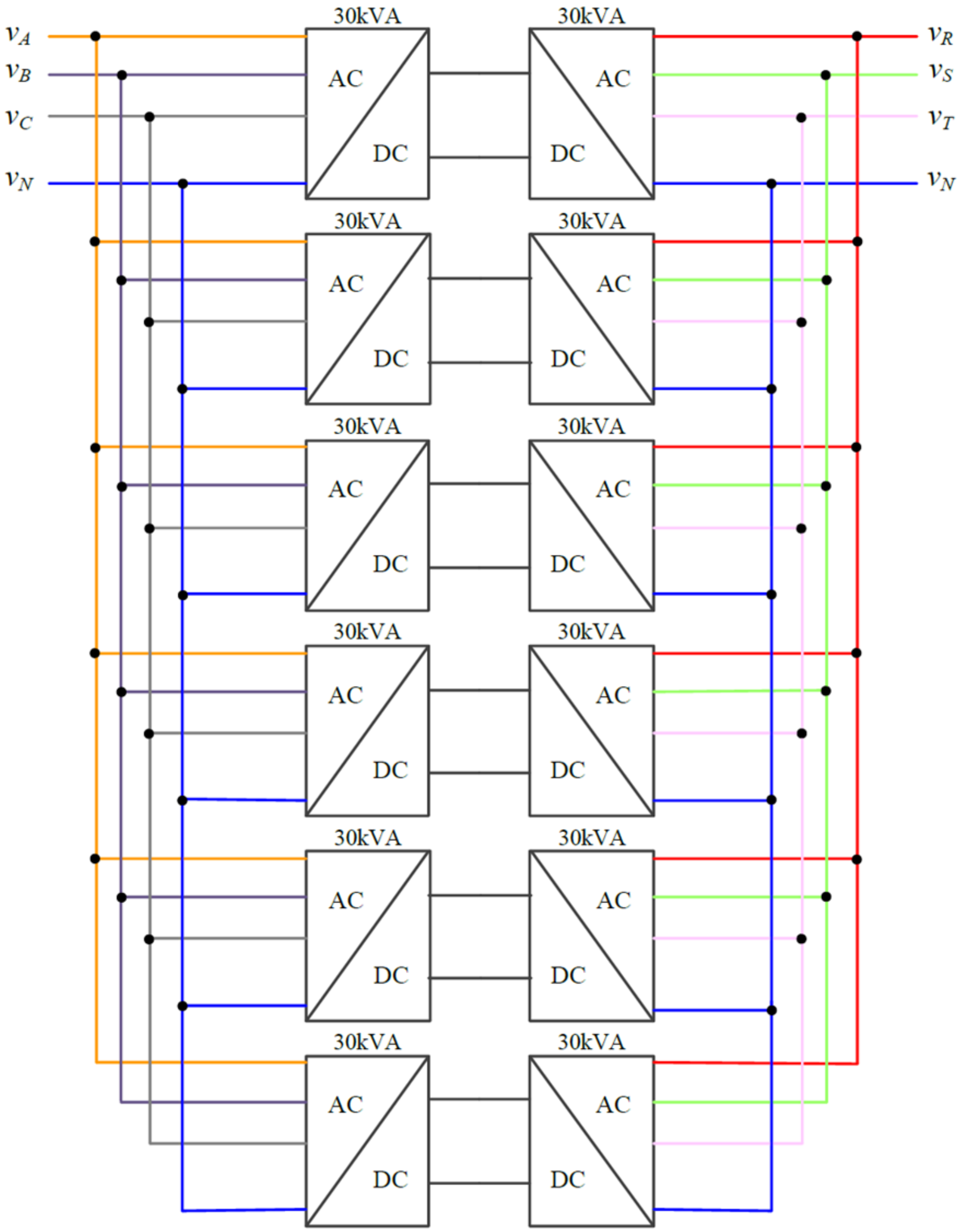


Figure 9. The largest capacity D-SOP, rated at 180kVA, compromising of twelve D-Suite 30kVA modules, connected back-to-back.

2.7.2. Alternatives to a Scalable Modular Approach

Suppliers can submit non-modular designs, if the submitted designs are partially rated, to allow a reduction in cost, size and cooling requirements over their standard products. The partial rating should be as close to the ratings in Section 8, as far as practical. The design should be based on current commercial products, with high TRL and where significant reduction in development time and cost, over developing a new modular solution, can be realised. Equal scoring shall be given to modular and partially rated, non-modular designs.

2.8. Redundancy

It is desirable to provide a modular design that can allow a level of redundancy of **D-Suite PED** components and improve the overall reliability and availability of **D-Suite PED**. This may include series or parallel redundancy of power electronic modules.

It is desirable that the replacement of any faulted module does not require de-energisation of **D-Suite PED** and can be conducted while **D-Suite PED** operates normally.

2.9. Cooling System

D-Suite PED shall deploy a low maintenance and reliable cooling system. The manufacturing partner shall design a cooling strategy that would be fit for purpose for application in **Secondary Substations** and fulfil the cooling requirements of the **D-ST** for operation in all network conditions and delivery of its **Core Functionalities**.

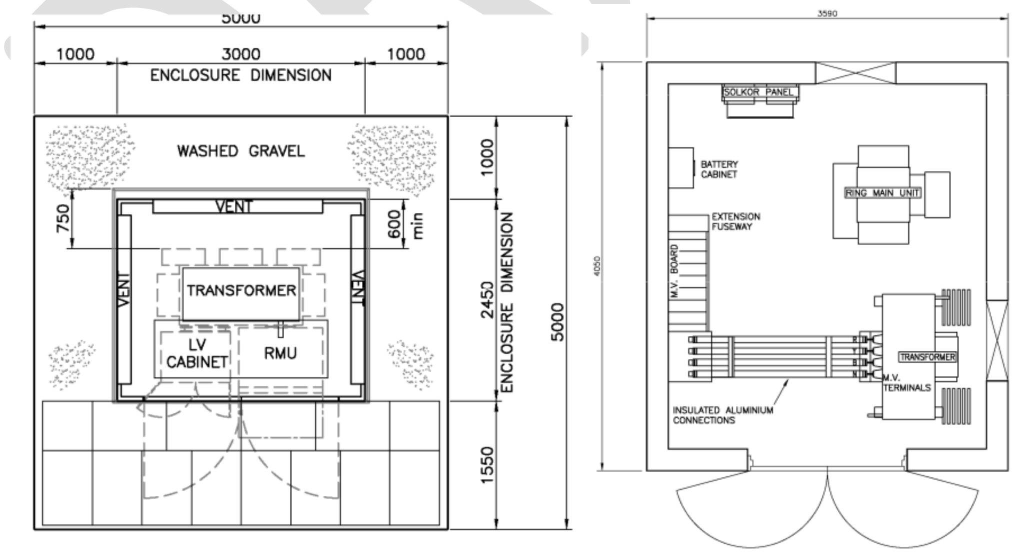
The cooling system shall include a design that avoids creating any obstruction with cable boxes, terminals, flanges and fittings or has adverse impact on the existing plant and equipment within the substation and any GRP enclosure/building modifications.

The cooling system should be limited maintenance, with a minimal number of filter changes through the lifetime of the system.

2.10. Construction & Footprint & Volume

2.10.1. D-ST

D-ST size shall be suitable for installation in the **Secondary Substations** along with other typical existing **LV** and **HV** plant equipment. The typical **Secondary Substation** layouts for outdoor and indoor designs are shown in Figure 10.



(a) Layout of outdoor direct coupled substation within GRP enclosure.

b) Typical layout of indoor substation within brick building.

Figure 10 – Typical substation layout (all dimensions are in mm)

ENA TS 35-1 Part 3 provides limiting dimensions for ground mounted substations with two different **HV** and **LV** terminal arrangements: i) **HV** and **LV** terminals are on opposite sides, ii) **HV** and **LV** terminals are on the same side. Figure 10 and Table 9 show the limiting dimensions for the two terminal arrangements. In addition to the ground mounted transformer types detailed in ENA TS 35-1, Part 3 a special "Tall type" transformer is deployed by the SP Energy Networks. The dimensions of the Tall Type transformer are shown in Figure 12.

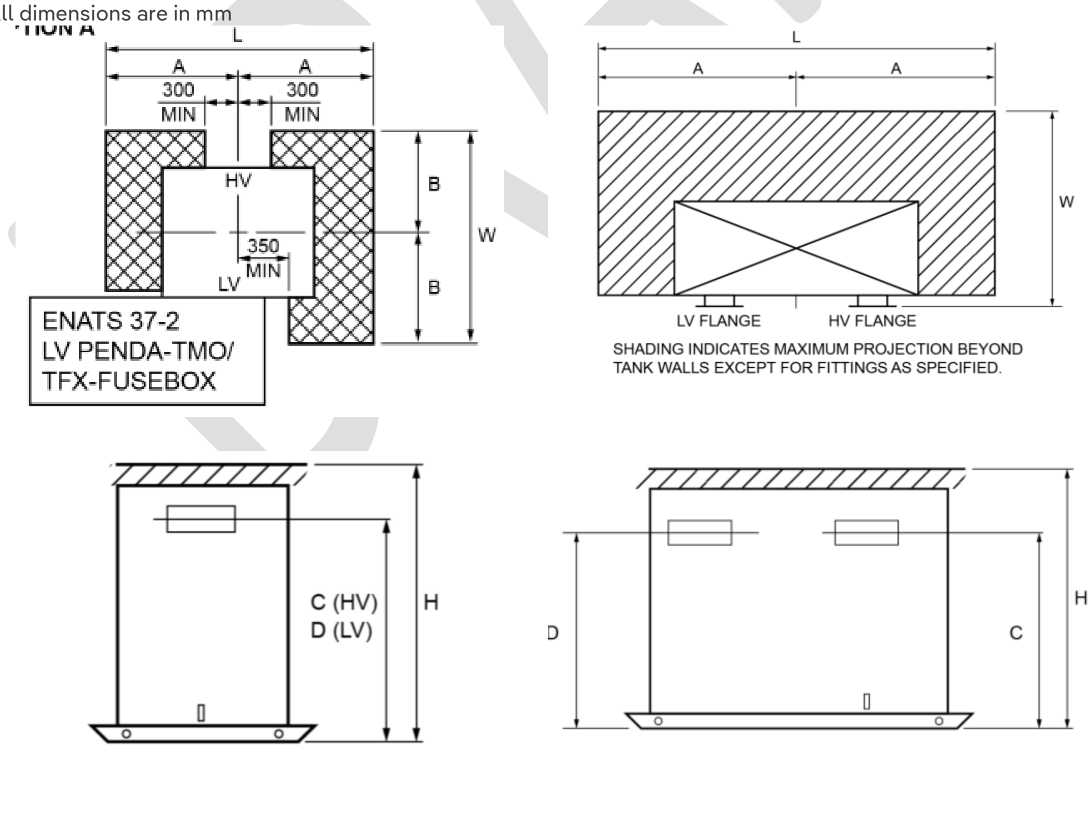
The limiting dimensions presented in Table 9, Figure 10 and Figure 11 shall be used as a guideline by the **D-ST supplier** to design an acceptable **D-ST** size. The manufacturing partner shall provide the estimated dimensions of their proposed **D-ST** design with realistic tolerances in the tendering response.

The **D-ST** shall be suitable for both indoor and outdoor arrangements shown in Figure 10. Topology 1 shall be a compact design that can be fitted within the majority of the existing substations.

Table 9 – Limiting Dimensions for 500kVA ground mounted transformer (ENA TS 35-1)

	L (MAX)	A (MAX)	W (MAX)	B (MAX)	C (HV)	D (LV)	H (MAX)
Figure 11 (a) - Ground Mounted Transformer with HV and LV terminals on opposite sides	1700	990	1220	710	1320	1320	1830
Figure 11 (b) - Ground Mounted Transformer with HV and LV terminals on the same sides	1900	1150	970	-	1320 (a) 1525 (b)	1320 (a) 1525 (b)	1750

All dimensions are in mm



(a) *(b)*

Figure 11 – Dimensions of typical ground mounted transformer. a) SPD MGT b) Manweb GMT.

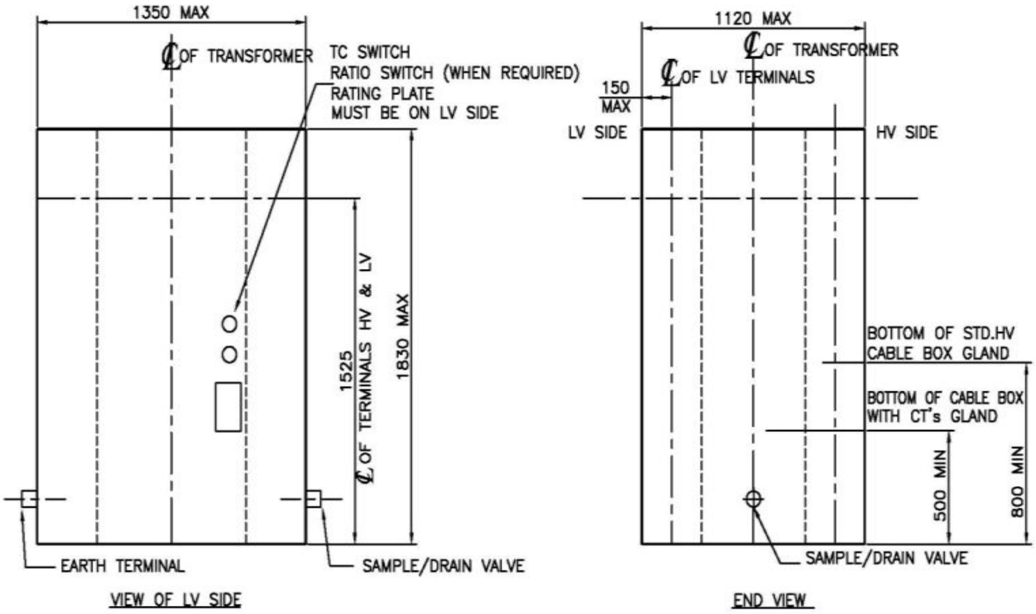


Figure 12 – Dimension of tall ground mounted transformer

2.10.2. D-SOP, D-STATCOM and D-HF

The maximum dimensions shall be 2600 mm (W) x 1800 mm (H) x 600 mm (D), with a maximum weight of 1500kg.

2.11. Alarms and Alerts – All D-Suite Devices

D-Suite PED shall be able to identify the following operation status, as a minimum, and provide appropriate alarms and alerts:

- Internal faults/trip – Fault and trip alarms shall contain information about specific type of fault location and source of trip.
- Overheating conditions – The maximum temperature threshold which triggers this alarm shall be configurable
- Overloading – The maximum loading threshold which triggers this alarm shall be configurable
- Cooling system alarms – An alarm stage, to forestall a future trip is required.

2.12. Built in Monitoring requirements - All D-Suite Devices

D-Suite PED shall be fitted with number of monitoring devices to provide following measurements:

- RMS voltage at all terminals
- Current, active power (if available) and reactive power at all terminals

- **Total Harmonic Distortion** at all terminals
- Voltage phase angles at **all terminals**
- Temperature measurement at hot spots if utilising a transformer.

In addition to real-time monitoring capability, **D-Suite PED** shall be able to determine and provide average values of monitored parameters over a configurable time period (as low as 1 minute) to **the NLCS** with appropriate time stamp.

All the measurement values shall comply with requirements specified by BS EN 61000-4-30.

2.13. Display - All D-Suite Devices

D-Suite PEDs shall be fitted with appropriate LED display which can show, as a minimum, the following parameters:

- Status of **D-Suite PED** (Active/Standby/Starting Up).
- Alarms and alerts listed in Section 2.10.2.
- Monitored parameters listed in Section 2.12.
- Overall loading of the **D-Suite PED.**

2.14. Operating losses - All D-Suite Devices

D-Suite PED operation losses is an imperative criterion for evaluating the **D-Suite PED** design. The cost of **D-Suite PED** losses will be considered for the commercial evaluation of tender response. The **D-Suite PED** losses data provided by manufacturing partners will be capitalised by **SPEN**, considering the losses cost coefficient specified in Table 10.

Table 10 – Losses coefficients cost

	% OF NOMINAL LOADING (500KW)					
	15%	25%	35%	50%	80%	100%
Losses coefficient (£/kW)	1,250	2,500	3,751	3,751	1,000	250

The following formula will be used to calculate the overall cost of a **D-ST and other D-Suite PED** solutions:

$$Total\ cost\ of\ a\ single\ unit\ (£) = Proposed\ unit\ cost\ (£) + \sum (L_i * C_i)$$

L_i : Losses at loading i (kW)

C_i : Losses coefficient at load level I (£/kW)

The **D-Suite PED supplier** shall provide the **D-Suite PED Efficiency** and **expected tolerances.** The efficiency shall include the operation of all the components of **D-ST** including the power electronics units, cooling systems, low frequency transformers (where applicable), auxiliary power etc.

2.15. Normal Operating Conditions - All D-Suite Devices

D-Suite PED shall be capable of delivering its **Core Functionalities** to the full extent in Normal Operating Conditions without causing any interruption to security, quality and continuity of supply to electricity customers in accordance with ESQCR. As a minimum, the conditions shown in Table 11 are considered the network's Normal Operating Conditions:

Table 11 – Network Normal Operation Conditions

NETWORK VARIABLE	NORMAL VARIATION RANGE	
	Lower bound	**Upper bound**
System Frequency	47.0Hz	52.0 Hz
HV Network Voltage (% of nominal voltage)	85.0%	115.0%
LV Network Voltage (% of nominal voltage)	85.0%	110.0%
Unbalance HV Voltage (% of nominal voltage)	0.0%	3.0%
Unbalance LV Load	0.0%	100.0%
Total Harmonic Voltage Distortion	0.0%	8.0%
Design fault levels		
HV (11kV) network design 3-ph fault level	250MVA	
HV (11kV) network design 1-ph fault level	250MVA	
LV (0.4kV) network design 3-ph fault level	25MVA	
LV (0.4kV) network design 1-ph fault level	25MVA	

2.15.1. Total System Frequency range

Total System Frequency range is between 47.0Hz to 52.0Hz for 100% of the time. For the purpose of **D-Suite PED** design, this range is considered as the normal frequency variations within the network. It should be noted that the Total System Frequency is between 49.5 to 50.5 for 95% of the time.

2.15.2. Voltage range

The voltage variation within **HV** network (11kV) is considered acceptable to be within 85% to 115% of the nominal rating.

The voltage variation within **LV** network (0.4kV) is considered acceptable to be within 85% to 110% of the nominal rating.

2.15.3. Unbalanced HV Voltage – DST Only

Network design standards, as specified in ER P29, allow 2% unbalanced phase voltage at **HV** networks (11kV). However, the unbalanced voltage can occasionally be as high as 3%. Up to 3% unbalanced phase **HV** voltage is considered acceptable in Normal Operation Conditions.

2.15.4. Unbalanced LV Load

Unbalanced load is normal in **LV** networks, and it can be as high as 100% between any 2 phases i.e., one phase fully loaded and the other phase at no-load. It is a requirement that **D-Suite-PED** continues its normal operation with extreme load imbalance conditions in the **LV** network.

2.15.5. Harmonic Voltage Distortion

As specified in BS EN 50160, the Total Harmonic Distortion in the network can be up to 8% under the normal operating conditions. **All D-Suite PED** shall operate normally under this harmonic voltage distortion level at either, or both, the **HV Primary Terminal (D-ST)** and the **LV AC Terminals,** together with individual harmonic orders limits given in Table 12.

Table 12 –Compatibility values of individual harmonic voltages at the supply terminals for orders up to 25 given in percent of the fundamental voltage, as specified in EN50160 and ENA ER G5-5.

Odd harmonics (non-multiple of 3)		Odd harmonics (multiple of 3)		Even harmonics	
Harmonic order (*h*)	**Harmonic voltage % *h* = 1**	**Harmonic order (*h*)**	**Harmonic voltage % *h* = 1**	**Harmonic order (*h*)**	**Harmonic voltage % *h* = 1**
5	6.0	3	5.0	2	2.0
7	5.0	9	1.5	4	1.0
11	3.5	15	0.5	6	0.5
13	3.0	21	0.3	8	0.5
$17 \leq h \leq 49$	$2.27(17/h) - 0.27$	≥ 23	0.2	≥ 10	$0.25(10/h) + 0.25$
$53 \leq h \leq 97$	$27/h$	—	—	—	—

2.15.6. Fault levels

System fault levels shall be constrained within the design limits for each voltage level which are summarised in Table 11. Design fault levels shall be considered in overall **D-suite PED** component design and protection requirements (for example internal protection).

2.16. Operation Under Over Voltage and Under Voltage Conditions

2.16.1. D-ST Only

Voltage dips usually occur in the **HV** (11kV) network due to the fault or energisation of particular devices. Voltage dips due to fault can be severe and depending on the proximity of the fault location, may temporarily reduce the voltage at the **HV Primary Terminal** to as low as 1.0% of the nominal voltage for around 3.0 seconds. As a minimum, **D-ST** shall remain stable and connected to the network (no need to restart) during this period. However, it is acceptable that:

- The temporary voltage dip at the **HV Primary Terminal** is transferred to the **AC Secondary Terminal** with no worse than equivalent voltage drop considering nominal conversion ratio (11.0kV/0.4kV).
- **D-ST** switches to standby mode in which it does not supply (no active or reactive power) to **LV** network with no **Voltage Control** at the **AC Secondary Terminal** when the voltage dip is greater than 20% of nominal **HV** voltage and lasts for longer than 3.0 second.

D-ST shall remain stable and connected to the network during any temporary voltage dip that occurs at the **AC Secondary Terminal** due to a LV network fault or energisation of particular devices.

Temporary overvoltage may occur in the **HV** network as a result of network asset switching or phase to ground faults at **HV** network. The phase to ground fault may cause overvoltage that is twice the nominal voltage (2 p.u) on the healthy phases and it lasts for the duration of the fault. **D-ST** shall remain stable and connected to the network (no need to restart in post-fault) during this temporary overvoltage, in addition:

- The temporary overvoltage at the **AC Secondary Terminal** shall not exceed 115% of nominal voltage as a result of overvoltage transfer from the **HV Primary Terminal**.
- It is acceptable that **D-ST** provides a permissive operation during temporary overvoltage between 120% to 150% of nominal voltage at **HV Primary terminal**. Details of permissive operation will be developed by **D-ST supplier** and shall be approved by SPEN before implementation.
- It is acceptable that **D-ST** switches to standby mode in which it does not supply (no active or reactive power) to **LV** network with no **Voltage Control** at the **AC Secondary Terminal** when the overvoltage is greater than 150% of nominal **HV** voltage and lasts for longer than 3.0 second.

The **D-ST supplier** shall recognise and consider all the voltage disturbances described in BS EN 50160 for designing **D-ST** and selecting relevant equipment for installation on or connected to the distribution network to ensure **D-ST** remain stable, intact and operational during various voltage disturbances.

It is desirable that **D-ST** provides transient voltage support by injecting/absorbing reactive power during transient voltage dip or overvoltage conditions within **Power Capability** of **D-ST**.

D-ST shall return to its normal operating conditions and deliver its **Core Functionalities** immediately after transient overvoltage or under voltage conditions are over.

2.17. Fail-Safe

The **D-Suite PED** shall have configurable default failsafe levels in case it fails to communicate with **NLCS,** or command received from **Control Engineer** remotely or locally. **D-Suite PED supplier** shall provide a failsafe levels analysis to provide recommendations to SPEN which parameters shall be considered for the default failsafe operation. SPEN need to approve the failsafe settings before implementation by **D-Suite PED supplier**.

2.18. Harmonic Distortion

The harmonic emissions generated by **D-ST** at **HV** Primary Terminal and by D-Suite PED at LV AC Terminals shall comply with the limits specified in ER G5/5 for 0.4kV and 11kV system voltage levels.

The harmonic voltage distortion contribution from **D-Suite PED** shall not cause THD and individual harmonic orders to exceed the planning levels specified in ER G5/5 for 0.4kV and 11kV system voltage levels at the AC Secondary Terminal and the **HV** Primary Terminal, respectively.

The harmonic emissions and harmonic voltage distortions shall be measured by the manufacturing partner at the time of installation for the harmonic orders up to 100th in accordance with methodology specified in IEC 61000-4-7.

2.19. Short Term Thermal Rating

It is desirable that **D-Suite PED** can provide short-term (> 1.0 minute) overload capability. The short-term overload capability may be required for short term demand increase due to **Cold Load Pick-Up** or load transfer between substations.

The manufacturing partner shall provide the short-term overload capability of their solution in the tender response.

2.20. Insulation Requirements

The insulation requirements of **D-Suite PED** shall comply with IEC 60076-3, IEC 62477-1, and IEC 62477-2 where applicable. Table 13 shows the insulation requirements for conventional transformers as specified IEC 60076-3.

Table 13 –Insulation requirements for conventional transformers

HIGHEST VOLTAGE FOR EQUIPMENT (KV R.M.S)	**NOMINAL VOLTAGE** (KV)	**RATED LIGHTNING IMPULSE VOLTAGE** (LI) (KV PEAK)	**50 HZ WITHSTAND VOLTAGE** (KV R.M.S)
1.1	0.40/0.23	-	3.0
7.2	6.6	60.0	20.0
12.0	11.0	75.0	28.0

The **D-Suite PED supplier** shall be responsible for carrying out all the insulation coordination studies according to IEC 60071 and providing results to SPEN.

All the clearances between phases, phase- earth and phase to neutral at the terminations and between them shall comply with IEC 60076-3-1 and **IEC** 62477 where **applicable.**

2.21. Shutdown and Start-up

Start up and shut down process of **D-Suite PED** shall not be associated with any hazard or safety risk. The **D-Suite PED supplier** shall consider the necessary interlocks, alarms and protection procedure required to be in place for a safe shut down and start up.

Start up and shut down of **D-Suite PED** shall have no impact on service lifetime or operation and maintenance of **D-Suite PED** i.e. Impact on hardware and software of **D-Suite PED** shall not be acceptable.

D-Suite PED shall be able to start up and shut down in all following options:

- Locally, by operation personnel on site locally.
- Remotely, by Control Engineer sending necessary commands.
- Automatically, by defining start up or shut down logics e.g., **D-ST** starts up after HV network is energised and stable HV voltage is applied. The **D-ST** Manufacturing Partner shall develop the logics and request approval from SPEN before implementation.
- Receiving appropriate command from **NLCS**.

D-Suite PED shall be capable of starting up immediately after receiving commands in one of the aforementioned options. No delay shall be required following multiple consecutive start up and shut down events.

A soft start up for **D-Suite PED** is required and start up shall not result in Inrush Current or voltage depression in **HV** or **LV** networks worse than those caused by conventional transformers. The existing **HV** protection settings usually allow some level of Inrush Current due to magnetisation of conventional transformers (typically 10 times of transformer rating for 100ms), hence, starting up **D-Suite PED** shall not trip **HV** protection.

The time required for **D-Suite PED** start up process from fully de-energised condition to fully live and functional condition shall not exceed 5.0 seconds.

In case any battery is required for **D-Suite PED** start up, it shall be provided by the **D-Suite PED Supplier**. The battery shall be fitted within the **D-Suite PED** enclosure with all the necessary charging equipment.

2.22. Enclosures – All D-Suite PED

All marshalling kiosks, enclosures and control cabinets shall be manufactured from stainless steel of the appropriate grade or 2.5mm thick galvanised steel plate. Cabinets, enclosures or cubicles made up of plastic are not acceptable. The design shall take suitable precautions to ensure condensation and corrosion are prevented, and there is adequate ventilation and free air circulation over all equipment. For outdoor design applications, the degree of protection required for the accommodation against the ingress of solid foreign objects and water shall be at least to IP 55 according to IEC 60529. When any doors are open, the degree of protection for persons against access to hazardous parts shall be at least to IP 2X according to IEC 60529. The door shall have adequate oil and weather resistant gaskets fitted to ensure a weatherproof seal.

Tanks, conservators, pipework etc. shall be cleaned by an appropriate means and treated with weather resistant paint to C5, design life/durability VH, as detailed in ISO 12944.

2.23. Handling

The **D-Suite PED** design shall allow movement in a stable and safe manner. The design shall allow movement to be achieved using a pinch bar and rollers, or any handling methodology approved by SPEN.

The **D-Suite PED Supplier** shall provide a detailed instruction document and training for handling the **D-Suite PED** in a safe manner to prevent any staff injury and damage to the equipment.

All parts within **D-Suite PED** shall stay stable and fixed securely during handling and installation.

2.24. Labelling

All enclosures shall be marked in accordance with Clause 5-10 of IEC 62271-1 as referred to in ENA TS 50-18.

A label showing black letters on a white background shall be affixed adjacent to each fitting and terminal, to indicate the function. In the case of a relay, if there is a visible internal label, no additional label is required.

The **D-Suite PED** enclosure shall be identified by a non-corroding, indelibly marked data plate giving the following information specified in IEC 60076-1, and marked in accordance with ENA TS 50-18:

Safety-warning labels shall comply with BS 5499 referenced in ENA TS 50-18.

2.25. Terminations

The layout of the **D-Suite PED** terminations shall be approved by SPEN through the design process, and it is desirable that Primary (11kV) AC terminals are on the opposite side of Secondary AC (0.4kV) Terminal for the **D-ST**. However, SPEN may consider alternative terminations arrangements proposed by the **D-Suite PED Supplier**.

The exact location of terminals shall be finalised in the design stage by the **D-Suite PED Supplier** and that should be approval by SPEN. The design shall provide appropriate interfacing with other **HV** and **LV** equipment within substation. All terminals required for testing and maintenance shall have convenient access to them. If inductive current transformers are used for current measurements, then these shall be provided with terminal blocks equipped with sliding disconnection links and test plugs. When disconnection links are removed, CTs shall be automatically short-circuited. CT terminal blocks shall be provided with spring and screw mechanisms to prevent inadvertent disconnection of CTs.

All terminals shall be marked and labelled in accordance with ENA TS 50-18.

2.25.1. HV Termination – D - ST

For connection of **HV** cables, **D-ST** shall be fitted with a dry type cable box complying with ENA TS 12-11, and suitable for the termination of XLPE single core cables (typically for up to 300mm^2 cross section).

Associated cables have a Cu wire screen of 35mm^2, and the cable box shall have a tin-plated Cu screen termination bar with M12 hex head fixing screws to accept the earth screen lugs, fixed to the inner face of the gland plate on the outside of the cables. The cable screen termination bar shall provide a means of externally connecting the main substation earth using an M12 fixing. **D-ST Supplier** shall ensure that cable boxes offered have adequate space for the termination of HV cables. It is recommended that cable box depth is greater than 270mm and that distance from centre of bushing to the point cable can be worked on (bottom of cable box / top of CTs if installed) is greater than 450mm.

The gland plates shall be non-magnetic. Where provided, split gland plates design shall ensure that all parts are effectively earthed. The gland plate shall be supplied with either suitably sized heat shrink glands or with non-metallic mechanical compression glands of size and type to approval, to suit cables with an outside dia. of 28mm – 32.2mm.

Transformers shall be fitted with HV bushings of the outside cone, plug-in type, rated for 250A, with sliding contact mechanism and interface type A, as defined in BS EN 50180-1, Table 14.

Connector bail holders shall be provided. Transformers shall use an HV bushing flange complying with type E to BS 2562.

2.25.2.LV AC Terminations

The 2T **D-SOP** and **D-STATCOM** will be connected to the LV network using two LV waveform mains cables having up to a 300mm^2 solid aluminium conductor. The neutral will be earthed in multiple locations.

The 3T **D-SOP** will be connected to the LV network using 12 single core, double insulated 240 mm^2 copper flexible LV cables. The neutral will be earthed in multiple locations.

For connection of **LV** cables, **D-ST** shall be fitted with a dry type cable box complying with ENA TS 12-11, and suitable for the termination of XLPE single core cables (typically for up to 740mm^2 cross section).

2.26.Interface with NLCS

D-Suite PED shall be fitted with appropriate data management and communication unit to communicate directly with **NLCS** via a secure hardwired or wireless communication solutions as specified by SPEN in collaboration with **the NLCS Supplier**. **D-Suite PED** data management and communication unit shall send or receive, as a minimum, the following information:

- All measurement data specified in section **2.12** together with relevant time stamps. The device shall use a network time synchronisation to ensure that events and logs are time-stamped accurately.
- Necessary handshaking and device authentications signals
- Set points of controlled parameters determined by SCS that includes:
    a. **LV Voltage Set Points** for each phase and corresponding tolerances
    b. **HV voltage set points** and corresponding tolerances (D-ST only)
    c. **Thermal loading set point** and corresponding tolerances
    d. **LV AC Active Power set point** and corresponding tolerances (D-ST and D-SOP only).
    e. **LV AC reactive power set point** and corresponding tolerances
- Alarms, alerts and **D-Suite PED** status

The **D-Suite PED Supplier** shall provide **D-Suite PED** communication and data management unit that supports different protocols e.g.

- IEC 60870-5-104, IEC 61850, DNP3, 101 serial connections
- MQTT, AMQP, TCP, CoAP, WebSocket, HTTP(S)

The exact communication protocol and communication solution shall be approved by SPEN in collaboration with the **NLCS Supplier.**

All communication and data management equipment shall be appropriately fitted within **D-Suite PED** enclosure.

2.27. Earthing

The **D-Suite PED** design shall comply with ENA TS 41-24 to facilitate the requirements for earthing system in the substation and ENA TS 37-2 where appropriate.

Any metalwork enclosing and supporting associated with **D-Suite PED** which is not intended to serve as a phase conductor shall be connected with earth. This is also applicable to any auxiliary equipment. Appropriate termination for connection to earth through a 70mm^2 cable shall be considered in the **D-Suite PED** design.

LV AC Terminals shall be connected to a 4-wire system consisting of the 3 phases and neutral wire. The **D-Suite PED** neutral point, provided at **LV AC Terminals** will be connected to the neutral bar in **LV** pillar.

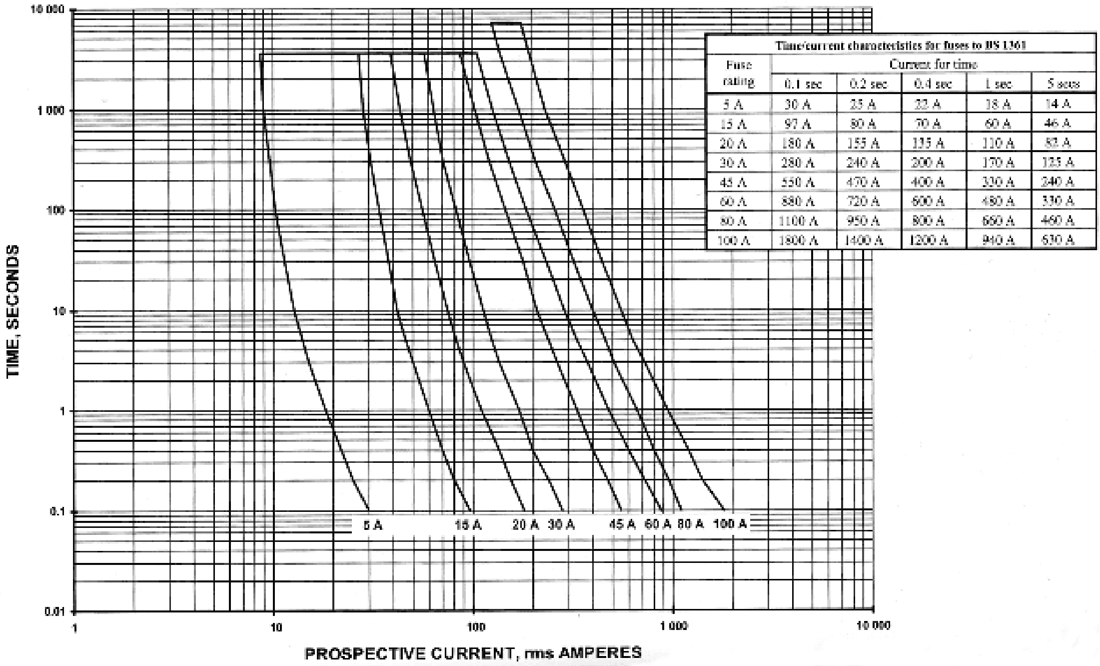
The earthing point of the **LV** AC neutral point may be the same in the **Secondary Substation**. **D-Suite PED supplier** shall adapt the **D-Suite PED** design based on this arrangement and advise on any issue that common earthing may cause considering their proposed design of **D-Suite PED**.

2.28. Protection requirements D-ST

Traditionally LV networks in the UK are protected by fuses:

- Cut-out fuses providing protection just before the customer premises and their internal metering/protection equipment. These are typically 100 A fuses with the characteristic shown in Figure 13.
- Fuses protecting LV circuits located on the fuse board in a **Secondary Substation**. These are typically 400 A fuses with the characteristic shown in Figure 14.

SPEN recognise that low fault infeed capability of **D-ST** may impose a significant challenge to the meet the protection requirements, hence, **D-Suite PED Supplier** is required to provide a **D-ST** design that meet the protection requirements within **LV** network. SPEN is planning to replace the existing **LV** feeder protection (400A fuses) with **LV** circuit breakers (**LV**CB) which allow a flexible protection setting input. However, the new **LV** feeder protection grading need to consider the operation time of existing 100A fuses and should be fitted within the area (between Green and Red lines) shown in Figure 13. **D-ST** shall be capable of providing adequate fault infeed to allow the new protection settings for the **LV** feeder.



Time/current characteristics for fuses to BS 1361					
Fuse rating	Current for time				
	0.1 sec	0.2 sec	0.4 sec	1 sec	5 secs
5 A	30 A	25 A	22 A	18 A	14 A
15 A	97 A	80 A	70 A	60 A	46 A
20 A	180 A	155 A	135 A	110 A	82 A
30 A	280 A	240 A	200 A	170 A	125 A
45 A	550 A	470 A	400 A	330 A	240 A
60 A	880 A	720 A	600 A	480 A	330 A
80 A	1100 A	950 A	800 A	660 A	460 A
100 A	1800 A	1400 A	1200 A	940 A	630 A

Figure 13 – Fuse time-current characteristics for current ratings 5A-100A fuses

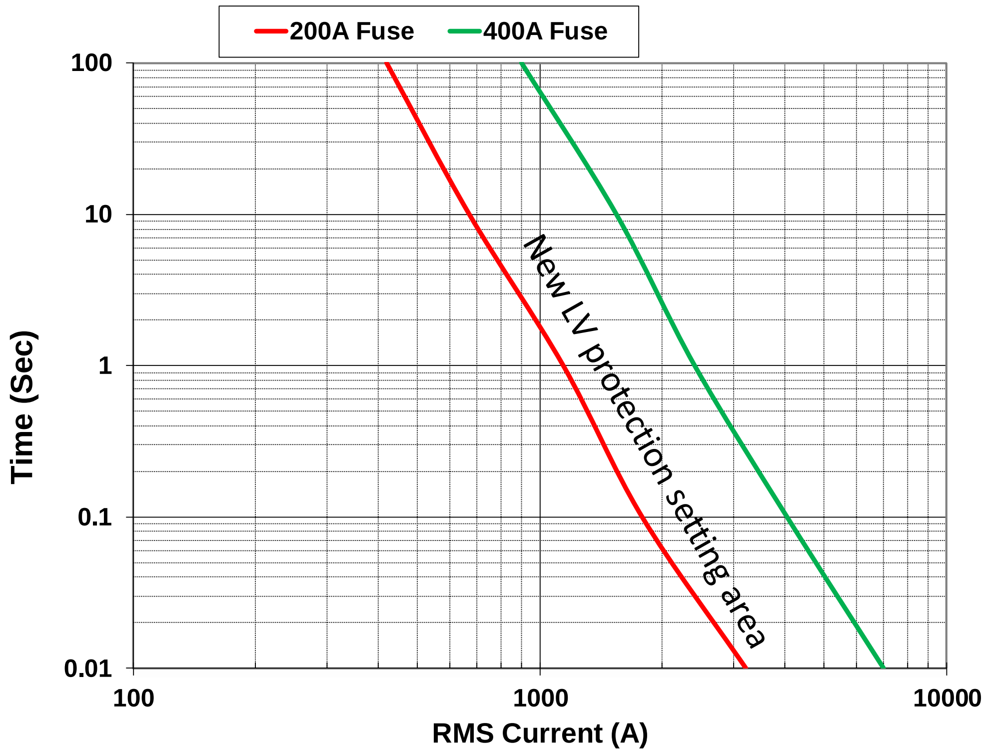


Figure 14 – Fuse Time-current zones for current ratings 200A, and 400A

Traditional **HV** protection at **Secondary Substations** will unlikely provide sufficient protection against **D-ST** internal faults. **D-ST** shall be capable of identifying the internal fault immediately and protect its internal components together with providing a tripping signal to the **HV** circuits breaker (e.g. Ring Main Unit).

D-ST will be operated in a **Meshed Network**; therefore, any internal fault may result in fault current contributions from **HV** network and **LV** network to the **D-ST** internal faulted point. As the fault infeed from **LV** network can be significant, **D-Suite PED Suppliers** shall provide a solution to protect the **D-ST** against **LV** infeed for internal faults.

Any CT and PT required for detecting and protecting internal faults shall be considered in the **D-ST** design and fitted within **D-ST** enclosure.

2.29. Drawings

D-Suite PED supplier shall provide, as a minimum, the following drawings:

- Foundation plan drawing and outline drawing for each type of **D-Suite PED** they are offering.
- General arrangement of cable entry boxes and disconnecting units (if applicable).
- General arrangement of enclosures/cabinets
- Arrangement of neutral bushing and all the terminals.
- Internal arrangement drawings covering all equipment **HV** side, **LV** AC and plan view.
- Rating and diagram plate showing connections of each **D-Suite PED** and associated equipment and the relation of leads taken out of the enclosure.
- Details and diagram of connections of protection and monitoring devices.
- Details diagram of communication and data management unit
- Schematic diagram of alarms, trips and indications.
- All wiring diagrams.
- Outline drawing showing the **D-Suite PED** accommodation arrangement for transportation to site

2.30. Test requirements

2.30.1. General

The equipment shall be subject to all routine, type and special tests required in accordance with the latest relevant IEC or BS EN standards, where appropriate.

SPEN shall have, at all reasonable times, access to inspect and examine the materials and workmanship of portions of equipment during manufacture and testing.

The **TEST Plan** shall be prepared by the **D-Suite PED Supplier**. SPEN will review and provide any modification required. SPEN requires at least 2 months' notice, for witnessing factory acceptance tests in order that SPEN representative may be present.

The **Test Plan** shall detail the connections required for the test, the test methodology and the voltages to be supplied to the **D-Suite PED** during the specific test. Full details of the test methodology shall be supplied to SPEN in the **Test Plan**.

The factory inspections and testing shall in no way relieve or reduce the responsibility and liability of the **D-Suite PED Supplier** for any defects found after the delivery and installation of the **D-Suite PED** and its associated equipment.

If the equipment fails a test, the **D-Suite PED Supplier** shall bear all costs associated with forensic investigation, rectification works, reinspection and re-testing including the cost of witnessing of all re-testing.

The **D-Suite PED Supplier** shall carry out the site tests after delivery and installation of all the components of the **D-Suite PED** to verify proper operation and performance.

Any proposed variation of tests shall be subject to approval by SPEN.

The **D-Suite PED Supplier** shall provide test reports to SPEN within 2 weeks of the test completion. That includes all the test results, measured parameters and raw test data in an agreed format with SPEN.

The **D-Suite PED Supplier** shall make available to the SPEN all information, test data, and evidence relating to the test results including failure or cause of the non-compliance. In case of any failure or damage to equipment, the **D-Suite PED Supplier** shall repair the failure (or resolve the non-compliance) and shall replace any part that may have been damaged or contaminated.

2.30.2. Summary of tests

Individual major components of the **D-Suite PED** shall be tested in accordance with the relevant equipment standards. This shall include semiconductor devices, DC capacitors, high frequency transformers, etc.

SPEN will send their representative to witness the tests of the complete each **D-Suite PED**.

The **D-Suite PED Supplier** shall propose the **Schedule of Test** in the tendering response, however, as a minimum, following tests shall be conducted by the **D-Suite PED Supplier**:

1. Energisation
    a. HV Terminal energisation – (**D-ST**)
    b. LV AC energisation
2. Voltage Ratio
3. Power flow
    a. Power supply only LV AC
4. Power capability
    a. Reactive power
    b. Active power (**D-ST** & **D-SOP**)
    c. Power factor range (**D-ST** & **D-SOP**)
5. Vector Group
6. Short-circuit withstand
    a. 3ph short circuit at LV terminal
    b. 3ph short circuit at HV terminal (**D-ST**)
    c. Internal short circuit
7. Protection capability
8. Losses
9. Dielectric
10. Voltage control
    a. LV AC voltage control
    b. HV voltage control (**D-ST**)

11. Power flow control
    a. LV AC supply power control
12. Operational performance
    a. Sound Power
    b. LV unbalance load operation
    c. HV unbalance voltage operation (D-ST)
    d. Harmonic injection
    e. Radio frequency interference
    f. Temporary loading capability

Any additional test required to be considered shall be declared in the tender response.

2.31. Cybersecurity

The manufacturer shall demonstrate the equipment's compliance with IEC 61850 by providing details of the tests prescribed in IEC 61850-10. Any non-compliance issues shall also be highlighted.

The manufacturer shall demonstrate the equipment's compliance with cyber security standards in particular IEC 62351, IEC 62443 and Network Information Systems Regulations 2018. Reference shall also be made regarding the equipment's security assurance level detailed in IEC 62443-3-3. Any non-compliance issues shall be highlighted.

The supplier shall provide the required information to undertake an SP Energy Networks cyber security assessment and no extra cost. Non-compliance with SP Energy networks cybersecurity policy shall be addressed by the PED supplier at no extra cost.