

**Capital Delivery
Design Handbook**

**GUIDANCE ON THE APPLICATION
OF SYSTEM DATA FOR PROTECTION PURPOSES**

DH 28

Issue 1

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1. PURPOSE

The purpose of this document is to give guidance on the application of system data (i.e. OHL Impedance and Fault Levels) for use in the calculation of protection settings.

Historically system data had been supplied on an annual basis for use in protection relay settings calculations. This data was produced using the network modelling tool 'ELLA' which at the time was the tool used within National Grid. Around 2008/2009 National Grid began the transition away from ELLA as they began to use a new program 'Power Factory' developed by the German company DlgSILENT. During the transitional period, an agreement was made that the Network Modelling Team within National Grid would provide system data on upon request from Technical Assurance.

Following several years of transition National Grid is now in a position where Power Factory has been fully embedded, and will once again publish system data on an annual basis. The system data is now available on National Grid's Livelink system, and this document provides guidance on where the data is obtained from, what the data represents and how the data should be applied with respect to National Grid's suite of Policies & Procedures.

2. REFERENCES

TS1	Ratings and Requirements for Plant, Equipment and Apparatus for the National Grid system
PS(T)010	Application and Protection Setting Policy for the National Grid UK Transmission System
UKBP/TP203	OLTA Data Model Change Management
UKBP/TP107	Protection and Control Relay Settings

3. RESPONSIBILITIES

3.1 Settings Engineer (Assurance)

The Settings Engineer (Assurance) has the accountability for ensuring that the correct parameters have been used in any protection relay settings calculations for which they are providing assurance. Where new circuits are to be installed as part of staged works (i.e. circuit reconfiguration, new substations, substation extensions), or where the project scope has altered significantly from the DID, the Settings Engineer (Assurance) shall be accountable for either; ensuring the system data provided is suitable and accounts for new/modified circuits, or liaising with National Grid System Design to ensure the production of new circuit parameters has been completed.

See TP107 for full definition of Settings Engineer (Assurance) duties.

3.2 Settings Engineer (Verification)

The Settings Engineer (Verification) has the responsibility for ensuring the correct parameters are used in any protection relay settings calculations which they are providing verification. Where new circuits are to be installed as part of staged works (i.e. circuit reconfiguration, new substations, substation extensions), or where the project scope has altered significantly from the DID the Settings Engineer (Verification) is to seek advice from the Settings Engineer (Assurance).

See TP107 for full definition of Settings Engineer (Verification) duties.

3.3 National Grid – Electricity Transmission Asset Management – Electricity Network Investment – System Design

Where new circuits are to be installed, or modifications are to be made to the existing power system which may alter circuit parameters (i.e. circuit reconfiguration, OHL spacer changes, SGT replacement), it is the responsibility of National Grid System Design to model the new/modified circuits and provide the required system data.

3.4 National Grid – Transmission Network Service – Network Strategy – Network Modelling Team Manager

The National Grid Network Modelling Team Manager (as identified in TP203 OLTA Data Model Change Management) is responsible for the annual production of system data comprising;

- Winter Peak Sub-transient 3 Phase Fault Levels
- Winter Peak Sub-transient 1 Phase Fault Levels
- Summer Minimum Transient 3 Phase Fault Levels
- Summer Minimum Transient 1 Phase Fault Levels
- Circuit Line Impedance Data
- SGT Impedance Data 2 Winding
- SGT Impedance Data 3 Winding

In addition to the system data outlined above, some additional data is to be made available. This is due to the outputs of the data interrogation tool. Whilst the additional data will be available to view, this should not be used without seeking advice from the Settings Engineer (Assurance)

4. REQUIREMENTS

The required system data is to be produced on an annual basis by National Grid Network Modelling Team Manager during December. The data provided will be the outputs from interrogation of the UK Electricity Transmission Network, as modelled using DIgSILENT's Power Factory software, and will contain information including;

- Winter Peak Sub-transient 3 Phase Fault Levels (for the current winter)
- Winter Peak Sub-transient 1 Phase Fault Levels (for the current winter)
- Summer Minimum Transient 3 Phase Fault Levels (for the following summer)
- Summer Minimum Transient 1 Phase Fault Levels (for the following summer)
- Circuit Impedance Data
- SGT Impedance Data 2 Winding
- SGT Impedance Data 3 Winding

The output of interrogation will be in the Comma Separated Values (.csv) format which can be opened and viewed using a variety of programmes including Microsoft Excel. Separate .csv files will be produced for each sub-set of information as shown in the bullet points above. These files will be made available in the Multi Access Relay Schedules (MARS) area of National Grid Livelink as shown in Figure 1 below, and can be accessed via the following links;

Circuit & Plant Impedance Data

<https://proj.info/livelink/livelink.exe?func=ll&objId=17546668&objAction=browse&sort=name&viewType=1>

Fault Level Data

<https://proj.info/livelink/livelink.exe?func=ll&objId=17546760&objAction=browse&sort=name&viewType=1>

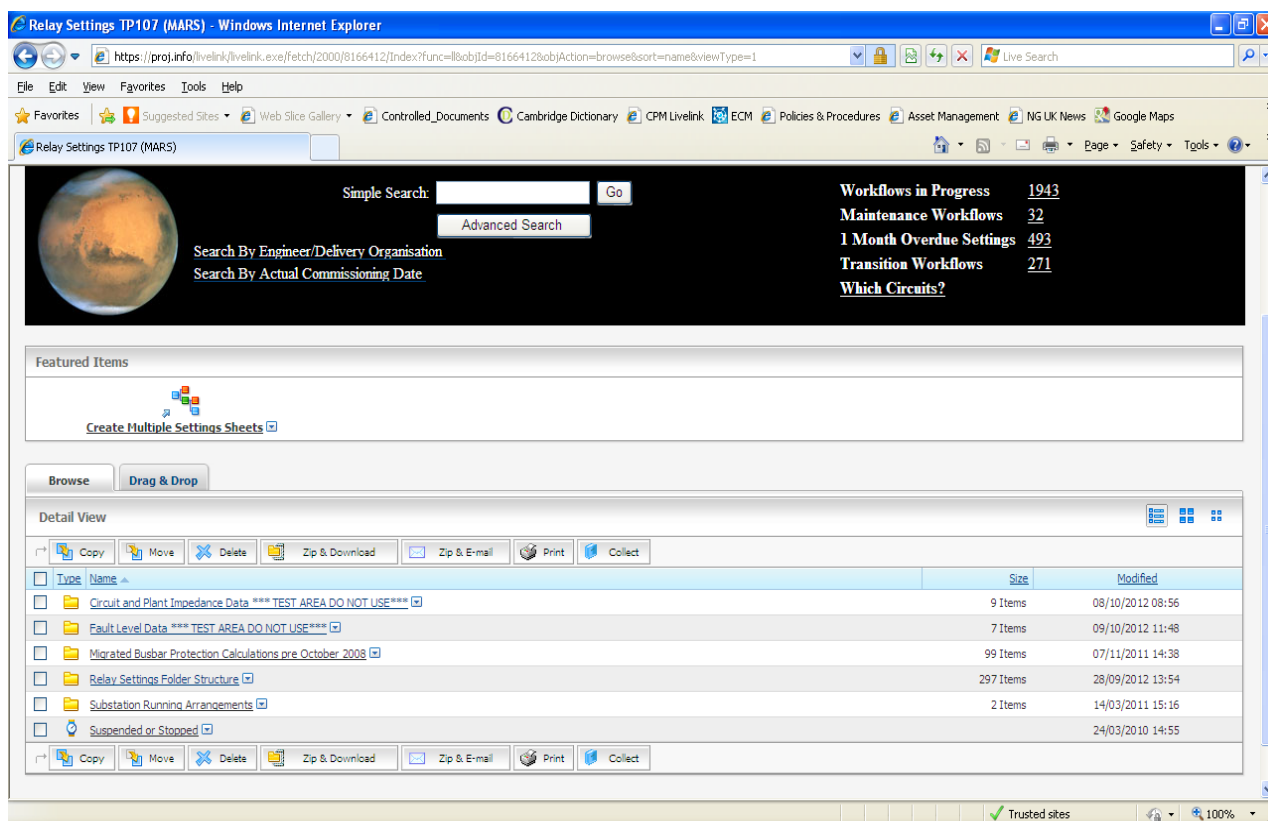


Figure 1 – MARS Livelink Screen Shot

4.1 Data File Content

The various data files available are outlined in the sections below. Details of information contained within the files is provided in each section, along with explanations of what the data means and how it should be applied to protection relay settings calculations.

4.1.1 Winter Peak 3 Phase Fault Levels

The Winter Peak 3 Phase Fault Levels are given in the folder 'Fault Level Data' and are identified as 'Winter Peak_yyyy_3Phase' where yyyy represents the year to which the study refers. The winter peak condition is considered as the period of maximum demand which conventionally occurs during the winter where heating is heavily relied upon across the nation and the UK Industrial sector is fully operational, thus maximum load. This will be the most onerous fault scenario determined by the model (the maximum fault level for which the National Grid 400kV System is designed is 63kA as defined in TS 1).

This particular data output is specific to 3 phase faults; however the single phase fault scenario is also modelled (Section 4.1.2) to confirm under which condition the highest fault level will occur.

An example output of the file is shown below in Figure 2

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
DateTime	31/12/2014	23:57:10	3-Phase Short-Circuit			
Substation	Node	Element (Infeed) Class	Element (Infeed)	Element Characteristic Name	Ikss Terminal i (kA)	Iks Terminal i (kA)
Drakelow 400kV						
	DRAK4_1				52.139444	45.124742
		ElmBranch	CELL4-DRAK4-1	A501	5.967565	5.438341
		ElmBranch	CELL4-DRAK4-2	A574	5.880777	5.35925
		ElmTr3	DRAK4 SGT 3A	SGT 3A	0	0
		ElmTr3	DRAK4 SGT 3B	SGT 3B	1.828407	1.305437
		ElmTr3	DRAK4 SGT 5	SGT 5	1.844721	1.317085
		ElmTr3	DRAK4 SGT 8	SGT 8	0.395119	0.169184
		ElmBranch	DRAK4-HAMH4-1	A514	6.141366	5.242029
		ElmBranch	DRAK4-OLD4-1	A519	1.860754	1.339481
		ElmBranch	DRAK4-RATS4-1	A575	8.466719	7.665001
		ElmBranch	DRAK4-RUGE4-1	A502	8.270732	7.087805
		ElmBranch	DRAK4-WILE4-1	A573	11.843733	10.528031
		ElmShnt	MSC 2	MSC2	0	0

Figure 2 – Example Output Winter Peak 3 Phase Fault Levels

As can be seen, this particular model refers to the system as of 31/12/2012 at midnight, and considers the event of a 3-Phase Short-Circuit at the busbars of a particular station. Each of the columns shown for the fault level data are explained below.

- Column 1: Substation – Describes the substation which has been considered for the fault condition.
- Column 2: Node –Identifies the Node within the model which has been considered for the fault. Each node is provided with a unique identifier containing the substations 4 letter short code (i.e. DRAK), the substation voltage (where the number 4 represents 400kV number 2 for 275kV and 1 for 132kV), and node number. For substations which are run solid only one node is shown; however for substations which are considered run split for fault level reasons multiple nodes will be shown for a single substation title.
- Column 3: Element (Infeed) Class – Identifies the type of plant which is connected to the busbar node where;
 - o ElmBranch refers to an Overhead Line (OHL) or cable
 - o ElmTr2 refers to a two winding transformer
 - o ElmTr3 refers to a three winding transformer
 - o ElmShnt refers to a form of shunt connected compensation plant i.e Mechanically Switched Capacitor (MSC)
 - o ElmSind refers to series reactors
 - o ElmSvs refers to Static Var Compensators (SVC)
 - o ElmLod refers to any connected load
 - o ElmSym refers to any connected generation
- Column 4: Element (Infeed) – Is related to column 3, but provides a name for the connected plant. The name provided for each plant type refers to an official title so that for connected lines this will be the circuit name and for transformers it will be the substation short code followed by transformer type and number.
- Column 5: Element Characteristic Name – Is an alternative naming convention to Element (Infeed). For connected lines this will be the NASAP code and for transformers it will be the transformer type and number as column 4; however this will not include the substation short code.

- Column 6: Ikss Terminal i (kA) – Is the Sub-Transient fault level in kA
- Column 7: Iks Terminal i (kA) – Is the Transient fault level in kA

For the purpose of protection relay settings calculations it is the Sub-Transient (Ikss) fault current which is used for determining Winter Peak Fault Levels. The Sub-Transient fault current is that which occurs in the first cycle following a fault and is when the greatest fault current occurs, albeit for a very short period of time.

Care should be taken in the case of transformer feeders and feeder circuits containing series reactors to ensure the correct contribution to the busbar has been considered. In some instances the fault level is shown for either side of the transformer/reactor and it is important to consider which contribution to select when undertaking the settings.

4.1.2 Winter Peak 1 Phase Fault Levels

The Winter Peak 1 Phase Fault Levels are given in the folder 'Fault Level Data' and are identified as 'Winter Peak_yyyy_1Phase' where yyyy represents the year to which the study refers. This particular data output is specific to 1 phase faults and is used in conjunction with section 4.1.1 to confirm under which condition the highest fault level will flow.

An example of the file is shown in below in Figure 3

Column 1	Column 2	Column 3	Column 4	Column 5	Column 6	Column 7
DateTime	31/12/2014	23:57:10	Single Phase to Ground			
Substation	Node	Element (Infeed) Class	Element (Infeed)	Element Characteristic Name	Ikss Terminal i (kA)	Iks Terminal i (kA)
Drakelow 400kV						
	DRAK4_1				46.566849	44.280589
		ElmBranch	CELL4-DRAK4-1	A501	4.480684	4.35697
		ElmBranch	CELL4-DRAK4-2	A574	4.392653	4.271734
		ElmTr3	DRAK4 SGT 3A	SGT 3A	0.462291	0.43919
		ElmTr3	DRAK4 SGT 3B	SGT 3B	2.005948	1.812504
		ElmTr3	DRAK4 SGT 5	SGT 5	2.203314	1.998987
		ElmTr3	DRAK4 SGT 8	SGT 8	0.713153	0.619161
		ElmBranch	DRAK4-HAMH4-1	A514	5.613853	5.30885
		ElmBranch	DRAK4-OLD4-1	A519	2.010249	1.817412
		ElmBranch	DRAK4-RATS4-1	A575	7.183647	6.955025
		ElmBranch	DRAK4-RUGE4-1	A502	8.326798	7.901008
		ElmBranch	DRAK4-WILE4-1	A573	9.688323	9.309099
		ElmShnt	MSC 2	MSC2	0	0

Figure 3 – Example Output Winter Peak 1 Phase Fault Levels

As can be seen, this particular model refers to the system as of 31/12/2012 at midnight, and considers the event of a 1-Phase to Ground Short-Circuit at the busbars of a particular station. Each of the columns shown for the fault level data are explained in section 4.1.1.

For the purpose of protection relay settings calculations it is the Sub-Transient (Ikss) fault current which is used for determining Winter Peak Fault Levels. The Sub-Transient fault current is that which occurs in the first cycle following a fault and is when the greatest fault current occurs, albeit for a very short period of time.

Care should be taken in the case of transformer feeders and feeder circuits containing series reactors to ensure the correct contribution to the busbar has been considered. In some instances the fault level is shown for either side of the transformer/reactor and it is important to consider which contribution to select when undertaking the settings.