1. SCOPE

This document provides guidance for the technical requirements for Customer Export and Import Limiting Schemes installed by customers within the SP Distribution and SP Manweb Distribution networks.

2. ISSUE RECORD

This is a Controlled document. The current version is held on the EN Document Library.

It is your responsibility to ensure you work to the current version.

Issue Date	Issue No.	Author	Amendment Details
January 2016	1	Osman Ali	Initial Issue
May 2017	2	Keith Evans	Updated to reflect changes to EREC G100
November 2020	3	Ramesh Pampana	Updated in line with EREC G100 Amendments
August 2024	4	Paul Dynes	Updated in line with EREC G100 Amendments The review period of this issue has been reduced to 12 months due to ongoing work on the management and coordination of Electricity Storage connections.

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
Paul Dynes Lead Design Engineer	Milana Plecas SPD Major Connections Manager	Kailash Singh Head of Distribution Network Connections p.p. I Divers, Head of Distribution Networks Date: ...16/08/2024...................

4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative change but at a period of no greater than 12 months from the last issue date.

5. DISTRIBUTION

This document is not part of a Manual maintained by Document Control and does not have a maintained distribution list. It is published on the SP Energy Networks website.

6. CONTENTS

7. REFERENCE AND RELATED DOCUMENTS

7.1 Legislation

The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR).

The Electricity at Work Regulations 1989.

7.2 Relevant ENA Engineering Recommendations (ER / EREC)

EREC G59	Recommendations for the Connection of Generating Plant to the **Distribution Systems** of Licensed **Distribution Network Operator**s
EREC G99	Requirements for the connection of generation equipment in parallel with public **Distribution Networks** on or after 27 April 2019
EREC G83	Recommendations for the Connection of **Type Tested** Small-scale Embedded Generators (Up to 16A per Phase) in Parallel with Low-Voltage **Distribution Systems**
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
EREC P28	Planning Limits for Voltage Fluctuations Caused by Industrial, Commercial and Domestic Equipment in the United Kingdom
ER P29	Planning Limits for Voltage Unbalance in the United Kingdom for 132 kV and below
ER G5	Harmonic Voltage Distortion and the Connection of Harmonic Sources and/or Resonant Plant to Transmission systems and **Distribution Networks** in the United Kingdom
EREC G100	Technical Requirements for **Customers' Export and Import Limitation Schemes**

7.3 SPEN Documents

ESDD-01-005	Distributed Generation Connection Requirements
ESDD-02-007	Equipment Ratings

8. DEFINITIONS

Active Network Management	Using flexible network **Customers** autonomously and in real-time to increase the utilisation of network assets without breaching operational limits, thereby reducing the need for reinforcement, speeding up connections and reducing costs.
Active Power	The product of voltage and the in-phase component of alternating current measured in units of watts, normally measured in kilowatts (kW) or megawatts (MW).

Apparent Power (VA)	The product of voltage and current at fundamental frequency, and the square root of three in the case of three-phase systems, usually expressed in kilovolt-amperes ('kVA') or megavolt-amperes ('MVA').
Component	A discrete unit within the **Customer's Installation** that, together with other similar units which are in secure communication with each other, form the **CLS**.
Connection Agreement	A contract between the **DNO** and the **Customer**, which includes the relevant **Customer's Installation**'s requirements and specific technical requirements for the **Customer**'s **Devices**. For **Domestic Installations** where there is no specific existing bilateral **Connection Agreement**, any agreement between the **Customer** and the **DNO** in relation to the requirements and operation of the **CLS** will be part of the National Terms of Connection.
Connection Point	A point on the **Distribution System** that provides **Customer** with a connection allowing power to flow to or from the **Distribution System**. Typically, this would be the **SPEN** fused cut-out or the metering circuit breaker.
Current Rating	A point on the **Distribution System** that provides **Customer** with a connection allowing power to flow to or from the **Distribution System**. Typically, this would be the **SPEN** fused cut-out or the metering circuit breaker.
Customer	A person who is the owner or occupier of premises that are connected to the **Distribution System**.
Customer Limitation Scheme (CLS)	The **Customer Export or Import Limitation Scheme (CLS)** is a system comprising of one or more **Components** providing control signals that interface with the **Customer**'s generation and/or load (i.e. the generation and load that is specifically intended to be controlled by the **CLS**, and referred to hereafter as the **Customer**'s **Devices**) to control the net flow of electricity into or from the **Distribution Network** at the **Connection Point** so as not to exceed the **MEL** or **MIL**. A **CLS** may be a single integrated unit (excepting transducer(s) at the **Connection Point**) or composed of a number of distributed discrete **Components**. In all cases the **CLS** is expected to include a **Component** that is a transducer that measures the current and voltage at the **Connection Point**. Note that this latter **Component** could form part of another piece of equipment entirely, one that measures the values appropriately, and is not associated originally with the **CLS**, provided it fulfils the same function and is appropriately integrated into the **CLS**'s overall behaviour (including appropriate secure and **Fail-Safe** communications).

Customer's Installation	The electrical installation on the **Customer**'s side of the **Connection Point** together with any equipment permanently connected or intended to be permanently connected thereto.
Device	Any significant load or generation equipment which is designed to be controllable by an external signal or set point. **Device**s can include equipment typically referred to as low carbon technologies, including renewable generation, electrical storage, heat pumps and electric vehicles. The term is used in relation to any such controllable load or generation installed in domestic, commercial, and industrial installations.
Demand Control Unit (DCU)	A **DCU** provides a means for demand to be turned on/off to limit **Active Power** exported to the **Distribution System**. This provides an alternative to controlling the output of **Generating Units** (or an additional measure).
Distribution Licence	A **Distribution Licence** granted under Section 6(1)(c) of the Electricity Act 1989 (as amended including by the Utilities Act 2000 and the Energy Act 2004).
Distribution Network	An electrical network for the distribution of electrical power from and to a third party(s) connected to it, a transmission network, or another **Distribution Network**.
Distribution Network Operator	The **Distribution Network Operator** (**DNO**) is the person or legal entity named in Part 1 of the **Distribution Licence** and any permitted legal assigns or successors in title of the named party. A **Distribution Licence** is granted under Section 6(1)(c) of the Electricity Act 1989 (as amended by the Utilities Act 2000 and the Energy Act 2004).
Domestic Installations	For the purposes of this document those **Customer Installations** connected at **LV** (typically single phase, but not exclusively so) and with a capacity of no more than 100A.
Extra High Voltage (EHV)	A voltage supplied at 33,000 Volts or above.
Fail-Safe	A design requirement that enables the **CLS** to limit export or import at the **Connection Point** to the **MEL** or **MIL** respectively, irrespective of the failure of one or more its **Component**s or the failure of any communications between the **CLS**'s **Components** and **Devices**.
Fully Type Tested	A **CLS** which has been tested to ensure that the design meets the relevant technical and compliance requirements of this EREC G100, and for which the **Manufacturer** has declared that

	all similar **CLSs** supplied will be constructed to the same standards and will have the same performance.
Generating Unit	Any apparatus that produces electricity.
High Voltage (HV)	A voltage 1,000V or above.
Installer	The party who is responsible for installation of the **CLS** in the **Customer's Installation**. The equipment installed may be a **Fully Type Tested CLS** or a **CLS** that is assembled in the **Customer's Installation** from **Components**.
Low Voltage (LV)	A voltage less than 1000 V
Manufacturer	The party responsible for the manufacture of **CLSs** deployed in **Customers' Installations** in Great Britain.
Maximum Export Limit (MEL)	The maximum current, as agreed between the **Customer** and the **DNO** which may be exported onto the **Distribution Network** via that **Connection Point**.
Maximum Import Limit (MIL)	The maximum current, as agreed between the **Customer** and the **DNO** which may be imported from the **Distribution Network** via that **Connection Point**.
Minimum Scheme	The **Minimum Scheme** is the grid connection design that provides the required capacity at the lowest overall capital cost, as estimated by the **Distribution Network Operator**.
Nominal Voltage	The **Distribution Network** operates at **Nominal Voltages** of 132kV, 66kV, 33kV, 22kV, 11kV, 6.6kV, 6.3kV, 400V and 230V.
Power Station Capacity	The aggregated capacity of all the **Generating Units** associated with a single **Power Station**.
Power Factor	The ratio of **Active Power** to **Apparent Power**.
Power Measurement Unit (PMU)	The **PMU**s function is to measure the voltage and current flow between the **Distribution Network** and the **Customer's** premises at the **Connection Point**.
Power Station	An installation comprising of one or more **Generation Units**.

Reactive Power	The imaginary component of the **Apparent Power** at fundamental frequency usually expressed in kilovar (kVAr) or Megavar (MVAr).
SP Distribution plc (SPD)	The **Distribution Licence** Holder for the distribution service area formerly known as ScottishPower.
SP Manweb plc (SPM)	The **Distribution Licence** Holder for the distribution service area formerly known as Manweb.
SPEN	ScottishPower Energy Networks, the brand name for the division of ScottishPower group of Companies that encompasses **SP Distribution** plc, SP Transmission plc, **SP Manweb** plc and SP Power Systems Ltd.
Statutory Voltage Limits	In the case of a **Low Voltage** supply, a variation not exceeding 10 per cent above or 6 per cent below the **Declared Voltage** at the declared frequency. In the case of a **High Voltage** supply operating at a voltage below 132,000 Volts, a variation not exceeding 6 per cent above or below the **Declared Voltage** at the declared frequency. In the case of a **High Voltage** supply operating at a voltage above 132,000 Volts, a variation not exceeding 10 per cent above or below the **Declared Voltage** at the declared frequency.
Type Tested	A **CLS**, or a **CLS Component**, or part of a **Component** which has been tested to ensure that the design meets the relevant requirements of this EREC G100, and for which the **Manufacturer** has declared that all similar products supplied will be constructed to the same standards and will have the same performance. The **Manufacturer**'s declaration will define clearly the extent of the equipment that is subject to the tests and declaration. The ENA provides a database, the Type Test Register, for **Manufacturers** to lodge their statements of compliance and supporting information.

9. INTRODUCTION

This document provides guidance on the connection of **Customer Export and Import Limiting Schemes** (**CLS**) that operates in parallel with the **Distribution Network**.

The guidance given is designed to facilitate the connection of **CLS** whilst maintaining the integrity of the **Distribution System**, both in terms of safety and supply quality.

This document shall be read in conjunction with ENA (Energy Networks Association) ERECs G83, G59, and from 27 April 2019 ERECs G98 and G99, and **SPEN** policy ESDD-01-005.

Customers are becoming increasingly aware of environmental issues and are seeking to install low carbon technology **Devices**, such as heat pumps, electric vehicle charging points and photovoltaic generation within their premises that might add significant load and/or generation (including electricity storage) on to **Distribution Networks**. Where **SPEN** has assessed that connection of such **Devices** will require costly reinforcement, or reinforcement that would take time to implement thus delaying the connection, some **Customers** may choose to restrict the net flows of electricity at their **Connection Point** rather than wait for, or contribute to, the reinforcement.

A typical **CLS** may be used in the following scenarios:

- Installing generation with an aggregate **Current Rating** greater than the permitted export to the network and limiting the peak export.
- Connecting significant new loads which cannot operate at their full capacities at the same time without exceeding the import capacity from the network.
- Using the flexibility of the **Customer's** loads and generation to stay within import or export limits.

The use of a **CLS** is not intended to interfere with any load or generation flexibility that **Customers** wish to make use of. Instead, its function is to ensure that the **Customer's Devices** do not impose current flows on the **Distribution Network** which are greater than the **Maximum Export Limit (MEL)** or **Maximum Import Limit (MIL)** as agreed in the **Connection Agreement**. This is illustrated for the current flow at the **Connection Point** of an example installation in **Figure 1**.

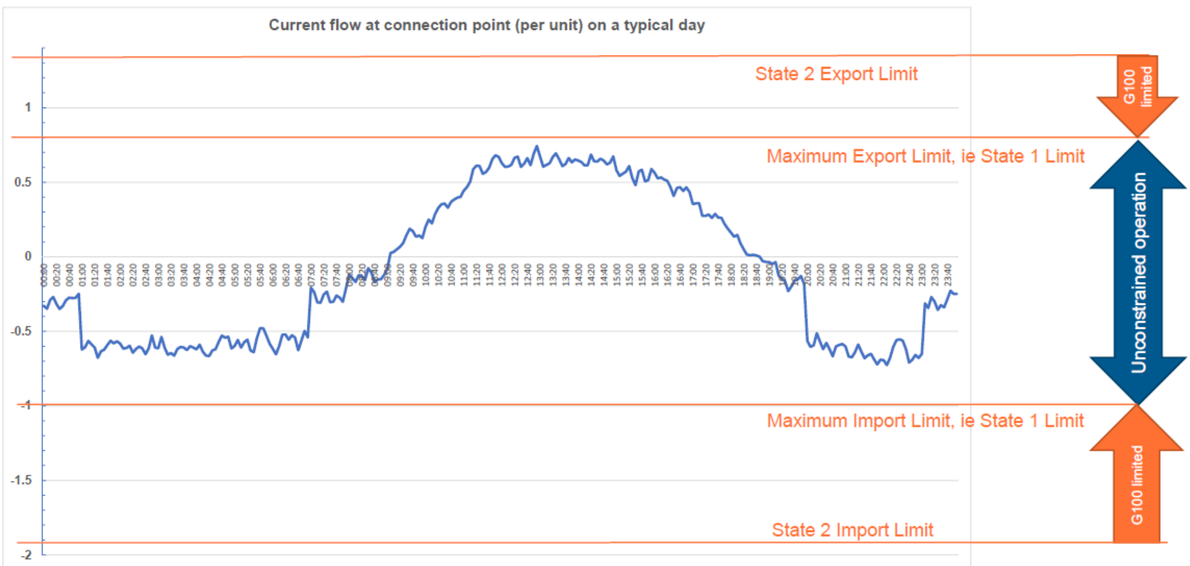


Figure 1. Operational State Concept

10. PURPOSE

This document applies to all **CLS** installed by **Customers** to restrict the **Active Power** imported or exported at the **Connection Point** or to prevent voltage limits on the **Distribution System** from being exceeded. For the avoidance of doubt, limitations on the connection or the operation of generation due to fault level exceedance will still apply.

The focus of this document is **Customers' Installations** connected at voltages up to 33kV in **SPD** and up to 132kV in **SPM**.

This document does not apply:

- where the aggregate **Current Rating** of the generation is less than the **MEL**; or
- where the sum of the **Current Rating** of both
    - the uncontrolled loads after making an appropriate allowance for diversity; and
    - the relevant controllable loads

connected in the installation is less than the **MIL.**

A **CLS** may not be compatible with some flexible connections. For example, in an area managed under **Active Network Management**, a **CLS** might counteract the instructions issued by the management system thus restricting deployment. It will be the responsibility of **SPEN** to assess the suitability of a **CLS** in these situations and authorise accordingly.

The requirements for **CLSs** assumes that the **CLS** will, or may be, controlling both import and export. Where it is certain that by design the **CLS** will only ever control one of these, then this shall be clearly indicated in the information provided by the **Manufacturer** or **Installer**. In these cases, for import only limitation schemes the export current can be ignored or omitted, and for export only limitation schemes import current can be ignored or omitted.

For **SPD** and **SPM** connections, the alternative for the **Customer** to install an overload protection and/or reverse power protection that trips the whole of the **Customer's Installation** to prevent the **Customer's** current flow breaching the **MEL** or **MIL** will not be permitted.

Reverse power protection will be appropriate where any generation within the **Customer's Installation** should never be able to export to **SPEN Distribution Network**, i.e. where the **MEL** is zero.

11. REQUIREMENTS

11.1 Concept

A **CLS** can control any number of **Devices**.

A **CLS** may comprise a single **Component**, communicating with one or more **Devices**, plus a **Component** which is a transducer at the **Connection Point**. Alternatively, a **CLS** might comprise several discrete **Components** distributed in the **Customer's Installation** which communicate securely with each other and with the **Devices** they are controlling.

A **CLS** might be included as a functional feature in any **Device**, with the capability to measure the magnitude of current and direction of power flows at the **Connection Point**.

However, the **CLS** is constructed and implemented, it shall have the characteristics and capabilities as described in this document.

Conceptually the **CLS** can be represented **Figure 2**.

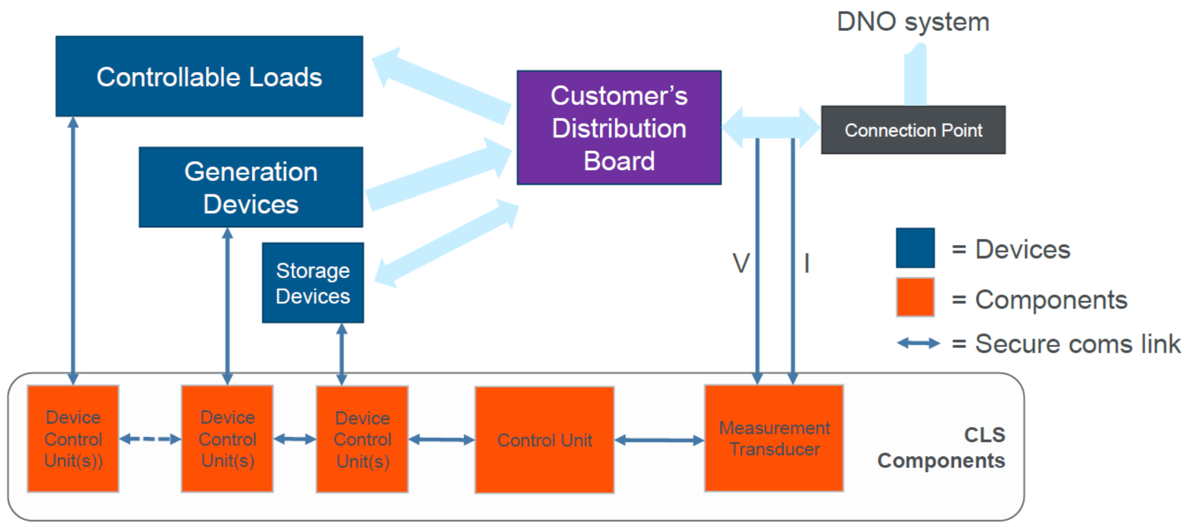


Figure 2. Conceptual Representation of a CLS

11.2 General CLS Features

The maximum permissible tolerance for the **CLS's** measurement and control of current is ± 2% of the greater of the **MEL** or the **MIL** at the **Connection Point**. These tolerances shall, as far as possible, take account of sensing and/or measurement errors, processing errors, communication errors and control errors. Consideration shall also be given to environmental factors (e.g., the expected ambient temperature range). For example, where the **MEL** is zero and **MIL** is 400A the maximum acceptable tolerance for the measurement and control of current is ± 2% of 400A = ± 8A.

A description of the **CLS**, its controls and settings, and a schematic diagram of the **CLS** must be provided to **SPEN** by the **Customer**. Where the **CLS** is controlling export, an operation diagram as required by EREC G59, G83, G98 or G99 as appropriate shall be permanently displayed at the **Customer**'s site. The schematic diagram can be of a form similar to **Figure 2** and include sufficient detail so that the interaction of the **Devices** and **Components** can be understood.

Note that the voltage measurement is shown in **Figure 2** as being at the **Connection Point**. In general, it will be admissible if voltage sensing is done elsewhere in the **Customer's Installation** that is appropriately representative of angle of the voltage at the **Connection Point**.

The settings and controls of the **CLS** will not be generally accessible to **Customers**. The **Manufacturer** or **Installer** shall consider how settings can be applied by, and access limited to, **Manufacturers** or **Installers** via password, PIN or physical access capable of being sealed. These arrangements shall be stated in the description of the **CLS** referred to in this section.

11.3 Operational States

A **CLS** has four operational states:

11.3.1 State 1 – Normal Operation

This is the normal operating state of the **CLS**. In this state the **CLS** will be modulating the consumption and generation of the **Devices** it controls such that current flowing at the **Connection Point** remains within that required by the **MEL** or **MIL** as appropriate and that the voltage at the **Connection Point** remains within statutory limits. The **CLS** might be modulating the consumption and generation of the **Devices** continually in real time. Alternatively, if the behaviour of the **Devices** is balanced, or controlled by other systems, such that the current flow at the **Connection Point** is normally within the **MEL** or **MIL**, then only by exception should the balance be disturbed sufficiently such that the current flow at the **Connection Point** encroaches on the **MEL** or **MIL**. In this latter case the **CLS** will then need to actively modulate the consumption and generation of the **Devices**.

Figure 1 illustrates this.

It is also possible that **Customers** might have their **Devices** controlled by other systems than the **CLS**, e.g., in response to market or other signals. However, in this case, the **CLS** must be able to override any such system to ensure that the current flowing at the **Connection Point** remains within the state 1 limits.

11.3.2 State 2 – Occasional Excursion

From time-to-time conditions within the **Customer's Installation** could be such that the current flow exceeds the **MEL** or **MIL**. This could be caused by normal operation (e.g., switching) of the **Customer**'s **Devices** or other loads in the **Customer's Installation** (e.g., a kettle in a **Domestic Installation**), or it could be caused by the sudden failure or tripping of part of the **Customer**'s load or generation equipment. Very short excursions into state 2 as part of normal operation are not problematic provided they are short, i.e. less than 15s. However, longer excursions, such as might accompany failure or tripping of a **Device** should be rare by definition, and therefore not considered as normal operation. In both cases the **CLS** will recognize the condition and shall have the capability to control the **Devices** and bring the current flowing at the **Connection Point** back within the **MEL** or **MIL** and within a maximum response time.

The default maximum response time for a **CLS** to bring the current flow back within **MEL** or **MIL** is 1 minute. For industrial or commercial installations where slow acting **Devices** (such as reciprocating gas engine driven generation, micro hydro etc) are controlled, a default maximum response time of 3 minutes will apply unless **SPEN** identifies that state 2 operation will result in network voltages above the statutory maximum. In these cases, **SPEN** may require the response time to be 1 minute. There is more detail on this condition in section 11.4 below.

As state 2 is designed to cater for rare events, the number of occasions that a **CLS** can operate in state 2 for more than 15s is limited. This is covered in more detail in section 11.5.

11.3.3 State 3 – Failed State

This state is designed to cater for a failure of the **CLS** in some way. In this state the **Devices** shall be set to operate at levels that cannot, whatever happens next to equipment in the **Customers Installation**, breach the **MEL** or **MIL**. In many cases this will simply mean that the **Devices** are tripped or switched off. An alternative could be that some **Devices** are set to a clearly defined low power state such that their operation can never result in the current flowing at the **Connection Point** approach the **MEL** or **MIL**.

If state 3 operation is caused by:

- excessive import then the generation **Devices** shall not be constrained or tripped by the **CLS**.
- excessive export then load **Devices** shall not be constrained or tripped by the **CLS**.

The failure mechanisms, consequences and responses are covered in section11.5 below.

When a failure is detected by the **CLS**, it shall set all the **Devices** into their state 3 operational state within a maximum of 15s. Subject to detailed assessment **SPEN** may request a reduced operation time in order to protect network assets.

11.3.4 State 4 – Operation without CLS

State 4 need not be implemented by default. It is a state that allows operation of some of the **Customer**'s **Devices** without the control of a **CLS**. Such a state might be required if the **CLS** is out of service for a considerable time for some reason.

The operational arrangements for state 4 in many cases will be the same as those for state 3, i.e., with the **Devices** switched off or set to a permanently clearly defined low power state. However, particularly for larger industrial or commercial installations, **SPEN** might specifically agree how the installation can be operated in the absence of a functioning **CLS**. State 4 operation will only be allowed by pre-agreement with **SPEN**.

11.4 Design Limits

The limitation on the capacities of **Customer**'s **Devices** is set by state 2 operation. In state 2 operation, the **MEL** or **MIL** is breached, and the resultant high current flows can lead to a number of undesirable or even dangerous situations. In general, temporary high currents can be tolerated provided there are appropriate caps on their magnitude and duration, and on consequential effects such as voltage rises or dips.

State 2 operation shall take account of the likely worst-case situation that might arise, taking into account common mode failures and effects that may affect **Devices**. The **Customer** will provide details of their anticipated worst-case State 2 operation to inform **Minimum Scheme** design.

For **Domestic Installations**, the effect of the **Customer**'s loads on the current flow at the **Connection Point** can be significant, either because they are very small compared to the generation, or where they are significant, they could be subject to sudden cessation or tripping. Therefore, for simplicity the default approach for all cases shall be to ensure that the aggregated **Current Rating** of all generation **Devices** is less than the limit of state 2 operation.

SPEN will assess the **Customers' Devices** and the proposed **CLS** in terms of their effect on:

- The thermal limits of **SPEN Distribution Network**
- The voltages at the **Customer**'s **Connection Point** and the **Connection Point** of other **Customer**s in the vicinity
- The relevant distribution protection systems
- The **Minimum Scheme** to connect to the **SPEN Distribution Network**

SPEN will assess the **Customers' Devices** and **CLS** proposal based on these criteria and the maximum **Current Ratings** of the **Customer**'s **Devices** shall be limited so that none of the criteria set out in the following sections are breached.

Any overload protection used for any **Device** in compliance with this document must be arranged to grade with, and match the characteristics of, **SPEN's** protection at the **Connection Point**. The maximum operating time of such protection must not exceed 10s, however may be required to operate quicker based on local network constraints.

As above where the relevant electrical protection of the **Device** has been arranged to fully grade with **SPEN's** protection, the capacities of **Customers' Devices** will be taken to be their nominal or practical rating. For example a group of 10 11kW single phase electric vehicle chargers operating as a single load controlled by a single controller (i.e. a controller for that purpose, not one that is specifically designed to meet the requirements of this document) that limits their overall instantaneous demand to 30kW (single phase), i.e. to allow for charging diversity, and is protected by a single 140A single phase MCB (for example) that can be demonstrated to grade with **SPEN's** protection, shall be considered to be a 30kW **Device**. Where **SPEN's** protection is provided by fuses the protection of the **Customers Device** (the MCB in this example) should be arranged to match this appropriately, e.g., an inverse characteristic.

11.4.1 Thermal Limits

The highest currents that can be imposed on **SPEN**'s **Distribution Network** will be assessed and **SPEN** will confirm that these currents are tolerable on **SPEN**'s **Distribution Network** for up to 5 minutes. This assessment will be made using the cyclic rating of effected cables and transformers, and the continuous rating of overhead lines and switchgear as defined in ESDD-02-007. Note that this is the design approach. The actual time that the **CLS** can allow state 2 operation to persist is only 1 minute (or 3 minutes where specifically notified to **SPEN** for appropriate technology such as reciprocating gas engine driven generation, micro hydro etc and where there is no adverse voltage effect as explained in section 11.3.2).

In state 1 operation, if there is a risk that operating at the **MEL** or **MIL** causes frequent inadvertent excursion from state1 operation into state 2 operation it will be appropriate to set a state 1 operating limit that is sufficiently within the **MEL** or **MIL** limits, in order to minimise the frequency or duration of state 2 operation to avoid triggering the **CLS** functionality set out in 11.5.2.1.

11.4.2 Voltage Limits

DNOs must respect the statutory limits on voltages as defined in the Electricity Safety Quality and Continuity Regulations (2002, SI 2002 2665). Circumstances, such as faults on **Customers' Installations**, or on **SPEN**'s **Distribution Network** may cause temporary excursions outside these limits. These exceptions are expected occasionally but must be limited. BS EN 50160 sets the expected worst case for excursions and any voltage excursion caused by state 2 operation shall fall within this envelope in BS EN 50160. Recognizing this limit, small excursions above or below the statutory limits should be limited to no more than 1 minute.

SPEN will assess the worst-case state 2 operation effect on the voltage of the **Distribution Network**. The **Customer**'s **Devices** will be limited in capacity such that:

- The worst-case highest voltage cannot exceed 111% of **Nominal Voltage** (ie 255.3V at a **Nominal Voltage** of 230V) where the **Customer**'s **Connection Point** is at **LV**, 107% of **Nominal Voltage** where the **Customer**'s **Connection Point** is at **HV** or **EHV**; and 111% of **Nominal Voltage** where the **Customer's Connection Point** is at 132kV
- The worst-case lowest voltage cannot be less than 93% of **Nominal Voltage** (ie 213.9V) where the **Customer**'s **Connection Point** is at **LV**, 93% of **Nominal Voltage** where the **Customer**'s **Connection Point** is at **HV** or **EHV** and 89% of **Nominal Voltage** where the **Customer's Connection Point** is at 132kV

Voltage limits are summarized in Table 1 below.

Voltage Level	**Overvoltage**		**Undervoltage**	
	Statutory Limit	State 2 Limit	Statutory Limit	State 2 Limit
LV	110%	111%	94%	93%
HV	106%	107%	94%	93%
EHV	106%	107%	94%	93%
132kV	110%	111%	90%	89%

Table 1. State 2 voltage limits

In addition, **SPEN** will consider the step voltage changes associated with transitions between state 1 and state 2 operation that will be imposed on the **Distribution Network** (and hence on other **Customers**) in accordance with EREC P28.

Optionally, a **Manufacturer** or **Installer** may include, by agreement with **SPEN**, a voltage-controlled response such that in those cases where the voltage at the **Connection Point** is likely to breach statutory limits the **CLS** instructs corrective action as an alternative to moving into state 2 operation (and hence risking triggering the state 3 **Fail-Safe** condition – see section 11.5.1.2).

11.4.3 Protections Limits

For installations where **SPEN**'s interface or upstream protection is provided by fuses, state 2 operation shall not impose a greater current flow than 145% of the nominal fuse rating.

Where **SPEN**'s interface or upstream protection is provided by relays, **SPEN** will assess the maximum current flow based on the appropriate settings for these relays.

11.4.4 Minimum Scheme Assessment

The operation of the **Customer's CLS** may have an impact on the **Minimum Scheme** to connect to the **Distribution Network**. Where the reasonable worst-case state 2 operation of a **CLS** would breach the thermal limits of the connection assets required to satisfy the requested **MIL** or **MEL SPEN** will inform the **Customer** of the impact on the **Minimum Scheme** for their connection.

11.4.5 Other Restrictions

It is possible that other factors may restrict the maximum **Power Station Capacity** at the site, for example fault level contribution, or possible transmission system related restrictions. Where this is the case **SPEN** shall notify the **Customer** of the reason for the restriction. For example, **SPEN** may impose a further limitation in areas subject to a Statement of Works process or other transmission restrictions.

11.5 Fail-Safe

All **CLSs** must fail to safety. If it is not inherently possible to arrange this within the **CLS**, alternative safety measures shall be provided as described in section 11.5.3.

For all **High Voltage** connected installations overload and/or reverse power protection (as described in section 11.5.3) shall be installed to disconnect the installation (or relevant **Devices** by agreement) in the event that the **CLS** fails to appropriately manage export or import. It shall be the responsibility of the **Customer** to specify and satisfy **SPEN** that the protection meets this requirement.

11.5.1 Failure Detection

Should a **CLS** fail, for any reason, there is the possibility that unsupportable high currents will flow, giving rise to the risk of damage to equipment or interference with other **Customers'** equipment and/or that excessively high or low voltages are present on the **Distribution Network** for unacceptable periods of time.

Failure detection shall include internal failure of the **CLS** and its **Components**, as well as the failure of any communication channels used by the **CLS** to communicate between its **Components** and between **Components** and **Devices** as described in this section.

Note that failure of the power supply to the **CLS**, or to the **Customer's Installation** or the zero voltage conditions associated with the controlled starting or stopping of the **CLS**, shall not be classed or detected as a low voltage condition triggering state 3 operation.

11.5.1.1 Internal Failure

The **CLS** shall detect any internal failure and move its operation into state 3 immediately (ie within 15s) after detecting such a failure. The **CLS Manufacturer** or **Installer** shall state how:

- The **CLS** will detect internal failures.
- The **Manufacturer** or **Installer** has assessed that this is the complete range of possible failures; and
- This can be demonstrated in testing.

11.5.1.2 Communication Failures

The **CLS** shall detect any defect in communication between its **Components** and **Devices**. This is especially necessary where the **CLS** is comprised of dispersed **Components**, including any **Components** that are transducers fitted at the **Connection Point** to measure current flows and direction. In particular the **CLS** shall detect discontinuity of the secondary circuit, or the magnetic circuit of any current transformers employed.

Any communication failure shall trigger a move into state 3 immediately (i.e., within 15s) after detecting such a failure.

Notwithstanding this, for communication between **Components** and between **Components** and **Devices** relying on non-hard-wired paths, short dropouts of communication of up to 15s are permissible before triggering state 3 operation.

Where, in response to a loss of communication to a **Device**, that **Device** immediately ceases operation (ie no current flows into or out of it), the **CLS** may remain in state 1 operation without registering a transition into state 3. All other provision of this EREC G100 shall apply to the operation of the **CLS** whilst communication to that **Device** is unavailable. When communication to that **Device** is restored, the **Device** shall restart in a controlled manner so there is minimal risk of an excursion into state 2 operation.

For **Components** and **Devices** which are both hard wired and close coupled (for example where a **Component** is integrated into a **Device**, is located immediately adjacent to it and there is essentially only internal wiring between the two) the need for detecting communication failures can be waived provided the **Manufacturer** or **Installer** can demonstrate that this is reasonable.

Note that the **CLS** shall treat the failure of a **Component**'s or **Device**'s power supply as a communication failure. Note that **Devices** may or may not have discrete separately connected power supplies from the main current carrying connections.

11.5.1.3 Excessive State 2 Operation

Although state 2 operation is expected, operation for periods exceeding 15s is not expected to be frequent. Accordingly, if a **CLS** breaches any of the following criteria, it shall enter state 3 operation immediately (i.e., within 15s):

- A single excursion into state 2 operation that persists for more than 1 minute (or 3 minutes as allowed in 11.3.2);
- There are more than three excursions (each of more than 15s and less than 1 minute (or 3 minutes as allowed in 11.3.2)) into state 2 operation in any 24-hour period;
- The time between any two consecutive excursions into state 2 operation of greater than 15s is 10 minutes or less (measured from the time of re-entry into state 1 operation from state 2 operation following the first excursion).; or
- For installations where the maximum excursion period is 3 minutes (as allowed in 11.3.2) the total time in state 2 operation in any 24-hour period, but neglecting any excursion of 15s or less, exceeds 8 minutes.

Excursions that do or do not count towards excessive state 2 operation are shown diagrammatically in **Figure 3**.

The implementation of the necessary counters and timers in the **CLS** must be done in non-volatile memory so that they are not reset if power to the **CLS** is lost.

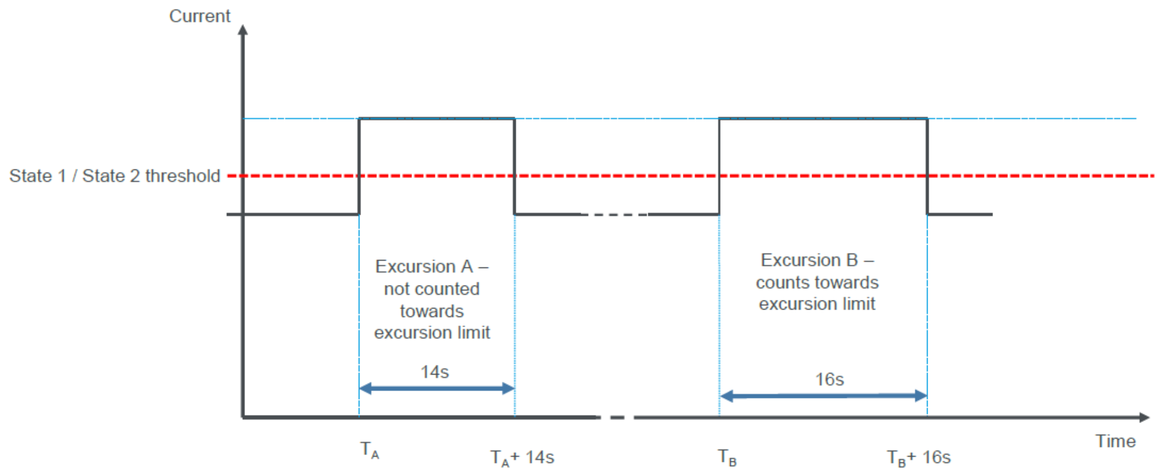


Figure 3. Excursions into Stage 2 counting towards the excursion limit

11.5.2 Recovery from Failure

The **CLS** should be capable of interrogation by the **Customer** to determine the nature of the failure.

The **Manufacturer** or **Installer** shall ensure that the **CLS** remains in state 3, including through the power supply to the **CLS** being cycled on/off, until it is reset. In most cases this will be by the **Customer**, via a **Manufacturer** or **Installer** provided facility, but subject to the additional requirements of this section.

Manufacturers or **Installers** may wish to provide a test facility so that testing whilst commissioning will not lead to multiple state 2 excursions triggering lock-out in state 3 (see 11.5.2.1). It must not be possible to leave the **CLS** operating in the test mode. **Manufacturers** or **Installers** shall explain how such a facility works and the risk of inappropriate use is controlled.

11.5.2.1 Internal Failures and Excessive State 2 Operation

For internal failures, and excessive state 2 operation, the **Customer**, following resolution of the cause of the failure, shall be able to reset the **CLS** back to normal operation as follows:

For **CLSs** installed in **Domestic Installations**, 3 resets shall be allowed in any 30-day period. If this criterion is breached the **CLS** will remain locked in state 3 pending further investigation and resolution of the issues causing the **CLS** to be locked-out in state 3. The **Manufacturer** or **Installer** shall propose how lock out in state 3 can be resolved.

For **CLSs** installed in non-domestic installations any excursion into state 3 operation shall not be capable of being reset within 4 hours of the start of state 3 operation. Should more than 3 resets by required in any 30-day period **SPEN** shall reserve the right to request information in writing from the **Customer** on the cause of the failure and action taken to prevent future failures to ensure ongoing compliance.

In both cases the **Manufacturer** or **Installer** has the option of performing a reset over the internet or by other remote means. Where such a remote reset facility is implemented, it must rely on direct communication between the **Customer** and the party implementing the reset to ensure that the reason for the lockout is understood and addressed.

Note that there is no limit to the number of resets that are allowed for state 3 operation arising from communication failures, as required by 11.5.1.2 and 11.5.2.2.

11.5.2.2 Communication Failures

The **Customer** shall be able to reset the **CLS** back to normal operation immediately in every case when communication has been restored, i.e., the lockout feature of 11.5.1.3 does not apply. A **CLS** may be arranged by the **Manufacturer** or **Installer** to self-reset from state 3 when state 3 operation is caused solely by communication failures.

11.5.3 Overload Protection and Alternatives to Fail-Safe

For **Customer's Installations** connected at **HV,** overload and/or reverse power protection shall always be fitted. For **Customers Installations** connected at **LV**, if the **Manufacturer** or **Installer** does not provide a **Fail-Safe CLS**, and/or the **Customer** cannot prove **Fail-Safe** functionality then a **CLS** can still be used, but the **Customer** will need to install appropriate protection at the **Connection Point**.

Suitable protection shall include overload protection (which might also need to be directional to cater for import and export limits) or reverse power protection.

Note that fuses, especially **SPEN**'s fuses, offer limited overload protection capabilities. Fuses generally are designed to be effective for short circuit faults rather than overloads. For overload protection it will not generally be appropriate for designs to uses fuses; overload (or reverse power) protection shall be designed to use appropriate relays that match the characteristics of **SPEN's** protection at the **Connection Point**. Overload protection arrangements are therefore unlikely to be suitable for **Domestic Installations**.

SPEN shall agree the design and settings of the protection and recorded in the **Connection Agreement**.

11.5.3.1 Overload or reverse power backing up a CLS

For all **HV** installations the **Customer** shall install overload, or reverse power, protection at the **Connection Point**. Overload protection shall be set no higher than the state 2 limits, import or export or both as appropriate. The protection shall be instantaneous (i.e., fast acting with no definite-time delay.)

11.5.3.2 Overload or reverse power as an alternative to a CLS

For overload protection used as an alternative to installing a **CLS**, the **Customer** can install overload protection at the **Connection Point**. In these cases, it should be set at the **MEL** or **MIL** or both as appropriate, with a default operating margin of 2%. Where overload protection is installed on individual **Devices**, as opposed to the whole of the **Customer's Installation** at the **Connection Point**, no margin shall be added to the **Device**'s rating, i.e., the setting shall be the same as, or less than, the **Device** rating. The characteristic of the protection shall be arranged to match that of the **DNO's** protection at the **Connection Point** and the maximum allowable operating time is 10s. Subject to detailed assessment **SPEN** may request a reduced operation time in order to protect network assets.

Where reverse power protection is appropriate it will generally be fitted at the **Connection Point** and can be arranged to trip either the relevant generation or the whole of the **Customer's Installation**, as agreed between **SPEN** and the **Customer**.

11.6 Communications

The **Manufacturer** or **Installer** must select an appropriate and secure communication medium for communication between the **Components** forming the **CLS**, and the **Devices** controlled by the **CLS**, noting that communication failures will cause state 3 operation of the **CLS**.

The **Manufacturer** or **Installer** shall provide information describing the communication media used in the **CLS** with supporting information as to why this is appropriate in terms of reliability and security.

11.7 Cyber security

Recognizing that cyber security is an evolving area, the **Manufacturer** or **Installer** shall consider the cyber security risks posed for the **CLS** both in terms of the communication between the **Components** forming the **CLS**, and the **Devices** controlled by the **CLS** and in terms of interaction with any other system, including any **Manufacturer**'s product management systems.

Accordingly, this document makes no specific cyber security compliance requirements. However, the **Manufacturer** or **Installer** shall provide information describing the high level cyber security approach, as well as the specific cyber security requirements complied with. The statement will make appropriate reference to the **CLS**'s compliance with any relevant aspects of:

- ETSI EN 303 645 CYBER; Cyber Security for Consumer Internet of Things: Baseline Requirements;
- Distributed Energy Resources – Cyber Security Connection Guidance – published by BEIS and the ENA;
- PAS 1879 Energy smart appliances – Demand side response operation – Code of practice; and
- Any other relevant standard that has been incorporated in the design of the **CLS**.

11.8 Access to SPEN Current and Voltage Signals

Customers will not have access to **SPEN**'s current transformers, and where the **Connection Point** is at **LV Customers** will generally be able to provide appropriate voltage signals themselves.

For the purposes of this document, Rogowski coils are an acceptable substitute for conventional current transformers.

The provisions of Distribution Code DPC6.7.8 shall apply for access to current and voltage signals from the **Connection Point**.

For voltage signals where the **Connection Point** is at **HV**, since the voltage signal is used for determining the direction of power flow, and for measuring the **Connection Point** voltage, it might be possible to use an **LV** supply within the **Customer's Installation** provided the phase angle between the measured voltage and that at the **Connection Point** remains fairly constant (e.g. where it is derived from a lightly loaded transformer electrically close to the **Connection Point**).

11.9 Generation in Non-exporting Sites

Where a **Customer** wishes to install generation but has no need to export power from the **Customers Installation**, an alternative to deploying a **CLS** is for the **Customer** to install reverse power protection at the **Connection Point**.

The reverse power protection can be arranged to control or trip the generation or to trip the whole of the **Customer's Installation**. The design of the reverse power protection, and its settings, shall be agreed with **SPEN** and recorded in the **Connection Agreement**.

11.10 Multiple CLSs in a Single Installation

In some installations **Customers** might want to install more than one **CLS** controlling separate sets of **Devices**. For **Customer's Installations** connected at **LV** the sum of all the **Current Ratings** of generation and storage (in export mode) **Devices**, and/or the sum of all the capacities of significant loads and storage (in import mode) **Devices** shall be less than the respective state 2 limits for that installation. Ideally one **CLS** should be configured to act as the master **CLS**, and all other **CLSs** configured to harmonize with it, but this is not an essential requirement. Multiple independent **CLSs** are not prohibited provided compliance with this document by the **Customer's Installation** is not compromised. **Customers** should note that multiple **CLSs** will need carefully setting up to avoid hunting, instability, or other forms of undesirable interactions between them.

For **Customer's installations** connected at **HV**, if it is not possible for a **CLS** to be confirmed as a master for the installation, suitable overload protection, directional if necessary, shall be fitted at the **Connection Point** and arranged to trip either the whole site, or appropriate **Devices**, within 1 minute (or 3 minutes for appropriate technologies and no other limitation on voltage rise – see 11.3.2) to ensure a **Fail-Safe** arrangement as described in 11.5.3. The **Customer** will agree with **SPEN** the exact arrangements and record the design approach in the **Connection Agreement**.

11.11 Domestic Installations

The principles and requirements of this document shall apply in full to **Domestic Installations**. It is expected that generally **Domestic Installations** will comprise **Fully Type Tested CLSs**.

Where a **CLS** is designed to manage export to **SPEN Distribution Network** and is **Fully Type Tested** it shall be capable of having the state 1 operating limit (i.e., the **MEL**) set to 16A, 32A, 60A, 80A or 100A (per phase values). **Manufacturers** can provide other settings, but not more than 100A, and shall ensure the design minimises the risk of **Installers** inadvertently selecting an inappropriate limit. The **Installer** shall make the appropriate selection for the specific installation, and which shall be protected from being changed in accordance with the requirements of section 11.2. **SPEN** would not expect to witness the installation, commissioning, and operation of the **CLS**.

Where a **CLS** is designed to manage import from **SPEN Distribution Network** and is **Fully Type Tested** it shall be capable of having the state 1 operating limit (ie the **MIL**) set to 60A, 80A or 100A (per phase values). **Manufacturers** can provide other settings, but not more than 100A and shall ensure the design minimises the risk of **Installers** inadvertently selecting an inappropriate limit. The **Installer** shall make the appropriate selection for the specific installation, and which shall be protected from being changed in accordance with the requirements of section 11.2. **SPEN** would not expect to witness the installation, commissioning and operation of the **CLS**.

These principles would also apply where a **Fully Type Tested CLS** is designed to manage both export to and import from **SPEN Distribution Network**.

For commissioning **Fully Type Tested CLSs** the requirements of 14.2 apply.

11.12 Interfaces with DNOs' Systems

By agreement it may be appropriate to interface a **Customer**'s **CLS** with systems used by **SPEN** to manage their network dynamically. This might be to implement **Active Network Management**, a flexible connection, or a flexibility contract between the **Customer** and **SPEN**.

The interface could be to accept a single new set point for the maximum current that can be exchanged at the **Connection Point**, or a variable set point. In either case **SPEN** will provide the protocols and other information necessary.

11.13 Quality

All installations must comply with the power quality requirements defined in:

- ENA Engineering Recommendation P28
- ENA Engineering Recommendation P29
- ENA Engineering Recommendation G5

Compliance of individual **Components** of the scheme will not guarantee the scheme as a whole will be compliant.

In accordance with the above documents and with BS7671 (The IET Wiring Regulations) and the Distribution Code**, Customers** shall discuss and agree the connection of any potentially disturbing equipment with **SPEN**. Such equipment includes motors, motor drives, pumps (including heat pumps), electric boilers, welders, furnaces, kilns, generators, switched capacitors etc.

In addition to the connected load and generation, the **CLS** may also create voltage disturbances and voltage distortion.

A **CLS** that quickly decreases or trips the generation or that quickly increases or decreases demand may give rise to rapid voltage changes and / or flicker. In such cases the **Customer** shall provide **SPEN** information on the maximum change in current or power, the characteristics of the change (e.g. step change, ramped change etc.). If the current is ramped up or down the maximum ramp rate and ramp duration shall also be provided. EREC P28 normally restricts rapid voltage changes to a maximum of 3%.

A **CLS** that relies on power electronics (e.g. converters etc.) to control the load shall also provide information demonstrating compliance with relevant harmonics standards (e.g. BSEN 61000-3-2 and/or BSEN 61000-3-12) or provide data on the harmonic current produced by the **CLS** in accordance with ENA EREC G5.

The scheme shall maintain the agreed **Power Factor** at the metering point.

SPEN reserves the right to retrospectively monitor the schemes for compliance.

12. MONITORING

Upon written request, the generator will provide suitable access to enable **SPEN** to monitor performance of the **CLS**. **SPEN** may also utilise the standard metering flows for the purpose of on-going enforcement.

13. APPLICATION AND ACCEPTANCE

Customers (or **Installers** on the **Customers'** behalf) shall provide information on the proposed **CLS** and **Devices** to enable **SPEN** to assess the risk to the **Distribution Network**.

The following information shall be provided with the **CLS** application (in addition to information required for any **Device** that is intended to be controlled by the **CLS**):

- Completed **CLS** application (Form A – appendix A);
- Schematic diagram of the **CLS** and associated **Devices**;
- Where the **CLS** has not been **Fully Type Tested**, the **Manufacturer**'s G100 Product Declaration (Form B - Appendix B) – including:
    - Explanation of the **CLS** operation;
    - Description of the **Fail-Safe** functionality, commissioning and demonstration of compliance.

If necessary, this can be submitted in stages if all the information is not available at the time of application.

14. WITNESS TESTING AND COMMISSIONING

The following section only applies to **CLS**s at installations with an aggregate **Generating Unit** capacity exceeding 16A (3.68kW) per phase.

14.1 General

The **Customer** (or the **Installer** on the **Customer**'s behalf) is responsible for demonstrating that any **CLS** installed in the **Customer's Installation** complies with the requirements detailed in this document.

Installers are responsible for demonstrating, via **Manufacturers'** type tests, other published information, and/or appropriate site tests that the **CLS** complies with the requirements detailed in this document. **Installers** are also responsible for providing **Customers** who own that equipment with sufficient information to enable **Customers** to meet their own obligations to demonstrate compliance.

In order to safely and effectively test a **CLS**, it is necessary to be able to simulate instances where the **CLS** is expected to operate. Where a **CLS** is integrated into the **Device** it controls, has a range of settings, and is intended to be a **Fully Type Tested CLS,** then it shall be tested at the extremities of its export and import current settings, and one intermediate export or import current setting. This requirement does not apply to stand alone **CLSs** that are commissioned on site.

14.2 Site commissioning of Fully Type Tested CLSs

Where the functions described in section 14.6 have been validated in a type test by the **Manufacturer** (i.e., the **CLS** is **Fully Type Tested**), a reduced set of tests can be undertaken on site.

In these cases, it will be sufficient to undertake the communication and power supply **Fail-Safe** tests in section 14.5 (i.e., all the tests in Table 2) to prove that the **CLS** reacts appropriately.

Form C (Appendix C) must be submitted in all cases, but Form B (Appendix B) is not required where the reference to the **Fully Type Tested** compliance information on the ENA's Type Test Register is included as a reference on Form C.

14.3 Commissioning Sequence

CLS commissioning shall only be undertaken after all other **Device** commissioning has been successfully completed.

The **Customer** (or the **Installer** on the **Customer**'s behalf) shall provide to **SPEN** all relevant scheme drawings and information to enable safe, informed commissioning of the **CLS**.

In order to ensure that commissioning does not cause any safety issues on **SPEN**'s **Distribution Network**, the following commissioning sequence shall be followed. Tests shall be performed in the sequence indicated and the process shall only proceed to the next stage once the preceding stage has been successfully undertaken:

The commissioning test actions shall be carried out in the following order:

1. Implement the measures to ensure that the **MEL** or **MIL** cannot be exceeded.
2. Perform **Fail-Safe** tests.
3. Perform operational testing.
4. Set export and/or import limits.
5. Verify export and import limits are correct.

14.4 Preventing the Limits Being Exceeded During Testing and Commissioning

Care shall be taken whilst testing and commissioning the **CLS** so that the **MEL** or **MIL** is not breached. This may involve setting the export or import limit to a lower threshold for compliance demonstration purposes. A combination of the following measures should be considered to ensure that **MEL** and/or **MIL** is not exceeded during setup/testing:

- Temporarily programming the **CLS** export and/or import or setpoint limits to 50% (or less) than **MEL** and/or **MIL**;
- Temporarily narrowing the range of the **CLS** voltage limits (i.e., bringing the set points closer to the **Nominal Voltage**);
- Restricting the maximum output of the generation (e.g., on a PV system with multiple inverters, turning off a number of the inverters);
- Restricting the amount of load that is connected; and
- Operating a temporary load, load bank or generator.

If the **CLS** settings need to be changed in order to demonstrate operation, then they shall be restored and confirmed once testing is complete.

Note that testing will lead to what normally would be considered excessive state 2 operation and hence lock-out. **Manufacturers** or **Installers** may provide a test mode to allow for this – see 11.5.2.

14.5 Fail-Safe Tests

The purpose of the **Fail-Safe** tests is to ensure that should any part of the **CLS** fail, the current flow across the **Connection Point**, and the voltage imposed on the **Distribution Network**, will remain within, or return within the required time to, the design limits.

There are a number of potential options for reducing the current flows such that the design limits are not breached including:

1. Switching off relevant **Devices** completely;
2. Reducing the number of the **Devices** operating such that the aggregate current capacity of the **Devices** remaining operational is equal or less than the **MEL** and / or **MIL**; and
3. Operating all **Devices** at a restricted output such that as in aggregate their combined current is safely and securely limited to be equal or less than the **MEL** and/or **MIL**.

The **Fail-Safe** test process comprises a sequence of tests on each separate **Component** of the **CLS**. Each **Component** and **Device** needs to have, where relevant, its communication medium removed or interrupted and, separately, its power supply interrupted.

At no time during the **Fail-Safe** test sequence shall the current flowing through the **Connection Point** rise above the programmed export and/or import limit (taking account of **Manufacturer**'s published tolerances) for a period of time longer than the specified reaction time.

NOTE: The power supplies for some **Components** may take a short while to power down (due to power stored in capacitors). This will cause a slight delay in the response time of the system. In such cases the reaction time is measured from the point at which the **Component** powers down, not the point at which the power supply is disconnected.

The following table describes a typical test sequence. Not all **CLSs** will have all of the **Components** listed and others may have additional **Components** that need to be included in the test sequence. The **CLS** shall be restored to normal operation after each of the tests below.

No.	Component	Test
1	**Connection Point Component** (ie transducer)	Remove power supply to transducer†
2	Principle **CLS Component(s)**	Remove power supply
3	**Components** controlling generation **Devices**	Remove power supply to each in turn
4	**Components** controlling storage **Devices**	Remove power supply to each in turn
5	**Components** controlling load **Devices**	Remove power supply to each in turn
6	Communication controller and or hubs/switches etc	Remove power supply to each in turn
7	Communication between **Components**	Remove/interrupt communication to each **Component** in turn*
8	Where applicable communication between **Components** and **Devices**	Remove/interrupt communication between each **Component** and associated **Device** in turn
9	**CLS** system	With reference to the **Manufacturer**'s published information on internal failures (see 4.5.1.1) undertake the recommended tests etc to confirm that the **CLS** detects and reacts appropriately to internal failures.

Table 2. Test Sequence

*There are safety issues in interrupting current transformer circuits, which can give rise to dangerously high voltages. Care must be taken to ensure that the current transformer connections and/or secondary circuits are either tested with zero primary current, or are short circuited, or ideally both, before the circuit to the transducer is opened.

For each test confirm that the **CLS** enters state 3 operation, and that on restoration of communication or power to the relevant **Component** or **Device** it is then possible to immediately reset the **CLS** into state 1 operation.

14.6 Operational tests

In order to safely and effectively test a **CLS**, it is necessary to simulate normal state 1 operation and then the transition from state 1 to state 2 to confirm that it responds appropriately. Note that operating setpoints must be reduced so that state 2 operation for testing purposes does not exceed the **MEL** or **MIL** as explained in section 14.4. Two different means may be employed to simulate this:

1. Manual control over the **Devices** operating on the site; or
2. Injection testing using a calibrated test set

The method adopted will depend on the nature of the site. On larger sites (e.g., an office, factory, or school with multiple distributed **Devices**), injection testing may be the only practical option.

Note that the tests described in 5.6.1 and 5.6.2 amalgamate the **CLS'**s control capability (i.e., regulating output/input levels of **Devices**) with the correct operation in states 1, 2 and 3. Depending on the design of the **CLS**, and its facilities for testing, it might be necessary to devise a test plan that tests these two aspects (ie control of **Devices** and correct movement between states) separately.

The correct orientation of any part of a **Component** that measures current and/or voltage shall be confirmed.

Operational testing shall be performed that demonstrates satisfactory transition between state 1 operation and state 2 operation. Tests shall be undertaken that demonstrate the correct operation in returning to state 1 operation from state 2 operation as well as showing that excessive state 2 operation will lead to state 3 operation (**Fail-Safe**). This is shown conceptually in **Figure 4**. Test A demonstrates that an excursion outside the test level threshold triggers the correct **CLS** response without triggering **Fail-Safe**, whereas test B should trigger the **Fail-Safe** condition.

Figure 4 shows the tests to be undertaken. Note that the time in brackets is for those technologies (see 11.4.1) where the three-minute limit on excess current flow in state 2 applies.

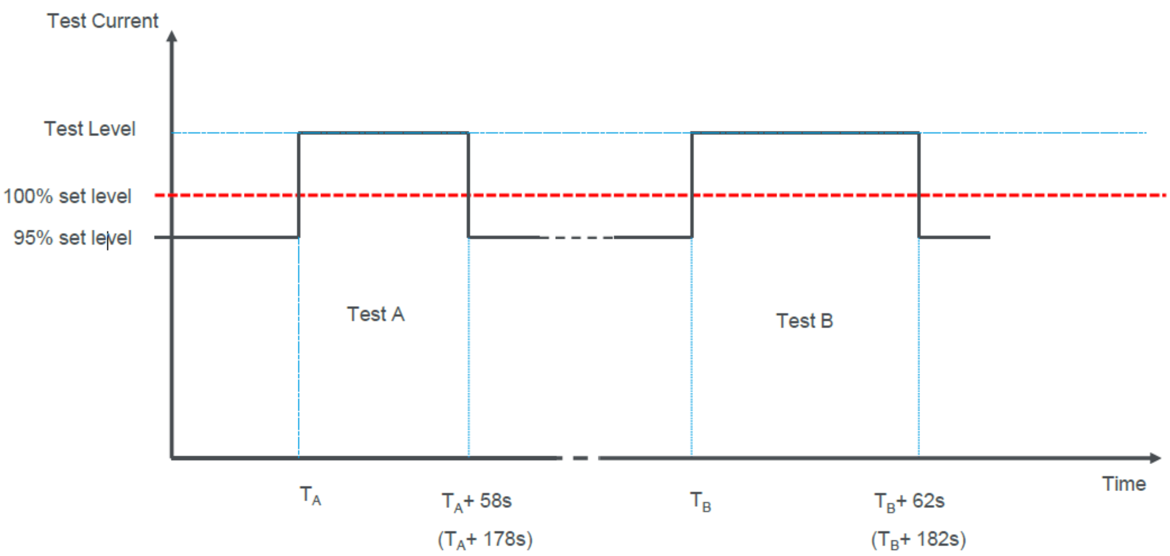


Figure 4. Current Steps Tests

To carry out the tests the site conditions should be adjusted, and a generic test method could be:

1. The export and import current limits are adjusted (i.e., set to zero or a percentage of the **MEL** or **MIL** value).
2. The consumption and/or output of the **Devices** are manually increased / decreased.

Note that if testing without a **Manufacturer**'s or **Installer**'s test mode, operation in state 2 will lead to lockout in state 3. This is not an issue for a **Fully Type Tested CLS**, but for an installation where the full EREC G100 tests are carried out on site, arrangements will need to be made to cater for this aspect.

Pass-Fail criteria: The **CLS** is considered to have passed the test if during the test sequence the current exported from or imported to the site at the **Connection Point** do not breach the set-point limits for a period of time longer than the specified reaction time.

14.6.1 Operational testing – Manual Load Control

The consumption and/or output of the **Devices** should be manually adjusted to achieve the test levels at the **Connection Point**. Arrangements will have to be made to hold the required test conditions at the **Connection Point** for sufficient time to demonstrate compliance noting that the natural behaviour of the **CLS** will be to resolve (i.e., reduce) the conditions, i.e., to move back from state 2 operation into state 1 operation. As described above it might be necessary to take other measures during testing to ensure that the correct **Fail-Safe** behaviour occurs when the conditions at the **Connection Point** are maintained for longer than the **Fail-Safe** time threshold.

14.6.2 Operational testing – Injection Testing

Export and/or import limit conditions can be simulated by temporarily injecting current into the transducer(s) using a calibrated injection test set.

When using an injection test set, there is normally no feedback loop between the **CLS** and the injection test set. This has two significant implications for the test process:

1. As soon as the **CLS** begins to operate, because it sees no corresponding decrease in current flow, the control loop will keep running until the relevant **Devices** reach the limit of their operating range; and
2. To ensure that the **CLS** is reacting by an appropriate amount and within an acceptable time period, a step change needs be applied by the test set to the **Connection Point** transducer.

14.6.3 Test Sequence

The following test sequence shall be performed as appropriate to the **Devices** installed (e.g., if there is no control over import, do not carry out the import tests).

Note that where testing is being done under manual load control, tests 1, 3, 4 and 6 shall be completed from Test A (i.e., tests 2 and 5 can be omitted.

Test A	Parameter stepped to the value shown and held there for 58s (or 178s by agreement with DNO)	Required outcome
1	Export = 105% of programmed limit value	State 1
2	Export = 110% of programmed limit value	"
3	Export = 120% of programmed limit value	"
4	Import = 105% of programmed limit value	"
5	Import = 110% of programmed limit value	"
6	Import = 120% of programmed limit value	"
Test B: repeat test 1 and 4 only of the above	**Test Level (step change) final value – maintained for 62s (or 182s by agreement with DNO)**	
7	Export = 105% of programmed limit value	State 3
8	Import = 105% of programmed limit value	"

Table 3. List of Tests

The procedure for performing the test is as follows. The test needs to be repeated for import and export as appropriate. Test A demonstrates normal excursion into state 2 followed by a return to state 1 operation. Test B demonstrates excessive state 2 operation and hence confirms the **Fail-Safe** functionality.

14.6.3.1 Test A

- Initially apply an injection of 100% of **Nominal Voltage** and inject current to mimic a current flow equivalent to of 95% of the limit setting.
- Step up the current to give a current flow equivalent to 105% of the limit (for Test 1), Check that change in level is registered appropriately by the **CLS**. Check that the **CLS** is in state 2.
- Check that the current from generation and exporting storage **Devices** reduces to a value at least 5% below the export limit setting within the specified reaction time. Be aware that as noted in 14.6.2 (1) the **CLS** will continue to drive the output of the **Device** away from its original set point.
- Within 58s reduce the injected current back to 95% of the limit. Check that the **CLS** has returned to state 1.
- Repeat the above for step increases from 95% to 110% of the set limit and from 95% to 120% of the set limit as detailed in Table 3.

14.6.3.2 Test B

- Initially apply an injection of 100% of **Nominal Voltage** and inject current to mimic a current flow equivalent to of 95% of the limit setting.
- Step up the current to give a current flow equivalent to 105% of the limit (for Test 7), Check that change in level is registered appropriately by the **CLS**. Check that the **CLS** is in state 2.
- After 62s (or 182s where appropriate) check that the **CLS** has moved into state 3; reduce the injected current back to 95% of the limit.
- Confirm that all **Devices** have assumed an operating state (including being tripped off) as required by state 3.
- Confirm that **Devices** remain in state 3 operating mode (or off) until the **CLS** is reset.

14.6.3.3 Confirm Reset from State 3

Confirm that state 3 remains in operation until reset, and that all **Devices** can only be operated (if at all) in their state 3 state.

Confirm that the **CLS** in a **Domestic Installations** can be reset to state 1 immediately and that the **CLS** locks into state 3 on the third occasion. Confirm that the **CLS** in a non-domestic installation can only be reset after 4 hours.

14.6.3.4 Test Completion

When injection testing is complete, the correct orientation of any current monitoring connections (including transducer orientations) which may have removed for the test must be checked and verified as being correct.

If settings have been changed in order to demonstrate operation, they must be restored and confirmed as being correct once testing is complete.

Finally allow the **CLS** to operate under normal conditions and confirm that there is no inappropriate control cycling or hunting.

14.7 Overload and Reverse Power Protection

Where overload protection and/or reverse power protection is used for **Customer's Installations** connected at **HV**, or as an alternative to installing an EREC G100 compliant **CLS**, or as an alternative to **Fail-Safe** (see 11.5.3 and 11.10) these shall be tested by secondary injection.

15. MANUFACTURERS G100 PRODUCT DECLARATION

Manufacturers of **CLS**s having undertaken the required tests shall complete the G100 Product Declaration as set out in Appendix C. Copy of this declaration shall be provided to the **Customer**. The **Customer** will then provide a copy of the product declaration to **SPEN** as set out in section 13 of this guidance policy.

APPENDIX A – CLS Application Information

This form is available in a Microsoft Word version from the ENA's website.

G100/2 - Form A – CLS Application Information

This form shall be used by all applicants considering installing a **CLS**. This form shall accompany any associated application for new connection to the **Distribution Network** or for the connection of any associated generation, storage or significant load to the **Customer's Installation**.

To ABC electricity distribution **DNO**
99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com

Customer Details:

Customer (name)	
Address	
Post Code	
Contact person (if different from **Customer**)	
Telephone number	
E-mail address	
MPAN(s)	
Customer signature	

Please provide the following information

Explanation / description of the **CLS** operation including a schematic diagram and a description of the **Fail-Safe** functionality, eg the response of the scheme following failure of:

- Any **Component**
- Any **Device**
- System internal failure
- Communication media

ENA Type Test Register system reference for the **CLS**, if known	

Capacities:	Ampere
Requested **Maximum Export Limit**	
Requested site **Maximum Import Limit**	

Aggregate sum of all generation and storage capacities	
Aggregate sum of all generation and storage that will be controlled by the **CLS**	
Aggregate sum of all loads (including storage) in the installation (ie those both controlled by the **CLS** and those that are not controlled by the **CLS.**)	
Aggregate sum of all loads (including storage) that will be controlled by the **CLS**	

APPENDIX B – Manufacturer's CLS Product Information

This form is available in a Microsoft Word version from the ENA's website.

G100/2 - Form B - Compliance Verification Report for Customer Export or Import Limitation Schemes

This form shall be used by the **Manufacturer** to demonstrate and declare compliance with the requirements of EREC G100. The form can be used in a variety of ways as detailed below:

1. For **Fully Type Tested** status

   The **Manufacturer** can use this form to obtain **Fully Type Tested** status for a **CLS** by registering this completed form with the Energy Networks Association (ENA) Type Test Register.

2. To obtain **Type Tested** status for a product

   The **Manufacturer** can use this form to obtain **Type Tested** status for one or more **Components** which are used in a **CLS** by registering this form with the relevant parts completed with the Energy Networks Association (ENA) Type Test Register.

3. One-off Installation

   The **Installer** can use this form to confirm that the **CLS** has been tested to satisfy the requirements of this EREC G100. This form shall be submitted to the **DNO** before commissioning.

A combination of (2) and (3) can be used as required, together with Form C where compliance of the **CLS** is to be demonstrated on site.

Note:

If the **CLS** is **Fully Type Tested** and registered with the Energy Networks Association (ENA) Type Test Register, Form C shall include the **Manufacturer**'s reference number (the Type Test Register system reference), and this form does not need to be submitted.

Where the **CLS** is not registered with the ENA Type Test Register or is not **Fully Type Tested** this form (all or in parts as applicable) shall be completed and provided to the **DNO**, to confirm that the **CLS** has been tested to satisfy all or part of the requirements of this EREC G100.

CLS Designation			
Manufacturer name			
Address			
Tel		Web site	
E-mail			
Installer's name			
Address			
Tel		Web site	
E-mail			

Export/Import capabilities			
Export	Y / N	Import	Y / N
Description of Operation			
EREC G100 section 4.2 requires a description of the **CLS**, and schematic diagram, to be provided to the **Customer**. Please provide that description and the diagram here.			

Communications Media
Document the provisions made for the use of various communication media, and both the inherent characteristics and the design steps made to ensure security and reliability.
Cyber Security
Confirm that the **Manufacturer** or **Installer** of the **CLS** has provided a statement describing how the **CLS** has been designed to comply with cyber security requirements, as detailed in EREC G100 section 4.7.
Power Quality Requirements
Where the **CLS** includes the power electronics that controls generation or loads (as opposed to the power electronics being included in **Devices** that are subject to their own power quality compliance requirements) please submit the harmonic and disturbance information here as required by EREC G5 and EREC P28.

Fail-Safe		
CLS internal failure: please submit here the description of the internal **Fail-Safe** design and operation. Please also document how it has been demonstrated, including the non-volatile recording of times and numbers of state 2 operations, and confirm the overall response of the **CLS** to this internal failure.		
Communication and power supply failures between **Components** and **Devices**. Please document here compliance with EREC G100 section 5.5.		
Component/Device number/description	Communication failure test	Power supply failure test

Operational Tests

In accordance with EREC G100 section 5.6 undertake the tests A and B to confirm correct operation in state 1 and state 2, that transition into state 3 occurs as required, and that behaviour in state 3 is also as required.

Test A						
Nominal Export Limit (for type tests this will be at maximum, minimum and one intermediate setting) in Amp:						
Nominal Import Limit (for type tests this will be at maximum, minimum and one intermediate setting) in Amp:						
No	Starting level	Step value	**CLS** registers change in level?	**CLS** and/or **Component** and/or **Device** initiates correct response of ≥ 5%?	Duration of step in test	Correct state 1/ state 2 operation
1						
2						
3						
4						
5						
6						
Test B						
Nominal Export Limit:						
Nominal Import Limit						
No	Starting level	Step value	**CLS** registers change in level?	**CLS** and/or **Component** and/or **Device** initiates correct response of ≥ 5%?	Duration of step in test	Correct state 3 operation
7						
8						

State 3 Reset
These tests are to demonstrate compliance with section EREC G100 4.5.2. Please document how the reset from state 3 to state 1 has been demonstrated. Please include how the reset is achieved. Please confirm that for **CLSs** to be installed in **Domestic installations** three (3) resets causes lockout or that for non-domestic installations lockout can only be reset after four hours. Please explain how lockout is reset.

APPENDIX C – CLS Installation and Commissioning Tests

This form is available in a Microsoft Word version from the ENA's website.

G100/2 - Form C: Installation Document for Customer Export or Import Limitation Schemes (CLS) Part 1 shall be completed for the installation. Part 2 shall be completed for [each of] the **CLS** being commissioned.	
Form C Part 1	
To ABC electricity distribution **DNO** 99 West St, Imaginary Town, ZZ99 9AA abced@wxyz.com	
Customer Details:	
Customer (name)	
Address	
Post Code	
Contact person (if different from **Customer**)	
Telephone number	
E-mail address	
MPAN(s)	
Customer signature	
Installer Details:	
Name	
Accreditation / Qualification	
Address	
Post Code	
Contact person	
Telephone Number	
E-mail address	
Signature	
Installation details:	
Address	
Post code	

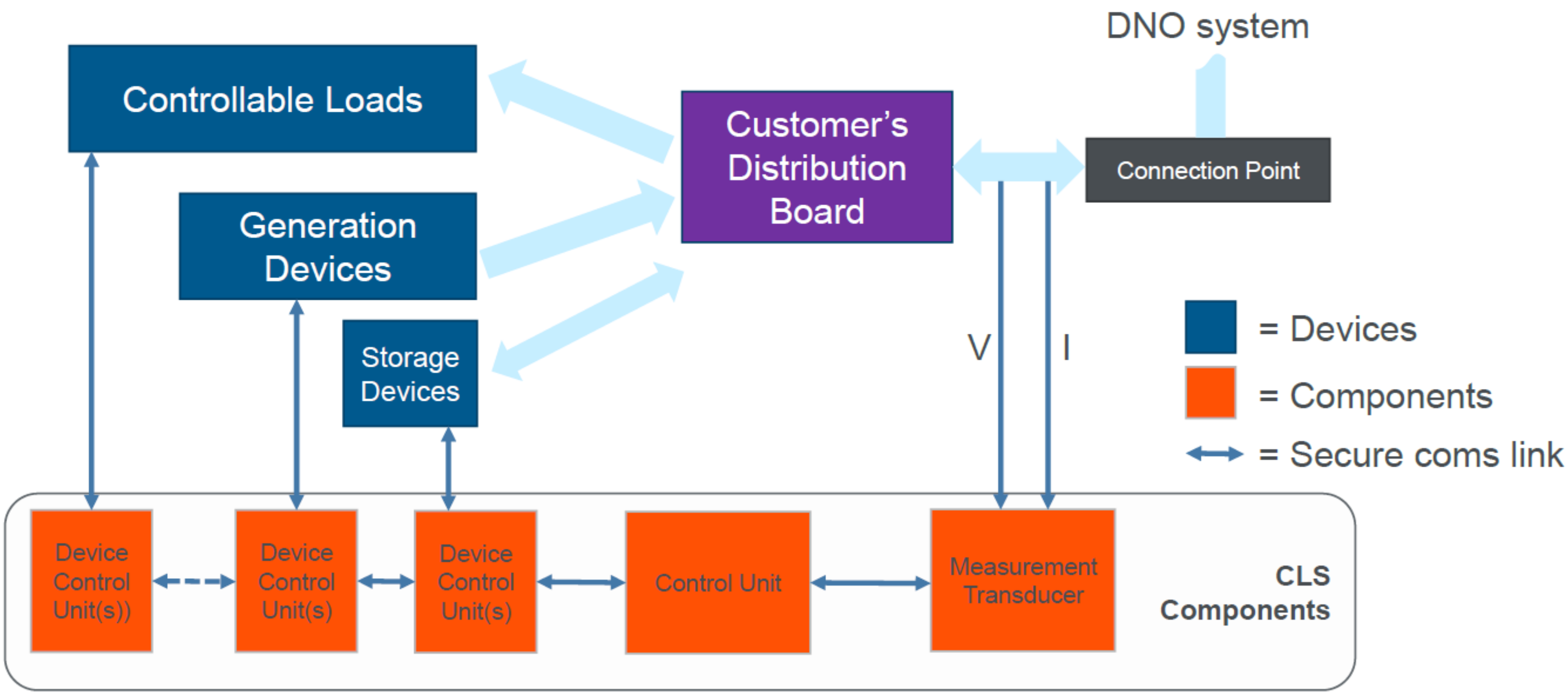
Location within **Customer's Installation**	

<table>
<tr><th colspan="7">Summary details of Devices within the Customer's Installation</th></tr>
<tr><td rowspan="3">Manufacturer / Reference (including ENA Type Test Register system reference)</td><td rowspan="3">Date of Installation</td><td rowspan="3">Nature of loads, sources of energy and conversion technology etc:</td><td colspan="4">Device capacity (A)</td></tr>
<tr><td rowspan="2">3-Phase Units</td><td colspan="3">Single Phase Units</td></tr>
<tr><td>PH1</td><td>PH2</td><td>PH3</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Form C Part 2	
Commissioning Checks	
Description	**Confirmation**
Customer's Installation satisfies the requirements of BS7671 (IET Wiring Regulations)?	Yes / No*
Schematic diagram and all relevant **Manufacturer**'s and **Installer**'s information safely retained on site?	Yes / No*
Operation diagram (if required, ie for export control) displayed correctly on site?	Yes / No*
Communication/Power supply failure tests?	Yes / No*
Fail-Safe Tests (Form B and/or ENA Type Test register system reference) completed successfully in full	Yes / No*/Ref
Final test to confirm no inappropriate control cycling or hunting	Yes/No*
Operational tests completed (Form B or **Manufacturer**'s reference)	Yes / No*/Ref
*Circle as appropriate. If "No" is selected the **CLS** is deemed to have failed the commissioning tests and the **CLS** shall not be put in service.	
Overload or Reverse Power Protection If fitted, please state settings here: Please state what tripping action the protection initiates: Confirm that the protection has been tested and please provide the test results:	
Additional comments / observations:	
Declaration – to be completed by **Customer** or **Installer**	

I declare that for the **CLS**, and the installation: 1. Compliance with the requirements of EREC G100 is achieved. 2. The commissioning checks detailed in this Form C have been successfully completed.	
Name:	
Signature:	Date:
Company Name:	
Position:	
Declaration – to be completed by **DNO** Witnessing Representative if applicable. Delete if not witnessed by the **DNO**	
I confirm that I have witnessed the commissioning checks detailed in this Form C	
Name:	
Signature:	Date:
Company Name:	

APPENDIX D – (INFORMATIVE)
EXPORT AND IMPORT LIMITATION SCHEME DIAGRAM



Typical Scheme Design for an Export and Import Limitation Scheme Arrangement

APPENDIX E – EXAMPLES

Example 1 – PV installation at a large Domestic Property

A domestic **Customer** wishes to install a PV system, but **SPEN** has restricted the **MEL** to 16A due to concerns over voltage rise. The cut-out fuse rating is 80A. A **CLS** is to be installed so that the capacity of the PV installation can be maximised.

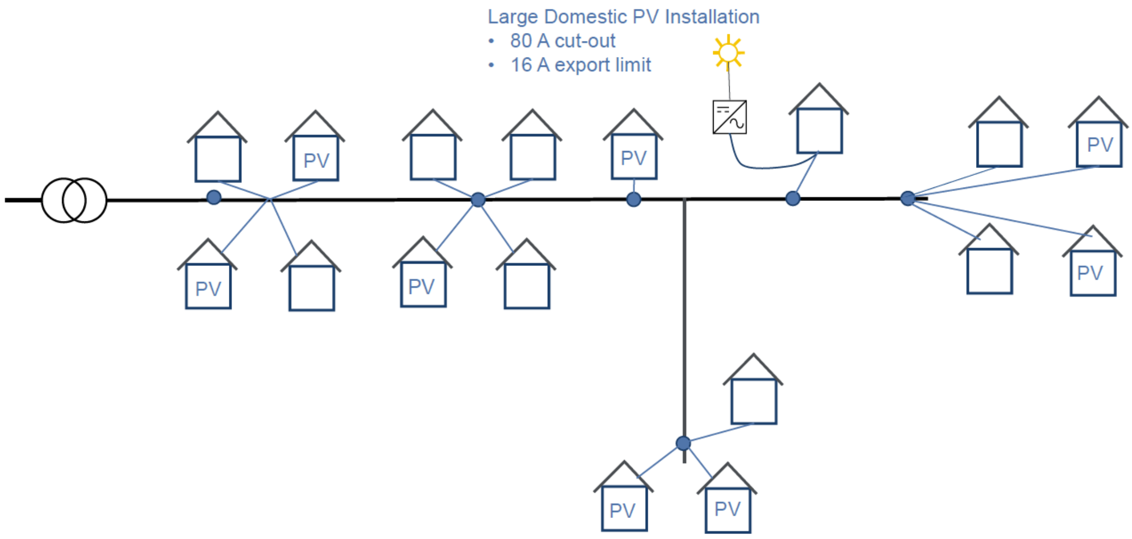


Figure 5. Large PV Installation at a Domestic Property

The **DNO** determines the maximum acceptable installed generation capacity, as follows:

Thermal Assessment:

The continuous rating of the cut-out and service cable are both in excess of 80A (18.4kW) and the state 2 five-minute **Distribution System** capability is substantially higher than this. **SPEN** determines that the thermal rating of the installation does not, in practice, limit the capacity of the PV system.

Protection Assessment:

The protection assessment restricts the state 2 limit to 1.45 x the cut-out fuse rating, i.e., 116A or 26.7kW.

Voltage Assessment:

The highest voltage that can be accepted on the **LV** network in state 2 is 111% of the **Nominal Voltage** = 111% of 230V = 255.3V.

SPEN calculates that when 10kW of generation is connected at the property the voltage at the end of the circuit reaches 255.3V.

Conclusion

If a **CLS** is installed that limits the export to 16A the maximum acceptable generation capacity is the lower the results from the state 2 thermal assessment, protection assessment and voltage assessment. In this case the generating capacity, i.e., the aggregate rating of the PV inverters, must be no higher than 44A (i.e., 10kW at **Nominal Voltage** and unity **Power Factor**).

PV inverters up to 44A can be installed, but **SPEN** requires that the **MEL** is restricted to 16A (with a **CLS** set to 16A) to prevent the voltage on the **LV** network exceeding the maximum statutory voltage limit of 230V + 10% of 230V = 253V.

Example 2 – Wind Turbine Installation at a Farm

A farmer would like to install a wind turbine with a capacity of 200kW. The farm has an **LV** connection with an **MIL** of 200kW (3 phase) but does not have an **MEL**. The cut-out fuses are 300A.

After carrying out a design study, **SPEN** is only able to offer a **MEL** of up to 220A (152kW) due to the voltage rise at the **Connection Point**. The **Installer** recommends the use of a **CLS** to allow the 200kW wind turbine to be installed.

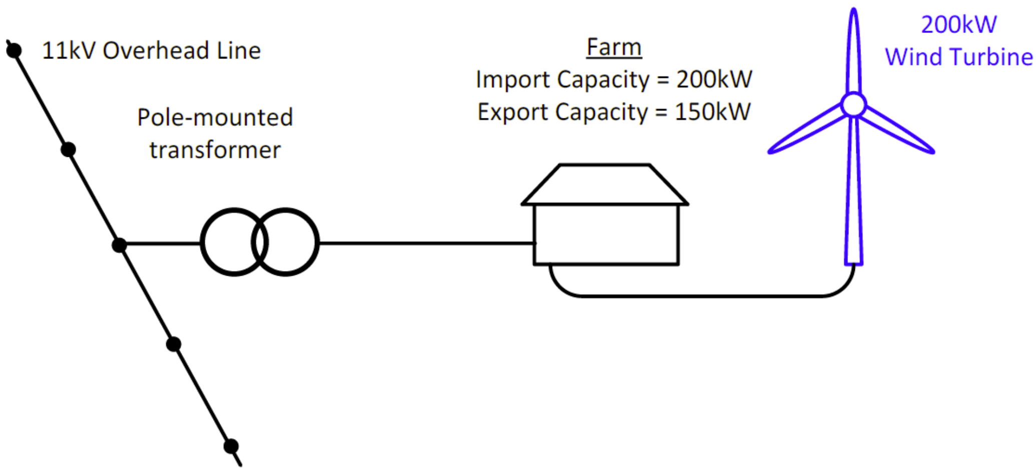


Figure 6. Wind Turbine Installation at a Farm

SPEN carries out the following assessments:

Thermal Assessment

SPEN establishes that the existing **HV** and **LV** network can accommodate 220A of export continuously (at **Nominal Voltage** and unity **Power Factor**) and substantially more than 290A (200kW) of export for the state 2 thermal limit.

Protection Assessment:

The protection assessment restricts the state 2 limit to 1.45 x 300A = 435A (300kW)

The proposed 200kW wind turbine satisfies the state 2 protection assessment.

Voltage Assessment:

SPEN assesses the generator's impact on the **LV** network voltage and the **HV** network voltage under minimum demand / maximum generation conditions. The voltage rise on the **HV** network voltage is found to be minimal, but the **LV** voltage is calculated to rise to 254V when the 200kW wind turbine operates at its maximum capacity (at unity **Power Factor**).

The highest voltage that can be accepted on the **LV** network in state 2 is 111% of the **Nominal Voltage** = 111% of 230V = 255.3V.

The estimated value of 254V satisfies this requirement.

Conclusion

The proposed 200kW wind turbine is below the maximum acceptable generation capacity with a suitable **CLS**. If a **CLS** is installed that limits the export to 152kW (ie 220A at **Nominal Voltage** and unity **Power Factor**), the proposal is acceptable.

Example 3 – A new PV farm connection

A **Customer** wishes to install a 5MW PV farm in a rural area. The PV farm also requires an import capability of 100kW to power the ancillary supplies.

The connection to the **HV** network is via a metering circuit breaker with IDMT relay protection set to 400A, 0.15tm.

SPEN carried out an assessment and offered a **MEL** of 120A (2.3MW at **Nominal Voltage** and unity **Power Factor**) pending reinforcement works. Once the network has been reinforced the full 5MW export capacity can be provided.

The **Customer** proposes to temporarily install a **CLS** until the reinforcement works are completed to maximise the capacity of PV installation during the interim period.

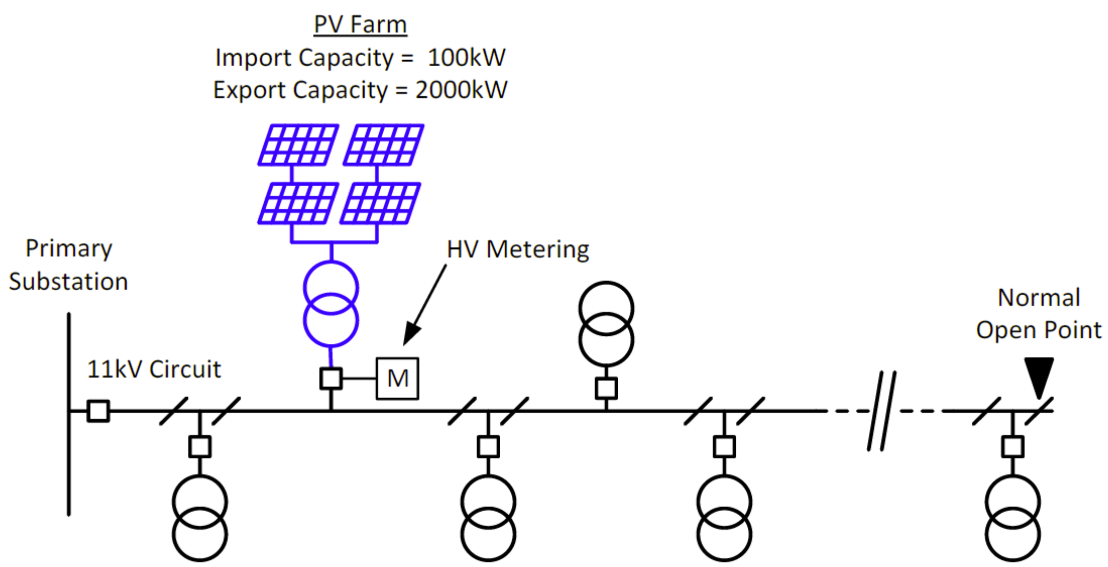


Figure 7. New PV Farm

SPEN assesses the maximum generation capacity, as follows:

Thermal Assessment

SPEN assesses the network is capable of withstanding an export of 240A (4.6MW at **Nominal Voltage** and unity **Power Factor**) for the state 2 design time of five minutes.

Protection Assessment

The relay is set to 400A; the maximum unrestricted export from the site would be 250A.

The protection does not present any limitations.

Voltage Assessment:

SPEN assesses the generator's impact on the 11kV network under minimum demand / maximum generation conditions. **SPEN** specifies an upper voltage limit of 11.66kV to prevent the voltage on the local **LV** network from exceeding statutory limits.

For the purposes of assessing the maximum acceptable generation capacity the voltage must not exceed upper voltage limit + (1% of the **Nominal Voltage**) = 11.66kV + (1% of 11kV) = 11.77kV during the state 2 operating time of the **CLS**.

SPEN calculates that the voltage will increase to 11.77kV if the site exports 4.8MW (at unity **Power Factor**).

Conclusion

If a **CLS** is installed with a **MEL** of 120A (that limits the export to 2.3MW) the maximum acceptable generating capacity (ie the maximum capacity of the PV farm) is the lower of results from

- The thermal assessment (4.6MW);
- The voltage assessment (4.8MW); and
- The protection assessment (9.5MW).

In this case the generating capacity must be temporally restricted to 240A (4.6MW) until the reinforcement work is completed (e.g., by not connecting all the PV arrays).

Example 4 – A new CHP connection

A **Customer** wishes to install a 3MW CHP installation in an existing industrial installation. There is no existing generation on the site. The site maximum demand is 1.5MW. There is significant (5MW) of generation already installed on the same 11kV feeder.

The connection to the **HV** network is via a metering circuit breaker with relay protection set to 200A, 0.15tm.

SPEN carried out an assessment and can offer a maximum export capacity of 100A (i.e., 1.91MW at unity **Power Factor** and **Nominal Voltage**). This will enable normal operation of the site but will pose problems when the site demand drops below 1.09MW and the generation is running at full output.

Thermal Assessment

SPEN assesses the network is capable of withstanding an export of 10MW (at **Nominal Voltage** and unity **Power Factor**) for the state 2 design time of five minutes.

Protection Assessment

The relay is set to 200A; the maximum unrestricted export from the site could be 171A.

The protection does not present any limitations.

Voltage Assessment:

SPEN assesses the generator's impact on the 11kV network under minimum demand / maximum generation conditions. **SPEN** specifies an upper voltage limit of 11.66kV to prevent the voltage on the local **LV** network from exceeding statutory limits.

For the purposes of assessing the maximum acceptable generation capacity the voltage must not exceed upper voltage limit + (1% of the **Nominal Voltage**) = 11.66kV + (1% of 11kV) = 11.77kV during the state 2 operating time of the **CLS**.

SPEN calculates that the voltage will increase to 11.77kV if the site exports 184A (i.e., 3.5MW.)

Conclusion

In this case the proposed 3MW generator is below the maximum acceptable generation capacity (at **Nominal Voltage** and unity **Power Factor**) and therefore if a **CLS** is installed with a **MEL** that limits the export to 100A (ie 1.91MW at unity **Power Factor**), the proposal is acceptable.

Example 5 – Domestic EV charging

A **Customer** wishes to install 2 x 7kW EV chargers at their domestic **Customer's Installation**. The **Customer** has a typical loads and installation. The installation does not include an electric shower or any other high-power appliances. The typical maximum demand of the installation without the EV chargers is 2kW, with short term peaks of 8kW.

The installation is connected to **SPEN**'s network via an 80A cut-out.

A **CLS** is installed which is intended to limit the maximum import to 72A.

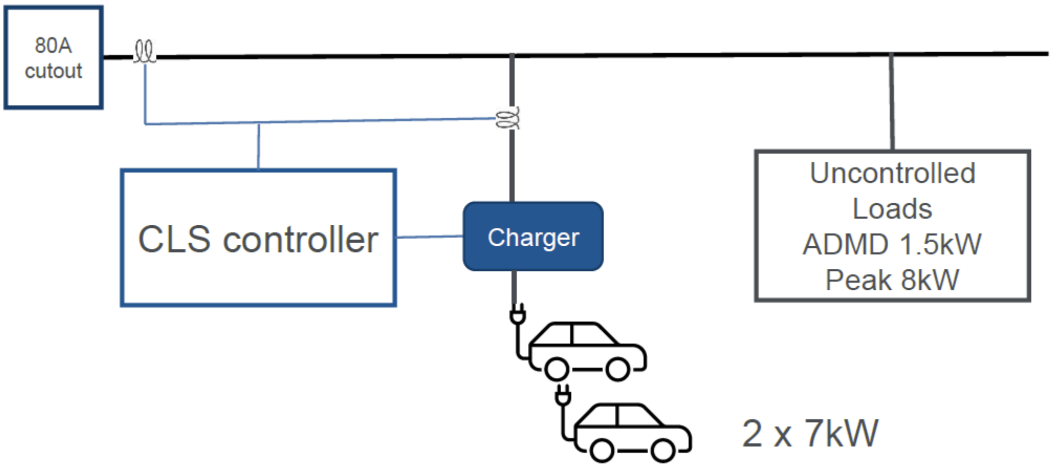


Figure 8. Domestic EV Charging

Thermal Assessment

The continuous rating of the cut-out and service cable are both in excess of 80A (18.4kW) and the state 2 five-minute **Distribution System** capability is substantially higher than this. **SPEN** determines that the thermal rating of the installation does not, in practice, limit the capacity of the EV system.

Protection Assessment

The protection assessment restricts the state 2 limit to 1.45 x the cut-out fuse rating, i.e., 116A or 26.7kW.

Voltage Assessment

SPEN assesses the maximum instantaneous demand that can be supported whilst maintaining the minimum statutory voltage is 35kW.

Conclusion

In this case the state 2 limit is set by the protection criterion, ie 26.7kW, which is 4.7kW above the maximum possible demand (8kW + 2 x 7kW = 22kW) of the installation. The proposal is acceptable.

If the installation had included an electric shower, for example, the potential instantaneous maximum demand would be too large for an 80A fuse and **SPEN** would need to upgrade the cut-out and/or cut-out fuse.

Example 6 – Commercial EV charging

A **Customer** wishes to install 50 x 22kW EV chargers (ie aggregate capacity 1100kW) in a supermarket car park.

The supermarket has an existing connection with a **MIL** of 300kW, supplied from an 11kV 1000kVA transformers with 500kW of spare capacity. The installation's existing maximum demand is 220kW.

The intention is to seek an increased **MIL** of 650kW, and to use a **CLS** to ensure the EV charging load is modulated such that the **MIL** is not exceeded.

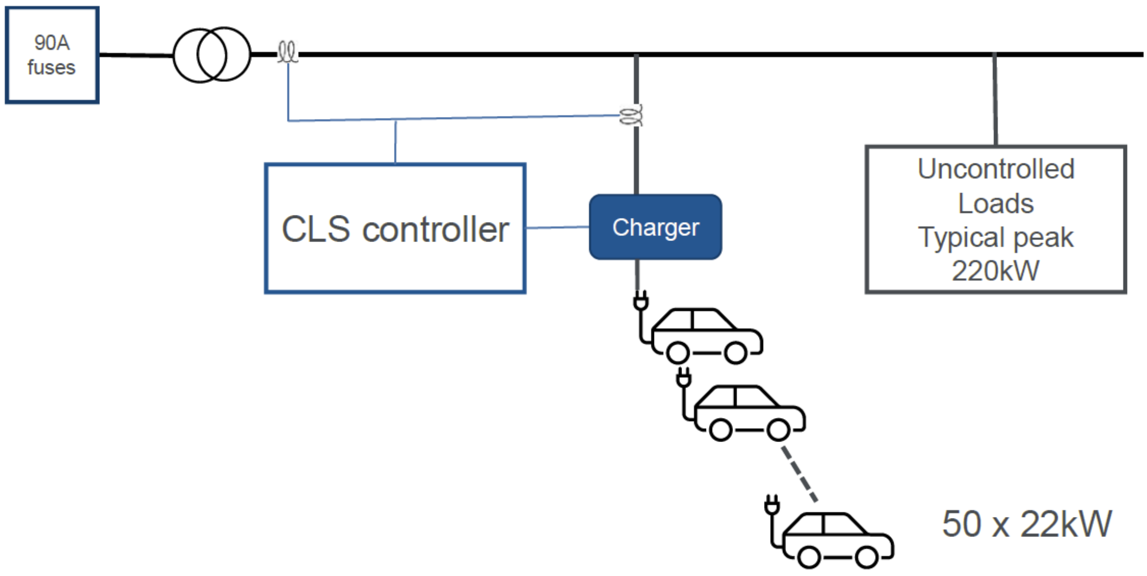


Figure 9. Commercial EV Charging

Thermal Assessment.

SPEN assesses that **SPEN's** network can withstand 1700kW for five minutes.

Protection Assessment.

The maximum instantaneous power that can be supported on the 90A **HV** fuses controlling the transformer is 2480kW.

Voltage Assessment

SPEN assesses the maximum instantaneous demand that can be supported whilst maintaining the minimum statutory voltage is 3000kW.

Conclusion

In this case the limit on the installed capacity, ie setting the state 2 limit, is the thermal capacity of **SPEN's** network at 1700kW. The installed capacity of the supermarket and its proposed EV chargers is 1320kW, comfortably within the state 2 limit. The proposal is acceptable and can proceed with no reinforcement required.

Example 7 – Use of Overload Protection

A **Customer** wishes to install 50 x 22kW EV chargers (aggregate capacity 1100kW) in a supermarket car park but limit the collective demand of the chargers rather than fit a **CLS**.

The supermarket has an existing connection with a **MIL** of 300kW supplied from an 11kV 1000kVA transformers with 500kW of spare capacity. The installation's existing maximum demand is 220kW.

The intention is to seek an increased **MIL** of 650kW, and to use overload protection to ensure the EV charging load is modulated such it never exceeds 350kW (i.e., 507A).

There are two options:

(a) install the overload protection as part of the EV charger installation

(b) install overload protection for the whole installation.

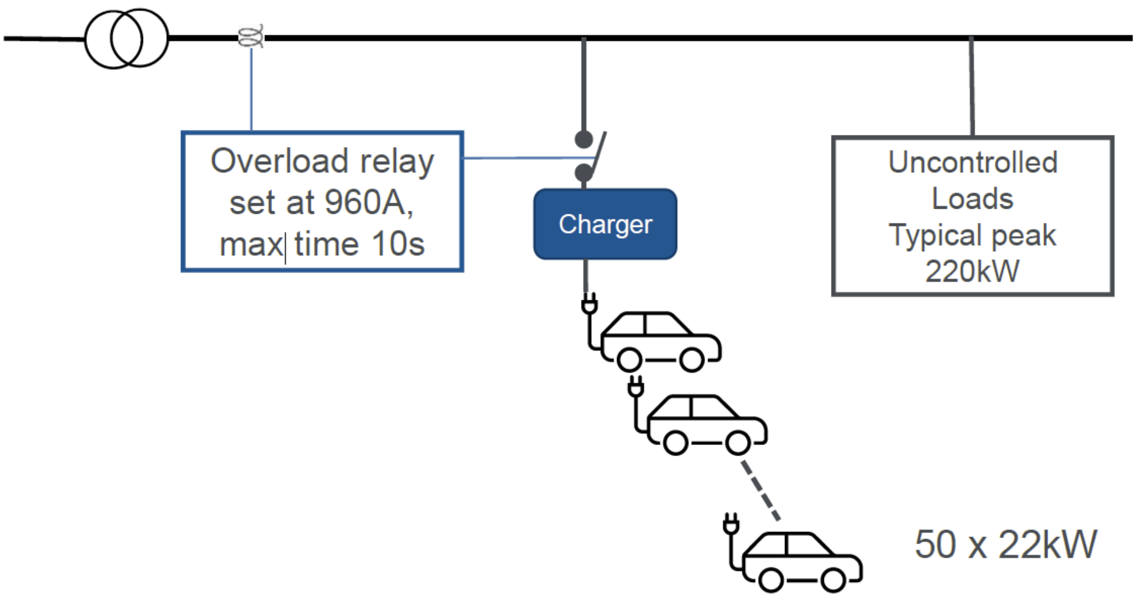


Figure 10. Overload Protection Option (a)

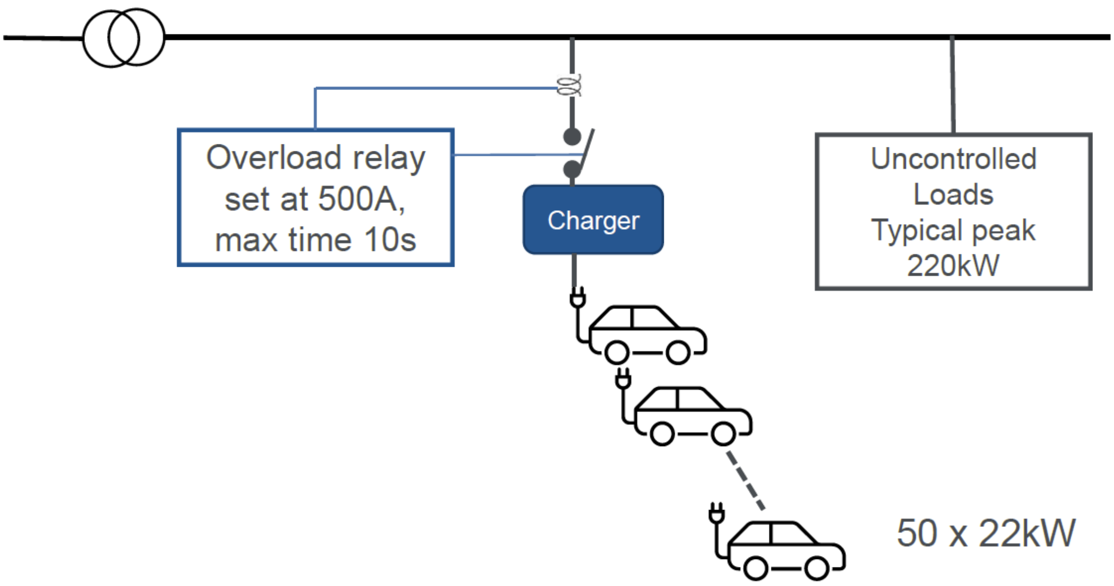


Figure 11. Overload Protection Option (b)

Thermal Assessment.

SPEN assesses that **SPEN's** network can withstand 1700kW for five minutes.

Protection Assessment.

The maximum instantaneous power that can be supported on the 90A **HV** fuses controlling the transformer is 2480kW.

Voltage Assessment

SPEN assesses the maximum instantaneous demand that can be supported whilst maintaining the minimum statutory voltage is 3000kW.

Overload protection setting for the two options:

(a) **MIL** is 650kW, 942A. Overload shall be set 2% greater than this – ie 960A, to grade with **DNO's** protection. Maximum operating time10s.

(b) EV charger demand is constrained to be 350kW, 507A. If 507A is not an available setting, the next lowest setting of 500A shall be selected, again to grade with **DNO's** protection. Maximum operating time 10s.

Conclusion

Provided **SPEN** is satisfied that the protection operating characteristics are appropriate, and that the installation is sufficiently tamper-proof, no **CLS** is required.

APPENDIX F – (INFORMATIVE) AC POWER AND DIRECTION OF POWER FLOW

Types of Power Measurement

Three different types of Power are applicable to A.C. systems, **Apparent Power**, **Active Power** and **Reactive Power**.

(a) **Apparent Power** = Voltage x Current and has units of Volt-Amperes (e.g. VA, kVA or MVA).

(b) **Active Power** = Voltage x Current x COS ϴ, where ϴ is the angle between the Voltage and Current waveforms. **Active Power** is expressed in Watts (e.g. W, kW or MW).

(c) **Reactive Power** = Voltage x Current x SIN ϴ, where ϴ is the angle between the Voltage and Current waveforms. **Reactive Power** is expressed in VARs (e.g. VAr, kVAr or MVAr)

COS ϴ is often referred to as the **Power Factor**

Direction of Power Flow

AC current, voltage and **Apparent Power** are, by themselves, non-directional quantities. The direction of active and **Reactive Power** flow depends on the relationship (angle) between the voltage waveform and the current waveform. This relationship can be shown in two ways, as a diagram of voltage and current by angular displacement (as shown in **Figure 12**) or as a vector diagram (as shown in **Figure 13**).

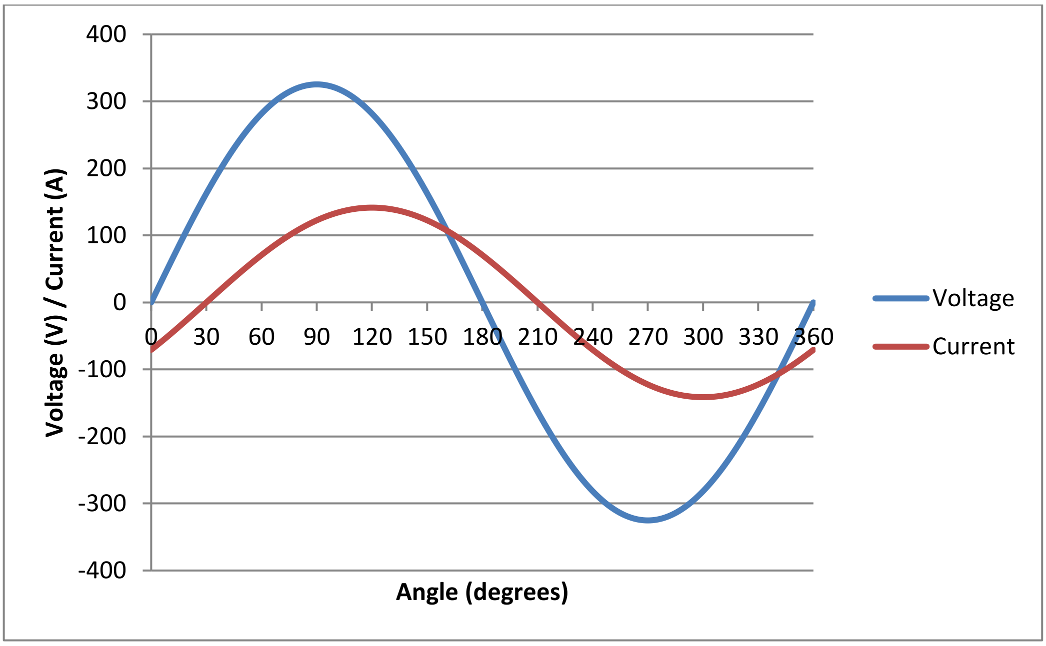


Figure 12. Current & Voltage V Waveforms – Current lagging Voltage by 30°

Note, A compete cycle (i.e. 360°) has a duration of 20ms where the frequency is 50Hz.

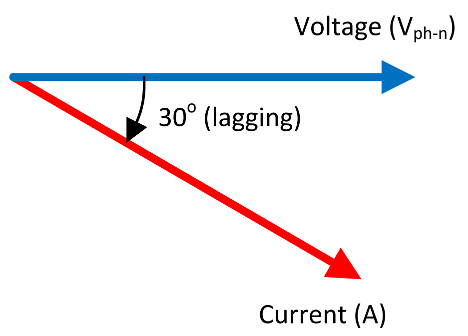


Figure 13. Vector Diagram – Current Lagging Voltage by 30°

Active Power

If the current lags or leads the voltage by 90° or less the **Active Power** is positive. If the current lags or leads the voltage by more than 90° the flow of **Active Power** is negative.

Reactive Power

If the current lags the voltage more than 90° and by less than 180° the **Reactive Power** is positive. If the current leads the voltage by more than 90° and less than 180° the flow of **Reactive Power** is negative.

Figure 14 shows the relationship between **Apparent Power**, **Active Power** and **Reactive Power**. In this case both **Active Power** and **Reactive Power** are positive since the current is lagging the voltage by less than 90°.

Figure 15 and **Figure 16** show how the direction of power flow changes as the angle between the current and voltage varies. Four examples are provided:

- I1 lags the voltage by approximately 20° and, in this case, the **Active Power** and **Reactive Power** are both positive.
- I2 leads the voltage by approximately 20° and in this case the **Active Power** is positive and the **Reactive Power** is negative.
- I3 lags the voltage by approximately 160° and so in this case the **Active Power** is negative and the **Reactive Power** is positive.
- I4 leads the voltage by approximately 160° and so in this case both the **Active Power** and the **Reactive Power** are negative.

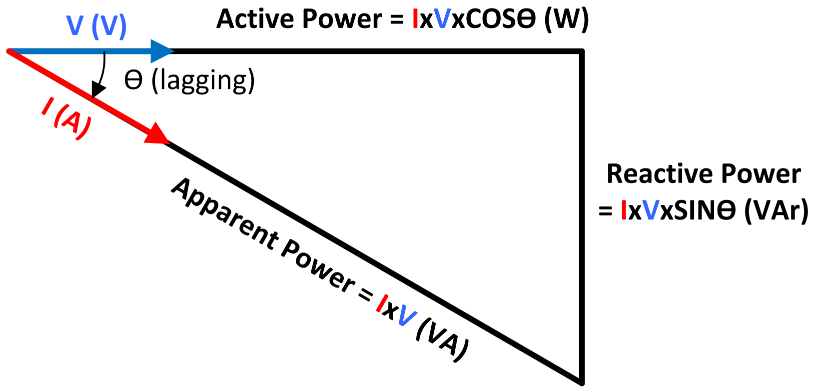


Figure 14. Apparent Power, Active Power and Reactive Power

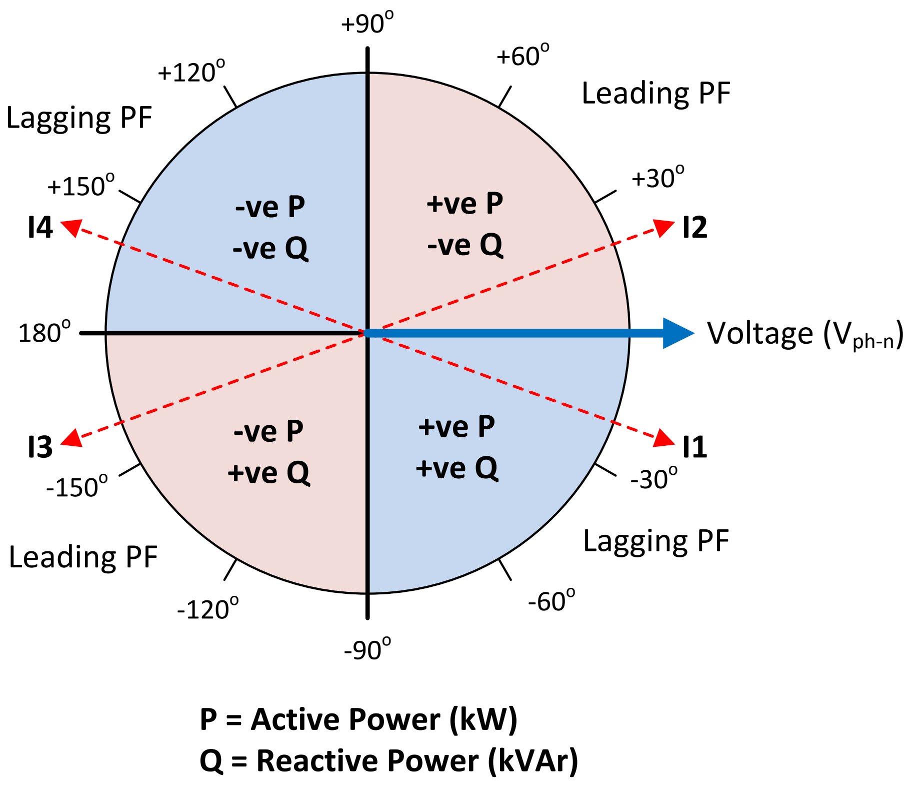
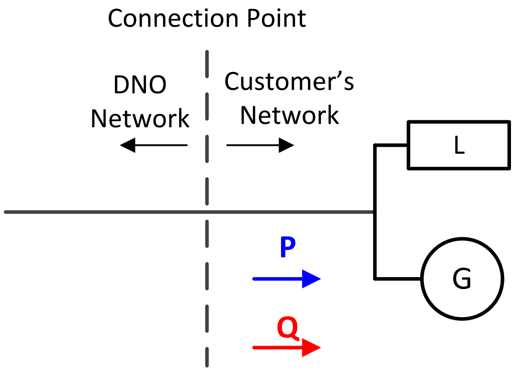
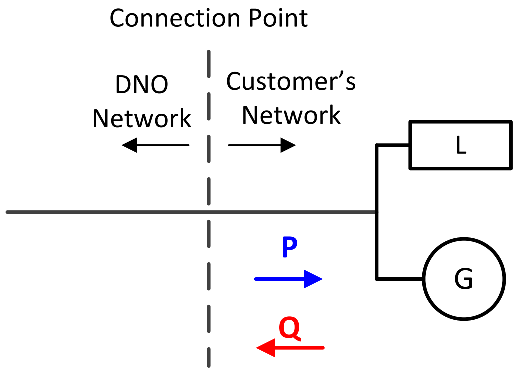


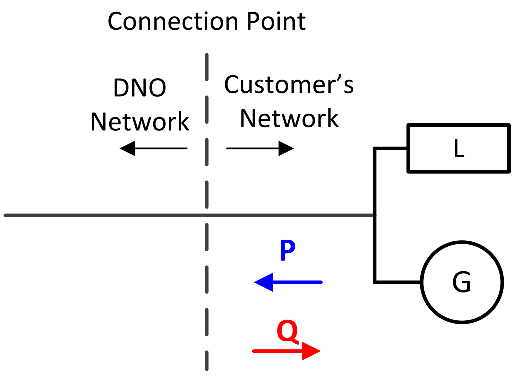
Figure 15. Four Quadrant Diagram – Direction of Power Flow



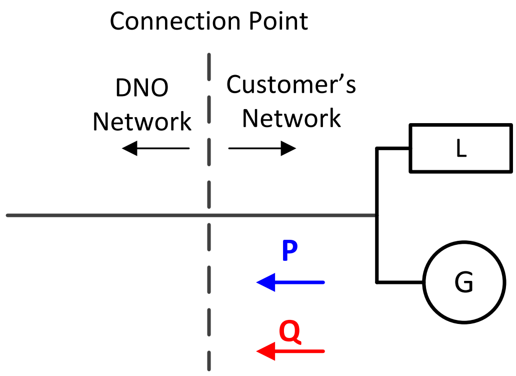
Current I1 Lagging Voltage by ≤ 90°



Current I2 Leading Voltage by ≤ 90°



Current I3 Lagging Voltage by >90° and <180°



Current Leading I4 Voltage by >90° and <180°

KEY:

Generating Units = G

Demand = L

Figure 16. Direction of Power Flow