ELEXON

Metering Dispensation D/560 – Scurf Dyke BESS

Imbalance Settlement Group

Date of meeting	**6 June 2023**	Paper number	**266/02**
Owner/author	**Mike Smith**	Purpose of paper	**Decision**
Classification	**Public**	Document version	**V1.0**

Summary

Elexon Ltd has applied for a lifetime Metering Dispensation application (D/560) from Code of Practice (CoP) 2. This is on behalf of FP Lux Scurf Dyke Solar Limited (a non-BSC Party). The application is for the location of the Metering Equipment associated with the Metering Systems for the Scurf Dyke Battery Energy Storage System. We invite the ISG to approve Metering Dispensation D/560, on a lifetime basis.

1. BSC requirements

1.1 Section L[1] of the Balancing and Settlement Code (BSC) requires all Metering Equipment to either:

- comply with the requirements set out in the relevant Code of Practice (CoP) at the time the Metering System is first registered for Settlement under the BSC (L3.2.2); or
- be the subject of, and comply with, a Metering Dispensation (L3.4).

1.2 Section L allows the Registrant of a Metering System, or prior to the appointment of a Registrant of a Metering System BSCCo, to apply for a Metering Dispensation if, for financial or practical reasons, Metering Equipment will not or does not comply with some or all the requirements of a CoP.

1.3 The process for applying for a Metering Dispensation is set out in BSCP32[2].

2. Background to Metering Dispensation

2.1 Scurf Dyke Solar Farm and Battery Energy Storage System (BESS) are a co-located Power Park Module (PPM) with a 33kV metered connection to the Northern Powergrid's (NPg) (Yorkshire) Distribution System.

2.2 The Solar Farm is metered to CoP2 standards at the Defined Metering Point (DMP), which is the point of connection to NPg's Distribution System.

2.3 The Solar Farm will be settled via a difference metering arrangement, with the BESS Metering System to be located below it, using an aggregation rule within the Solar Farm's Complex Site Supplementary Information Form (CSSIF).

[1] 'Metering'
[2] 'Metering Dispensations'

3. Metering Dispensation D/560 – Scurf Dyke BESS

3.1 Elexon Ltd has applied for this Metering Dispensation (D/560) on behalf of FP Lux Scurf Dyke Solar Limited (Attachment A). This is because FP Lux Scurf Dyke Solar Limited are not a BSC Party and a Registrant for the BESS Metering System has not yet been appointed[3].

3.2 Metering Dispensation D/560 relates to the Metering Equipment associated with the Scurf Dyke BESS. The Actual Metering Points (AMPs) for the BESS Metering Equipment (i.e. for the BESS and auxiliary transformer circuits) are not located at the DMP but the two BESS circuits will be metered to CoP2 standards. In addition, the BESS circuit Meters will use a busbar connected voltage transformer (VT), as opposed to a circuit connected VT. The busbar VT is located two metres (m) from the BESS circuit being measured by the associated current transformers so, the losses (volt-drop) between the two locations is negligible.

3.3 The AMP for the BESS circuit is located approximately 25m below the DMP. The losses from the DMP, over 25m of 630 millimetre squared (mm^2) copper cable, to the site's 33kV busbar, where the BESS and auxiliary transformer circuits connect, have been calculated and are deemed negligible (0.0029%). Therefore, the BESS Metering System (i.e. the BESS and BESS.AUX Meters) will not be compensated for these losses.

3.4 The AMP for the BESS auxiliary transformer circuit is on the low voltage (LV) side of the BESS auxiliary transformer with 125m of 95mm^2 aluminium cable between its high voltage (HV) side and the 33kV site busbar. Losses from the LV side to the 33kV busbar have been calculated as 1.422% and will be applied to this BESS auxiliary transformer Metering Sub-System via an aggregation rule within a CSSIF for the BESS Metering System[4]. As result, the BESS Metering System will remain within CoP2 overall accuracy limits at the DMP.

4. MDRG comments

4.1 We circulated the Metering Dispensation application and its attachments to the Metering Dispensation Review Group (MDRG) for comments (Attachments A – F).

4.2 Three MDRG Members responded. One declared an interest as their company is the Meter Operator Agent for the site. The two other MDRG Members who responded support the application on the following bases:

- they agree with the approach and therefore support the application; and
- that the (CoP2) overall accuracy limits for the BESS circuits will be maintained at the DMP by compensating for the losses between the AMP and DMP (not required for the BESS circuit due to how small they are).

5. LDSO comments

5.1 We circulated the Metering Dispensation application and its attachments to the Licensed Distribution System Operator (LDSO) for comments (Attachments A - F).

5.2 The LDSO, NPg, supports the application as the Metering Dispensation is reasonable, and it doesn't envisage any negative impacts, or risk, to Settlements.

6. ELVA's comments

6.1 We circulated Metering Dispensation application and its attachments to the Electrical Loss Validation Agent (ELVA) and asked it to validate the proposed loss compensation factor (Attachments A – F).

6.2 At the time of writing the ELVA is re-assessing information, following initial comments provided to the applicant. We will provide a verbal update about the ELVA's views, of the suitability of the proposed compensation, at the ISG meeting.

[3] Elexon has been able to submit Metering Dispensation applications on behalf of non-BSC Parties since 17 November 2022. This was the date when we implemented Modification Proposal P437 'Allowing non-BSC Parties to request Metering Dispensations'. This is the first such application Elexon has progressed on behalf of a non-BSC Party.

[4] These losses will also be included in the aggregation rule within the CSSIF for the Solar Farm.

7. Elexon's view

7.1 Elexon supports this application as CoP2 overall accuracy limits for the BESS Metering System will be maintained at the DMP.

7.2 The losses from the site's 33kV busbar to the DMP are negligible (0.0029%) and will not be compensated for. Compensation (1.422%) will be applied for losses in the BESS auxiliary transformer, and 125m of aluminium cable, to the site's 33kV busbar, via the BESS Metering System's CSSIF aggregation rule.

7.3 The BESS Metering System will also be differenced off the Solar Farm Metering System, the measurement transformers for which are located at the DMP. This will be done via the Solar Farm's CSSIF aggregation rule.

8. Recommendation

8.1 We invite the ISG to:

a) APPROVE Metering Dispensation D/560, from Code of Practice 2, for the Metering Equipment associated with the Scurf Dyke Battery Energy Storage System, on a lifetime basis.

Attachments

Attachment A – Metering Dispensation application (D/560)

Attachment B – D/560 Prysmian copper cable datasheet

Attachment C – D/560 Prysmian aluminium cable datasheet

Attachment D – D/560 Appendix – Loss calculation

Attachment E – D/560 Appendix – Simulation results

Attachment F – D/560 BESS auxiliary transformer datasheet

For more information, please contact:

Mike Smith, Metering Analyst

mike.smith@elexon.co.uk

020 7380 4033

BSCP32/4.1 Application for a Metering Dispensation

Part A – Applicant Details

To: BSCCo	**Date Sent:** *28/04/2023_*
From: Requesting Applicant Details Name of Sender: Contact email address: Contact Tel. No.	Contact Fax. No.: *N.A.*
Name of Applicant Company: *Elexon Ltd, 350 Euston Road, London NW1 3AW on behalf of:*	
FP LUX SCURF DYKE SOLAR LIMITED, 22 Chancery Lane, London, England	
Post Code: *WC2A 1LS*	Our Ref: *N/A*.
Name of Authorised Signatory: *Applicant is not a BSC party, but is requesting that Elexon, as BSCCo raise this dispensation on their behalf.* Authorised Signature:	Password:

Confidentiality:

Does any part of this application form contain confidential information?

Request for Confidentiality *NO*

If 'YES', please state the parts of the application form that are considered confidential, including justification below. Information that is considered confidential:
Reasons for requesting confidentiality: …… number, site name, expiry date (if any) and BSC Panel determinations will routinely be made available in the public domain unless the applicant informs BSCCo otherwise at the time of application

BSCP32/4.1 Application for a Metering Dispensation (Cont.)

Part B - Affected Party Details

Number of Affected parties__*2*_

Does this Metering Dispensation affect the metering arrangements for a generator that has applied for/obtained a CFD Agreement? ☒Yes ☐No

If Yes, you must contact the Low Carbon Contracts Company and advise them of your Metering Dispensation application and include them as an Affected Party.

Have you notified all Affected Parties? ☒Yes ☐No

Contact Name at Affected party:	
Contact email address:	
Contact Tel. No:	Contact Tel. No.
Company Name of Affected party: *Low Carbon Contracts Company*	
Address: *10 South Colonnade, Canary Wharf, London*	
Post Code: *E14 4PU*	

Contact Name at Affected party:	
Contact email address:	
Contact Tel. No:	Contact Tel. No.
Company Name of Affected party: *Northern Powergrid Ltd*	
Address: *Lloyds Court, 78 Grey Street, Newcastle Upon Tyne*	
Post Code: *NE1 6AF*	

BSCP32/4.1 Application for a Metering Dispensation (Cont.)

Part C – Reason for Application

If the application is an extension or update for an existing Metering Dispensation, enter existing ref: D/…….

Site Specific

Describe why you require a Metering Dispensation. Include any steps you propose to limit the impact on Settlement and other Registrants:

Scurf Dyke Solar PV and BESS is a co-located power park module with a 33kV metered connection to the Northern Powergrid (York) distribution network. Scurf Dyke's contract allows for a maximum 49.9MW export and 10MW of import at the DNO interface.

The site was originally developed as a solar PV site, the design and the grid connection contract were subsequently altered to include battery energy storage.

Development activity commenced in 2019, design and procurement exercises are concluding. Construction started in November 2022 and energisation is scheduled for September 2023. The current construction and commissioning programme has the BESS being commissioned a few months after energisation.

FP LUX SCURF DYKE SOLAR LIMITED is having ongoing discussions with potential PPA counterparties but the identity of the Registrant has not yet been determined.

A single line diagram is provided in the Any Other Technical Information section which shows the proposed metering arrangement.

All the ancillary power requirements of the BESS (HVAC, light etc) are provided by an auxiliary transformer referred to as BESS.AUX.

This Metering Dispensation application relates to the Scurf Dyke Solar Farm's (SF) Battery Energy Storage System (BESS). A dispensation is being requested for the BESS facility (BESS and BESS.AUX). The SF will have Code of Practice (CoP) 2 compliant Metering Equipment located at the Boundary Point with Northern Powergrid Ltd.'s Distribution System (i.e., the Actual Metering Point (AMP) is at the Defined Metering Point (DMP)). The SF will be settled via difference metering arrangement using an aggregation rule within a Complex Site Supplementary Information Form (CSSIF).

This Metering Dispensation is required as the two assets (SF and BESS) will be traded and settled independently of each other. The AMPs for the BESS Metering Equipment (BESS and BESS.AUX) are not located at the DMP but will be to CoP2 standard. In addition, the BESS circuit Meters will use a busbar connected VT as opposed to a circuit connected VT.

A fully compliant solution for the BESS would require a separate HV metered at the DMP which would render both SF and BESS not viable and unable to contribute toward the

Department for Business, Energy and Industrial Strategy Energy Security and UK wider Net Zero aspirations and targets.

For Settlement purposes the BESS (COP2) Imports and the BESS.AUX Imports (effectively a CoP5 circuit but metered to CoP2 standard at the Low Voltage side of the BESS.AUX), will be aggregated.

To ensure there is no impact on Settlement, losses between AMP and the DMP for BESS (COP2) have been calculated (see attached Appendix). These calculations show no compensations need to be applied to the CoP2 Metering Sub-System for BESS as it will remain within its overall accuracy for COP2 at the DMP. Therefore, it can be incorporated into the difference metering aggregation rule, with the SF metering, without any adjustments.

Cable and auxiliary power transformer loss compensation is required between the AMP and DMP for BESS.AUX. The rationale for the metering being located on the LV (415V) side of BESS.AUX is that if it were metered on the HV (33kV) side an additional dedicated VT would be required which would be uneconomic and would be challenging to install given that the substation switchboard is at an advanced stage of manufacturing.

To ensure that overall accuracy for both BESS and SF Metering Systems are kept within COP2 overall accuracy limits, the BESS.AUX circuit, whilst technically a CoP5 circuit, will be fitted with Class 0.2S CT and Class 0.5S meters (main and check). The auxiliary power transformer and cable loss compensation calculated will be applied via a multiplication factor by the Data Collector using an aggregation rule in the CSSIF.

Calculations are provided in "Appendix: Scurf Dyke Solar PV Loss Calculation" and when applied will ensure the Metering Systems will be metering in line with CoP2 without impact to Settlement.

The voltage drop from the busbar VT to the BESS circuit (and its CTs) will be negligible over 2 metres of busbar.

Period of Metering Dispensation required.

Lifetime

Provide justified reasoning for the period of Metering Dispensation requested in the box below:

Rationale for duration of Metering Dispensation:

The business case for this site is reliant on the operation of the Solar PV and the BESS as separately traded assets for their lifetime.

Part D1 - Loss Adjustments for Power Transformer and/or Cable/Line Losses

Where loss adjustments are proposed and applied (or are to be applied) to the Metering System or Asset Metering System for power transformer and/or cable/line losses, provide the following information:

Describe how do you propose to correct the Metering System, or Asset Metering System, to account for the losses of this power transformer?

Losses for BESS – There are no TX losses for BESS as will be metered on the 33kV side (the same voltage level as at the DMP).
Losses for BESS.AUX - a loss adjustment factor will be applied by the Data Collector via an aggregation rule in the CSSIF (this will include cable losses detailed below).Meter programming is likely not possible due to the relative rarity of Class 0.5 LV rated meters.

In order to validate the loss adjustments applied (or to be applied) to the Metering System, or Asset Metering System, please provide the following information together with supporting data (e.g. power transformer test certificates):

What are the iron losses for this power transformer?

2.8kW (no load loss)

What are the copper losses for this power transformer?

10kW (full load loss)

Are there any other losses that have been taken into account?

Yes, see below losses in the sections of cables between the DMP and the AMPs.

Describe how do you propose to correct the Metering System, or Asset Metering System, to account for the losses of the power cable/line?

BESS - The losses due to 25m of 630mm^2 Cu cable have been evaluated between the DMP and AMP M2 have been determined as 0.0029%. These losses are negligible, and we do not intend to adjust the BESS Metering Sub-System to account for them.

BESS.AUX - The combined losses due to 25m of double 630mm^2 Cu cable and 125m of 95mm^2 Al cable have been evaluated between the DMP and AMP M3 and have been determined as 1.442%. A compensation factor will be applied to the BESS.AUX CoP2 Metering Sub-System via a CSSIF aggregation rule.

In order to validate the loss adjustments applied (or to be applied) to the Metering System, or Asset Metering System, please provide the following information together with supporting data (e.g., cable/line manufacturer's data sheet):

Cable data sheets provided – see document entitled "Prysmian copper cable datasheet" and "Prysmian aluminium cable datasheet".

What is the type of power cable/line?

- *630mm2 cross sectional area, stranded Copper conductor, XLPE/CWS/MDPE*
- *95mm2 cross sectional area, stranded Aluminium conductor, XLPE/CWS/MDPE*

What is the length of this power cable/line?

BESS – 25m from AMP to BESS TX 630mm2 Cu

BESS.AUX – 25m from AMP to BESS TX 630mm2 Cu then teed off 125m from AMP to BESS.AUX TX 95mm^2 Al.

What is the DC resistance of this power cable/line?

Maximum conductor DC resistance in Ohms/km at 20^{o}C (according to IEC 60228):

- *Cu: 0.028*
- *Al: 0.320*

What is the impedance of this power cable/line?

In Ohms/km

- *Cu: 0.109*
- *Al: 0.435*

What is the capacitance of this power cable/line?

Capacitance in µF/km:

- *Cu: 0.352*
- *Al: 0.174*

Are there any other losses that have been taken into account?

No.

Materiality

Please complete the following:

What is the cost of providing compliant Metering Equipment or Asset Metering Equipment?	What does this cost entail?
Approximately £1.2m.	*The cost of separate metered connection for the BESS. It includes the DNO works, a private substation, balance of plant and the cost of CoP2 compliant Metering Equipment (instrument transformers and a metering annexe) at a (separate) DMP from the Solar Farm DMP.*
What is the cost of the proposed solution?	What does this cost entail?
A cost of ~£80,000 is anticipated.	*CoP2 compliant instrument transformers, and meters at the BESS feeder and at the BESS SUB AUX TX and appropriate metering enclosures at BESS SUB AUX TX location.*
What is the impact to Settlement of your proposed solution?	Why?
Metered energy volumes from and to the PV and BESS will be settled independently of each other. *There will be no mis – or unallocated metered volumes in Settlement.*	*This Metering Dispensation will enable the Solar PV and BESS to be registered as distinct, separately controllable, assets.* *Due to the proposed adjustments in the BESS Metering System, and differencing off the SF Metering System, all losses will be accurately accounted for, as if the BESS (and its auxiliary supplies) were metered at the DMP.*
What is the impact to other Registrants of your proposed solution?	Why?
There is no impact to other Registrants.	*Overall accuracy for the SF and BESS CoP2 Metering System will both be maintained within CoP2 limits at the DMP. Registrants associated with other connections should not be impacted by this arrangement except in a situation where a metering fault were to occur at this site. Estimation in accordance with BSCP502 would be used which is standard practice for any metering faults.*

Site Details (for Site Specific Metering Dispensation)

Site Name:	*Scurf Dyke Solar PV*
Site Address:	*Northeast of Eastfield Farm, Stockbridge Lane, Hutton Cranswick, East Riding of Yorkshire. YO25 9RB*
MSID(s) / AMSID(s): *Delete as applicable.	*TBC*
Registered in: SMRS *Delete as applicable.	*SMRS*
For SMRS, please advise of SMRA in space provided.	*Northern Powergrid Ltd*

Manufacturer Details (for Generic Metering Dispensation)

Manufacturer Name:	N/A
Metering Equipment / Asset Metering Equipment Details*: *Delete as applicable	N/A

BSCP32/4.1 Application for a Metering Dispensation (Cont.)

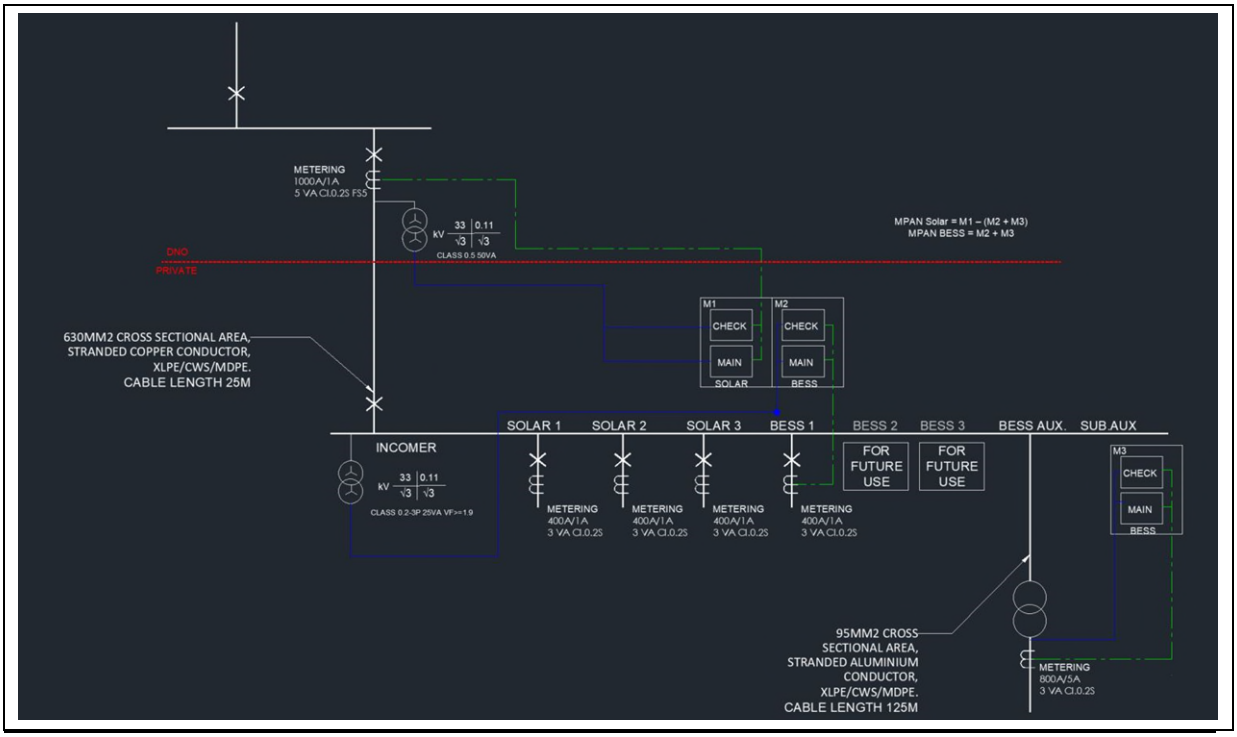
Part D - Technical Details

Code of Practice details

Metering Dispensation against Code of Practice*	*Code of Practice 2: The Metering of Circuits with a Rated Capacity not Exceeding 100 MVA for Settlement Purposes*
Issue of Code of Practice*:	*Code of Practice 2: Issue 5, Version 17*
If against Code of Practice 11 against which Asset Metering Type	*N/A*
Capacity of Metering Circuits/Site Maximum Demand (MW/MVA):	*At DMP: Capacity 52MVA/ max export 49.9MW / max import 10MW* *At AMP M2: Capacity 18MVA / max export 8MW / max import 8MW* *At AMP M3: Capacity 0.75MVA/ max import 0.5MW*
(Proposed) Commissioning Date of Metering:	*August 2023*
Accuracy at Defined Metering Point:	*As per CoP2 requirements.*
Accuracy of Proposed Solution (including loss adjustments):	*Within CoP2 tolerance.*
Outstanding non-compliances on Metering Systems:	*None.*
Deviations from the Code of Practice (reference to appropriate clause):	*AMP not at DMP for BESS Metering System. Appendix A, Paragraph 6:* *"For transfers between a Distribution System operated by a Licensed Distribution System Operator and Generating Plant, the DMP shall be at the point(s) of connection of the generating station to the Distribution System operated by a Licensed Distribution System Operator."* *Use of a busbar connected VT rather than a circuit connected VT:* *"5.1.2 Voltage Transformers* *Voltage transformer primary windings shall be connected to the circuit being measured for Settlement purposes and a dedicated secondary winding shall be provided for the main and check metering."*

* insert Code of Practice number and issue

Any Other Technical Information



Declaration

We declare that other than as set out above we are in all other respects, in compliance with the requirements of the relevant Code of Practice and the BSC. A schematic is attached to this application for clarification of the metering points involved.

Signature: ..... *Date:* *24/05/2023*

Password: .....

Duly authorised for and on behalf of Applicant Company

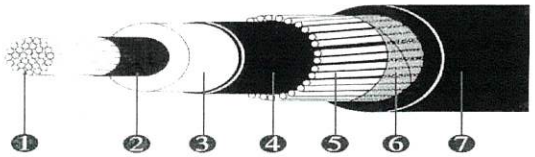
Confirmation of Receipt and Reference

BSCCo acknowledges receipt of this document and has assigned the reference number as indicated on the first page.

Signature: *Date: 24 May 2023*

Duly authorised for and on behalf of BSCCo

JK Cables - 01215657040



1 Stranded Copper conductor (optional water blocking)
2 Semi-conducting screen
3 XLPE insulation
4 Semi-conducting screen (optional water blocking tape)
5 35mm² Copper wire screen (optional equalisation)
6 Water Blocking Tape
7 MDPE sheath (optional graphite coating)

PRYSMIAN CABLES & SYSTEMS

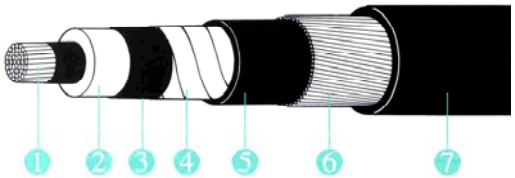
Electricity Supply Industry
19000/33000V
Extruded insulation
Stranded copper conductor
W/B 35mm² Copper wire screened
BS7870-4.10

Constructional Data		Outside Range of Manufacture												
Conductor - nominal cross-sectional area	mm²	**50**	**70**	**95**	**120**	**150**	**185**	**240**	**300**	**400**	**500**	**630**	**800**	**1000**
Conductor - diameter	mm	8.2	9.9	11.5	13.0	14.4	16.1	18.2	20.5	23.7	27.1	31.0	35.4	39.7
Insulation - nominal thickness	mm	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Copper wire screen - nominal area	mm	35	35	35	35	35	35	35	35	35	35	35	35	35
Oversheath - minimum average thickness	mm	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.4	2.5	2.6	2.7	2.8	3.0
Overall diameter	mm	35.0	36.5	38.5	40.0	41.5	43.0	45.5	48.0	51.5	55.5	59.5	64.0	69.0
Triplexed diameter (if applicable)	mm	75.0	78.5	82.5	86.0	89.0	93.0	98.0	103.5	-	-	-	-	-
Installation Data														
Cable mass	kg	1.5	1.7	2.0	2.3	2.6	3.0	3.5	4.2	5.1	6.2	7.6	9.5	11.7
Minimum bending radius	mm	700	750	800	800	850	900	950	1000	1100	1200	1200	1300	1400
Maximum pulling tension (on conductor)	kg	250	350	475	600	750	925	1200	1500	2000	2000	2000	2000	2000
Nominal diameter of twin wall PE duct (**1 cable**)	mm	100	100	100	100	100	100	100	100	100	100	100	100	125
Nominal external diameter of twin wall PE duct	mm	120	120	120	120	120	120	120	120	120	120	120	120	150
Nominal diameter of twin wall PE duct (**Triplex cable**)	mm	150	150	150	225	225	225	225	225	-	-	-	-	-
Nominal external diameter of twin wall PE duct	mm	180	180	180	270	270	270	270	270	-	-	-	-	-
Electrical Data														
Conductor - maximum DC resistance @ 20°C	Ω/km	0.387	0.268	0.193	0.153	0.124	0.099	0.075	0.060	0.047	0.037	0.028	0.022	0.018
Conductor - maximum AC resistance @ 90°C	Ω/km	0.494	0.342	0.247	0.196	0.159	0.127	0.098	0.079	0.062	0.050	0.040	0.034	0.029
Copper wire screen - maximum DC resistance @ 20°C	Ω/km	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542	0.542
Capacitance* - maximum	µF/km	0.143	0.159	0.174	0.188	0.200	0.216	0.234	0.255	0.283	0.318	0.352	0.390	0.429
Charging current - maximum at normal voltage and frequency*	A/km	0.854	0.948	1.039	1.120	1.196	1.287	1.397	1.522	1.692	1.897	2.102	2.330	2.558
Reactance @ 50Hz	Ω/km	0.152	0.143	0.136	0.131	0.127	0.122	0.117	0.113	0.108	0.105	0.101	0.097	0.094
Impedance @ 50Hz	Ω/km	0.516	0.371	0.282	0.235	0.203	0.176	0.153	0.138	0.125	0.116	0.109	0.103	0.099
Zero Sequence Resistance	Ω/km	0.929	0.810	0.735	0.695	0.666	0.641	0.618	0.603	0.590	0.580	0.572	0.566	0.562
Zero Sequence Reactance	Ω/km	0.093	0.085	0.079	0.074	0.070	0.066	0.062	0.058	0.054	0.051	0.047	0.044	0.042
Current Ratings														
Laid in air	Amps	255	315	385	440	500	575	670	770	890	1025	1180	1335	1480
Laid direct in ground	Amps	215	265	320	360	405	455	525	590	670	755	850	940	1020
Drawn into trefoil ducts	Amps	210	255	300	340	375	420	480	530	595	670	745	825	885
Drawn into 1 duct	Amps	185	225	270	315	355	400	460	515	-	-	-	-	-
Short circuit ratings (1s, adiabatic)														
Conductor (90 to 250°C)	kA	7.2	10.0	13.6	17.2	21.5	26.5	34.3	42.9	57.2	71.5	90.1	114.5	143.1
Copper wire screen (80 to 250°C)	kA	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9	4.9
Current rating conditions														
Air temperature	°C	25												
Ground temperature	°C	15												
Depth of burial (to centre of cable group)	mm	800												
Thermal resistance of soil	°C m/W	1.2												
Single core cables in trefoil, bonded and earthed at both ends.														

All data are nominal and subject to manufactur ng tolerances
* For EPR, multiply capacitance and charging current values by 1.2
Ref: IEC60287-2-1 (A2:2006)

Drums ~~40~~ 250 mt.
" 120
"
"

CEF [~~55~~ mt.



1	Stranded aluminium conductor
2	XLPE insulation
3	Semi-conducting screen
4	Copper tape screen
5	PVC/LSOH bedding
6	Aluminium wire armour
7	PVC/LSOH sheath

PRYSMIAN CABLES & SYSTEMS

Industrial Supply Industry

19000/33000V

Extruded insulation

Stranded aluminium conductor

1-core armoured

BS6622 / BS7835

Constructional Data

Conductor cross-sectional area	mm²	**50**	**70**	**95**	**120**	**150**	**185**	**240**	**300**	**400**	**500**	**630**	**800**	**1000**
Conductor diameter	mm	8.25	9.85	11.6	13.0	14.45	16.1	18.65	20.5	23.9	27.4	31.0	35.35	39.7
Insulation thickness	mm	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Bedding sheath thickness	mm	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.7
Armour - diameter of wires	mm	2.0	2.0	2.0	2.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Oversheath thickness	mm	2.2	2.2	2.3	2.3	2.4	2.5	2.5	2.6	2.7	2.8	2.9	3.1	3.2
Overall diameter of cable	mm	40.0	41.5	43.5	45.0	47.5	49.5	52.0	54.5	58.0	62.0	66.0	71.0	75.5

Installation Data

Cable mass	kg	1.7	1.9	2.1	2.2	2.6	2.8	3.1	3.5	3.9	4.5	5.2	6.1	7.1
Minimum bending radius	mm	600	650	700	700	750	750	800	850	900	950	1000	1100	1150
Maximum pulling tension (on conductor)	kgf	150	210	285	360	450	555	720	900	1200	1500	1890	2000	2000
Internal diameter of twin wall PE duct (**1 cable per duct**)	mm	100	100	100	100	100	100	100	100	100	100	125	125	125
External diameter of twin wall PE duct (**1 cable per duct**)	mm	120	120	120	120	120	120	120	120	120	120	150	150	150
Internal diameter of twin wall PE duct (**Trefoil in 1 duct**)	mm	225	225	225	225	225	225	225	225	225	300	300	300	300
External diameter of twin wall PE duct (**Trefoil in 1 duct**)	mm	270	270	270	270	270	270	270	270	270	360	360	360	360

Electrical Data

Maximum DC resistance of conductor @ 20°C	Ω/km	0.641	0.443	0.320	0.253	0.206	0.164	0.125	0.1000	0.0778	0.0605	0.0469	0.0367	0.0291
Maximum AC resistance of conductor @ 90°C	Ω/km	0.822	0.568	0.411	0.325	0.265	0.211	0.1611	0.1292	0.1012	0.0795	0.0627	0.0504	0.0416
Capacitance	µF/km	0.144	0.159	0.175	0.188	0.201	0.216	0.239	0.255	0.285	0.321	0.352	0.390	0.429
Maximum charging current at normal voltage and frequency	mA/m	0.859	0.948	1.044	1.120	1.199	1.287	1.424	1.522	1.702	1.913	2.102	2.330	2.558
Reactance @ 50Hz	Ω/km	0.159	0.151	0.143	0.138	0.135	0.130	0.124	0.121	0.115	0.111	0.107	0.103	0.100
Impedance @ 50Hz	Ω/km	0.837	0.588	0.435	0.353	0.297	0.248	0.203	0.177	0.153	0.137	0.124	0.115	0.109
Zero sequence resistance @ 20°C	Ω/km	0.841	0.635	0.501	0.427	0.338	0.291	0.247	0.215	0.187	0.161	0.141	0.125	0.112
Zero sequence reactance @ 50Hz	Ω/km	0.104	0.096	0.089	0.084	0.080	0.076	0.070	0.067	0.062	0.058	0.055	0.051	0.048

Current Ratings

Laid in air	Amps	195	245	295	340	385	435	510	580	670	765	870	980	1085
Laid direct in ground	Amps	170	205	245	280	310	350	405	450	510	570	635	695	755
Drawn into trefoil ducts	Amps	160	195	230	260	285	315	355	395	435	485	525	570	615
Laid in a single duct (3 cables in trefoil)	Amps	150	180	215	245	270	305	350	390	440	505	560	610	660

Short circuit ratings (1 second, adiabatic)

Conductor (90 to 250°C)	kA	4.7	6.6	9.0	11.3	14.2	17.5	22.7	28.3	37.8	47.2	59.5	75.6	94.5
Armour (80 to 200°C)	kA	12.3	12.8	13.6	14.1	18.8	19.6	20.4	21.7	22.9	25.0	26.7	28.8	30.8

Current rating conditions

Air temperature	°C	25
Ground temperature	°C	15
Depth of burial (to centre of cable group)	mm	800
Thermal resistance of soil	°C m/W	1.2

Single core cables in trefoil, bonded and earthed at both ends.

All data are nominal and subject to manufacturing tolerances

Project:	**Scurf Dyke Solar PV and BESS**
Title:	**Loss Calculation**
Author:	**BayWa r.e. Grid Team EMEA**

1 Scope

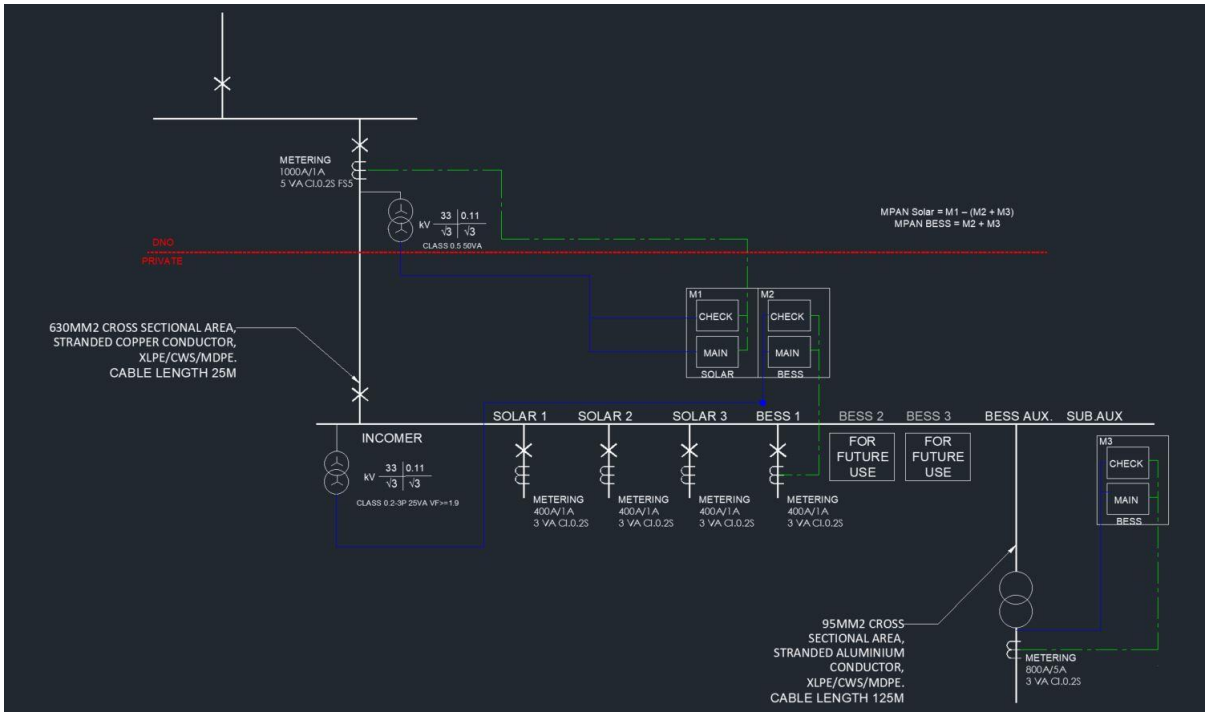
Scurf Dyke Solar PV and BESS is a co-located power park module with a 33kV metered connection to the Northern Powergrid (York) distribution network. Scurf Dyke's contract allows for a maximum 49.9MW export and 10MW of import at the DNO interface.

This appendix was prepared in support of the attached metering dispensation application and provides additional technical information.

It provides the result of load flow analysis which shows the losses between:

1. The CoP2 compliant metering system at the DMP, M1 and the CoP2 compliant BESS metering system at M2. These are the worst-case losses seen across 25m of a 2 x 3 x 1 x 630mm² copper cable.
2. The CoP2 compliant metering system at the DMP, M1 and the CoP2 compliant BESS AUX metering system at M3. These are the worst-case losses seen across 25m of a 2 x 3 x 1 x 630mm² copper cable, 125m of 3 x 1 x 95mm² aluminium cable and a 750kVA 33/0.415kV transformer.

The schematic below shows the proposed metering configuration.



2 Cable and Transformer Data

The underground cable connecting the 33kV incoming circuit breaker at the customer substation with the Northern Powergrid (NPg) owned 33kV outgoing circuit breaker has the following specifications:

Manufacturer	Prysmian
Voltage	19/33kV
Cable type	BS7870-4.10
Conductor	Stranded copper conductor
Cross section	2x3x1x630mm²
Overall cable diameter	59.5mm
Maximum DC resistance @20°C	0.028 Ohm/km
Maximum AC resistance @90°C	0.040 Ohm/km
Current Rating laid in ground	850A
Length	25m

The underground cable connecting the 33kV BESS Aux circuit breaker to the 33kV busbar at the customer substation has the following specification:

Manufacturer	Prysmian
Voltage	19/33kV
Cable type	BS7835
Conductor	Stranded aluminium conductor
Cross section	1x95mm²
Overall cable diameter	43.5mm
Maximum DC resistance @20°C	0.320 Ohm/km
Maximum AC resistance @90°C	0.411 Ohm/km
Current Rating laid in ground	245A
Length	125m

Transformer Datasheet

- Continuous Power Rating: 750kVA @ 65ºC Temp Rise
- No Load Voltage Ratio: 33/0.415kV
- Rated Voltage - Um: 36kV
- Number of Phases: 3
- Number of Windings: 2: HV/LV
- Frequency: 50Hz
- Impedance: 6.7% @ 1000kVA
- HV Winding Impulse Level: 170kVp
- LV Winding Impulse Level: As per IEC standard
- Vector Group: Dyn11
- Steady State Temperature Rise: 65ºC above ambient
- Design & Guaranteed No Load Losses: 2800 Watts (+0%)
- Design & Guaranteed Load Losses: 10800 Watts (+0%)
- HV Winding Earthing: Unearthed, Insulated

3 Method

Losses have been calculated in a spreadsheet, “Scurf_Dyke Solar PV_losses_calculation” which has been provided alongside this document.

The operation of the power park module (PPM), comprising solar PV and battery energy storage generating units, as well as conditions on the NPg network were simulated to enable conditions that would result in the maximum loss across the cables and the BESS AUX transformer.

4 Result

The initial conditions assumed are as follows:

Voltage@33kV: 1.0p.u. (stable due to onload tap changer on the NPg owned 90MVA 132/33kV grid transformer)

- Max. allowed apparent power injection: 52.52MVA @ a power factor of 0.95.
- Max. allowed active power injection: 49.9MW
- Max. allowed reactive power injection: 16.36MVar
- BESS AUX demand: 500kW

4.1 DMP and AMP, M2

The maximum allowed active power injection of 49.9MW (52.52MVA @ a power factor of 0.95) the losses between M1 and M2, exclusively due to the 25m long 2x3x1x630mm² copper cables is 1.45kW, equating to a loss of 0.0029%.

The voltage drop over is negligible, at around 1V.

The anticipated losses and difference in voltage measured between AMP, M2, and the DMP are small enough to be within the tolerance allowed for the minimum standard of accuracy specified in CoP2 for CTs (Class 0.2S) and VTs (Class 0.5) respectively.

4.2 DMP and AMP, M3

Metering at M3 has to take into account the cable losses set out above in addition to losses over 125m of 3 x 1 x 95mm² aluminium cable and a 750kVA 33/0.415kV transformer.

The additional losses between M1 and M3 are predominantly seen across the BESS AUX transformer.

The simulation results indicate losses of 0.014kW on the 125m of 3 x 1 x 95mm² aluminium cable and 10.799kW across the transformer.

The total loss (M1 to M3) equates to 10.82kW, equivalent to 1.442%.

External Grid

P=-49,731 MW
Q=-8,94 Mvar
I=0,221 kA
S=50,528 MVA
i1r=-0,130 p.u.
i1i=0,023 p.u.

Ul=132,000 kV
u=1,00 p.u.
phiu=0,0 deg

132 kV Busbar

P=-49,731 MW
Q=-8,94 Mvar
I=0,221 kA
S=50,528 MVA
i1r=-0,553 p.u.
i1i=0,099 p.u.

Power Transformer
loading=58,1 %

2

P=49,900 MW
Q=16,36 Mvar
I=0,914 kA
S=52,514 MVA
i1r=0,546 p.u.
i1i=0,196 p.u.

Metering Point M1

Terminal

Ul=33,166 kV
u=1,01 p.u.
phiu=37,9 deg

P=-49,900 MW
Q=-16,36 Mvar
I=0,914 kA
S=52,514 MVA
i1r=-0,506 p.u.
i1i=-0,182 p.u.

Power Controller
qini=16,36 Mvar
qres=16,45 Mvar

Terminal to 33 kV Busbar
25,00 m
2x 630 Cu 19 33kV
53,8 %

P=49,902 MW
Q=16,36 Mvar
I=0,914 kA
S=52,514 MVA
i1r=0,506 p.u.
i1i=0,182 p.u.

Metering Point M2

33 kV Busbar

Ul=33,167 kV
u=1,01 p.u.
phiu=37,9 deg

P=-14,640 MW
Q=-5,90 Mvar
I=0,275 kA
S=15,784 MVA
i1r=-0,587 p.u.
i1i=-0,168 p.u.

P=-14,844 MW
Q=-5,90 Mvar
I=0,278 kA
S=15,976 MVA
i1r=-0,593 p.u.
i1i=-0,173 p.u.

P=-12,941 MW
Q=-5,16 Mvar
I=0,243 kA
S=13,933 MVA
i1r=-0,518 p.u.
i1i=-0,150 p.u.

P=-7,974 MW
Q=0,50 Mvar
I=0,139 kA
S=7,989 MVA
i1r=-0,231 p.u.
i1i=-0,205 p.u.

P=0,498 MW
Q=0,11 Mvar
I=0,009 kA
S=0,510 MVA
i1r=0,033 p.u.
i1i=0,016 p.u.

33 kV Busbar to Terminal(1)
150,00 m
1x BS6622/BS7835 33kV 95mm²
3,6 %

TS4 to 33 kV Busbar
100,00 m
1x BS6622/BS7835 33kV 300mm²
32,9 %

P=7,974 MW
Q=-0,51 Mvar
I=0,139 kA
S=7,990 MVA
i1r=0,231 p.u.
i1i=0,205 p.u.

P=-3,987 MW
Q=0,25 Mvar
I=0,070 kA
S=3,995 MVA
i1r=-0,168 p.u.
i1i=-0,149 p.u.

TS3 to TS4
50,00 m
1x BS6622/BS7835 33kV 150mm²
23,9 %

P=3,987 MW
Q=-0,26 Mvar
I=0,070 kA
S=3,995 MVA
i1r=0,168 p.u.
i1i=0,149 p.u.

P=-0,498 MW
Q=-0,12 Mvar
I=0,009 kA
S=0,512 MVA
i1r=-0,033 p.u.
i1i=-0,015 p.u.

T4 to 33 kV Busbar
166,00 m
1x BS6622/BS7835 33kV 300mm²
55,6 %

TS4
Ul=33,170 kV
u=1,01 p.u.
phiu=37,9 deg

TS3
Ul=33,172 kV
u=1,01 p.u.
phiu=37,9 deg

Terminal(1)
Ul=33,166 kV
u=1,01 p.u.
phiu=37,9 deg

P=3,987 MW
Q=0,26 Mvar
I=0,070 kA
S=3,995 MVA
i1r=-0,676 p.u.
i1i=-0,600 p.u.

TS4-Trafo
loading=90,4 %

3

P=4,000 MW
Q=0,00 Mvar
I=2,870 kA
S=4,000 MVA
i1r=0,286 p.u.
i1i=0,857 p.u.

TS3-Trafo
loading=90,4 %

P=0,498 MW
Q=0,12 Mvar
I=0,009 kA
S=0,512 MVA
i1r=0,619 p.u.
i1i=0,280 p.u.

2-Winding Transformer
loading=67,9 %

0

P=-0,490 MW
Q=-0,10 Mvar
I=0,705 kA
S=0,500 MVA
i1r=-0,394 p.u.
i1i=-0,549 p.u.

Metering Point M3
for BESS AUX

TS4_LV
Ul=0,805 kV
u=1,01 p.u.
phiu=71,5 deg

TS3_LV
Ul=0,805 kV
u=1,01 p.u.
phiu=71,5 deg

Terminal(2)
Ul=0,410 kV
u=0,99 p.u.
phiu=65,8 deg

P=4,000 MW
Q=0,00 Mvar
I=2,870 kA
S=4,000 MVA
i1r=0,315 p.u.
i1i=0,943 p.u.

P=0,490 MW
Q=0,10 Mvar
I=0,705 kA
S=0,500 MVA
i1r=0,592 p.u.
i1i=0,823 p.u.

500kVA
cosphi 0,98

General Load

TS4-Inverter
100,0 %
4,2 MW
0,0 Mvar

TS3-Inverter
100,0 %
4,2 MW
0,0 Mvar

T7 to T4
329,00 m
1x BS6622/BS7835 33kV 95mm²
37,1 %

T5 to 33 kV Busbar
110,00 m
1x BS6622/BS7835 33kV 300mm²
56,2 %

T4 to T3
402,00 m
1x BS6622/BS7835 33kV 95mm²
54,8 %

T3 to T2
193,00 m
1x BS6622/BS7835 33kV 95mm²
36,5 %

T2 to T1
223,00 m
1x BS6622/BS7835 33kV 95mm²
15,1 %

T6 to T7
249,00 m
1x BS6622/BS7835 33kV 95mm²
19,8 %

P=12,9..
Q=5,15 ..
I=0,242 ..
S=13,9..
i1r=0,517..
i1i=0,150..

P=-4,7(
Q=-1,8
I=0,08(
S=5,0(
i1r=-0,3
i1i=-0,1

P=-6,516 MW
Q=-2,61 Mvar
I=0,122 kA
S=7,019 MVA
i1r=-0,479 p.u.
i1i=-0,138 p.u.

P=6,523 MW
Q=2,59 Mvar
I=0,122 kA
S=7,018 MVA
i1r=0,478 p.u.
i1i=0,140 p.u.

P=-4,348 MW
Q=-1,73 Mvar
I=0,081 kA
S=4,681 MVA
i1r=-0,319 p.u.
i1i=-0,093 p.u.

P=4,350 MW
Q=1,72 Mvar
I=0,081 kA
S=4,678 MVA
i1r=0,318 p.u.
i1i=0,093 p.u.

P=-2,175 MW
Q=-0,87 Mvar
I=0,041 kA
S=2,341 MVA
i1r=-0,159 p.u.
i1i=-0,046 p.u.

P=2,175 MW
Q=0,85 Mvar
I=0,041 kA
S=2,337 MVA
i1r=0,159 p.u.
i1i=0,047 p.u.

P=4,71..
Q=1,85 ..
I=0,088 ..
S=5,06..
i1r=0,344..
i1i=0,102..

P=-2,35..
Q=-0,93..
I=0,044 ..
S=2,53..
i1r=-0,17..
i1i=-0,05..

P=2,35..
Q=0,92 ..
I=0,044 ..
S=2,52..
i1r=0,172..
i1i=0,051..

T5-Trafo
loading=77,5 %

T8-Trafo
loading=76,9 %

T9-Trafo
loading=79,8 %

T10-Trafo
loading=79,8 %

T11-Trafo
loading=79,8 %

T12-Trafo
loading=77,4 %

T13-Trafo
loading=64,8 %

T4-Trafo
loading=73,7 %

T3-Trafo
loading=73,8 %

T2-Trafo
loading=73,8 %

T1-Trafo
loading=73,8 %

T7-Trafo
loading=79,8 %

T6-Trafo
loading=79,8 %

P=14,848 MW
Q=5,90 Mvar
I=0,278 kA
S=15,976 MVA
i1r=0,593 p.u.
i1i=0,173 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,398 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,563 p.u.

P=2,282 MW
Q=1,00 Mvar
I=1,746 kA
S=2,491 MVA
i1r=-0,528 p.u.
i1i=-0,558 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,747 kA
S=2,491 MVA
i1r=-0,529 p.u.
i1i=-0,558 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,814 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,472 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,917 MW
Q=0,84 Mvar
I=1,472 kA
S=2,093 MVA
i1r=-0,448 p.u.
i1i=-0,467 p.u.

P=1,735 MW
Q=0,76 Mvar
I=1,330 kA
S=1,893 MVA
i1r=-0,508 p.u.
i1i=-0,534 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,678 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,260 kA
S=1,794 MVA
i1r=-0,534 p.u.
i1i=-0,562 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,678 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,562 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,561 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,561 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,532 p.u.
i1i=-0,563 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,397 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,397 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,735 MW
Q=0,76 Mvar
I=1,330 kA
S=1,893 MVA
i1r=-0,508 p.u.
i1i=-0,534 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,678 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,508 p.u.
i1i=-0,535 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,260 kA
S=1,794 MVA
i1r=-0,534 p.u.
i1i=-0,562 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,678 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,562 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,561 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,534 p.u.
i1i=-0,561 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,532 p.u.
i1i=-0,563 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,397 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,397 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

T4-SG250
79,7 %
1,826 MW
0,000 Mvar

T4-SG125
79,7 %
0,091 MW
0,000 Mvar

T3-SG250
79,7 %
2,191 MW
0,000 Mvar

T2-SG250
79,7 %
2,191 MW
0,000 Mvar

T1-SG250
79,7 %
2,191 MW
0,000 Mvar

T7-SG250
79,7 %
2,374 MW
0,000 Mvar

T6-SG250
79,7 %
2,374 MW
0,000 Mvar

33 kV Busbar to T14
66,00 m
1x BS6622/BS7835 33kV 300mm²
55,5 %

T12 to T5
409,00 m
1x BS6622/BS7835 33kV 95mm²
31,3 %

T8 to T5
409,0
783
5,2

T8 to T9
122,00 m
BS7835
49,0 %

T9 to T10
10,0
378
2,6

T10 to T11
137,00 m
/BS7835
16,3 %

T13 to T12
185,00 m
/BS7835
16,0 %

P=-3,7
Q=-1,4
I=0,07
S=4,0
i1r=-0,
i1i=-0,(

P=-9,322 MW
Q=-3,69 Mvar
I=0,174 kA
S=10,026 MVA
i1r=-0,372 p.u.
i1i=-0,109 p.u.

P=9,327 MW
Q=3,66 Mvar
I=0,174 kA
S=10,019 MVA
i1r=0,371 p.u.
i1i=0,110 p.u.

P=-7,062 MW
Q=-2,77 Mvar
I=0,132 kA
S=7,587 MVA
i1r=-0,516 p.u.
i1i=-0,153 p.u.

P=7,064 MW
Q=2,77 Mvar
I=0,132 kA
S=7,587 MVA
i1r=0,516 p.u.
i1i=0,153 p.u.

P=-4,709 MW
Q=-1,85 Mvar
I=0,088 kA
S=5,059 MVA
i1r=-0,344 p.u.
i1i=-0,102 p.u.

P=4,710 MW
Q=1,84 Mvar
I=0,088 kA
S=5,058 MVA
i1r=0,344 p.u.
i1i=0,102 p.u.

P=-2,355 MW
Q=-0,93 Mvar
I=0,044 kA
S=2,530 MVA
i1r=-0,172 p.u.
i1i=-0,051 p.u.

P=2,355 MW
Q=0,92 Mvar
I=0,044 kA
S=2,527 MVA
i1r=0,172 p.u.
i1i=0,051 p.u.

P=3,71..
Q=1,48 ..
I=0,070 ..
S=3,99..
i1r=0,273..
i1i=0,079..

P=-1,904 MW
Q=-0,77 Mvar
I=0,036 kA
S=2,053 MVA
i1r=-0,140 p.u.
i1i=-0,040 p.u.

P=1,904 MW
Q=0,76 Mvar
I=0,036 kA
S=2,050 MVA
i1r=0,140 p.u.
i1i=0,041 p.u.

P=14,848 MW
Q=5,90 Mvar
I=0,278 kA
S=15,976 MVA
i1r=0,593 p.u.
i1i=0,173 p.u.

Ul=33,176 kV
u=1,01 p.u.
phiu=37,9 deg

P=-1,812 MW
Q=-0,71 Mvar
I=0,034 kA
S=1,945 MVA
i1r=-0,742 p.u.
i1i=-0,221 p.u.

Ul=33,196 kV
u=1,01 p.u.
phiu=37,9 deg

P=-2,265 MW
Q=-0,89 Mvar
I=0,042 kA
S=2,432 MVA
i1r=-0,736 p.u.
i1i=-0,219 p.u.

Ul=33,208 kV
u=1,01 p.u.
phiu=37,9 deg

P=-2,355 MW
Q=-0,92 Mvar
I=0,044 kA
S=2,527 MVA
i1r=-0,764 p.u.
i1i=-0,229 p.u.

Ul=33,217 kV
u=1,01 p.u.
phiu=37,9 deg

P=-2,355 MW
Q=-0,92 Mvar
I=0,044 kA
S=2,527 MVA
i1r=-0,764 p.u.
i1i=-0,229 p.u.

Ul=33,221 kV
u=1,01 p.u.
phiu=37,9 deg

P=-2,355 MW
Q=-0,92 Mvar
I=0,044 kA
S=2,527 MVA
i1r=-0,764 p.u.
i1i=-0,228 p.u.

Ul=33,197 kV
u=1,01 p.u.
phiu=37,9 deg

P=-1,812 MW
Q=-0,71 Mvar
I=0,034 kA
S=1,945 MVA
i1r=-0,741 p.u.
i1i=-0,221 p.u.

Ul=33,202 kV
u=1,01 p.u.
phiu=37,9 deg

P=-1,904 MW
Q=-0,76 Mvar
I=0,036 kA
S=2,050 MVA
i1r=-0,621 p.u.
i1i=-0,181 p.u.

T5
T8
T9
T10
T11
T12
T13

P=1,826 MW
Q=0,80 Mvar
I=1,398 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,563 p.u.

P=2,282 MW
Q=1,00 Mvar
I=1,746 kA
S=2,491 MVA
i1r=-0,528 p.u.
i1i=-0,558 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,814 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,814 kA
S=2,591 MVA
i1r=-0,548 p.u.
i1i=-0,580 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,472 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,917 MW
Q=0,84 Mvar
I=1,472 kA
S=2,093 MVA
i1r=-0,448 p.u.
i1i=-0,467 p.u.

T5-Trafo
loading=77,5 %

T8-Trafo
loading=76,9 %

T9-Trafo
loading=79,8 %

T10-Trafo
loading=79,8 %

T11-Trafo
loading=79,8 %

T12-Trafo
loading=77,4 %

T13-Trafo
loading=64,8 %

P=1,826 MW
Q=0,80 Mvar
I=1,398 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,563 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,677 kA
S=2,392 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=0,091 M
Q=0,04 Mvar
I=0,070 kA
S=0,100 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,815 kA
S=2,591 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=2,374 MW
Q=1,04 Mvar
I=1,814 kA
S=2,591 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=2,191 MW
Q=0,96 Mvar
I=1,675 kA
S=2,392 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=0,183 MW
Q=0,08 Mvar
I=0,140 kA
S=0,199 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,397 kA
S=1,993 MVA
i1r=-0,533 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,255 kA
S=1,993 MVA
i1r=-0,538 p.u.
i1i=-0,561 p.u.

P=0,091 MW
Q=0,04 Mvar
I=0,070 kA
S=0,100 MVA
i1r=-0,538 p.u.
i1i=-0,561 p.u.

T5-SG250
79,7 %
1,826 MW
0,000 Mvar

T8-SG250
79,7 %
2,191 MW
0,000 Mvar

T8-SG125
79,7 %
0,091 MW
0,000 Mvar

T9-SG250
79,7 %
2,374 MW
0,000 Mvar

T10-SG250
79,7 %
2,374 MW
0,000 Mvar

T11-SG250
79,7 %
2,191 MW
0,000 Mvar

T11-SG125
79,7 %
0,183 MW
0,000 Mvar

T12-SG250
79,7 %
1,826 MW
0,000 Mvar

T13-SG250
79,7 %
1,826 MW
0,000 Mvar

T13-SG125
79,7 %
0,091 MW
0,000 Mvar

T17 to T19
426,00 m
1x BS6622/BS7835 33kV 95mm²
57,0 %

T15 to T14
247,00 m
/BS7835 33k
53,2 %

T16 to T15
276,00 m
/BS7835 33k
57,4 %

T17 to T16
141,00 m
/BS7835 33k
47,4 %

T19 to T18
168,00 m
/BS7835 33k
13,7 %

T20 to T19
179,00 m
/BS7835 33k
29,6 %

T21 to T20
170,00 m
/BS7835 33k
14,4 %

P=-12,3..
Q=-4,98..
I=0,232 ..
S=13,3..
i1r=-0,49..
i1i=-0,14..

P=12,3..
Q=4,96 ..
I=0,232 ..
S=13,3..
i1r=0,495..
i1i=0,143..

P=-10,4..
Q=-4,17..
I=0,195 ..
S=11,2..
i1r=-0,53..
i1i=-0,15..

P=10,4..
Q=4,15 ..
I=0,195 ..
S=11,2..
i1r=0,534..
i1i=0,155..

P=-8,59..
Q=-3,45..
I=0,161 ..
S=9,26..
i1r=-0,44..
i1i=-0,12..

P=8,59..
Q=3,44 ..
I=0,161 ..
S=9,26..
i1r=0,441..
i1i=0,128..

P=-6,78..
Q=-2,73..
I=0,127 ..
S=7,31..
i1r=-0,49..
i1i=-0,14..

P=1,63..
Q=0,65 ..
I=0,030 ..
S=1,75..
i1r=0,119..
i1i=0,035..

P=-1,63..
Q=-0,66..
I=0,030 ..
S=1,75..
i1r=-0,12..
i1i=-0,03..

P=6,79..
Q=2,71 ..
I=0,127 ..
S=7,31..
i1r=0,497..
i1i=0,145..

P=-3,53..
Q=-1,41..
I=0,066 ..
S=3,80..
i1r=-0,25..
i1i=-0,07..

P=3,53..
Q=1,40 ..
I=0,066 ..
S=3,79..
i1r=0,258..
i1i=0,076..

P=-1,72..
Q=-0,69..
I=0,032 ..
S=1,85..
i1r=-0,12..
i1i=-0,03..

P=1,72..
Q=0,68 ..
I=0,032 ..
S=1,85..
i1r=0,125..
i1i=0,037..

P=14,657 MW
Q=5,86 Mvar
I=0,274 kA
S=15,787 MVA
i1r=0,586 p.u.
i1i=0,169 p.u.

Ul=33,212 kV
u=1,01 p.u.
phiu=37,9 deg

P=-2,265 MW
Q=-0,89 Mvar
I=0,042 kA
S=2,432 MVA
i1r=-0,735 p.u.
i1i=-0,219 p.u.

Ul=33,228 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,995 MW
Q=-0,79 Mvar
I=0,037 kA
S=2,146 MVA
i1r=-0,649 p.u.
i1i=-0,190 p.u.

Ul=33,251 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,812 MW
Q=-0,71 Mvar
I=0,034 kA
S=1,945 MVA
i1r=-0,740 p.u.
i1i=-0,221 p.u.

Ul=33,260 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,812 MW
Q=-0,71 Mvar
I=0,034 kA
S=1,945 MVA
i1r=-0,740 p.u.
i1i=-0,221 p.u.

Ul=33,305 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,632 MW
Q=-0,65 Mvar
I=0,030 kA
S=1,755 MVA
i1r=-0,667 p.u.
i1i=-0,196 p.u.

Ul=33,301 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,632 MW
Q=-0,64 Mvar
I=0,030 kA
S=1,755 MVA
i1r=-0,667 p.u.
i1i=-0,196 p.u.

Ul=33,310 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,812 MW
Q=-0,71 Mvar
I=0,034 kA
S=1,946 MVA
i1r=-0,739 p.u.
i1i=-0,220 p.u.

Ul=33,314 kV
u=1,01 p.u.
phiu=38,0 deg

P=-1,722 MW
Q=-0,68 Mvar
I=0,032 kA
S=1,850 MVA
i1r=-0,703 p.u.
i1i=-0,208 p.u.

T1
T15
T16
T17
T18
T19
T20
T21

P=2,282 MW
Q=1,00 Mvar
I=1,746 kA
S=2,491 MVA
i1r=-0,528 p.u.
i1i=-0,558 p.u.

P=2,009 MW
Q=0,88 Mvar
I=1,540 kA
S=2,192 MVA
i1r=-0,468 p.u.
i1i=-0,490 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,395 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,395 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,256 kA
S=1,794 MVA
i1r=-0,481 p.u.
i1i=-0,504 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,256 kA
S=1,794 MVA
i1r=-0,481 p.u.
i1i=-0,504 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,393 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,561 p.u.

P=1,735 MW
Q=0,76 Mvar
I=1,324 kA
S=1,893 MVA
i1r=-0,506 p.u.
i1i=-0,532 p.u.

T14-Trafo
loading=71,1 %

T15-Trafo
loading=67,7 %

T16-Trafo
loading=77,3 %

T17-Trafo
loading=77,3 %

T18-Trafo
loading=69,0 %

T19-Trafo
loading=69,0 %

T20-Trafo
loading=77,2 %

T21-Trafo
loading=73,4 %

T14-LV
Ul=0,824 kV
u=1,03 p.u.
phiu=-109,8..

T15-LV
Ul=0,822 kV
u=1,03 p.u.
phiu=-110,1..

T16-LV
Ul=0,825 kV
u=1,03 p.u.
phiu=-109,8..

T17-LV
Ul=0,825 kV
u=1,03 p.u.
phiu=-109,8..

T18-LV
Ul=0,824 kV
u=1,03 p.u.
phiu=-110,0..

T19-LV
Ul=0,824 kV
u=1,03 p.u.
phiu=-110,0..

T20-LV
Ul=0,826 kV
u=1,03 p.u.
phiu=-109,8..

T21-LV
Ul=0,825 kV
u=1,03 p.u.
phiu=-109,9..

P=2,191 MW
Q=0,96 Mvar
I=1,676 kA
S=2,392 MVA
i1r=-0,532 p.u.
i1i=-0,562 p.u.

P=2,009 MW
Q=0,88 Mvar
I=1,540 kA
S=2,192 MVA
i1r=-0,536 p.u.
i1i=-0,561 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,395 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,395 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,562 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,256 kA
S=1,794 MVA
i1r=-0,534 p.u.
i1i=-0,560 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,256 kA
S=1,794 MVA
i1r=-0,534 p.u.
i1i=-0,560 p.u.

P=1,826 MW
Q=0,80 Mvar
I=1,393 kA
S=1,993 MVA
i1r=-0,531 p.u.
i1i=-0,561 p.u.

P=1,643 MW
Q=0,72 Mvar
I=1,256 kA
S=1,794 MVA
i1r=-0,534 p.u.
i1i=-0,560 p.u.

P=0,091 MW
Q=0,04 Mvar
I=0,070 kA
S=0,100 MVA
i1r=-0,532 p.u.
i1i=-0,560 p.u.

T14-SG250
79,7 %
2,191 MW
0,000 Mvar

T14-SG125
79,7 %
0,091 MW
0,000 Mvar

T15-SG250
79,7 %
2,009 MW
0,000 Mvar

T16-SG250
79,7 %
1,826 MW
0,000 Mvar

T17-SG250
79,7 %
1,826 MW
0,000 Mvar

T18-SG250
79,7 %
1,643 MW
0,000 Mvar

T19-SG250
79,7 %
1,643 MW
0,000 Mvar

T20-SG250
79,7 %
1,826 MW
0,000 Mvar

T21-SG250
79,7 %
1,643 MW
0,000 Mvar

T21-SG125
79,7 %
0,091 MW
0,000 Mvar

Transformer Datasheet

- Continuous Power Rating: 750kVA @ 65ºC Temp Rise
- No Load Voltage Ratio: 33/0.415kV
- Rated Voltage - Um: 36kV
- Number of Phases: 3
- Number of Windings: 2: HV/LV
- Frequency: 50Hz
- Impedance: 6.7% @ 1000kVA
- HV Winding Impulse Level: 170kVp
- LV Winding Impulse Level: As per IEC standard
- Vector Group: Dyn11
- Steady State Temperature Rise: 65ºC above ambient
- Design & Guaranteed No Load Losses: 2800 Watts (+0%)
- Design & Guaranteed Load Losses: 10800 Watts (+0%)
- HV Winding Earthing: Unearthed, Insulated