SDRC2 Appendix A – BSP Scoring Matrix

Network Equilibrium - BSP Matrix

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Ranking	1	2	3	4	5	6	7	8	9	10	11	12
Criteria	Bowhays Cross	Radstock Main	Totnes	Tiverton	Taunton Main	Woodcote	Paignton	Exeter Main	Sowton	Exeter City	Bridgwater Main	Street
Voltage Modification Capability	Category A	Category A	Category A	Category B	Category B	Category B	Category C	Category C	Category C	Category D	Category D	Category D
	Significant target voltage modification capability	Significant target voltage modification capability	Significant target voltage modification capability	Good target voltage modification capability	Good target voltage modification capability	Good target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability	Very limited target voltage modification capability	Very limited target voltage modification capability	Very limited target voltage modification capability
Existing AVC Capability	No ability to remotely control settings	No ability to remotely control settings	No ability to remotely control settings	Can receive fine control and remotely select group settings	No ability to remotely control settings	No ability to remotely control settings	Can remotely select up to 2 group settings	Can remotely select up to 2 group settings	No ability to remotely control settings	Can remotely select up to 2 group settings	Can remotely select up to 2 group settings	No ability to remotely control settings
	Alstom MVGC01 installed - no ability to change settings remotely for SVO	Alstom MVGC01 installed - no ability to change settings remotely for SVO	AVE5 electro-mechanical relays installed - no ability to change settings remotely	Fundamentals SuperTAPP n+ relays installed - ability to receive fine control and remotely change group settings	Alstom MVGC01 installed - no ability to change settings remotely for SVO	Alstom MVGC01 installed - no ability to change settings remotely for SVO	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Reyrolle SuperTAPP relays installed - no ability to change settings remotely	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom MVGC01 installed - no ability to change settings remotely for SVO
Substation Condition	Excellent Condition	Good Condition	Poor Condition	Average Condition	Good Condition	Good Condition	Average Condition	Average Condition	Average Condition	Good Condition	Good Condition	Average Condition
	Transformers and switchgear replaced in 2010, substation in excellent condition	Transformers currently being changed. Substation in good condition	Original equipment from 1960's, transformers require regular preventative maintenance	New 33kV switchgear, transformers manufactured 1964. Minor issues reported with transformers	Three transformers installed in 2009 to 2011. New 33kV switchroom in 1998. No issues with substation	T1 and T2 replaced in 2008/2009, T3 replaced in 1999. 33kV repalced in 2009. Substation is in good condition	Transformers replaced in 2008, auxiliary systems not replaced	Transformers replaced in 2010, some 33kV switchgear replaced in 2002. No major issues with substation	Two new transformers commissioned in 2003, auxiliary systems not replaced. No major issues with substation	All major equipment replaced circa 2009. Substation in good condition	T1 and T2 replaced in 2013, T3 manufactured in 1987. No reported issues with the substation	Transformer replaced in 1998, auxiliary systems not replaced
Connected Customer Impact	Voltage sensitive customer(s)	Voltage sensitive customer(s)	No significant impact	No significant impact	No significant impact	No significant impact	No significant impact	No significant impact	Voltage sensitive customer(s)	No significant impact	Voltage sensitive customer(s)	Voltage sensitive customer(s)
	One sensitive customer connected on the 33kV fed from Bowhays Cross	One sensitive customer connected on the 33kV fed from Radstock	No impact expected for customers connected to Totnes 33kV	No impact expected for customers connected to Tiverton 33kV	No impact expected for customers connected to Taunton 33kV	No impact expected for customers connected to Woodcote 33kV	No impact expected for customers connected to Paignton 33kV	No impact expected for customers connected to Exeter Main 33kV	One sensitive customer connected on the 33kV fed from Sowton	No impact expected for customers connected to Exeter City 33kV	One sensitive customer connected on the 33kV interconnected network between Bridgwater and Street	One sensitive customer connected on the 33kV interconnected network between Bridgwater and Street
Customer Connection Activity	Average number of connection applications	High number of connection applications	Average number of connection applications	Average number of connection applications	High number of connection applications	Average number of connection applications	Average number of connection applications	Average number of connection applications	Little or no connection applications	Average number of connection applications	High number of connection applications	High number of connection applications
	Average connection activity with three committed 33kV connections	Connection activity in the local area is high with six committed 33kV connections	Average connection activity with three committed 33kV connections	Average connection activity with four committed 33kV connections	Connection activity in the local area is high with seven committed 33kV connections	Average connection activity with five committed 33kV connections	Average connection activity with three committed 33kV connections	Average connection activity with three committed 33kV connections	Low connection activity with only two committed 33kV connections	Average connection activity with three committed 33kV connections	Connection activity in the local area is high with seven committed 33kV connections on the interconnected network with Street	Connection activity in the local area is high with seven committed 33kV connections on the interconnected network with Bridgwater
Score	54.2	50	36.7	81.7	55	51.7	56.7	56.7	35.8	64.2	62.5	42.5

SDRC 2 Appendix B - Primary Substation Scoring Matrix

Network Equilibrium - Primary Matrix

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

Ranking	1	2	3	4	5	6	7	8	9	10
Criteria	Waterlake	Lydeard St Lawrence	Marsh Green	Dunkeswell	Staplegrove	Colley Lane	Tiverton Moorhayes	Millfield	Nether Stowey	Tiverton Junction
Voltage Modification Capability	Category 1	Category 1	Category 1	Category 1	Category 1	Category 2	Category 2	Category 2	Category 2	Category 2
	Good target voltage modification capability	Good target voltage modification capability	Good target voltage modification capability	Good target voltage modification capability	Good target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability	Limited target voltage modification capability
Existing AVC Capability	Can remotely select more than 2 group settings	Can remotely select more than 2 group settings	Can remotely select up to 2 group settings	No ability to remotely control settings	No ability to remotely control settings	Can remotely select more than 2 group settings	Can remotely select up to 2 group settings	Can remotely select up to 2 group settings	No ability to remotely control settings	No ability to remotely control settings
	MicroTAPP installed - ability to select more than 2 group settings	MicroTAPP installed - ability to select more than 2 group settings	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom MVGC01 installed - no ability to change settings remotely for SVO	AVE5 electro-mechanical relays installed - no ability to change settings remotely	MicroTAPP installed - ability to select more than 2 group settings	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom KVGC202 relays installed - ability to control 2 group settings remotely	Alstom MVGC01 installed - no ability to change settings remotely for SVO	AVE5 electro-mechanical relays installed - no ability to change settings remotely
Substation Condition	Excellent Condition	Excellent Condition	Average Condition	Good Condition	Poor Condition	Excellent Condition	Good Condition	Good Condition	Good Condition	Average Condition
	Modern transformers and equipment, ssubstation in excellent condition	Modern transformers and equipment, substation in excellent condition	T1 manufacturered in 1960, T2 in 1980. New 11kV switchboard. No issues reported with this substation	New equipment installed in 1997, no reports of any issues with this substation	Transformers in very poor condition with significant oil leaks. Site requires frequent attention	Modern transformers and equipment, ssubstation in excellent condition	Transformers installed in 2006, no reported issues with the substation	Transformers installed in 2004, no reported issues with the substation	New equipment installed in 1990, no reports of any issues with this substation	Substation equipment from 1950's, well maintained but starting to show signs of deterioration
Connected Customer Impact	No significant impact	Voltage sensitive customer(s)	No significant impact	No significant impact	No significant impact	No significant impact	No significant impact	Voltage sensitive customer(s)	No significant impact	Voltage sensitive customer(s)
	No impact expected for customers connected to Waterlake	PV generation with dedicated 11kV feeder	No impact expected for customers connected to Marsh Green	No impact expected for customers connected to Dunkeswell	No impact expected for customers connected to Staplegrove	No impact expected for customers connected to Colley Lane	No impact expected for customers connected to Tiverton Moorhayes	PV generation and storage customers with dedicated 11kV feeders	No impact expected for customers connected to Nether Stowey	PV generation with dedicated 11kV feeder
Customer Connection Activity	Little or no connection applications	Little or no connection applications	Little or no connection applications	Little or no connection applications	Little or no connection applications	Average number of connection applications	Little or no connection applications	Little or no connection applications	Little or no connection applications	Little or no connection applications
	Only a limited number of connection applications	Only a limited number of connection applications	Only a limited number of connection applications	Only a limited number of connection applications	Only a limited number of connection applications	Average connection activity with 7.75MW of generation commited	Only a limited number of connection applications	Little connection activity with only 1MW of generation commited	Only a limited number of connection applications	Only a limited number of connection applications
Score	80.8	75.8	53.3	48.3	33.3	84.2	60.8	55.8	48.3	35.8

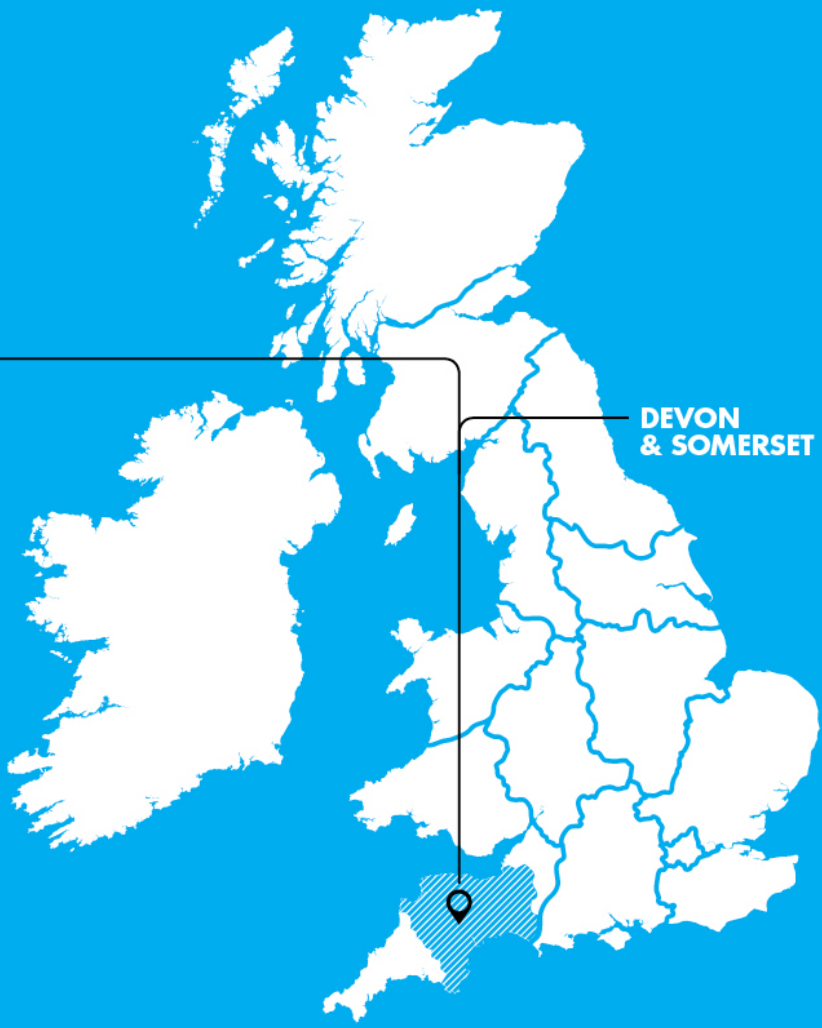
SDRC 2 Appendix C - AVC Relay Report

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

Network Equilibrium Project AVC Report



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Contents

Glossary

Term	Definition
AVC Relay	Automatic Voltage Control Relay – relay utilised to control automatic adjustment of a transformer tap position when control of the voltage is required as load varies.
DMS	Distribution Management System - a collection of applications designed to monitor and control a distribution network efficiently and reliably. DMS acts as a decision support system to assist the control room and field operating personnel with the monitoring and control of the electric distribution system.
CAN Bus	Controller area network - CAN bus is a vehicle bus standard designed to allow substation relays and devices to communicate with each other in applications without a host computer.
DNP3	Distributed Network Protocol – DNP3 is a communication protocol used between components in substation automation systems. It is primarily used for communication between a master station, RTUs and IEDs within a substation.
EMS	Energy Management System - EMS is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimise the performance of or the distribution system.
GOOSE	Generic Object Oriented Substation Events - GOOSE is a controlled model mechanism in which any format of data (status, value) is grouped into a data set and transmitted within a time period of 4 milliseconds.
K-Bus	A communication interface and protocol designed to meet the requirements of communication with protective relays and transducers within the power system substation environment.
PowerON System	Software system that addresses the operational and control needs of Western Power Distribution to meet the WPD's security, reliability and financial objectives and alerts the user to events affecting the network.
RTD Module	Resistance Temperature Detector Module - utilised in an AVC relay to provide measurement of transformer winding temperature.

SCADA	Supervisory Control and Data Acquisition - is a software system for remote monitoring and control of substations operating over communication channels. SCADA systems typically allow commands to be issued from central control and monitoring points to the substation enabling full remote substation control.
TCP/IP	Transmission Control Protocol/Internet Protocol - is the basic communication language or protocol of the Internet. It can also be used as a communications protocol in a private network in a substation (either an intranet or an extranet).

1 Introduction

The following report investigates the operational performance of automatic voltage control (AVC) relays and their suitability for use with the SVO method. Details are provided on the AVC relays currently in service at potential SVO substations, WPD approved relays and a selection of relays available on the market that could be utilised for the SVO method.

2 System Voltage Optimisation Sites of Interest

Table 1 below lists the WPD Bulk Supply Points (BSP) and Primary substations under consideration for inclusion of SVO technology and the AVC relays currently installed at each.

Table 2-1: Potential SVO Substations and currently installed relays

	Substation Name	AVC Relay
Bulk Supply Points	Radstock Main	GEC MVGC01
	Bridgwater Main	Alstom KVGC202
	Street	GEC MVGC01
	Exeter City	Alstom KVGC202
	Totnes	GEC AVE5
	Woodcote	GEC MVGC01
	Taunton	GEC MVGC01
	Bowhays Cross	GEC MVGC01
	Tiverton	Fundamentals SuperTAPP n+
	Exeter Main	Alstom KVGC202
	Paignton	Alstom KVGC202
	Sowton	Reyrolle SuperTAPP
Primary Substations	Nether Stowey	GEC MVGC01
	Staplegrove	GEC AVE5
	Lydeard St Lawrence	Siemens MicroTAPP
	Waterlake	Siemens MicroTAPP
	Colley Lane	Siemens MicroTAPP
	Tiverton Junction	GEC AVE5
	Tiverton Moorhayes	Alstom KVGC202
	Marsh Green	Alstom KVGC202
	Dunkeswell	GEC MVGC01
	Millfield	Alstom KVGC202

3 AVC Relay Requirements

Each AVC relay was evaluated with respect to its suitability for use in the SVO method based on the following criteria:

i. The AVC relays current functionality and the ability of the AVC relay to function with embedded generation connected to the network.
ii. The ability of the AVC relay to receive voltage target set-point values that are directly sent via the WPD SCADA communication platform (DNP3).
iii. The ability of the AVC relay to receive different setting groups that will be directly sent via the WPD SCADA communication platform (DNP3).
iv. The capability of the AVC relay to support communications protocols that are compatible with current WPD communication interfaces (DNP3).
v. The AVC relays ability to allow the National Grid enforced demand reduction of 3% and 6%.
vi. The ability to set hard limits to prevent target voltage settings that are outside the safe limits to be accepted and used.
vii. Specific details of the AVC Relay including pictures and wiring details for each relay.
viii. AVC Relay input and output capability.
ix. The AVC Relay’s ability to communicate with AVC relays already installed on existing WPD substations for split parallel situations.

The report also details, if an AVC relay is to be replaced, whether it can be and is optimal to do so in the existing protection panel or if a new protection panel/wallbox should be installed.

4 Existing AVC Relays Installed on WPD Substations

4.1 GEC AVE5 and Reyrolle SuperTAPP

Both of these relays are mechanical in operation and cannot be utilised in the SVO method. Therefore the relays were not investigated further in this report.

4.2 GEC/Alstom MVGC01

4.2.1 Functionality

The MVGC01 relay has the following functionality.

- Solid state device offering line drop compensation, supervision and alarm functions.
- The regulated voltage, Vs is set by means of a digital thumbwheel switch and the appropriate deadband setting, ΔV% selected.
- In order to minimise unnecessary tap changes due to transient voltage fluctuations, the relay incorporates a continuously variable delay before the reclosure of the relevant tap change initiating contact for 1 second. The initial time delay is selectable for either a definite time or a time delay which is inversely proportional to the degree of voltage variations from the Vs setting.

4.2.2 Ability to Receive Target Set Points and Select Different Setting Groups

The adjustable settings are detailed in Table 2 below. Local indication of selected load shedding is given by LED indicators on the relay with a selector switch available to select either local or remote/SCADA operation.

Table 4-1: MVGC01 Adjustable Settings

	Substation Name
Regulated Voltage Setting (Vs)	100–139V in 1V steps ±0.5%
Loading Shedding or Voltage targets	–3%, –6%, –9% Vs or +3%, +1.5%, or –1.5% of Vs ±0.5% External selection can be remote or local
Deadband setting ΔV%	±0.5 to ±3.0% of Vs Continuously Adjustable Accuracy: ±0.2% of Vs Setting

4.2.3 Ability Support Communication Protocol Compatible with WPD System

The MVGC01 cannot receive remote target voltage set-point values or alternative setting group changes that are directly sent via the WPD SCADA communication platform.

4.2.4 Allow National Grid Demand Reduction of 3% and 6%

The MVGC01 relay allows the National Grid enforced demand reduction of 3% and 6%.

4.2.5 Hard Voltage Limit Capability

The MVG01 AVC relay has hard limits built into the design to prevent target voltage settings that are outside the safe limits to be accepted and utilised.

4.2.6 Relay Details (Pictures, Panel, Wiring Details)

The relay is housed in standard Size 8 case, as shown in Figure 4-2 below, incorporating a terminal block for external connections.

Figure 4-1: Picture of an installed MVGC01

Figure 4-2: Picture of MVGC01 inside Panel

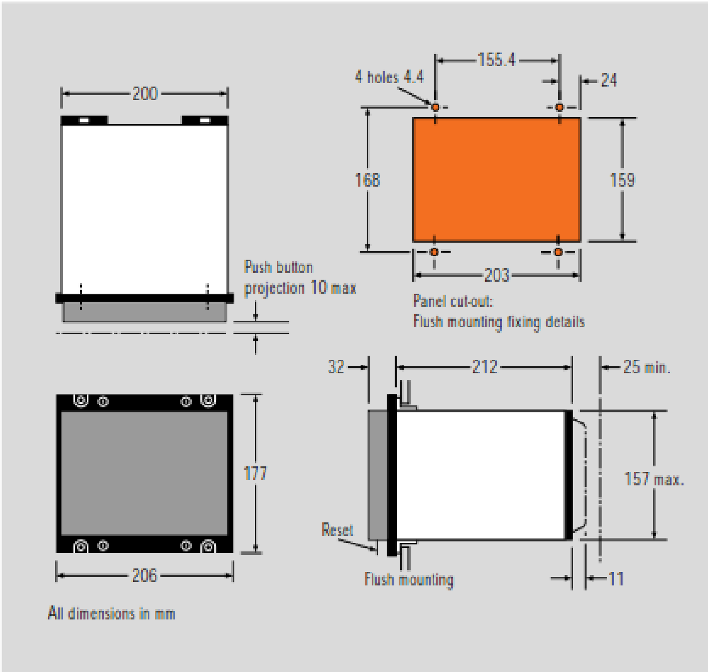


Figure 4-3: MVGC01 Relay Case Size

4.2.7 Relay Input and Output Capability

The relay input and output capability is shown in Figure 4-4 below.

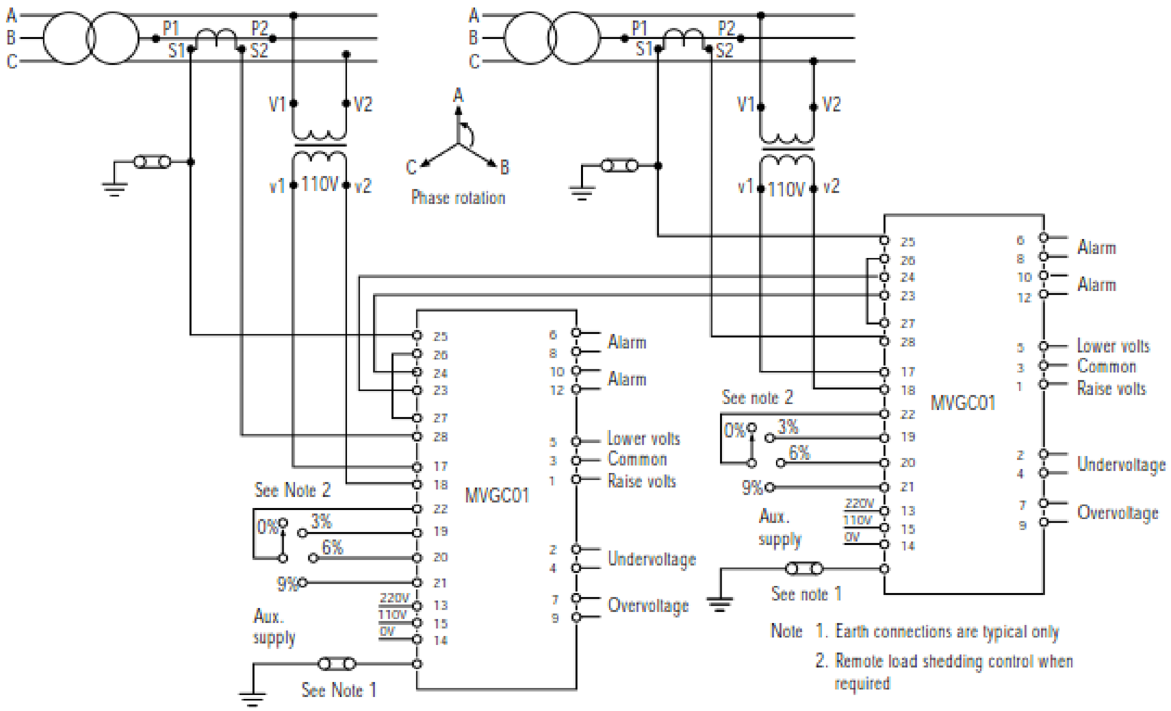


Figure 4-4: MVGC01 Input and Output Diagram

4.2.8 Conclusion

The GEC/Alstom MVGC01 relay lacks the ability to receive remote target set-point voltage values and is unable to receive remote alternative setting group changes that will be directly sent via the WPD SCADA communication platform. Subsequently, the relay is not suitable for utilisation as part of the SVO method.

4.3 Alstom KVGC202

4.3.1 Functionality

The KVGC202 relay is the K Range version of the MVGC voltage regulating relay based on the K Range series 2 relays. The KVGC202 has retained the existing functionality of the MVGC relay and additional functionalities and features have been added to the relay, to allow greater flexibility.

- Transformer Tap Change Control – To maintain the system voltage within finite limits, the target regulated voltage (Vs) and the deadband (dVs) are set on the relay.
- Line Drop Compensation – The KVGC202 relay has the ability to simulate resistive and reactive power drop across the power line.
- Parallel Transformer Applications – The KVGC202 relay has two methods for parallel transformer application. The pilot method requires an interconnection between the KVGC202 relays and compensates based upon the measured circulating current component. The reverse reactance method requires no interconnection and relies upon the user setting the line drop compensation to compensate for the circulating current.
- Load Shedding and Boosting – The regulated voltage (Vs) can be lowered or raised by up to 10% of the target regulated voltage Vs.
- The KVGC202 relay includes an extensive range of control and data gathering functions to provide a completely integrated system of control, instrumentation, data logging and event recording. The relays have a 32 character liquid crystal display (LCD) with 4 push-buttons which allow menu navigation and setting changes.
- By utilising the simple 2-wire communication link all of the relay functions can be read, reset and changed on demand from a local or remote PC, loaded with the relevant software.
- The relay can operate in Automatic, Manual or Remote mode.
- If embedded generation is installed close to the load centre, this can cause reduction or possibly reversal of real power flow through upstream transformers. The KVGC202 has a reverse current element which can be used to block tap changing or change setting groups where there is reverse power flow caused by embedded generation. If the load current (IL) is in reverse direction, the 'Irev' output relay allocated in the relay mask will pick up the reverse current condition to give an alarm indication. The logic can be configured to block the operation of the tap changer for a reverse current or select group 2 settings will be selected for a reverse current.

4.3.2 Ability to Receive Target Set Points and Select Different Setting Groups

- An interface keypad on the front of the relay allows the user to navigate through the menu to change settings. As an alternative the relay can be connected to a computer via the serial communication port and the relay menu accessed on-line as per Figure 4-5 below.
- Two setting groups are available to allow the user to set Group 1 to normal operating conditions while Group 2 can be set to cover abnormal operating conditions (Embedded Generation).
- Remote change of the KVGC202 relay setting group is possible. The selected setting group is stored when the relay is powered down and restored on power up.
- The effective regulated voltage level (Vs) can be lowered or raised by means of the load shedding/boosting option. This allows a system operator to override the automatic regulation to increase or decrease the system voltage supply. Three programmable levels are available settable between 0 to ±10% Vs and can be selected either via K-Bus or by using external contacts to select one of 3 binary inputs assigned to 'Level 1', 'Level 2' and 'Level 3' as required by the user.

Settings available on the KVGC202 are shown in Table 3 below.

Table 4-2: Alstom FVGC202 Settings

Setting	Adjustment Range	Step
Setting Voltage (Vs)	90 – 139V	0.1V
Dead Band (dVs)	±0.5% to ±20% of Vs	0.1% for an average tap step increment of 1.4% on the transformer.
Load Shedding/Boosting	0 – ±10 % of Vs	1%

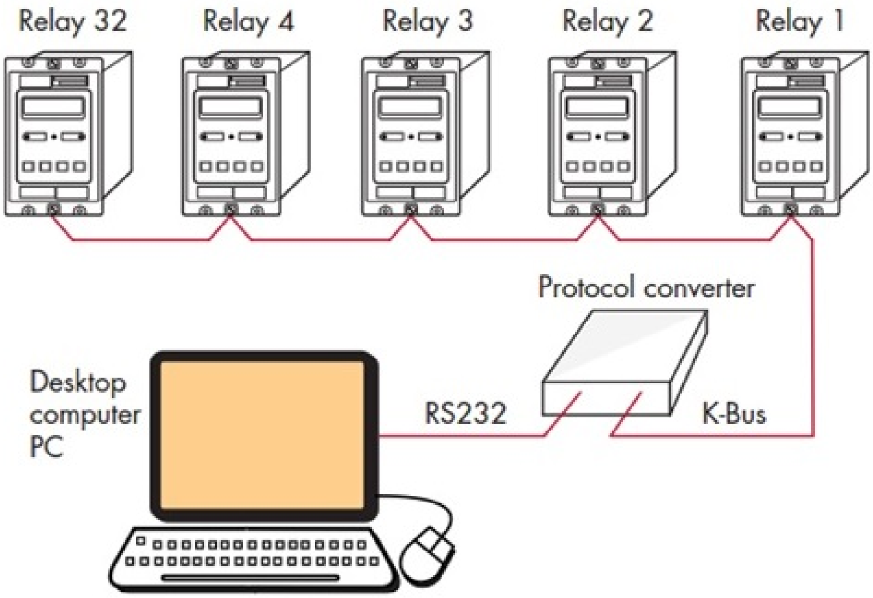


Figure 4-5: Alstom KVGC202 Communications System

4.3.3 Ability to Support Communication Protocol Compatible with WPD

By utilising the simple two-wire communication link shown in Figure 4-5, all of the relay functions can be read, reset and changed on demand from a local or remote computer. This includes changing relay settings, change of setting groups, and remote control of the operating modes. The KVGC202 voltage regulating relay has a serial communication port configured to K-Bus Standards

4.3.4 Allow National Grid Demand Reduction of 3% and 6%

The KVGC202 relay allows the National Grid enforced demand reduction of 3% and 6%. The regulated voltage (Vs) can be lowered or raised by up to 10% of Vs.

4.3.5 Relay Details (Pictures, Panel, Wiring Details)

Figure 4-6: Picture of KVGC202 Relay

Figure 4-7: Picture of KVGC202 inside Panel

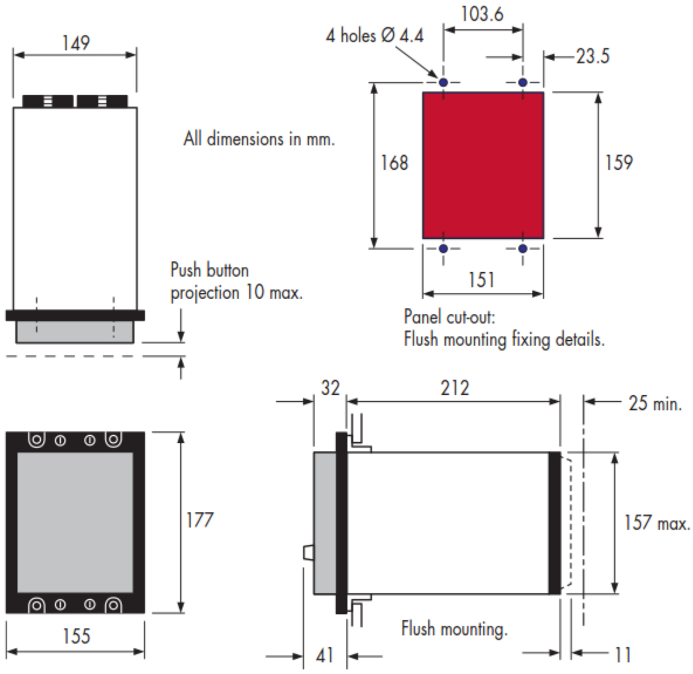


Figure 4-8: KVGC202 Relay Case Size

4.3.6 Relay Input and Output Capability

Figure 4-9 below shows the Input and Output diagram for the KVGC202. Six multiplexed analogue inputs are available, sampled eight times per power frequency cycle. Eight output relays can be programmed to respond to any of the control functions and eight logic inputs can be allocated to control functions. The logic inputs are filtered to ensure that Induced AC current in the external wiring to these inputs does not cause an incorrect response.

10 KVGC202 00 sheet 3

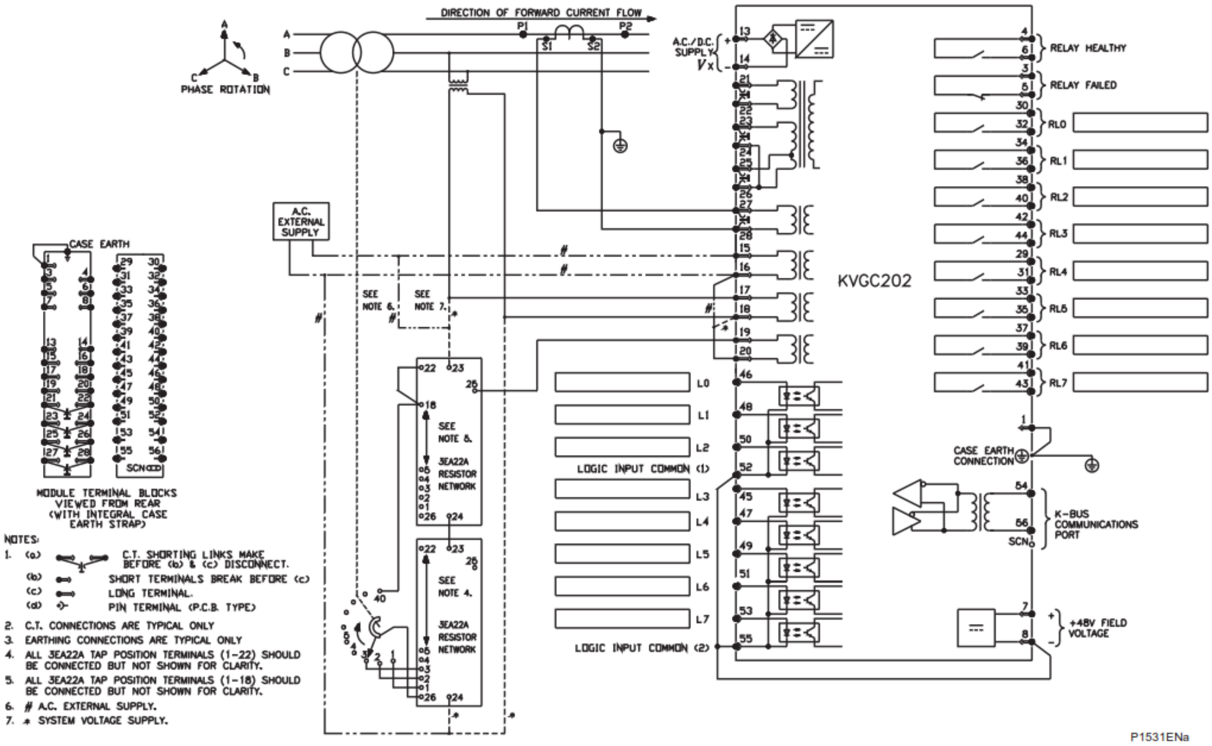


Figure 4-9: KVGC202 Input and Output Diagram

4.3.7 Relay Capability to communicate with existing AVC Relays at Site

The AVC relay can communicate with existing KVGC202 relays already in service at the substation. A simple master-follower scheme could be arranged with a KVGC relay on each parallel transformer. The master AVC relay is set to AUTO mode and the followers set to MANUAL mode. The master relay is set to regulate the busbar voltage and operate the local tap changer in the standard way with two of its output contacts arranged to give raise and lower commands. The followers are controlled from two more contacts on the master relay set to give raise and lower commands to the manual raise and lower binary inputs on the follower relays. In this way when the master relay issues a raise or lower command the follower relays will give a raise or lower commands via their manual tap change controls.

4.3.8 Conclusion

- The KVGC202 relay has the ability to receive and modify remote target set-point voltage values and alter two setting groups within the relay which can be sent via the WPD SCADA communication platform utilising an RS232 serial connection.

- The KVGC202 has a reverse current element which can be used to block tap changing or change setting groups where there is reverse power flow caused by embedded generation.

A limit of only two setting groups (Normal/Abnormal) is insufficient for the KVGC202 relay utilisation as part of the network equilibrium project.

4.4 Fundamentals SuperTAPP n+

4.4.1 Functionality

The SuperTAPP n+ voltage control relay is available as a 'basic' model or as an 'advanced' model with the functionality of each model detailed in Table 4.

Table 4-3: SuperTAPP n+ Functionality

Feature	Basic Model	Advanced Model
Activated VT Inputs	1	2
Activated CT Inputs	1	3
Line Drop Compensation	Yes	Yes
Transformer Paralleling	Yes	Yes
Voltage Reduction	Yes	Yes
Embedded Generation Functions	No	Yes
Load Exclusion	No	Yes
Load Inclusion	No	Yes
Load Correction	No	Yes
Av for Double Sec Winding	No	Yes
VT Switching	No	Yes

- Parallel Transformer Applications – The SuperTAPP n+ employs the 'enhanced TAPP' method to calculate the circulating current (site and network components) and convert it into a corrective voltage bias, V_{circ}. The voltage bias modifies the target voltage of the relays in order to promote tap changer operations which will reduce the circulating current to a minimum. The site circulating current is calculated using the 'true circulating current' method, which is dependent on the individual transformer load and the summed load of paralleled transformers. The network circulating current is calculated using the 'TAPP' method (Transformer Automatic

Paralleling Package) which is dependent on the group load and target power factor setting of the relay.

- The circulating currents are then converted into V_{circ} using the following relay settings:
  i. Transformer rating
  ii. Firm capacity
  iii. Transformer % impedance
  iv. Sensitivity factor for network circulating current*
  **the sensitivity factor is included to reduce the errors associated with a fluctuating load power factor (for example due to embedded generation). The default setting is 10% as a safety margin*.
- Load Drop Compensation - The SuperTAPP n+ incorporates a reverse LDC function in both the basic model and the advanced model.
- In order that the voltage is boosted for Load drop compensation the bias to apply to the relay for positive LDC is calculated using the following:
  i. LDC setting
  ii. Group load
  iii. Target power factor (relay setting)
  iv. Firm capacity (relay setting)
- The applied LDC bias is capped at the setting level, it cannot be more than the setting level even if the group load increases to above the firm capacity setting level
- The basic relay model can be configured to apply reverse LDC in such a way that mirrors the forward power flow response.
- The advanced relay model has extra LDC settings available to provide more flexibility for reverse power flow. Other settings for reverse LDC are 'max reverse load' and 'reverse LDC level'. The 'max reverse load' defines the group load level at which the 'reverse LDC level' is applied. The target power factor which the relay uses to calculate the LDC response can be modified for reverse power. The relevant setting is called 'reverse power factor'.
- The advanced model of the relay has extra VT and CT inputs available to provide enhanced voltage control for all application complexities. The extra inputs are used for the following:
  i. Feeder current measurements to accommodate embedded generation, reactive sources/loads or special applications proportional to load.
- There are two modes of operation for the relay as follows:
  i. Auto Mode – relay controls the tap changer
  ii. Non-Auto Mode – operator controls the tap changer
- These modes of operation can exist in Local and Remote control to give the following combinations of control mode:
  i. Local Auto – tap changer controlled by the relay
  ii. Local Non-Auto – tap changer manually controlled by an operator at the substation (at the tap changer or at the relay panel)
  iii. Remote Auto – tap changer controlled by the relay but influenced by SCADA communications (DNP3, IEC 61850 etc.)
  iv. Remote Non-Auto – tap changer controlled via an operator by remote raise and lower commands over SCADA communications (DNP3, IEC 61850 etc.)

- The relay has binary inputs available to switch between Auto and Non-Auto control modes.
- In order to solve the problems associated with embedded generation the SuperTAPP n+ relay has functions available which utilise feeder current measurements as detailed below:
    i. Accurate LDC based on the 'true' group load. With generation present the summed transformer currents do NOT represent the group load .The relay can determine generation output(s) based on feeder current measurements and utilise the measurement to calculate the 'true' group load.
    ii. Generation compensation –A reduction in relay target voltage in proportion with calculated generation output levels.
- The RTMU relay is also available and is used to provide extra functions for independent monitoring and control of the tap changer:

i. Tap position indication
ii. Voltage monitoring
iii. Runaway prevention
iv. VT fuse monitoring
v. Auto/Non-auto control switches

WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR's. The SuperTAPP n+ relay **does not** have the ability to provide tap stagger functionality.

4.4.2 Ability to Receive Target Set Points and Select Different Setting Groups

- The SuperTAPP n+ relay can accept remote target voltage values through its CAN bus communications interface, as well as other control commands such as auto/manual select. Target voltage settings can be sent to the SuperTAPP n+ relay and be set to any value.
- The voltage target setting value of the relay can be modified by remote voltage adjustments applied via digital status inputs or SCADA communications.
- Three status inputs are available on the SuperTAPP n+ providing added flexibility for different applications. The inputs can be configured to operate in two modes:
    i. Fixed - adjustments are applied as permanent signals and result in fixed changes to the relay basic target voltage while the signals are active.
    ii. Step - adjustments are applied as fleeting signals and result in step changes to the relay basic target voltage each time a signal is received.
- All measured values, setting group status, target voltage, relay status are available through remote communication. A life contact indicating relay healthy is also available as well as tap changer mechanism control.
- An alternative setting group and three voltage adjustments are available in the SuperTAPP n+ and the associated settings are shown in Table 5.

Table 4-4: Fundamentals SuperTAPP n+ Available Settings

Setting	Adjustment Range	Default Setting
Target Voltage	90 % - 110 % step 0.1 %	100 %
Bandwidth	0.5 % - 5 % step 0.1 %	1.5 %
Voltage Target Adjustment 1	-6 % to +6 % step 0.1 %	-3 %
Voltage Target Adjustment 2	-6 % to +6 % step 0.1 %	-6 %
Voltage Target Adjustment 3	-6 % to +6 % step 0.1 %	3 %
Step Size	0.5 % to 3 % step 0.1 %	1 %

4.4.3 Ability to Support Communication Protocol Compatible with WPD

- Remote Communication is achieved by the use of a protocol converter to convert the proprietary CAN communications protocol that the SuperTAPP n+ AVC relays utilises into DNP3 data points. The protocol converter utilised is the ENVOY unit that has an Ethernet connection for communication by DNP3 over TCP/IP. There is also serial RS232 available for communication.
- Communications to WPD ENMAC interfaces are supported. DNP3 and IEC61850 have been utilised in previous SuperTAPP n+ projects such as the Northern Power Grid Skegness low carbon hub.
- The SuperTAPP n+ is already successfully utilised with DNP3 communication via WPD SCADA as part of the dynamic voltage control project.
- Remote tap changer operation is controlled via the relay by SCADA communications (DNP3, IEC61850 etc.). SCADA communication is available only with an accompanying ENVOY unit (communications platform developed specifically for use with the SuperTAPP n+ relay).

4.4.4 Allow National Grid Demand Reduction of 3% and 6%

The SuperTAPP n+ relay allows the National Grid enforced demand reduction of 3% and 6%. Voltage reduction commands can be sent through the communications interface or hard wired inputs can be utilised to reduce demand.

4.4.5 Hard Voltage Limit Capability

The SuperTAPP n+ scheme has settable high and low voltage limits to prevent the scheme from tapping outside of these limits.

4.4.6 Relay Details (Pictures, Panel, Wiring Details)

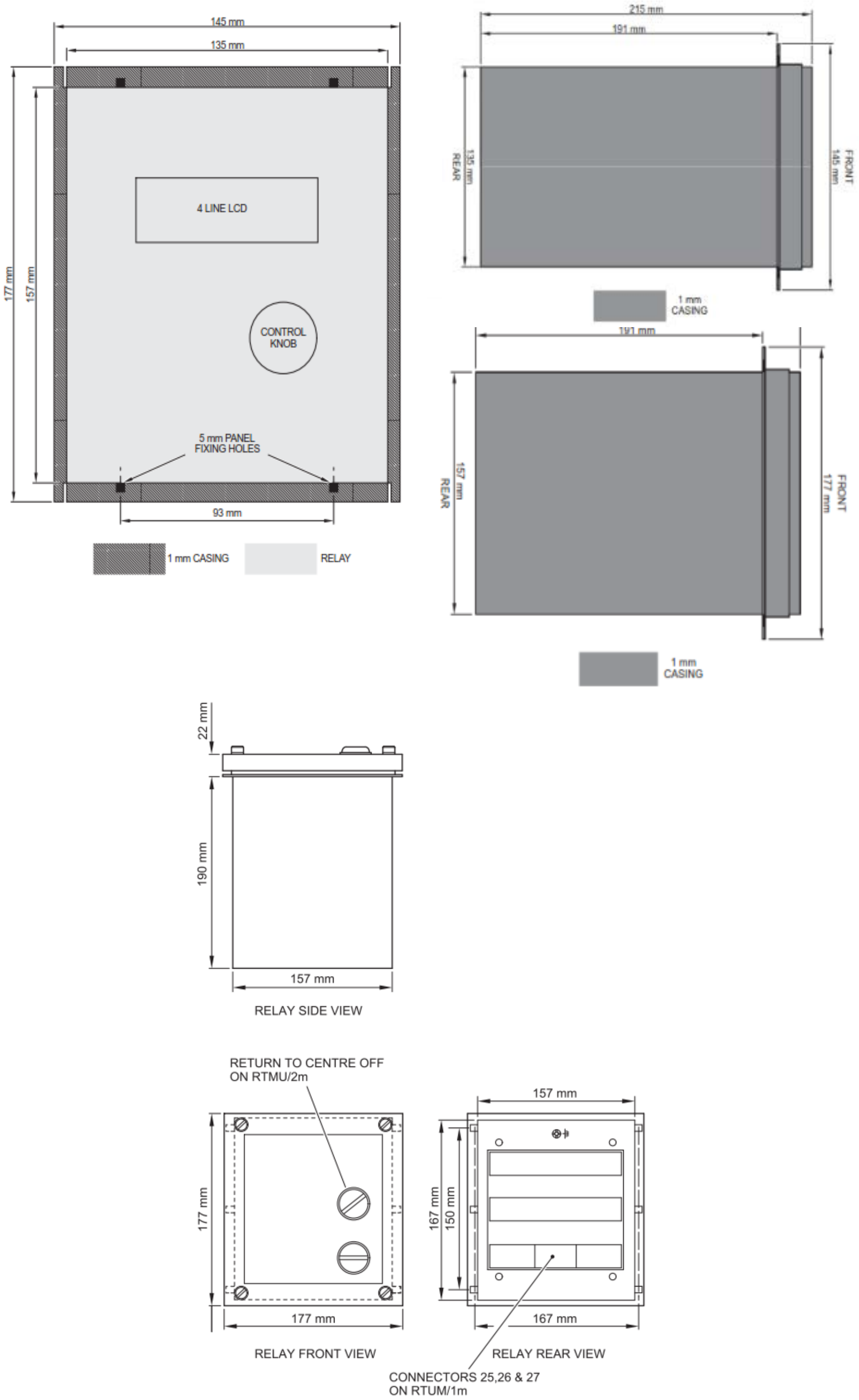


Figure 4-10: Fundamentals SuperTAPP n+ Relay and RTMU Dimensions

- The SuperTAPP n+ relay is mounted in a 19'' panel using 4mm screws with an accompanying Fundamentals RTMU monitor relay to give a complete SuperTAPP n+ voltage control system as shown in Fig.9. All connections to the relay are made at the rear through Phoenix type connectors
- The SuperTAPP n+ relay accompanied by an RTMU monitor (Tap position indication, Voltage monitoring, Runaway prevention, VT fuse monitoring, Auto/Non-auto control switches) and control relay (Fundamentals product) to form a complete AVC (automatic voltage control) system.

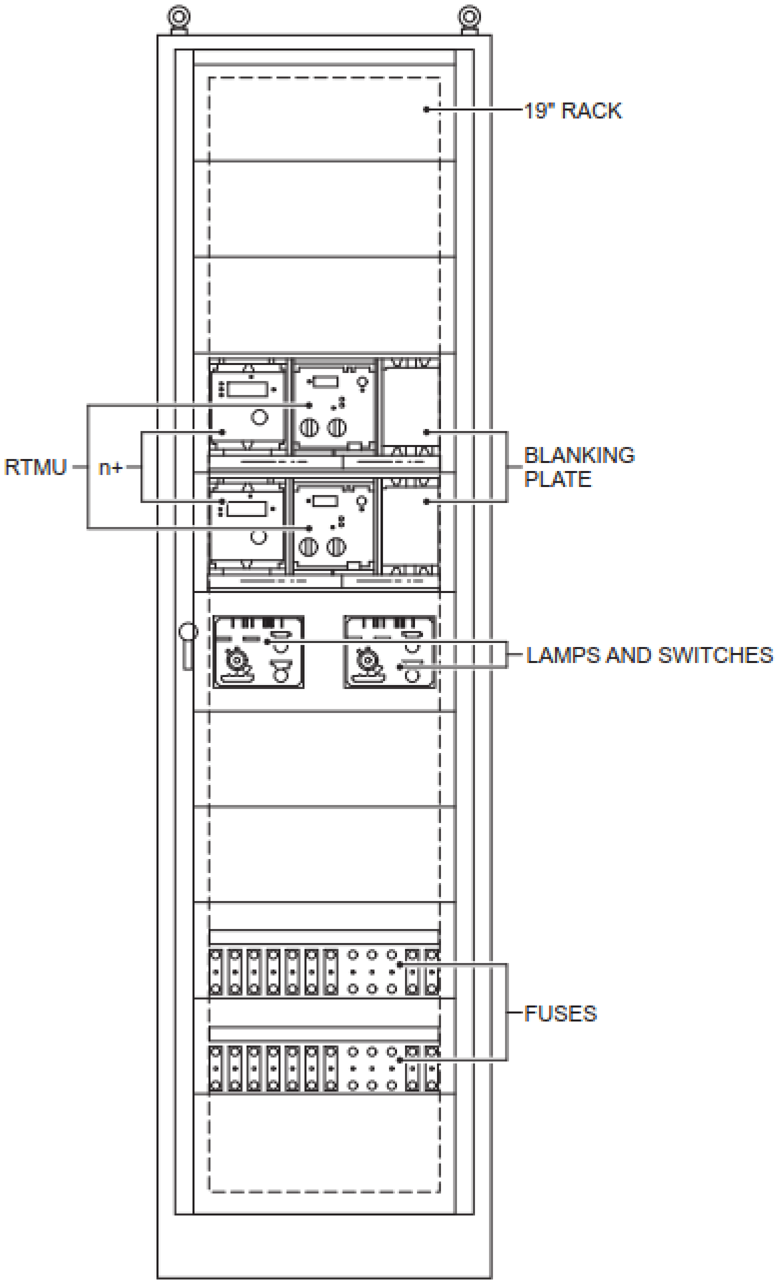
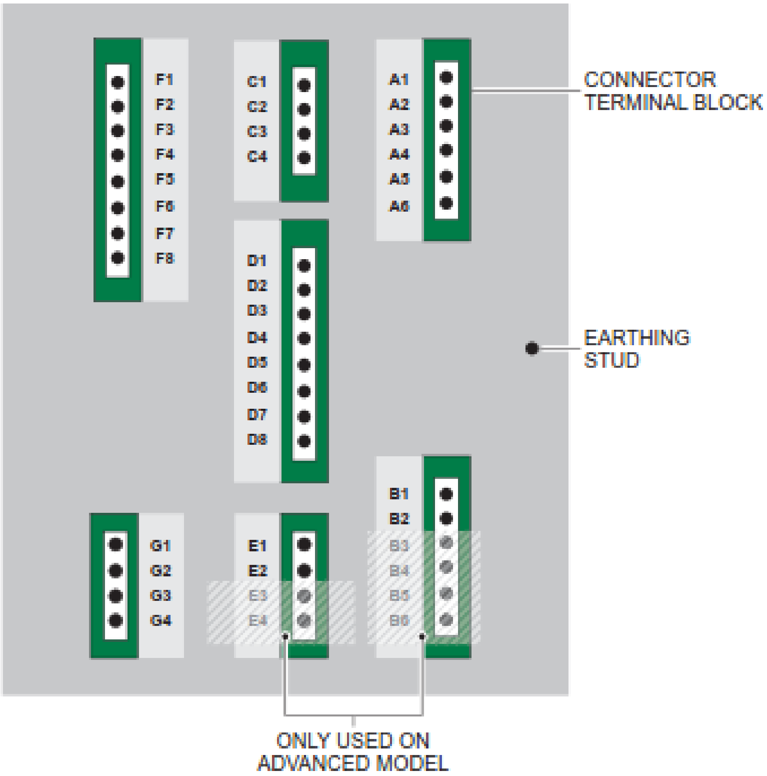


Figure 4-11: Fundamentals SuperTAPP n+ Typical Panel Mounting

4.4.7 Relay Input and Output Capability

- The SuperTAPP n+ relay has 2 VT inputs and 3 CT inputs available for use. The basic model has one VT and one CT activated. The advanced model has all inputs activated for use.
- SuperTAPP n+ relay Input/Output Capability is shown in Fig.10 with Typical connections shown in Fig.11



Terminal Reference	Description
A1 – A6	Power Supply
B1 – B6	Current Measurement Inputs
C1- C4	Lower Tap/Common/Common/Raise Tap
D1 – D6	Relay Healthy/Relay Fail/AVC Alarm/Control (Non-Auto)/Control Automatic
E1 – E4	Voltage Measurement Inputs
F1 – F8	Voltage Adjustment 1,2,3 / Remote, Local/Auto, Non-Auto/Alternative Settings/Common

Figure 4-12: Fundamentals SuperTAPP n+ Relay Input/Output Capability

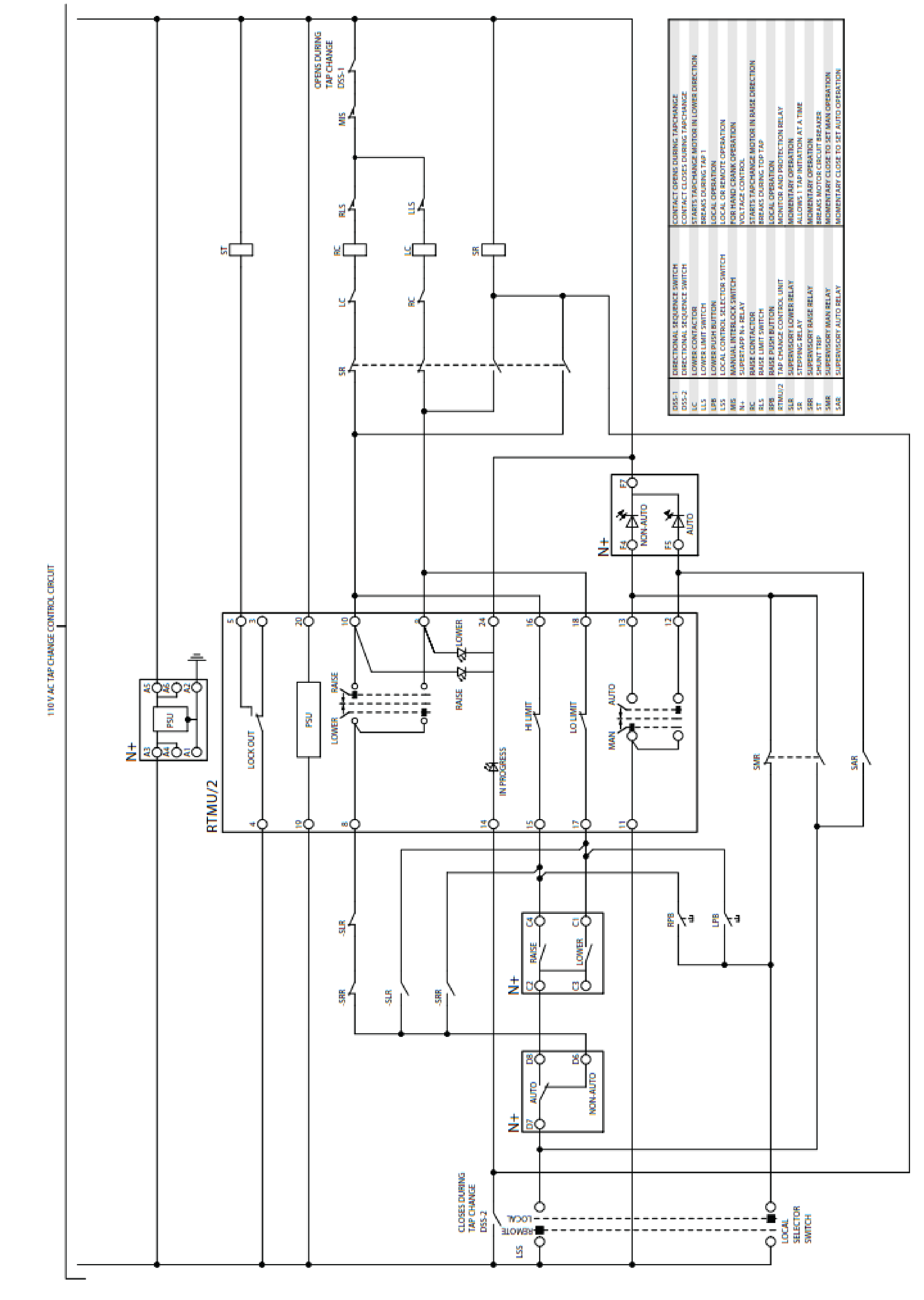


Figure 4-13: Fundamentals SuperTAPP n+ Circuit Diagram

4.4.8 Relay Capability to communicate with existing AVC relays at Site

- SuperTAPP n+ relay can accommodate parallel operation of up to six units using the peer-to-peer communications bus system (CAN bus). Units operating together on the CAN bus should have the same software version to ensure compatibility.
- Each relay on the CAN bus reports measurement and status information which is received by all relays on the bus. Each relay has a transformer ID and a group ID which are configured in the settings.
- The SuperTAPP n+ relays can communicate with other SuperTAPP n+ relays to operate transformers in parallel. However, communication with alternative AVC relays at site is not viable.

4.4.9 Relay Installation at Site

The SuperTAPP n+ relay (And the RTMU Unit Dimensions) dimensions do not allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01 or Alstom KVGC202 relay on the existing substation relay panels without modifying the existing panel aperture.

4.4.10 Conclusion

- The SuperTAPP n+ relay has the capability to accept target voltage values and alternative setting groups through its CAN bus communications interface and has been utilised previously on the WPD system using DNP3 WPD SCADA control as part of the dynamic voltage control project.
- The SuperTAPP n+ has facilities to facilitate problems associated with embedded generation and reverse power flow on a network with functions available utilising feeder current measurements.
- The SuperTAPP n+ relay dimensions combined with the RTMU unit do not allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01 or Alstom KVGC202 relay on existing substations.
- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR’s. The SuperTAPP n+ does not have the ability to provide tap stagger functionality.
- The SuperTAPP n+ **advanced** model contains the embedded generation functionality.

4.5 Siemens MicroTAPP Relay

4.5.1 Functionality

The Siemens MicroTAPP relay has the following functionality.

- Two methods of control are provided by the MicroTAPP relay
  1. The TAPP system which uses an enhanced negative reactive circulating current principle.
  2. Detection of circulating current between transformers connected to the same busbar but not through a network.

- The MicroTAPP control algorithm calculates the magnitude of the circulating current which is the vector difference between load, IT1load, and the individual transformer current and determines the target voltage bias value according to the following rules: -
  i. If reactive current flows OUT a bias equivalent to the change in voltage is added to the measured voltage
  ii. If reactive current flows IN a bias equivalent to the change in voltage is deducted from the measured voltage

  It is not possible for this method of circulating current control to be used when networks are operated in parallel as the summed load at that site can also contain reactive current flowing between remote transformers.
- A modification of the circulating current principle is used to overcome the limitations of the circulating current system described above and allow operation of transformers in any configuration, in parallel at a site, or across a network. A network Power Factor setting is used to calculate the magnitude of circulating current as the vector difference between IT1 (and IT2) and the transformer target load line at the target power factor. Unlike the previously described circulating current method, the TAPP system does not require load information from other transformers in order to minimise reactive current.
- The MicroTAPP can be configured for use with a Master/Follower tap change control scheme; however this arrangement is complex and imposes severe limitations on network operation. It is not recommended.
- Up to 16 transformers operating in parallel can be controlled as a group.
- Load Drop Compensation – The MicroTAPP includes a 'Load Drop Compensation' facility which is be used to offset the effect of load related voltage drops. Unlike normal controls that respond to transformer load only, the MicroTAPP uses a communication system for the transfer of load information to other relays, thus allowing each relay to determine the summed site load (I load). Regardless of the number of transformers in service at any time the LDC effect will be accurate, unlike those systems where the transformer load and thus the LDC effect changes as the number of transformers in a group changes.
- The advanced MicroTAPP relay (MT1-102) is available for applications where MW and MVar power flow is more dynamic, for instance when applied to Generator step up Transformers or at embedded generation sites. The voltage control point can be switched between HV and LV depending upon the running arrangement of the plant. This is done by switching relay setting groups from the plant status fed to the relay via hardwired inputs or via the communication network.
- The MicroTAPP relay has tap stagger functionality to allow the import or export of reactive power. However, to gain enough reactive power the tap changers have to be adjusted 6 taps apart. MicroTAPP tap stagger functionality is not good enough to achieve the required reactive power import requirements (*Ref: Electricity North West Customer Load Active System Services Second Tier LCN Fund Project Closedown Report - 30 September 2015.)*

4.5.2 Ability to Receive Target Set Points and Select Different Setting Groups

- Settings applicable to a particular site can be applied to the relay either locally from the relay display, a PC via the relay fascia serial port, or remotely over a communications link via the rear mounted fibre optic connections.
- 8 groups of settings can be stored by the relay with three auxiliary target settings available. When the relay is energised, it will operate with the settings group that was last applied.
- The MicroTAPP **does not** support new target voltage settings through external communications interface. The MicroTAPP target voltage settings can only be adjusted via pre-set fixed values at the relay.
- Siemens MicroTAPP settings are shown in Table.6

Table 4-5: Siemens MicroTAPP Settings

Setting	Adjustment Range	Step
Target Voltage (% of nominal voltage)	85 to 115% (Nominal 100%)	0.1%
Voltage Band (% of nominal voltage)	0.5 to 10.0%	0.1%
Auxiliary Target 1 (% of nominal voltage)	55 to 115%	0.1%
Auxiliary Target 2 (% of nominal voltage)	55 to 115%	0.1%
Auxiliary Target 3 (% of nominal voltage)	55 to 115%	0.1%

4.5.3 Ability to Support Communication Protocol Compatible with WPD

- The MicroTAPP relay has provision for communication either locally to a computer or remotely to the operations centre. IEC60870-5-103 is utilised by the relay for the transfer of data.
- The Communication Interface incorporates the following ports:
  i. A pair of fibre optic ST connectors for transmit and receive communications to a substation SCADA or integrated control system (Com 1).
  ii. A pair of fibre optic ST connectors for access by protection engineers (Com 2).

4.5.4 Allow National Grid Demand Reduction of 3% and 6%

The MicroTAPP relay allows the National Grid enforced demand reduction of 3% and 6%.

4.5.5 Hard Voltage Limit Capability

The MicroTAPP scheme has settable high and low limits voltage to prevent the scheme from tapping outside of the prescribed limits.

4.5.6 Relay Details (Pictures, Panel, Wiring Details)

The relay is contained within a standard Epsilon case of 4U (177mm) in height and E8 (208mm) or E12 (312mm) in width. The case size selected depends upon the input/output requirements of the scheme connections (Fig.12).

MicroTAPP Rear View (E8 case)

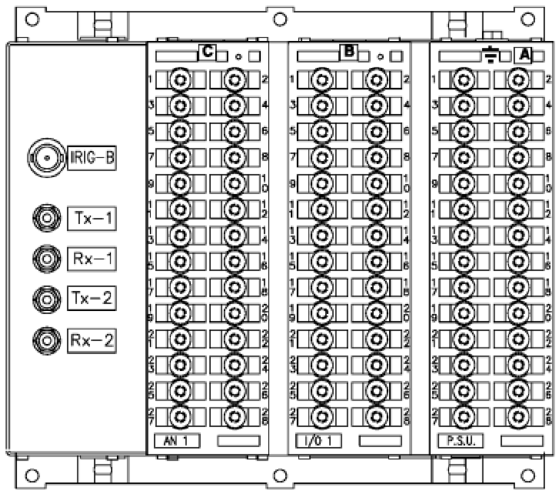


Figure 4-14: Siemens MicroTAPP Relay (E8 Case)

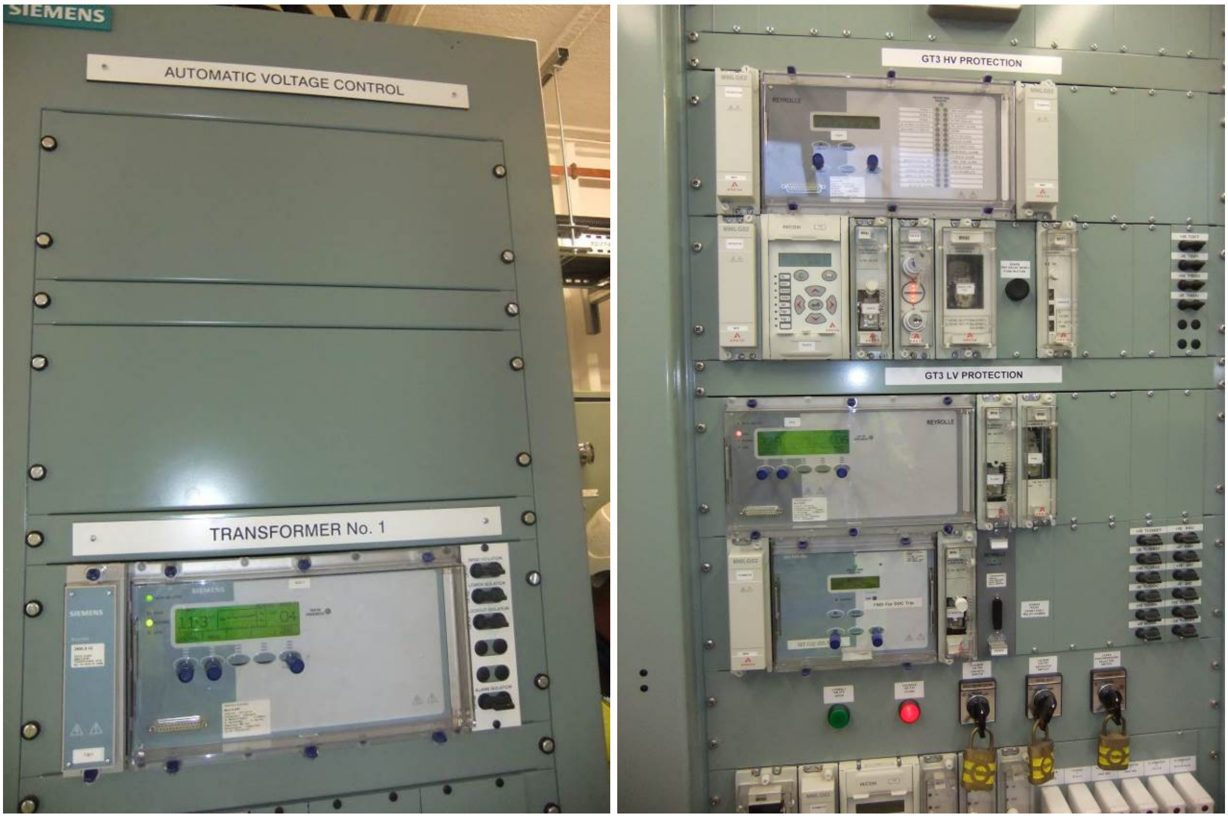


Figure 4-15: MicroTAPP Relay (E12) Typical Panel Mounting

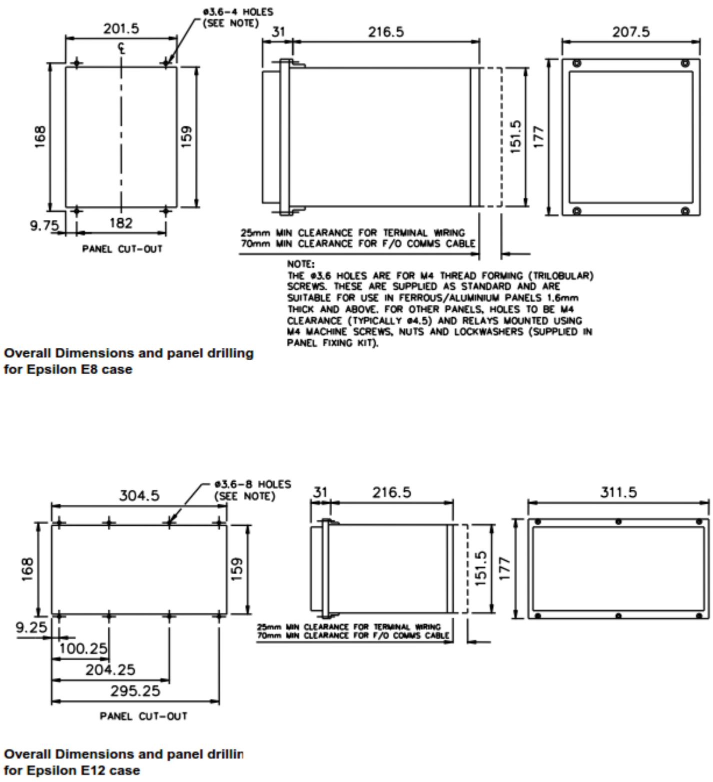


Figure 4-16: Siemens MicroTAPP Relay Dimensions (E8 and E12 Case)

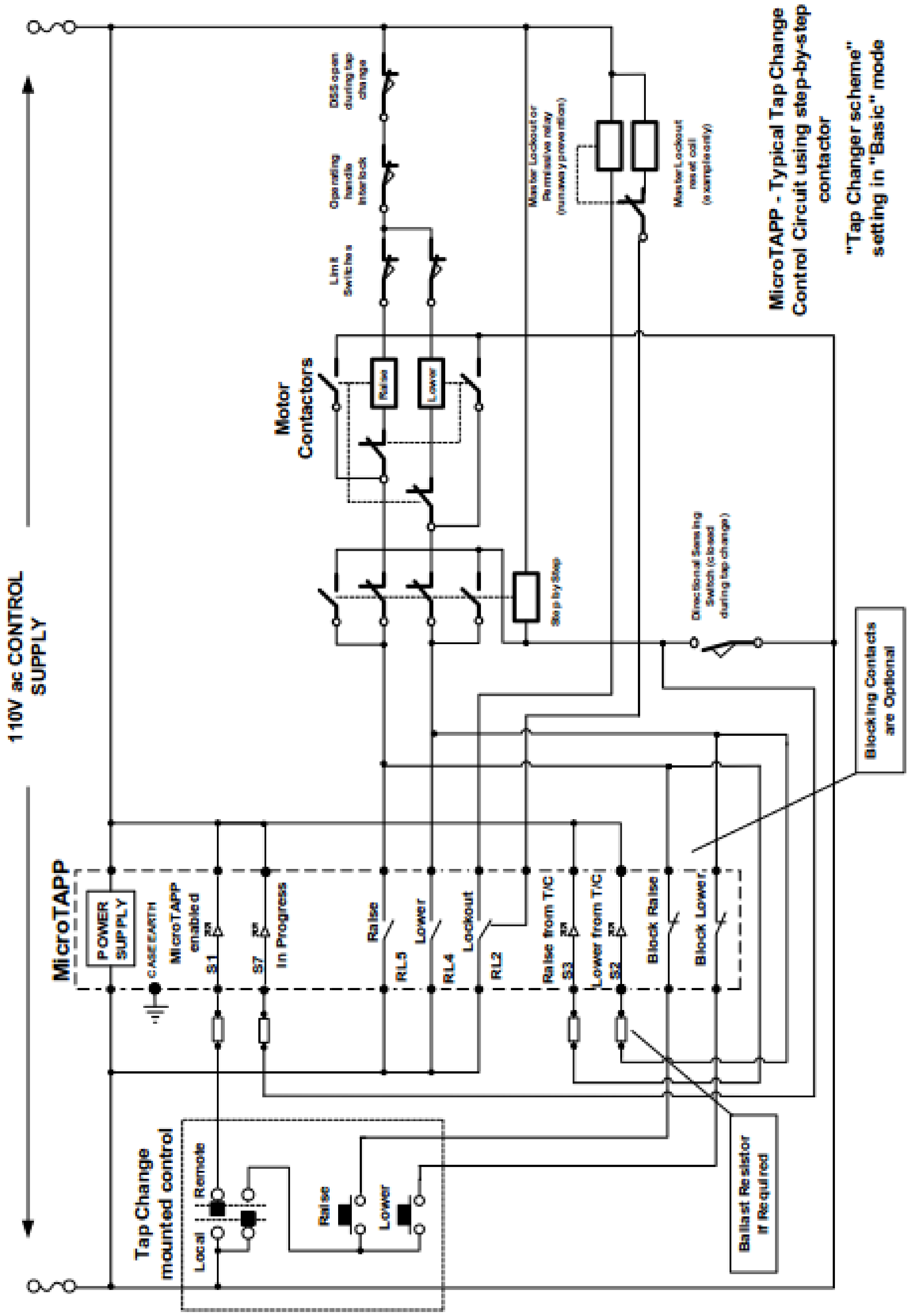


Figure 4-17: Siemens MicroTAPP Typical Connections Diagram

4.5.7 Relay Input and Output Capability

- 11 status inputs are available and 5 binary output are available which are user programmable
- Inputs to the relay and outputs for indications and control are user programmable
- Other inputs include the digital tap position indicator and the resistor tap position indicator.

4.5.8 Relay Capability to communicate with existing AVC relays at Site

- At a site each MicroTAPP can connect to another MicroTAPP relays through a screened twisted pair cable. The MicroTAPP Peer to Peer Communication system (MPPC) is used to transfer data between the relays relating to the overall operation of the MicroTAPP group at a site.
- The MicroTAPP cannot communicate to other manufacturers relays currently installed in WPD substations.

4.5.9 Conclusion

- The MicroTAPP does not support new target voltage settings through external communications interface. However, the MicroTAPP target voltage settings can be adjusted via pre-set fixed values.
- IEC60870-5-103 is utilised by the relay for the transfer of data rather than DNP3 protocol as per WPD requirements for the SVO project.
- The MicroTAPP is being discontinued by Siemens and replaced with the MR TAPCON relay.
- A cost effective method of modifying the existing MicroTAPP AVC scheme to allow utilisation as part of the SVO project is to utilise interposing relays to modify the MicroTAPP group settings. This modification is detailed in a separate report with proposed typical circuit diagrams provided.
- The MicroTAPP relay has tap stagger functionality to allow the import or export of reactive power. However, to gain enough reactive power the tap changers have to be adjusted 6 taps apart. MicroTAPP tap stagger functionality is not good enough to achieve the required reactive power import requirements. (*Ref: Electricity North West Customer Load Active System Services Second Tier LCN Fund Project Closedown Report - 30 September 2015)*

5 New AVC Relays for the SVO Project

5.1 A-Eberle REG-D

5.1.1 Functionality

The A-Eberle REG-D relay has the following functionality.

- The Eberle REG-D relay offers several voltage control methods:
  i. Master-Slave - This operation is only suitable for transformers of the same nominal power, short-circuit voltage, number of tap-changes, tap-changing.
  ii. Master-Follower - If the transformers have a different tap-change position, the master will set all transformers which are in this parallel-switching to the master‘s tap-change position.
  iii. ΔI sinφ - Busbar parallel operation with a maximum of five transformers with equal nominal power and equal short-circuit voltage. The tap-changes may differ and the cos φ in the net may take any values requested
  iv. ΔI sinφ (S) - Transformers with different nominal power which feed in the net by a bus bar. The short-circuit voltages of the transformers should be as equal as possible because deviations may cause a different capacity utilisation of the transformers.
  v. Δ cosφ - Transformers which are feeding in one network independently from each other and for which there is no bus link between the assigned regulators.
- The REG-D also includes individual feeders into the AVC scheme providing a solution to cope with dynamic changes of the voltage at local level caused by renewable generation and with reverse power flow
- Some of the existing AVC manufacturers use direct circulating current method for measurement. However, renewable generation and increase of nonlinear loads on the grid cause cos ϕ values to fluctuate, thus making this method unreliable as a method of minimising circulating currents. The ATCC scheme based on REG-D provides the solution for changing cos ϕ using an adaptive Δcosϕ algorithm. Thus it can successfully work in an environment where cosϕ is changing (embedded generation). See Appendix A for further information.
- REG-D has the capability to deal with reverse power flow. In case the power flow changes direction, REG-D 'sends' the tap changer to a fixed position predetermined by the grid condition of the grid node the transformer has been connected to. This functionality allows the use of any other voltage controller(s) installed in the downstream network to work to its widest regulating range by setting the transformer tap changer into an appropriate position.
- The Generation Exclusion Module (GEM) of the relay consists of a single phase bidirectional active power transducer connected via current sensors to an existing feeder CT. GEMS are used on each predominantly generation feeder especially where full reversal of the power flow is expected on a given feeder. The amount and direction of active power measured from these feeders is then

used to modulate LDC (line drop compensation) to cater for changes in the bar / feeder voltage profile.

- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR's. The Eberle REG-D relay does have the ability to execute commands providing tap stagger functionality. Eberle REG-D can tap stagger to any number of taps apart.

5.1.2 Ability to Receive Target Set Points and Select Different Setting Groups

- New target voltage settings within active setting groups can be modified remotely using the communication link. Dead band settings can also be changed remotely.
- Apart from 3% and 6% reduction, the ATCC scheme based on Eberle REG-D relay has seven setting groups. Within each setting group, target set point voltages, dead bands and other setting within a group can also be adjusted to a desired level using remote commands.
- The change of each setting group can be performed remotely. Alternatively, active setting groups can be selected from the REG-D front panel graphic user interface and via any of the available binary inputs.

5.1.3 Ability to Support Communication Protocol Compatible with WPD

The change of each setting group or alternative target voltage setting can be carried out remotely using a SCADA/DMS/EMS communication link which utilises one of the industry established communication protocols such as IEC101/IEC103/IEC104, **DNP3**, IEC61850, MODBUS RTU, TCP/IP.

5.1.4 Allow National Grid Demand Reduction of 3% and 6%

REG-D relay allows the National Grid enforced demand reduction of 3% and 6%. Voltage reduction commands can be sent through the remote communications interface.

5.1.5 Hard Voltage Limit Capability

Voltage limit settings can be fixed but can also be programmable. There are several voltage limit settings, each of them programmable either in relative or in absolute values (Fig.16)

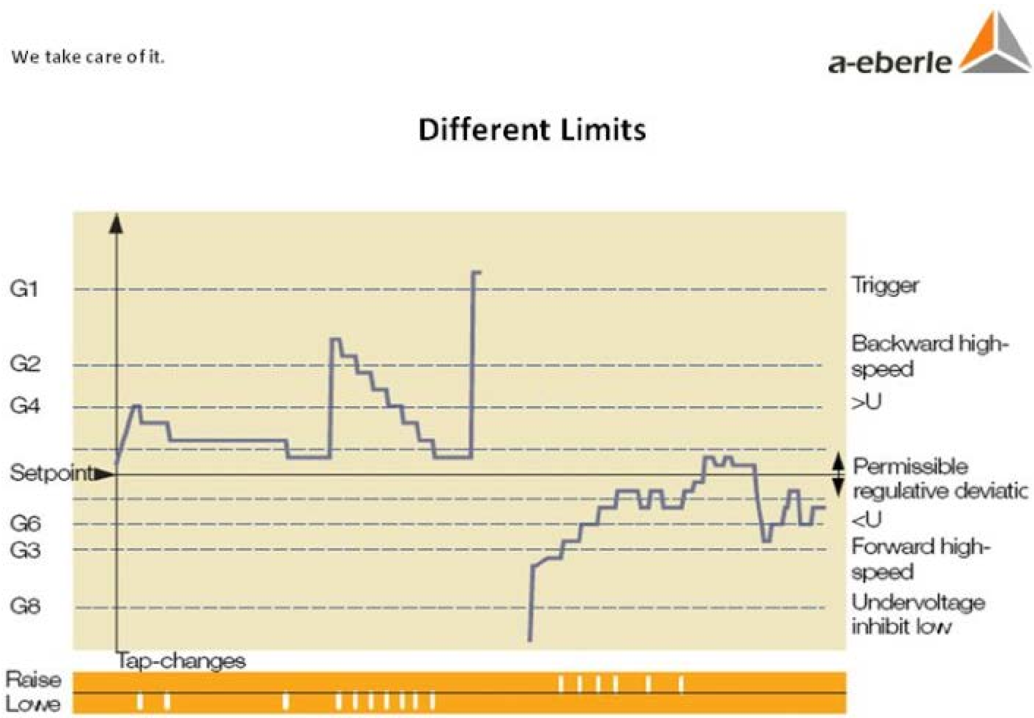


Figure 5-1: A-Eberle REG-D Hard Voltage Limit Capability

The Eberle REG-D relay is configured such that target voltage settings issued via SCADA will be rejected if the voltage change falls outside of the voltage limit settings.

5.1.6 Relay Details (Pictures, Panel, Wiring Details)

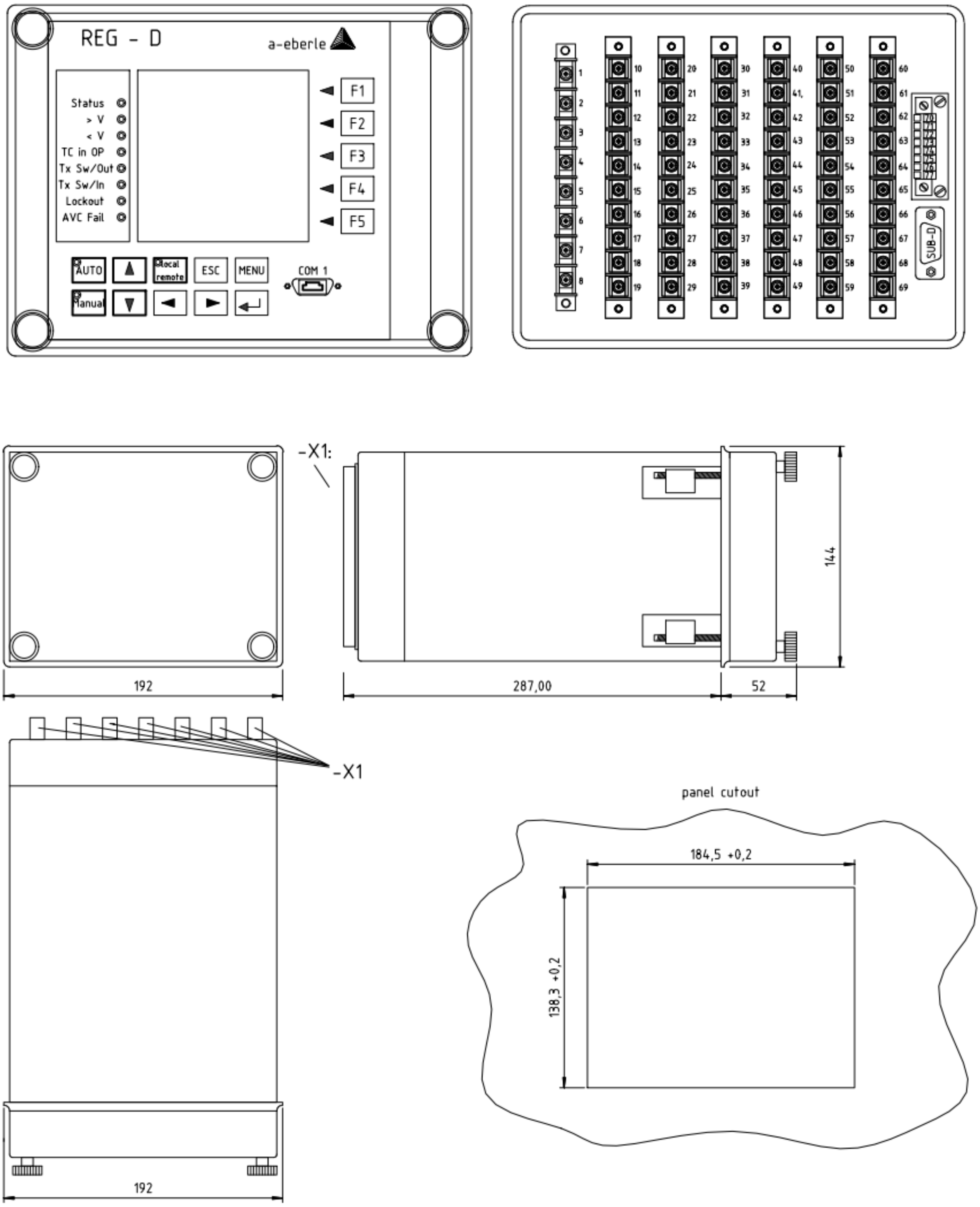


Figure 5-2: A-Eberle REG-D Relay Dimensions and GA

5.1.7 Relay Input and Output Capability

- Two independent CT and VT inputs are available for a single phase current / active/reactive/apparent power measurement and two CT and VT inputs are always used for three winding transformers whilst one current and one voltage input is used for two winding transformers.
- 16 Digital Inputs are available by an additional module BIN-D (8 or 16 DI per module subject to case space/terminals available). A further three slots are available for any combination of any of the three modules to be used for tap position indication etc.
- 2 x DC mA inputs are available and one Pt100 probe connection when transformer monitoring is activated. The Two DC mA inputs provided are used to cater for feeder active power measurement (bidirectional -20...0...20 mA DC) using external single phase active power transducer and current sensors to cater for renewable generation influence on the bar/feeder voltage profile. Where an extended number of feeders is required on the scheme the number of DC mA inputs can be extended by an additional module ANA-D (8 DC mA inputs per module).
- 17 binary outputs are available expandable by an additional BIN-D module (8 or 16 DO per module subject to case space/terminals available). Some of the binary outputs are factory configured whilst some are freely programmable. One or all of the three slots available for any combination of any of the three modules.
- One slot can be utilised for 2 x DC mA outputs where remote hard wired indication of tap position is required or any other remote indication using DC mA hard wired connection to an existing RTU/IED.

5.1.8 Relay Capability to communicate with existing AVC relays at Site

The majority of AVC relays in the market utilise proprietary methods to communicate between AVC relays at site. Harmonisation of the Eberle REG-D relay with other manufacturer’s existing relays at WPD sites is not viable.

5.1.9 Relay Installation at Site

- The Eberle REG-D relay dimensions allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01 but the Eberle REG-D relay cannot be used as a replacement for the Alstom KVGC202 relay on existing WPD substations as part of the SVO project without modifying the panel apeture due to the REG-D relay dimensions.
- Where commissioning or assistance during the commissioning is required, remote assistance can be performed. An air gap technique (limited by time and physical connectivity) is used by Eberle for secure access to the substation. Subsequently no installation software is required on the commissioning engineers PC. However, the air gap technique is to be utilised during commissioning only and **must** be disconnected following energisation.

3.5 Panel-mounting housing, type 30 TE

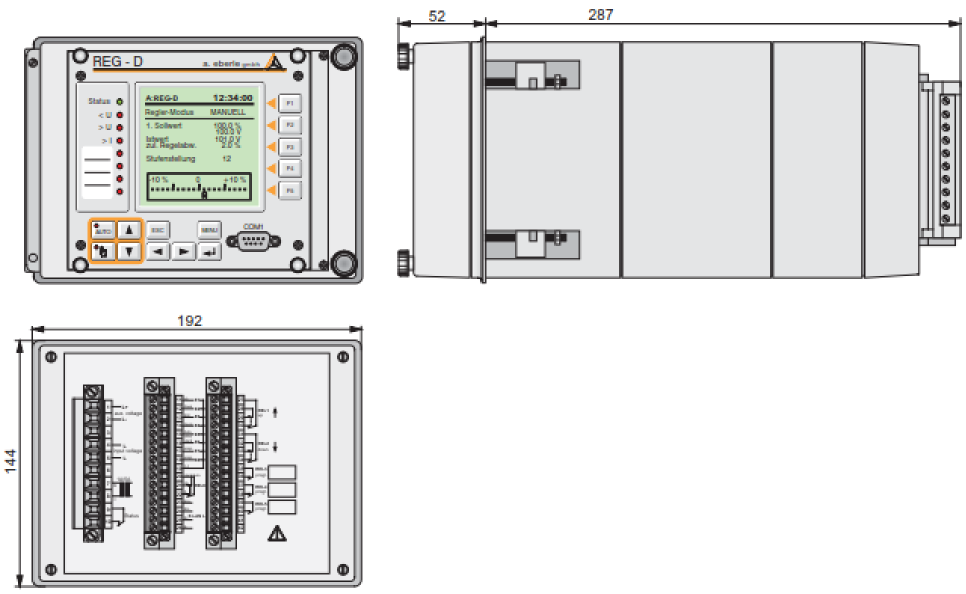


Figure 5-3: A-Eberle REG-D Panel Mounting Dimensions

5.1.10 Conclusion

- The Eberle REG-D relay has the capability to accept target voltage values and alternative setting groups through a communication interface.
- ATCC scheme based on REG-D provides the solution for changing cos ϕ using an adaptive Δcosϕ algorithm. Thus it can successfully work in the environment (embedded generation) where cosϕ is changing
- Eberle REG-D relay is utilised extensively by Scottish and Southern Energy and Scottish Power for automatic voltage control on their respective networks.
- The Eberle REG-D relay dimensions allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01 but the relay cannot be used as a replacement for the Alstom KVGC202 relay on existing WPD substations as part of the SVO scheme due to REG-D relay dimensions.
- Eberle REG-D can do tap stagger to any number of tap apart.
- Product/commissioning support in provided from outside the UK.
- The Erbele REG-D relay is technically suitable for utilisation as part of the Network Equilibrium Project.
- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR's. The Eberle REG-D relay does have the ability to execute commands providing tap stagger functionality. Eberle REG-D can tap stagger to any number of taps apart

5.2 Maschinenfabrik Reinhausen (MR) TAPCON ISM

5.2.1 Functionality

The MR TAPCON relay has the following functionality.

- The TAPCON ISM (Integrated Smart Module) relay is of modular configuration and can operate in four modes:
  - i. Auto mode (AVR AUTO) - In auto mode, the device automatically regulates the voltage in accordance with the set parameters. Manual tap-change operations using operating controls, inputs or a control system are not possible.
  - ii. Manual mode (AVR MANUAL) - In manual mode, the user can perform manual tap-change operations to increase or decrease the voltage. The voltage is not regulated automatically.
  - iii. Local mode (LOCAL) - In the Local operating mode, the user can make entries and input commands using the device's operating controls. The user cannot use inputs or the control system to make entries or enter commands.
  - iv. Remote mode (REMOTE) - In the Remote operating mode, the user can make entries and carry out commands using digital inputs or the control system, depending on remote access.
- Parallel operation of up to 16 transformers in 2 groups is possible using the following methods:
  - i. Parallel operation following the "Circulating reactive current minimisation" principle. The circulating reactive current is calculated from the transformer currents and their phase angles. A voltage proportional to the circulating reactive current is added to the independently regulating TAPCON relay as a correction for the measurement voltage
  - ii. Parallel operation following the "Tap synchronisation" (master/follower) principle. With the Tap synchronisation parallel operation method, the user needs to designate one voltage regulator as the master and all others as followers. The master handles voltage regulation and transmits its latest tap positions to all followers via a CAN bus. The followers compare the tap position received with their own tap position,
  - iii. Negative Reactance principle is also available without CAN bus connection
- The TAPCON ISM relay can be supplied with a Dynamic Set point Control (TDSC) function used to adapt the desired voltage value depending on the measured active power. This function allows the relay to compensate for a voltage drop during increased load or an increase in voltage due to a decentralised feed as encountered with embedded generation. Depending on whether positive or negative active power is measured, the desired value calculation is based on 2 linear equations.

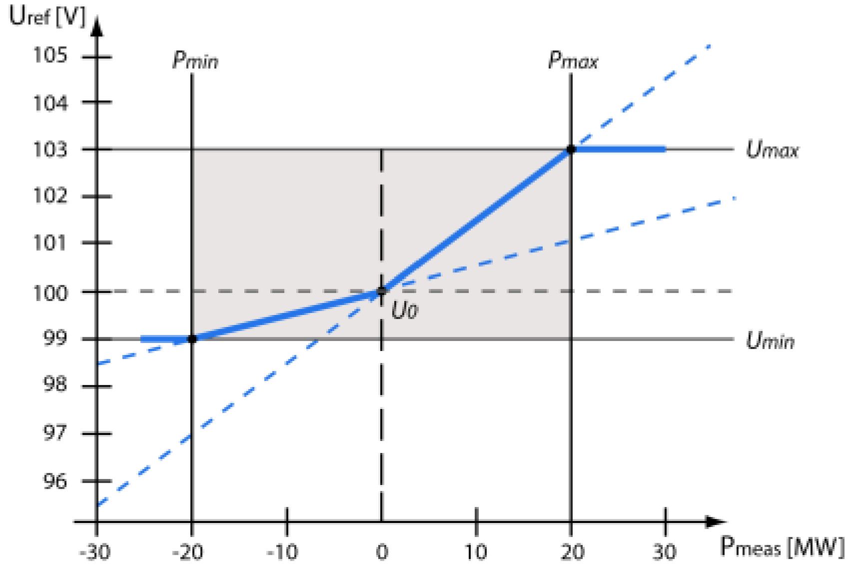


Figure 5-4: Active Power Dependent Adjustment of Desired Voltage Value

- Figure 5-4 shows:
  i. If the measured active power Pmeas exceeds the set parameter Pmax, the value Umax is adopted as the desired value.
  ii. If the measured active power Pmeas falls below the set parameter Pmin, the value Umin is adopted as the desired value.
- Dynamic set point control can be chosen with one of three different sets of parameters.
- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR's. The TAPCON ISM relay does not have the ability to provide tap stagger functionality but MR are currently investigating the possibility of providing such functionality in future firmware.
- A line drop compensation facility is provided. The device provides 2 methods of compensation for this purpose:
  i. R and X compensation which required precise line data. The TAPCON calculates ohmic and inductive voltage drop.
  ii. Z compensation to activate a current dependent increase in voltage.

5.2.2 Ability to Receive Target Set Points and Select Different Setting Groups

- The following settings can be defined remotely using the communication link.

Table 5-1: TAPCON ISM Relay Settings

U_{ref}	Desired value	U_{min}	Minimum desired value
P_{meas}	Measured active power	U_{max}	Maximum desired value
P_{min}	Active power at minimum desired value	U_0	Set desired value when measured active power = 0
P_{max}	Active power at maximum desired value		

- 3 alternative setting groups can be set locally and subsequently can then be altered remotely to select each group.
- Following selection of a setting group, a target voltage setting can then be adjusted remotely.

5.2.3 Ability to Support Communication Protocol Compatible with WPD

TAPCON ISM can operate remotely via **DNP3**, MODBUS ASCII, MODBUS RTU, IEC 60870-5-101, IEC 60870-5-103 and IEC61850.

5.2.4 Allow National Grid Demand Reduction of 3% and 6%

The TAPCON relay allows the National Grid enforced demand reduction of 3% and 6%. Voltage reduction commands can be sent through the remote communications interface.

5.2.5 Hard Voltage Limit Capability

The TAPCON ISM relay has a parameter allowing the user to define how the device behaves when a limit value is infringed. The options available may vary depending on the limit value. The following options are available in Table 5-2.

Table 5-2: TAPCON ISM Relay Limit Options

Option	Description
Off	The limit value is not monitored.
High-speed re-turn	The device continues to perform tap-change opera-tions in the required direction until the limit value is no longer infringed. The devices ignores the set delay time T1 of automatic voltage regulation.
Auto blocking	The device blocks automatic voltage regulation.
Auto-manual blocking	The device blocks automatic voltage regulation and manual tap-change operations.
Auto blocking for lower step	The device blocks tap-change operations to a lower tap position.
Auto blocking for raise step	The device blocks tap-change operations to a higher tap position.
Auto-manual blocking for low-er step	The device blocks automatic voltage regulation and manual tap-change operations to a lower tap position.
Auto-manual blocking for raise step	The device blocks automatic voltage regulation and manual tap-change operations to a higher tap position.
Switch to Man-ual	The devices switches to manual mode.

5.2.6 Relay Details (Pictures, Panel, Wiring Details)

- The device is designed as 19 inch slide-in housing with modular configuration and multiple modular connection via CAN bus.
- The relay is provided with a measurement modules, CPU and I/O Modules.
- The relay dimensions are 483W x 133H x 178D as shown in Figure 5-5.

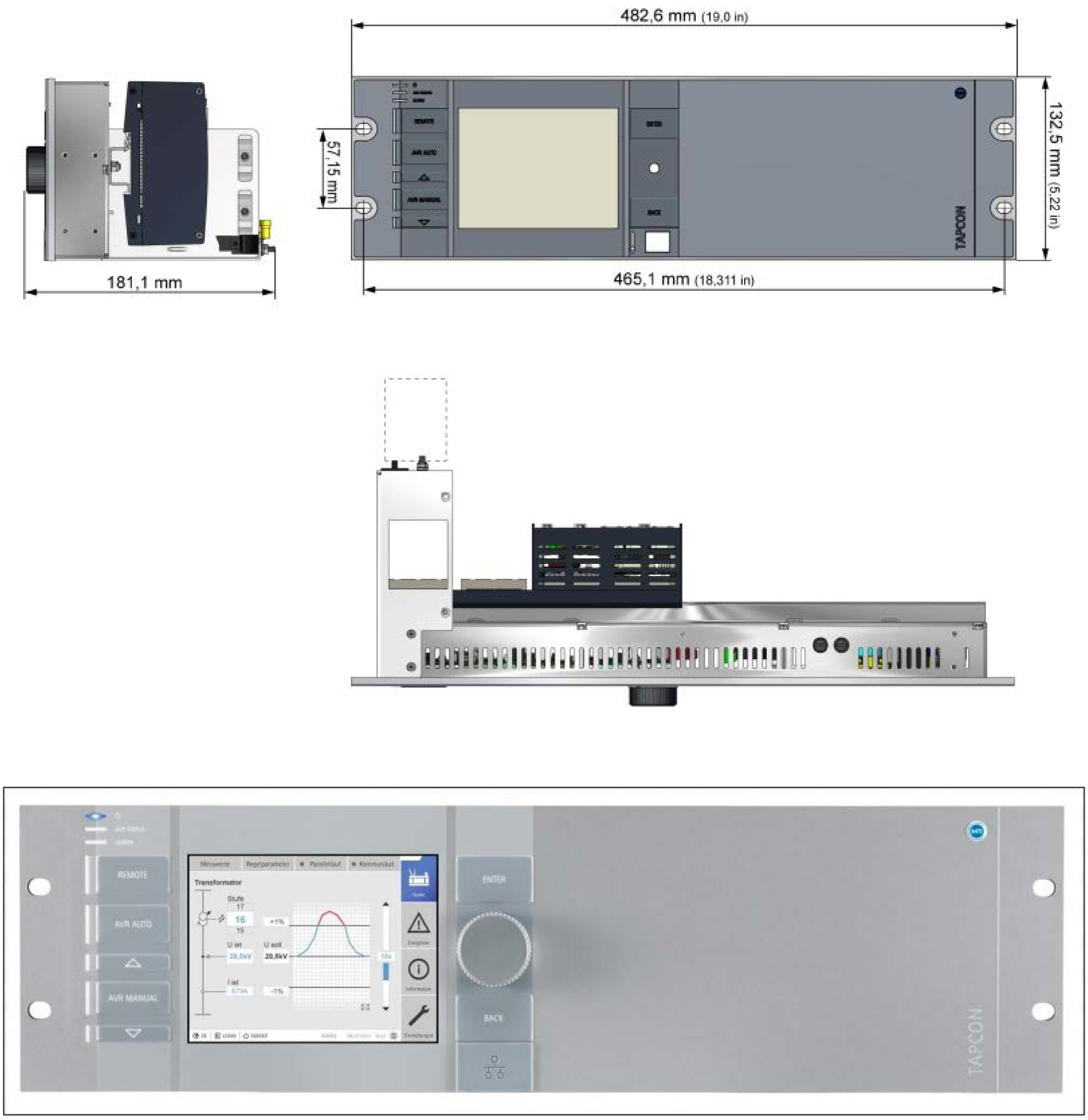


Figure 5-5: Dimensions for TAPCON ISM Relay

Figure 5-6: TAPCON Typical Panel Mounting

5.2.7 Relay Input and Output Capability

- The TAPCON ISM relay is supplied with two units for measuring current and voltage. The UI1 assembly is utilised for single-phase measurement of voltage and current. The UI 3 assembly is used for 3-phase measurement of voltage and current.
- The TAPCON ISM relay can be supplied with various numbers of digital inputs and outputs depending on the version ordered:
    i. DIO 28-15: 28 inputs, 15 outputs (6 normally open contacts, 9 changeover contacts)
    ii. DIO 42-20: 42 inputs, 20 outputs (8 normally open contacts, 12 changeover contacts)

- TAPCON ISM Relay assemblies provide analog inputs and outputs with 2 channels and four channels respectively.

5.2.8 Relay Capability to communicate with existing AVC relays at Site

The majority of AVC relays available in the market utilise proprietary methods to communicate between AVC relays at site. Harmonisation of the TAPCON ISM relay via CAN bus with other manufacturer existing relays at WPD sites is not viable.

5.2.9 Relay Installation at Site

The TAPCON ISM relay dimensions (Full 19" Rack) does not allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01, Alstom KVGC202 relay or the MicroTapp relay on existing WPD substations as part of the SVO project. Product/commissioning support is provided by Siemens Monkton Office in the UK.

5.2.10 Conclusion

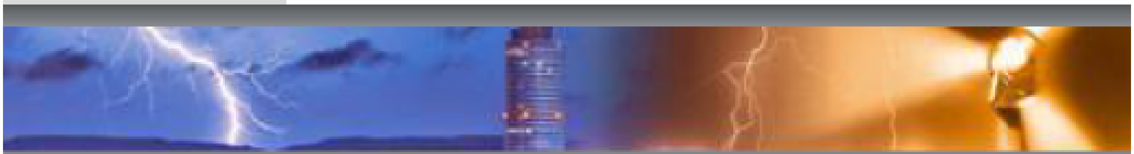
- Northern Powergrid has purchased two TAPCON relays for trial on the NPG network and have experienced the following issues during utilisation.
    i. The configuration files are not transferrable like normal relays. However, the relay settings are relatively simple so this should not be an issue.
    ii. DNP communication has proved to be an issue when communicating with the RTU, however this issue is currently being resolved
    iii. A separate transducer is required for tap position indication but this should not cause any issues.
- Product/Commissioning support is provided by Siemens UK Monkton office.
- Tap Raise/Tap Lower is software driven via the relay. Subsequently if relay power is lost, it is not possible to manual tap outside of the relay. (MR TAPCON are currently investigating this issue and are to propose a solution to WPD)
- The TAPCON ISM relay dimensions does not allow the relay to be utilised as a direct replacement for the GEC/Alstom MVGC01, Alstom KVGC202 relay or Mircotapp relay on existing WPD substations as part of the SVO project due to the relay dimensions without modifying the panel aperture.
- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR's. The TAPCON ISM relay **does not** have the ability to provide tap stagger functionality but MR are currently investigating the possibility of providing such functionality.

5.3 Fundamentals SuperTAPP Ultimate SG

5.3.1 Conclusion

- The SuperTAPP Ultimate SG relay is the successor the to the SuperTAPP n+ relays with DAM units and Envoy units configured into a single unit. The relay incorporates additional features to the SuperTAPP n+ relay including
  i. Integrated manual controls
  ii. Load/line Drop Compensation
  iii. Paralleling multiple transformers through:
  iv. Transformer Advanced Paralleling Principle
  v. Negative Reactance
  vi. True Circulating Current (Master-follower can also be handled)
  vii. Tap-changer monitoring and runaway prevention
  viii. Additional I/O and mA loop options
  ix. Autonomous algorithms for frequency and load-based voltage adjustments
  x. Tap stagger
  xi. Smart Grid logic processing
- The SuperTAPP SG relay will not communicate with the Super TAPP n+ relay
- The relay is currently still under development and is not currently approved for utilisation on the WPD network. Fundamentals are currently reluctant to provide any information or technical manuals.
- WPD are being asked by National Grid to tap stagger when National Grid volts are high and there is a lack of reactive power on the network to import VAR’s. The SuperTAPP SG **(Ultimate)** does have the ability to provide the required tap stagger functionality.

6 Appendix A: REG-D Adaptive Δcosϕ Scheme



Description of the

Adaptive Δcos(φ) Scheme

of the

REG-D™ and REG-DA

Issue 11.09.2015

GB

1. Scope of use

The automatic tuning of the parameter "Net-cos(φ)" represents an extension to the Δcos (φ) parallel method implemented in the REG-D(A) devices. The description of the Δcos (φ) parallel method can be found in the document etz_20_2000gb.pdf (Parallel Regulation of Transformers) that is available on the A. Eberle Homepage (www.a-eberle.de). Based on this adaption it is possible to run the Δcos (φ) method also in power grids with fluctuating cos (φ). This is happening without tolerating excessive circulating currents or an influence on the voltage level, as in the standard Δcos (φ) method when the Net-cos(φ) setting does not fit to the real cos(φ) of the power grid.

2. Function description of the adaptive method

The self-tuning of the Net-cos(φ) setting for the Δcos(φ) parallel scheme is based on the assumption that the cos(φ) of the grid changes slowly and in small steps.

If there is an immediate and large change in the cos(φ) this most likely indicates an tap operation of an parallel running transformer. If such a major change happens the calculated circulating current exceeds the permissible circulating current and the parallel program of the REG-D(A) starts to work automatically.

In this case the automatic tuning of the Net-cos(φ) stops and the parallel regulation scheme takes care that the voltage and the circulating current is driven back into their boundaries. If the system resumes its stability, which means that the voltage and circulating current are inside their defined bandwidths, the self-tuning scheme becomes active again.

When the self-tuning is active the Net-cos(φ) is modified to slowly adapt to the present

cos(φ) of the grid, as measured by the REG-D(A). The time constant for the adaption is 0.5h in the standard deployment, but this time constant can be modified and if necessary also provided as separate setting.

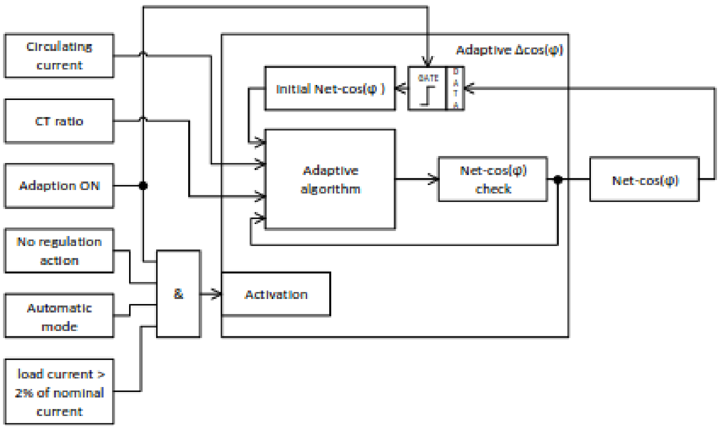
To prevent a drift between some transformers while using the adaptive method, there is an initial cos(φ) used within the algorithm, as a long term guiding value. The initial cos(φ) is automatically set at the activation of the adaptive mode.

Before the modified Net-cos(φ) is used for the parallel regulation there is a check implemented that the adapted phase angle φ is within the limit of -45 to 45 degrees. After this check the adapted value is used for the Net-cos(φ) parameter of the Δcos(φ) parallel program.

In general the adaptive algorithm becomes active if:

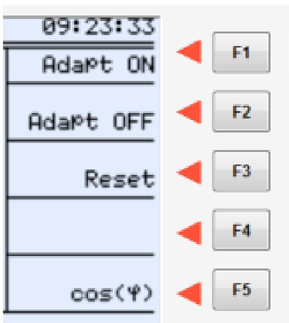
- the adaption is set ON in general (Parameter)
- the REG-D(A) is in automatic mode
- the present load current is more than 2% of the nominal current of the CT
- there is no regulation activity (voltage and circulating current is inside the boundaries).

2.1 Block diagram



2.2 Parameters, Controls and Indications

In addition to the standard Δcos(φ) program the adaptive version has the following parameters, controls and indicators.



F1: Self-tuning of the Net-cos (φ) on

F2: Self-tuning of the Net-cos (φ) off

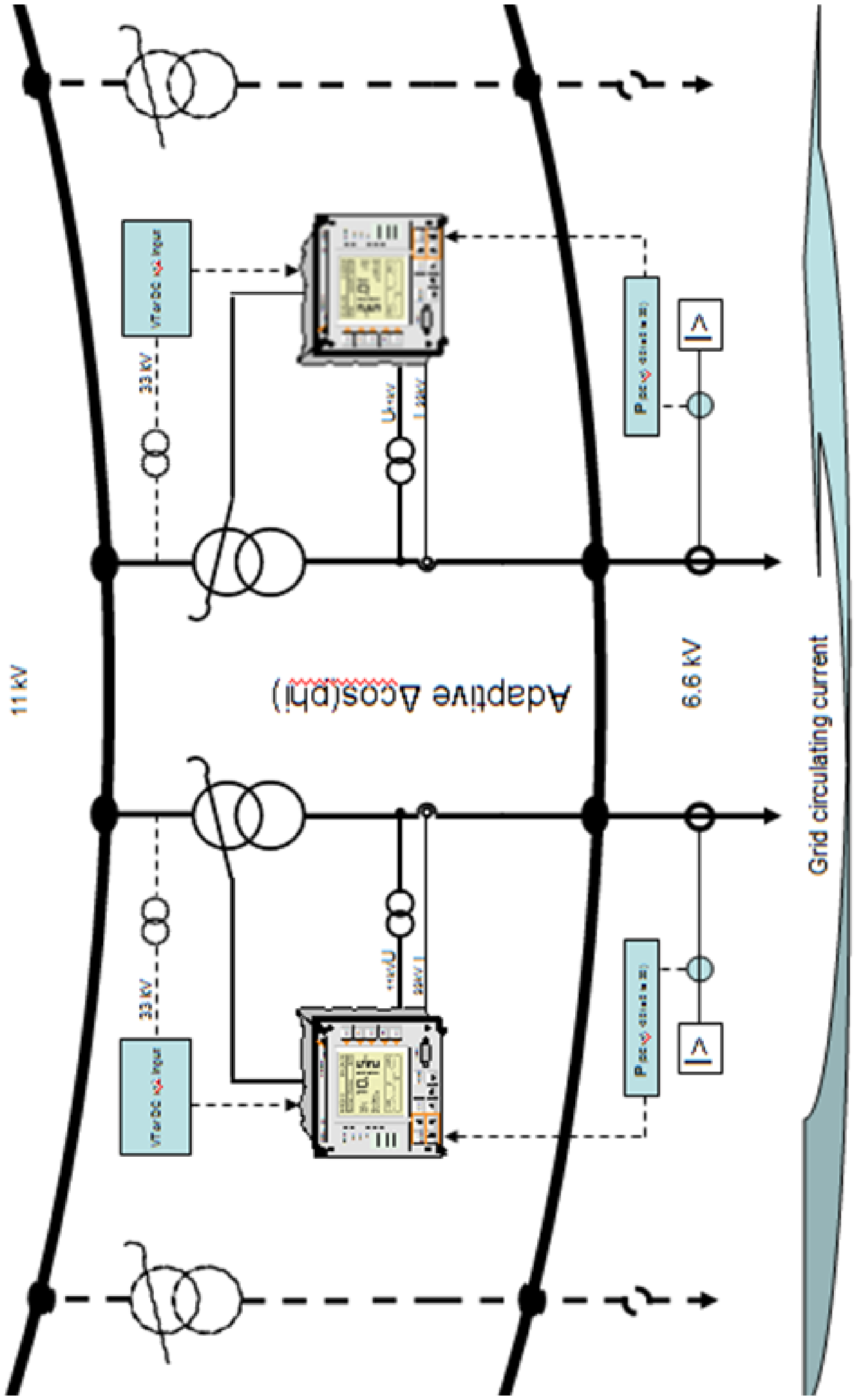
F3: Reset Net-cos (φ) to the initial value that was captured before the self-tuning became active

F5: Show self-tuned and initial Net-cos (φ)

The tuning of the network cos (φ) is only active if

- the tuning is set ON in general (Parameter)
- the REG-D(A) is in automatic mode
- the present load current is more than 2% of the nominal current of the CT
- there is no regulation activity (voltage and circulating current is inside the boundaries).

The activity of the adaption of the network cos (φ) is shown on a selectable LED, by default this is LED 1.

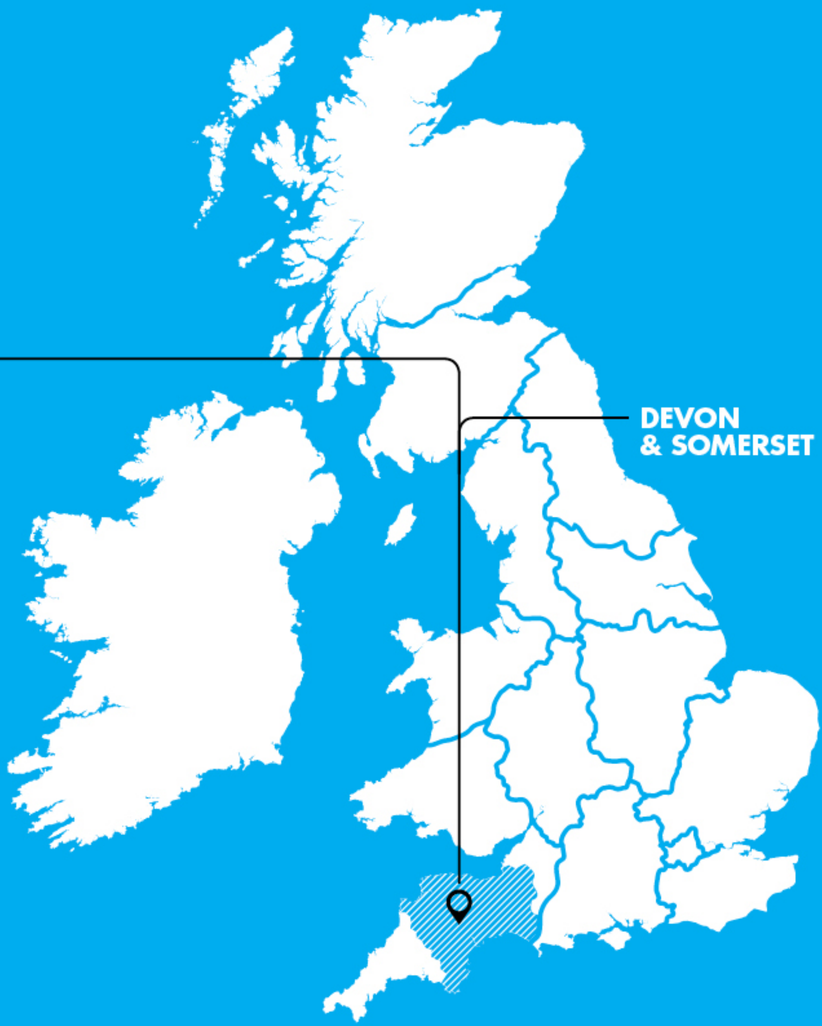

11 kV
33 kV
33 kV
Adaptive Δcos(phi)
6.6 kV
Grid circulating current

SDRC2 Appendix D - AVC Modification Options

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND



Project Network Equilibrium

AVC Modification and Outage Options

LCN Fund
Low Carbon Networks

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Contents

1 Panel Design A - Front Swing Frame, Fixed Rear Panel Design

Substation: Bowhays Cross, Street BSP, Taunton, Colley Lane, Dunkeswell, Lydeard St Lawrence, Marsh Green, Mill Field, Nether Stowey, Tiverton Moorhayes, WaterLake

Panel Design A Option 1 – Outage on 132/33kV Transformer No.1 and Transformer No.2 Circuits - Existing Front Sheet Modifications

i. Outage on 132/33kV transformer No.1 and ensure the associated relay panel and AVC panel is isolated.
ii. 132/33kV transformer No.2 AVC relay set to manual tap.
iii. Remove 132/33kV transformer No.1 AVC relay and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
iv. Plasma cut/chain drill transformer No.1 AVC relay panel front sheet (under risk of trip) to accommodate new AVC relay (Depending on replacement AVC Relay Dimensions)
v. Install new transformer No.1 AVC relay in the existing panel and any associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new AVC relay communication to RTU.
vi. Test and commission transformer No.1 AVC relay panel.
vii. Energise 132/33kV transformer No.1 (New AVC relay set to manual tap) and subsequently take an outage on 132/33kV transformer No.2. Ensure the associated No.2 relay panel and No.2 AVC panel is isolated.
viii. Remove 132/33kV transformer No.2 AVC Relay and associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
ix. Plasma cut/chain drill transformer No.2 AVC relay panel front sheet (under risk of trip) to accommodate new AVC relay (Depending on replacement AVC Relay Dimensions)
x. Install new transformer No.2 AVC relay into the existing panel and any associated equipment (AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU.
xi. Test and commission transformer No.2 AVC relay panel.
xii. Energise 132/33kV transformer No.2
xiii. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xiv. Repair AVC relay panel front sheets with blanking plates as required.

Panel Design A Option 2 – Reduced Risk of Trip on 132/33kV Transformer No.1 and Transformer No.2 Circuits – New AVC Panel Front Sheets to Existing Carcass

i. Outage on 132/33kV transformer No.1 and ensure the associated relay panel and AVC panel is isolated.
ii. 132/33kV transformer No.2 AVC relay set to manual tap.
iii. Remove 132/33kV transformer No.1 AVC relay panel front sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is

to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.

iv. Install new transformer No.1 AVC relay front sheet on the existing panel carcass and all associated equipment (New AVC Relay Panel Front Sheet to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU.
v. Test and commission new transformer No.1 AVC relay panel with new front sheet.
vi. Energise 132/33kV transformer No.1 (New AVC relay set to manual tap) and subsequently take an outage on 132/33kV transformer No.2. Ensure the associated relay panel and AVC panel is isolated.
vii. Remove 132/33kV transformer No.2 AVC relay panel front sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
viii. Install new transformer No.2 AVC relay panel front sheet on the existing panel carcass and all associated equipment (New AVC relay panel front sheet to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new AVC relay communication to RTU.
ix. Test and commission transformer No.2 AVC relay panel.
x. Energise 132/33kV transformer No.2
xi. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.

Panel Design A Option 3 – Minimum Outage on Existing 132/33kV Transformer No.1 and Transformer No.2 Circuits – New AVC Panel (Space in the Relay Room to be clarified on an substation by substation basis)

i. Deliver, install and cold commission New AVC 132/33kV transformer No.1/transformer No.2 relay panel containing 2 x new AVC relays and associated equipment including new relay communication to RTU.
ii. New multi-core/multi-pair cables to be installed at site.
iii. Existing 132/33kV transformer No.2 AVC relay set to manual tap.
iv. Reduced outage on 132/33kV transformer No.1 to connect new multi-core cables, multi-pair cables and associated communication to RTU panel.
v. Test and commission transformer No.1 AVC relay and associated equipment.
vi. Energise 132/33kV transformer No.1 (New AVC relay set to Manual Tap) and subsequently take an outage on 132/33kV transformer No.2.
vii. Reduced outage on 132/33kV transformer No.2 to connect new multi-core cables, multi-pair cables and associated communication to RTU panel.
viii. Test and Commission transformer No.2 AVC relay and associated equipment.
ix. Energise 132/33kV transformer No.2.

x. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.

xi. Removed existing 132/33kV transformer No.1 and transformer No.2 relay panels from the substation and repair the substation floor accordingly.

xii. Multi-core cables which become obsolete as a result of any panel modifications must be tied back. This is to be agreed with the Western Power Distribution SAP on a site-by-site, panel-by-panel basis.

2 Panel Design B – Fixed Front, Rear Access Panel Design, 19" Rack

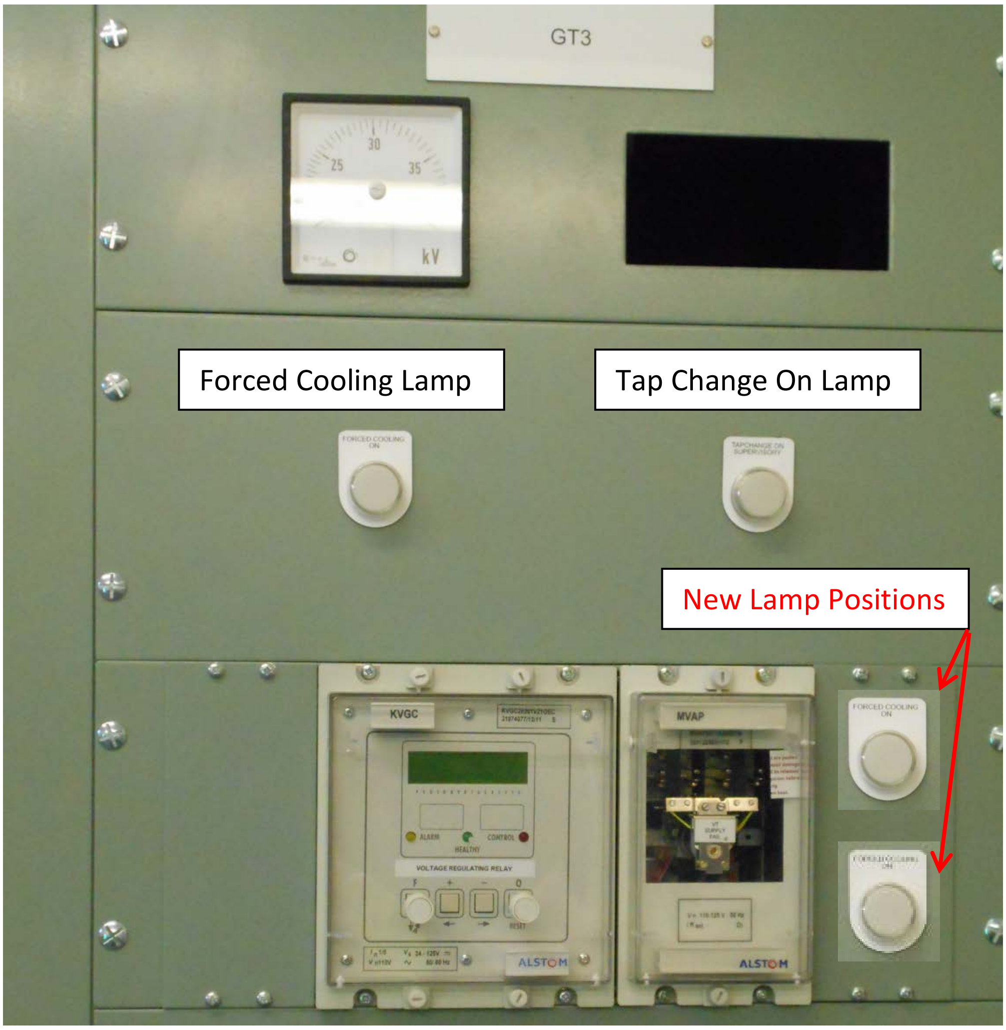
Substation: Bridgewater Main BSP

Panel Design B Option 1 – Outage on 132/33kV Transformer No.1 and Transformer No.2 Circuits –Remove Existing AVC Relays and Install New AVC Relays.
(Confirmation from WPD required for wiremen to work in a Live Relay Panel)

i. Outage on 132/33kV transformer No.1 and ensure the associated existing AVC relay is isolated (Transformer No.1 AVC Relay only).
ii. 132/33kV transformer No.2 AVC relay set to manual tap.
iii. Remove existing transformer No.1 AVC relay and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
iv. Install new transformer No.1 AVC Relay (With associated relay collar) in the existing panel and associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU. Wire transformer No.1 AVC relay and associated equipment to spare terminals in the rear of the panel
v. Test and commission transformer No.1 AVC relay
vi. Energise 132/33kV transformer No.1 (New AVC relay set to manual tap) and subsequently take an outage on 132/33kV transformer No.2 and ensure the associated AVC relay is isolated (Transformer No.2 only).
vii. Remove existing transformer No.2 AVC relay and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
viii. Install new transformer No.2 AVC relay (With associated relay collar) in the existing panel and associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU. Wire transformer No.2 AVC relay and associated equipment to spare terminals in the rear of the panel
ix. Test and commission transformer No.2 AVC relay
x. Energise 132/33kV transformer No.2
xi. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xii. Fit blanking plates to the relay panel as required.

Panel Design B Option 2 – Reduced Outage on 132/33kV Transformer No.1 and Transformer No.2 Circuits –Existing AVC Relays Maintained with New AVC Relays Installed Above. (Confirmation from WPD required for wiremen to work in a Live Relay Panel)

i. Modify existing transformer No.1/transformer No.2 AVC panel moving forced cooling lamp and tap change on supervisory lamp to lower tier (See Photograph below) clearing upper tier for New AVC Relay Installation.



i. Install new transformer No.1 AVC Relay (With associated relay collar) in the existing panel in tier above existing AVC relay and install associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU. Wire transformer No.1 AVC relay and associated equipment to spare terminals in the rear of the panel.

ii. Install new transformer No.2 AVC Relay (With associated relay collar) in the existing panel in tier above existing AVC relay and install and associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU. Wire transformer No.2 AVC relay and associated equipment to spare terminals in the rear of the panel

iii. Outage on 132/33kV transformer No.1 and ensure the associated existing AVC relay is isolated (Transformer No.1 AVC Relay only).
iv. 132/33kV Transformer No.2 AVC relay set to manual tap.
v. Move associated multi-core cables and multi-pair cables from existing AVC relay connections to new AVC relay connections.
vi. Test and commission transformer No.1 AVC relay.
vii. Energise 132/33kV transformer No.1 (New AVC relay set to manual tap) and subsequently take an outage on 132/33kV transformer No.2 and ensure the associated AVC relay is isolated (transformer No.2 only).
viii. Move associated multi-core cables and multi-pair cables from existing AVC relay connections to new AVC relay connections.
ix. Test and commission transformer No.2 AVC relay
x. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xi. Remove transformer No.1 AVC relay, voltage transformer supervision relay and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
xii. Remove transformer No.2 AVC relay, voltage transformer supervision relay and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
xiii. Fit blanking plates to the relay panel as required.

Panel Design B Option 3 – Minimum Outage on Existing 132/33kV Transformer No.1 and Transformer No.2 Circuits – New AVC Panel (Space in the Relay Room to be clarified on a substation by substation basis)

i. Deliver, install and cold commission New AVC 132/33kV transformer No.1/transformer No.2 Relay Panel containing 2 x new AVC relays and associated equipment.
ii. New multi-core/multi-pair cables to be installed at site and associated communication to RTU panel.
iii. 132/33kV transformer No.2 AVC relay set to Manual Tap.
iv. Reduced outage on 132/33kV transformer No.1 to connect new multi-core cables, multi-pair cables and associated communication to RTU panel.
v. Test and commission transformer No.1 AVC relay and associated equipment.
vi. Energise 132/33kV transformer No.1 (New AVC relay set to Manual Tap) and subsequently take an outage on 132/33kV transformer No.2.
vii. Reduced outage on 132/33kV transformer No.2 to connect new multi-core cables, multi-pair cables and associated communication to RTU panel.
viii. Test and commission transformer No.2 AVC relay and associated equipment.
ix. Energise 132/33kV transformer No.2.
x. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xi. Remove existing 132/33kV transformer No.1 and transformer No.2 AVC relays and the associated equipment and fit blanking plates as required.
xii. Multi-core cables which become obsolete as a result of any panel modifications must be tied back. This is to be agreed with the Western Power Distribution SAP on a site-by-site, panel-by-panel basis.

3 Panel Design C – Fixed Front, Rear Access Panel Design, No 19" Rack or Swing Frame

Substation: Tiverton Junction, Radstock Main

Panel Design C Option 1 – Outage on 132/33kV Transformer No.1 and Transformer No.2 Circuits- Existing Front Sheet Modifications

i. Outage on 132/33kV transformer No.1 and ensure the associated relay panel and AVC panel is isolated.

ii. 132/33kV transformer No.2 AVC relay set to Manual Tap.

iii. Remove 132/33kV transformer No.1 AVC Relay and the associated wiring/equipment.

iv. Plasma cut/chain drill the transformer No.1 AVC relay panel front sheet (under risk of trip) to accommodate new AVC relay (Depending on replacement AVC relay dimensions)

v. Install new transformer No.1 AVC Relay in the existing panel and associated equipment (New AVC relay to be pre-wired with 5m loom and pre-ferruled prior to the outage) including installation of new relay communication to RTU.

vi. Test and commission transformer No.1 AVC relay panel.

vii. Energise 132/33kV transformer No.1 (AVC relay set to Manual Tap) and subsequently take an outage on 132/33kV transformer No.2 and ensure the associated relay panel and AVC panel is isolated.
viii. Remove 132/33kV transformer No.2 AVC relay and the associated wiring/equipment
ix. Plasma cut/chain drill transformer No.2 AVC relay panel front sheet (under risk of trip) to accommodate new AVC relay (Depending on replacement AVC relay dimensions)
x. Install new transformer No.2 AVC Relay into the existing panel and associated equipment (AVC relay to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new relay communication to RTU.
xi. Test and commission transformer No.2 AVC relay panel.
xii. Energise 132/33kV transformer No.2
xiii. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xiv. Repair AVC relay panel front sheets with blanking plates as required.

<u>Panel Design C Option 2 – Reduced Risk of Trip on 132/33kV Transformer No.1 and Transformer No.2 Circuits - New AVC Panel Front Sheets to Existing Carcass</u>

i. Outage on 132/33kV transformer No.1 and ensure the associated relay panel and AVC panel is isolated.
ii. 132/33kV transformer No.2 AVC relay set to Manual Tap
iii. Remove 132/33kV transformer No.1 AVC relay panel front sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
iv. Install new transformer No.1 AVC relay front sheet on the existing panel carcass and all associated equipment (New AVC relay panel front sheet to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new relay communication to RTU.
v. Test and commission transformer No.1 AVC relay panel.
vi. Energise 132/33kV transformer No.1 (AVC set to manual tap) and subsequently take an outage on 132/33kV transformer No.2 and ensure the associated relay panel and AVC panel is isolated.
vii. Remove 132/33kV transformer No.2 AVC relay panel front sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.
viii. Install new transformer No.2 AVC relay panel front sheet into the existing panel carcass and all associated equipment (AVC relay panel front sheet to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new relay communication to RTU.

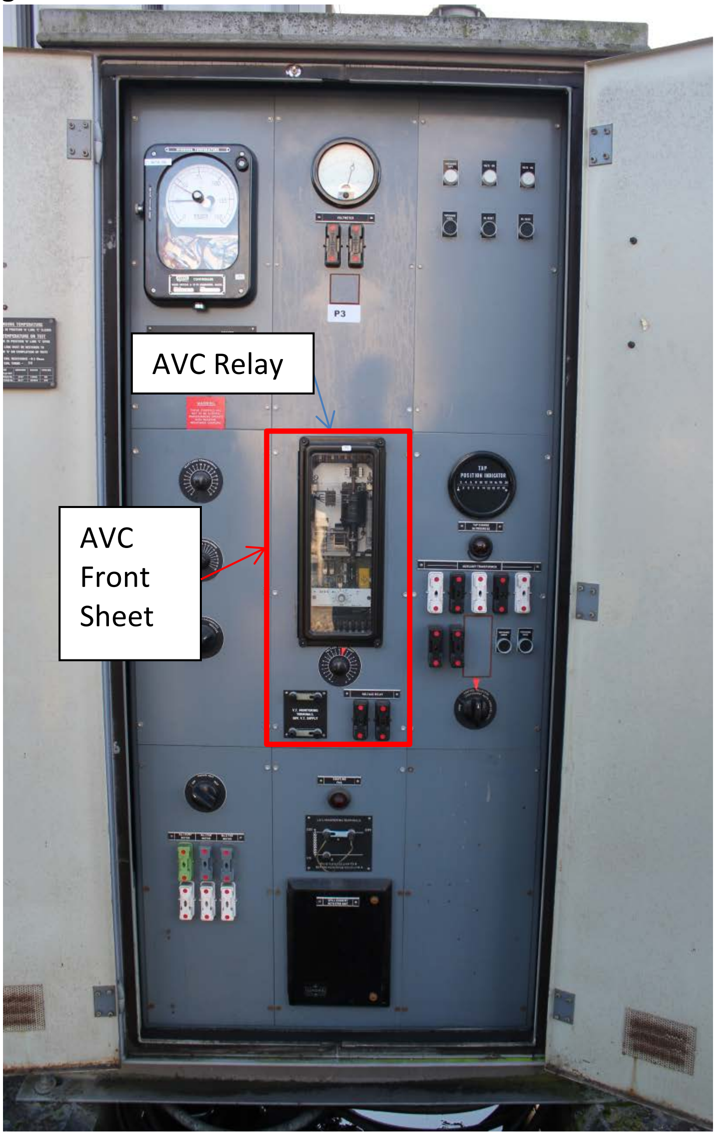
ix. Test and commission transformer No.2 AVC relay panel.
x. Energise 132/33kV transformer No.2
xi. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.

Panel Design C Option 3 – Minimum Outage on existing 132/33kV Transformer No.1 and Transformer No.2 Circuits – New AVC Panel (Space in the Relay Room to be clarified on a substation by substation basis)

i. Deliver, install and cold commission new AVC 132/33kV transformer No.1/transformer No.2 relay panel containing 2 x new AVC relays and associated equipment.
ii. New multi-core/multi-pair cables to be installed at site.
iii. 132/33kV transformer No.2 AVC relay set to manual tap.
iv. Reduced outage on 132/33kV transformer No.1 to connect new multi-core cables, multi-pair cables and associated communication to the RTU panel.
v. Test and commission transformer No.1 AVC relay and associated equipment.
vi. Energise 132/33kV transformer No.1 (New AVC relay set to manual tap) and subsequently take an outage on 132/33kV transformer No.2.
vii. Reduced outage on 132/33kV transformer No.2 to connect new multi-core cables, multi-pair cables and associated communication to the RTU panel.
viii. Test and commission transformer No.2 AVC relay and associated equipment.
ix. Energise 132/33kV transformer No.2.
x. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.
xi. Removed existing 132/33kV transformer No.1 and transformer No.2 relay panels from the substation and repair the substation floor accordingly
xii. Multi-core cables which become obsolete as a result of any panel modifications must be tied back. This is to be agreed with the Western Power Distribution SAP on a site-by-site, panel-by-panel basis.

4 Panel Design D – Fixed Front, Transformer Mounted AVC Relay

Substation : Staplegrove



<u>Panel Design D Option 1 – Reduced Risk of Trip on 132/33kV Transformer No.1 and Transformer No.2 Circuits - New AVC Panel Front Sheet to Existing Cubicle</u>

i. Outage on 132/33kV transformer No.1 and ensure the associated relay panel and AVC relay is isolated.

ii. 132/33kV transformer No.2 AVC relay set to manual tap

iii. Remove 132/33kV transformer No.1 AVC Relay Panel front Sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.

iv. Install new transformer No.1 AVC relay front sheet on the existing panel carcass and all associated equipment (New AVC Relay Panel Front Sheet to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new relay communication to RTU.

v. Test and commission transformer No.1 AVC relay panel.

vi. Energise 132/33kV transformer No.1 (AVC set to Manual Tap) and subsequently take an outage on 132/33kV transformer No.2 and ensure the associated relay panel and AVC panel is isolated.

vii. Remove 132/33kV transformer No.2 AVC Relay Panel Front Sheet and the associated wiring/equipment. All panel wiring which is obsolete following equipment removal is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.

viii. Install new transformer No.2 AVC relay panel front sheet into the existing panel carcass and all associated equipment (AVC relay panel front sheet to be pre-wired with 5m looms and pre-ferruled prior to the outage) including installation of new relay communication to RTU.

ix. Test and commission transformer No.2 AVC relay panel.

x. Energise 132/33kV transformer No.2

xi. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.

5 Panel Design E (MicroTAPP Only) – Cost Effective Modification of Existing MicroTAPP AVC Scheme to allow Utilisation as part of SVO Project.

Substation: Colley Lane, Lydeard St Lawrence, Waterlake

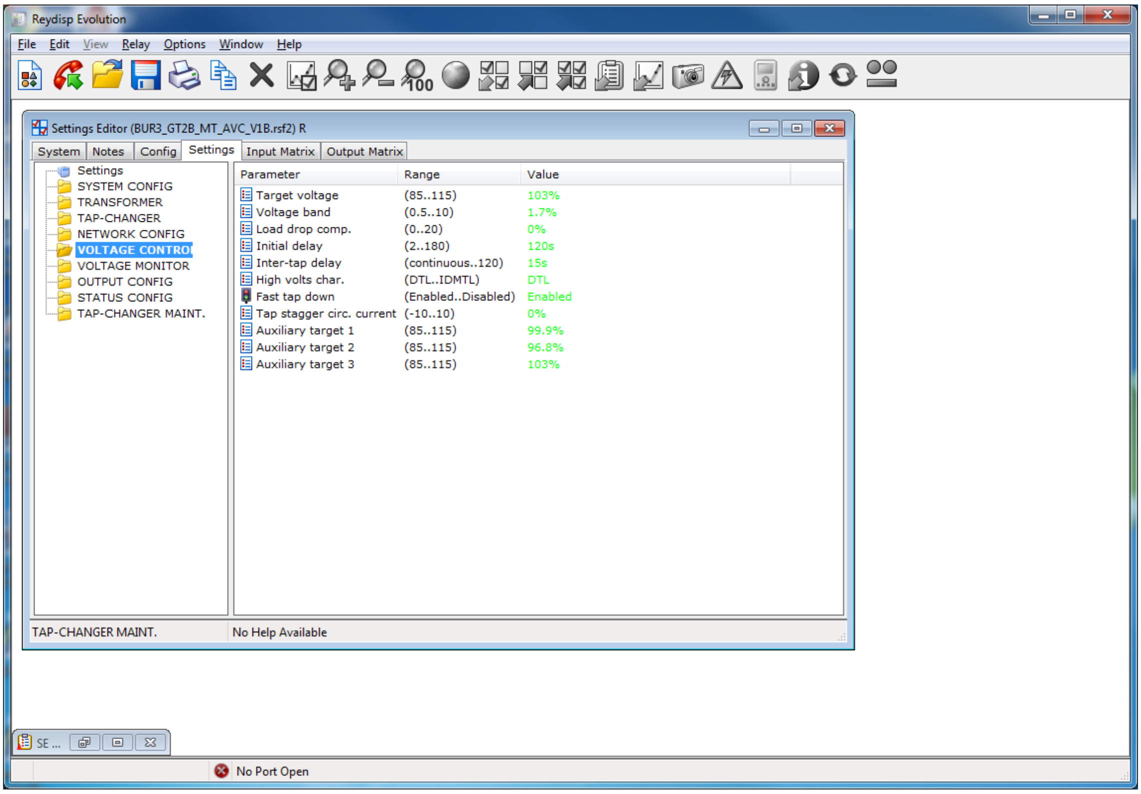
Panel Design E (MicroTAPP) Option 1 – Outage on 132/33kV Transformer No.1 and Transformer No.2 Circuits – Utilise Existing AVC Relays as part of SVO Project.
AVC Circuit Diagram T1 WP109592 Revision 3 (Green / Red Markups)
AVC Circuit Diagram T2 WP109593 Revision 3 (Green / Red Markups)

i. Extract Reydisp files from MicroTAPP relays (transformer No.1 and transformer No.2)
ii. Outage on 132/33kV transformer No.1 and ensure the associated protection relay and MicroTAPP AVC relay is isolated.
iii. 132/33kV transformer No.2 MicroTAPP AVC relay set to manual tap.

iv. Remove wiring indicated on circuit diagram WP109592 (Green Markup). All panel wiring which is obsolete is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.

v. Install required new wiring and new group setting relays (Arteche Type BF-3BB – 5 off).

vi. Test and commission transformer No.1 AVC relay panel. (New Reydisp file is required to be uploaded to the relay with the relevant six settings groups incorporated as shown below)



vii. Energise 132/33kV transformer No.1 (MicroTAPP AVC relay set to manual tap) and subsequently take an outage on 132/33kV Transformer No.2 and ensure the associated relay panel and MicroTAPP AVC panel is isolated.

viii. Remove wiring indicated on circuit diagram WP1109593 (Green Markup). All panel wiring which is obsolete is to be completely removed from the panel and the trunking. Cutting panel wiring back to the trunking is not acceptable.

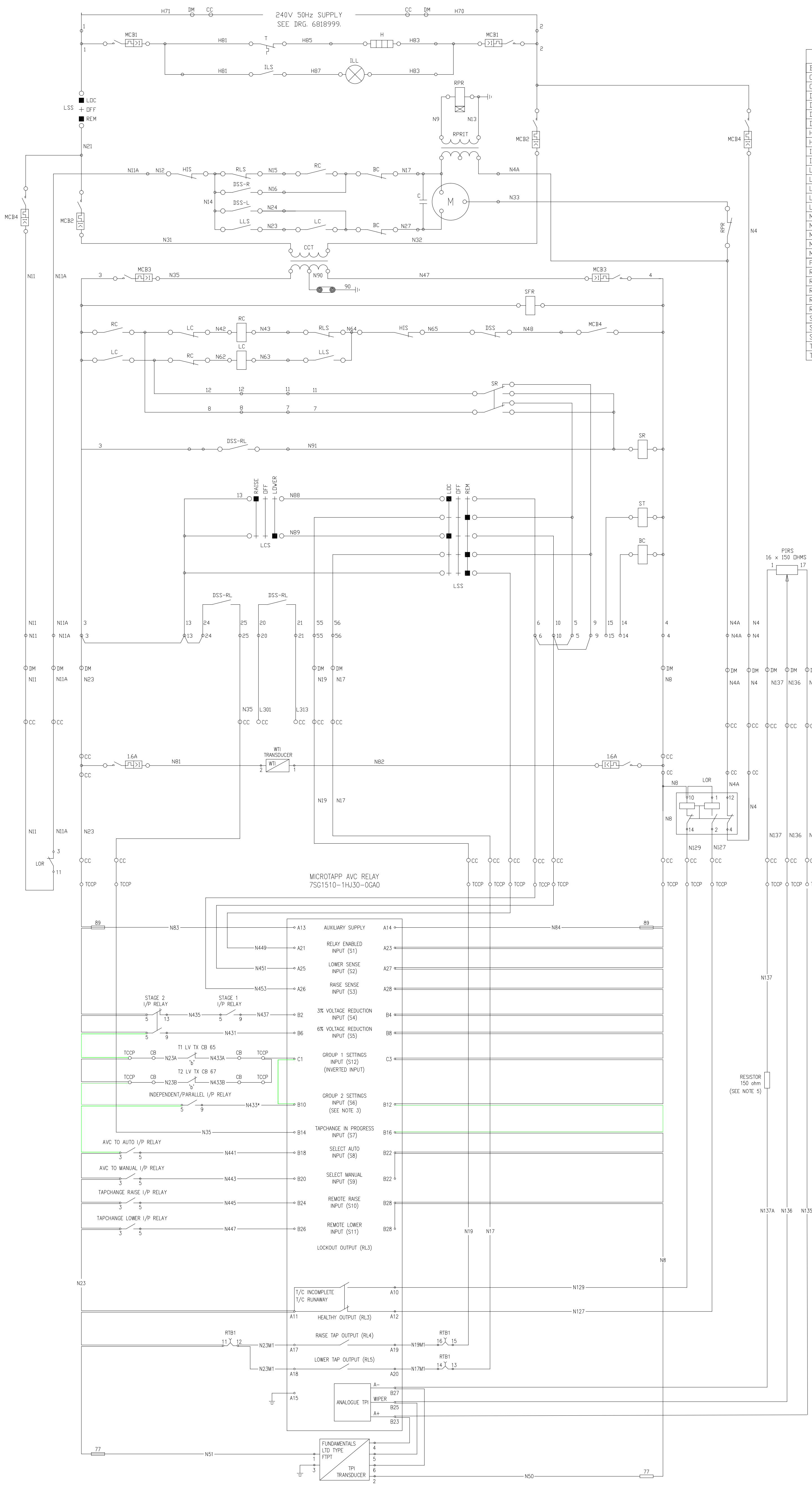
ix. Install required new wiring and new group setting relays (Arteche Type BF-3BB 5 off).

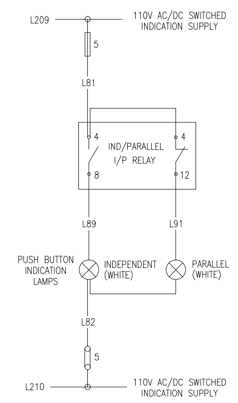
x. Test and commission transformer No.2 AVC relay panel. (New Reydisp file is required to be uploaded to the relay with the relevant six settings groups incorporated)

xi. Energise 132/33kV Transformer No.2

xii. Switch 132/33kV transformer No.1 and 132/33kV transformer No.2 AVC relays from MANUAL to AUTO tap.

SDRC2 Appendix E - Sample SVO Designs (Waterlake substation)





DRIVE MECHANISM CUBICLE (DM)

REF.	DESCRIPTION
BC	BLOCKING CONTACTOR
C	CAPACITOR
CCT	CONTROL CIRCUIT TRANSFORMER (200VA 240/55-0-55V)
DMS	DIRECTIONAL MEMORY SWITCH
DSS-L	DIRECTIONAL SEQUENCE SWITCH - LOWER
DSS-R	DIRECTIONAL SEQUENCE SWITCH - RAISE
DSS-RL	DIRECTIONAL SEQUENCE SWITCH - RAISE OR LOWER
H	HEATER
HIS	HANDLE INTERLOCK SWITCH
ILL	ILLUMINATION LAMP
ILS	ILLUMINATION SWITCH
LC	LOWER CONTACTOR
LCS	LOCAL CONTROL SWITCH (RAISE/OFF/LOWER)
LLS	LOWER LIMIT SWITCH
LOR	LOCKOUT RELAY (ARTECHE BF-3)
LSS	LOCAL SELECTOR SWITCH (LOCAL/OFF/REMOTE)
M	MOTOR
MCB1	MINIATURE CIRCUIT BREAKER - 6 AMP
MCB2	MINIATURE CIRCUIT BREAKER - 10 AMP
MCB3	MINIATURE CIRCUIT BREAKER - 6 AMP
MCB4	MOTOR CIRCUIT BREAKER
PIRS	POSITION INDICATION RESISTANCE SWITCH
R	RESISTOR
RC	RAISE CONTACTOR
RLS	RAISE LIMIT SWITCH
RPR	RUNAWAY PREVENTION RELAY (6 SECONDS)
RPRIT	RUNAWAY PREVENTION RELAY INTERPOSING TRANSFORMER
SFR	SUPPLY FAILURE RELAY
SR	STEPPING RELAY
ST	SHUNT TRIP (MOTOR CIRCUIT BREAKER)
T	THERMOSTAT
TIS	TAPCHANGER ISOLATOR SWITCH (OFF/ON)

GENERAL NOTES

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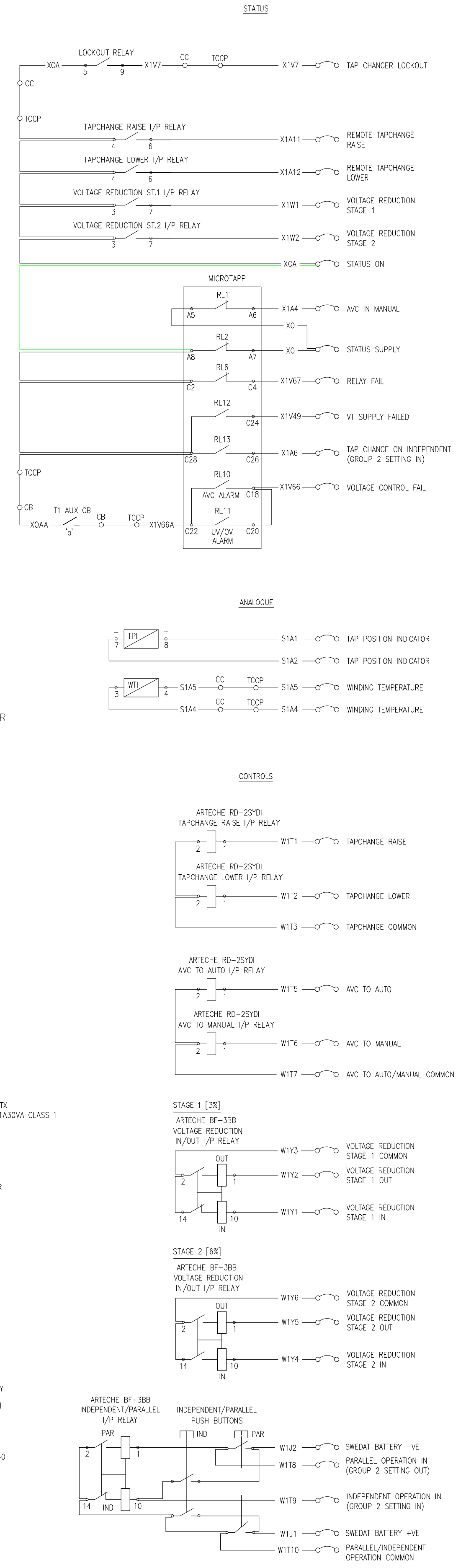
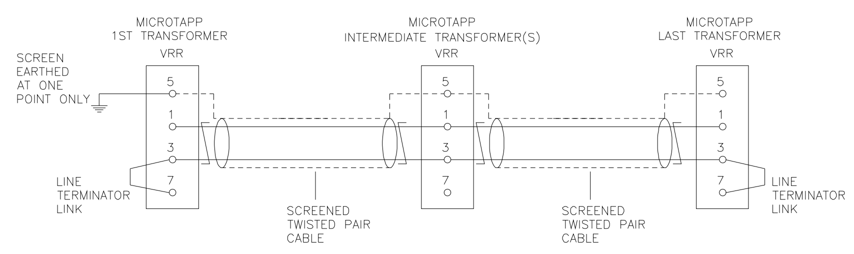
3. FOR OTHER CIRCUITS SEE DRG. 6818999.





TAPCHANGE CONTROL PANEL FUSE & LINK TABLE

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2	VOLTAGE REGULATING RELAY AUXILIARY SUPPLY	110V AC	89	2A	
3	VOLTAGE REGULATING RELAY VT SUPPLY (L1)	110V AC	71	2A	
4	VOLTAGE REGULATING RELAY VT SUPPLY (L2)	110V AC	71	2A	
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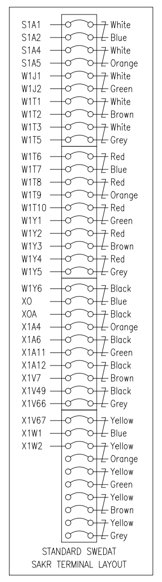
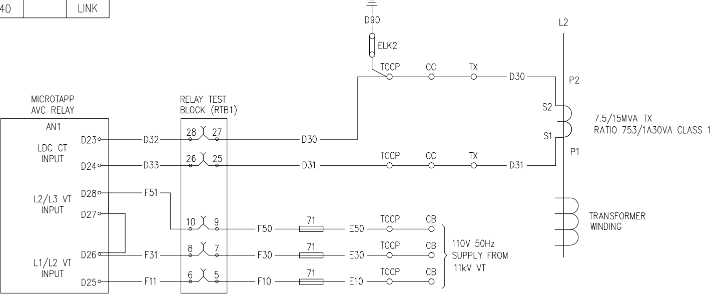
35	INDICATION AC/DC SUPPLY	110V AC/DC	5	2A	
36	INDICATION AC/DC SUPPLY	110V AC/DC	5		LINK
47	CUBICLE ILLUMINATION SUPPLY PH	240V AC	40	2A	
48	CUBICLE ILLUMINATION SUPPLY N	240V AC	40		LINK





NOTES

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2. FOR TWO OR MORE TRANSFORMERS IN PARALLEL AT THE SAME SITE, THE PREFERRED MODE OF OPERATION IS CIRCULATING CURRENT.
3. WHEN TWO OR MORE TRANSFORMERS ARE OPERATING IN PARALLEL CIRCULATING CURRENT MODE, THE LOSS OF ONE TRANSFORMER SHOULD CAUSE 'GROUP 2' SETTINGS TO BE SELECTED ON THE RELAY. LV CB AUXILLIARY CONTACTS ARE TO BE USED TO ACHIEVE THIS. THE GROUP 2 SETTINGS WILL NORMALLY BE CONFIGURED FOR INDEPENDENT AUTO OPERATION. MANUAL SELECTION OF 'INDEPENDENT' OR 'PARALLEL' OPERATION SHOULD ALSO BE PROVIDED.
4. FOR CERTAIN CONDITIONS (COMMUNICATION LOSS BETWEEN RELAYS, VT FAIL), THE RELAYS WILL REVERT TO TAPP MODE FOR THIS REASON, A VALID SYSTEM POWER FACTOR MUST BE SET, EVEN WHEN USING CIRCULATING CURRENT MODE OF CONTROL.
5. ADDITIONAL RESISTOR REQUIRED WHEN TRANSFORMER USES RESISTOR TYPE TPI SENDER UNIT. THE VALUE OF THE RESISTOR IS TO BE THE SAME AS TAP INTERVAL RESISTOR. THE RESISTOR LADDER SHOULD HAVE A TOTAL RESISTANCE GREATER THAN 250 AND LESS THAN 100k.
6. MICROTAPP RELAY TERMINAL NUMBERS AS FOLLOWS:
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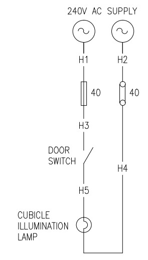
   IO1 MODULE, PREFIX 'B'
   IO2 MODULE, PREFIX 'C'
   AN1 MODULE, PREFIX 'D'
7. TELECONTROL INTERPOSING RELAYS ARE FITTED WITH INTERNAL ARC SUPPRESSION DIODES
8. TAPCHANGER DRAWING TAKEN FROM A BRUSH TRANSFORMER WITH ON LOAD TAPCHANGER TYPE ATL. TAPCHANGER SHOWN AT LOWER LIMIT POSITION (TAP 1 WITH LLS OPEN)
9. ASTERISK DENOTES A FOR CONNECTIONS TO T1 AVC RELAY AND B FOR CONNECTIONS TO T2 AVC RELAY.



DELETIONS DENOTED IN GREEN

REV	DATE	BY	DESCRIPTION	CHK	APP
2	3/06/15		UPDATED		MBE
1	18/09/13		GROUP 1 SETTINGS INPUT ADDED TO AVC RELAY		MBE

DRAWING STATUS:

http://www.wspgroup.com

CLIENT: WESTERN POWER DISTRIBUTION

ARCHITECT:

PROJECT: WPD LCNF TIER-2 NETWORK EQUILIBRIUM

TITLE: WATERLAKE 33/11kV SUBSTATION CIRCUIT DIAGRAM CONTROL FOR AUTOMATIC VOLTAGE & TAP CUBICLE CONTROL FOR T1

SCALE:	CHECKED:		APPROVED:
NTS	KY		KY
PROJECT NUMBER: 70017751-PO1	DESIGNED: DS	DRAWN: DS	DATE: 19.01.2016

DRAWING No: WP109592 — REV: 2

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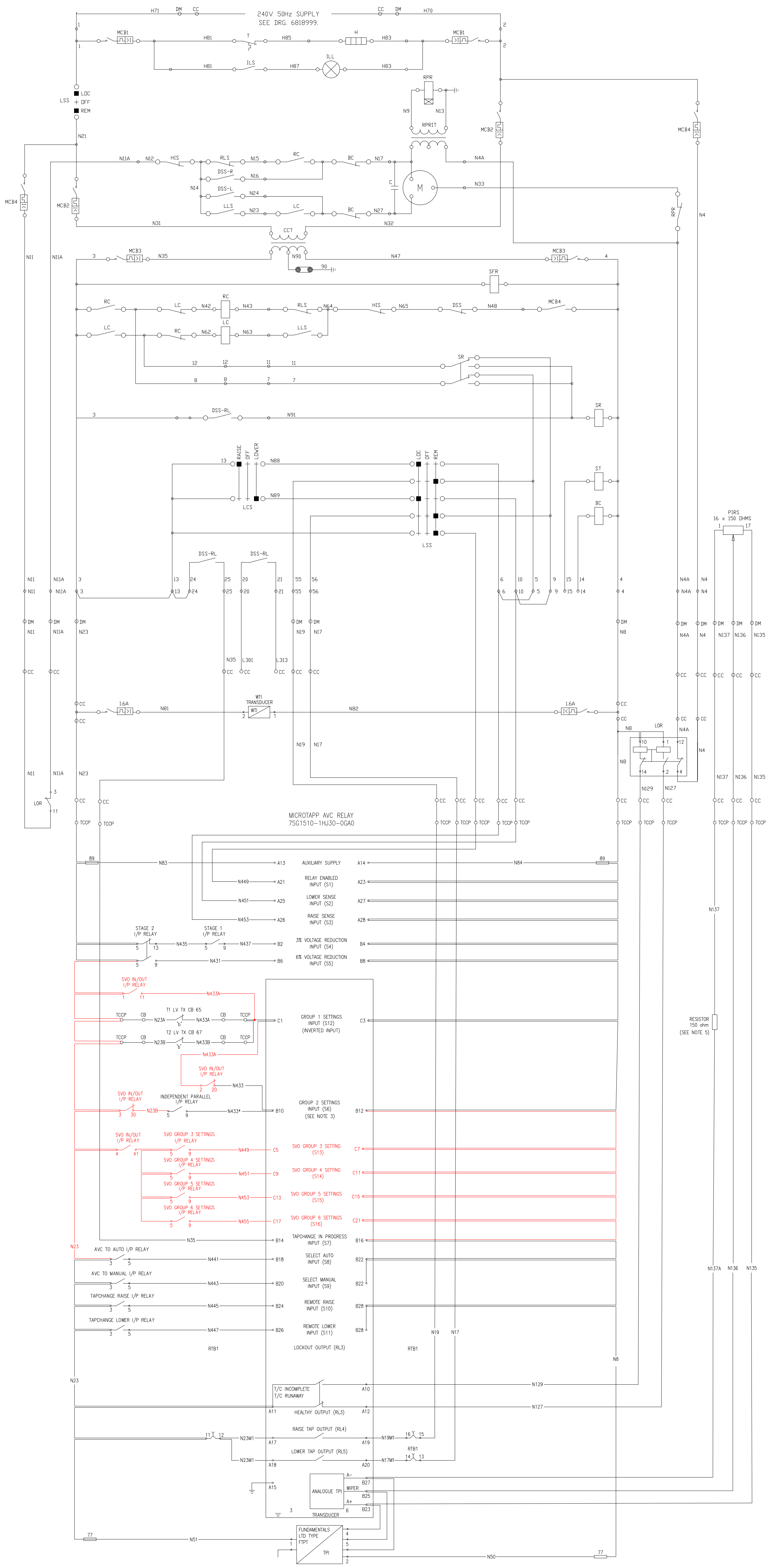

DRIVE MECHANISM CUBICLE (DM)

REF.	DESCRIPTION
BC	BLOCKING CONTACTOR
C	CAPACITOR
CCT	CONTROL CIRCUIT TRANSFORMER (200VA 240/55-0-55V)
DMS	DIRECTIONAL MEMORY SWITCH
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ILL	ILLUMINATION LAMP
ILS	ILLUMINATION SWITCH
LC	LOWER CONTACTOR
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R	RESISTOR
RC	RAISE CONTACTOR
RLS	RAISE LIMIT SWITCH
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SR	STEPPING RELAY
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TIS	TAPCHANGER ISOLATOR SWITCH (OFF/ON)

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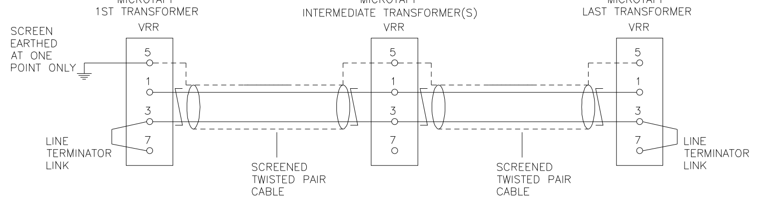
PEER TO PEER COMMUNICATION BETWEEN MICROTAPP RELAYS



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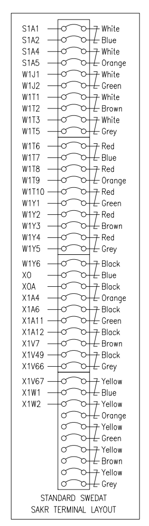

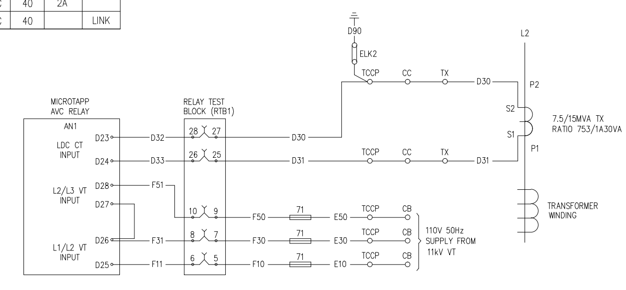

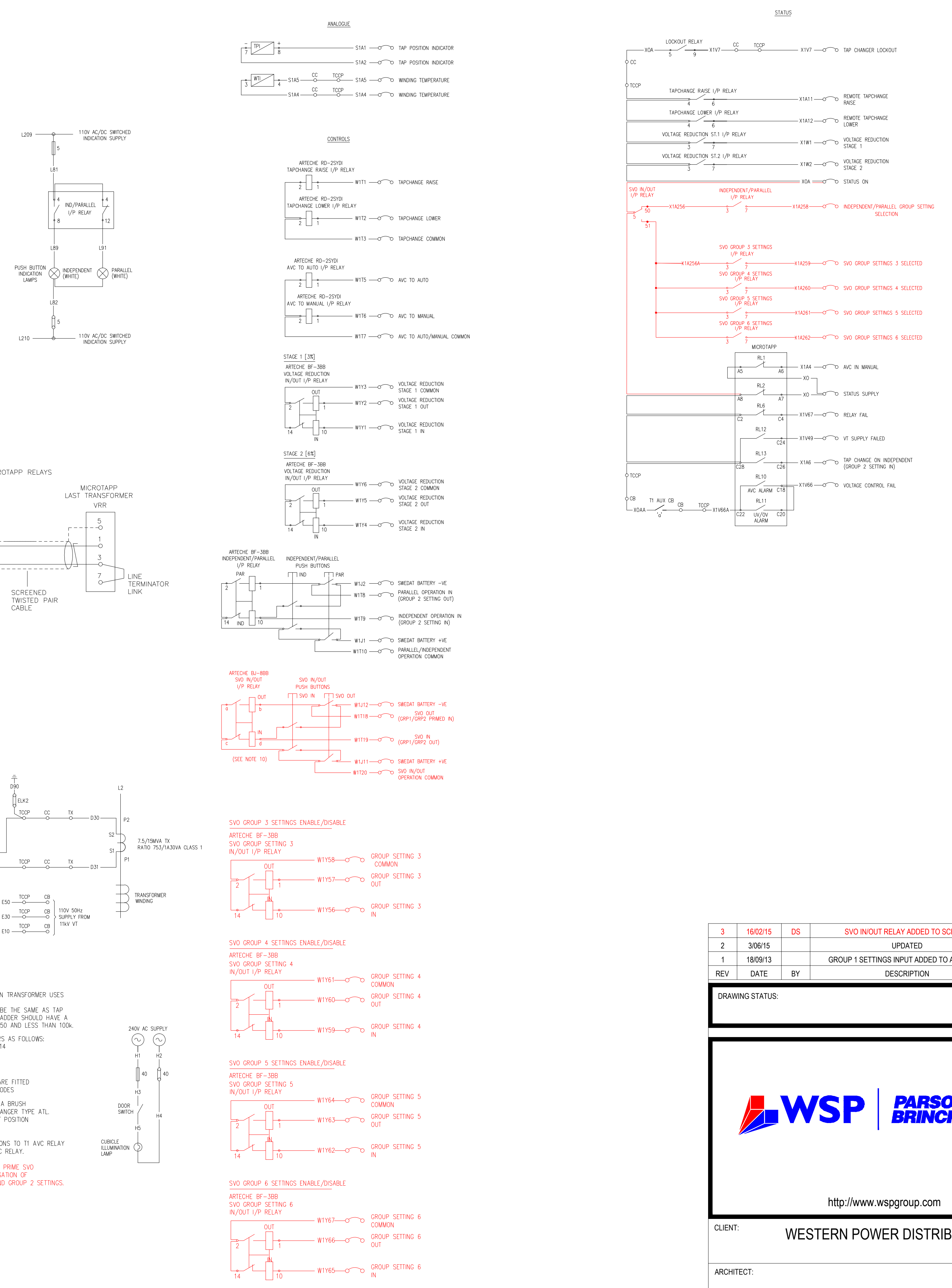

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9. ASTERISK DENOTES A FOR CONNECTIONS TO T1 AVC RELAY AND B FOR CONNECTIONS TO T2 AVC RELAY.
10. MANUAL SELECTION OF SVO 'IN' WILL PRIME SVO GROUP 3-6 AND DISABLE THE UTILISATION OF PARALLEL/INDEPENDENT GROUP 1 AND GROUP 2 SETTINGS.

ADDITIONS DENOTED IN RED

REV	DATE	BY	DESCRIPTION	CHK	APP
3	16/02/15	DS	SVO IN/OUT RELAY ADDED TO SCHEME	DS	KY
2	3/06/15		UPDATED		KY
1	18/09/13		GROUP 1 SETTINGS INPUT ADDED TO AVC RELAY		KY

DRAWING STATUS:

http://www.wspgroup.com

CLIENT: WESTERN POWER DISTRIBUTION

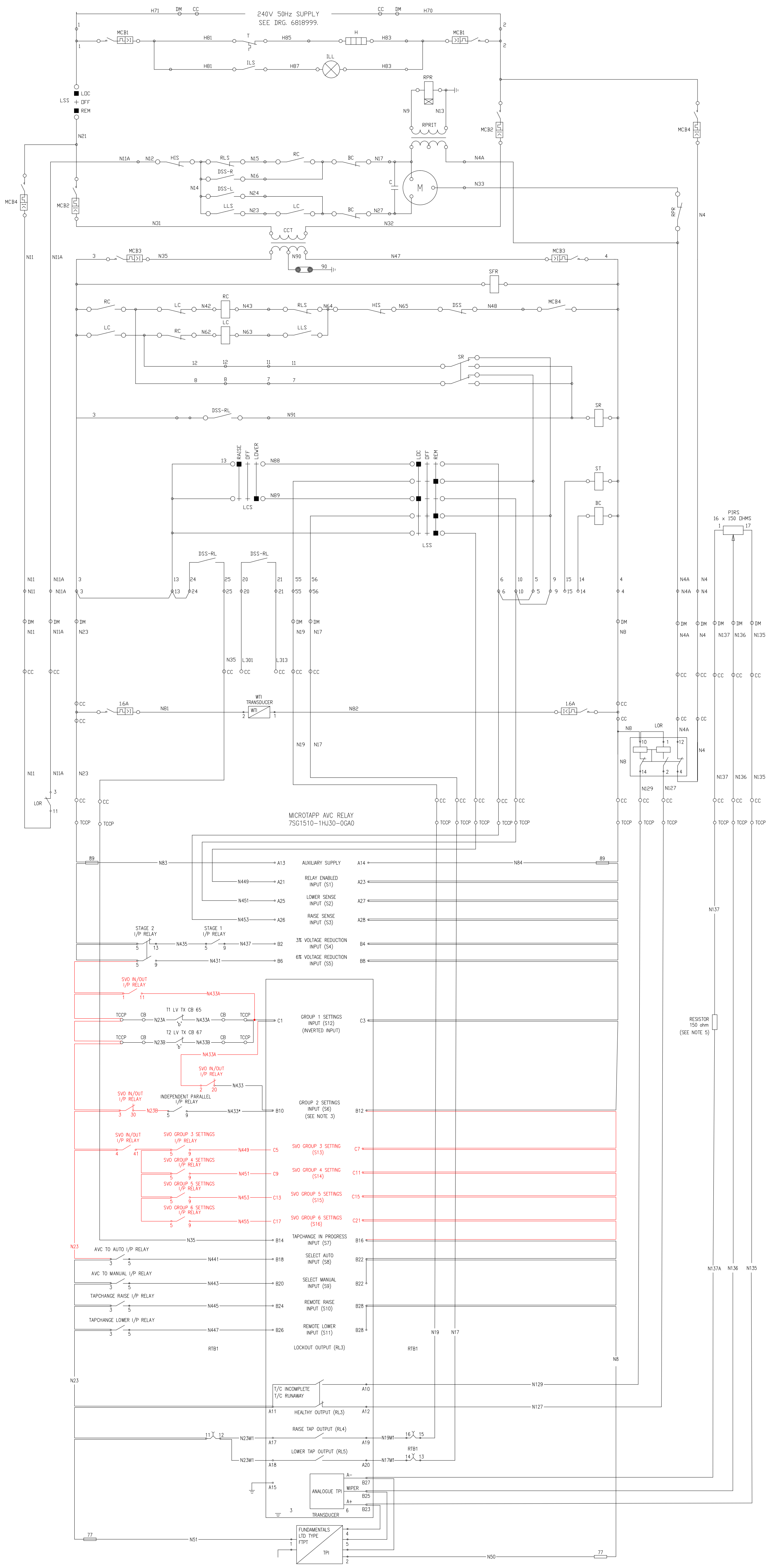
ARCHITECT:

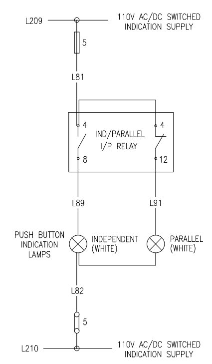
PROJECT: WPD LCNF TIER-2 NETWORK EQUILIBRIUM

TITLE: WATERLAKE 33/11kV SUBSTATION CIRCUIT DIAGRAM CONTROL FOR AUTOMATIC VOLTAGE & TAP CUBICLE CONTROL FOR T1 OPTION 2

SCALE:	CHECKED:		APPROVED:
NTS	KY		KY
PROJECT NUMBER: 70017751-PO1	DESIGNED: DS	DRAWN: DS	DATE: 19.01.2016

DRAWING No: WP109592_OPTION 2 REV: 3





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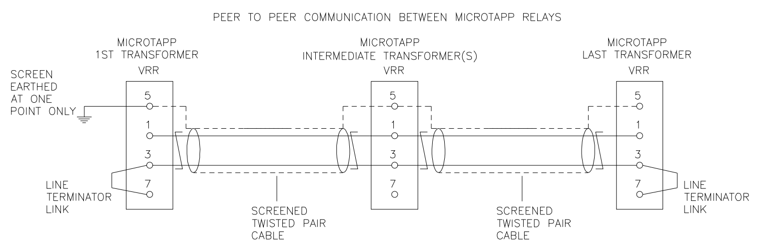

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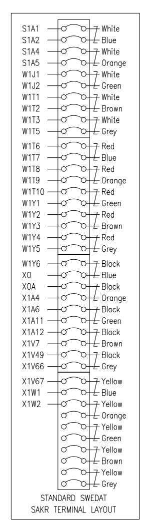

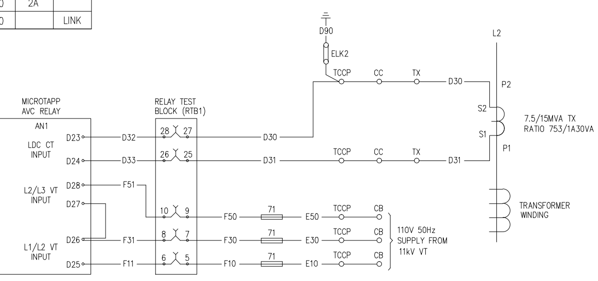

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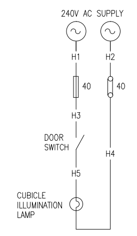
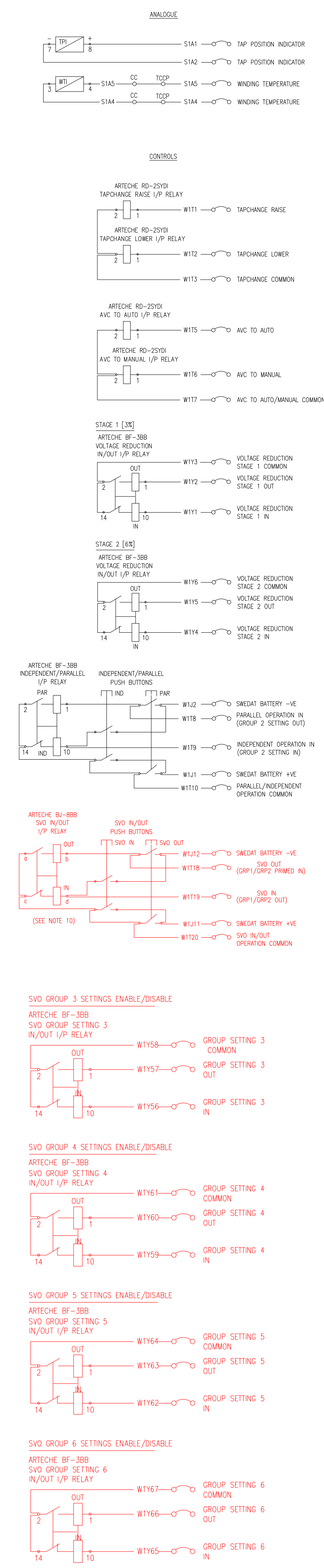
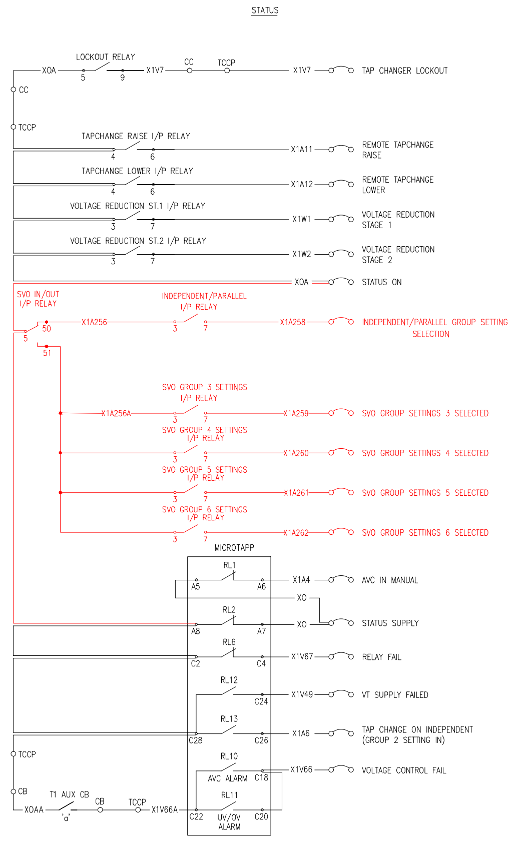
10. MANUAL SELECTION OF SVO 'IN' WILL PRIME SVO GROUP 3-6 AND DISABLE THE UTILISATION OF PARALLEL/INDEPENDENT GROUP 1 AND GROUP 2 SETTINGS.







ADDITIONS DENOTED IN RED

REV	DATE	BY	DESCRIPTION	CHK	APP
3	16/02/15	DS	SVO IN/OUT RELAY ADDED TO SCHEME	DS	KY
2	3/06/15		UPDATED		KY
1	18/09/13		GROUP 1 SETTINGS INPUT ADDED TO AVC RELAY		KY

DRAWING STATUS:

WSP | PARSONS BRINCKERHOFF

http://www.wspgroup.com

CLIENT: WESTERN POWER DISTRIBUTION

ARCHITECT:

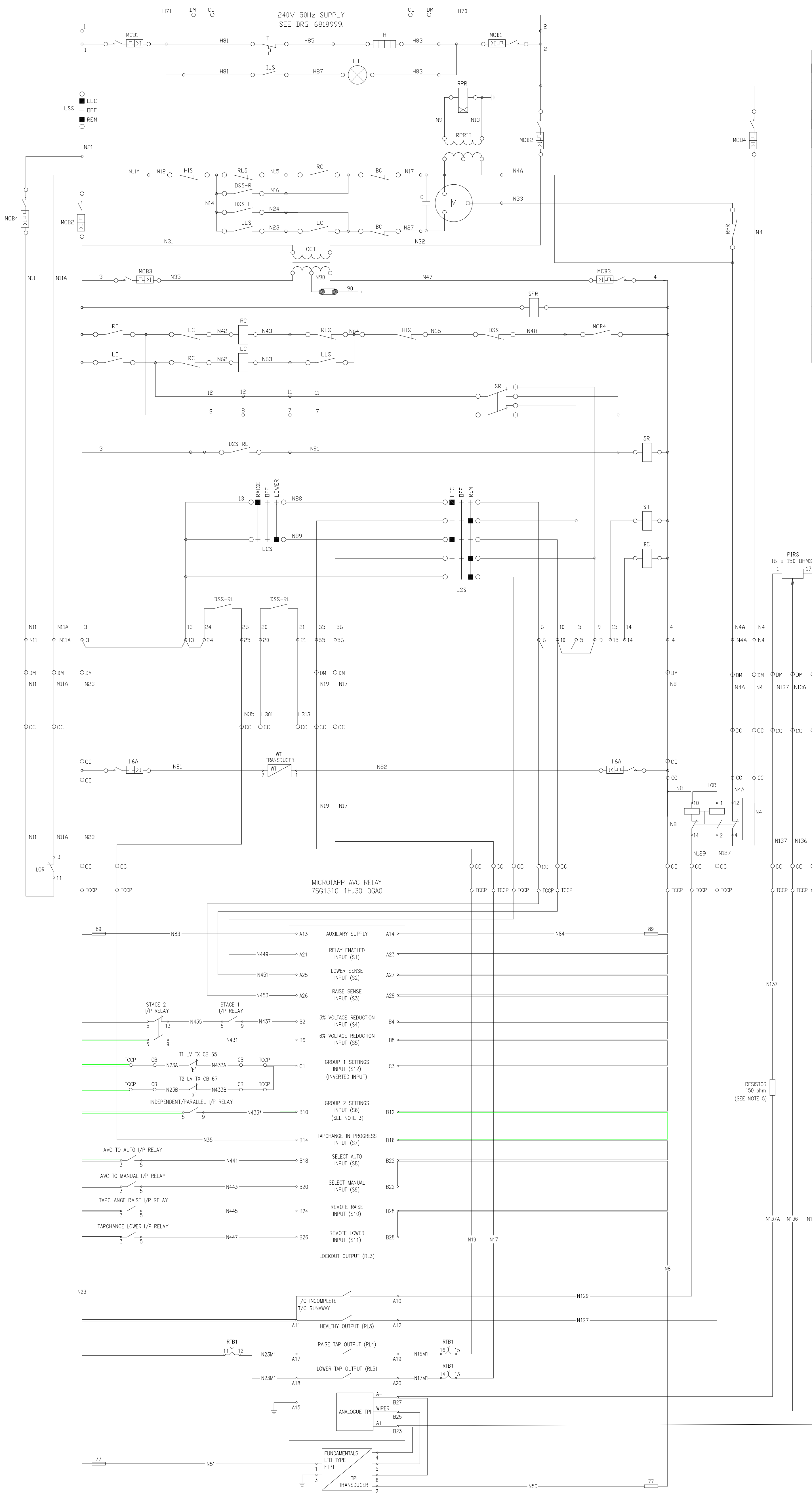
PROJECT: WPD LCNF TIER-2 NETWORK EQUILIBRIUM

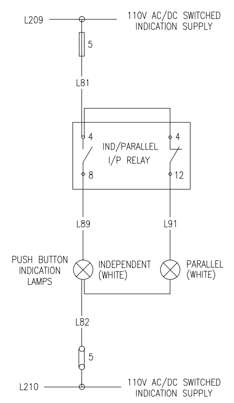
TITLE: WATERLAKE 33/11kV SUBSTATION CIRCUIT DIAGRAM CONTROL FOR AUTOMATIC VOLTAGE & TAP CUBICLE CONTROL FOR T2 OPTION 2

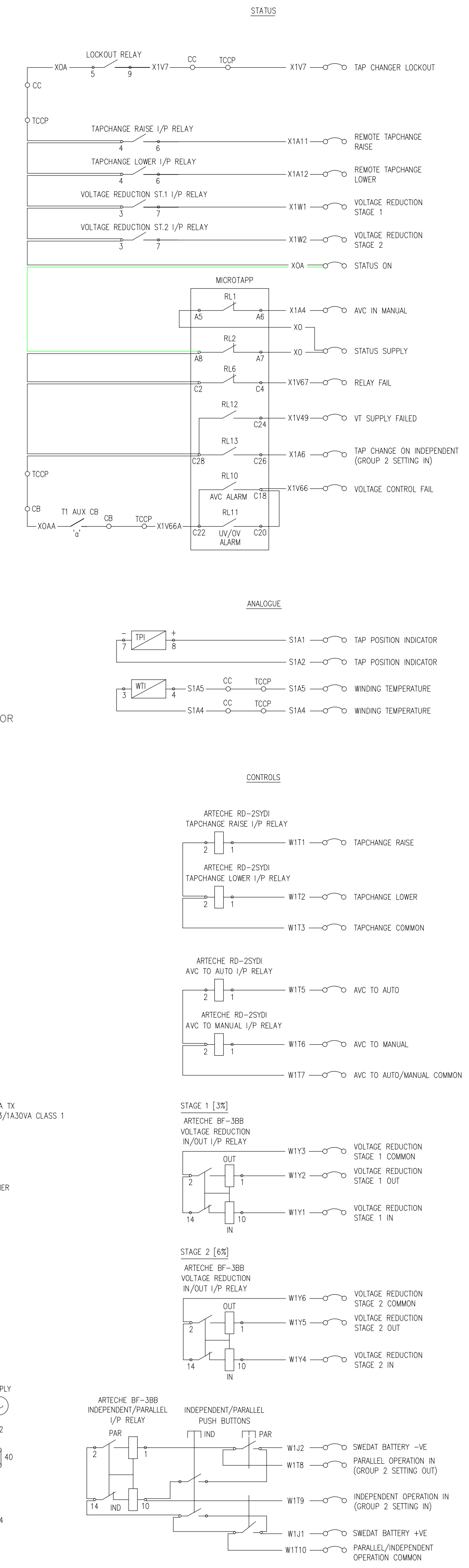
SCALE: NTS | CHECKED: KY | APPROVED: KY

PROJECT NUMBER: 70017751-PO1 | DESIGNED: DS | DRAWN: DS | DATE: 19.01.2016

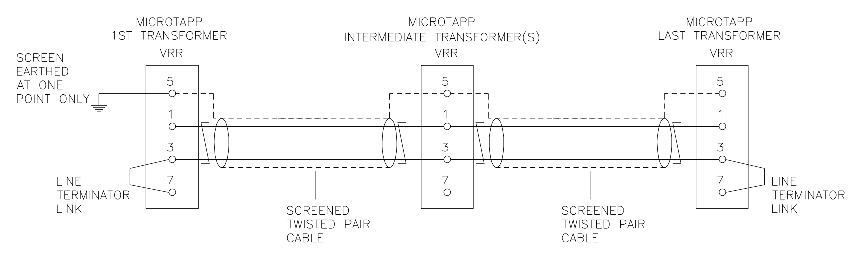
DRAWING No: WP109593_OPTION 2 | REV: 3







PEER TO PEER COMMUNICATION BETWEEN MICROTAPP RELAYS



DRIVE MECHANISM CUBICLE (DM)

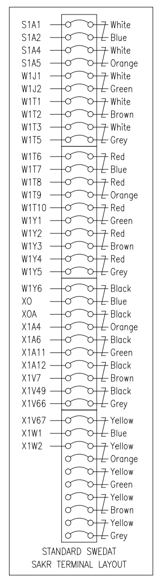
REF.	DESCRIPTION
BC	BLOCKING CONTACTOR
C	CAPACITOR
CCT	CONTROL CIRCUIT TRANSFORMER (200VA 240/55-0-55V)
DMS	DIRECTIONAL MEMORY SWITCH
DSS-L	DIRECTIONAL SEQUENCE SWITCH - LOWER
DSS-R	DIRECTIONAL SEQUENCE SWITCH - RAISE
DSS-RL	DIRECTIONAL SEQUENCE SWITCH - RAISE OR LOWER
H	HEATER
HIS	HANDLE INTERLOCK SWITCH
ILL	ILLUMINATION LAMP
ILS	ILLUMINATION SWITCH
LC	LOWER CONTACTOR
LCS	LOCAL CONTROL SWITCH (RAISE/OFF/LOWER)
LLS	LOWER LIMIT SWITCH
LOR	LOCKOUT RELAY (ARTECHE BF-3)
LSS	LOCAL SELECTOR SWITCH (LOCAL/OFF/REMOTE)
M	MOTOR
MCB1	MINIATURE CIRCUIT BREAKER - 6 AMP
MCB2	MINIATURE CIRCUIT BREAKER - 10 AMP
MCB3	MINIATURE CIRCUIT BREAKER - 6 AMP
MCB4	MOTOR CIRCUIT BREAKER
PIRS	POSITION INDICATION RESISTANCE SWITCH
R	RESISTOR
RC	RAISE CONTACTOR
RLS	RAISE LIMIT SWITCH
RPR	RUNAWAY PREVENTION RELAY (6 SECONDS)
RPRIT	RUNAWAY PREVENTION RELAY INTERPOSING TRANSFORMER
SFR	SUPPLY FAILURE RELAY
SR	STEPPING RELAY
ST	SHUNT TRIP (MOTOR CIRCUIT BREAKER)
T	THERMOSTAT
TIS	TAPCHANGER ISOLATOR SWITCH (OFF/ON)

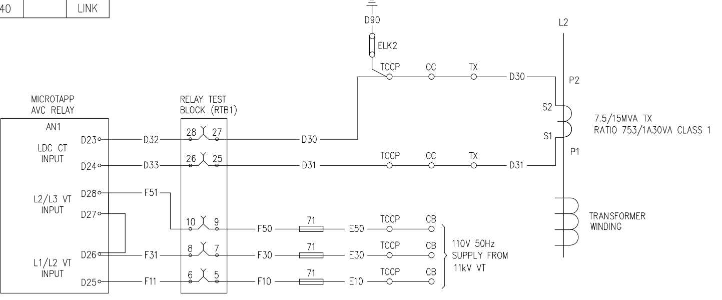
GENERAL NOTES

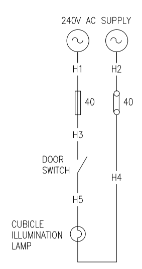
1. ALL EQUIPMENT SHOWN IN THE UNOPERATED NO CURRENT CONDITION.
2. ELECTRICAL SYMBOLS ARE IN ACCORDANCE WITH BS 3939.
3. FOR OTHER CIRCUITS SEE DRG. 6818999.

TAPCHANGE CONTROL PANEL FUSE & LINK TABLE

PANEL POS.	INSCRIPTION		REF	FUSE	LINK
1	VOLTAGE REGULATING RELAY AUXILIARY SUPPLY	110V AC	89	2A	
2	VOLTAGE REGULATING RELAY AUXILIARY SUPPLY	110V AC	89	2A	
3	VOLTAGE REGULATING RELAY VT SUPPLY (L1)	110V AC	71	2A	
4	VOLTAGE REGULATING RELAY VT SUPPLY (L2)	110V AC	71	2A	
5	VOLTAGE REGULATING RELAY VT SUPPLY (L3)	110V AC	71	2A	
11	TAP POSITION INDICATOR TRANSDUCER SUPPLY	110V AC	77	2A	
12	TAP POSITION INDICATOR TRANSDUCER SUPPLY	110V AC	77	2A	
35	INDICATION AC/DC SUPPLY	110V AC/DC	5	2A	
36	INDICATION AC/DC SUPPLY	110V AC/DC	5		LINK
47	CUBICLE ILLUMINATION SUPPLY PH	240V AC	40	2A	
48	CUBICLE ILLUMINATION SUPPLY N	240V AC	40		LINK







NOTES

1. DRAWING SHOWS CIRCUITS WITH CB's & DISCONNECTORS IN THE OPEN POSITION, RELAYS DE-ENERGISED AND SUPPLIES OFF (MICROTAPP RELAY IN MANUAL & SUPERVISORY)
2. FOR TWO OR MORE TRANSFORMERS IN PARALLEL AT THE SAME SITE, THE PREFERRED MODE OF OPERATION IS CIRCULATING CURRENT.
3. WHEN TWO OR MORE TRANSFORMERS ARE OPERATING IN PARALLEL CIRCULATING CURRENT MODE, THE LOSS OF ONE TRANSFORMER SHOULD CAUSE 'GROUP 2' SETTINGS TO BE SELECTED ON THE RELAY. LV CB AUXILLIARY CONTACTS ARE TO BE USED TO ACHIEVE THIS. THE GROUP 2 SETTINGS WILL NORMALLY BE CONFIGURED FOR INDEPENDENT AUTO OPERATION. MANUAL SELECTION OF 'INDEPENDENT' OR 'PARALLEL' OPERATION SHOULD ALSO BE PROVIDED.
4. FOR CERTAIN CONDITIONS (COMMUNICATION LOSS BETWEEN RELAYS, VT FAIL), THE RELAYS WILL REVERT TO TAPP MODE FOR THIS REASON, A VALID SYSTEM POWER FACTOR MUST BE SET, EVEN WHEN USING CIRCULATING CURRENT MODE OF CONTROL.
5. ADDITIONAL RESISTOR REQUIRED WHEN TRANSFORMER USES RESISTOR TYPE TPI SENDER UNIT. THE VALUE OF THE RESISTOR IS TO BE THE SAME AS TAP INTERVAL RESISTOR. THE RESISTOR LADDER SHOULD HAVE A TOTAL RESISTANCE GREATER THAN 250 AND LESS THAN 100k.
6. MICROTAPP RELAY TERMINAL NUMBERS AS FOLLOWS:
   PSU MODULE, PREFIX 'A'. i.e. A13, A14
   I01 MODULE, PREFIX 'B'
   I02 MODULE, PREFIX 'C'
   AN1 MODULE, PREFIX 'D'
7. TELECONTROL INTERPOSING RELAYS ARE FITTED WITH INTERNAL ARC SUPPRESSION DIODES
8. TAPCHANGER DRAWING TAKEN FROM A BRUSH TRANSFORMER WITH ON LOAD TAPCHANGER TYPE ATL. TAPCHANGER SHOWN AT LOWER LIMIT POSITION (TAP 1 WITH LLS OPEN)
9. ASTERISK DENOTES A FOR CONNECTIONS TO T1 AVC RELAY AND B FOR CONNECTIONS TO T2 AVC RELAY.

DELETIONS DENOTED IN GREEN

REV	DATE	BY	DESCRIPTION	CHK	APP
2	3/06/15		UPDATED		MBE
1	18/09/13		GROUP 1 SETTINGS INPUT ADDED TO AVC RELAY		MBE

DRAWING STATUS:

http://www.wspgroup.com

CLIENT: WESTERN POWER DISTRIBUTION

ARCHITECT:

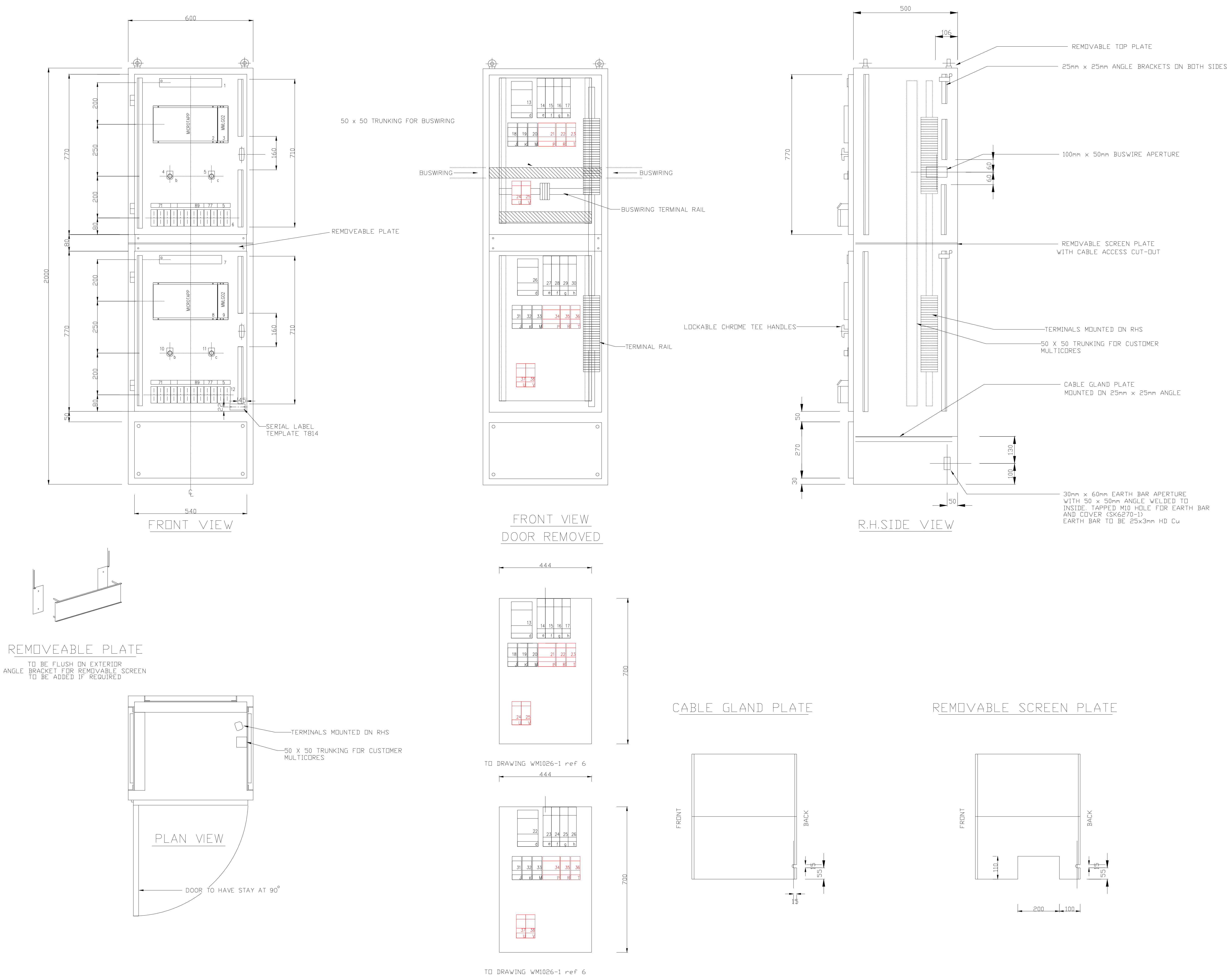
PROJECT: WPD LCNF TIER-2 NETWORK EQUILIBRIUM

TITLE: WATERLAKE 33/11kV SUBSTATION CIRCUIT DIAGRAM CONTROL FOR AUTOMATIC VOLTAGE & TAP CUBICLE CONTROL FOR T2

SCALE:	CHECKED:		APPROVED:
NTS	KY		KY
PROJECT NUMBER: 70017751-PO1	DESIGNED: DS	DRAWN: DS	DATE: 19.01.2016

DRAWING No: WP109593 | REV: 2

DRAWING CREATED IN REVIT.



EQUIPMENT SCHEDULE			
REF.	DESCRIPTION	TAG No.	TEMPLATE
1	MAIN LABEL 300 x 50		T661
2	SIEMENS MICROTAPP RELAY 7SG1510-1HJ30-0GA0	IR0098	T758/M12
3	ALSTOM MMLG02R1AA0001E TESTBLOCK	SR0001	T758/M2
4	HIGHLAND ELECTRONICS ILLUMINATED PUSHBUTTON PARALLEL	PB0002	23MM DIA
5	HIGHLAND ELECTRONICS ILLUMINATED PUSHBUTTON INDEPENDENT	PB0002	23MM DIA
6	GEC RS20P FUSE & LINK FITTINGS MOUNTED AT 32mm C/C		T679
7	MAIN LABEL 300 x 50		T661
8	SIEMENS MICROTAPP RELAY 7SG1510-1HJ30-0GA0	IR0098	T758/M12
9	ALSTOM MMLG02R1AA0001E TESTBLOCK	SR0001	T758/M2
10	HIGHLAND ELECTRONICS ILLUMINATED PUSHBUTTON PARALLEL	PB0002	23MM DIA
11	HIGHLAND ELECTRONICS ILLUMINATED PUSHBUTTON INDEPENDENT	PB0002	23MM DIA
12	GEC RS20P FUSE & LINK FITTINGS MOUNTED AT 32mm C/C		T679
13	FUNDAMENTALS FTPT/2 TAP POSITION TRANSDUCER	TR0001	INTERNAL
14	ARTECHE RD-2SYDI 48V TAPCHANGE RAISE I/P RELAY	SR0055	INTERNAL
15	ARTECHE RD-2SYDI 48V TAPCHANGE LOWER I/P RELAY	SR0055	INTERNAL
16	ARTECHE RD-2SYDI 48V AVC TO AUTO I/P RELAY	SR0055	INTERNAL
17	ARTECHE RD-2SYDI 48V AVC TO MANUAL I/P RELAY	SR0055	INTERNAL
18	ARTECHE BF-3BB 48V STAGE 1 VOLTAGE REDUCTION IN/OUT I/P RELAY	SR0056	INTERNAL
19	ARTECHE BF-3BB 48V STAGE 2 VOLTAGE REDUCTION IN/OUT I/P RELAY	SR0056	INTERNAL
20	ARTECHE BF-3BB 48V INDEPENDENT/ PARALLEL I/P RELAY	SR0056	INTERNAL
21	ARTECHE BJ-8BB 48V SVO IN/OUT I/P RELAY T1	TBC	INTERNAL
22	ARTECHE BF-3BB 48V SVO GROUP 3 SETTING ENABLE/DISABLE T1	TBC	INTERNAL
23	ARTECHE BF-3BB 48V SVO GROUP 4 SETTING ENABLE/DISABLE T1	TBC	INTERNAL
24	ARTECHE BF-3BB 48V SVO GROUP 5 SETTING ENABLE/DISABLE T1	TBC	INTERNAL
25	ARTECHE BF-3BB 48V SVO GROUP 6 SETTING ENABLE/DISABLE T1	TBC	INTERNAL
26	FUNDAMENTALS FTPT/2 TAP POSITION TRANSDUCER	TR0001	INTERNAL
27	ARTECHE RD-2SYDI 48V TAPCHANGE RAISE I/P RELAY	SR0055	INTERNAL
28	ARTECHE RD-2SYDI 48V TAPCHANGE LOWER I/P RELAY	SR0055	INTERNAL
29	ARTECHE RD-2SYDI 48V AVC TO AUTO I/P RELAY	SR0055	INTERNAL
30	ARTECHE RD-2SYDI 48V AVC TO MANUAL I/P RELAY	SR0055	INTERNAL
31	ARTECHE BF-3BB 48V STAGE 1 VOLTAGE REDUCTION IN/OUT I/P RELAY	SR0056	INTERNAL
32	ARTECHE BF-3BB 48V STAGE 2 VOLTAGE REDUCTION IN/OUT I/P RELAY	SR0056	INTERNAL
33	ARTECHE BF-3BB 48V INDEPENDENT/ PARALLEL I/P RELAY	SR0056	INTERNAL
34	ARTECHE BJ-8BB 48V SVO IN/OUT I/P RELAY T2	TBC	INTERNAL
35	ARTECHE BF-3BB 48V SVO GROUP 3 SETTING ENABLE/DISABLE T2	TBC	INTERNAL
36	ARTECHE BF-3BB 48V SVO GROUP 4 SETTING ENABLE/DISABLE T2	TBC	INTERNAL
37	ARTECHE BF-3BB 48V SVO GROUP 5 SETTING ENABLE/DISABLE T2	TBC	INTERNAL
38	ARTECHE BF-3BB 48V SVO GROUP 6 SETTING ENABLE/DISABLE T2	TBC	INTERNAL

REF	INSCRIPTION	SIZE	QUANTITY
a	33/11kV TRANSFORMER No.1 /No.2	300 x 50	1 each
b	PARALLEL	LBL22	2
c	INDEPENDENT	LBL22	2
d	TPI TRANSDUCER	100 x 24	2
e	TAPCHANGE RAISE	40 x 24	2
f	TAPCHANGE LOWER	40 x 24	2
g	AVC TO AUTO INTERPOSING	40 x 24	2
h	AVC TO MANUAL INTERPOSING	40 x 24	2
j	VOLTAGE REDUCTION INTERPOSING RELAY STAGE 1	60 x 24	2
k	VOLTAGE REDUCTION INTERPOSING RELAY STAGE 2	60 x 24	2
m	INDEPENDENT / PARALLEL INTERPOSING	60 x 24	2
n	EARTH LINK LDC CT	40 x 8	2
P	SVO IN/OUT I/P RELAY	82 x 112	2
R	GROUP SETTINGS 3	45 x 112	2
T	GROUP SETTINGS 4	45 x 112	2
U	GROUP SETTINGS 5	45 x 112	2
V	GROUP SETTINGS 6	45 x 112	2

NOTES

1. PANELS ARE TO BE CONSTRUCTED GENERALLY FROM 3mm SHEET STEEL FOLDED AND WELDED.
2. PAINT FINISH TO BE; EXTERIOR & INTERIOR BS381C SHADE 631 SEMI GLOSS
3. ALL DIMENSIONS ARE SHOWN IN mm
4. ALL LABELS ARE TO BE WHITE TRAFFOLYTE ENGRAVED WITH BLACK LETTERING FIXED TO SUFACE OF PANEL WITH M3 X 6 BRASS NICKEL
5. EQUIPMENT PLATE AND METAL STRAPS ARE TO BE CUT TO FIT SIDE AND AND BACK BRACKETS (NON-STANDARD)
6. EARTHING FIXTURE NEEDED ON BOTH DOORS
7. TO BE CONSTRUCTED GENERALLY TO DRAWING WM3570-3

ADDITIONS DENOTED IN RED

REV	DATE	BY	DESCRIPTION	CHK	APP
B	18/02/16	DS	SVO RELAYS ADDED TO DRAWING	KY	KY
A	27/01/16	DS	FIRST ISSUE	KY	KY

DRAWING STATUS: ISSUED FOR COMMENT

WSP | PARSONS BRINCKERHOFF

http://www.wspgroup.com

CLIENT: WESTERN POWER DISTRIBUTION

ARCHITECT:

PROJECT: WESTERN POWER DISTRIBUTION NETWORK EQUILIBRIUM PROJECT

TITLE: WATERLAKE 33/11kV SUBSTATION GENERAL ARRANGEMENT OF T1 & T2 DUAL CIRCUIT AVC CUBICLE OPTION 2

SCALE @ A1: NTS | CHECKED: KY | APPROVED: KY

PROJECT NUMBER: 70017751-PO1 | DESIGNED: DS | DRAWN: DS | DATE: 18.02.2016

DRAWING No: WP112946_OPTION 2 | REV: B

DRAWING CREATED IN REVIT

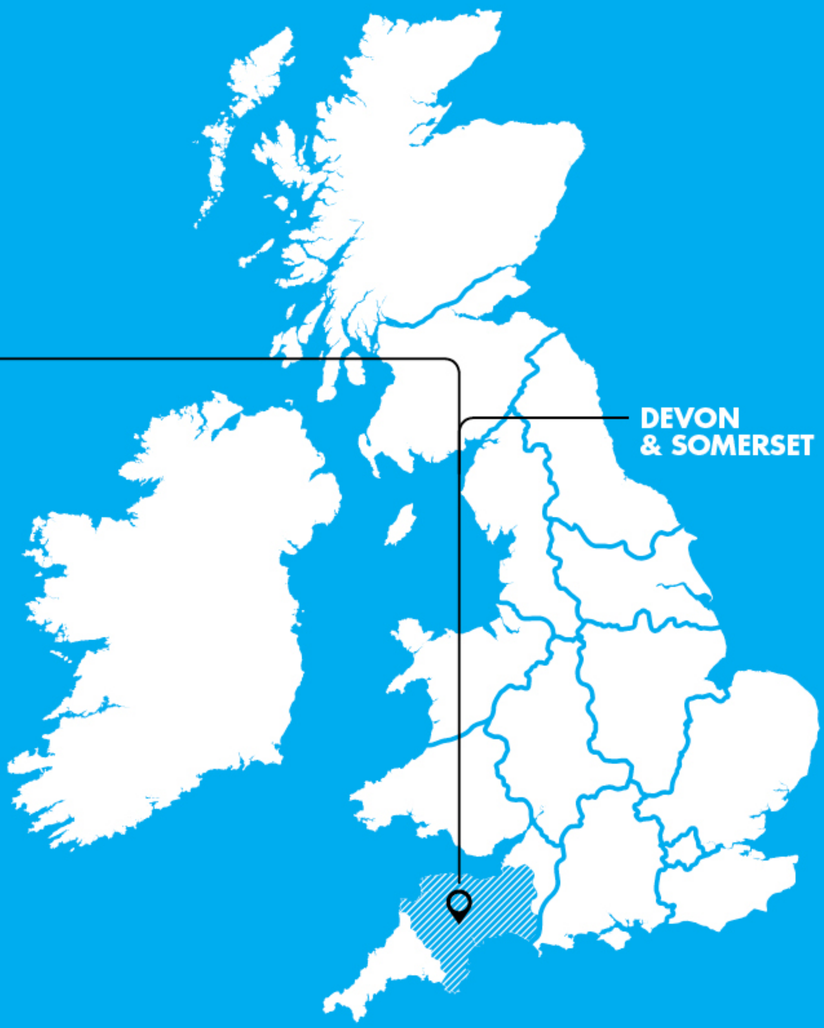
SDRC2 Appendix F - Substation Investigation Reports

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Bowhays Cross 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Bowhays Cross Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Bowhays Cross 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Bowhays Cross 132/33kV Substation belongs to the Seabank-Bridgwater-Taunton Grid Group and is normally fed via two 132kV overhead circuits from Taunton GSP. It has two 40/60MVA 132/33kV transformers operating with the bus section normally closed.

The substation was originally constructed in the mid 1970's with both transformers replaced between 2006 and 2008 and the 33kV switchgear replaced in 2010.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to remain relatively constant over the next five years with the firm capacity not being reached.

Table 2-1: Load forecast for Bowhays Cross 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Bowhays Cross	132/33	0.96	44.89	44.45	44.53	44.63	44.87	45.22	78

2.4 Customers

2.4.1 Number of Customers

Bowhays Cross supplies five primary substations with normally open connections to a further two. The total number of customers supplied is 42,736.

2.4.2 Type of Loads

The primary substations supplied from Bowhays Cross are located in mainly rural areas and as such the main load types are domestic and light industrial. There is a single 33kV supplied load customer connected to Bowhays Cross BSP via two 33kV feeders. There is a single customer on the 33kV network that is considered as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation currently feeding into the Bowhays Cross BSP network is 5.82MW from a single solar PV connection. Three further solar PV connections are committed which will be connected to the 33kV network adding a further 17.52MW of generation to give a total of 23.34MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

The two 40/60MVA 132/33kV transformers at Bowhays Cross were manufactured in 2001 and 2005 respectively and commissioned on site between 2006 and 2008. Both were manufactured by EBG with 19 position ATL-AE3 tap changers installed.

2.5.2 Automatic Voltage Control Relays

Bowhays Cross currently utilises two MVGC01 relays for voltage control of its transformers. The existing scheme was installed in 1994 with modifications carried out following the replacement of the 132/33kV transformers and 33kV switchgear.

2.5.3 Auxiliary Systems

The substation contains an 110V battery that was installed in 2009 alongside the replacement of the 33kV switchgear. The D20 SCADA communications system was also installed alongside the 33kV switchgear replacement works.

3 SVO Method Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Bowhays Cross Feeder Voltage Analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.034	1.006
2	1.042	1.007
3	**1.069**	1.019
4	1.039	1.019
5	1.041	1.023
6	1.049	0.997
7	1.031	**0.994**

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Bowhays Cross BSP over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

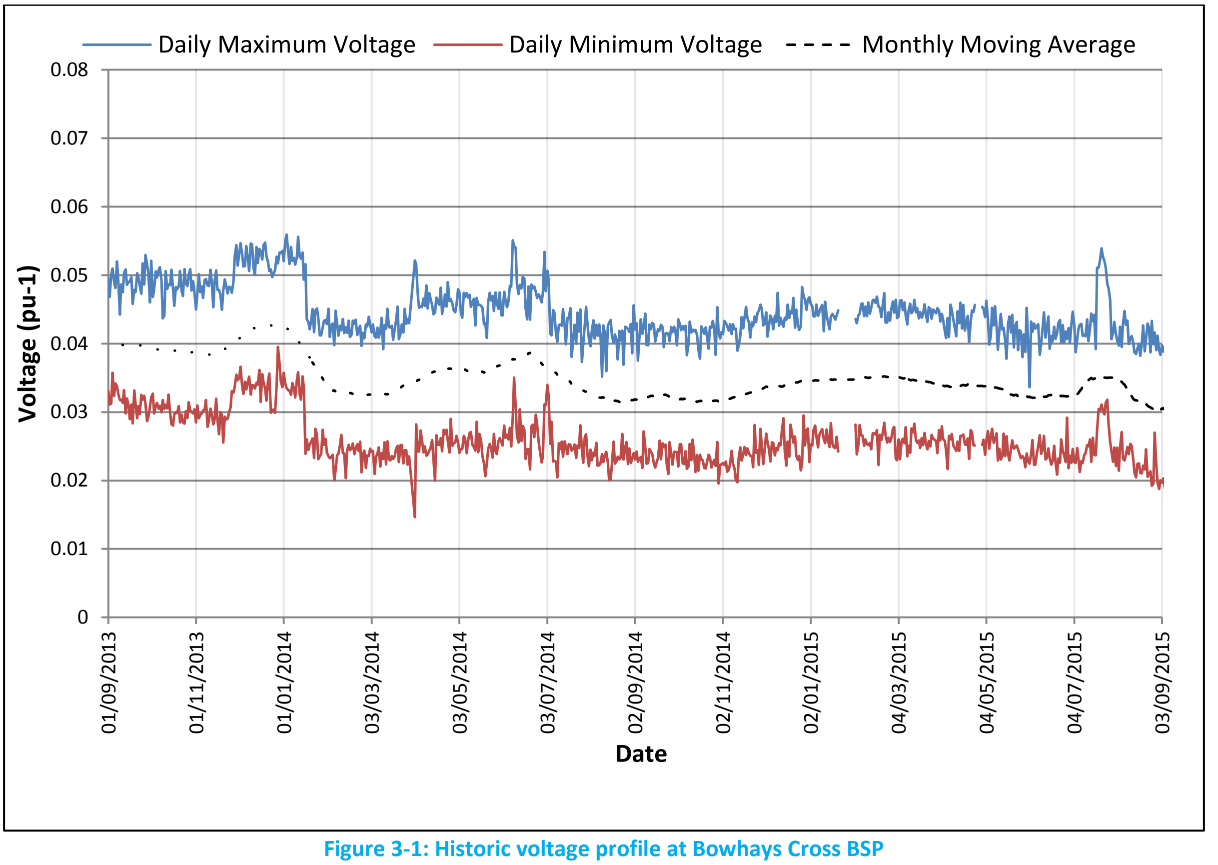


Figure 3-1: Historic voltage profile at Bowhays Cross BSP

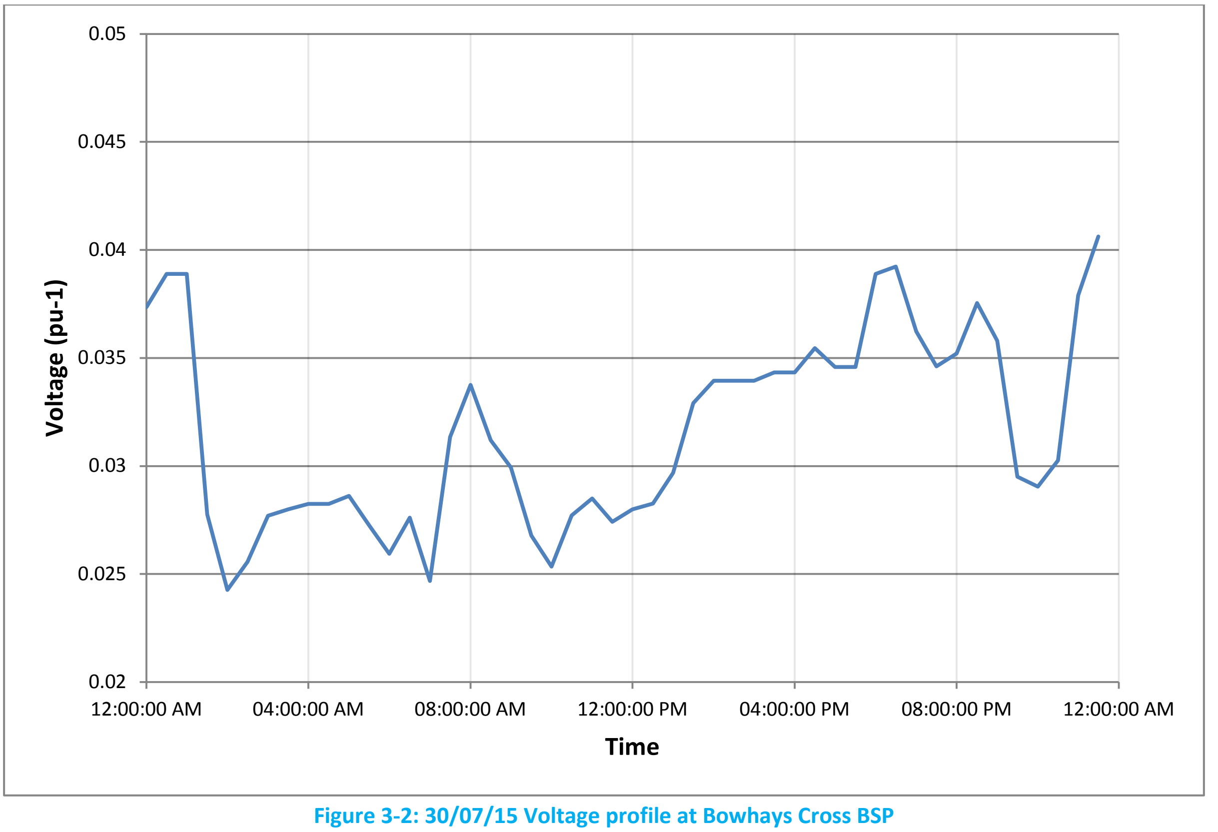


Figure 3-2: 30/07/15 Voltage profile at Bowhays Cross BSP

3.2.3 Results

The study results show that for Bowhays Cross BSP, the voltage can be reduced by 0.054pu and still keep all parts of the 33kV network within statutory limits. It is not possible to increase the voltage and remain within statutory limits.

The historical voltage profiles show that the voltage has gradually decreased from 0.04pu to 0.03pu above nominal over the last two years with an average daily fluctuation in voltage of 0.019pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Bowhays Cross the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Bowhays Cross Feeder Measurement Locations

Bowhays Cross BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Alcombe 11kV	NO	YES
Holford 11kV	NO	YES
Luckwell Road 11kV	YES	YES
Periton 11kV	NO	YES
Wiveliscombe 11kV	YES	YES
Bowhays Cross 11 kV	YES	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Bowhays Cross BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Bowhays Cross BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

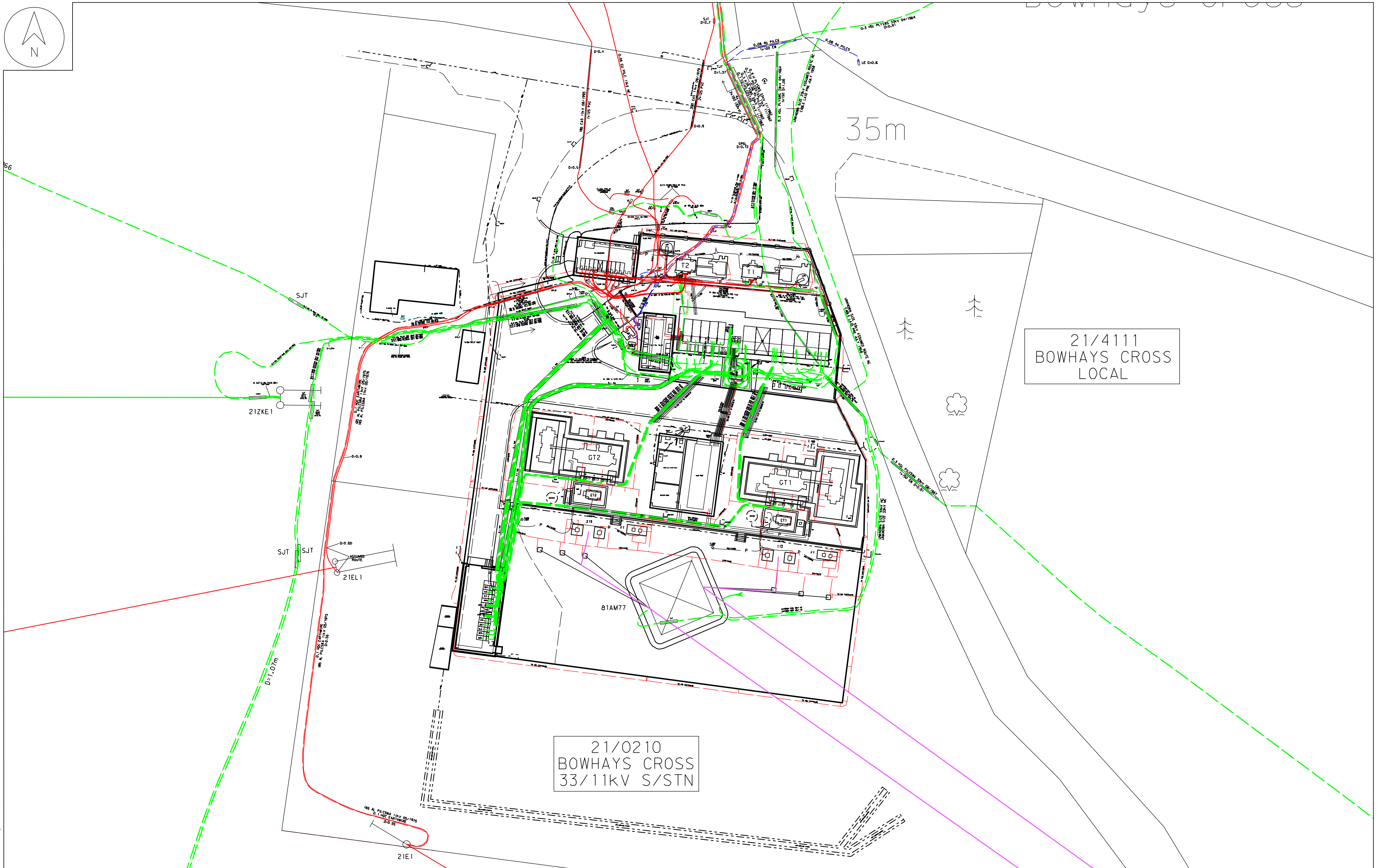
Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS — S — S —

PILOT CABLES P —— P —— P

	OVERHEAD LINE	UNDERGROUND CABLE
PL		
SERVICE		
LV		
HV (11kV)		
HV (33kV)		
HV (66kV)		
HV (132kV)	✳	✳

PME Earth

E — Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: BOWHAYS CROSS
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 306398.019,140783.296

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
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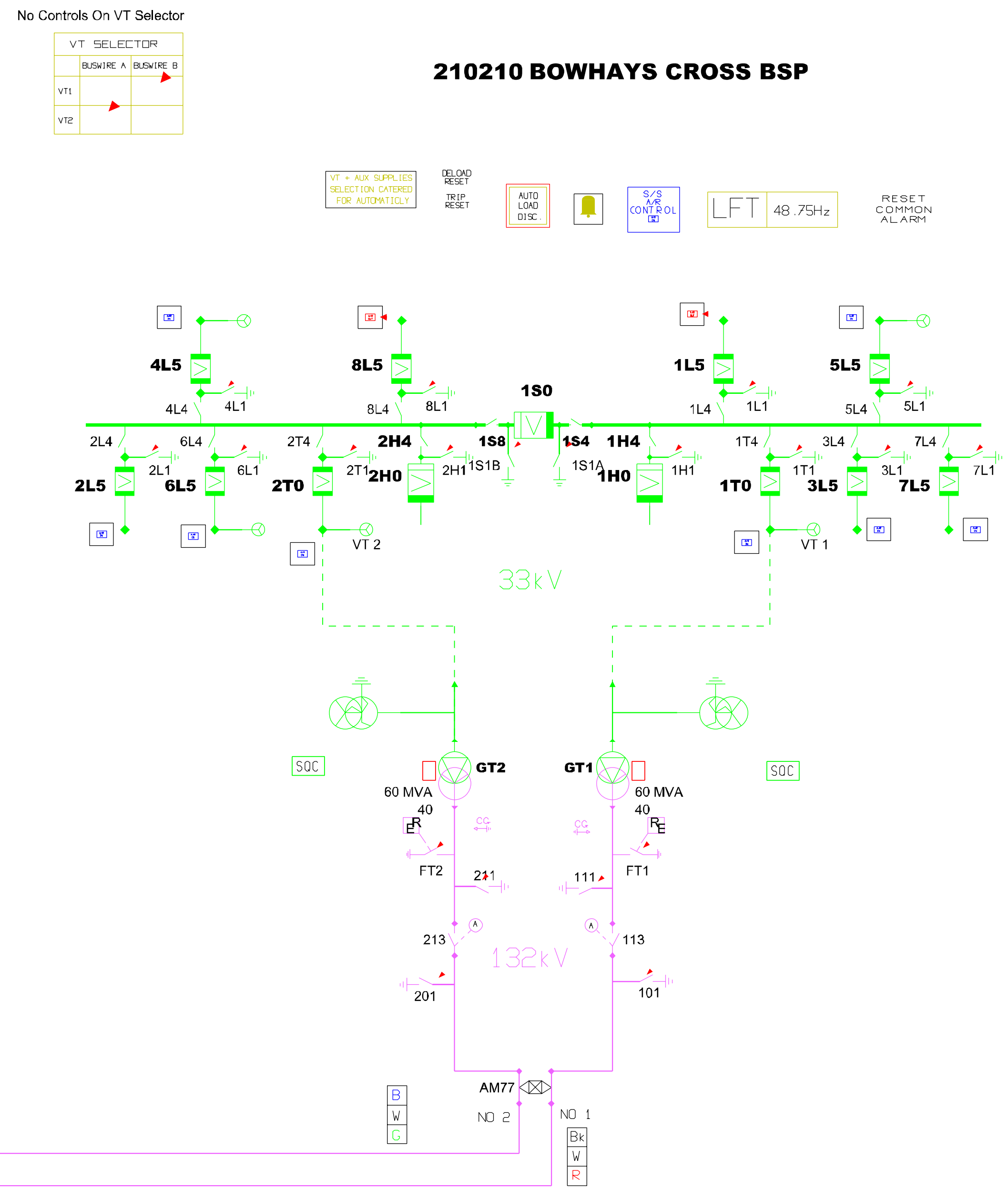
210210 BOWHAYS CROSS BSP



Tiles: 28, 29, 39, 40

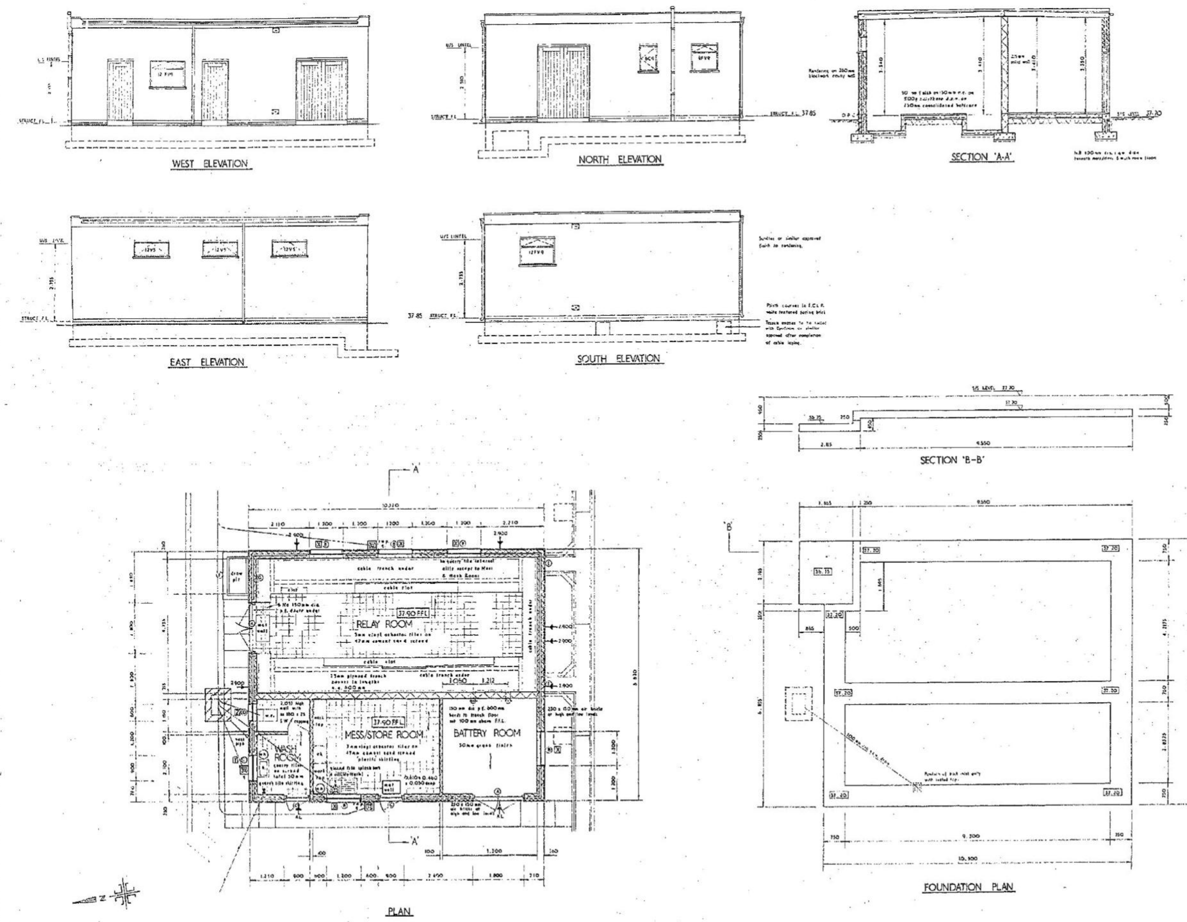
Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT

BOWHAYS CROSS — 02/C908



LINTEL SCHEDULE

PLAN	DETAILS			BENDING SCHEDULE								SECTION
	LOCATION	No	LENGTH	MARK	TYPE & SIZE	No EACH	TOTAL No	LENGTH	BENDING	POSITION	DIM'S	DIMENSIONS :- a = 215, b = 190
LENGTH; 1.500 (A), 1.200 (B), 900 (C), 600 (D), 500 (E)	A	2	2.230	1	R12	2	4	2.315	2 155	BOTTOM	b	
				2	R12	1	2	2.155	STRAIGHT	TOP		
				3	R12	1	2	1.740	STRAIGHT	TOE		
				4	R6	12	24	705		155 crs		
	B	5	1.630	5	R10	2	10	1.555	1.555	BOTTOM	a	
				6	R10	1	5	1.555	STRAIGHT	TOP		
				7	R10	1	5	1.150	STRAIGHT	TOE		
				8	R6	8	40	560		160 crs		
	C	3	1.330	9	R10	2	6	1.360	1.260	BOTTOM		
				10	R10	1	3	850	STRAIGHT	TOE		
				11	R6	7	21	190	STRAIGHT	140 crs		
	D	1	1.030	12	R10	2	2	1.060	950	BOTTOM		
				13	R10	1	1	550	STRAIGHT	TOE		
				11	R6	5	5	190	STRAIGHT	150 crs		
	E	2	760	14	R10	2	4	800	700	BOTTOM		
				15	R10	1	2	450	STRAIGHT	TOE		
				11	R6	4	8	190	STRAIGHT	140 crs		
1.650	F	1	1.660	12	R12	2	2	1.720	1.500	BOTTOM		215 × 215
				13	R10	2	2	1.600	STRAIGHT	TOP		
				14	R6	8	8	720		215 crs		
1.730	G	1	1.730	15	R12	3	3	1.790	1.670	BOTTOM		310 × 215
				16	R10	2	2	1.670	STRAIGHT	TOP		
				17	R6	8	8	910		225 crs.		

SILL SCHEDULE

PLAN	SECTION	DETAILS			REINFORCEMENT
		LOCATION	No	LENGTH	
LENGTH; 50 OPENING 50; 1.300 (X), 0.900 (Y), 0.600 (Z)		X	5	1300	Each sill to receive nominal reinforcement, 2 No. R10 bars laid in bottom. (15mm min. bottom cover & 25mm min. cover to exposed surfaces)
		Y	1	1000	
		Z	1	0700	

NOTES:

1. For location see Drg No. 02/C903
2. For Control Building - Building Details see Drg. No. 02/C909
3. For LVAC / Relay Room Floor Details see Drg. No. 02/C910
4. For details of external trenches see Drg. No. 00/16/118 & 00/16/119.
5. Span of roof units shown thus :- ⟵
6. Letters thus Ⓐ indicate type of lintel.
7. Letters thus ☒ indicate type of sill.
8. Concrete lintels & sills to be 35(20) mix & fair faced on exposed surfaces
9. Internal Thermalite blockwork to be suitable for paint finish. External blockwork to be standard for rendered finish.
10. Position of heating & lighting conduit shown thus :- ⟵ A.L. = above lintel 2.900 = height above substation level.

B423 - D

Issue	Revision	Sig	Date	Issue	Revision	Sig	Date				Drawing Number
								FIRST ISSUE	Date	SOUTH WESTERN ELECTRICITY BOARD, AREA HEADQUARTERS, BRISTOL	02/C908.
								Drawn MWR/RS	14.5.75	BOWHAYS CROSS 132/33kV SUBSTATION CONTROL BUILDING, PLAN AND ELEVATION.	
								Checked			
								Approved			
								SCALE 1:50			

APPENDIX D - SITE PHOTOS


P5
132/33kV TRANSFORMER Nº2
TAP POSITION INDICATOR
MVGC

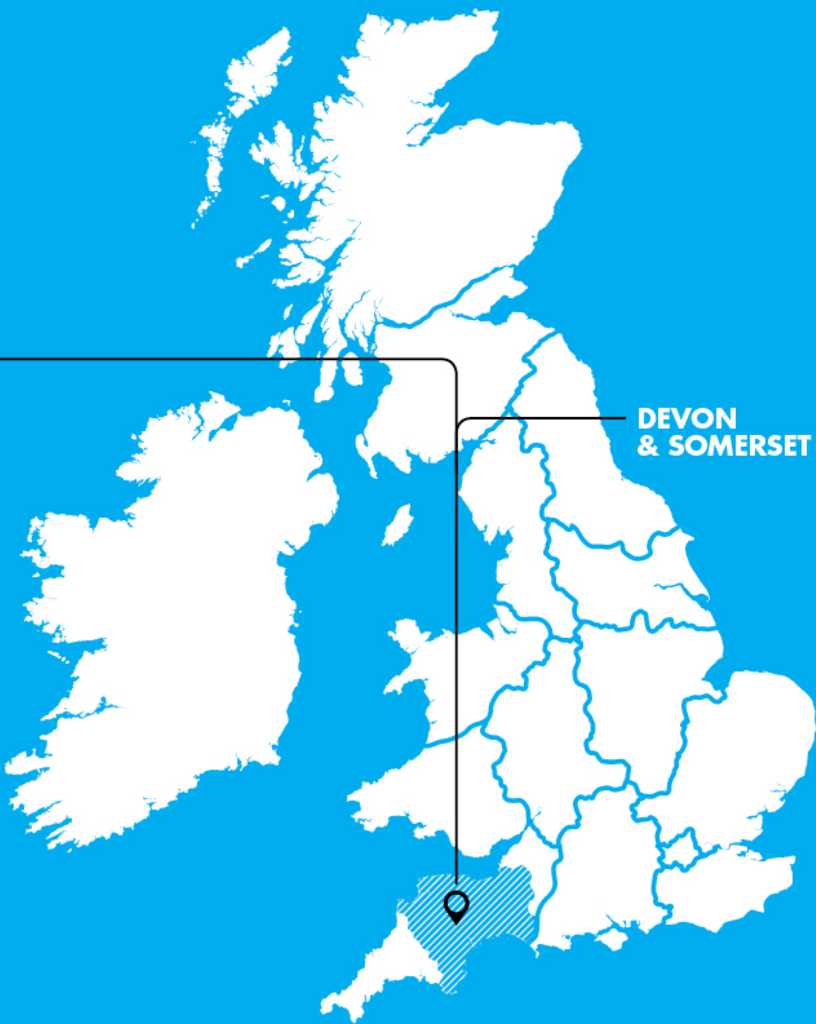

MVGC
ALARM
VOLTS HIGH
TAP
VOLTS LOW
TEST VOLTS ADJUST
VOLTAGE MONITOR

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Bridgwater 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Bridgwater Main Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

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1 Introduction

The following report details the findings from the investigation of Bridgwater Main 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Bridgwater Main 132/33kV substation belongs to the Seabank-Bridgwater-Taunton Grid Group and is normally fed via three 132kV circuits from Bridgwater Main GSP. The substation is normally operated in parallel with a single transformer at Street 132/33kV substation. Bridgwater Main BSP has one 132/33kV 30/60MVA transformer and two 40/60MVA transformers operating together with the bus section normally closed.

The substation was originally constructed in the mid 1970's with the 33kV switchboard and two of the transformers upgraded in 2013.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at this substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to decrease until 2017/18 before increasing again. The peak demand has reached the firm capacity of the substation.

Table 2-1: Load forecast for Bridgwater Main 132/33kV substation [2015 LTDS: Table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Bridgwater Main	132/33	0.96	142.02	139.26	137.58	136.62	136.85	138.43	137.16

2.4 Customers

2.4.1 Number of Customers

The combined Bridgewater Main and Street BSPs supply sixteen primary substations. The total number of customers supplied from both is 47,398.

2.4.2 Type of Loads

The primary substations supplied from Bridgwater Main and Street BSPs are located in both urban and rural areas. The substation therefore supplies a wide range of load types with both high and low demands. There are also several 33kV connected customers including a landfill site and multiple farms. There is a single customer on the 33kV network that is considered as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Bridgwater Main network is currently 115.66MW. Connected to the 33KV network is 81.45MW, with the 11kV network having 34.21MW connected.

The 33kV connection is made up of 10 solar PV sites totalling 61.75MW and two gas sites totalling 19.7MW. Seven further solar PV sites are committed for future connection to the 33KV network which will add a further 62.22MW of generation.

The 34.21MW connected to the 11kV networks fed from Bridgwater Main BSP is made up of a mix of PV, STOR, CHP and other alternative sources. A further 18.35MW of solar PV generation is committed for future connection.

Overall, the committed generation at both voltage levels will add 80.57MW of embedded generation giving a total of 196.23MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

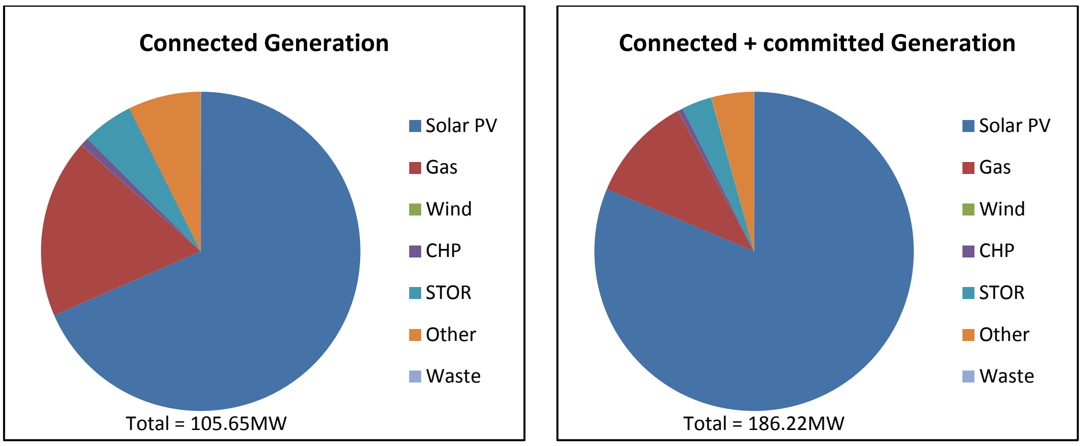


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

The original two transformers at Bridgwater Main BSP were replaced in 2013 with two 40/60MVA transformers from ABB with 19 position ABB VUCG tap changers. The other 30/60MVA transformer was manufactured by Peebles Power Transformers in 1987 and has a 19 position tap changer.

2.5.2 Automatic Voltage Control Relays

Bridgwater Main BSP currently utilises three KVGC202 relays for voltage control of its transformers. The existing scheme was installed in 2013 alongside the replacement the switchgear and transformers.

2.5.3 Auxiliary Systems

The substation contains an 110V battery that was installed in 2013 alongside the replacement of the 33kV switchgear. The D20 SCADA communications system was also installed alongside the 33kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Bridgwater Main Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.030	**0.940**
2	1.018	0.986
3	**1.060**	0.973
4	1.037	0.985
5	1.032	0.996
6	1.031	0.990
7	1.032	1.007
8	1.034	1.006
9	1.041	0.990
10	1.049	0.963
11	1.032	1.001
12	1.032	1.001
13	1.032	1.006
14	1.033	1.007

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Bridgwater Main over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

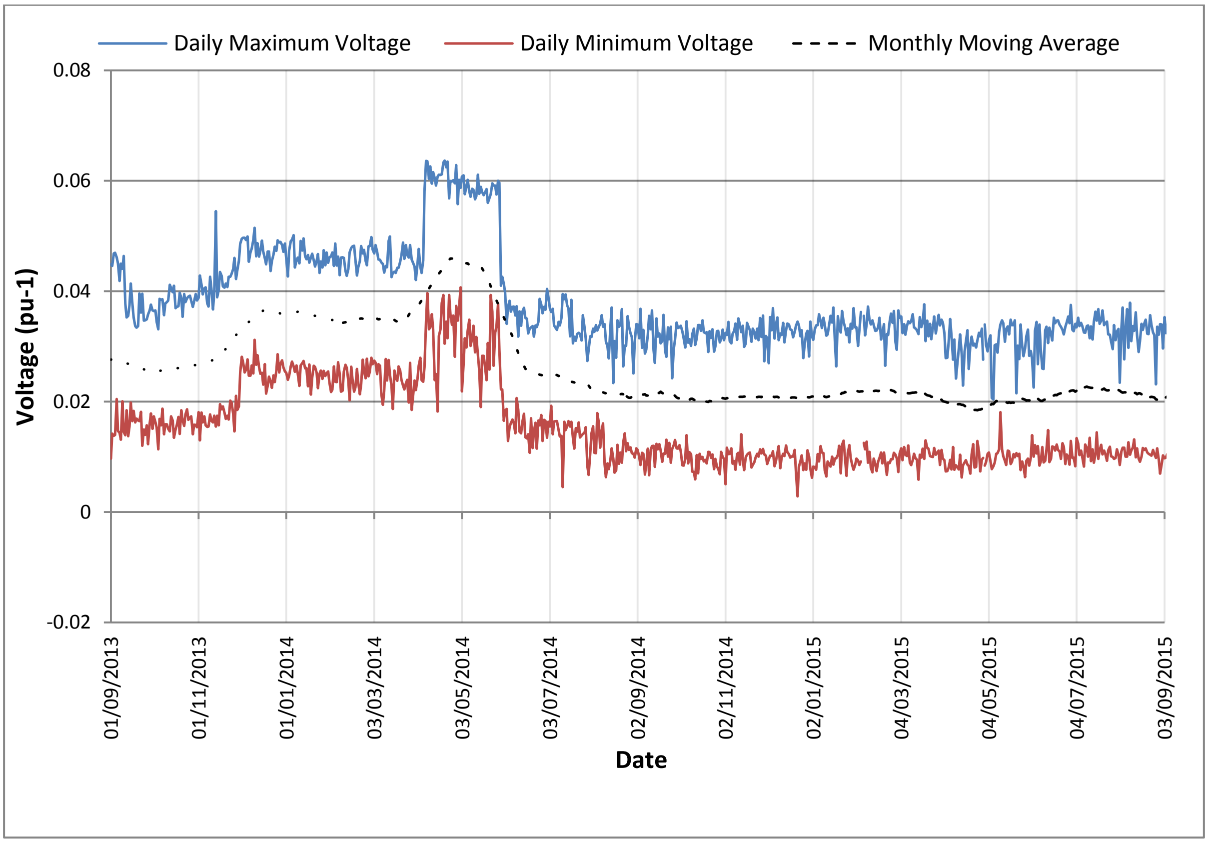


Figure 3-1: Historic voltage profile at Bridgwater 132/33kV

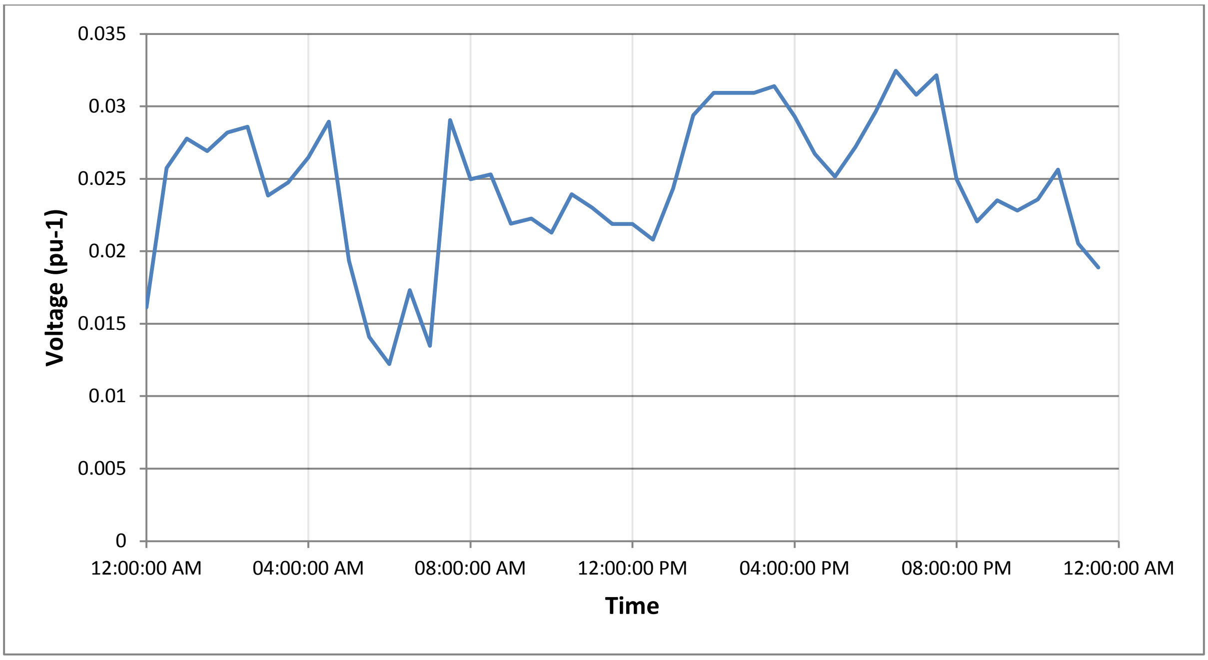


Figure 3-2: 10/07/15 Voltage profile at Bridgwater 132/33kV

3.2.3 Results

The study results show that for Bridgewater Main BSP, the voltage cannot be reduced or increased and remain within statutory limits.

The historical voltage profiles show that the voltage initially fluctuated due to replacement works being carried out, but following completion of the works in the summer of 2014 the average voltage has been consistently around 0.02pu above nominal.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Bridgwater Main BSP the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panel at Bridgwater Main BSP is a fixed front, rear access 19" panel. Therefore, the existing relay can be easily removed, along with some blanking plates in order to accommodate a new relay. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Bridgwater Main BSP feeder measurement locations

Bridgwater Main BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Bath Road 11kV	YES	YES
Bridgwater Local 11kV	YES	YES
Burnham 11kV	NO	YES
Colley Lane 11kV	NO	YES
Creech St Michael 11kV	YES	YES
Nether Stowey 11kV	NO	YES
Watchfield 11kV	YES	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing auxiliary systems at the substation are sufficient for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Bridgwater Main BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Bridgwater Main BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

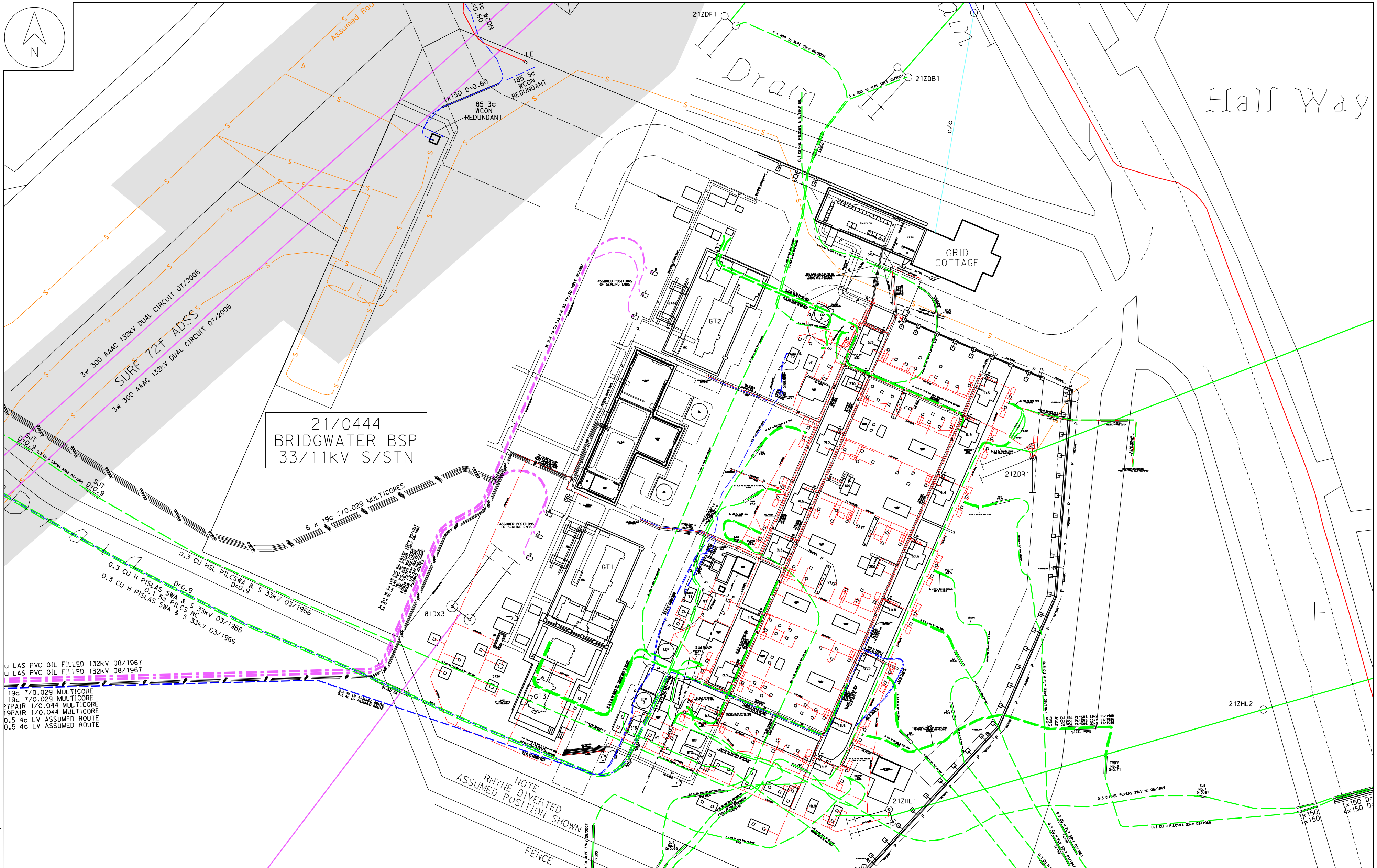
Table 4-1: Site specific risks

Risk	Effect	Action
One of the remaining two transformers trip when working on one transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

SURF TELECOMS APPARATUS	OVERHEAD LINE	UNDERGROUND CABLE
PILOT CABLES	PL	
	SERVICE	
	LV	
	HV (11kV)	
	HV (33kV)	
	HV (66kV)	
	HV (132kV)	

PME Earth — Underground Earth — Pole Mounted Transformer — Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: BRIDGWATER BSP
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 332505.936,135867.744

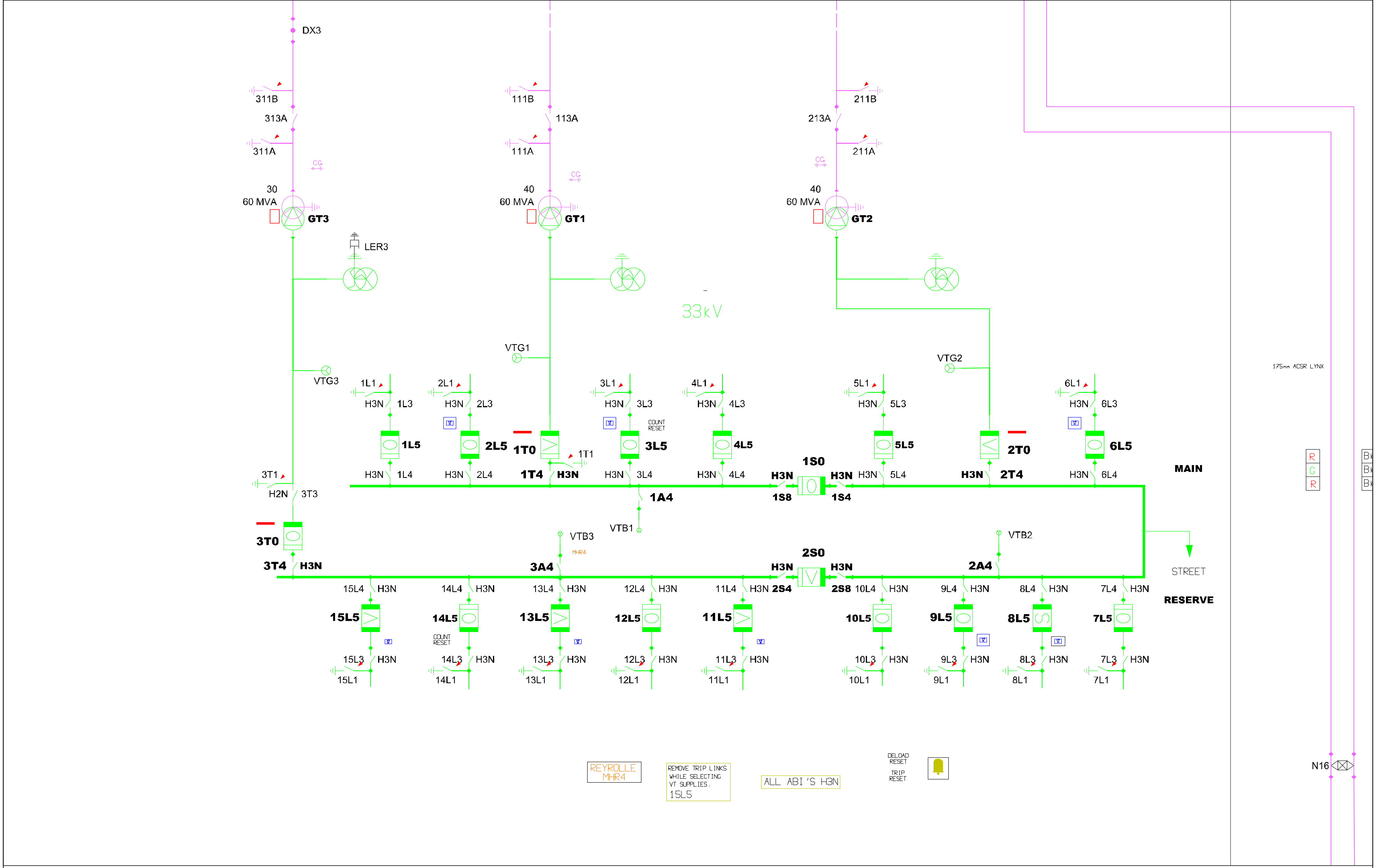
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

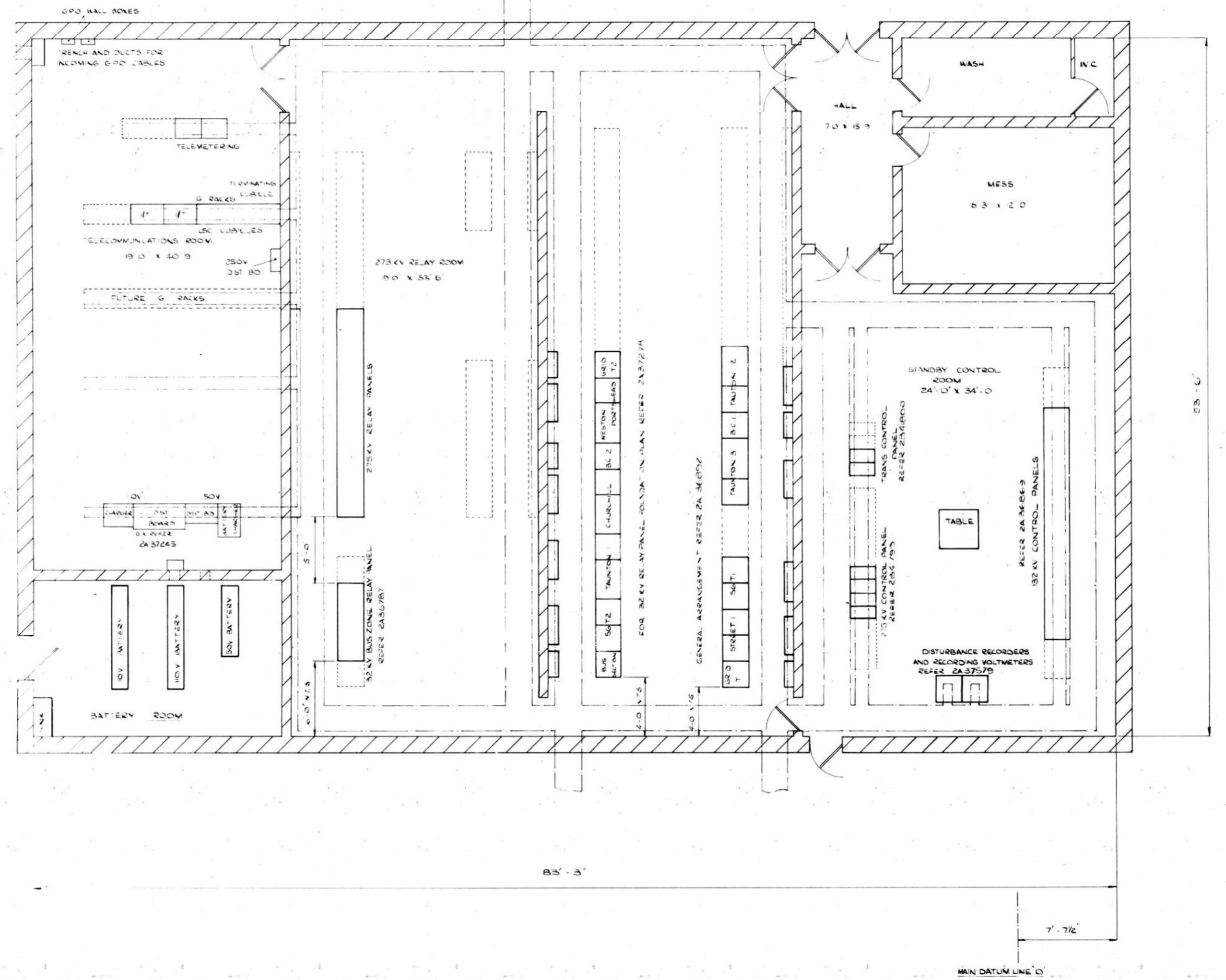
WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



APPENDIX C - CONTROL ROOM LAYOUT

B4195



FOR SUBSTATION LAYOUT PART 1 REFER 2A35815
" " " " 2 " 2A35816
SECTIONS " 2A35743

B4195

SCALE– ¼" = 1FT	TOLERANCE TO 21X3 UNLESS OTHERWISE STATED

PRINTS ISSUED	THE GENERAL ELECTRIC Co. LTD. WITTON, ENGLAND.	3RD ANGLE PROJECTION
W.K.S. / MANUF. PLAN / BUYING OFF. / SAMPLE INSP. / OVERSEAS MFG.	SWITCHGEAR DIVISION	DRG. No. 2A37678
	DRAWN BY F. SHAW — DATE 7/8/67	LAYOUT OF CONTROL BUILDING
	TRACED BY — DATE	C.E.G.B. BRIDGWATER
W.O. No.	CHECKED BY — DATE	
	S.L.C. JOHNSON — APPVD.	

CONTRACT TPG/SW/S2018 & S2021
C.E.G.B. BRIDGEWATER

21/21223

APPENDIX D - SITE PHOTOS


AVC PANEL
GT1
GT2


KVGC
KVGC20201V21GEC
31974078/12/11 S
34.26kV TP 1
05 UP No Opera
ALARM
HEALTHY
CONTROL
VOLTAGE REGULATING RELAY
F
+
–
0
RESET
I_n 1/5
V n110V
V_x 24 - 125V
50/ 60 Hz
ALSTOM


GT3
kV
KVGC
VOLTAGE REGULATING RELAY
ALSTOM
BRIDGWATER BSP GRID TRANSFORMER TAP CHANGER CONTROLS
PLEASE NOTE – GT3 TAP CHANGE PANEL IS SITUATED IN THE 33kV RELAY ROOM.
GT1 +GT2 TAP CHANGE PANELS ARE SITUATED IN THE NEW 132kV RELAY ROOM.
GT1, GT2 AND GT3 RUN TOGETHER IN A NEGATIVE REACTANCE SCHEME.
THE NORMAL RUNNING ARRANGEMENT IS FOR EACH TAP CHANGER TO BE SET TO AUTO
(NOT PARALLEL).
STATUS SWITCH

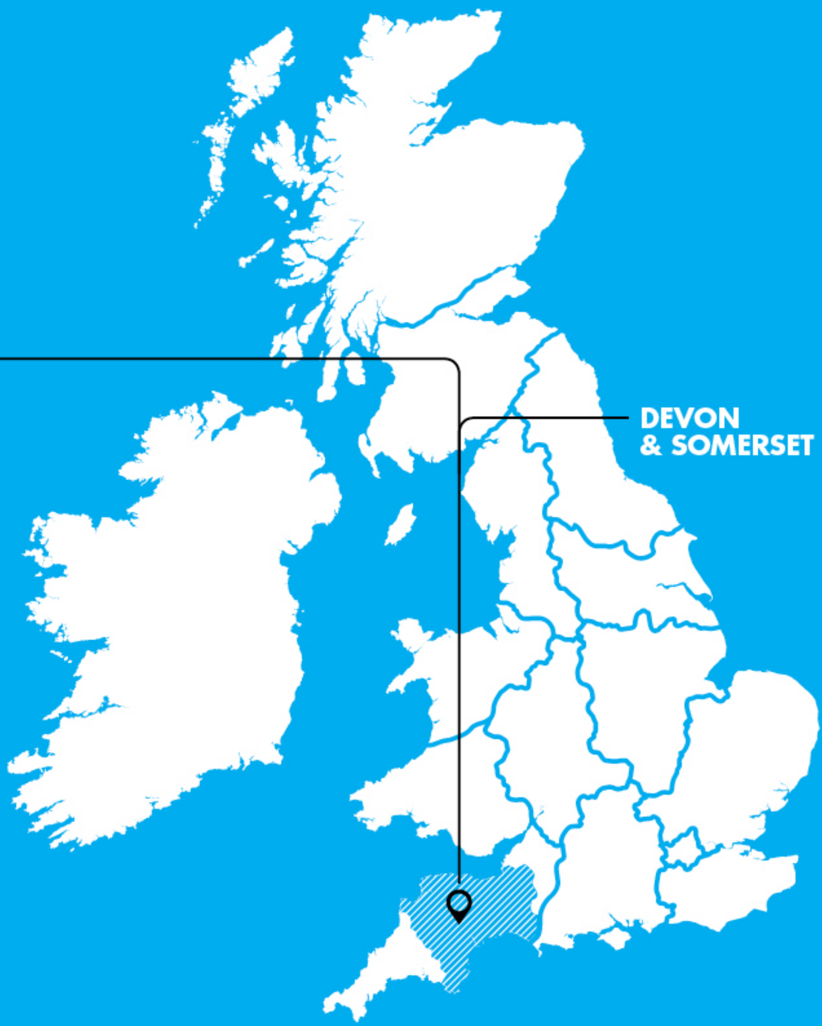

TRANSFORMER GT3

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Colley Lane 33/11kV



Report Title	:	Colley Lane Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Colley Lane 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Colley Lane 33/11kV Substation is normally fed via two 33kV circuits from Bridgwater BSP. The substation consists of three 12/24MVA 33/11kV transformers. The substation was originally commissioned in the early 1970s but has recently had two transformers replaced and there is currently works underway to replace the 33kV switchboard which is due for completion in 2016.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are capital replacement works currently in progress at the site due for completion in 2016. A new 11kV board is also planned for installation at the substation.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. Overall the load is expected to decrease by 0.64MVA over the next five years.

Table 2-1: Load forecast for Colley Lane 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Colley Lane	132/33kV	0.96	25.34	24.85	24.55	24.38	24.42	24.70	41.06

2.4 Customers

2.4.1 Number of Customers

Colley Lane currently supplies 4,400 customers none of which are voltage sensitive.

2.4.2 Type of Loads

The main loads connected to the substation are domestic customers and heavy industrial customers.

2.4.3 Generation

Currently the largest single generation source at Colley Lane is a 750kVA generator from an alternative fuel source. There is one solar PV site committed for the future which will provide 7.7MW of generation.

2.5 Voltage Control Equipment

2.5.1 Transformers

The two newer transformers at Colley Lane were manufactured in 2008 by Brush and are 12/24MVA units with 17 position ATV 317 44/300L tap changers. The third transformer was manufactured by Hawker Siddeley Transformers and was installed in 1989 with a 19 position tap changer.

2.5.2 Automatic Voltage Control Relays

Colley Lane utilises three MicroTAPP relays for Voltage Control of its transformers. There is currently only a single scheme commissioned as part of the capital works with the other two schemes scheduled for completion by June 2016.

2.5.3 Auxiliary Systems

The substation has an 110V battery system installed as part of the 33kV switchgear replacement. The D20 SCADA communications system was also installed alongside the 33kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Colley Lane feeder voltages using WPD IPSA models determined that there is no voltage reduction available at Colley Lane whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Colley Lane over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

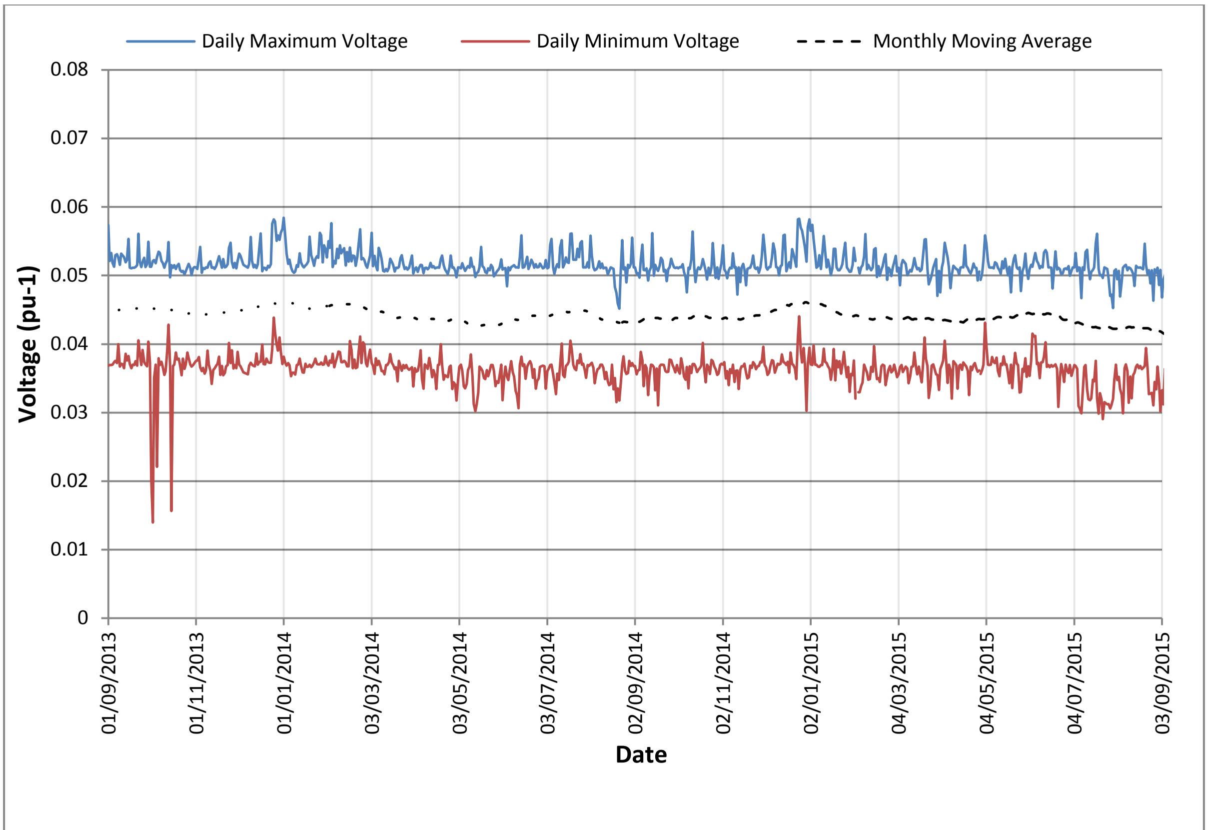


Figure 3-1: Historic voltage profile at Colley Lane

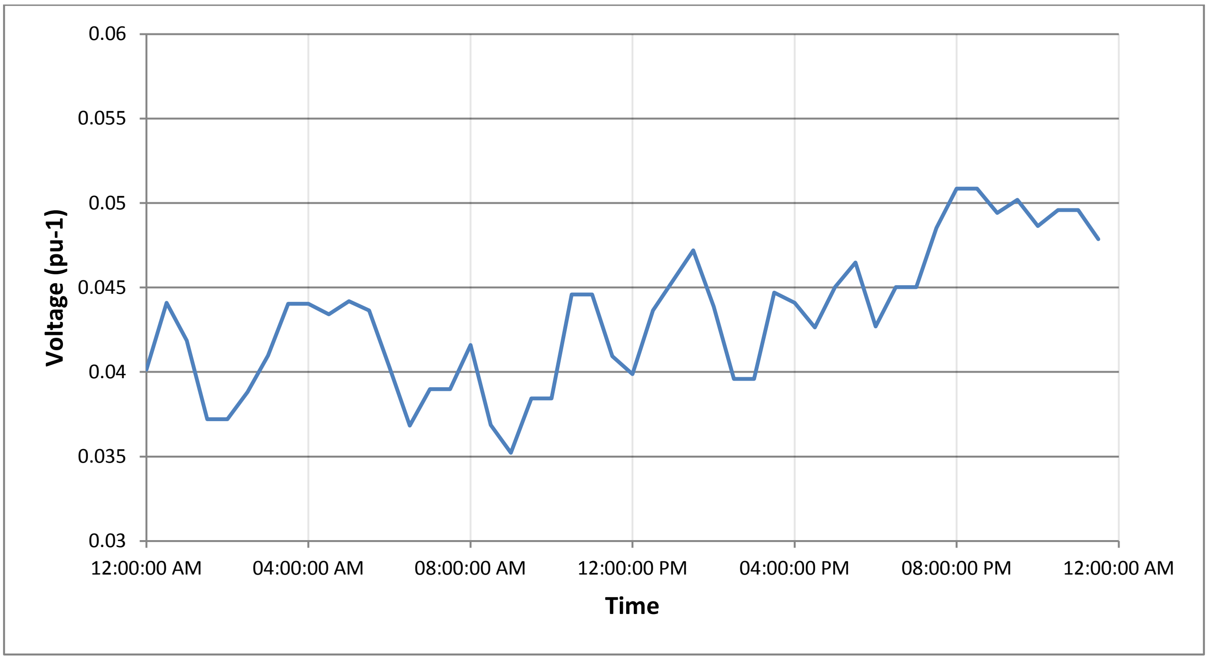


Figure 3-2: 01/06/15 Voltage profile at Colley Lane

3.2.3 Results

The voltage studies have shown that the voltage cannot be reduced below 1pu and remain within statutory limits.

The historical voltage profiles show that the moving average has fluctuated a little over the two years between 0.041pu and 0.046pu with an average of 0.044pu. The daily fluctuations in voltage are roughly constant with an average of 0.017pu.

With the substation operating at around 0.04pu above nominal it may be possible to achieve some voltage reduction.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

As the existing MicroTAPP relays have the function to control group settings, it is planned to utilise them as part of the SVO method and enable them for use via the installation of interposing relays. The relay will require minor wiring modifications and commissioning with new settings.

3.3.2 AVC Panel

Each AVC panel will be modified to include the required number of interposing relays internally. These will be mounted to the existing internal rail with all additional wiring utilising the existing cable containment within the panel.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, sixteen potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable selection of the different AVC settings groups.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Colley Lane. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Colley Lane will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

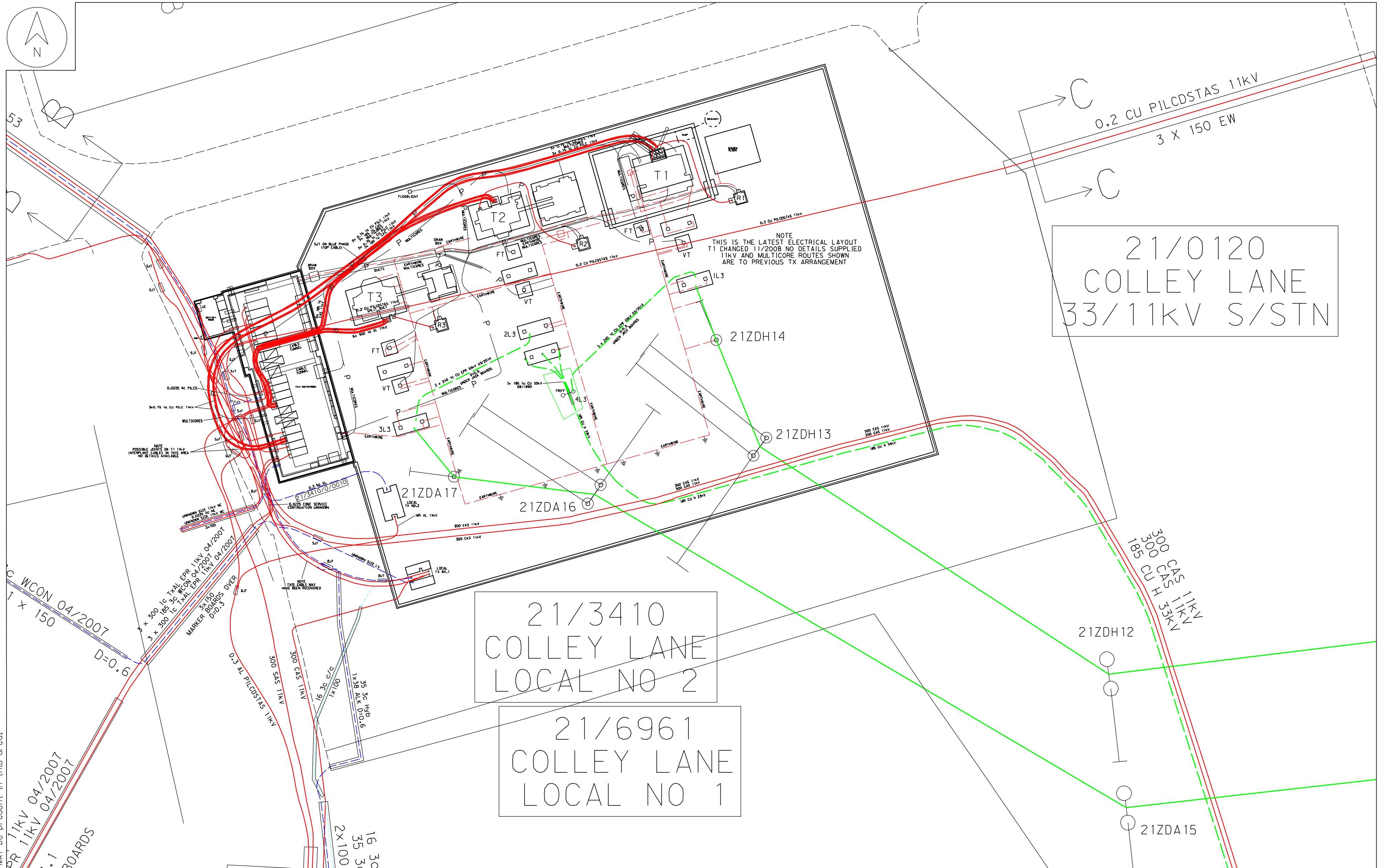
Table 4-1: Site specific risks

Risk	Effect	Action
One of the remaining two transformers trip when working on one transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.



SURF TELECOMS APPARATUS	OVERHEAD LINE		UNDERGROUND CABLE
S		PL	
		SERVICE	
		LV	
PILOT CABLES		HV (11kV)	
P		HV (33kV)	
		HV (66kV)	
	✳	HV (132kV)	✳

PME Earth
Underground Earth
Pole Mounted Transformer
Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: COLLEY LANE
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:250 @ A3
PLOT CENTRE: 330899.611,136000.081

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

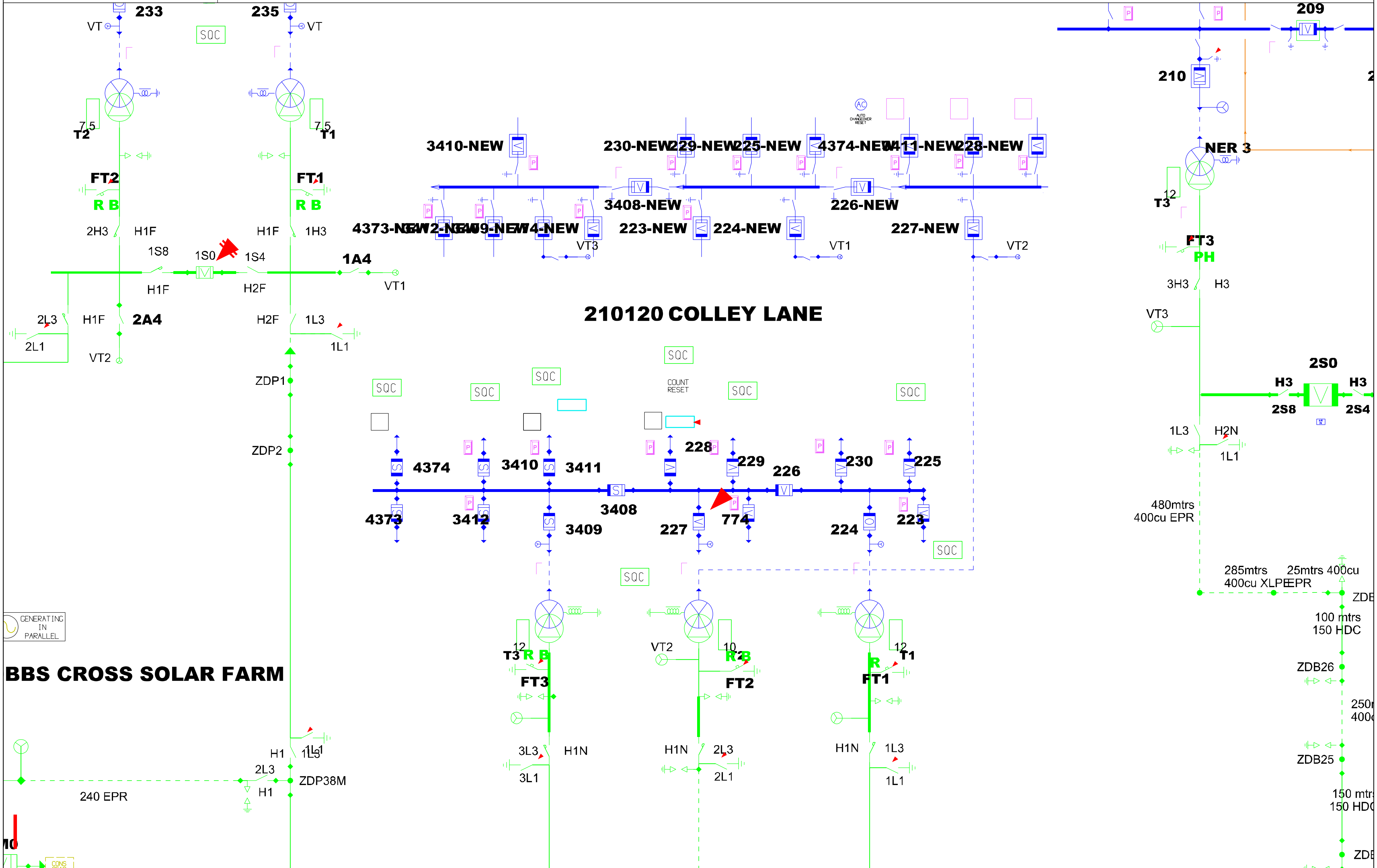
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



Tiles: 177

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

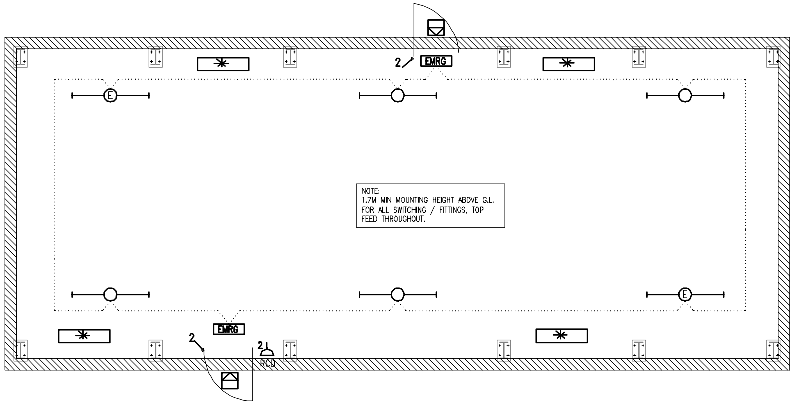
APPENDIX C - CONTROL ROOM LAYOUT

GENERAL NOTES
1/THIS DRAWING MUST BE READ IN CONJUNCTION WITH WPD DOCUMENT 'MASTER SPECIFICATION FOR SWITCHGEAR BUILDING LIGHTING, HEATING AND POWER.

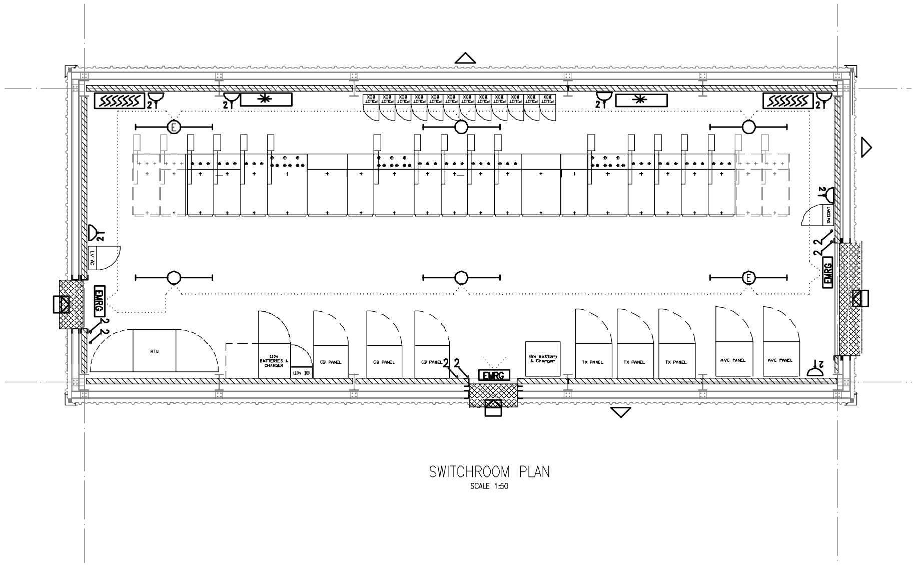
2/ EXACT POSITIONING OF ELECTRICAL APPARATUS WILL BE DEPENDANT ON CONFIGURATION OF WPD SWITCHGEAR AND ASSOCIATED APPARATUS CONSULT SCHEME DRAWING FOR INFORMATION.

KEY TO SYMOBOLS

- DOUBLE SWITCHED 13A SOCKET OUTLET
- WALL-MOUNTED DEHUMIDIFIER (WIRED VIA 13A FUSED SWITCHED CABLE OUTLET NOT SHOWN)
- 3.0 kW ELECTRIC WALL-MOUNT PANEL HEATER (WIRED VIA 13A FUSED SWITCHED CABLE OUTLET NOT SHOWN)
- 1500mm LONG TWIN FLUORESCENT 58 WATT FLUORESCENT LUMINAIRE
- 1500mm LONG TWIN FLUORESCENT 58 WATT FLUORESCENT LUMINAIRE WITH 3 HOUR EMERGENCY
- EMRG: ILLUMINATED FIRE EXIT SIGN OVER DOORWAY
- 1 WAY 2 GANG LIGHT SWITCH
- EXTERNAL BUILDING-MOUNTED BULKHEAD LIGHT FITTING
- EXTERNAL BUILDING-MOUNTED FLOODLIGHT LIGHT FITTING
- MAEV: THERMOSTATICALLY CONTROLLED MECHANICAL AIR EXTRACT VENTILATOR AT HIGH LEVEL



SUBSTATION LEVEL PLAN
SCALE 1:50



SWITCHROOM PLAN
SCALE 1:50

PRELIMINARY ISSUE

Rev No	Drawn	Chk'd	App'd	Date	Revision

ORIGINAL ISSUE		Date
Drawn	ASM	MAY 14
Checked		
Approved		
SCALE: AS SHOWN		
ORIGINAL SHEET SIZE: A1		

WESTERN POWER DISTRIBUTION
Design Department.
Avonbank, Feeder Road, Bristol BS2 0TB
Tel: 0117 933 2000 Fax: 0117 933 2001.

Title
COLLEY LANE 11kV SUBSTATION
HEATING, LIGHTING AND POWER LAYOUT FOR 11kV SWITCHGEAR BUILDING

WESTERN POWER DISTRIBUTION

Drg. No. CP111369
Rev No. 1

APPENDIX D - SITE PHOTOS


33/11kV TRANSFORMER No.1
33/11kV TRANSFORMER No.2


NER2


33/11kV TRANSFORMER No.3

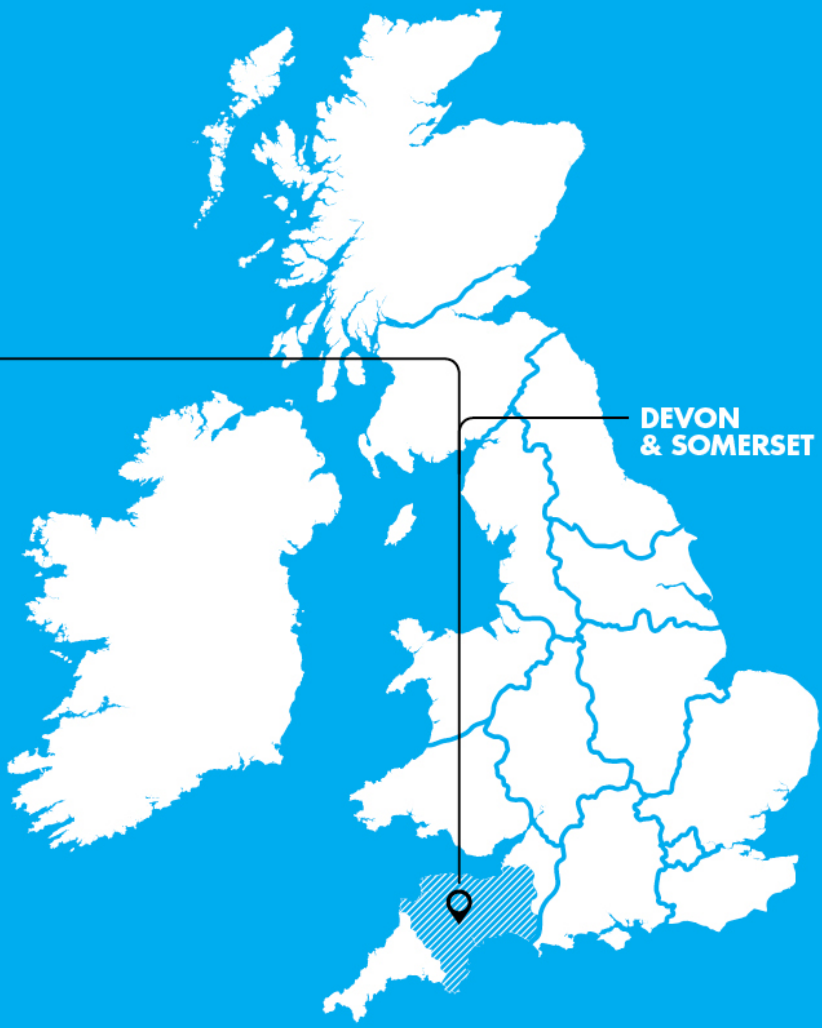

POSITION
T2

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Dunkeswell 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Dunkeswell Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Dunkswell 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Dunkeswell 33/11kV Substation is supported by a single 5/6.25MVA transformer fed from Tiverton BSP, with another identical transformer run normally open fed from Exeter Main.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are no plans for capital replacement works at this substation within RII0-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to increase by 0.11MVA over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Dunkeswell 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Dunkeswell	33/11	0.98	4.50	4.50	4.51	4.43	4.56	4.61	7.7

2.4 Customers

2.4.1 Number of Customers

Dunkeswell currently supplies 1,500 customers none of which are voltage sensitive.

2.4.2 Type of Loads

The main loads connected to the substation are light industrial and domestic customers.

2.4.3 Generation

The total amount of embedded generation feeding into the Dunkeswell network is currently 5.82MW from a single solar PV connection at Higher Bye Farm. Three further solar PV connections are committed to in the future which will add 17.52MW to the current level of generation. This will give a total of 23.34MW of generation. [Reference to 2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers at the substations were manufactured by Brush and were installed in 1997. The transformers are rated at 5/6.25MVA and have a 17 position AT 317 44/300L Tap Changer. The site is currently operated with only the single transformer in service at any one time due to 33kV supplies from different BSPs.

2.5.2 Automatic Voltage Control Relays

Dunkeswell utilises two MVGC01 relays for voltage control of its transformers. Each relay is located in its own dedicated panel with no other operation equipment installed.

2.5.3 Auxiliary Systems

The substation has an 110V battery and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Dunkeswell feeder voltages using WPD IPSA models determined that a 0.041pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Dunkeswell over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

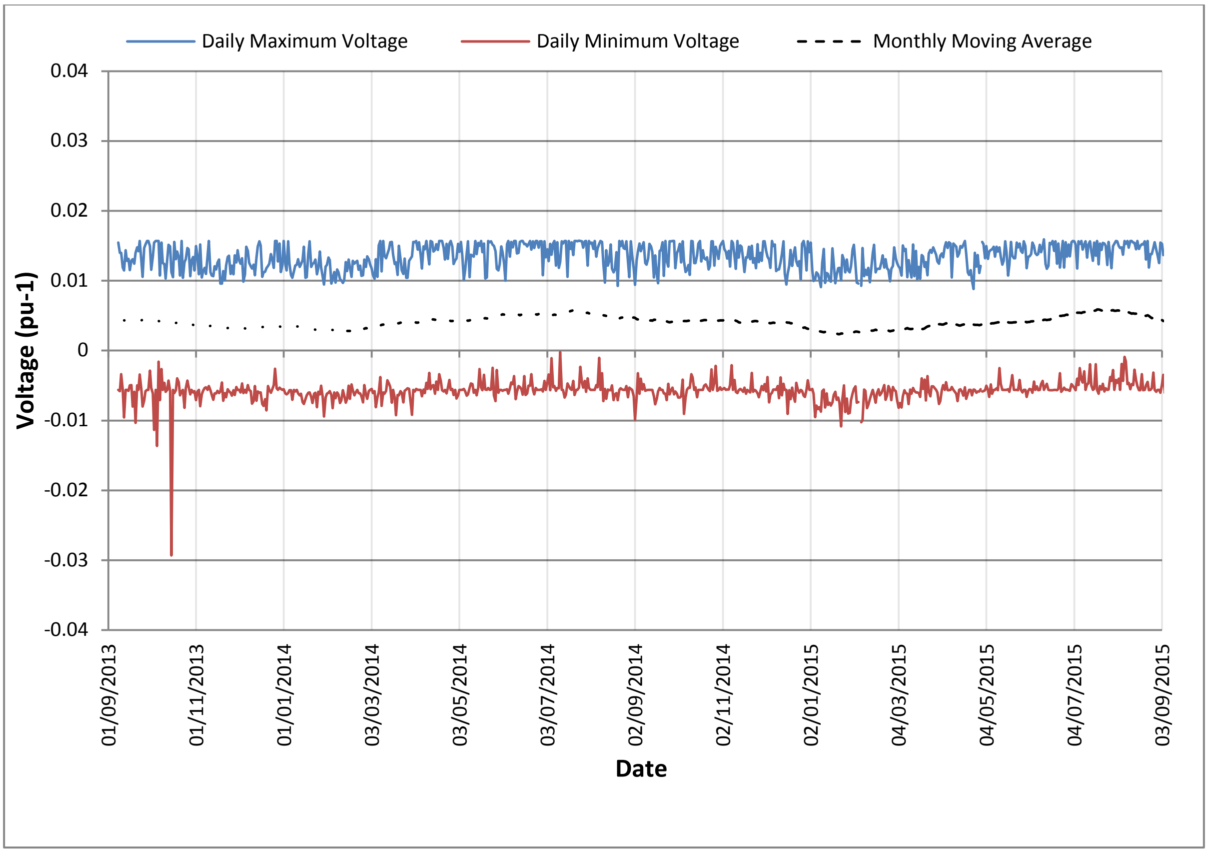


Figure 3-1: Historic voltage profile at Dunkeswell

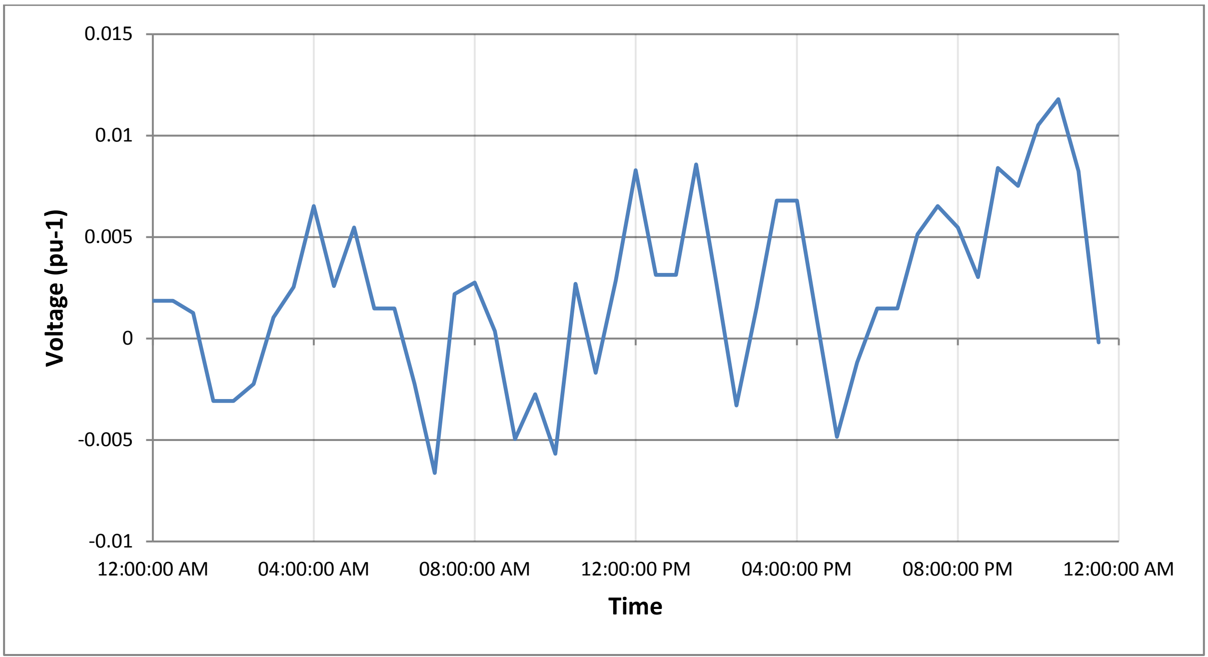


Figure 3-2: 01/06/15 Voltage profile at Dunkeswell

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.041pu below nominal and remain within statutory limits.

The historical voltage profiles show that the moving average has fluctuated a little over the two years between the values of 0.0023pu and 0.0059pu, on average the value has been at 0.0041pu. The daily fluctuations in voltage have remained roughly constant over the last two years at an average of 0.021pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Dunkeswell the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The switchroom contains minimal space for a new AVC panel to be installed. Therefore the new relays will be retrofitted to the existing panels that contain suitable space once the existing relays have been removed.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, three potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Modifications are required to the existing SCADA system to enable the full operational capability required for the SVO. This will involve the installation of extra communication cards and associated wiring.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Dunkeswell. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Dunkeswell will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

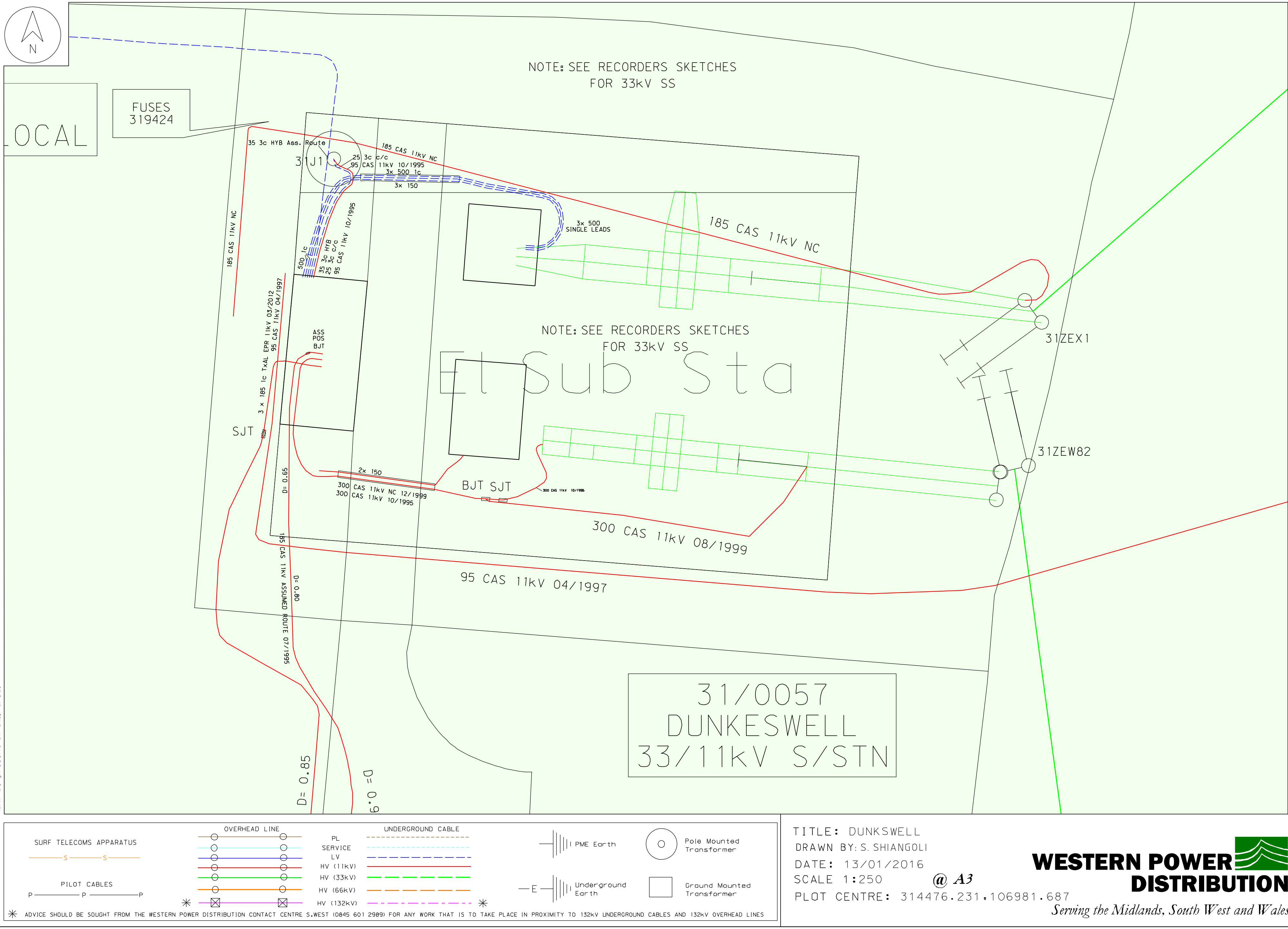
Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.



TITLE: DUNKSWELL
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:250 @ A3
PLOT CENTRE: 314476.231,106981.687

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
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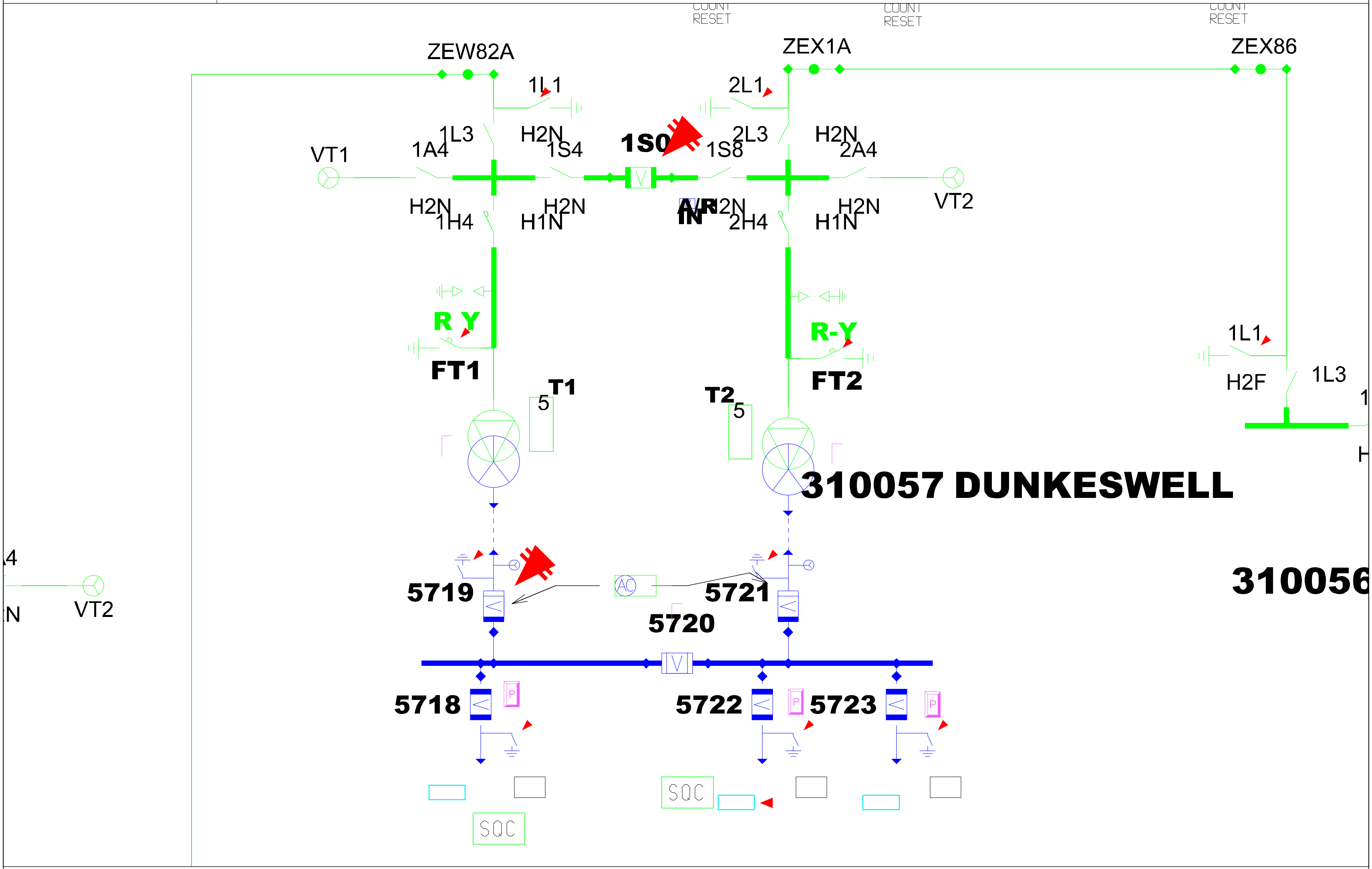


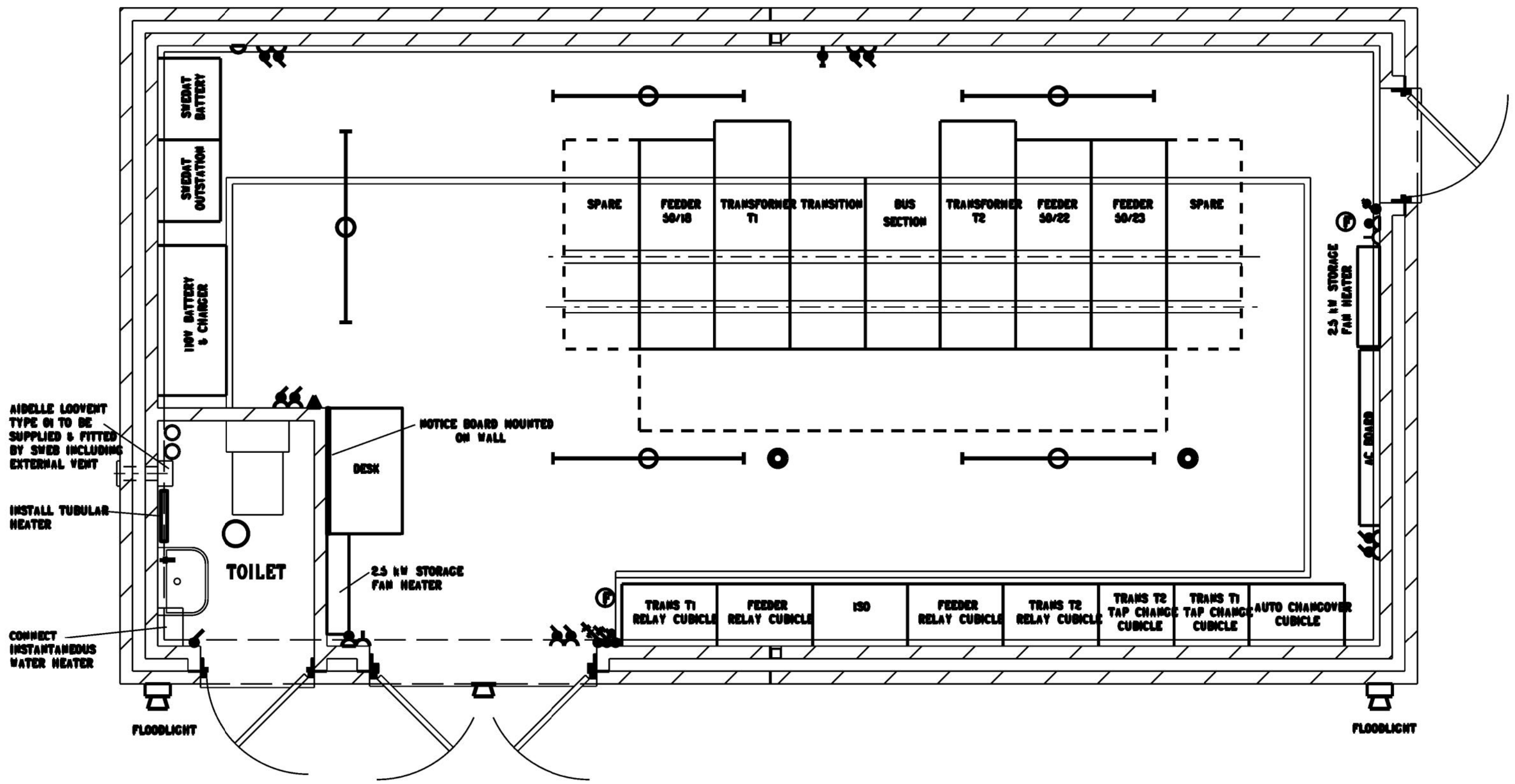
Tiles: 299

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT



LEGEND

- 1.524M LONG FLUORESCENT LAMPS
- EMERGENCY LIGHT FITTING (MENVIER Type KLBMM3 3Hr NON MAINTAINED)
- FILAMENT LAMP
- 13A TWIN SWITCHED SOCKET OUTLET
- SPUR SOCKET OUTLET
- FUSE SWITCH FOR OPERATING HEATER FAN
- 20A SWITCHED OUTLET HEATER SUPPLY
- 5A 1-WAY SWITCH
- 5A 2-WAY SWITCH
- EMERGENCY LIGHT
- FLOOD LIGHTING SWITCH
- WEATHERPROOF BULKHEAD LIGHT WITH PERSONAL SENSOR
- TELEPHONE POINT
- 4.5KG CO2 FIRE EXTINGUISHER
- THERMOSTAT

ASSOCIATED DRAWINGS

PROPOSED CONTROL BUILDING — Drg No DP1018

2 H.M.F — LIGHT, HEATER & FITTINGS IN TOILET & THERMOSTAT IN CONTROL ROOM ADDED

1 H.M.F — SOCKETS, LIGHTS, HEATERS & FITTINGS Etc ADDED

1 : 20

DUNKESWELL 33/11kV SUBSTATION
PROPOSED CONTROL ROOM LAYOUT

DP1045 2

APPENDIX D - SITE PHOTOS

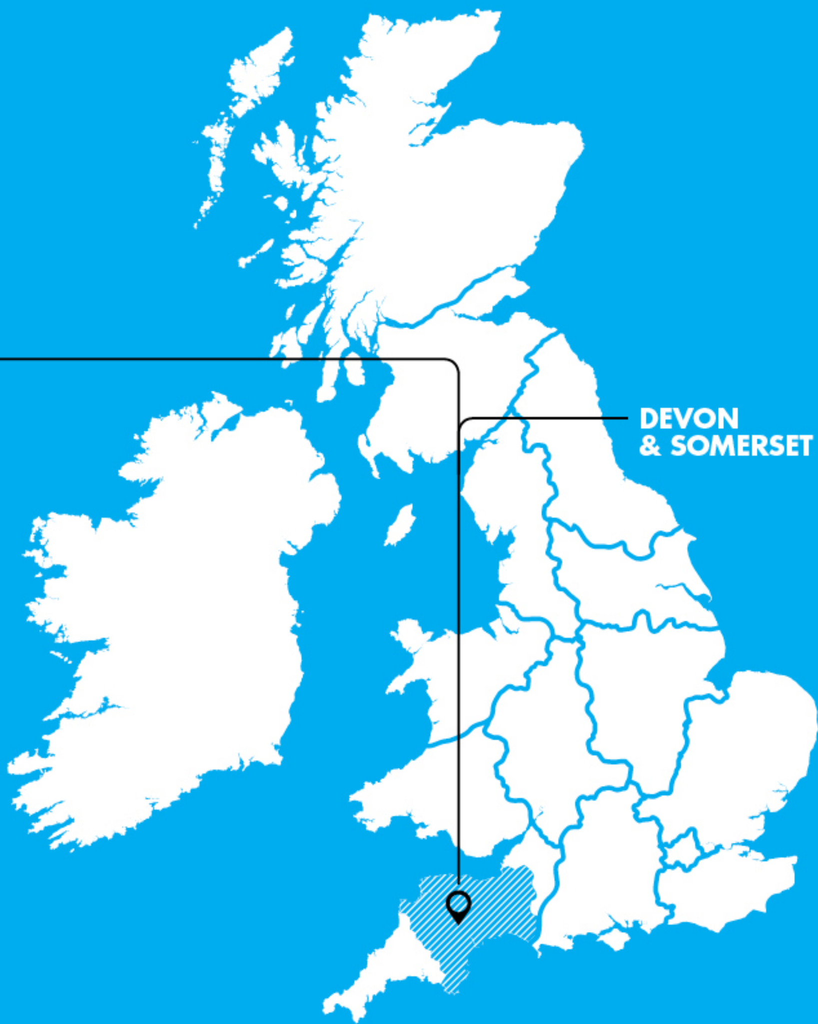

33/11kV
TRANSFORMER No1
kV
TAP
POSITION INDICATOR

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Exeter City 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Exeter City Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

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1 Introduction

The following report details the findings from the investigation of Exeter City 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2 Substation Overview

2.1 Description

Exeter City 132/33kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 132kV circuits from Exeter Main GSP. It has two 132/33kV 45/90MVA transformers operating with the bus section normally closed. The substation was originally constructed in the early 1970's with the 33kV switchboard and transformers being replaced between 2008 and 2010.

A selection of photos and the control, single line and EMU diagrams are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at this substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The demand at the substation is forecast to increase gradually over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Exeter City 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Exeter City	132/33	0.98	97.07	102.85	101.98	102.56	102.72	103.80	114.31

2.4 Customers

2.4.1 Number of Customers

Exeter City supplies eleven primary substations with normally open connections to a further three. The total number of customers supplied is 58,104.

2.4.2 Type of Loads

The primary substations supplied from Exeter City are located in mainly urban areas so provides a mix of domestic, commercial and industrial loads. There are no 33kV load customers connected to the Exeter City network. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Exeter City network is currently 8.85MW from the 11kV network. A further 1.5MW of solar PV is committed for future connection to the 11kV network. On the 33kV network three solar PV sites totalling 15.75MW and two STOR sites totalling 40.88MW are committed for connection. Overall the future commitments at both voltage levels will add 58.13MW of embedded generation giving a total generation of 66.98MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

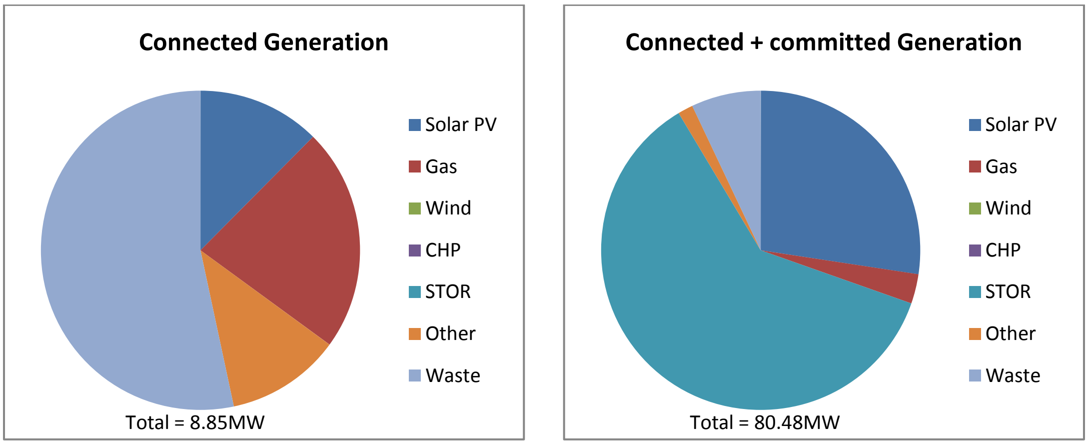

Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers were manufactured by EBG with 19 position ATL-AE3 tap changers and were installed and commissioned in 2009.

2.5.2 Automatic Voltage Control Relays

Exeter City currently utilises two KVGC202 relays for Voltage Control of its transformers. The existing scheme was modified in 2010 alongside the change in switchgear.

2.5.3 Auxiliary Systems

The substation contains an 110V battery that was installed in 2010 alongside the replacement of the 33kV switchgear. The D20 SCADA communications system was also installed alongside the 33kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Exeter City Main Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.010	0.985
2	1.010	0.985
3	1.010	0.985
4	1.010	0.985
5	**1.032**	**0.934**
6	**1.032**	**0.934**
7	**1.032**	**0.934**
8	1.013	0.987
9	1.011	0.986
10	1.011	0.986
11	1.011	0.987
12	1.012	0.987

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Exeter City over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

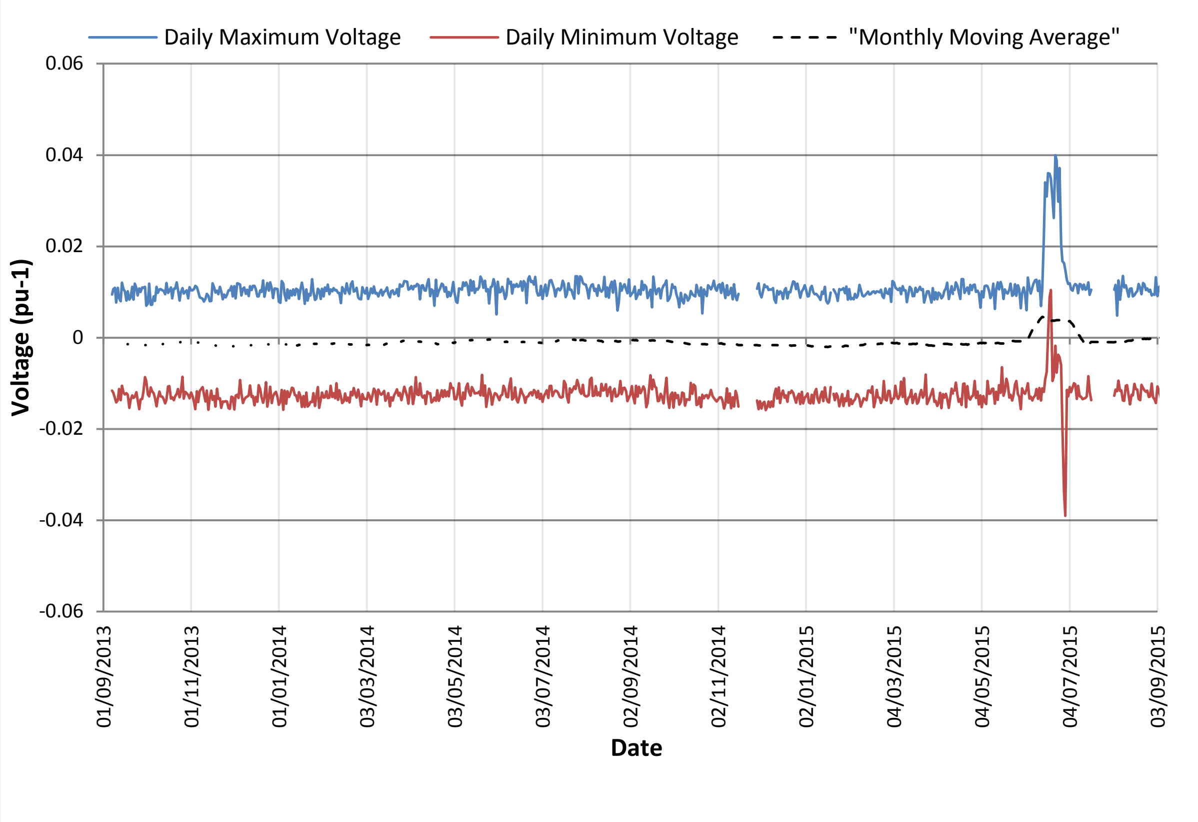

Figure 3-1: Historic voltage profile at Exeter City

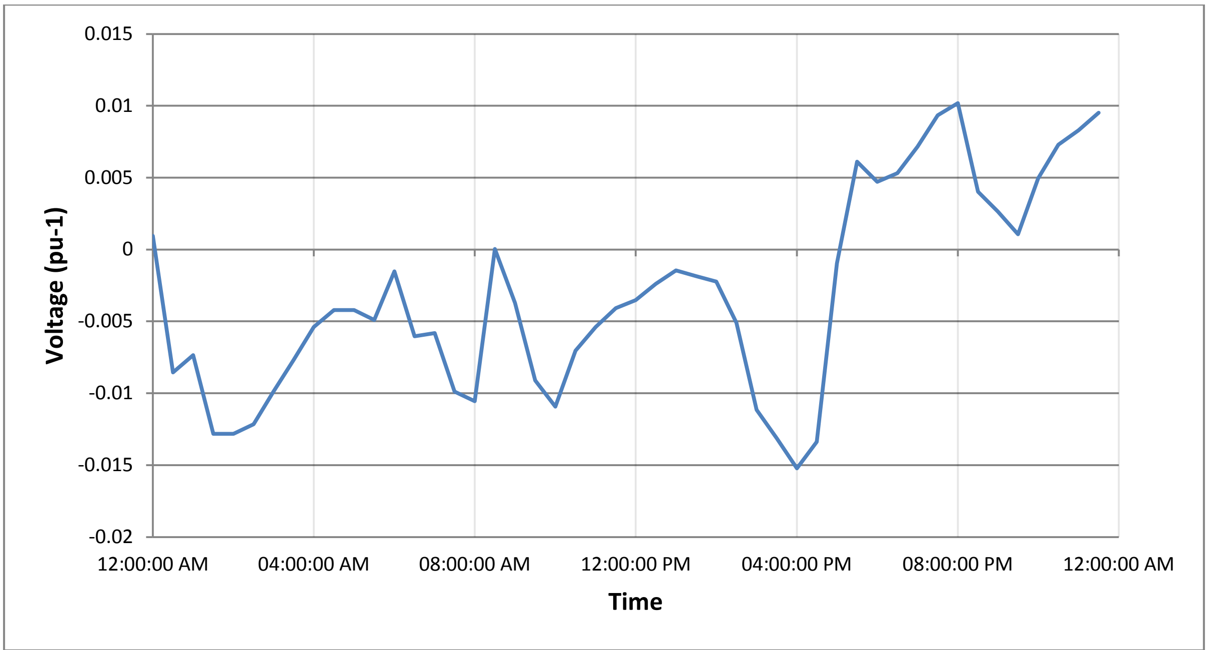

Figure 3-2: 10/07/15 Voltage profile at Exeter City

3.2.3 Results

The study results show that for Exeter City BSP, the voltage cannot be reduced and remain with statutory limits. However, the study has indicated that the voltage can increase by 0.028pu and remain within statutory limits.

The historical voltage profiles show that the voltage has remained at nominal voltage on average over the two year period analysed with an average daily fluctuation in voltage of 0.023pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Exeter City the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Exeter City BSP Feeder measurement locations

Exeter City BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Athelstan Road 11kV	NO	YES
Cowley Road 11kV	NO	YES
Crediton 11kV	YES	YES
Exminster 11kV	YES	YES
Folly Bridge 11kV	NO	YES
Haven Road 11kV	NO	YES
Lapford 11kV	NO	YES
Marsh Barton 11kV	NO	YES
Newton St Cyres 11kV	YES	YES
St Thomas 11kV	NO	YES
Witheridge 11kV	NO	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Exeter City BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Exeter City BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service(ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

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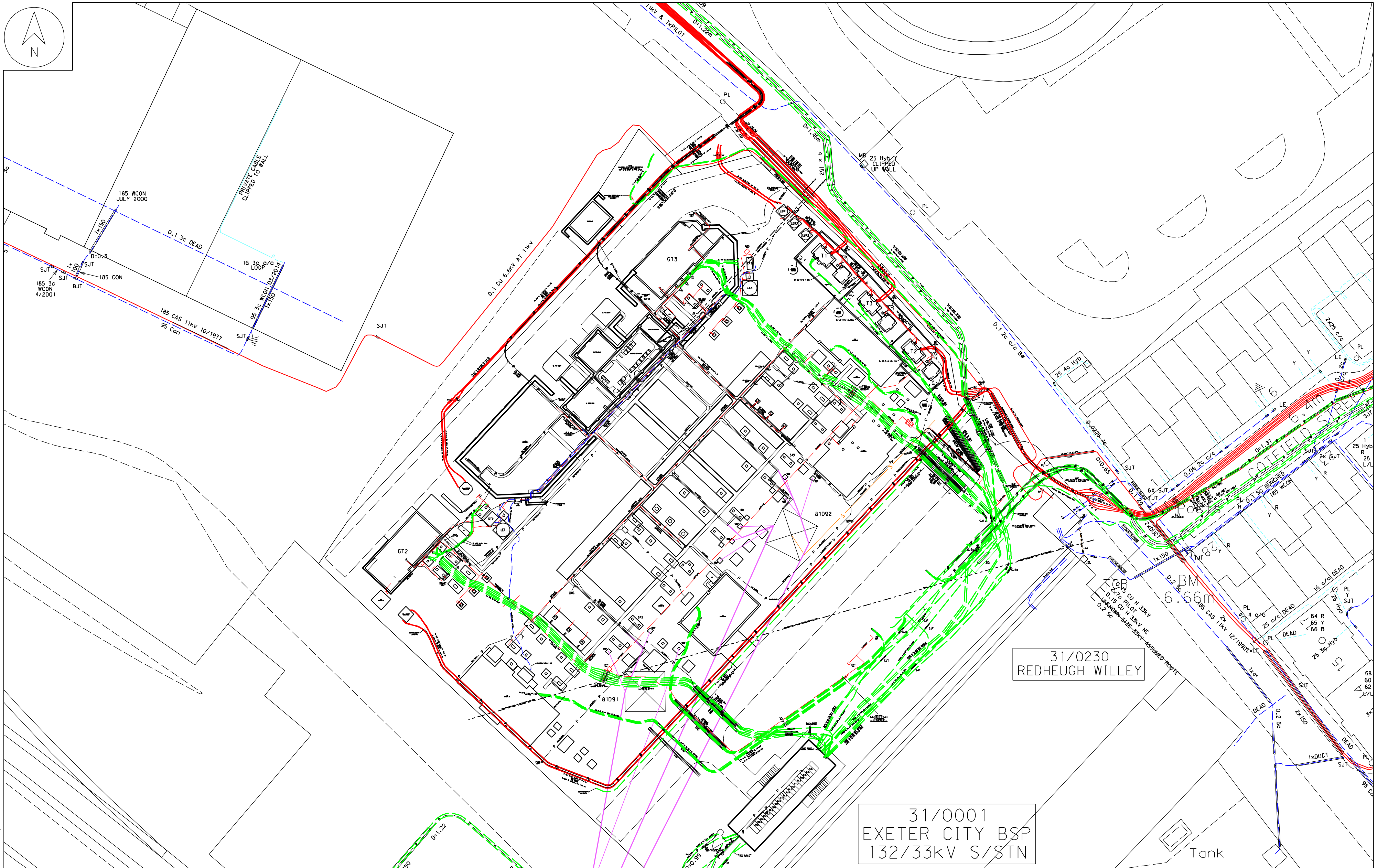

SURF TELECOMS APPARATUS	OVERHEAD LINE	UNDERGROUND CABLE
—S—S—	PL	PL
PILOT CABLES —P—P—P—	SERVICE	SERVICE
	LV	LV
	HV (11kV)	HV (11kV)
	HV (33kV)	HV (33kV)
	HV (66kV)	HV (66kV)
	✳ HV (132kV)	HV (132kV) ✳

PME Earth — Underground Earth — Pole Mounted Transformer — Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: EXETER CITY
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:600 @ A3
PLOT CENTRE: 292183.535,091392.575

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
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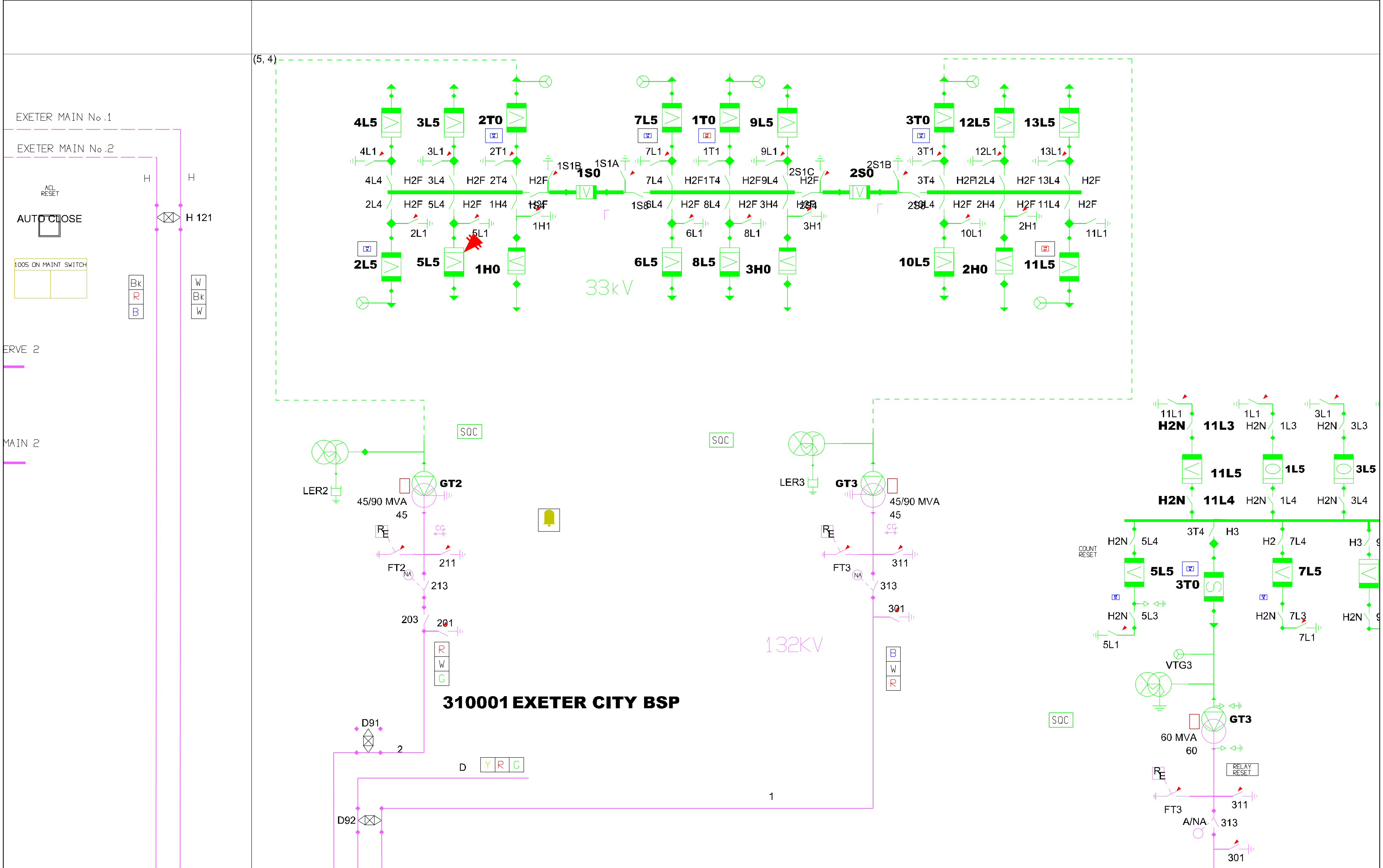
and it's accuracy cannot be guaranteed.

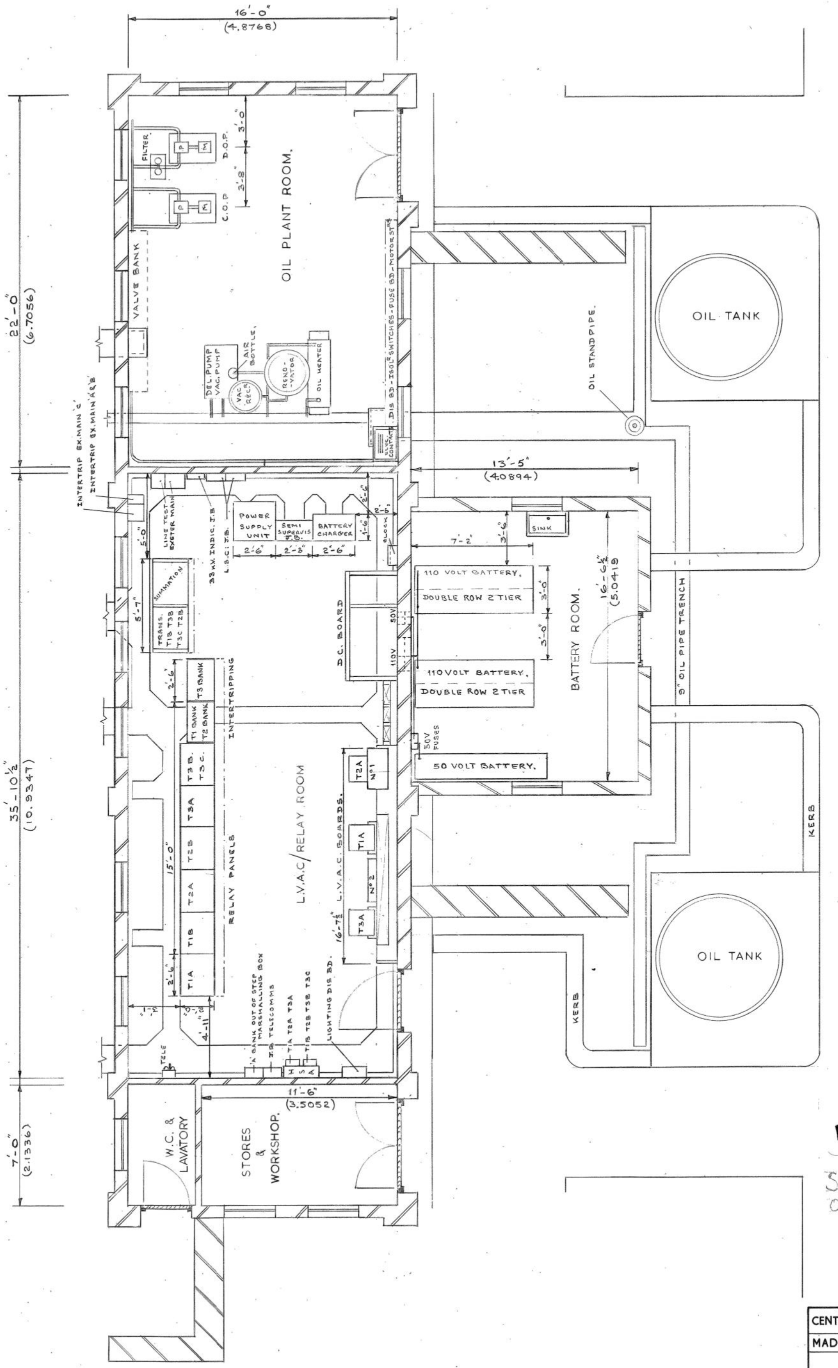


310001 EXETER CITY BSP

APPENDIX C - CONTROL ROOM LAYOUT

EC598

CENTRAL ELECTRICITY GENERATING BOARD, SOUTH WESTERN REGION, BRADFORD HOUSE, ST. STEPHEN'S AVE., BRISTOL, 1.



E598 -R

SUPERSEDED BY
03/35/2131

REVISION	DATE	AUTH.D.	DRAWN	CHECKED	APPROVED
FIRST ISSUE	12. 10. 67				

NOTE: THIS DRAWING SUPERSEDES THE FOLLOWING DRAWINGS.
AS. 4969 (21/6743)
"PLAN OF EQUIPT - ELECTRICAL PLANT ROOM"
AS. 5373 (66/1436)
G.A. OF OIL PURIFICATION PLANT

PRELIMINARY
NOT TO BE WORKED TO

SCALE
Originally Drawn :- 1/4" = 1'-0"

CENTRAL ELECTRICITY GENERATING BOARD, SOUTH WESTERN REGION.

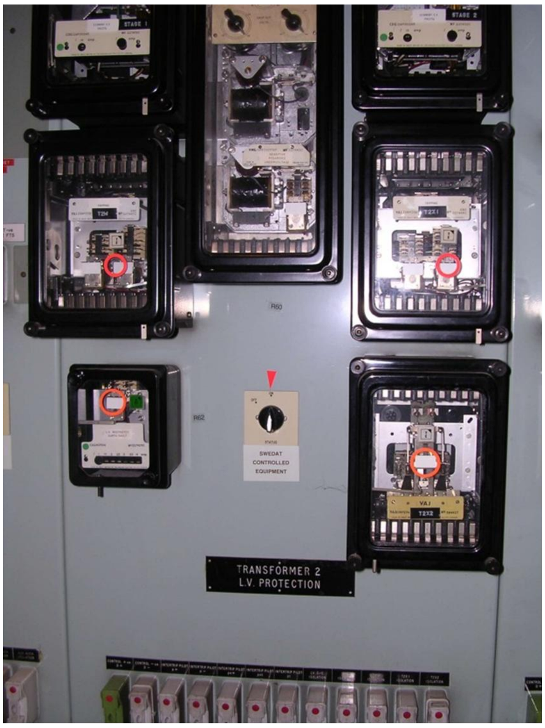
MADE FOR :-

SHEET SIZE F

LAYOUT OF EQUIPMENT IN AUXILIARY PLANT BUILDING.

EXETER CITY. 2/15/21/8

APPENDIX D - SITE PHOTOS


TRANSFORMER 2
L.V. PROTECTION
SWEDAT
CONTROLLED
EQUIPMENT


GRID TRANSFORMER T3
FAULT - TRIP OPERATIONS

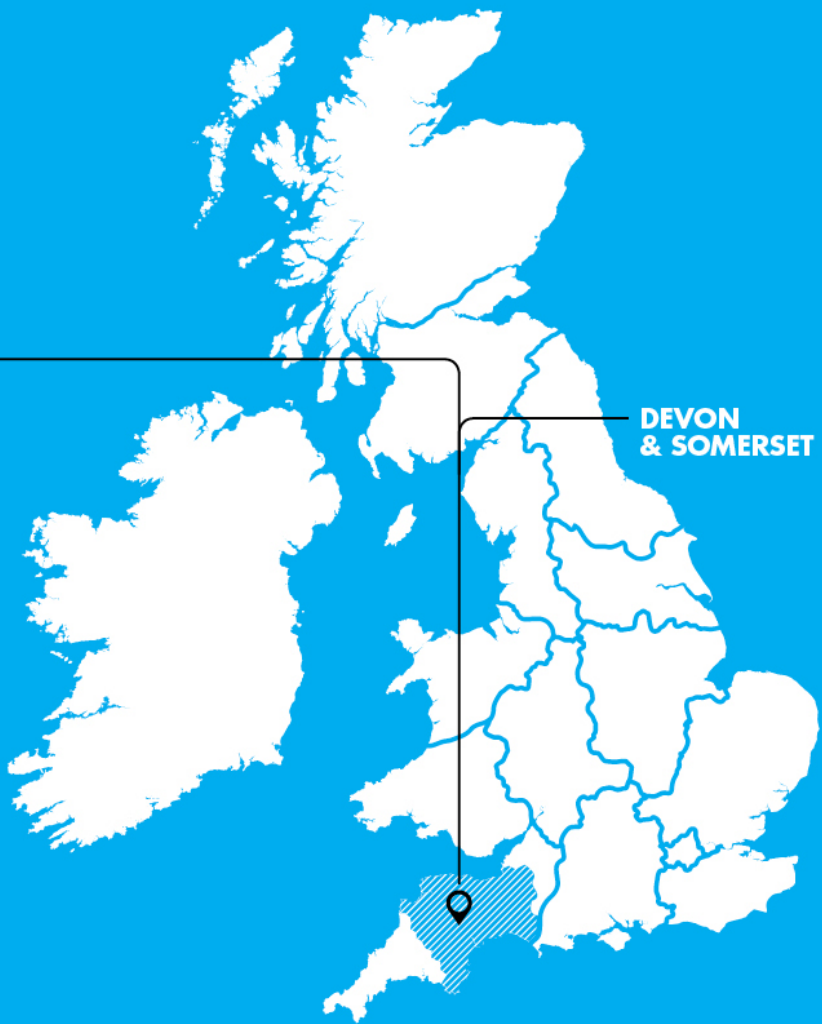

AUTO-TRIP OPERATIONS
ISO

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Exeter Main 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Exeter Main Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Exeter Main 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Exeter Main 132/33kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 132kV circuits from Exeter Main GSP. It has two 132/33kV transformers operating with the bus section normally open. The substation was originally constructed in the early 1960's with some oil filled 33kV circuit breakers replaced in 2002 and with both transformers being replaced in 2010.

A selection of photos and the control, single line and EMU diagrams are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is predicted to increase by 0.5MW over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Exeter Main 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Exeter Main	132/33	0.99	31.63	31.75	31.56	31.72	31.77	32.12	68.58

2.4 Customers

2.4.1 Number of Customers

Exeter Main supplies six primary substations with a normally open connection to another. The total number of customers supplied is 22,820.

2.4.2 Type of Loads

The primary substations supplied from Exeter Main are located in mainly rural areas and as such the main load types are domestic and light industrial. There are two 33kV supplied load customers connected directly to Exeter Main with another 33kV customer teed into another circuit. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation currently feeding into the Exeter Main Network is 23.95MW. Of this generation, 18.95MW is connected to the 33kV network with 5MW connected to the 11kV network.

The 33kV connected generation is made up of two solar PV sites at Burrowton Farm (10.9MW) and Till House (8.05MW). Three further solar PV connections are committed for future connection to the 33kV network which will add 22.63MW of generation. The 5MW connected to the 11kV network is from a single solar PV site. Overall the future commitments will increase the embedded generation by 22.63MW to 46.58MW [2015 LTDS table 5].

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers were replaced in 2010 with Siemens 40/60MVA transformers with 19 position tap changers.

2.5.2 Automatic Voltage Control Relays

Exeter Main currently utilises two KVGC202 relays for Voltage Control of its transformers. The existing scheme was modified in 2010 alongside the transformer replacement.

2.5.3 Auxiliary Systems

The substation contains an 110V battery and a D20 SCADA communications system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Exeter Main Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	0.999	0.964
2	0.999	0.964
3	**1.026**	**0.946**
4	1.019	0.958

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile of Exeter Main over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

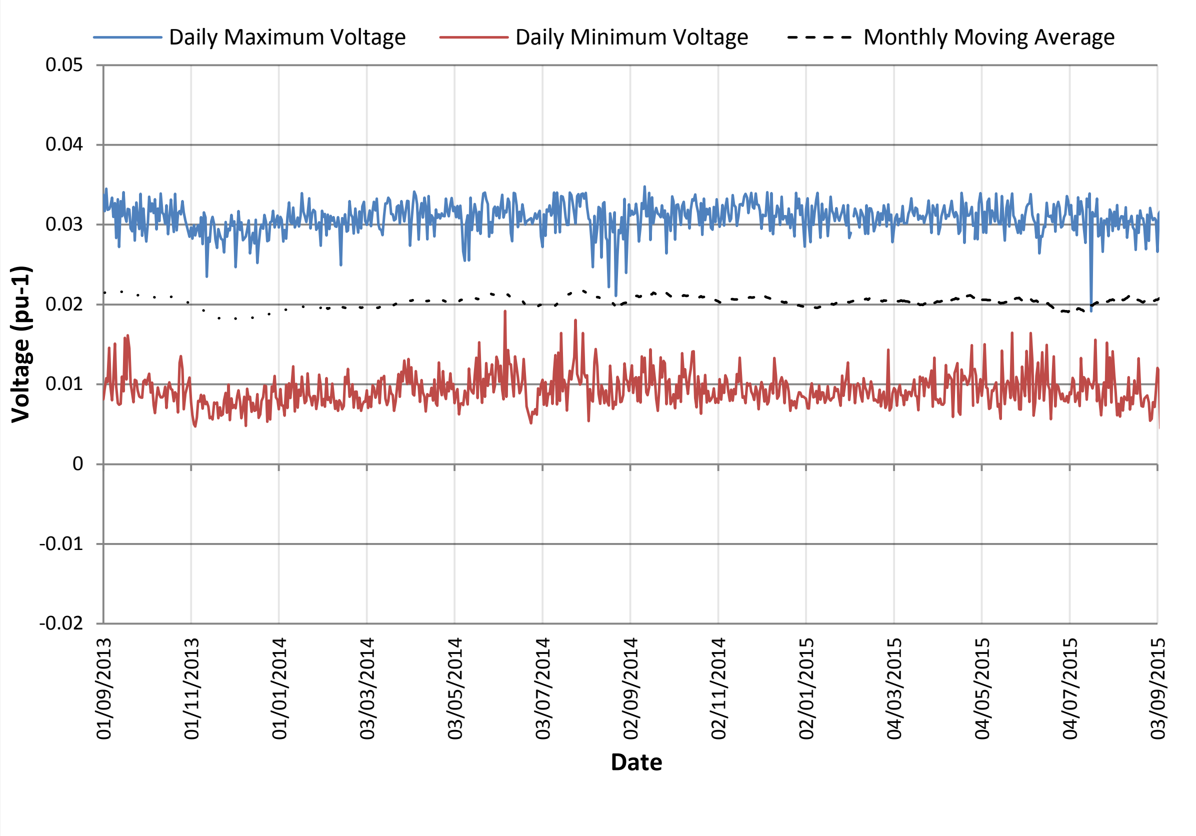


Figure 3-1: Historic voltage profile at Exeter Main

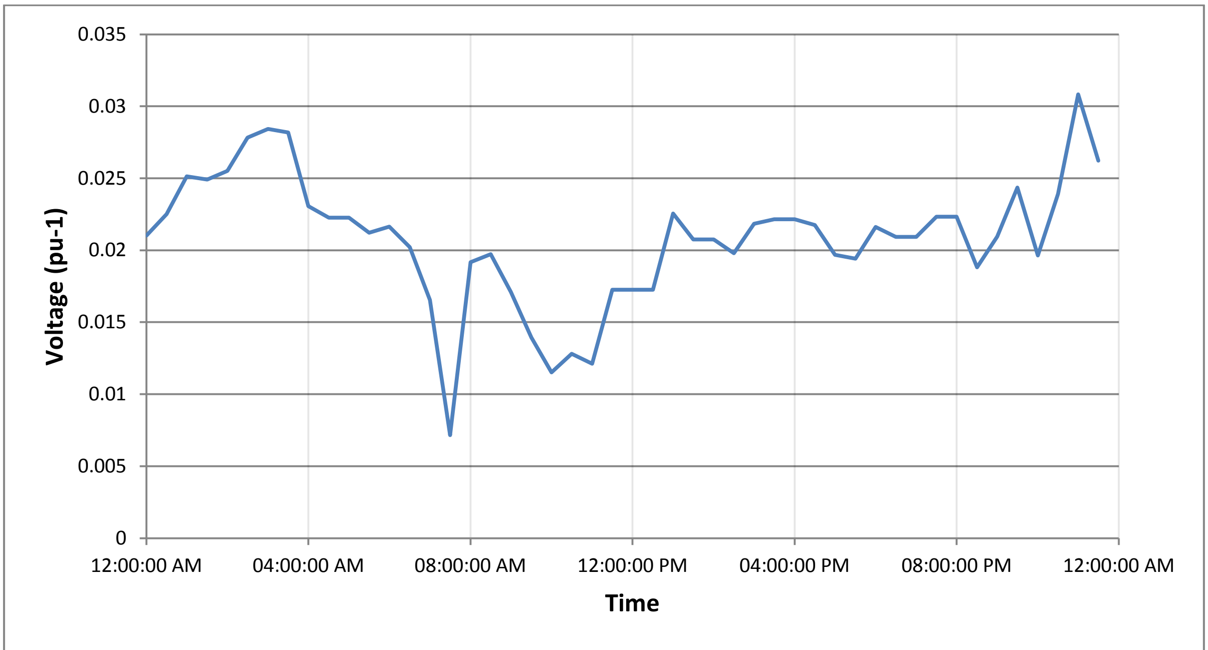


Figure 3-2: 01/09/15 Voltage profile at Exeter Main

3.2.3 Results

The study results show that for Exeter Main BSP, the voltage can be reduced by 0.006pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.034pu and be within the statutory limits.

The historical voltage profiles show that the voltage has remained steady over the two year period analysed at 0.02pu above nominal with an average daily fluctuation in voltage of 0.022pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Exeter Main the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Exeter Main BSP Feeder measurement locations

Exeter Main BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Core Hill 11kV	NO	YES
Honiton Heathfield 11kV	YES	YES
Marsh Green 11kV	YES	YES
Offwell 11kV	YES	YES
Ottrey St Mary 11kV	YES	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Bowhays Cross BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Exeter Main BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

The table below highlights the site specific risks when carrying out the proposed modifications to the substation.

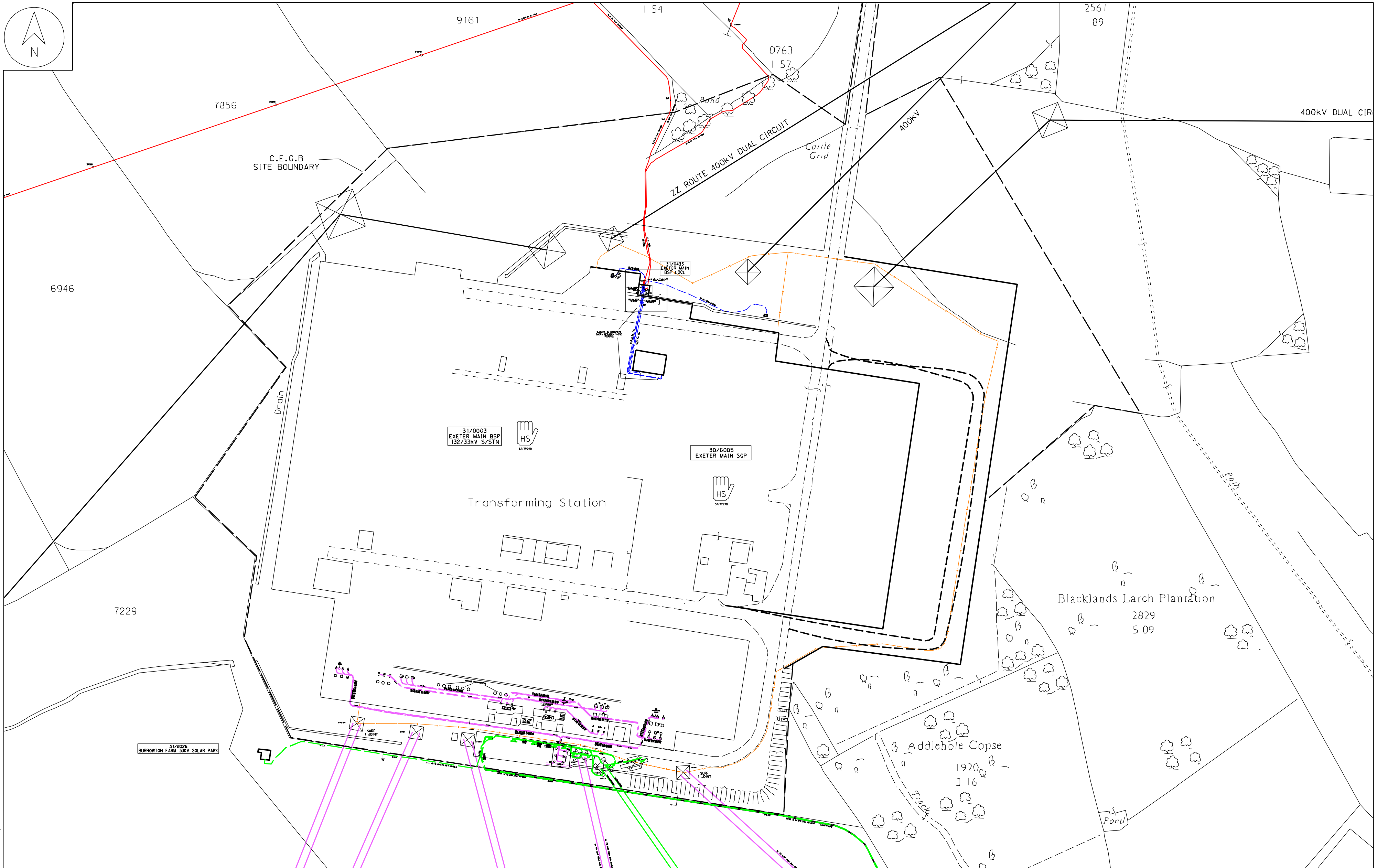
Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS — S — S —

PILOT CABLES P — P — P

OVERHEAD LINE		UNDERGROUND CABLE
	PL	
	SERVICE	
	LV	
	HV (11kV)	
	HV (33kV)	
	HV (66kV)	
✳	HV (132kV)	✳

PME Earth

—E— Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: EXTER MAIN
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:2000 @ A3
PLOT CENTRE: 301024.707,097369.688

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

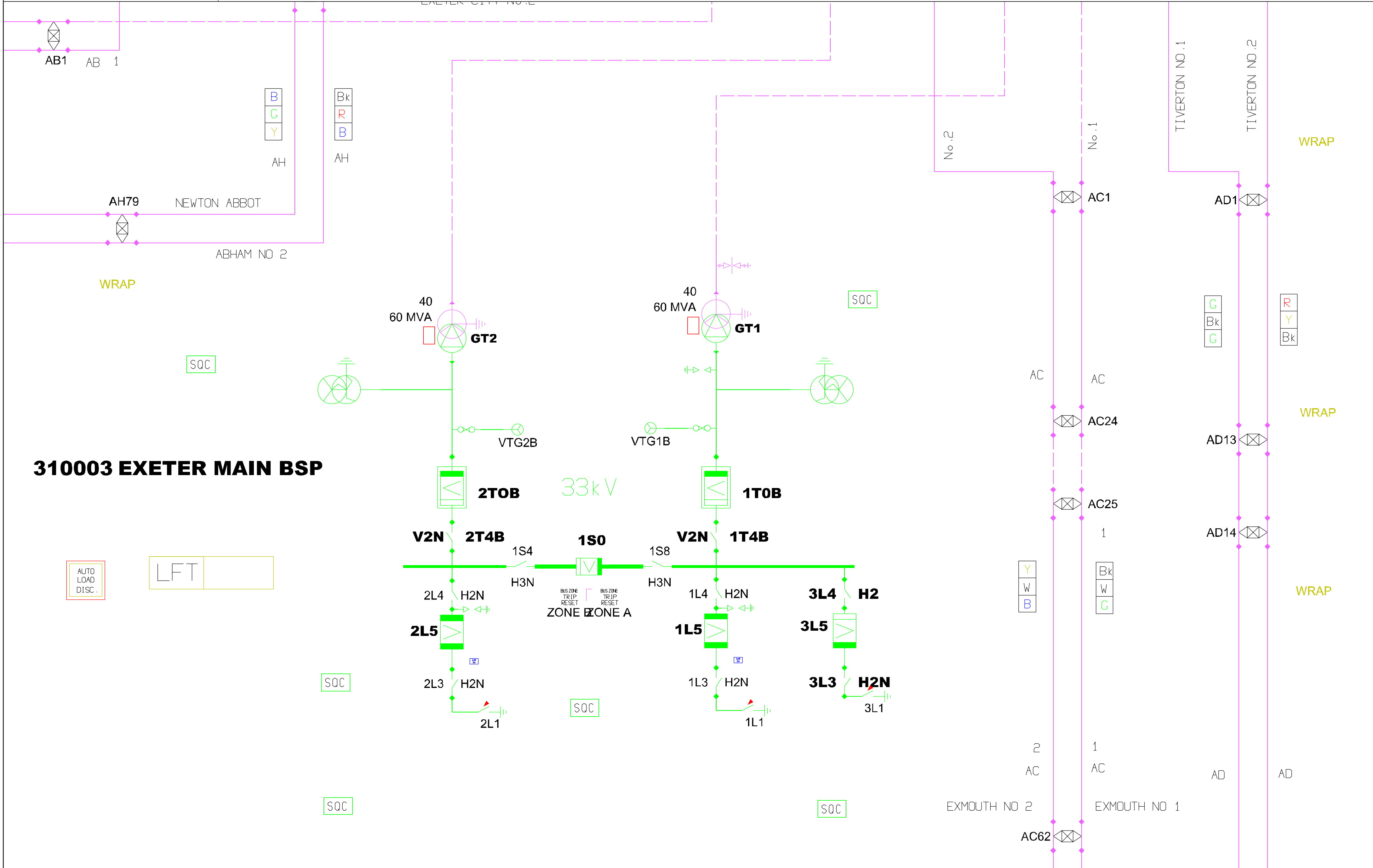
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

310003 EXETER MAIN BSP



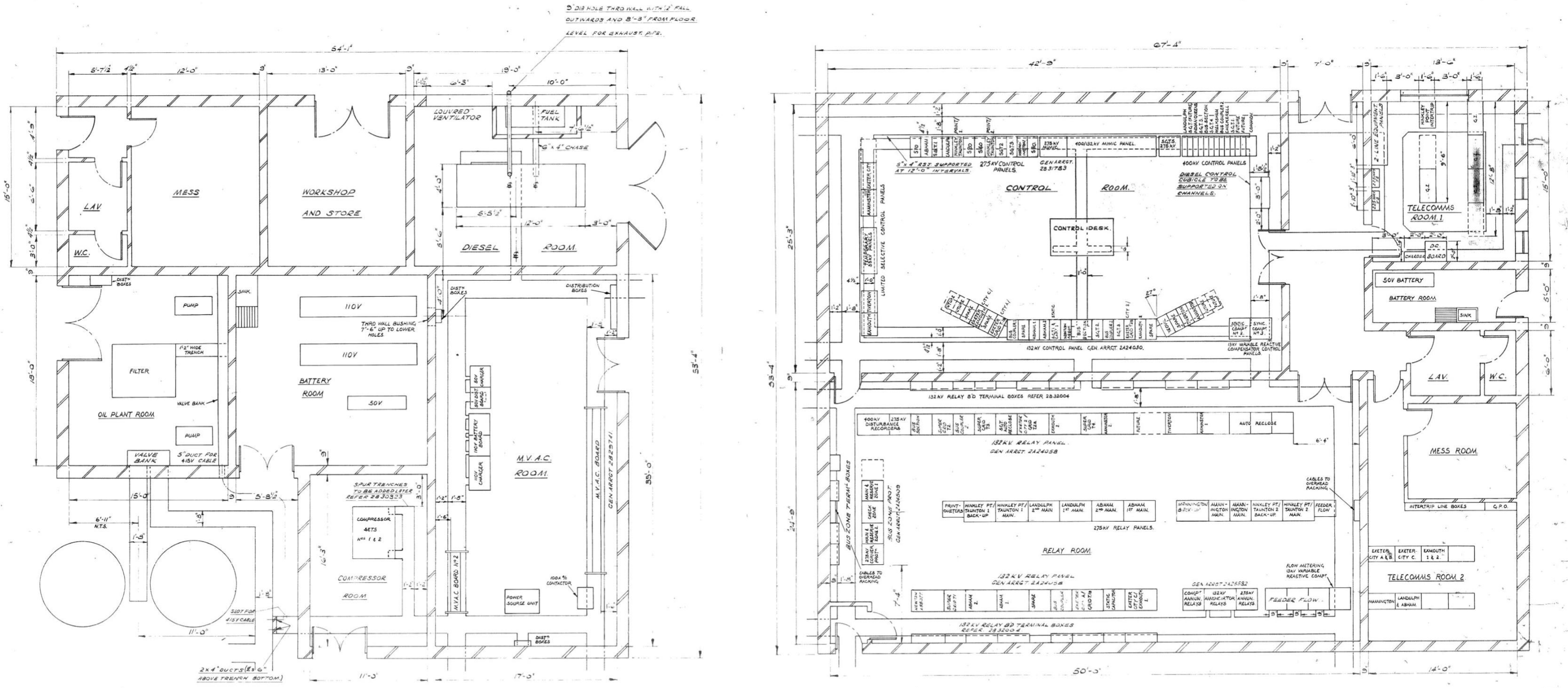
Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT

2A26492



SCALE 1/4" = 1FOOT

ADDED BY	DATE
1	275KV EQUIPMENT ADDED
2	J.A.D. 25-9-69 AMENDED TO SITE INFORMATION IN LINE WITH LETTER FROM S.W. REGION DATED 3.1.68.

FILMED

DESCRIPTION OF TOOL | T.A | DESCRIPTION OF TOOL | T.A

PLANNING SHEET No.

PRINTS ISSUED: SW. WKS. | TOOL RM. | PATT. SHOP | MICA SHOP | FAB. SHOP | TOOL REQ. No. | W.O. No.

XM 70472 XM 70492

THE GENERAL ELECTRIC Co. LTD
WITTON, ENGLAND.

DRAWN BY A.E.C DATE 8-9-60.
TRACED BY DATE
CHECKED BY DATE
S.L. J.R. DARBY. APPROVED

ALL DIMENSIONS TO BE WITHIN THE LIMITS INDICATED ON STANDARD No. 21 x 3, UNLESS OTHERWISE STATED ON DRAWING.

DRG. No. 2A26492

LAYOUT OF EQUIPMENT IN SUBSTATION BUILDINGS FOR EXETER MAIN

C.E.G.B. T(4)3666

21/12839

RACT T(4) C.E.G.B.- S666- EXETER MAIN

APPENDIX D - SITE PHOTOS


BUS SECTION X-Y
ISO

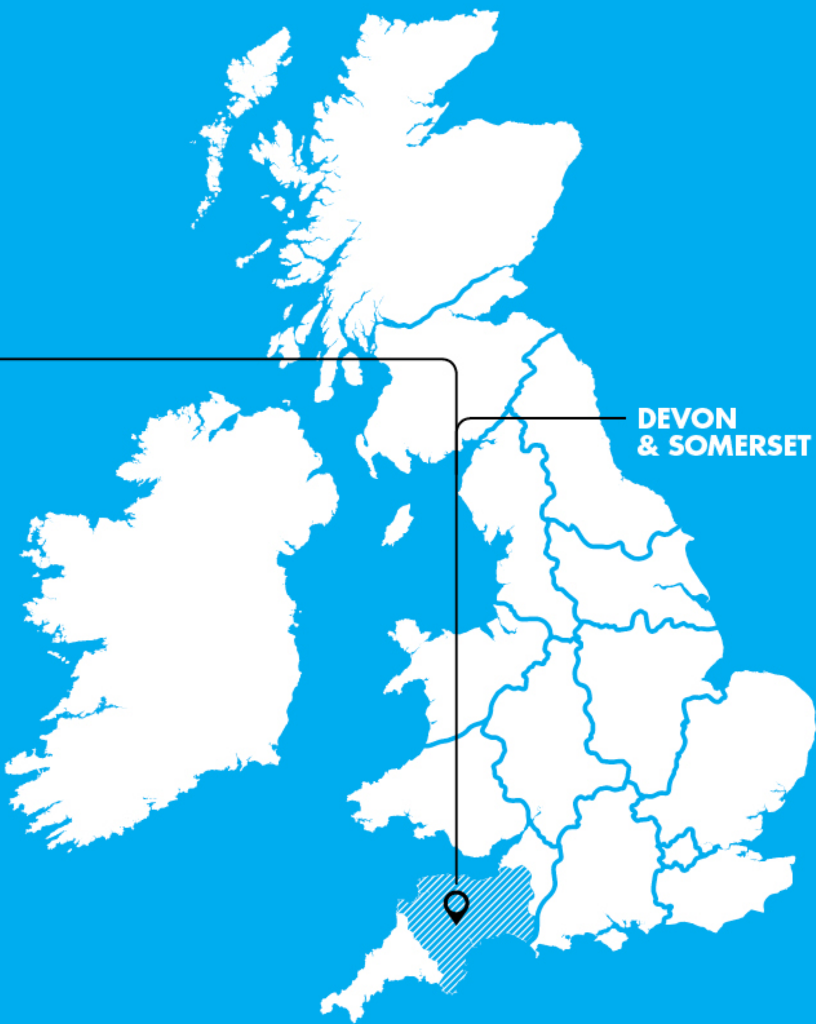

TRANSFORMER T1B


WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Lydeard St Lawrence 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Lydeard St Lawrence Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Lydeard St Lawrence 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Lydeard St Lawrence 33/11kV Substation is fed via two no. 33kV overhead line circuits with one from Taunton BSP and the other from Bowhays Cross BSP. The substation consists of two no. 5/6.25MVA 33/11kV transformers and an eight panel 11kV switchboard, both of which were commissioned in 2014.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There is no capital works planned for the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to remain relatively stable over the next 5 year period with no constraints predicted in the substation capacity.

Table 2-1: Load forecast for Lydeard St Lawrence substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Lydeard St Lawrence	33/11	0.99	3.52	3.46	3.41	3.39	3.40	3.43	6.5

2.4 Customers

2.4.1 Number of Customers

Lydeard St Lawrence currently supplies 4,400 customers and has two large generators over 1 MW connected.

2.4.2 Type of Loads

The main loads connected to the substation are light industrial and domestic customers.

2.4.3 Generation

The total amount of embedded generation feeding into the Lydeard St Lawrence 11kV network is 5.4MW. This is supplied by a two solar PV sites. There are currently no connections committed for the future over 1MW.

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers at the substations were manufactured by Brush and were installed in 2014. The transformers are rated at 5/6.25MVA and have a 17 position AT 317 44/300L Tap Changer. The site is currently operated with only the single transformer in service at any one time due to 33kV supplies from different BSPs.

2.5.2 Automatic Voltage Control Relays

There are currently two no. MicroTAPP relays installed in a single panel providing voltage control of both transformers. The panel was installed along with the replacement of the transformers and switchgear.

2.5.3 Auxiliary Systems

The substation has an 110V battery system installed in 2014 as part of the 11kV switchgear replacement. This has enough spare capacity for any site modifications required for the SVO method. The D20 SCADA communications system was also installed along with the 11kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Lydeard St Lawrence feeder voltages using WPD IPSA models determined that a 0.015pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Lydeard St Lawrence after the transformers were replaced in 2014. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

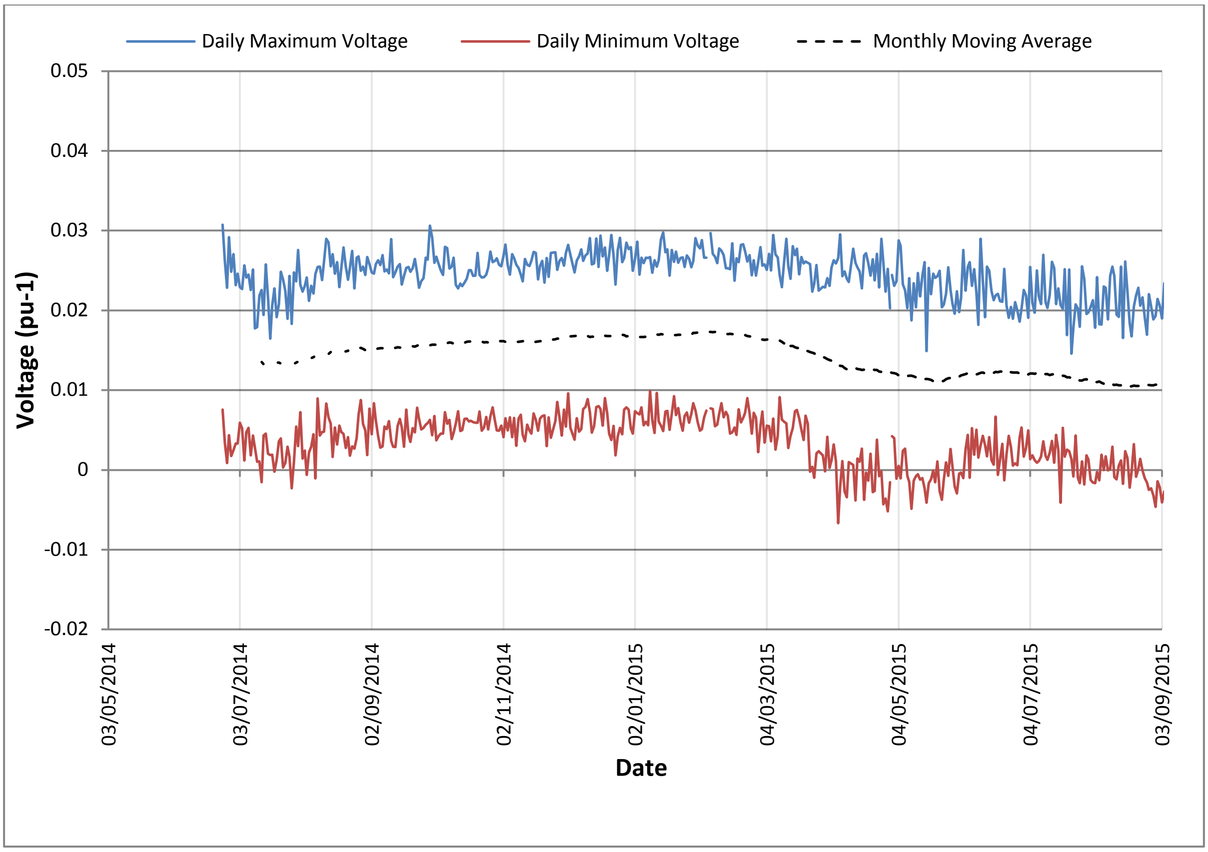


Figure 3-1: Historic voltage profile at Lydeard St Lawrence

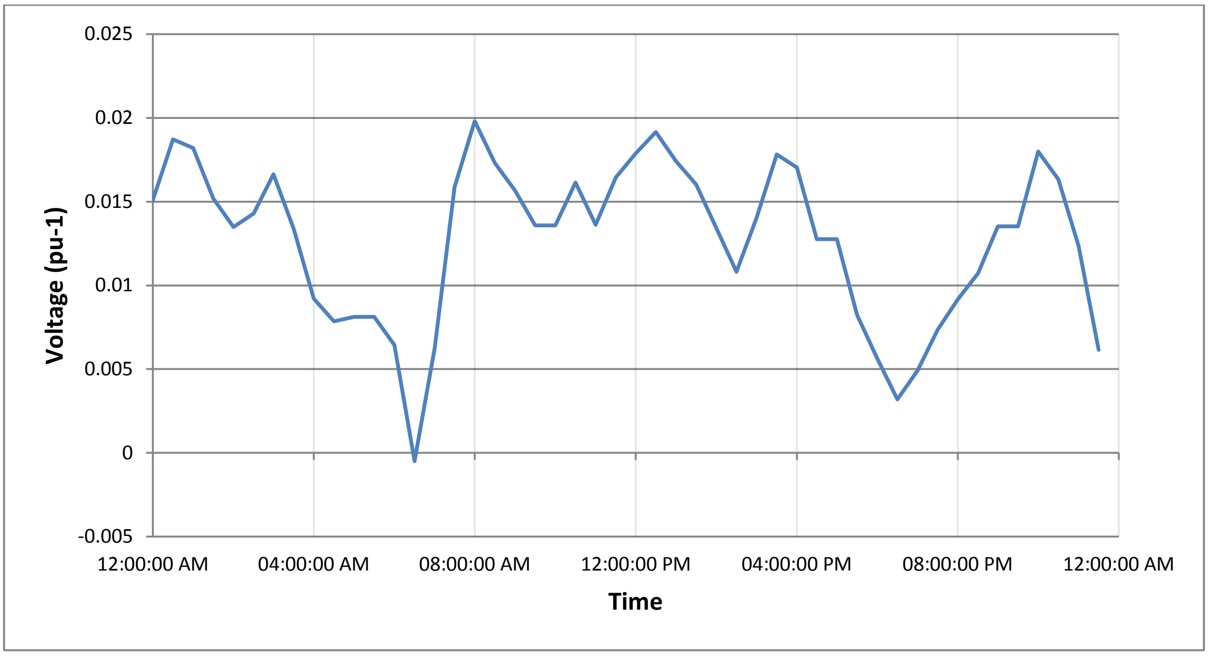


Figure 3-2: 01/06/15 voltage profile at Lydeard St Lawrence

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.015pu below nominal and remain within statutory limits.

The historical voltage profiles show that the general trend for the moving average has been to decrease after an initial rise ending up at a value of 0.1pu in September 2015. The daily fluctuations in voltage have remained roughly constant over the last two years at an average of 0.023pu.

With the substation operating at around 0.01pu above nominal it may be possible to achieve a 0.025pu voltage reduction.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

As the existing MicroTAPP relays have the function to control group settings, it is planned to utilise them as part of the SVO method and enable them for use via the installation of interposing relays. The relay will require minor wiring modifications and commissioning with new settings.

3.3.2 AVC Panel

Each AVC panel will be modified to include the required number of interposing relays internally. These will be mounted to the existing internal rail with all additional wiring utilising the existing cable containment within the panel.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, six potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable selection of the different AVC settings groups.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Lydeard St Lawrence. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Lydeard St Lawrence will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

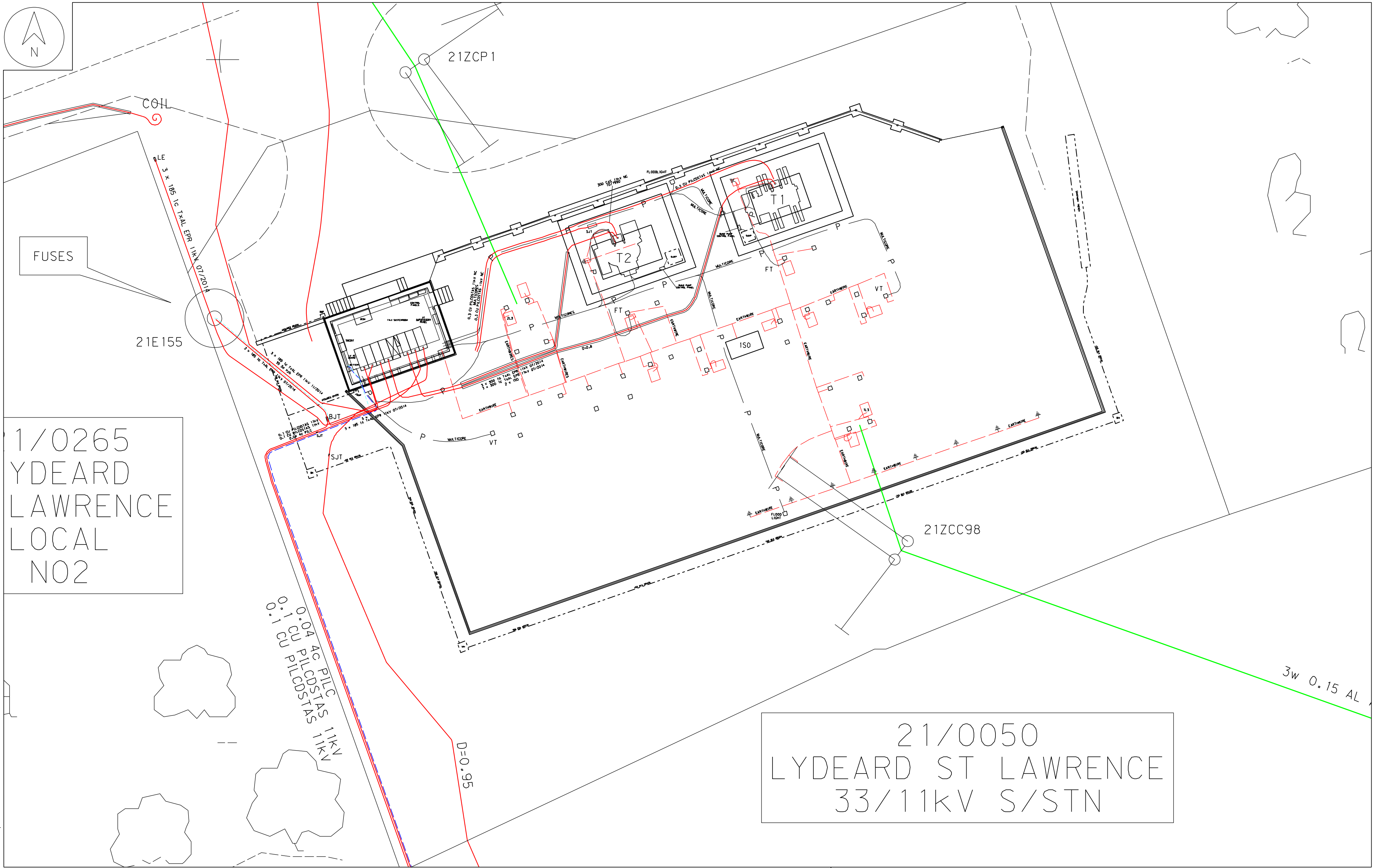
Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.



SURF TELECOMS APPARATUS	OVERHEAD LINE		UNDERGROUND CABLE
S		PL	
PILOT CABLES P		SERVICE	
		LV	
		HV (11kV)	
		HV (33kV)	
		HV (66kV)	
		HV (132kV)	

PME Earth — Pole Mounted Transformer
Underground Earth — Ground Mounted Transformer

* ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: LYDEARD ST LAWRENCE
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:250 @ A3
PLOT CENTRE: 313327.565,131885.904

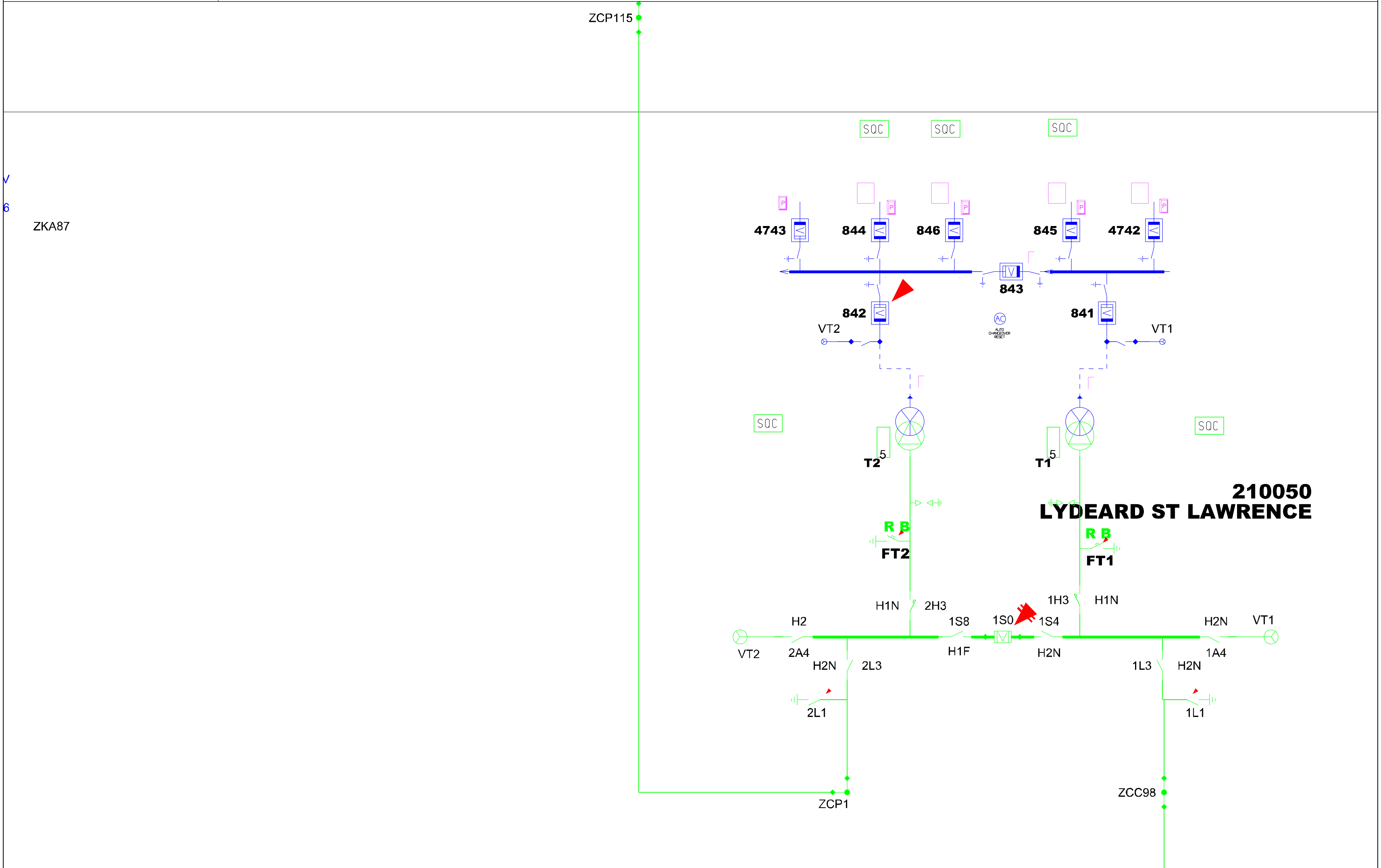
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

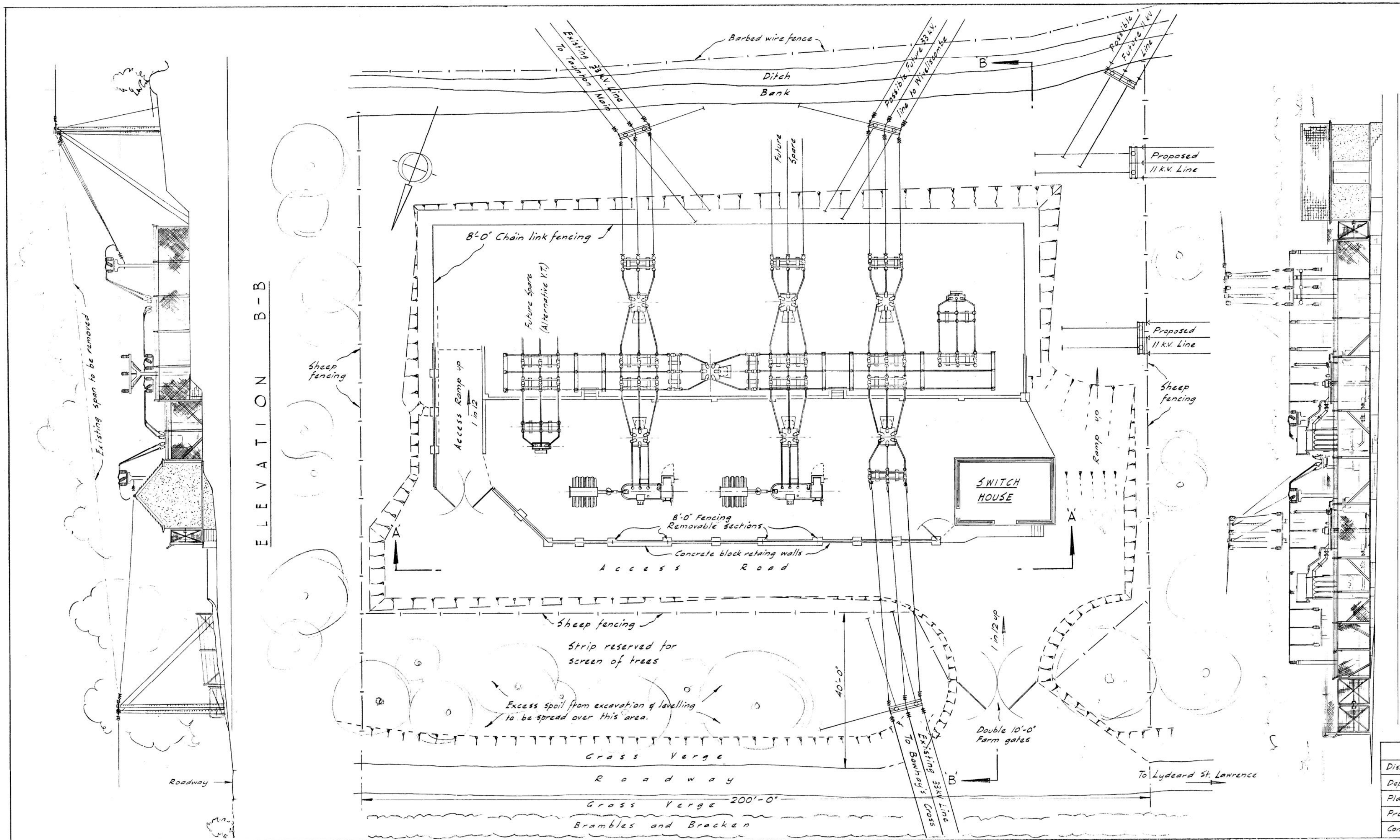
WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

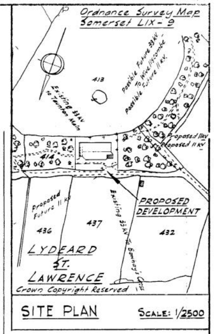
Information is given as a guide only
and it's accuracy cannot be guaranteed.



APPENDIX C - CONTROL ROOM LAYOUT

20/7729





APPROVED BY	SIGNATURE	DATE
District Manager		
Deputy Group Engineer	[illegible]	[illegible]
Planning Engineer	[illegible]	[illegible]
Protection Engineer	[illegible]	[illegible]
Construction Engineer	[illegible]	[illegible]

PROPOSED ULTIMATE LAYOUT FOR 33/11 K.V. SUBSTATION AT LYDEARD ST. LAWRENCE

C.R.S. 5.11.59

1/8" to 1 foot

2/6/5058

20/7729

APPENDIX D - SITE PHOTOS


PANEL
33/11kV TRANSFORMER No.1
33/11kV TRANSFORMER No.2


-110V BATTERY & CHARGER-
-48V BATTERY & CHARGER-


BRUSH
T2
T1

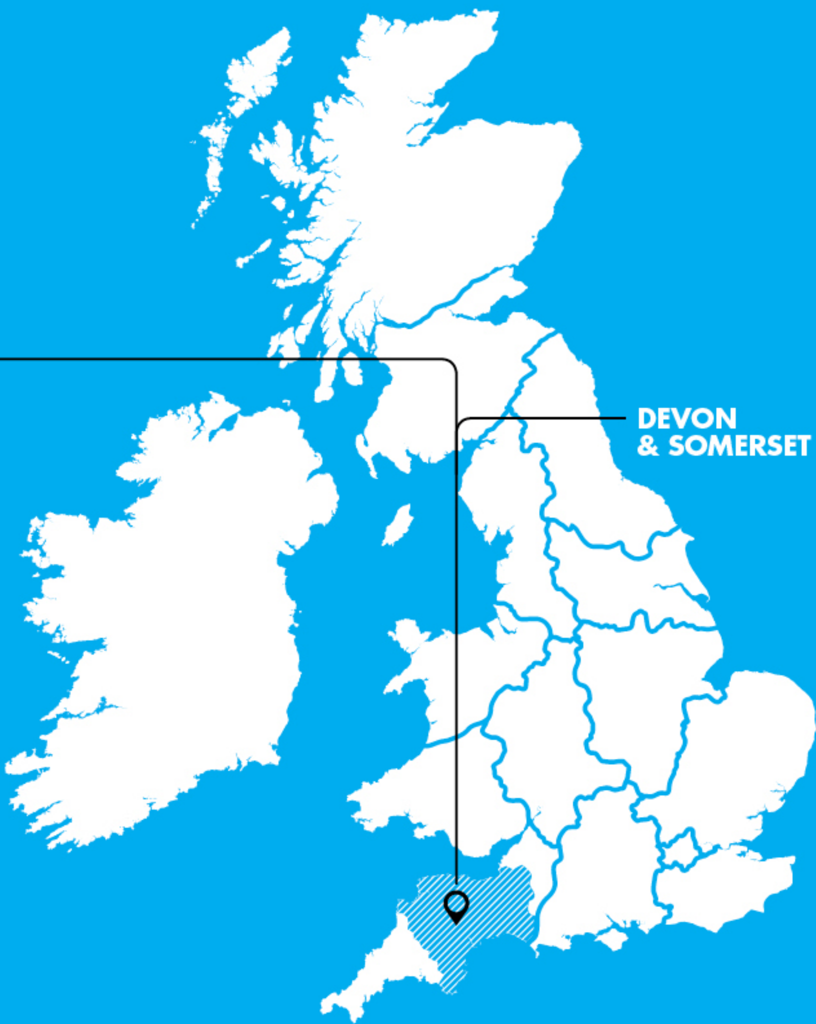

T1

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Marsh Green 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Marsh Green Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Marsh Green 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each subsation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Marsh Green 33/11kV Substation is fed via one circuit from Exeter Main BSP via Ottery St Mary and one circuit from Sowton BSP via Clyst Honiton. The substation consists of two 5/7.7MVA transformers with a six panel 11kV switchboard. The substation was originally commissioned in 1960 with the 11kV switchboard being replaced in 2008. Due to 33kV supplies from different BSPs the substation is operated with the 11kV transformers split via the 11kV bus section.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There is no capital works planned for the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to remain relatively stable on both transformers over the next 5 year period with no constraints predicted in the substation capacity.

Table 2-1: Load forecast for Marsh Green substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Marsh Green T1	33/11	0.99	3.85	3.85	3.81	3.78	3.79	3.83	7.7
Marsh Green T2	33/11	0.98	1.21	1.44	1.43	1.42	1.42	1.44	7.7

2.4 Customers

2.4.1 Number of Customers

Marsh Green currently supplies 2,796 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

The main loads connected to the substation are light industrial and domestic customers.

2.4.3 Generation

The total amount of embedded generation feeding into the Marsh Green 11kV network is 5MW. This is supplied by a single solar PV site. There are currently no connections committed for the future above 1MW.

2.5 Voltage Control Equipment

2.5.1 Transformers

The first transformer at the substation was manufactured in 1960 by Ferranti Transformer and is rated at 5/7.7MVA with a 17 position tap changer. The second transformer was manufactured in 1980 by Johnson and Phillips Ltd and is rated at 5/7.7MVA with an 11 position tap changer.

2.5.2 Automatic Voltage Control Relays

There are currently 2 no. KVGC202 relays installed in a single panel providing voltage control of both transformers. The panel was installed alongside the replacement of the 11kV switchgear.

2.5.3 Auxiliary Systems

The substation has an 110V battery system installed as part of the 11kV switchgear replacement. The D20 SCADA communications system was also installed alongside the 11kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Marsh Green feeder voltages using WPD IPSA models determined that a 0.014pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Marsh Green over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

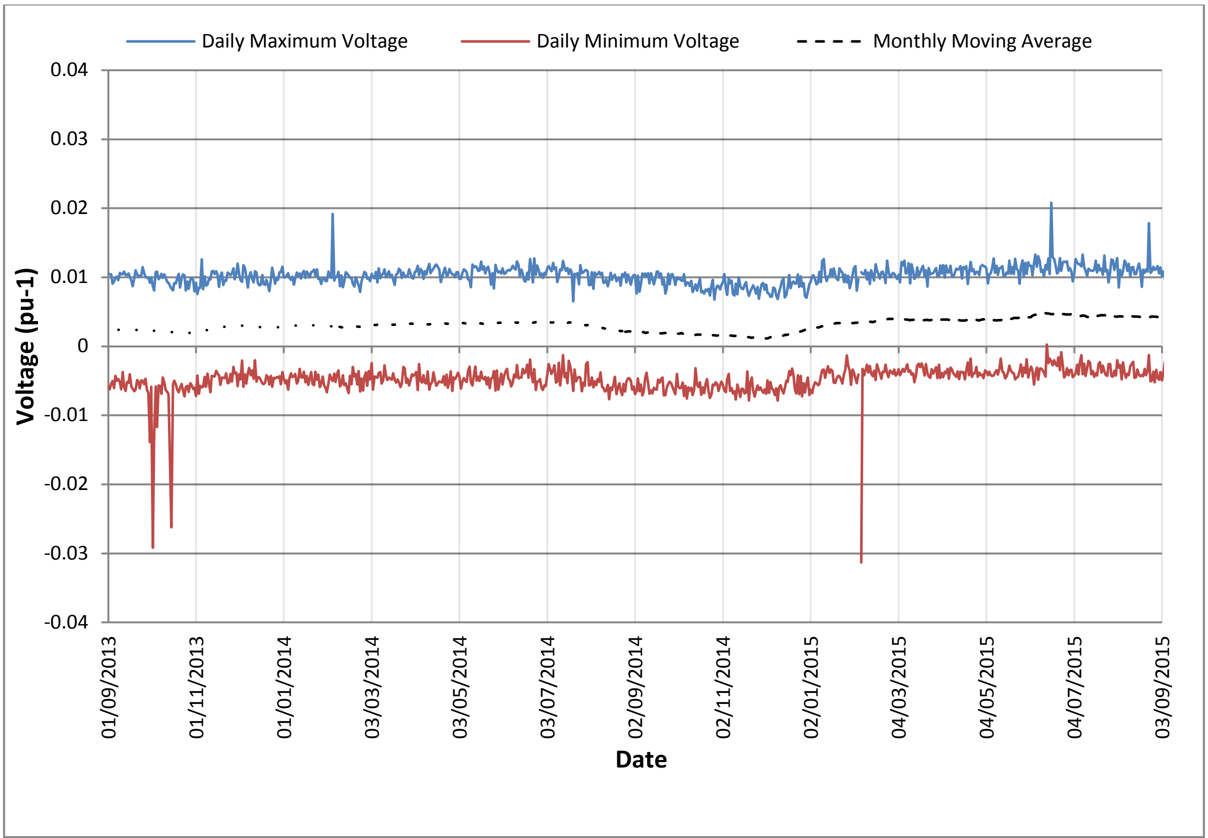


Figure 3-1: Historic voltage profile at Marsh Green

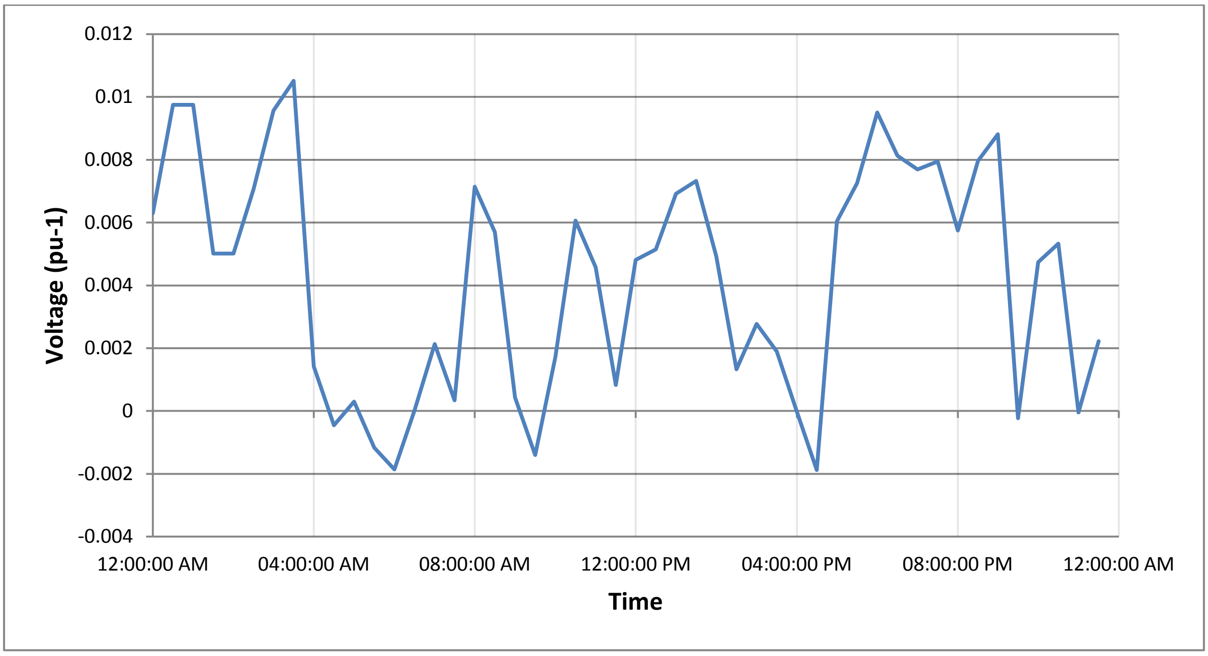


Figure 3-2: 01/06/15 voltage profile at Marsh Green

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.014pu below nominal and remain within statutory limits.

The historical voltage profiles show that the moving average has fluctuated over the two years between the values of 0.0011pu and 0.0048pu, on average the value has been at 0.0031pu. The daily fluctuations in voltage have remained roughly constant over the last two years at an average of 0.017pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Marsh Green the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The front swing door for each AVC panel will be modified to accommodate a new AVC relay and auxiliary relays. This will require the cutting of the panel to fit the new relay and associated wiring.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, five potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable the full operational capability required for the SVO.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Marsh Green. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Marsh Green will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

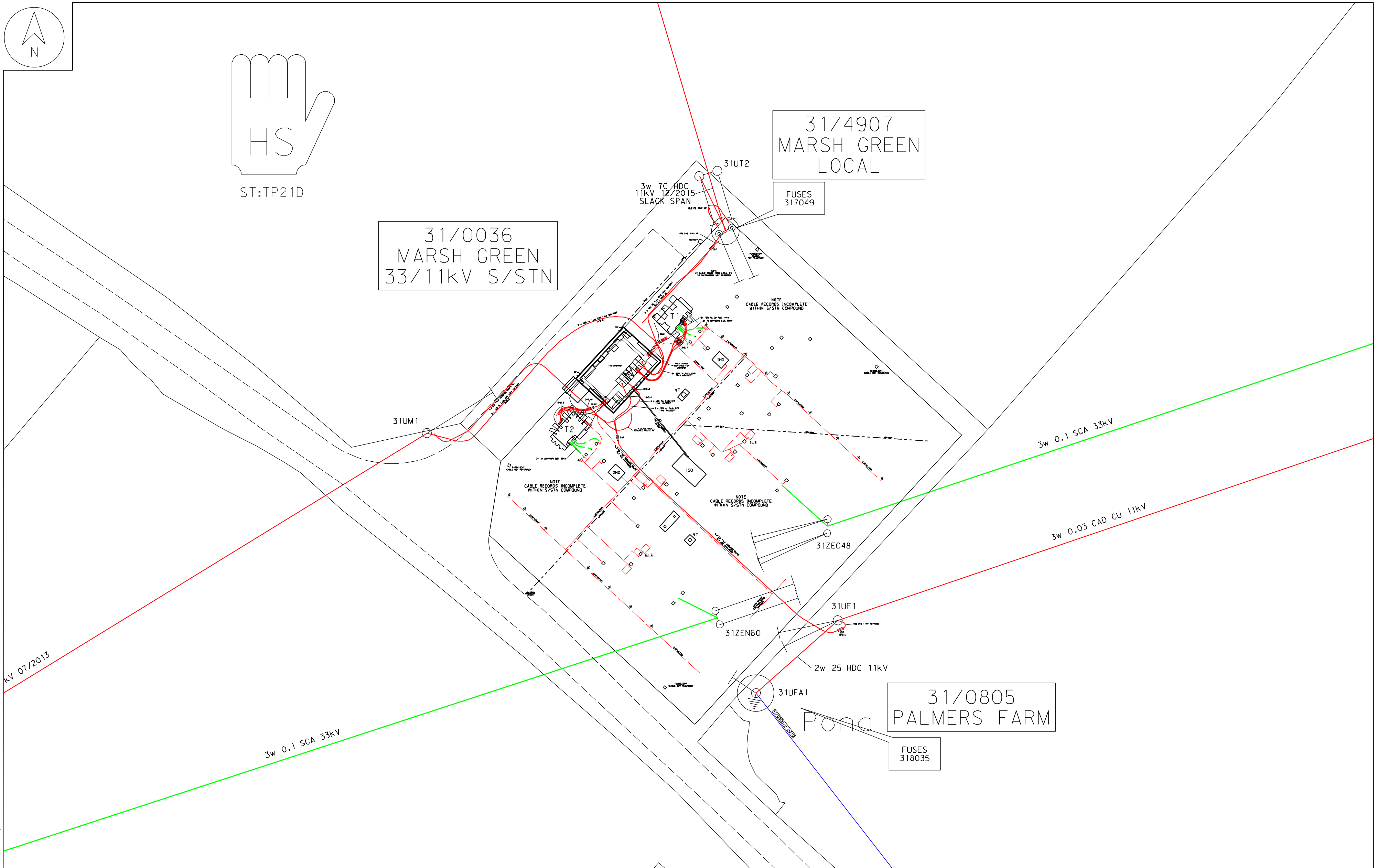
Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Cutting Panels will cause vibrations.	The vibrations can transmit to adjacent panels. If these house old mechanical relays they may be triggered by the vibrations causing unwanted changes in voltage. This can lead to trips occurring.	Remove the door and modify off the panel if possible. Ensure all live panels are labelled clearly. Ensure WPD approved methods are used for cutting existing panels.
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
The old transformer and the new relay may not be compatible.	This may restrict the level of control that can be applied	Check the functionality of the transformer before choosing the relay to be used. Select an alternative site if necessary.
Old transformer degrades at a faster rate due to stricter voltage control requiring more frequent tap changes.	The lifetime of the tap changer reduces.	Aim to install at the sites were the transformers are in better condition. Expect to replace the transformer sooner than anticipated.

APPENDIX A - Overall Network Diagram

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.



Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution. Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

	OVERHEAD LINE		UNDERGROUND CABLE
SURF TELECOMS APPARATUS		PL	
PILOT CABLES		SERVICE	
		LV	
		HV (11kV)	
		HV (33kV)	
		HV (66kV)	
		HV (132kV)	

PME Earth — Pole Mounted Transformer
Underground Earth — Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: MARSH GREEN
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 304719.469,094133.601

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

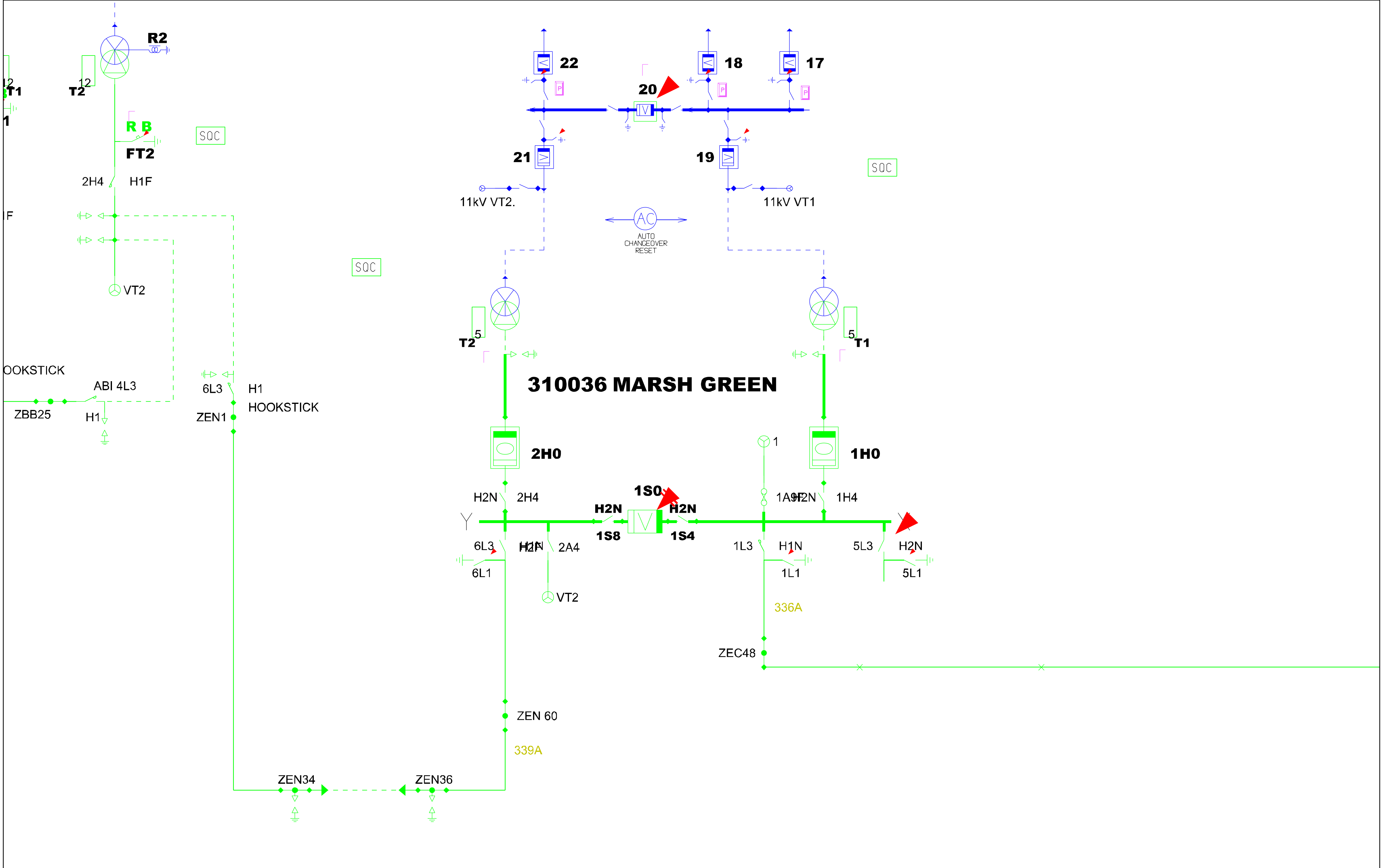
APPENDIX B - Single Line Diagram

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

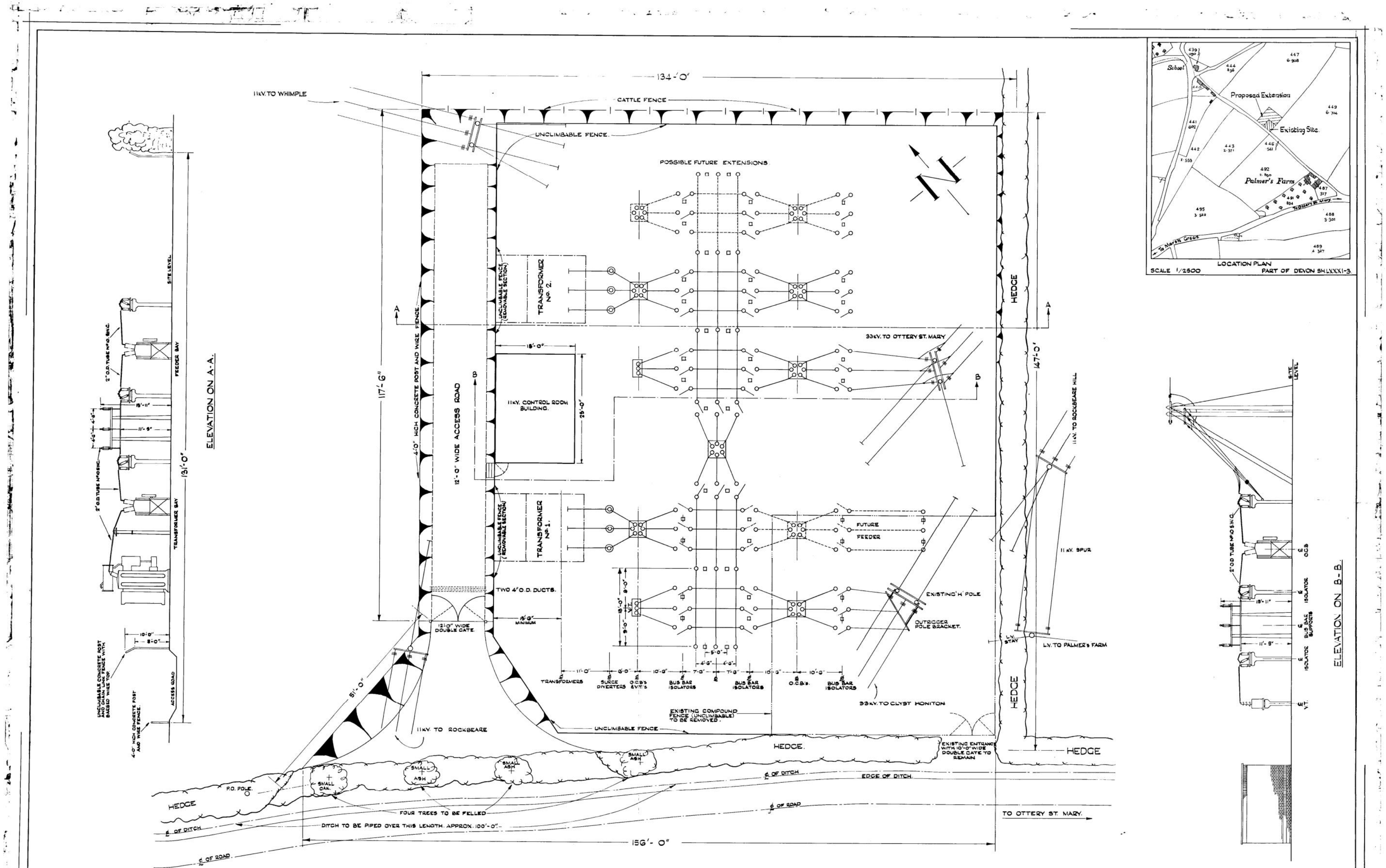
WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

310036 MARSH GREEN



APPENDIX C - Control Room Layout



SOUTH WESTERN ELECTRICITY BOARD
DEVON GROUP

MARSH GREEN.

PROPOSED 33/11kV S/S LAYOUT.

DRAWN BY:	SCALE: 1/8" TO 1 FOOT.
TRACED BY: CHECKED BY:	
APPROVED BY: J.R.W.	Drg. No.30/3012.
DATE: 19 · 10 · 59.	

8012

APPENDIX D - Site photos

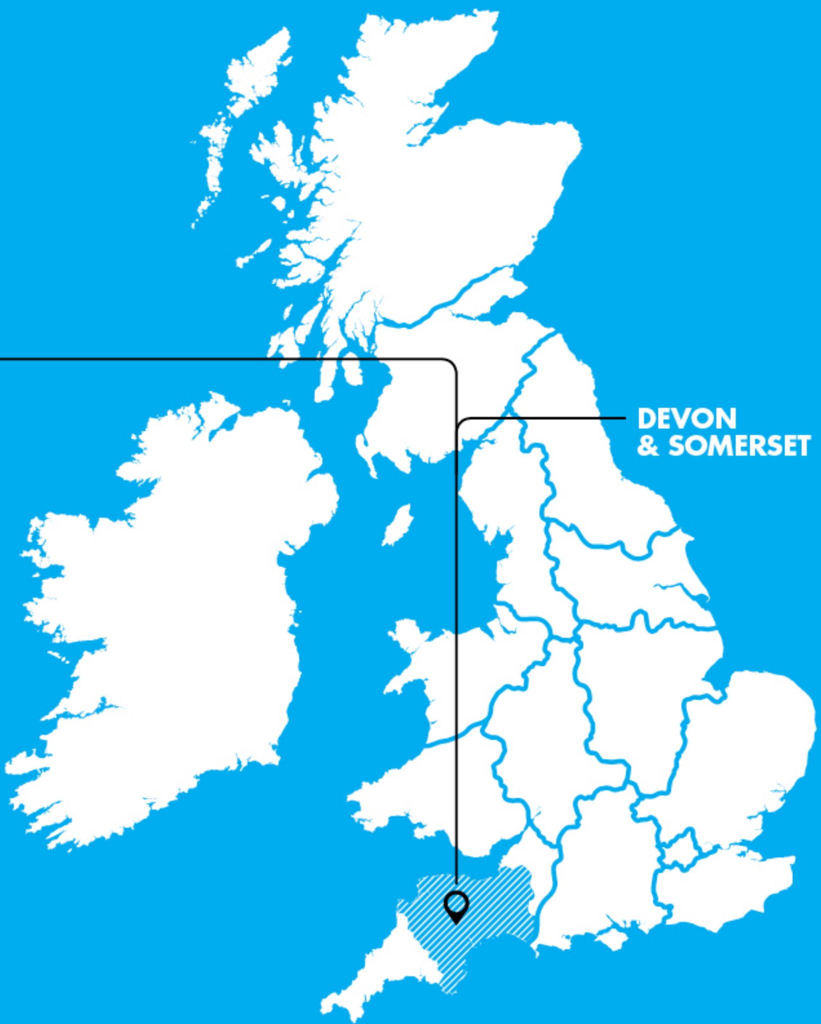

33/11kV TRANSFORMER No.1

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Millfield 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Millfield Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

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1 Introduction

The following report details the findings from the investigation of Millfield 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Millfield 33/11kV substation is supplied via two no. overhead line circuits from Street BSP and consists of two no. 12/24MVA transformers and an 11 panel 11kV switchboard. The substation was originally commissioned in 1979 with the transformers being replaced in 2004.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There is no capital works planned for the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. Overall the load is expected to decrease by 0.48MVA over the next five years.

Table 2-1: Load forecast for Millfield substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Millfield	33/11	0.96	18.86	18.49	18.27	18.14	18.17	18.38	22.86

2.4 Customers

2.4.1 Number of Customers

Millfield currently supplies 4,400 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

The main loads connected to the substation are light industrial and domestic customers.

2.4.3 Generation

The total amount of embedded generation feeding into the Millfield 11kV network is 10.03MW. This is supplied by two solar PV sites. There is a single 1MW solar PV site currently committed for connection; however no commissioning date is currently set.

2.5 Voltage Control Equipment

2.5.1 Transformers

The two 12/24MVA transformers at the substation were manufactured by Brush in 2004 with AT 317 44/300L tap changers providing 17 taps for each transformer.

2.5.2 Automatic Voltage Control Relays

There are currently two no. KVGC202 relays installed in a single panel providing voltage control of both transformers. The panel was installed alongside the replacement of the transformers.

2.5.3 Auxiliary Systems

The substation has an 110V battery and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Millfield feeder voltages using WPD IPSA models determined that there is no voltage reduction available at Millfield whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Millfield over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

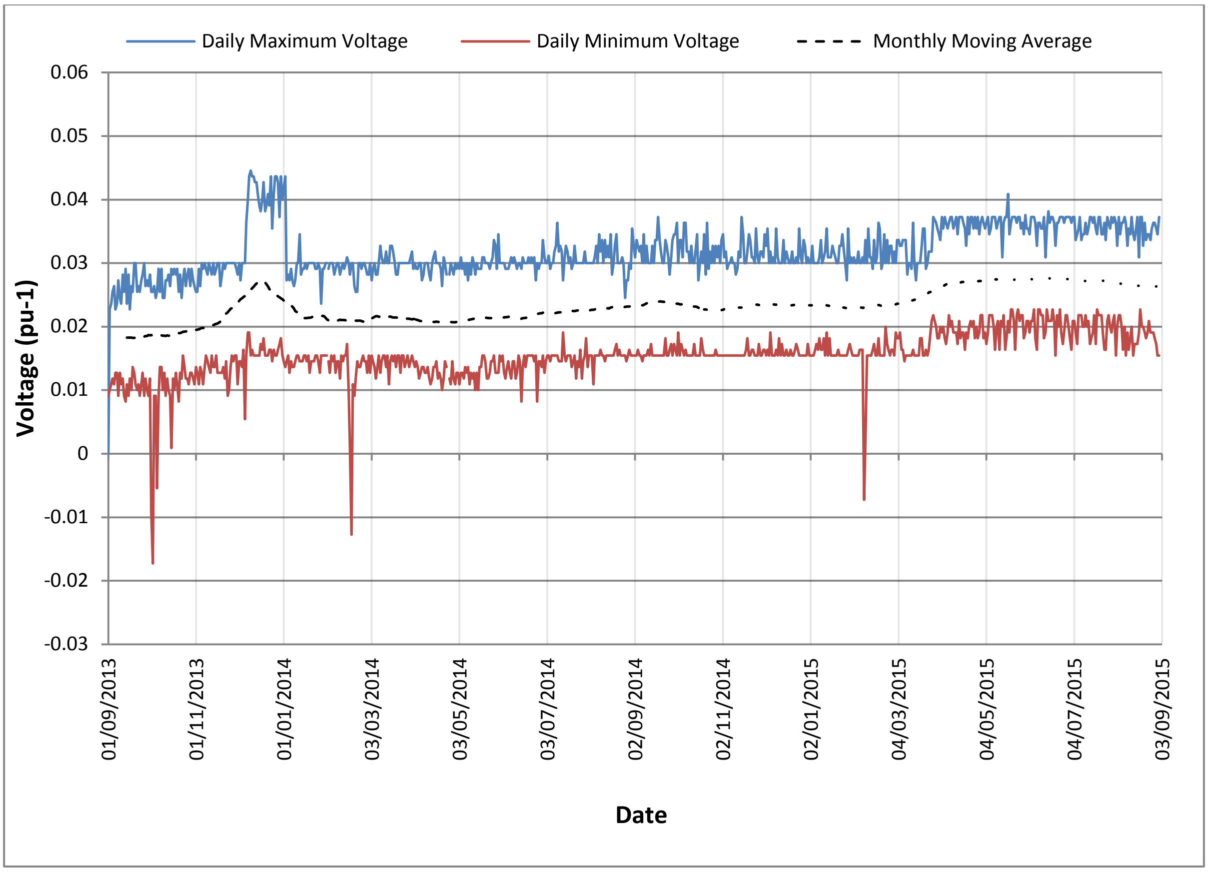


Figure 3-1: Historic voltage profile at Millfield

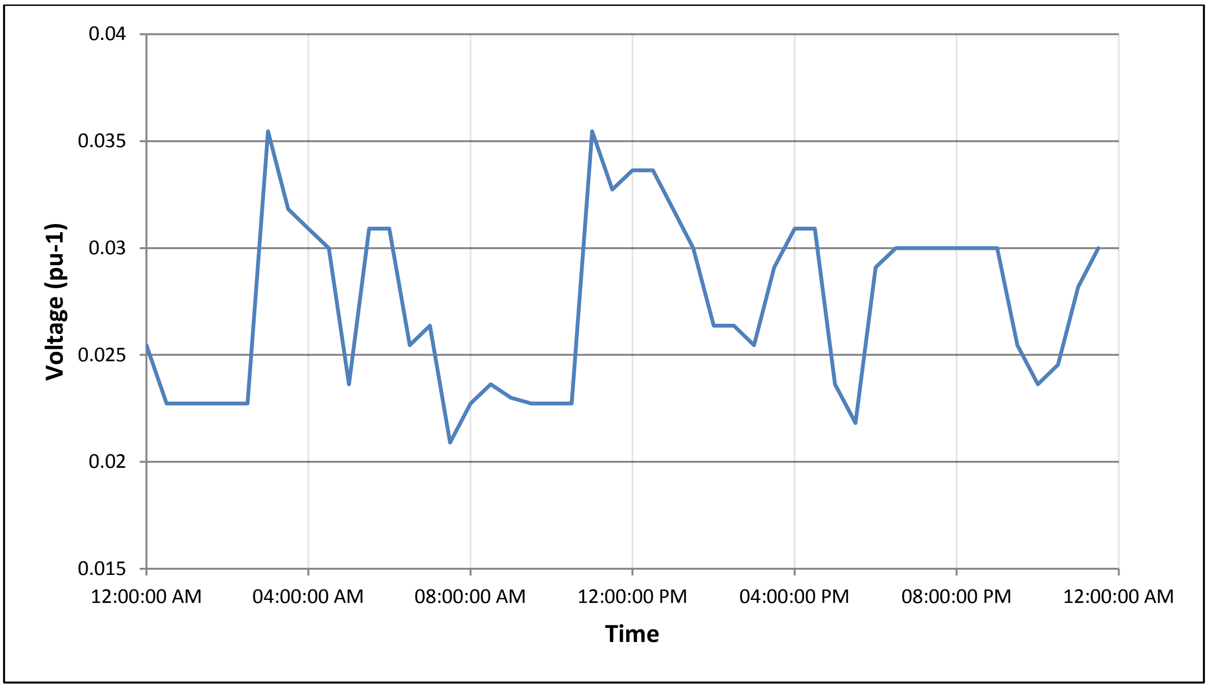


Figure 3-2: 01/06/15 Voltage profile at Millfield

3.2.3 Results

The voltage studies have shown that the voltage cannot be reduced below 1pu and remain within statutory limits.

The historical voltage profiles show that in the first six months September 2013 to March 2014 there were large variations in the daily fluctuations and the average voltage. Past this point the daily fluctuations in voltage on average have been 0.016pu. After the first six months the moving average has risen from a level of 0.021pu to 0.027pu.

With the substation operating at around 0.03pu above nominal it may be possible to achieve some voltage reduction.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Millfield the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The front swing door for each AVC panel will be modified to accommodate a new AVC relay and auxiliary relays. This will require the cutting of the panel to fit the new relay and associated wiring.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, twelve potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable the full operational capability required for the SVO.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Millfield. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Millfield will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

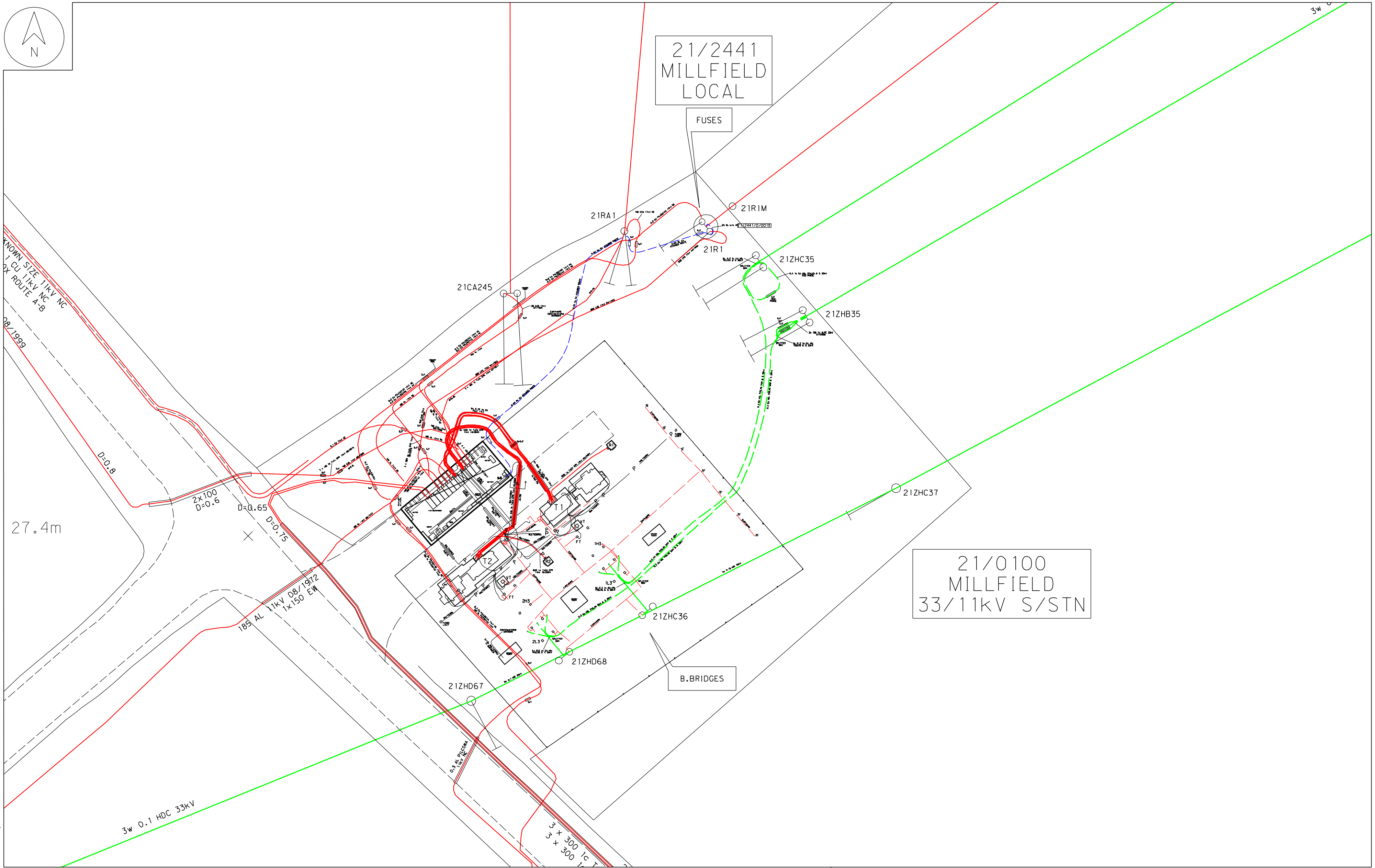
Table 4-1: Site specific risks

Risk	Effect	Action
Cutting Panels will cause vibrations.	The vibrations can transmit to adjacent panels. If these house old mechanical relays they may be triggered by the vibrations causing unwanted changes in voltage. This can lead to trips occurring.	Remove the door and modify off the panel if possible. Ensure all live panels are labelled clearly. Ensure WPD approved methods are used for cutting existing panels.
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

SURF TELECOMS APPARATUS	OVERHEAD LINE		UNDERGROUND CABLE
—S—S—		PL	
		SERVICE	
		LV	
		HV (11kV)	
PILOT CABLES —P—P—		HV (33kV)	
		HV (66kV)	
	✳	HV (132kV)	✳

PME Earth
Underground Earth
Pole Mounted Transformer
Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: MILLFIELD
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 349646.168,135914.719

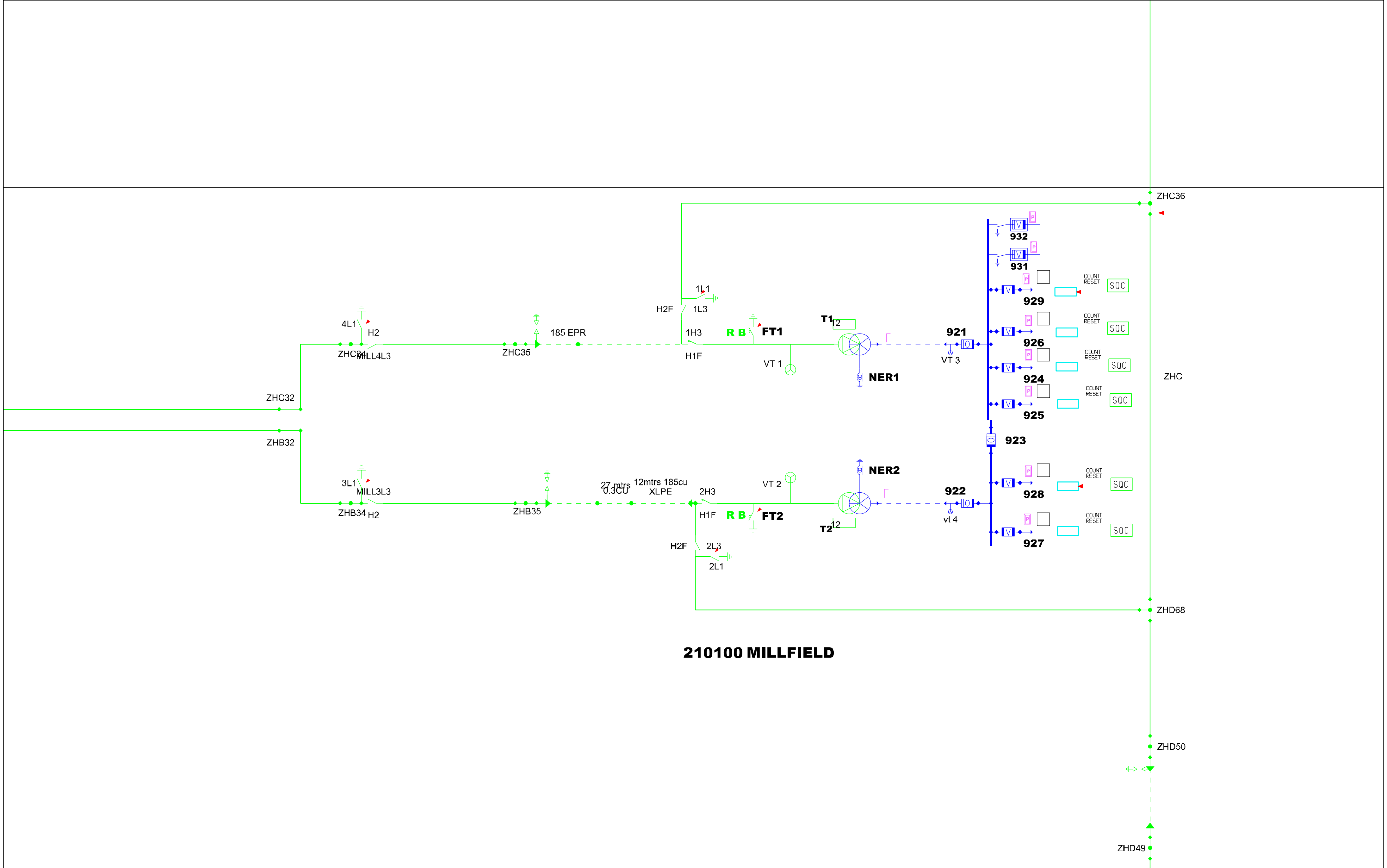
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



210100 MILLFIELD

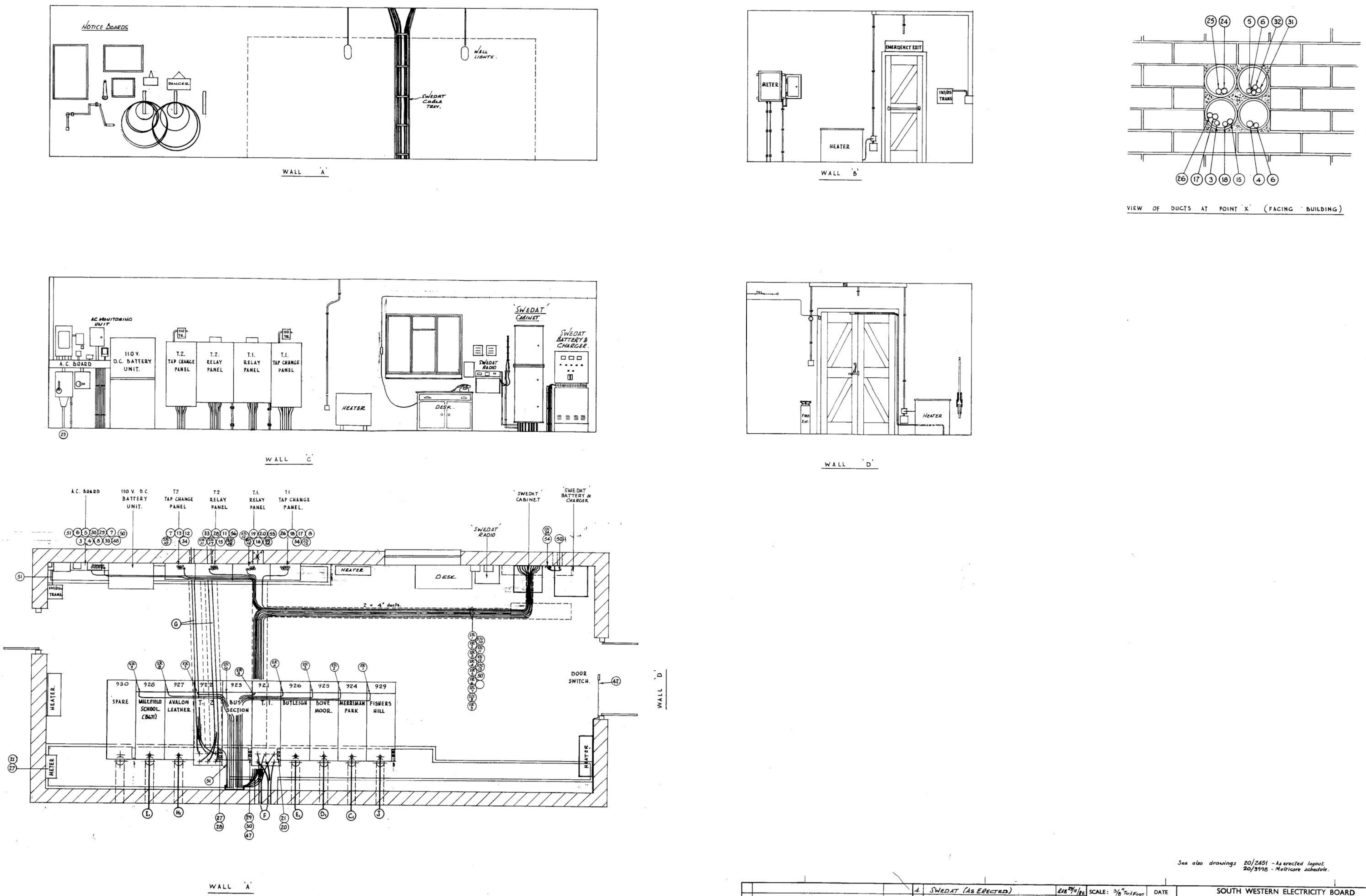
Tiles: 179, 192

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT



See also drawings 20/2451 - As erected layout.
20/3998 - Multicore schedule.

No.	REVISION	SIG./DATE	No.	REVISION	SIG./DATE		DATE
			4	SWEDAT (AS ERECTED)	RAB 27/11/86	SCALE: 3/8" To 1 Foot	DATE
			3	As ERECTED	RAB 9.1.79	DRAWN: P.J.N.	19.5.72.
6	MULTICORES 55 & 5C ADDED	RAB 20/4/95	2	Data logger panel added, also m/cores 48 & 49.	PJN. 10-10-73.	CHECKED:	
5	SWEDAT COMMISSIONED	RAB 13/10/87	1	Redrawn to 'as erected.'	PJN. 19-5-72.	APPROVED:	

SOUTH WESTERN ELECTRICITY BOARD

C. C. D. DISTRICT/GROUP

TITLE MILLFIELD 33/11 kV. S/S.

LAYOUT OF 11 kV SWITCH HOUSE.

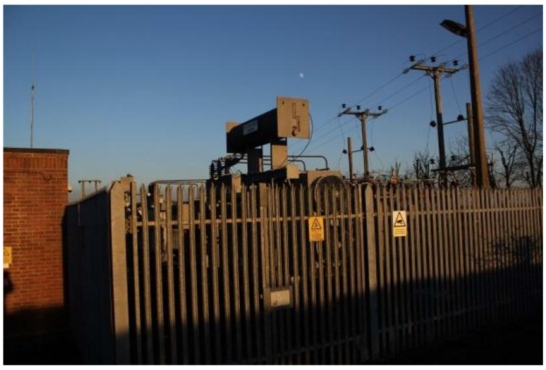
DRAWING NUMBER 20/3999

ADMEL 3171

APPENDIX D - SITE PHOTOS


33/11kV
TRANSFORMER No.1
P11
33/11kV
TRANSFORMER No.2



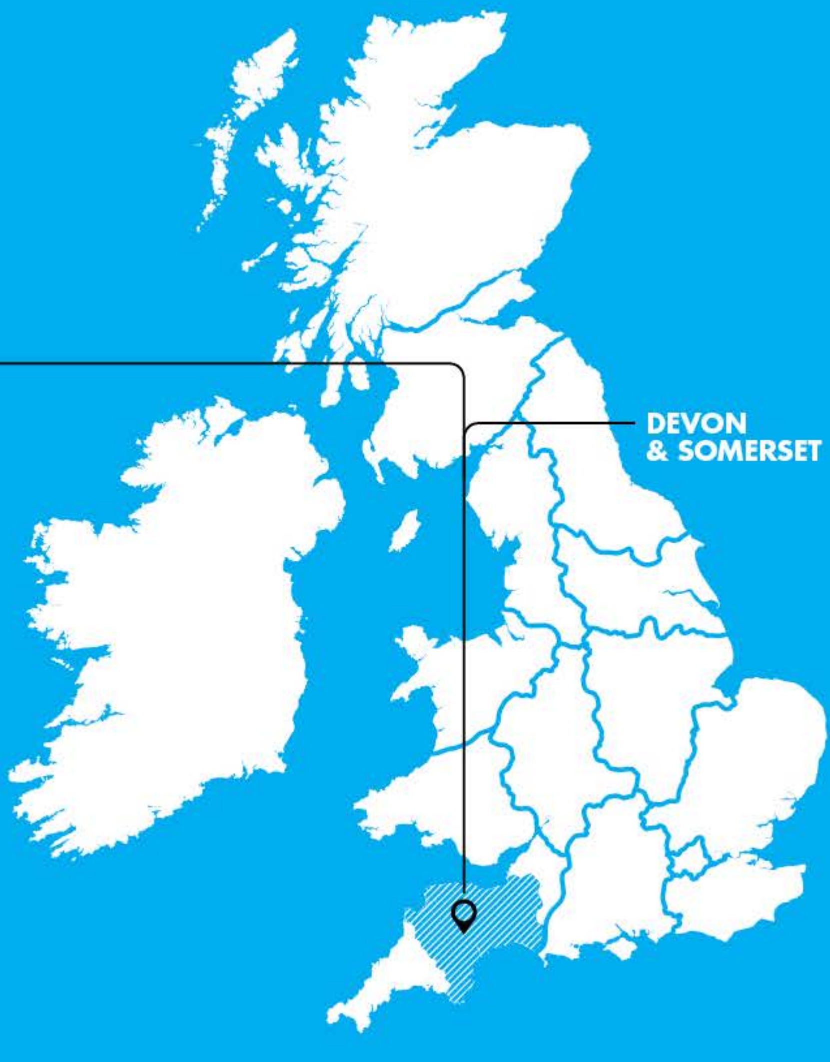
33/11kV
TRANSFORMER No.2
P12


DANGER
LIVE
APPARATUS

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND



SVO Substation Investigation
Nether Stowey 33/11kV

LCN Fund
Low Carbon Networks

Report Title	:	Nether Stowey Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Contents

1 Introduction

The following report details the findings from the investigation of Nether Stowey 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Nether Stowey 33/11kV Substation is fed via two 33kV overhead line circuits with one from Bridgwater BSP and the other from Bowhays Cross BSP. The substation consists of two 7.5/15MVA 33/11kV transformers and a six panel 11kV switchboard, both of which were commissioned in 1990.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There is no capital works planned for the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to remain roughly constant over the next five years.

Table 2-1: Load forecast for Nether Stowey substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Nether Stowey	33/11	0.96	6.18	6.06	5.99	5.94	5.98	6.04	14

2.4 Customers

2.4.1 Number of Customers

Nether Stowey currently supplies 4,400 customers and no voltage sensitive customers.

2.4.2 Type of Loads

The main loads connected to the substation are light industrial and domestic customers.

2.4.3 Generation

The total amount of embedded generation feeding into the Nether Stowey 11KV network is 1.36MW from a single alternative source. There are currently no connections committed for the future above 1MW.

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers at the substations were manufactured by Brush and were installed in 1990. The transformers are rated at 7.5/15MVA and have a 17 position AT 317 44/300L Tap Changer. The site is currently operated with only the single transformer in service at any one time due to 33kV supplies from different BSPs.

2.5.2 Automatic Voltage Control Relays

There are currently two no. MVGC01 relays installed in separate panels alongside the transformer winding temperate and buchholz trip relays for the respective transformers. The panels were installed alongside the replacement of the transformers.

2.5.3 Auxiliary Systems

The substation has an 110V battery and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Nether Stowey feeder voltages using WPD IPSA models determined that a 0.013pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Nether Stowey over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

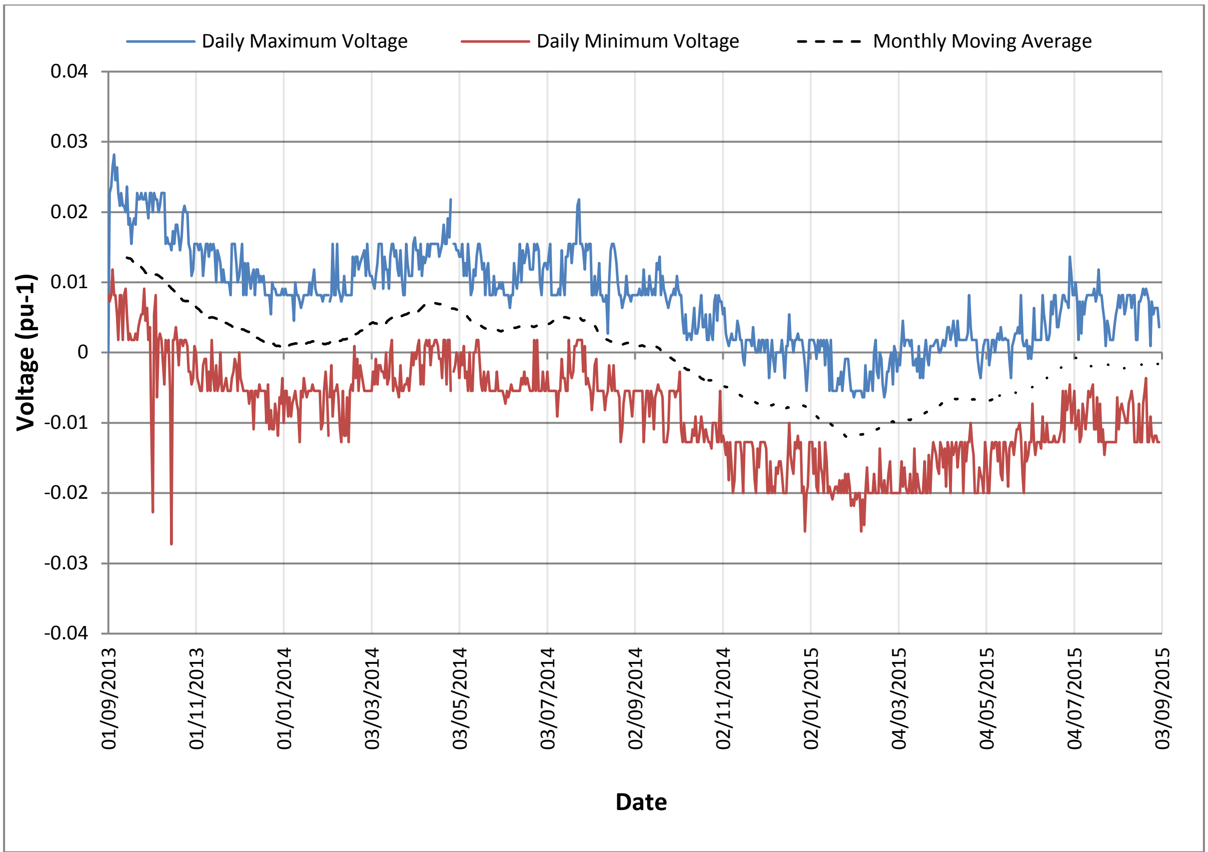


Figure 3-1: Historic voltage profile at Nether Stowey

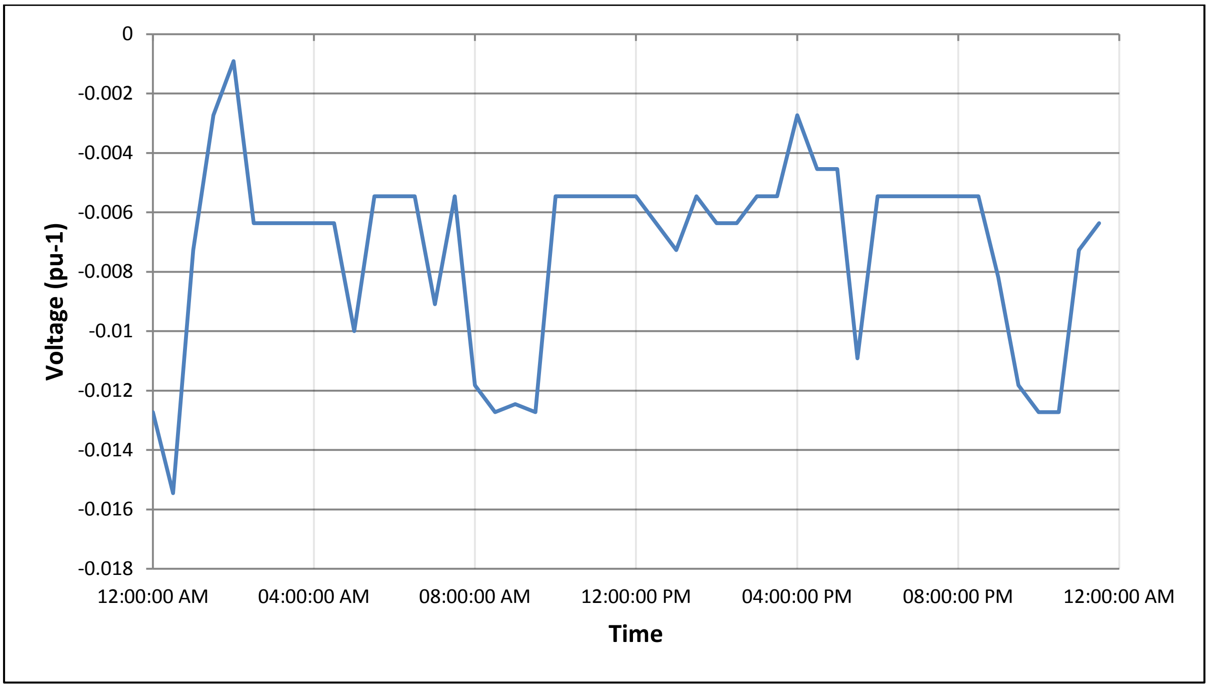


Figure 3-2: 01/06/15 Voltage profile at Nether Stowey

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.013pu below nominal and remain within statutory limits.

The historical voltage profiles show that the moving average has oscillated over the last two years with a maximum value of 0.0134pu in September 2013, minimum value of -0.0120 in February 2014 and an average value of -0.0006pu. The daily fluctuations in voltage have remained roughly constant over the last two years at an average 0.016pu.

The voltage history shows the site has been subject to large variations and sometimes dropping below the limits recommended in the studies. The addition of SVO at the substation may help to control the voltage and to limit the level of fluctuation.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Millfield the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The front swing door for each AVC panel will be modified to accommodate a new AVC relay and auxiliary relays. This will require the cutting of the panel to fit the new relay and associated wiring.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, six potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Modifications are required to the existing SCADA system to enable the extra communications required. This will include additional wiring and communications cards.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Nether Stowey. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Nether Stowey will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

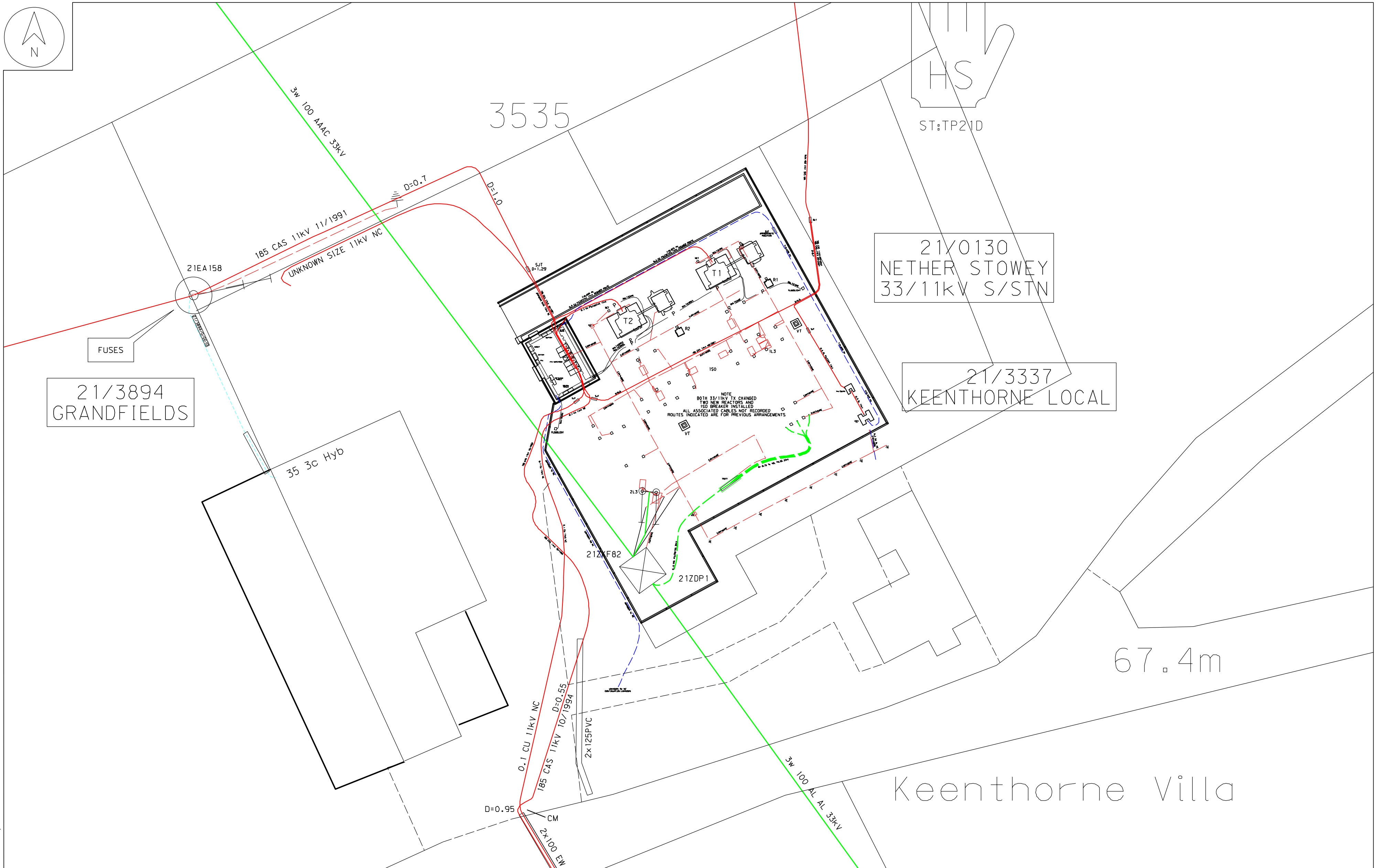
Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

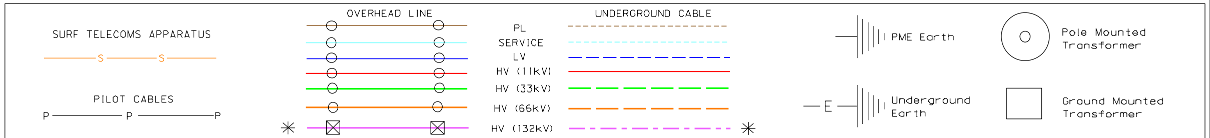
APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.



Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.



✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: NETHER STOWEY
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 321357.000,139337.595

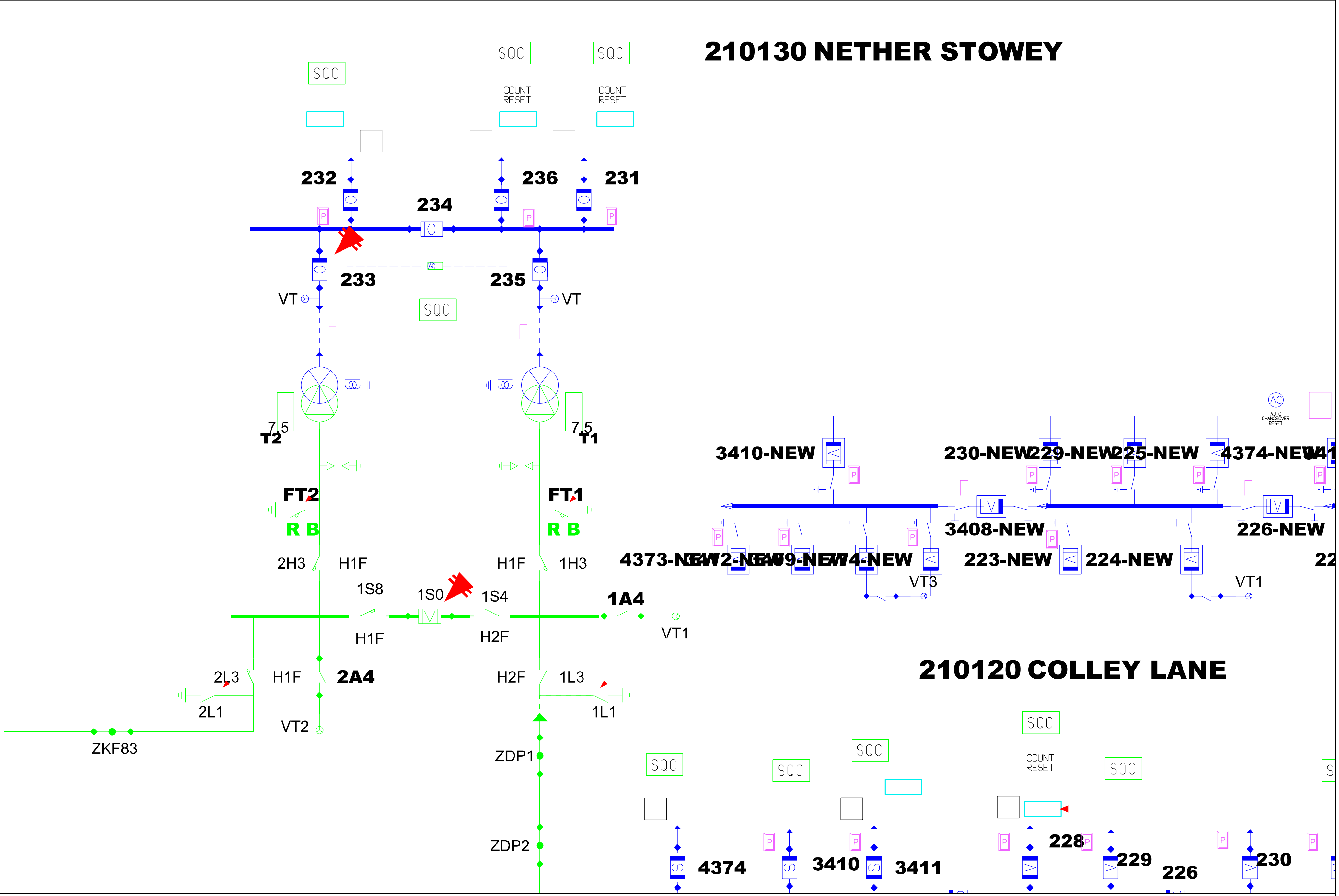
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

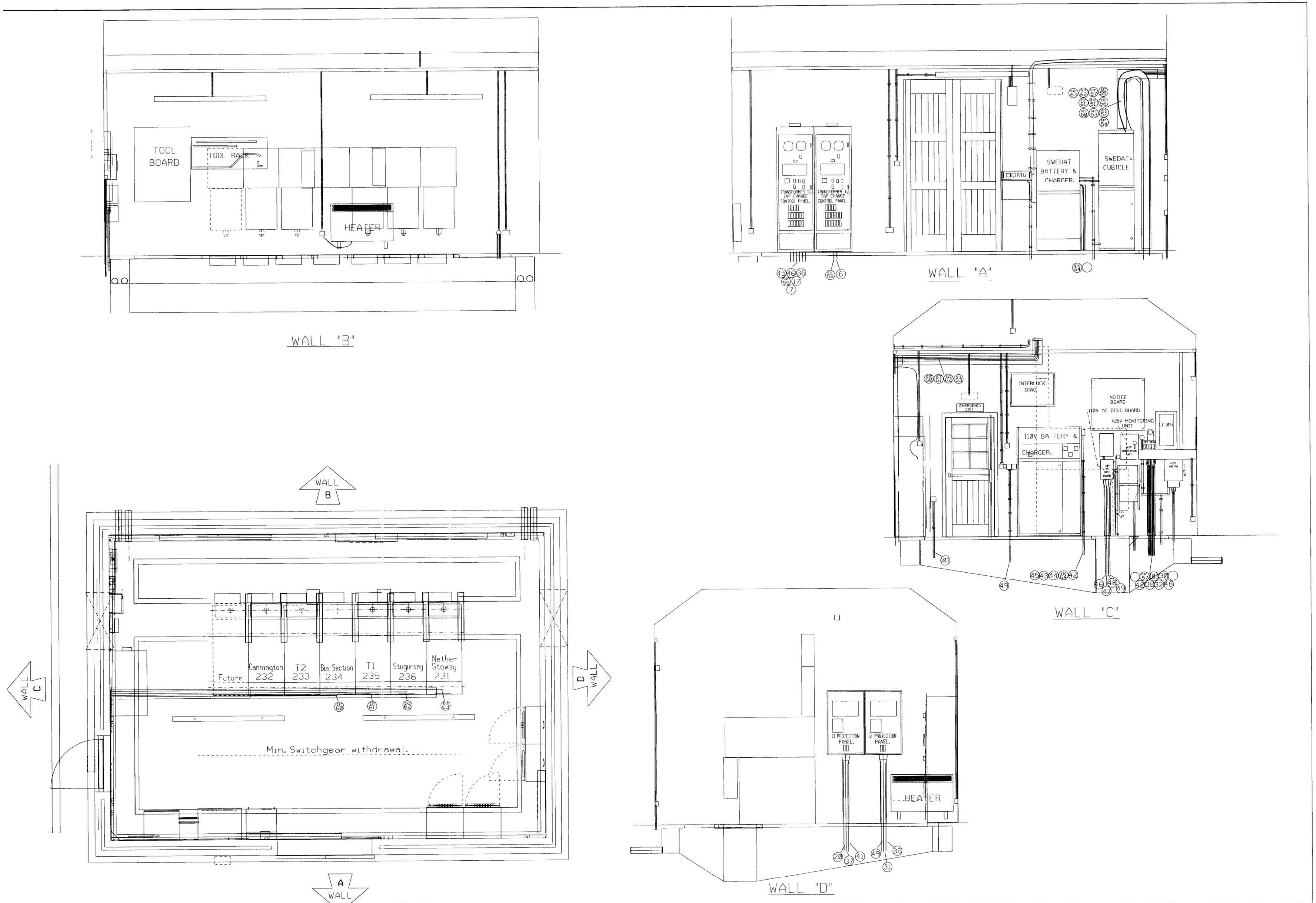
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



APPENDIX C - CONTROL ROOM LAYOUT



Issue	Revision	Sig	Date
1.	Statter 11kV Board moved 125mm. to the right. New 100 x 50mm channels set across trench at 572mm. ctrs.	N.R.	10/05/91

PLAN COMPOSITION	
SITE LAYOUT	
ELECTRICAL LAYOUT	
CIVIL LAYOUT	

LEVEL CHART

FIRST ISSUE	
Drawn N.R.	16/05/91
Checked	
Approved	
SCALE	1:25

SOMERSET AREA

11KV SWITCH HOUSE
33/11KV PRIMARY SUBSTATION 130
NETHER STOWEY.

Drawing Number
TE/10/470356

20/1606

CAD FILE 130NS02.DGN

APPENDIX D - SITE PHOTOS


TRANSFORMER 2
P11


MVAA
MCAA
21
23
41
43
TEST VOLTS ADJUST
VOLTAGE MONITOR


T1 TRANSFORMER PROTECTION PANEL
T2 TRANSFORMER PROTECTION PANEL
P7
P8
P9

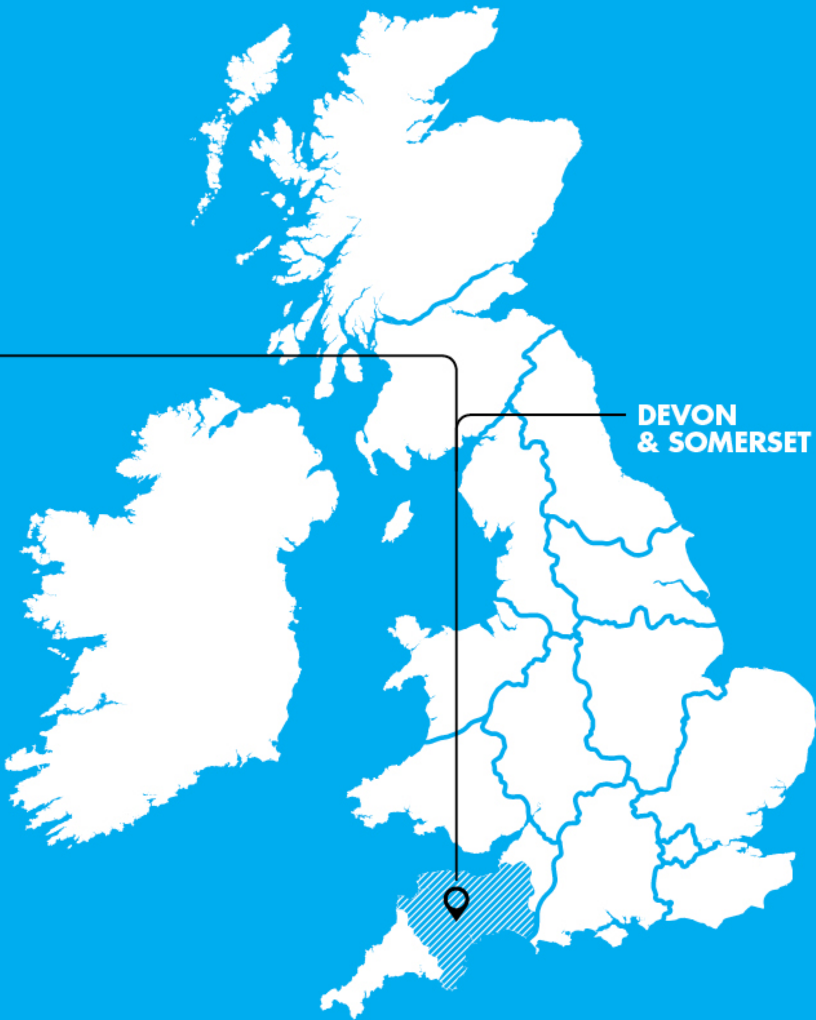

P11

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Paignton 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Paignton Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Paignton 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Paignton 132/33kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 132kV circuits from Abham GSP. It has two 60/90MVA 132/33kV transformers operating with the bus section normally closed. The substation was originally constructed in the mid 1970's with the transformers replaced in 2008.

The control, single line and EMU diagrams are provided in Appendices A-C of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at the substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is predicted to increase by 1MW over the next 5 years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Paignton 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Paignton	132/33	1.00	67.75	68.60	68.10	67.84	67.95	68.70	114.3

2.4 Customers

2.4.1 Number of Customers

Paignton supplies eight primary substations with a total of 47,534 customers supplied.

2.4.2 Type of Loads

The primary substations supplied from Paignton BSP are located in mainly rural areas and as such the main load types are domestic and light industrial. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation currently feeding into the Paignton BSP network is 3MW from a single solar PV site connected to the 33kV network. Two further solar sites totalling 8.59MW are committed for future connection along with a single 21.05MW STOR connection. All are planned for connection to the 33kV network. This will add 29.64MW of generation to the network giving a total of 32.64MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

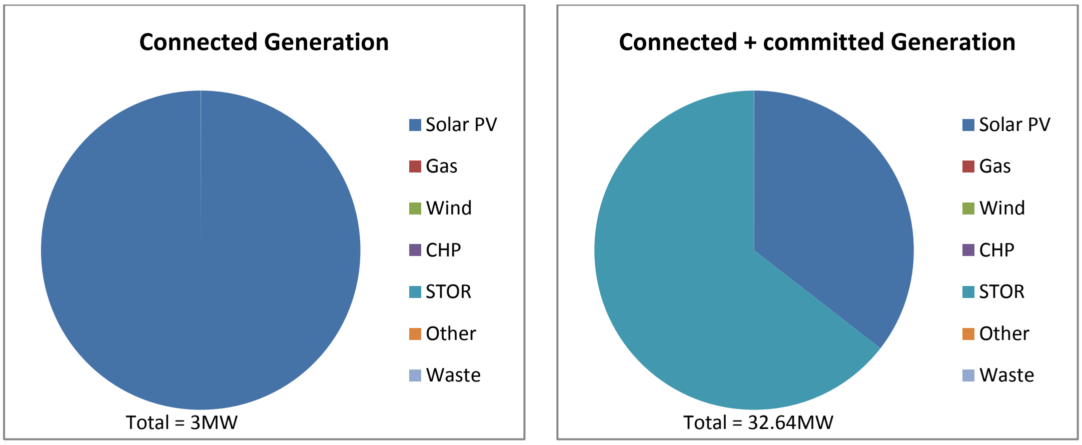


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

The two transformers at Paignton BSP were manufactured in 2007 and 2008 by EBG Transformers. They were both installed in 2008 and have 19 position tap changers.

2.5.2 Automatic Voltage Control Relays

Paignton BSP currently utilises two KVGC202 relays for Voltage Control of its transformers. The existing scheme was installed in 2006 alongside the replacement of the transformers.

2.5.3 Auxiliary Systems

The substation contains an 110V battery and a D20 SCADA communications system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Paignton BSP Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.008	0.981
2	1.008	0.981
3	1.009	0.984
4	1.009	0.984
5	**1.020**	**0.945**
6	1.009	0.982
7	1.009	0.982
8	**1.020**	**0.945**
9	**1.020**	**0.945**

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Paignton BSP over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

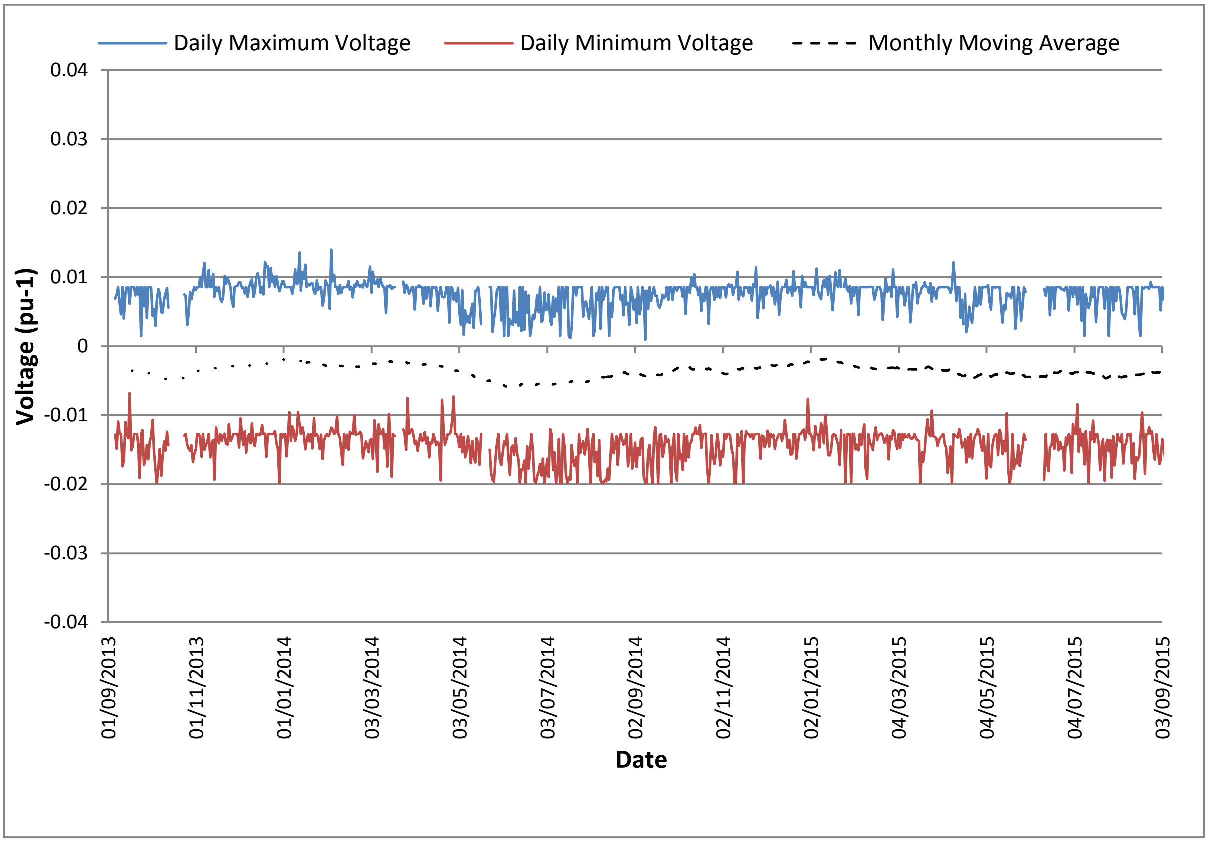


Figure 3-1: Historic voltage profile at Paignton BSP

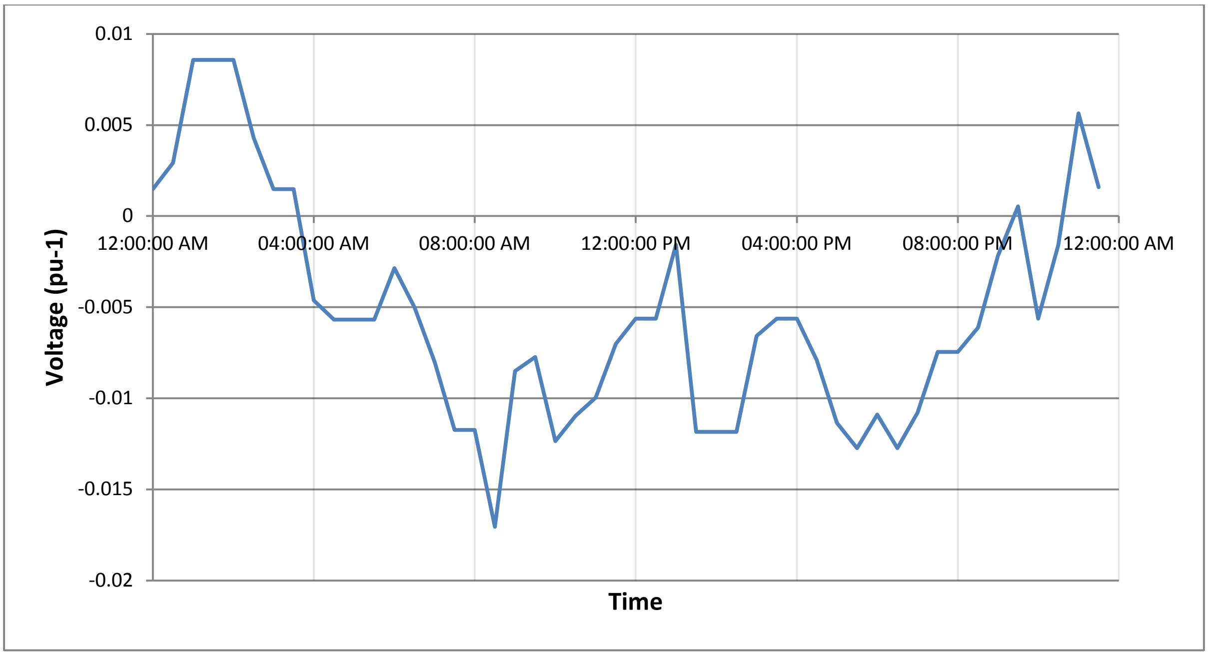


Figure 3-2: 01/09/15 Voltage profile at Paignton BSP

3.2.3 Results

The study results show that for Paignton BSP, the voltage can be reduced by 0.005pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.040pu and be within the statutory limits.

The historical voltage profiles show that the average voltage has remained around -0.005pu over the two year period analysed with an average daily fluctuation in voltage of 0.021pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Paignton the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Paignton BSP Feeder measurement locations

Paignton BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Blackawton 11kV	NO	YES
Churston 11kV	NO	YES
Colley End 11kV	NO	YES
Dartmouth 11kV	YES	YES
Hollicombe 11kV	NO	YES
Laywell Brixham 11kV	YES	YES
Paignton 11kV	NO	YES
Stokenham 11kV	NO	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Paignton BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Paignton BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

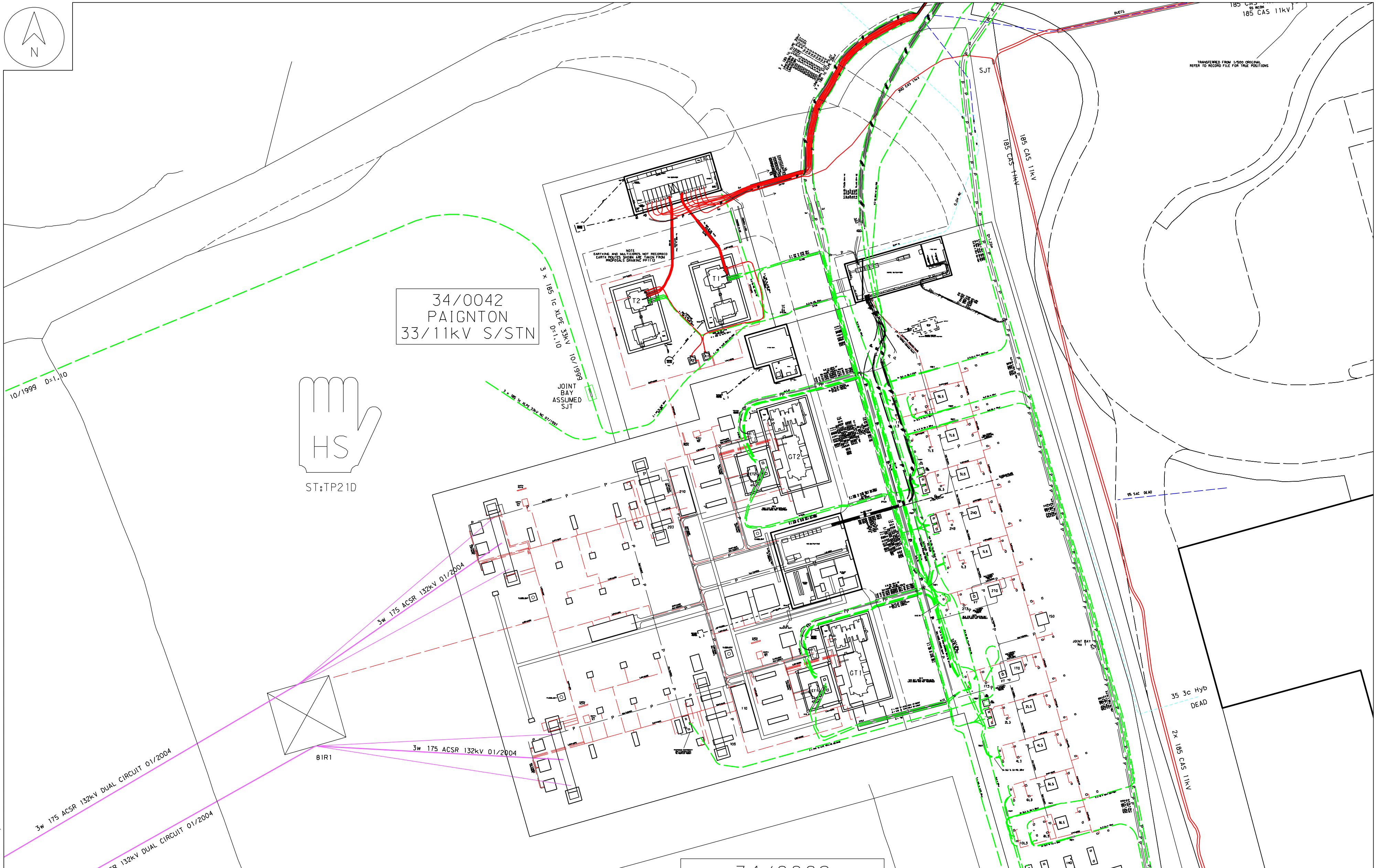
The table below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS
PILOT CABLES

	OVERHEAD LINE	UNDERGROUND CABLE
PL		
SERVICE		
LV		
HV (11kV)		
HV (33kV)		
HV (66kV)		
HV (132kV)		

PME Earth
Underground Earth
Pole Mounted Transformer
Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: PAIGNTON
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 287126.077,059148.082

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

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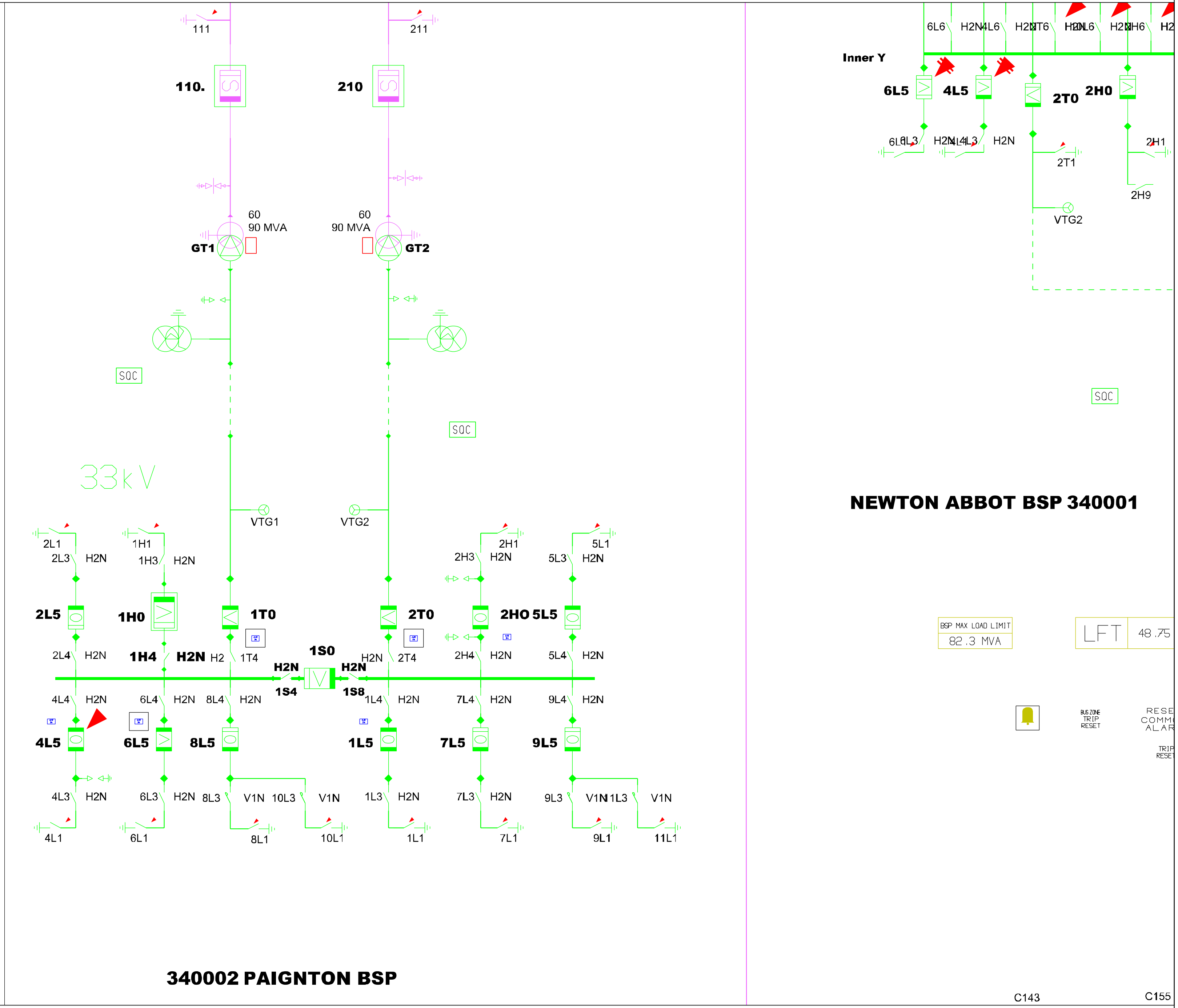
and it's accuracy cannot be guaranteed.



Tiles: 70, 71

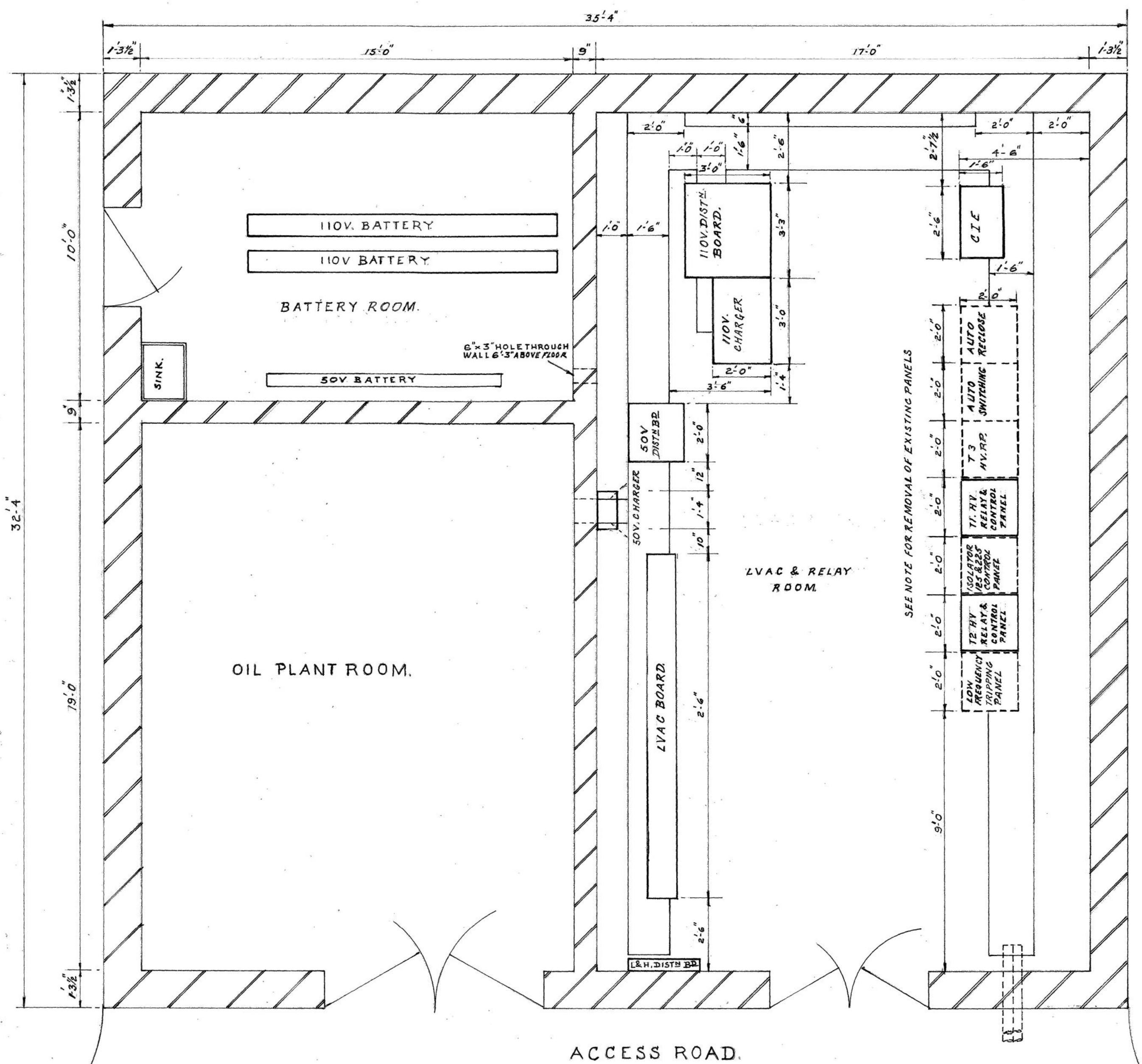
Date: 14/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT

PN906



NOTE:-
THESE EXISTING PANELS IN LVAC & RELAY ROOM TO BE REMOVED.
(1) AUTO RECLOSE
(2) OCB 110 INTERPOSING RELAYS
(3) N.C.I.
(4) OCB 210 INTERPOSING RELAYS
(5) OCB 110 & 210./132 kV STAND BY CONTROL.

REF:-
EXISTING WORK SHOWN THUS :- ————
NEW WORK SHOWN THUS :- – – – –

DRG REF:-
132/33kV ELECTRICAL LAYOUT 03/55/2545.
33kV ELECTRICAL LAYOUT WITH GRID T2 & T3 ADDITIONS 03/55/2696

P906-R

Issue	Revision	Sig	Date	Issue	Revision	Sig	Date	FIRST ISSUE	Date
								Drawn E H	10.3.75.
								Checked	7.4.75
								Approved	8.4.75
								SCALE 3/8" = 1 Ft	

SOUTH WESTERN ELECTRICITY BOARD
......AREA HEADQUARTERS.. BRISTOL.

Title PAIGNTON 132/33kV. SUBSTATION. LAYOUT OF EQUIPMENT IN 132kV. AUXILIARY PLANT BUILDING.

Drawing Number 03/35/2615.

sml 70

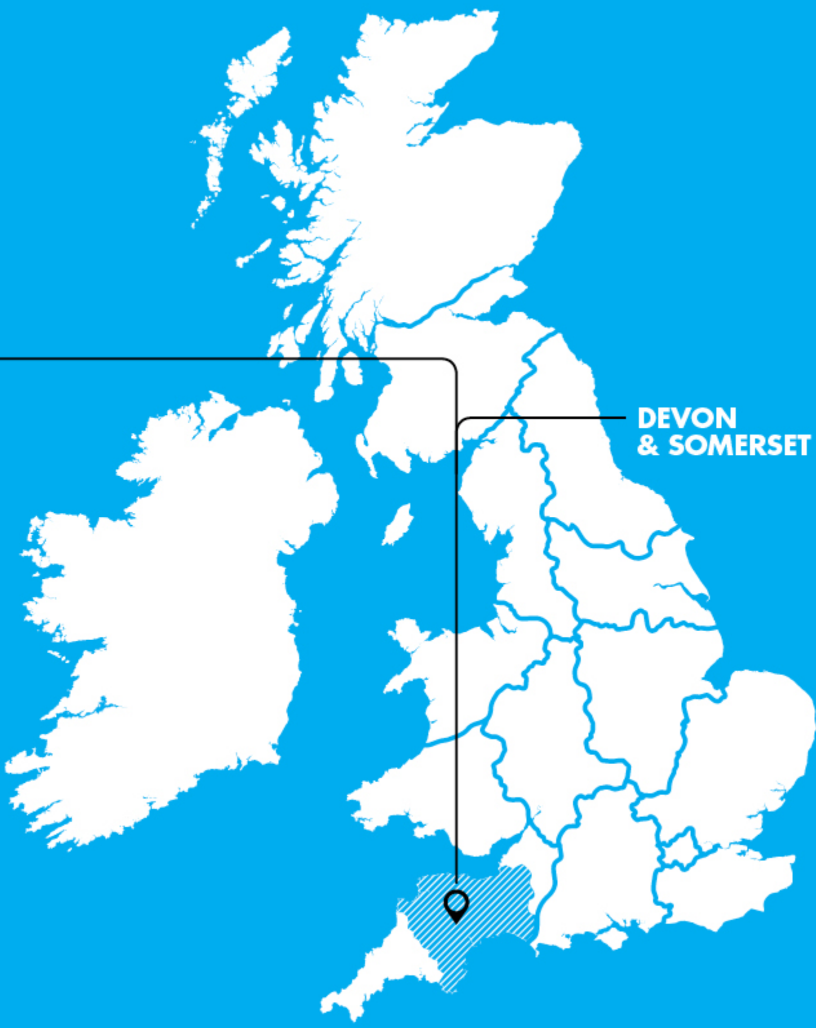
APPENDIX D - SITE PHOTOS

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Radstock Main 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Radstock Main Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Contents

1 Introduction

The following report details the findings from the investigation of Radstock Main 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring the BSP sites to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Radstock Main 132/33kV substation belongs to the Seabank-Bridgwater-Taunton Grid Group and is normally fed via two 132kV circuits from Seabank GSP. It has two 60/90MVA 132/33kV transformers operating with the bus section normally closed. The substation was originally constructed in the early 1960's with an AIS 33kV compound.

A selection of photos and the control, single line and EMU diagrams are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

As part of RIIO-ED1 Investment plans both transformers are currently being replaced at this substation.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to decrease by 0.72MW over the next two years before increasing by 1.57MW over the next three. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Radstock Main BSP [2015 LTDS 2015 table 3]

Name	Voltage	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Radstock Main	132/33kV	1.00	79.55	79.10	78.83	79.48	79.59	80.40	97

2.4 Customers

2.4.1 Number of Customers

Radstock Main BSP supplies twelve primary substations with a normally open connection to a further one. The total number of customers supplied is 53,398.

2.4.2 Type of Loads

The primary substations supplied from Radstock Main BSP are located in mainly rural areas and as such the main load types are domestic and light industrial. There are multiple 33kV connected load customers mainly consisting of farms. There is a single customer on the 33kV network that is considered as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Radstock Main BSP network is 33.75MW with 25.25MW connected to the 33kV network and 8.5MW connected to the 11kV.

The 33kV connections are made up of six solar PV sites (23.25MW) and a single wind site (2MW). Six further solar PV sites are committed for future connection to the 33kV network which will add 33.72MW of generation.

The 8.5MW connected to the 11kV primary networks fed from Radstock Main BSP are made up of a solar PV site and another unidentified technology. A further 18.5MW of generation is committed for future connection from gas, wind and solar PV installations.

Overall the future commitments at both voltage levels will add 52.22MW of embedded generation giving a total of 85.97MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

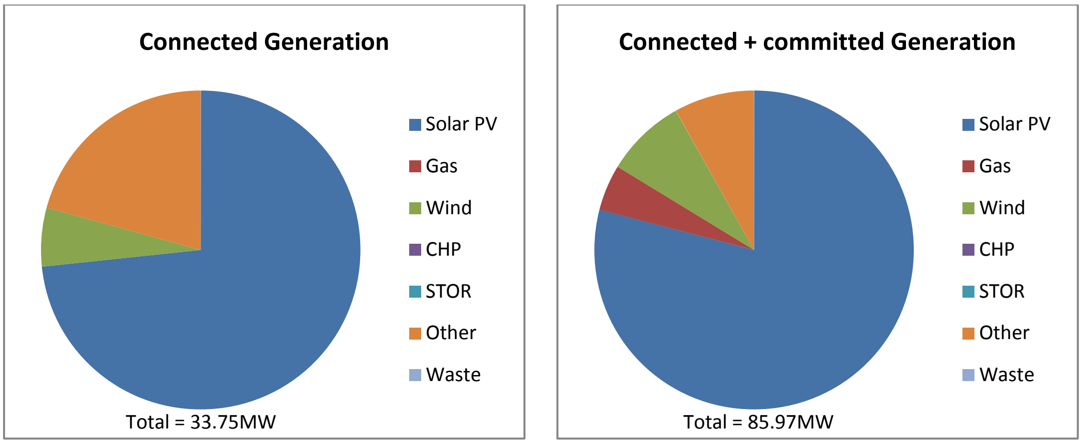


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

Both of the transformers were manufactured in 2013 with 60/90MVA CG Powersystems Transformers with 19 position tap changers. The transformers are currently being installed at the substation.

2.5.2 Automatic Voltage Control Relays

Radstock Main BSP currently utilises MVGC01 relays for Voltage Control of its transformers. The existing scheme has been modified alongside the replacement of the 132/33kV transformers.

2.5.3 Auxiliary Systems

The substation has an 110V battery system and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trail will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Radstock Main Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	0.989	0.989
2	0.989	0.989
3	0.986	0.985
4	0.989	0.977
5	0.989	0.977
6	0.989	0.977
7	**1.024**	0.965
8	**1.024**	0.965
9	**1.024**	0.965
10	0.983	**0.964**
11	0.983	**0.964**

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Radstock Main over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

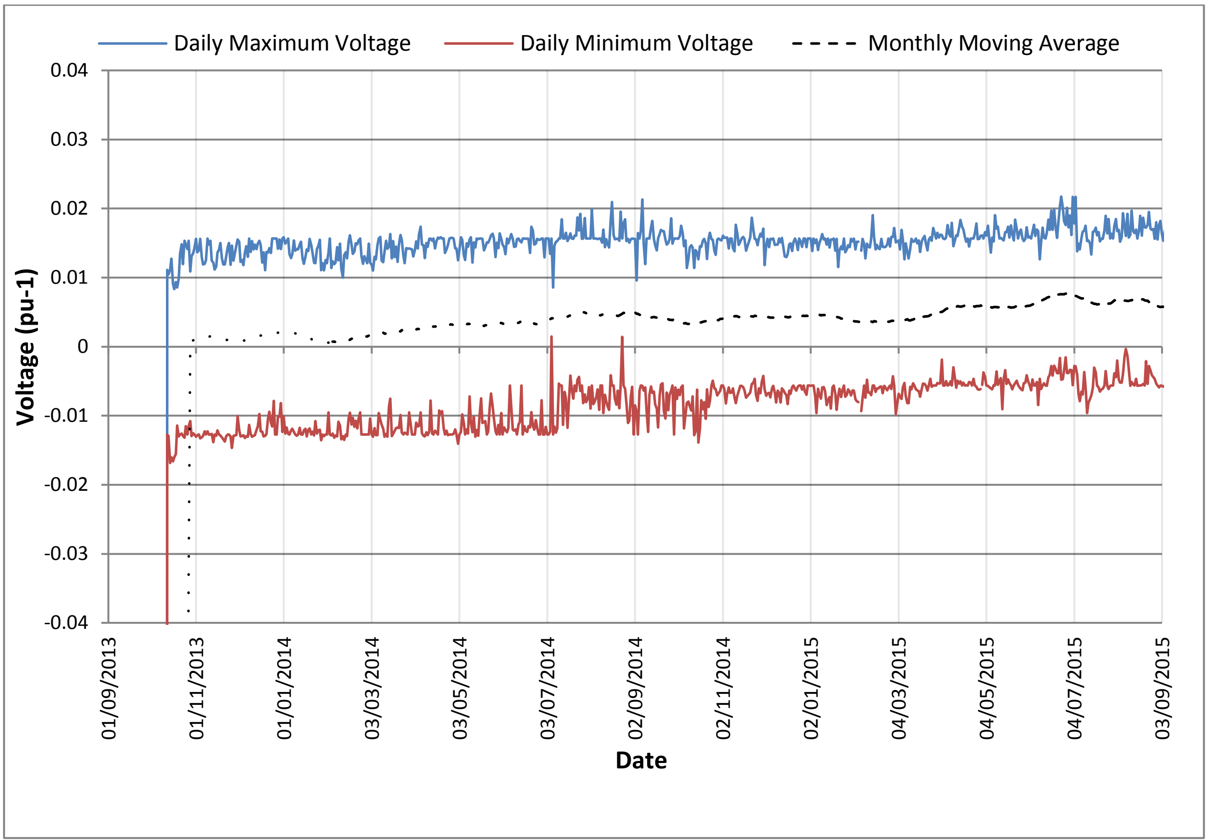


Figure 3-1: Historic voltage profile at Radstock Main BSP

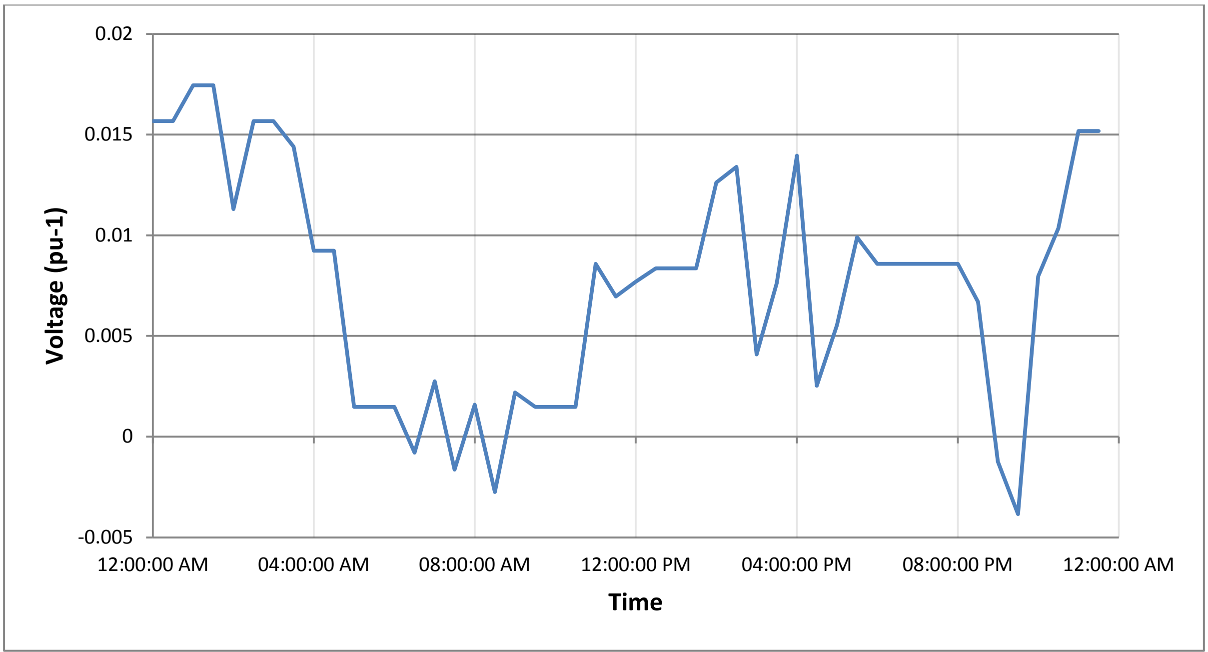


Figure 3-2: 01/08/15 Voltage profile at Radstock Main BSP

3.2.3 Results

The study results show that for Radstock Main BSP, the voltage can be reduced by 0.024pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.036pu and be within the statutory limits.

The historical voltage profiles show that the voltage has gradually increased from nominal to nearly 0.01pu over the two year period analysed. The average daily fluctuation in voltage has reduced slightly from 0.026pu to 0.022pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Radstock Main the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Radstock Main BSP Feeder measurement locations

Radstock Main BSP Feeder Measurement Locations	33 kV VT	11 kV VT
KEYNSHAM EAST 11 kV	YES	YES
PAULTON 11 kV	YES	YES
HIGH LITTLETON	YES	YES
MIDSOMER NORTON 11 kV	NO	YES
FOXHILLS 11 kV	YES	YES
WHATLEY QUARRY MELLS	NO	YES
NEWBURY 11 kV	YES	YES
EVERCREECH 11 kV	YES	YES
SHEPTON MALLET 11 kV	YES	YES
DINDER 11 kV	YES	YES
CHEWTON MENDIP	NO	YES
WELLS 11 kV	YES	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Radstock Main BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Radstock Main BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

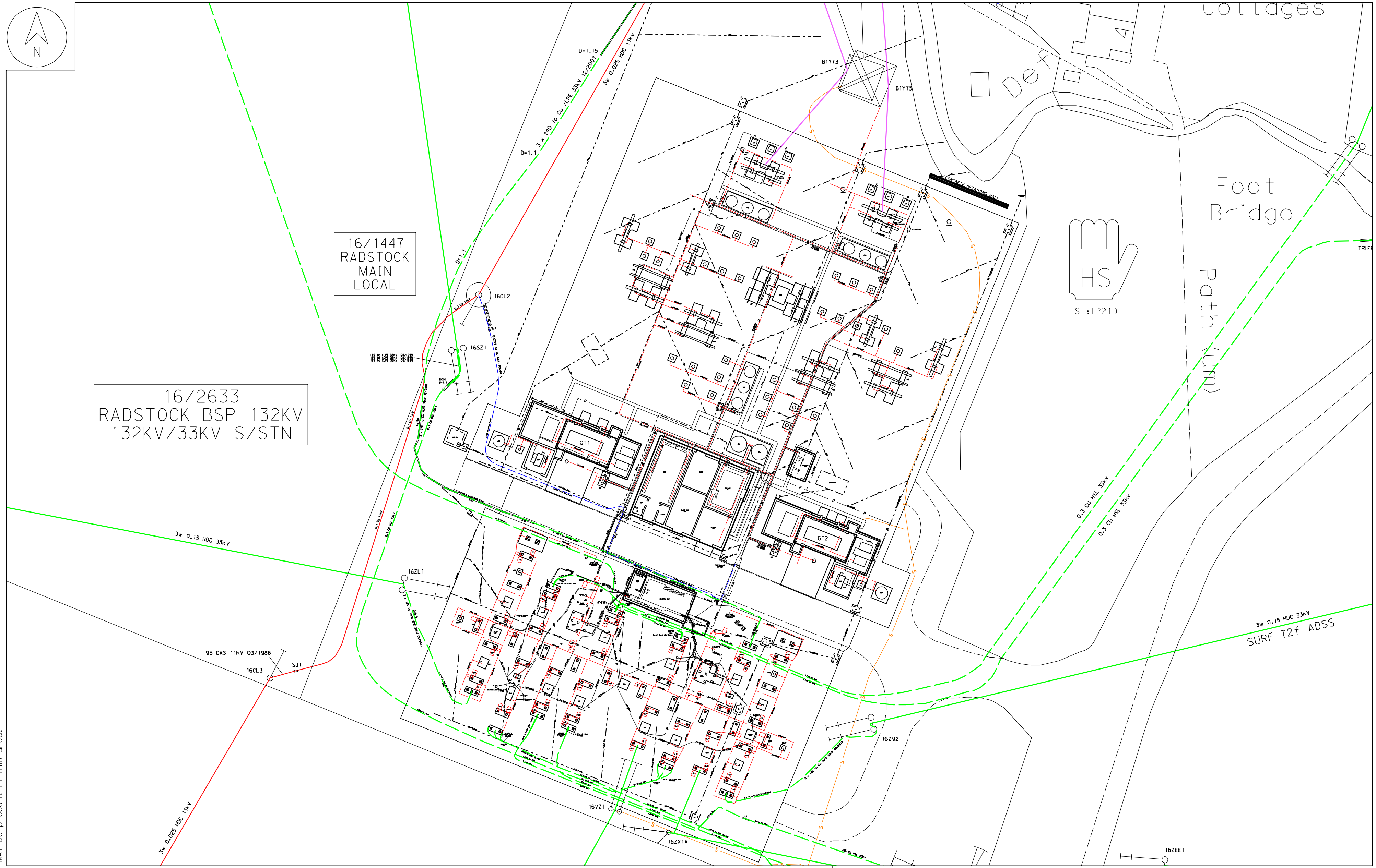
The table below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.



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PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

SURF TELECOMS APPARATUS

PILOT CABLES

OVERHEAD LINE		UNDERGROUND CABLE
	PL	
	SERVICE	
	LV	
	HV (11kV)	
	HV (33kV)	
	HV (66kV)	
✳	HV (132kV)	✳

PME Earth

Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: RADSTOCK MAIN
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:600 @ A3
PLOT CENTRE: 364628.611,154749.107

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

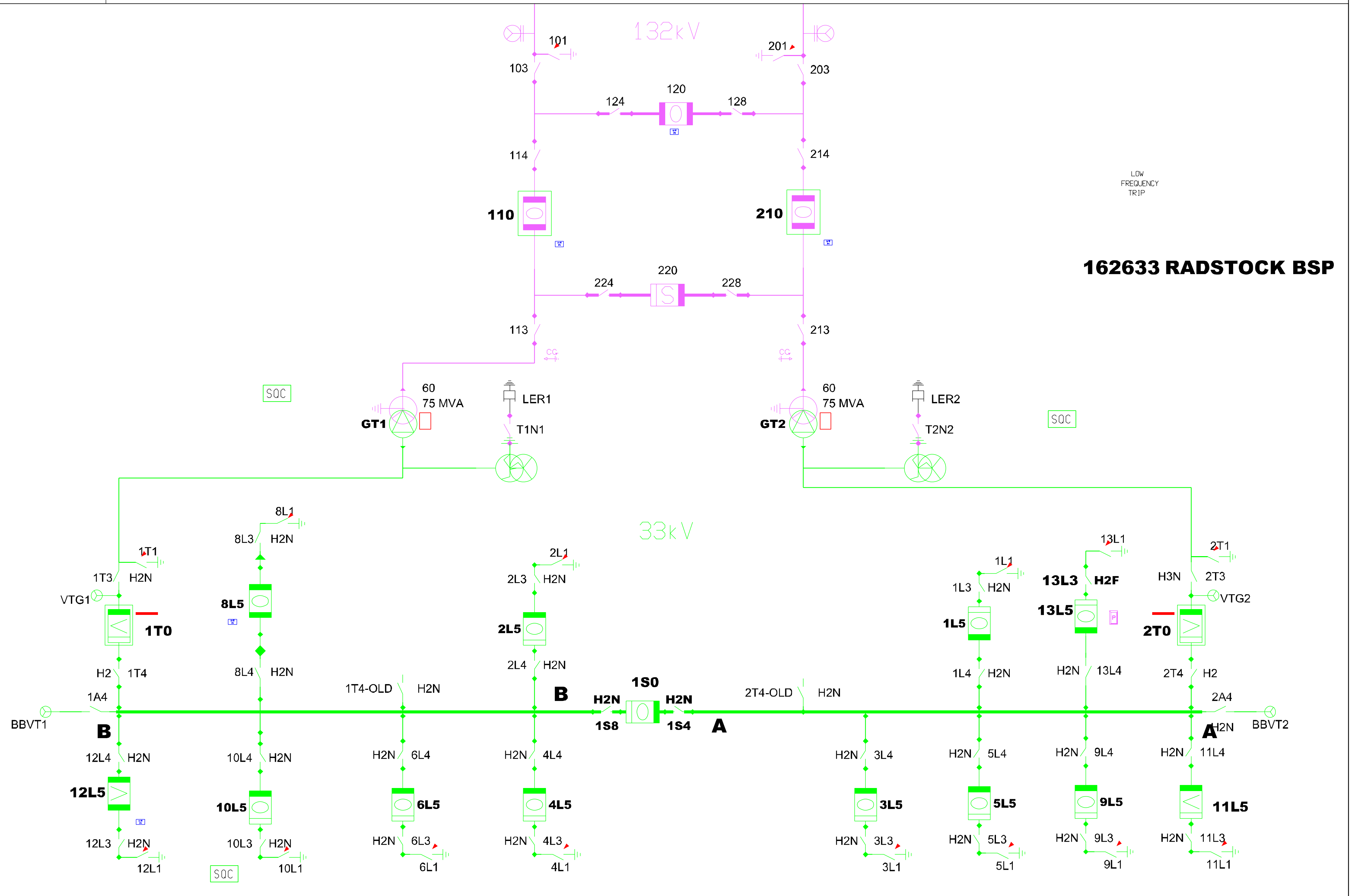
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

162633 RADSTOCK BSP



Tiles: 41, 52

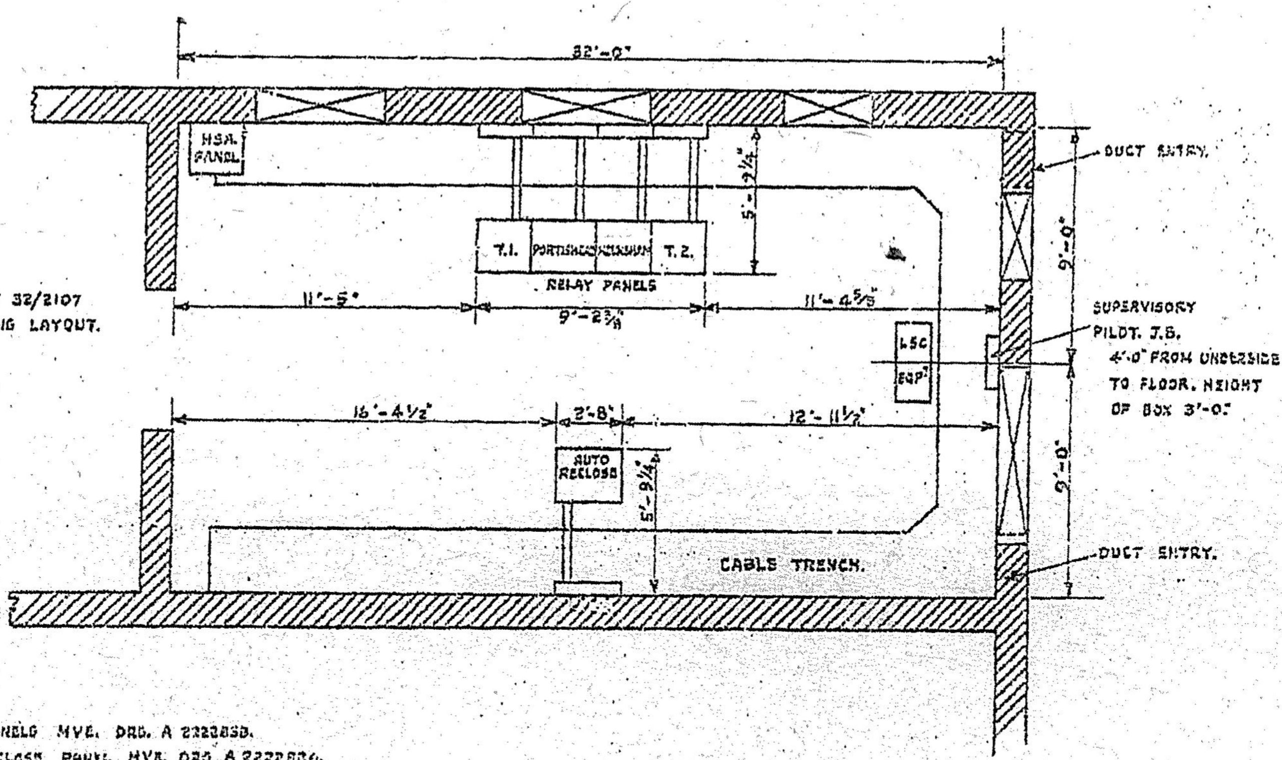
Date: 14/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT

CENTRAL ELECTRICITY GENERATING BOARD. SOUTH WESTERN DIVISION



REFER DRG. 32/2107
FOR BUILDING LAYOUT.

RELAY PANELS M.V.E. DRG. A 2222835.
AUTO RECLOSE PANEL M.V.E. DRG A 2222836.

DATE	14.5.59
DRAWN	A.H.H.
CHECKED	
APPROVED	

PRINT ISSUE

LAYOUT OF 132 KV.
RELAY ROOM.

SCALE

RADSTOCK D.S. 6046.

APPENDIX D - SITE PHOTOS

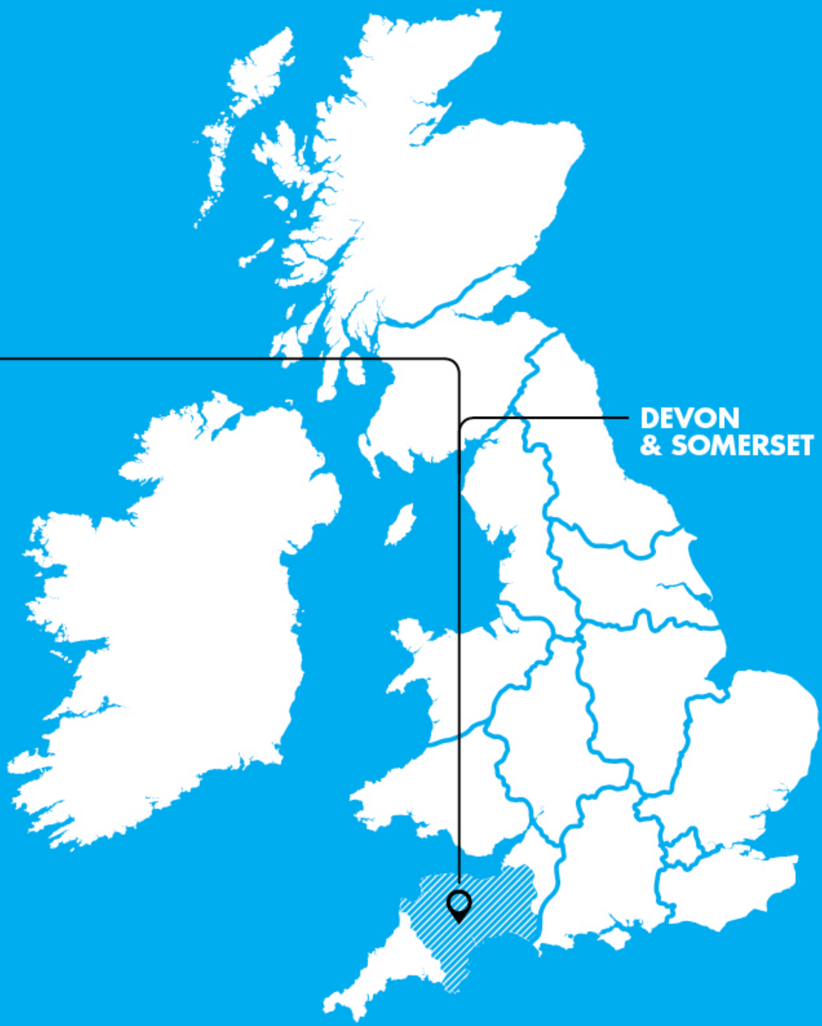

GRID TRANSFORMERS
T1
T2
DATA COLLECTION

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Sowton 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Sowton Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Sowton 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Sowton 132/33kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 132kV circuits from Exeter Main GSP. It has two 60/90MVA 132/33kV transformers commissioned in 2003 which operate with the bus section normally closed.

The control, single line and EMU diagrams are provided in Appendices A-C of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at this site as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to increase by 19MVA over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Sowton 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Sowton	132/33	0.98	66.18	74.13	82.93	83.31	84.51	85.25	114.3

2.4 Customers

2.4.1 Number of Customers

Sowton BSP supplies eleven primary substations with normally open connections to a further two. The total number of customers supplied is 29,961.

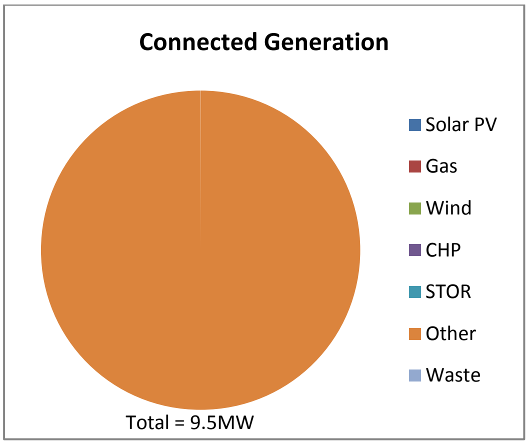
2.4.2 Type of Loads

The majority of the primary substations supplied from Sowton BSP are located in mainly rural areas with only three within Exeter City. The substations within the city area supply mainly industrial and commercial loads with some domestic customers. The rural primaries supply a mainly domestic load. There are several customers connected directly to the 33kV network. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Sowton Network is 9.5MW from the 11kV network. In the future 12MW from STOR and Gas generation is committed for connection to the 11kV network. At the 33kV level, two Solar PV sites are committed to which will add 19.9MW of generation.

Overall the future commitments at both voltage levels will add 31.9MW of embedded generation giving a total of 41.4MW of embedded generation [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.



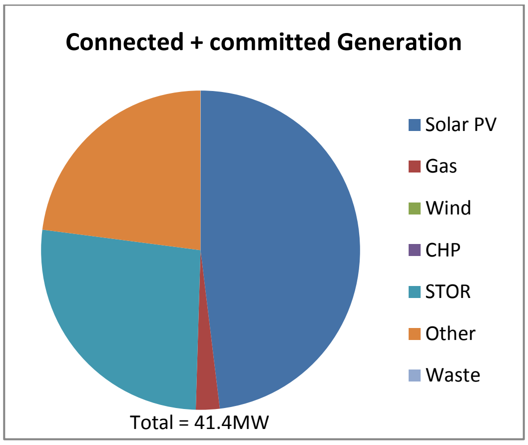


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

The substation has two 60/90MVA transformers that were both commissioned in 2003. Both are manufactured by EBG with 19 position tap changers.

2.5.2 Automatic Voltage Control Relays

Sowton BSP currently utilises Reyrolle SuperTAPP relays for voltage control of its transformers.

2.5.3 Auxiliary Systems

The substation has an 110V battery supply and a D20 SCADA system installed with spare capacity available.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trail will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Sowton feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.023	0.999
2	1.023	1.001
3	1.023	1.001
4	1.022	0.999
5	1.022	1.000
6	1.022	1.000
7	1.022	0.999
8	1.029	0.999
9	1.022	0.996
10	**1.038**	0.995
11	1.026	**0.947**

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Sowton BSP over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

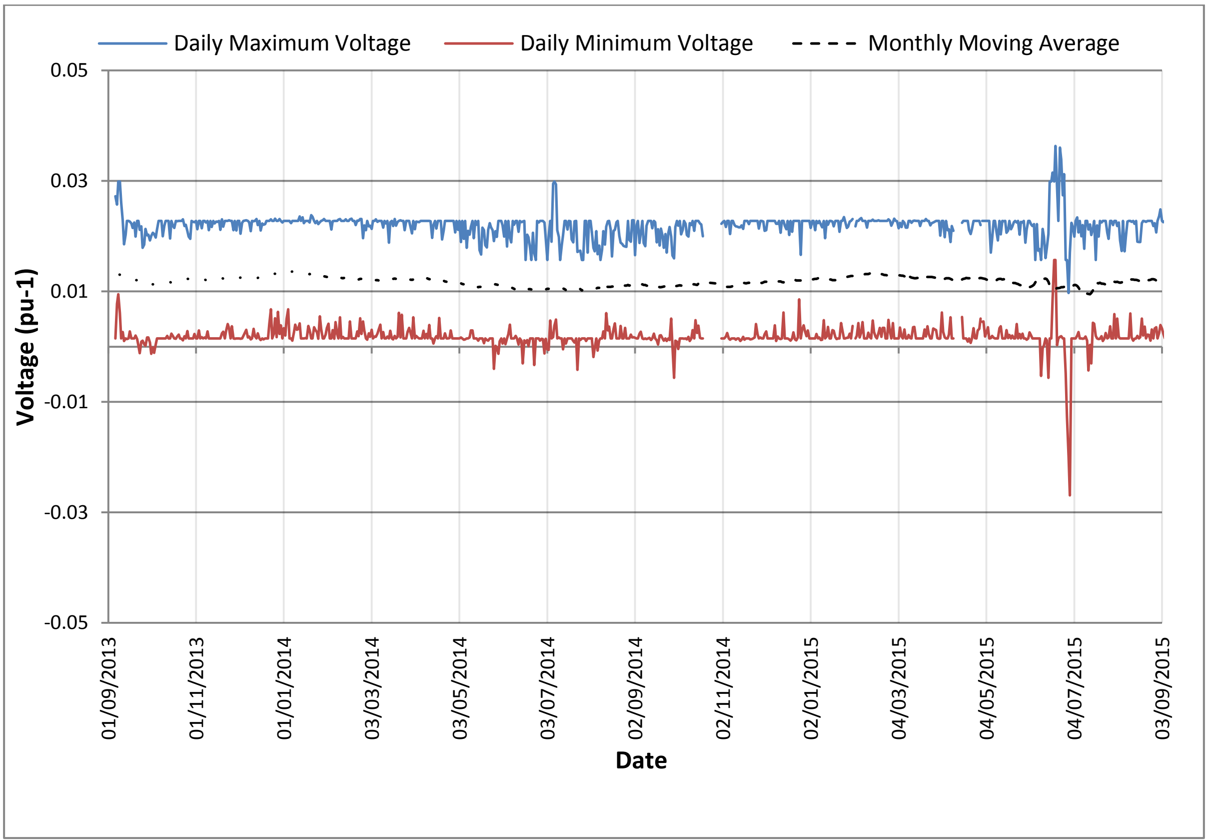


Figure 3-1: Historic voltage profile at Sowton BSP

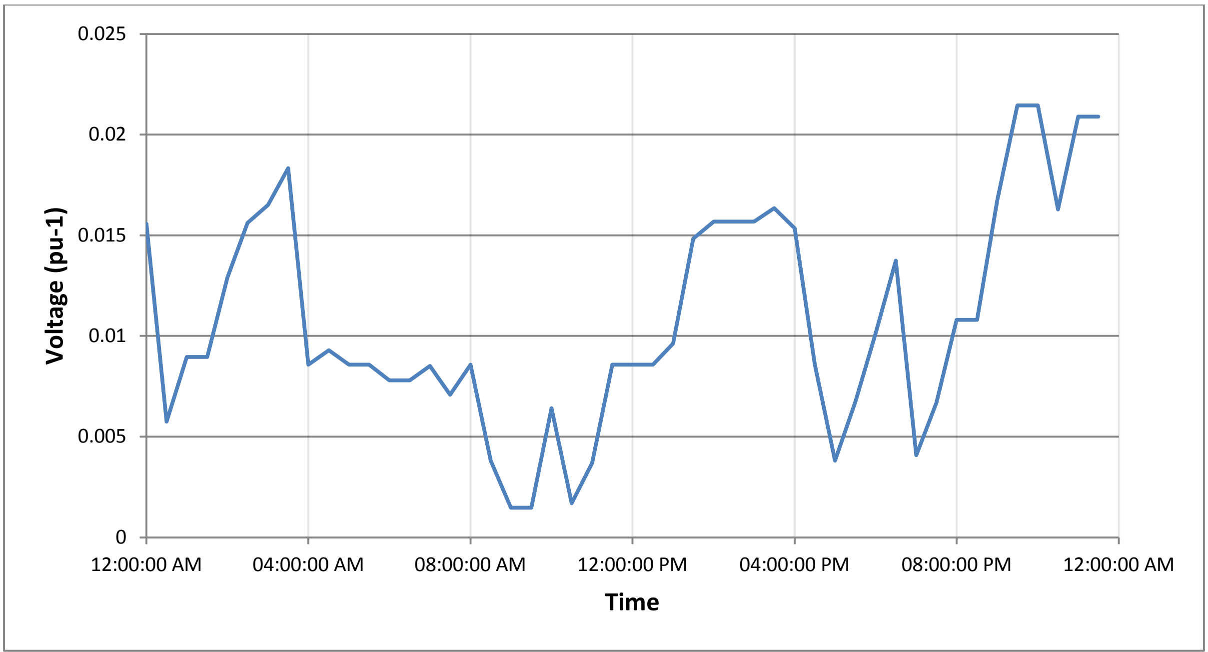


Figure 3-2: 04/03/15 Voltage profile at Sowton BSP

3.2.3 Results

The study results show that for Sowton BSP, the voltage can be reduced by 0.007pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.022pu and be within the statutory limits.

The historical voltage profiles show that the voltage has remained steady over the two year period analysed at 0.012pu above nominal with an average daily fluctuation in voltage of 0.020pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Sowton the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

Due to the complexity of change from mechanical to numerical relays, it is proposed to install a new AVC panel at this substation. This will require the removal of redundant equipment still inside the 33kV switchroom.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Sowton BSP Feeder measurement locations

Sowton BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Clyst Honiton 11kV	NO	YES
Core Hill 11kV	NO	YES
Countess Wear 11kV	NO	YES
Exeter Science Park 11kV	NO	YES
Heavitree 11kV	NO	YES
Marsh Green 11kV	T1: NO, T2: YES	YES
Ottery St Mary 11kV	YES	YES
Pinhoe 11kV	NO	YES
Sidmouth Town 11kV	NO	YES
Topsham 11kV	NO	YES

3.3.4 SCADA

Minor modifications will be required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Sowton BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Sowton BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

The table below highlights the site specific risks when carrying out the proposed modifications to the substation.

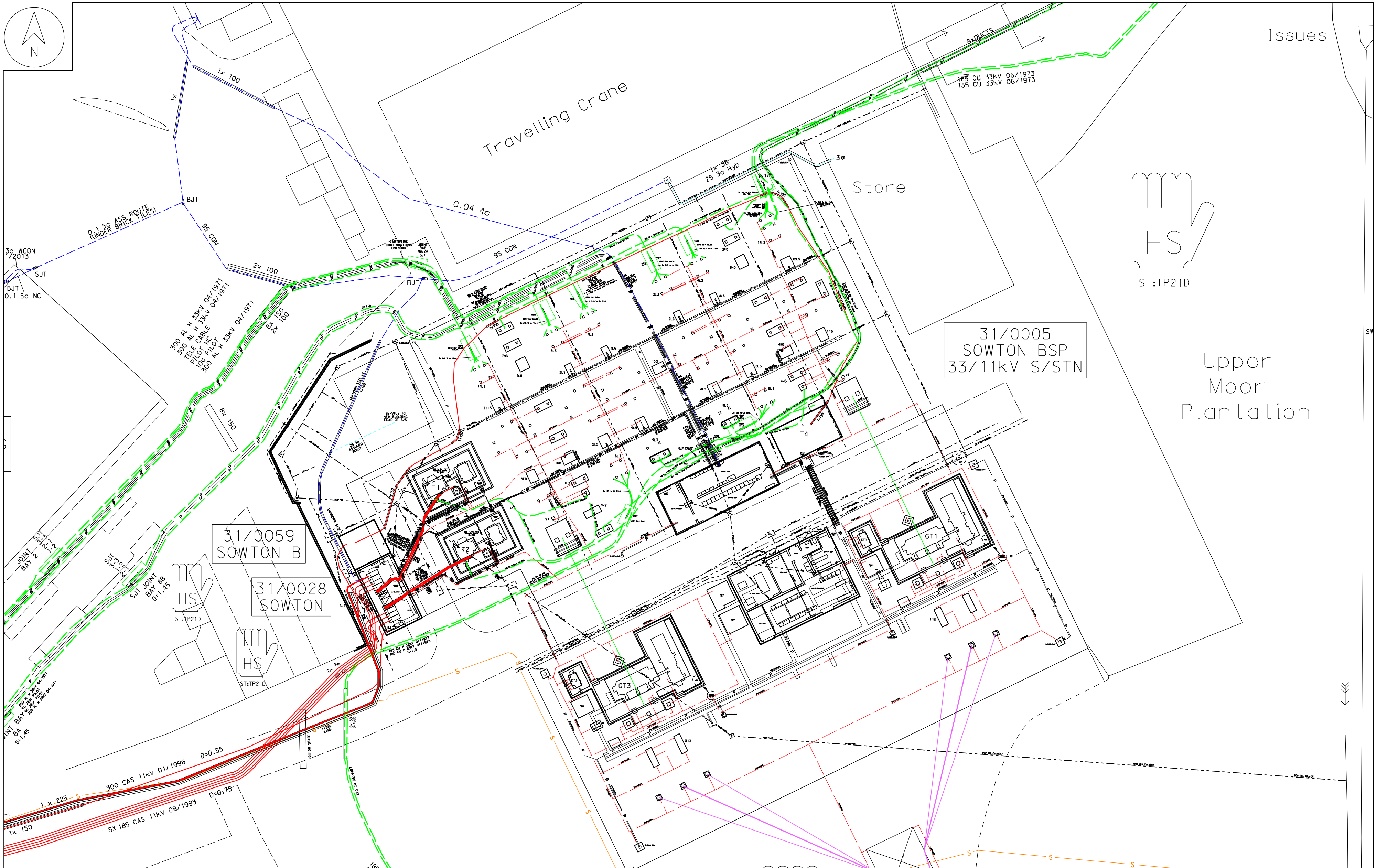
Table 4-1: Site specific risks

Risk	Effect	Action
Asbestos in the fuse casing can release dust particles if moved.	If inhaled asbestos can cause harm/injury.	Carry out an asbestos survey. Hire a specialist to remove the asbestos if it is found.
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
The old transformer and the new relay may not be compatible.	This may restrict the level of control that can be applied	Check the functionality of the transformer before choosing the relay to be used. Select an alternative site if necessary.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution. Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.



SURF TELECOMS APPARATUS

PILOT CABLES

	OVERHEAD LINE	UNDERGROUND CABLE
PL		
SERVICE		
LV		
HV (11kV)		
HV (33kV)		
HV (66kV)		
HV (132kV)		

PME Earth

Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

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TITLE: SOWTON
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 296602.782,092899.018

WESTERN POWER DISTRIBUTION
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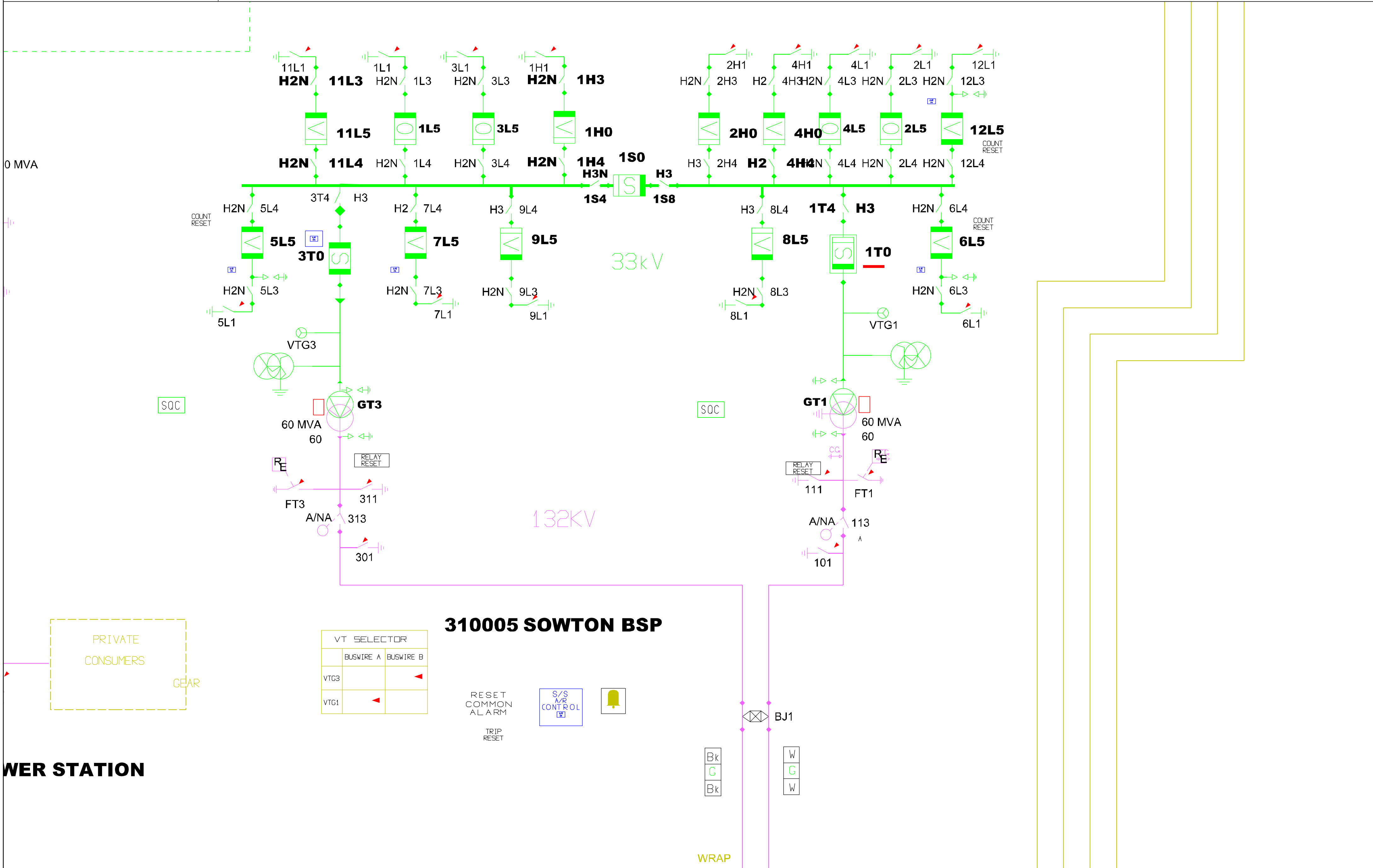
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

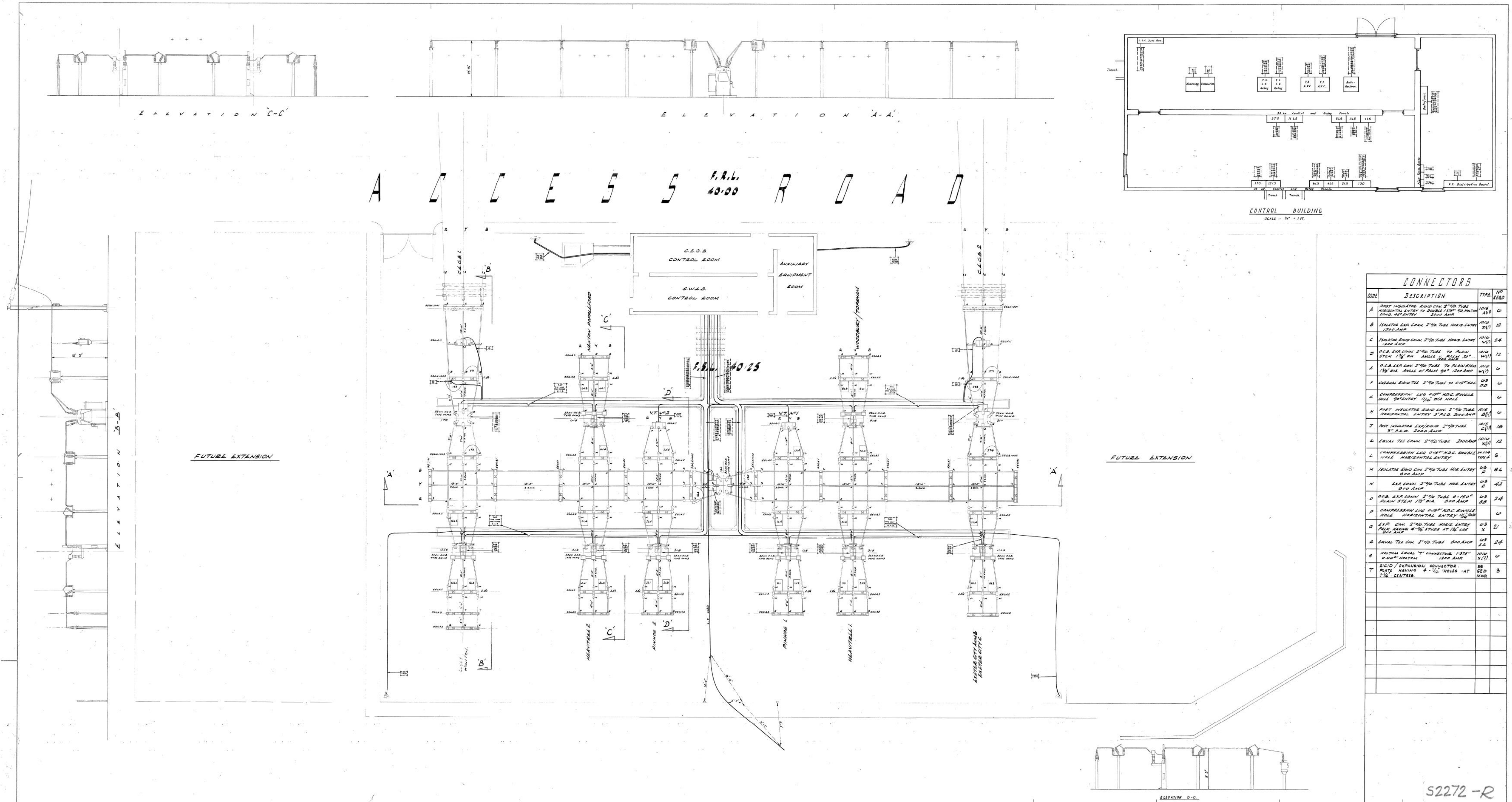
Information is given as a guide only
and it's accuracy cannot be guaranteed.



Tiles: 50 Date: 13/01/2016 FOR INTERNAL USE ONLY A3

APPENDIX C - CONTROL ROOM LAYOUT

S02272



CONNECTORS

CODE	DESCRIPTION	TYPE	No REQD
A	POST INSULATOR RIGID CON. 2" O/D. TUBE HORIZONTAL ENTRY TO DOUBLE 1.375" O/D. HOLTOM COND. 45° ENTRY 2000 AMP.	1015 A(i)	6
B	ISOLATOR EXP. CONN. 2" O/D. TUBE HORIZ. ENTRY 1200 AMP	1016 Z(i)	12
C	ISOLATOR RIGID CONN. 2" O/D. TUBE HORIZ. ENTRY 1200 AMP	1016 V(i)	24
D	O.C.B. EXP. CONN. 2" O/D. TUBE TO PLAIN STEM 1 3/8" DIA ANGLE & PALM 30° 1200 AMP	1016 W(i)	12
E	O.C.B. EXP. CON. 2" O/D TUBE TO PLAIN STEM 1 3/8" DIA. ANGLE OF PALM 90° 1200 AMP	1016 W(i)	6
F	UNEQUAL RIGID TEE 2" O/D TUBE TO 0.15" H.D.C.	63 DD	6
G	COMPRESSION LUG 0.150" H.D.C. SINGLE HOLE 90° ENTRY 11/16" DIA HOLE		6
H	POST INSULATOR RIGID CON. 2" O/D TUBE HORIZONTAL ENTRY 3" P.C.D. 2000 AMP	1015 B(ii)	6
J	POST INSULATOR EXP/RIGID 2" O/D TUBE 3" P.C.D. 2000 AMP	1015 C(ii)	18
K	EQUAL TEE CONN. 2" O/D. TUBE 2000 AMP	1016 X(ii)	12
L	COMPRESSION LUG 0.15" H.D.C. DOUBLE HOLE HORIZONTAL ENTRY	SC224 TYPE 4	6
M	ISOLATOR RIGID CON. 2" O/D TUBE HOR. ENTRY 800 AMP	63 P	84
N	EXP. CONN. 2" O/D. TUBE HOR. ENTRY 800 AMP	63 R	42
O	O.C.B. EXP. CONN 2" O/D TUBE 0.150" PLAIN STEM 1 1/2" DIA. 800 AMP	63 BB	24
P	COMPRESSION LUG 0.150" H.D.C. SINGLE HOLE HORIZONTAL ENTRY 11/16" Hole		6
Q	EXP. CON. 2" O/D. TUBE HORIZ. ENTRY PALM HAVING 4-3/8" STUDS AT 1 1/4" CRS 800 AMP	63 X	21
R	EQUAL TEE CON. 2" O/D. TUBE 800 AMP	63 EE	24
S	HOLTOM EQUAL 'T' CONNECTOR 1.375" 0.660" HOLTOM 1200 AMP.	1016 X(i)	6
T	RIGID / EXPANSION CONNECTOR PLATE HAVING 4-7/16" HOLES AT 1 1/4" CENTRES.	SS 62D MOD.	3

S2272 -R

No.	REVISION	SIG./DATE	No.	REVISION	SIG./DATE
6	ELEVATION B-B MODIFIED; O/H ENTRY DELETED; SWGA CONNS & B/B ADDED.	LGW 19/7/71	4	O/H TERMINATION TO CLYST HONITON BAY ADDED.	LGW 17/6/70
5	'As Constructed.'	5·8·8·70	3	PHASING REV. TO SUIT DRG. 30/12129/4	LGW 16/3/70
			2	FLOODLIGHTS ADDED.	LGW 1/12/69
			1	GENERAL MODIFICATIONS	R.C. 4-8-69

SCALE: 1/8" TO 1 FOOT
DRAWN: R.A.B. R.C. — DATE 15.7.69
CHECKED: LGW — 16.7.69
APPROVED:

SOUTH WESTERN ELECTRICITY BOARD
CENTRAL CONSTRUCTION DEPT

TITLE: SOWTON B.S.P. ELECTRICAL LAYOUT

DRAWING NUMBER: 01/F32/120

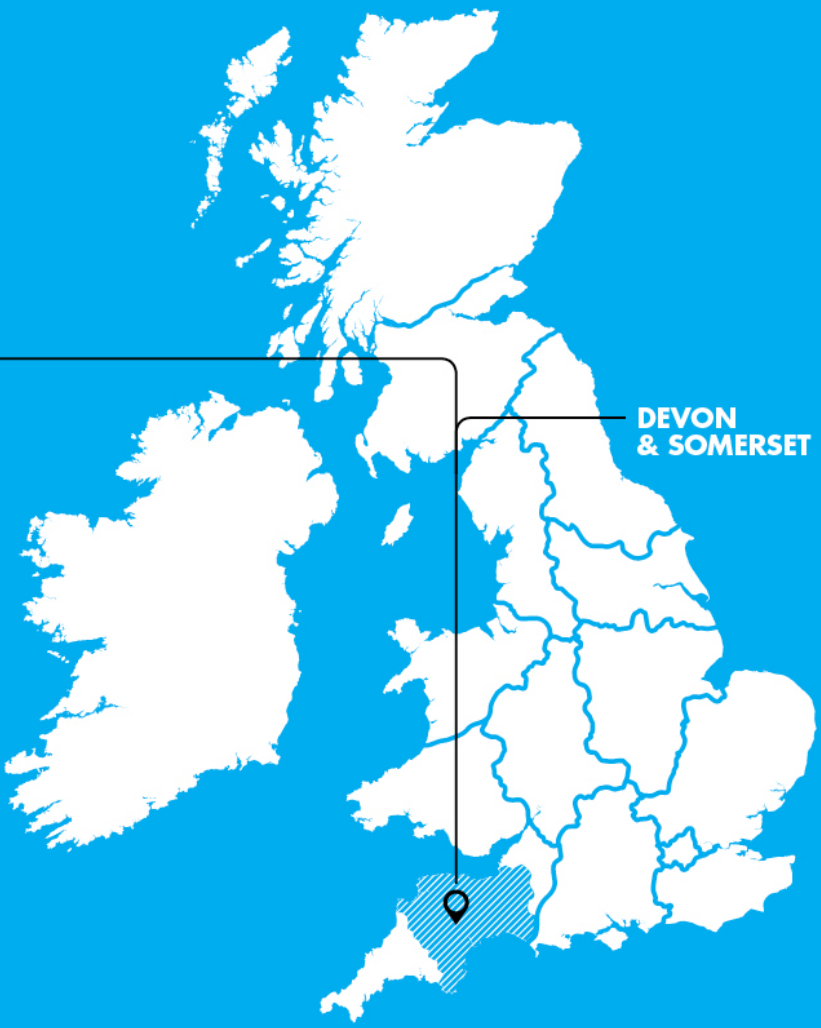
ADMEL 3172

APPENDIX D - SITE PHOTOS

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND



SVO Substation Investigation
Staplegrove 33/11kV

LCN Fund
Low Carbon Networks

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Report Title	:	Staplegrove Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

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1 Introduction

The following report details the findings from the investigation of Staplegrove 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Staplegrove 33/11kV substation belongs to the Seabank-Bridgwater-Taunton Grid Group and is normally fed via two 33kV circuits from Taunton BSP. It has two 11.5/23MVA 33/11kV transformers operating with the bus section normally closed. The substation was originally constructed in 1966 with the original equipment still in operation.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at this site as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to reduce by 0.31MVA over the next five years.

Table 2-1: Load forecast for Staplegrove 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Staplegrove	33/11	0.99	12.4	12.16	12.01	11.93	11.95	12.09	22.86

2.4 Customers

2.4.1 Number of Customers

Staplegrove currently supplies 9,559 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

Staplegrove is located in an urban area therefore the typical loads at the substation are domestic and larger industrial and commercial customers. There are no voltage sensitive customers connected to the substation.

2.4.3 Generation

The total amount of embedded generation feeding into the Staplegrove 11KV network is 5MW. This is supplied by two solar PV sites. There are currently no connections committed for the future which are over 1MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

Both of the 11.5/23MVA transformers were manufactured by Ferranti Transformers in 1966 and have 17 position tap changers. The transformers are currently being closely monitored due to their condition and require more maintenance than other transformers.

2.5.2 Automatic Voltage Control Relays

The substation currently has two GE AVE5 relays installed in external cubicles next to the transformer for voltage control.

2.5.3 Auxiliary Systems

The substation has an 110V battery supply that was installed with the transformers and switchgear in 1966. The substation has D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Staplegrove feeder voltages using WPD IPSA models determined that a 0.015pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Staplegrove over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

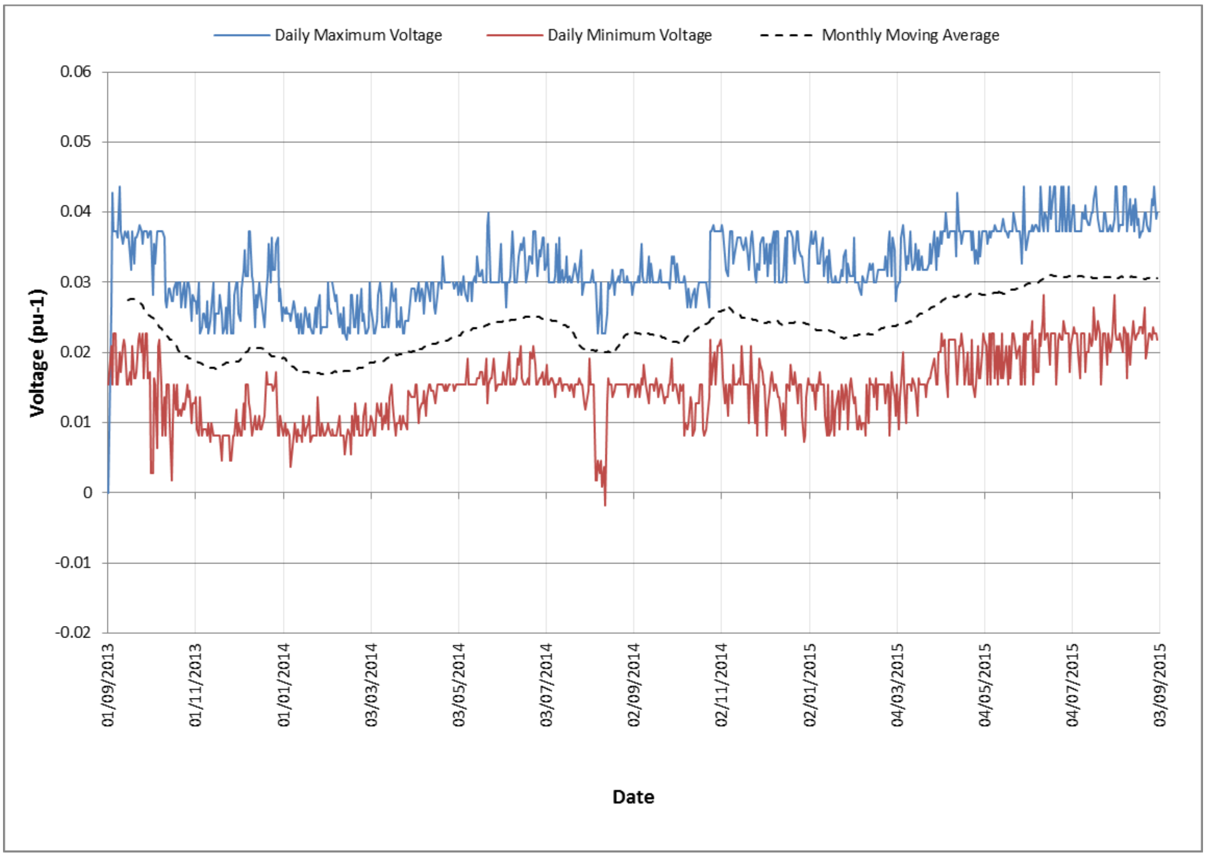


Figure 3-1: Historic voltage profile at Staplegrove

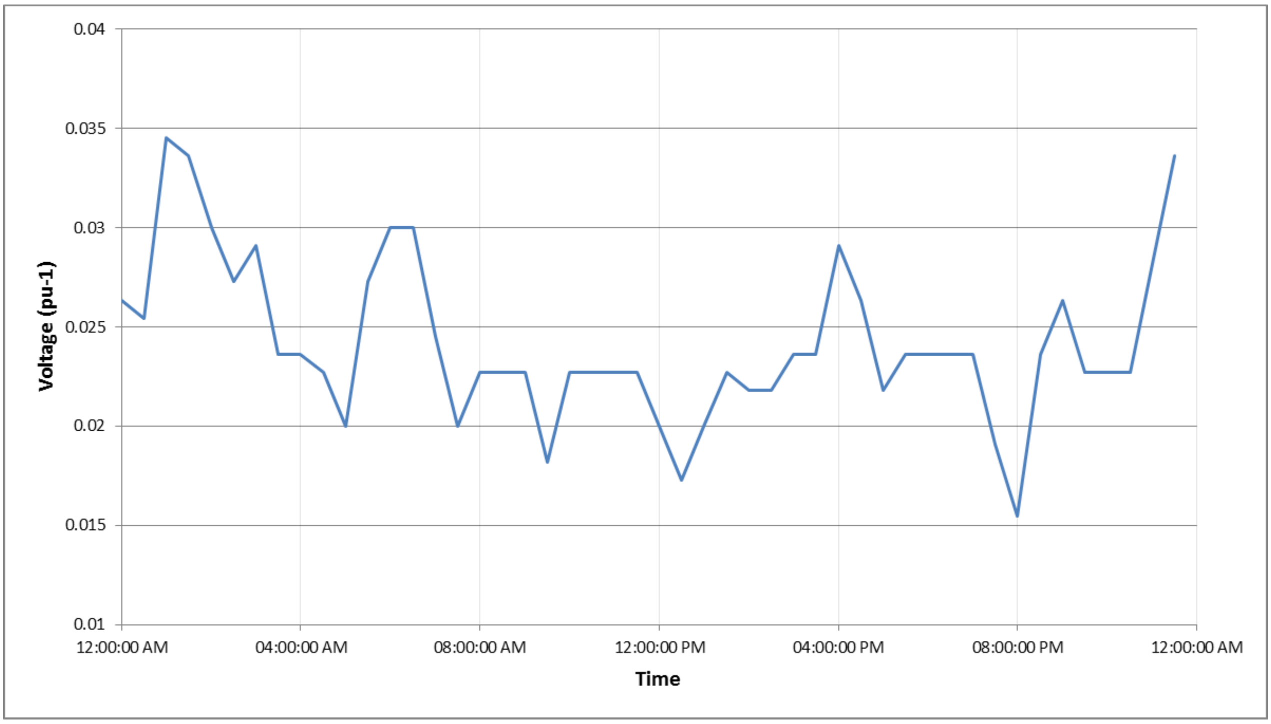


Figure 3-2: 01/06/15 Voltage profile at Staplegrove

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.015pu below nominal and remain within statutory limits.

The historical voltage profiles show that the moving average has fluctuated over the last two years between 0.018pu and 0.031pu but settled down to 0.031pu for the last two months. The daily fluctuations in voltage are approximately constant at an average of 0.017pu.

With the substation operating at around 0.031pu above nominal it may be possible to achieve a 0.046pu voltage reduction.

3.3 Scope of work to enable SVO

Due to the condition of both transformers at Staplegrove, it is not recommended that the SVO method is deployed at this substation.

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Staplegrove the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing AVC panels are mounted in external cabinets next to the transformers. In order to install the new relay required the whole panel will require replacement and positioned inside the substation building where space is available.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, six potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

The change from mechanical to numerical relays for voltage control will require a large number of new interfaces. The existing SCADA equipment has capacity to accept new signals, however wiring and communications cards will be required.

3.3.5 Auxiliary systems

The existing substation auxiliary systems are suitable for any modifications required to operate new equipment for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Staplegrove. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Staplegrove will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

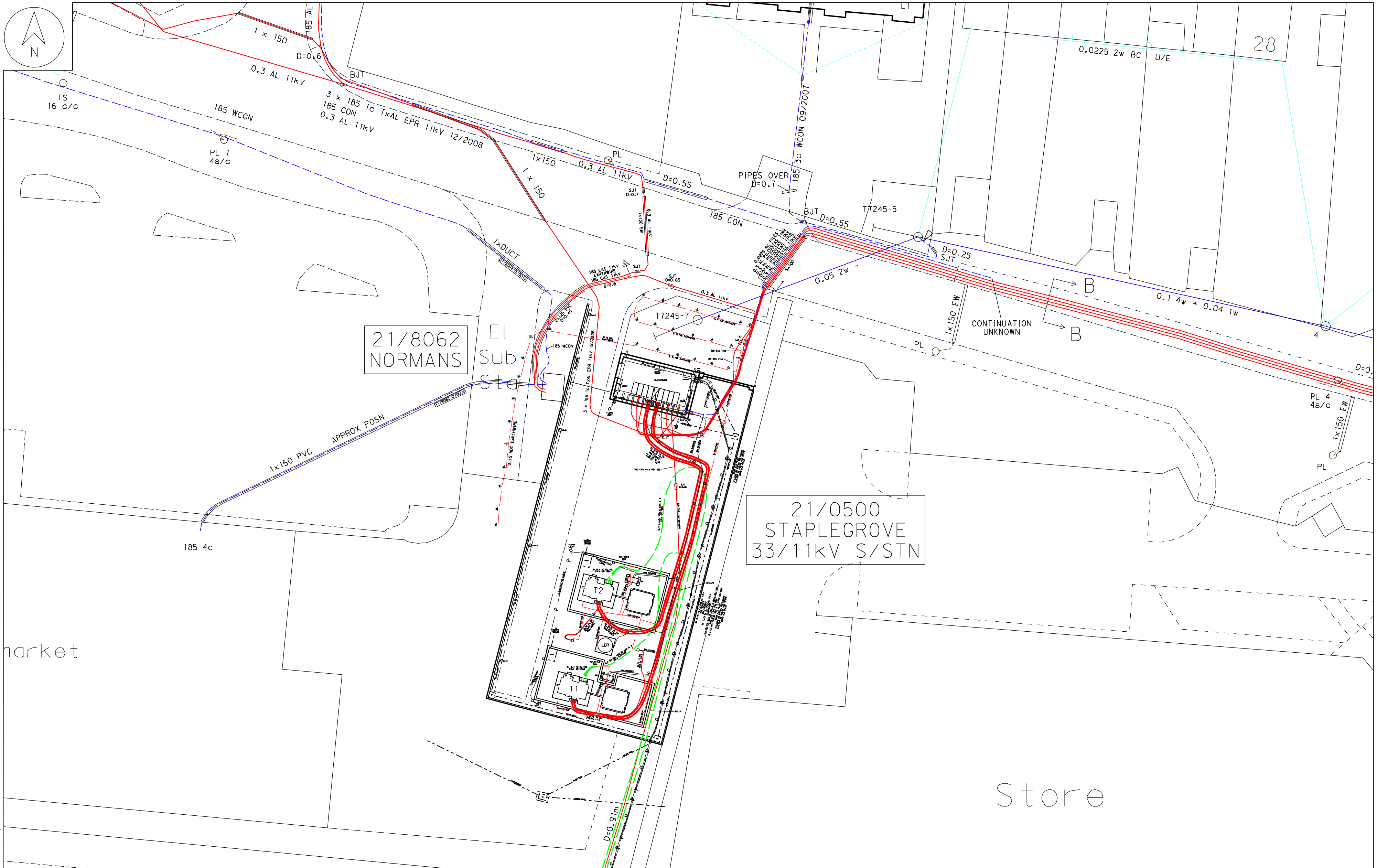
Table 4-1: Site specific risks

Risk	Effect	Action
Asbestos in the fuse casing can release dust particles if moved.	If inhaled asbestos can cause harm/injury.	Carry out an asbestos survey. Hire a specialist to remove the asbestos if it is found.
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
The old transformer and the new relay may not be compatible.	This may restrict the level of control that can be applied	Check the functionality of the transformer before choosing the relay to be used. Select an alternative site if necessary.
Old transformer degrades at a faster rate due to stricter voltage control requiring more frequent tap changes.	The lifetime of the tap changer reduces.	Aim to install at the sites were the transformers are younger and in better condition. Expect to replace the transformer sooner than anticipated.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS	OVERHEAD LINE		UNDERGROUND CABLE
		PL	
		SERVICE	
		LV	
		HV (11kV)	
		HV (33kV)	
PILOT CABLES		HV (66kV)	
		HV (132kV)	

PME Earth — Pole Mounted Transformer
Underground Earth — Ground Mounted Transformer

* ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: STAPLEGROVE
DRAWN BY: S. SHIANGOLI
DATE: 14/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 321509.505,125693.610

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

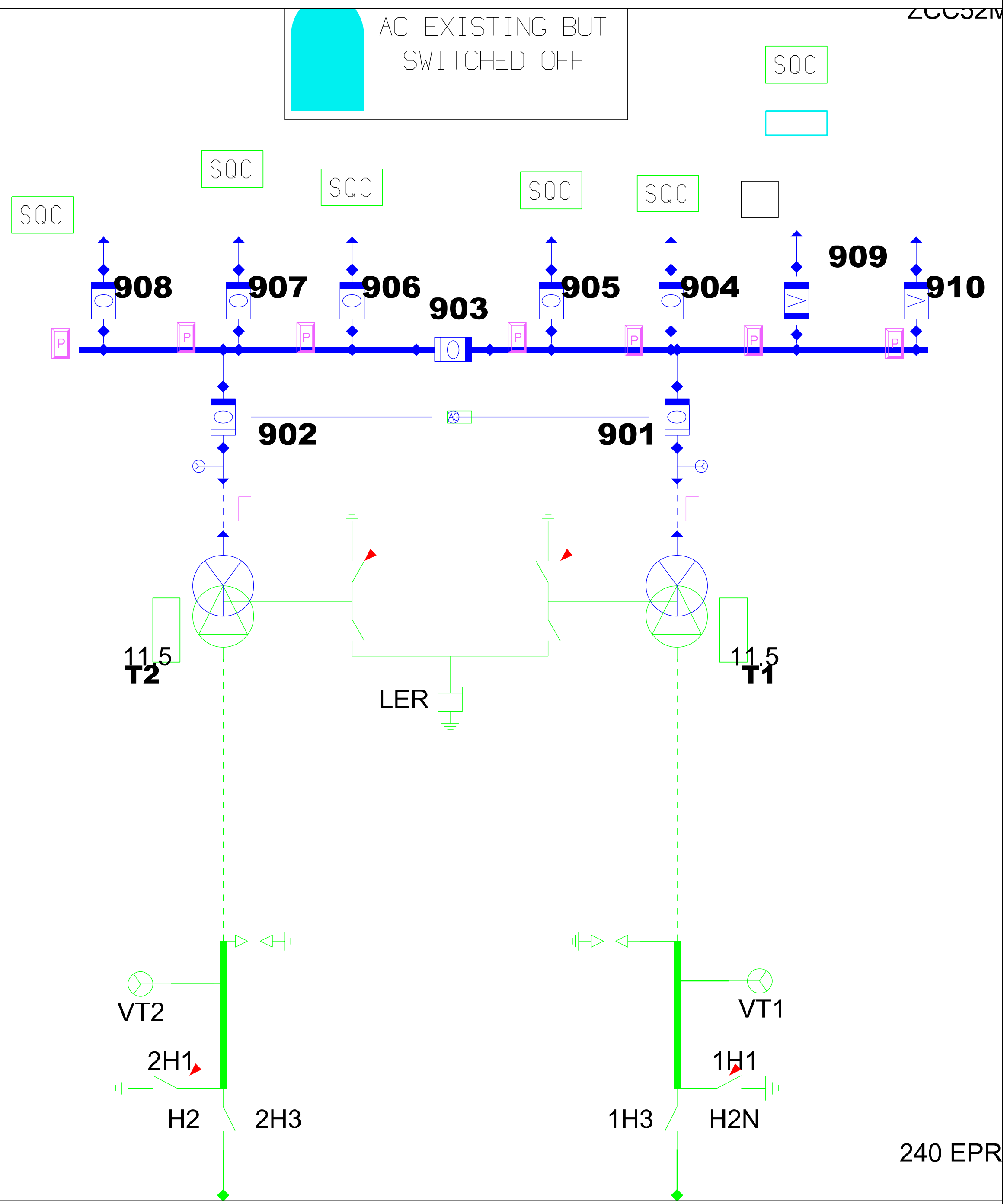
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

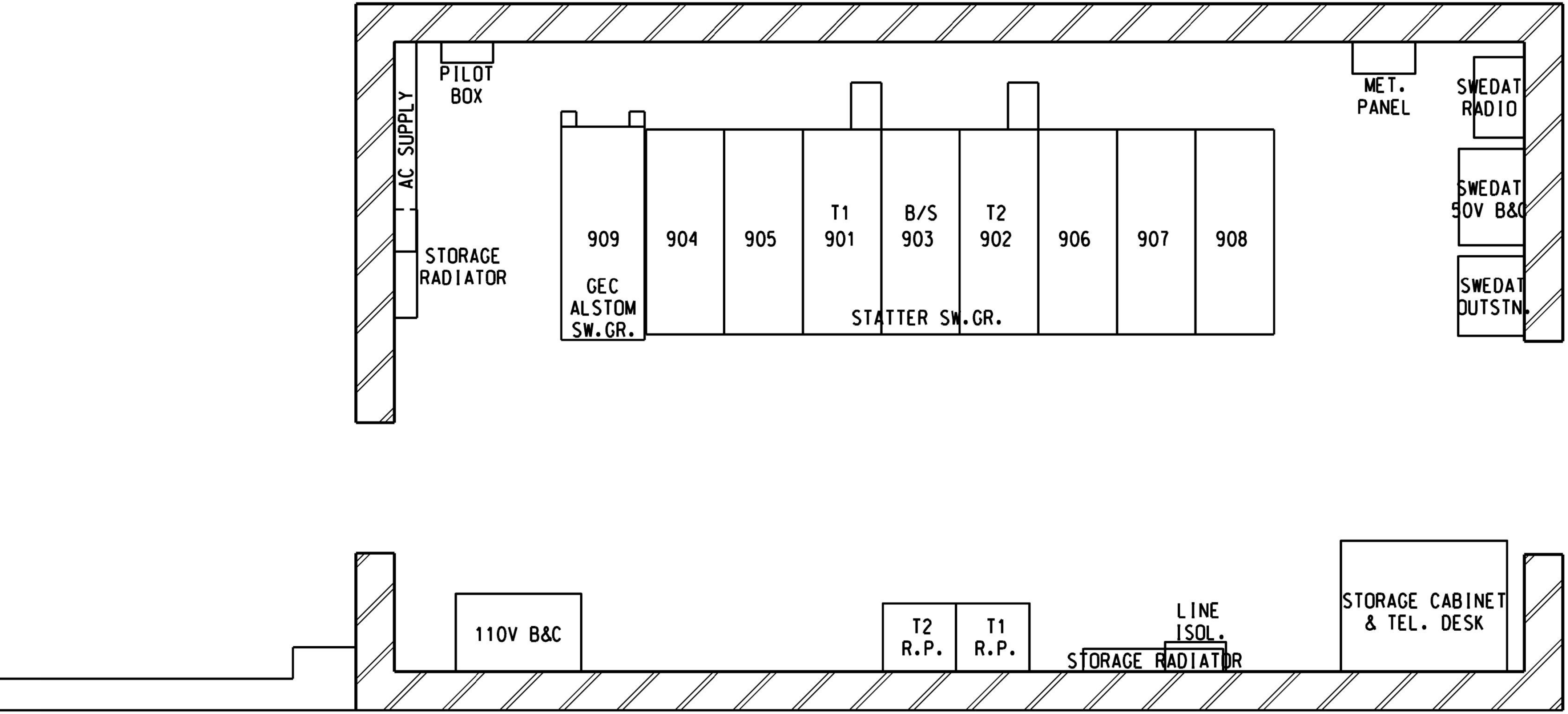
WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

210500 STAPLEGROVE



APPENDIX C - CONTROL ROOM LAYOUT



AC SUPPLY
PILOT BOX
STORAGE RADIATOR
909
GEC ALSTOM SW.GR.
904
905
T1 901
B/S 903
T2 902
906
907
908
STATTER SW.GR.
MET. PANEL
SWEDAT RADIO
SWEDAT 50V B&C
SWEDAT OUTSTN.
110V B&C
T2 R.P.
T1 R.P.
STORAGE RADIATOR
LINE ISOL.
STORAGE CABINET & TEL. DESK

APPENDIX D - SITE PHOTOS

P3

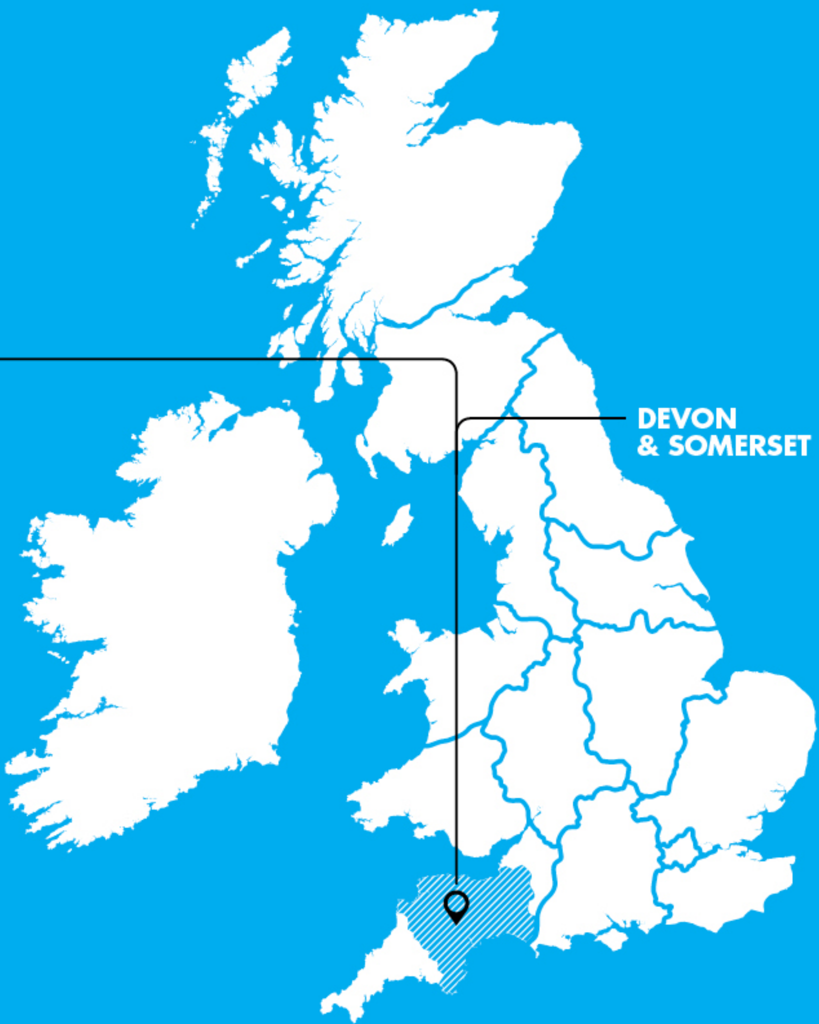
TRANSFORMER Nº1
P1
P4

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Street 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Street Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

WESTERN POWER DISTRIBUTION
NETWORK EQUILIBRIUM

Contents

1 Introduction

The following report details the findings from the investigation of Street 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Street 132/33kV substation belongs to the Seabank-Bridgwater-Taunton Grid Group and is normally fed via one 132kV circuit from Bridgwater GSP. The substation is operated in parallel with Bridgwater 132/22kV BSP. The substation contains a single 30/60MVA 132/33kV transformer. The substation was originally constructed in the late 1960's with the transformer being replaced in 1998.

A selection of photos and the control, single line and EMU diagrams are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no committed plans to carry out investment works at this substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to remain stable over the next five years with the firm capacity not being reached.

Table 2-1: Load forecast for Street 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Street	132/33	0.96	38.56	38.03	37.86	37.97	38.03	38.46	68.58

2.4 Customers

2.4.1 Number of Customers

The combined Street and Bridgwater BSPs supply sixteen primary substations. The total number of customers supplied from Street and Bridgwater BSP is 47,398.

2.4.2 Type of Loads

The primary substations supplied from Street and Bridgwater BSPs are located in both urban and rural areas. The substation therefore supplies a wide range of load types with both high and low demands. There are also several 33kV connected customers including a landfill site and multiple farms. There is a single customer on the 33kV network that is considered as voltage sensitive.

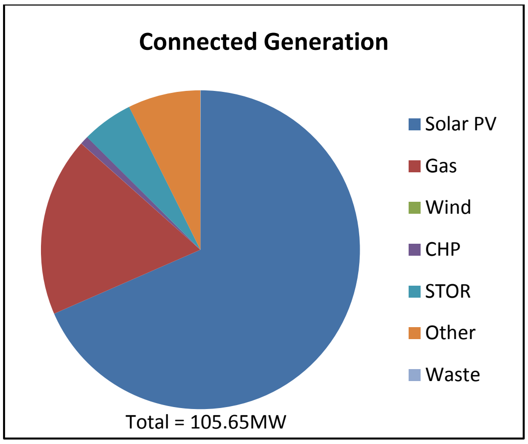
2.4.3 Generation

The total amount of embedded generation feeding into the Bridgwater Main network is currently 115.66MW. Connected to the 33KV network is 81.45MW, with the 11kV network having 34.21MW connected.

The 33kV connection is made up of 10 solar PV sites totalling 61.75MW and two gas sites totalling 19.7MW. Seven further solar PV sites are committed for future connection to the 33kV network which will add a further 62.22MW of generation.

The 34.21MW connected to the 11kV networks fed from Bridgwater Main BSP is made up of a mix of PV, STOR, CHP and other alternative sources. A further 18.35MW of solar PV generation is committed for future connection.

Overall, the committed generation at both voltage levels will add 80.57MW of embedded generation giving a total of 196.23MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.



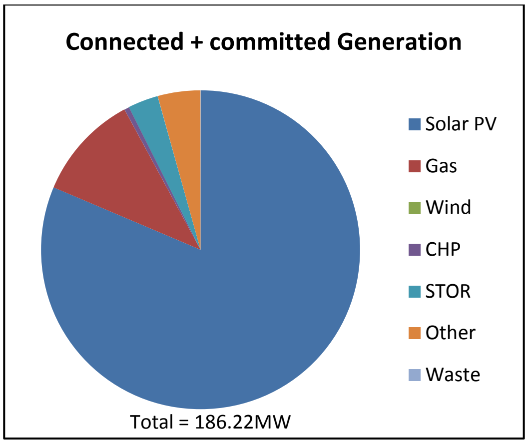


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

The existing transformer was manufactured by Hawker Siddeley Transformers in 1997 with a 19 position tap changer.

2.5.2 Automatic Voltage Control Relays

Street BSP currently utilises a single MVGC01 relays for Voltage Control of its transformer. The existing scheme was installed alongside the transformer change in 1998.

2.5.3 Auxiliary Systems

The substation has an 110V battery supply and a D20 SCADA communications system.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trail will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Street Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.018	0.986
2	0.996	0.947
3	1.004	0.962
4	1.004	0.962
5	**1.030**	**0.939**

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Street over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

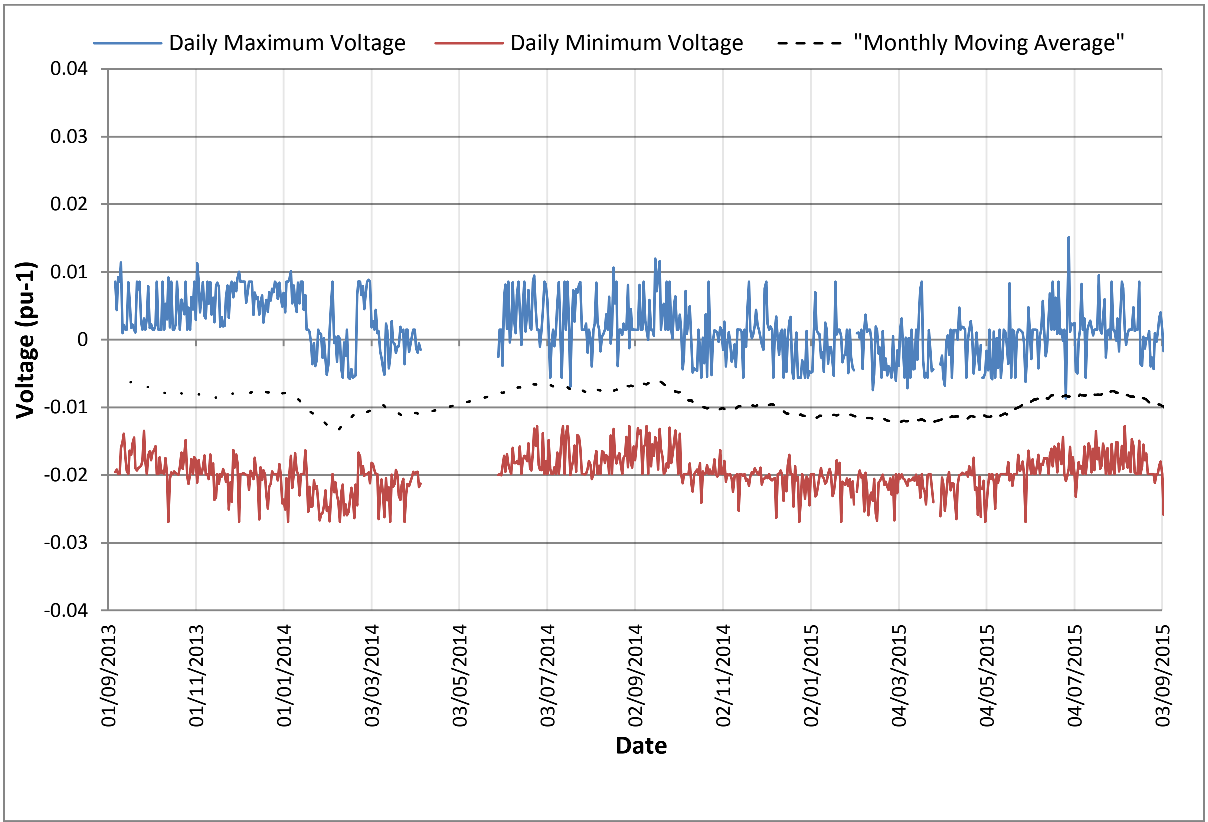


Figure 3-1: Historic voltage profile at Street BSP

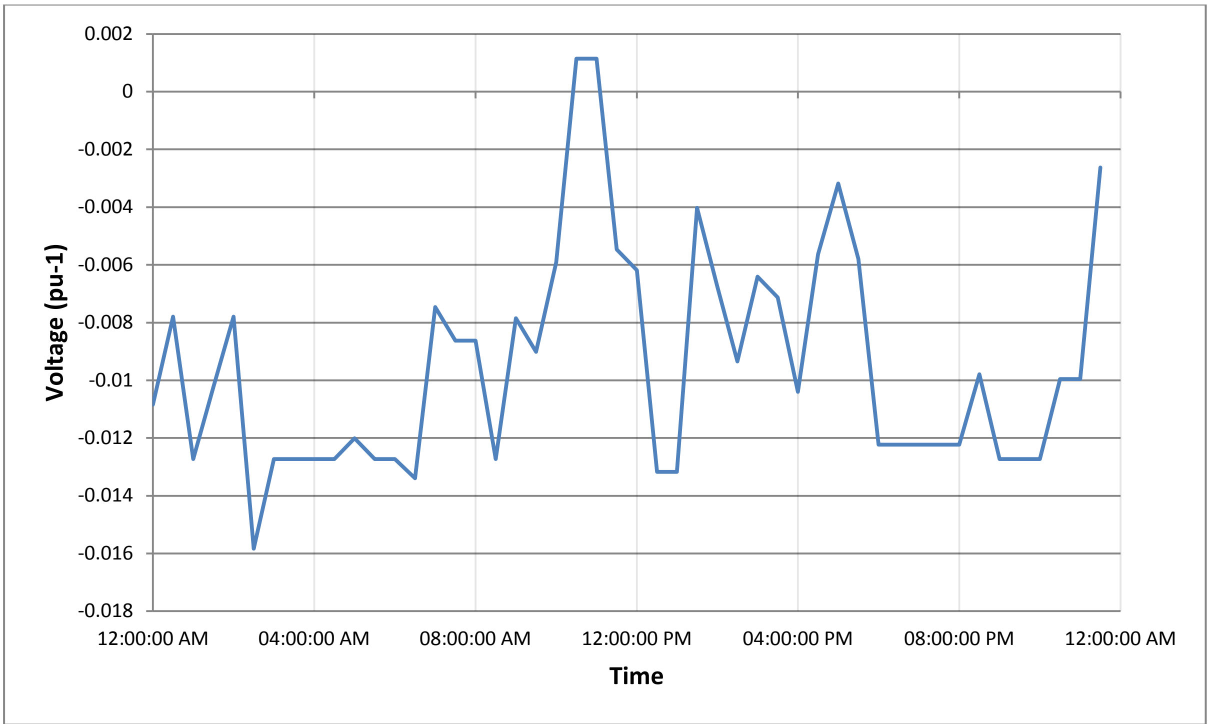


Figure 3-2: 01/07/15 Voltage profile at Street BSP

3.2.3 Results

The study results show that for Street BSP, the voltage can be increased by 0.03pu and still keep all parts of the 33kV network within statutory limits. It is not possible to decrease the voltage and remain within statutory limits.

The historical voltage profiles show that the voltage is fluctuating around 0.01pu below nominal with a typical daily variation of 0.018pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Street BSP the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relays. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Street BSP Feeder measurement locations

Street BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Bath Road 11kV	YES	YES
Bridgwater Local 11kV	YES	YES
Burnham 11kV	NO	YES
Colley Lane 11kV	NO	YES
Creech St Michael 11kV	YES	YES
Nether Stowey 11kV	NO	YES
Watchfield 11kV	YES	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Street BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Street BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

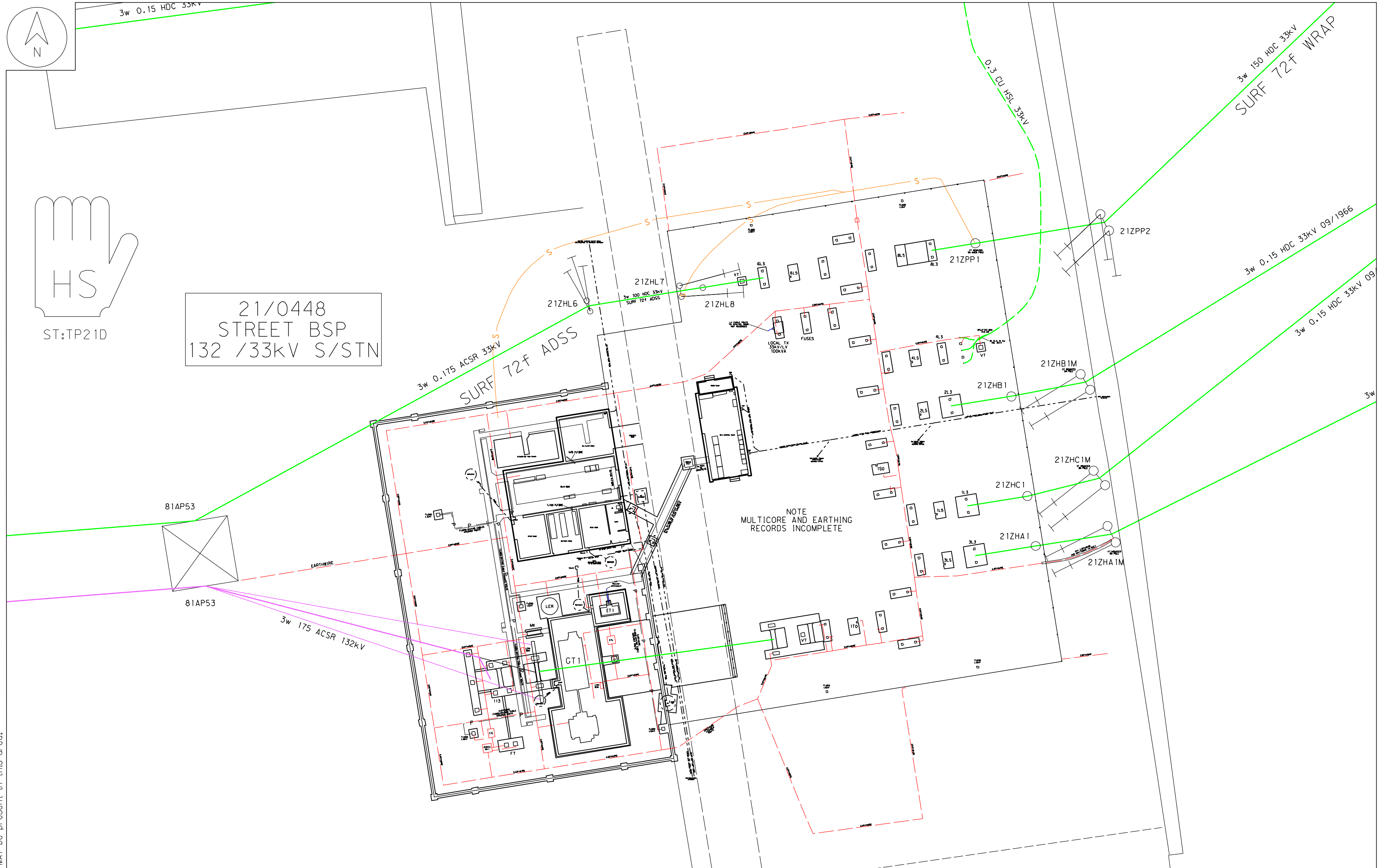
4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Cutting Panels will cause vibrations.	The vibrations can transmit to adjacent panels. If these house old mechanical relays they may be triggered by the vibrations causing unwanted changes in voltage. This can lead to trips occurring.	Remove the door and modify off the panel if possible. Ensure all live panels are labelled clearly. Ensure WPD approved methods are used for cutting existing panels.
There is only one transformer at this substation.	The substation operates in parallel with Bridgwater so there will be additional load on this site when modifying Street BSP.	Consider surveying the overhead lines which supply Bridgwater. Stage the work to meet the Emergency Return To Service (ERTS) Ensure the Bridgwater transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM



Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS	OVERHEAD LINE	UNDERGROUND CABLE
PILOT CABLES	PL	
	SERVICE	
	LV	
	HV (11kV)	
	HV (33kV)	
	HV (66kV)	
	HV (132kV)	

PME Earth
Underground Earth
Pole Mounted Transformer
Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: STREET BSP
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 347408.132,137148.926

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

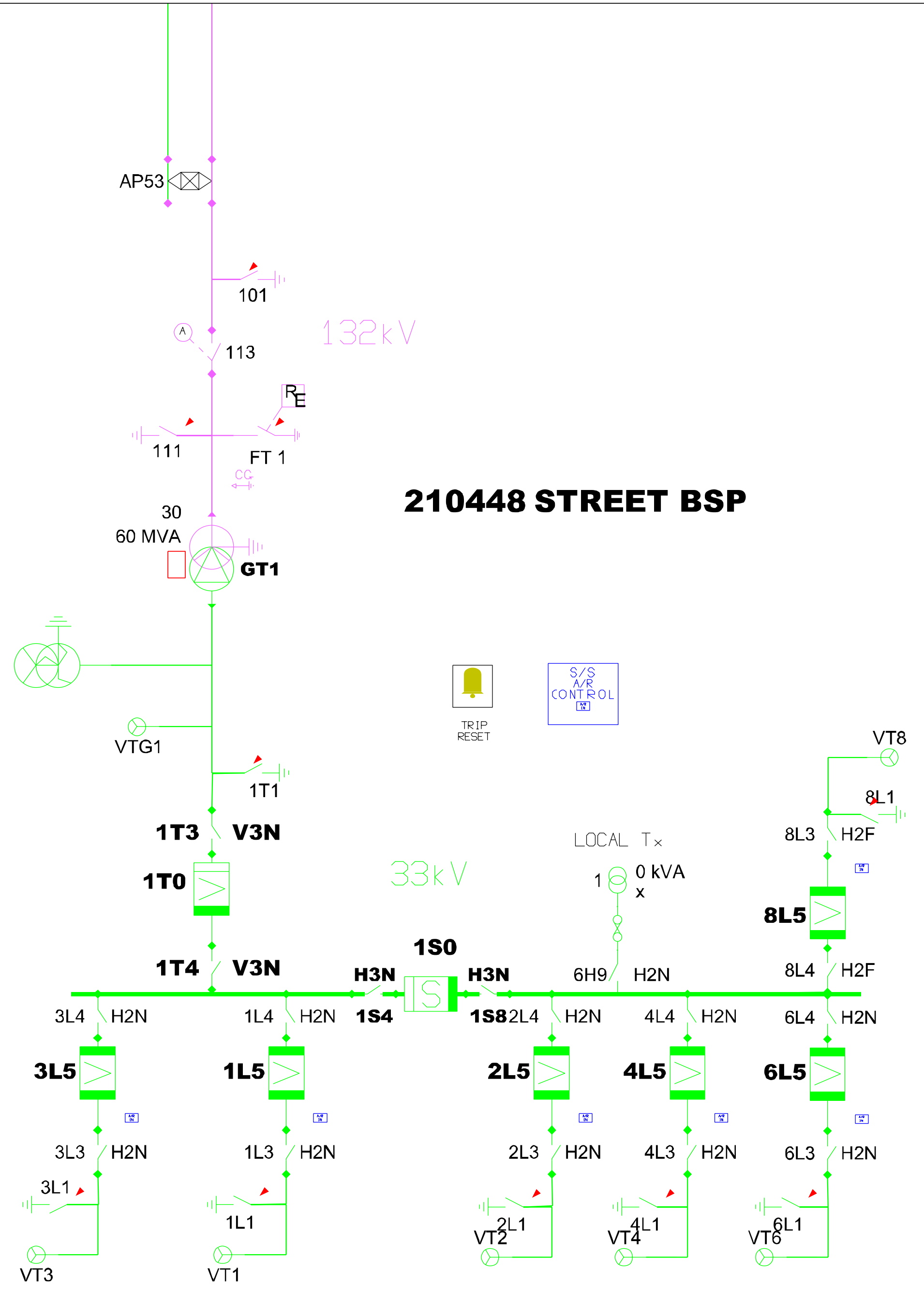
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

210448 STREET BSP



Date: 13/01/2016

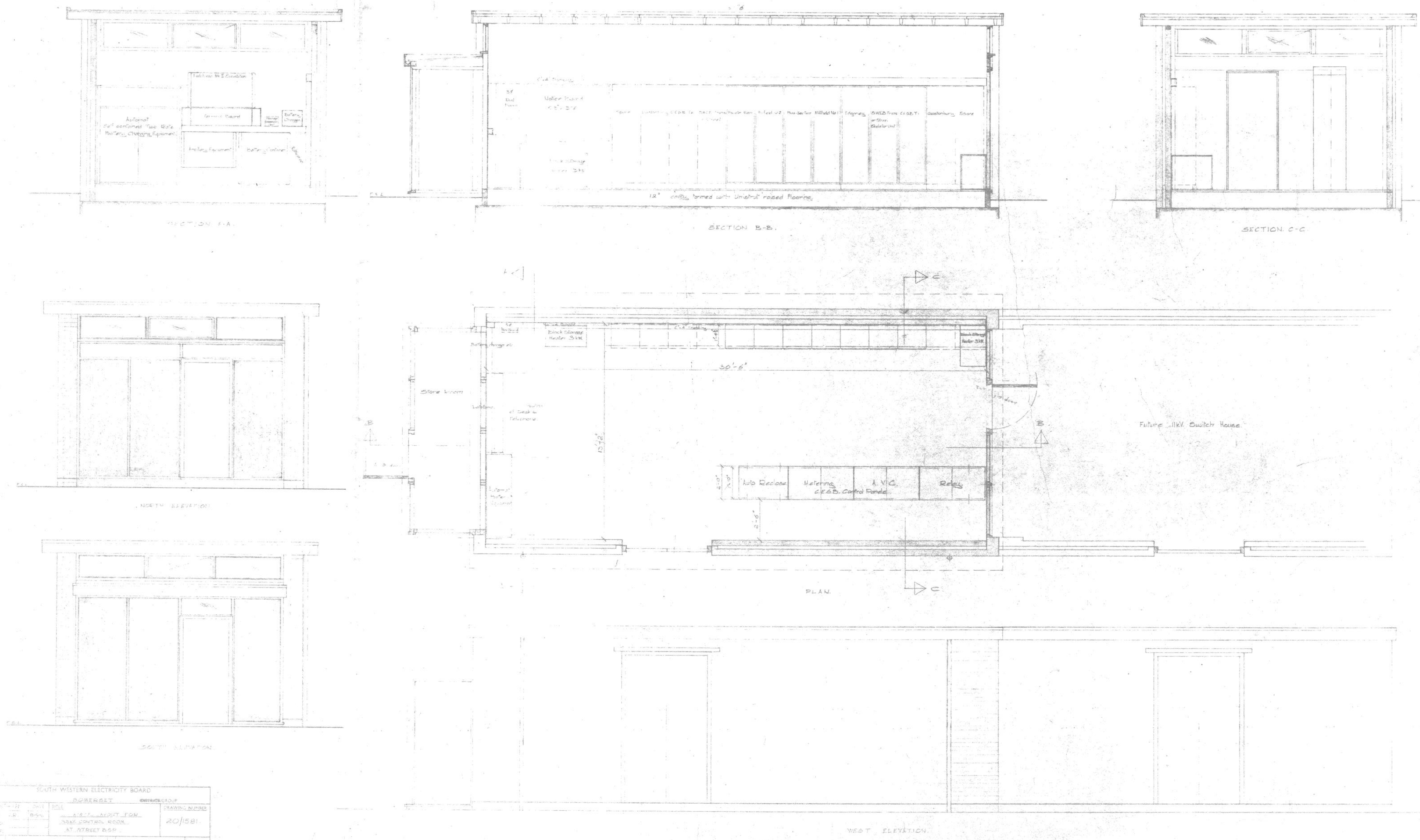
FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT

1581

S4142



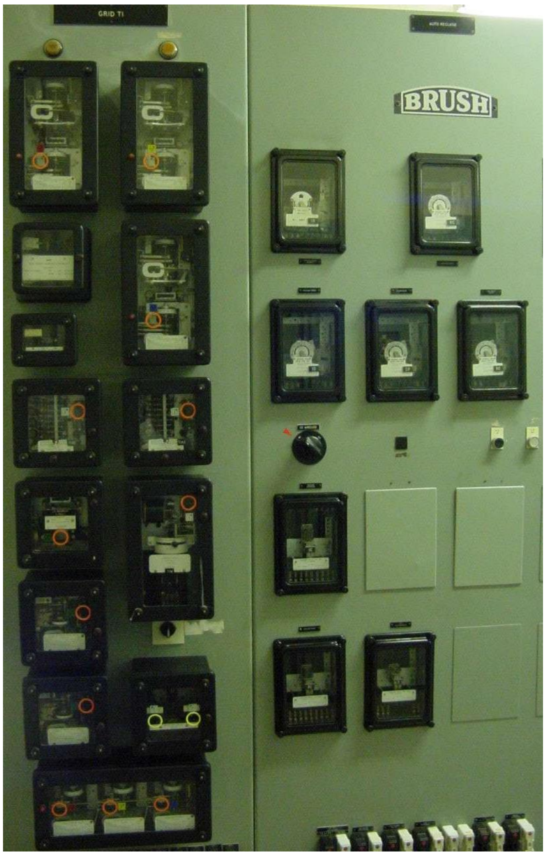
SOUTH WESTERN ELECTRICITY BOARD
SOMERSET GROUP

TITLE ... LAYOUT FOR 33KV CONTROL ROOM AT STREET B.S.P.	DRAWING NUMBER 20/1581.

S4142

APPENDIX D - SITE PHOTOS


MVGC

ET 1

BRUSH

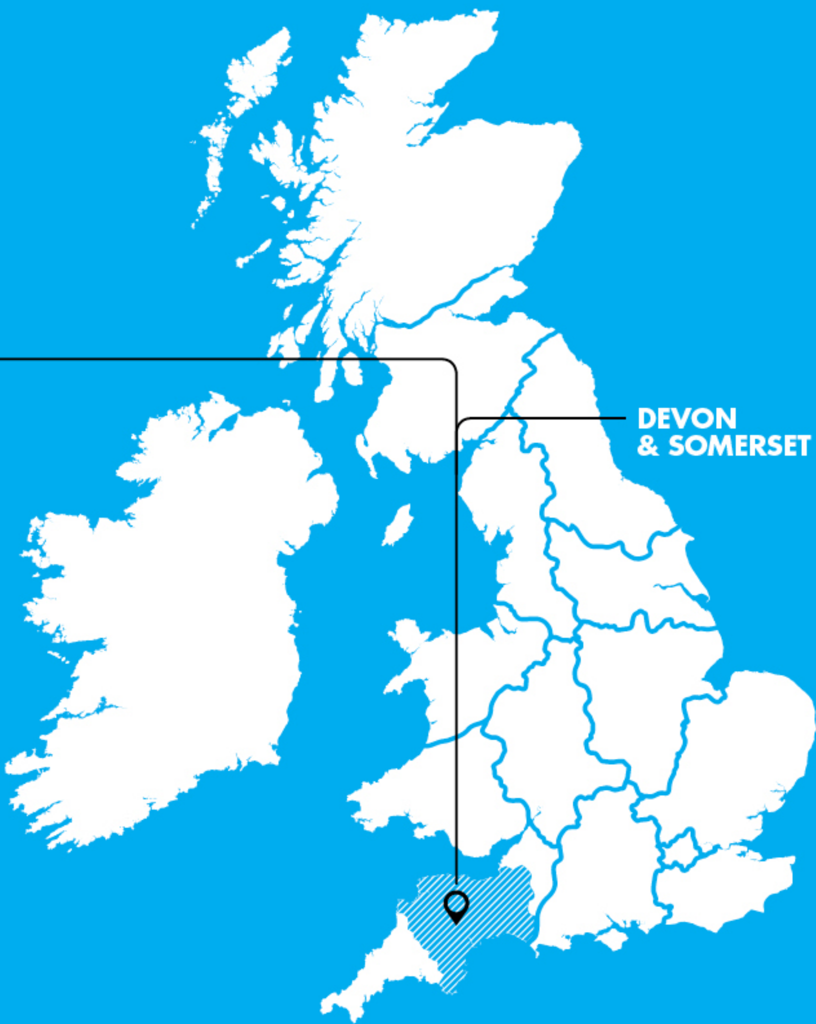

GT1

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Taunton Main 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Taunton Main Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

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1 Introduction

The following report details the findings from the investigation of Taunton Main 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Taunton Main 132/33kV substation belongs to the Taunton, Seabank and Bridgwater Grid Group and is normally fed via three 132kV circuits from Taunton GSP. It has three 132/33kV transformers operating with the bus section normally closed. The 33kV switchroom was constructed in 1998 with the transformers being replaced in between 2009 and 2011.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no committed plans to carry out investment works at this substation as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to decrease for the next 3 years before starting to increase again. The firm capacity will not be reached.

Table 2-1: Load forecast for Taunton Main 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Taunton Main	132/33	0.99	87.22	85.52	84.49	83.90	84.04	85.01	129.95

2.4 Customers

2.4.1 Number of Customers

Taunton Main supplies a total of ten primary substations with a total number of customers of 55,937.

2.4.2 Type of Loads

The primary substations supplied from Taunton Main are located in a mixture of urban and rural areas with a mixture of domestic, commercial and industrial loads. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Taunton Main network is 32.25MW with 30.75MW connected to the 33kV network and 1.5MW of generation connected to the 11kV network.

The 33kV connection is made up of five solar PV sites (30.75MW) with a further six solar farms generating 28.41MW and a single 20MW STOR committed for future connection. There is a single 1.5MW solar PV farm connected to the 11kV primary network.

Overall the future generation will add 48.41MW of embedded generation giving a total of 80.66MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

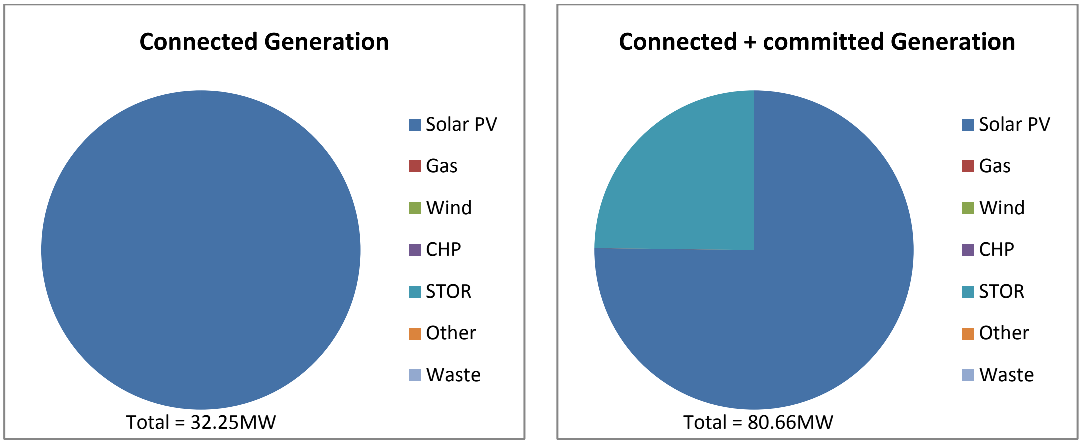


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

All three transformers were manufactured after 2008 by Siemens Transformers with a 19 position tap changer.

2.5.2 Automatic Voltage Control Relays

Taunton Main currently utilises three MVGC01 relays for Voltage Control of its transformers. The existing scheme was installed alongside the switchgear upgrade in 1998.

2.5.3 Auxiliary Systems

The substation has an 110V battery supply, installed in 1998 in conjunction with the change in switchgear and has spare capacity available. The substation also has a D20 SCADA communications system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Taunton Main Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.017	0.998
2	1.017	0.998
3	1.035	0.992
4	1.027	**0.962**
5	1.028	0.994
6	1.018	0.993
7	**1.042**	0.994
8	1.015	0.990
9	1.038	0.990
10	1.016	0.996
11	1.016	0.996

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Taunton Main BSP over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

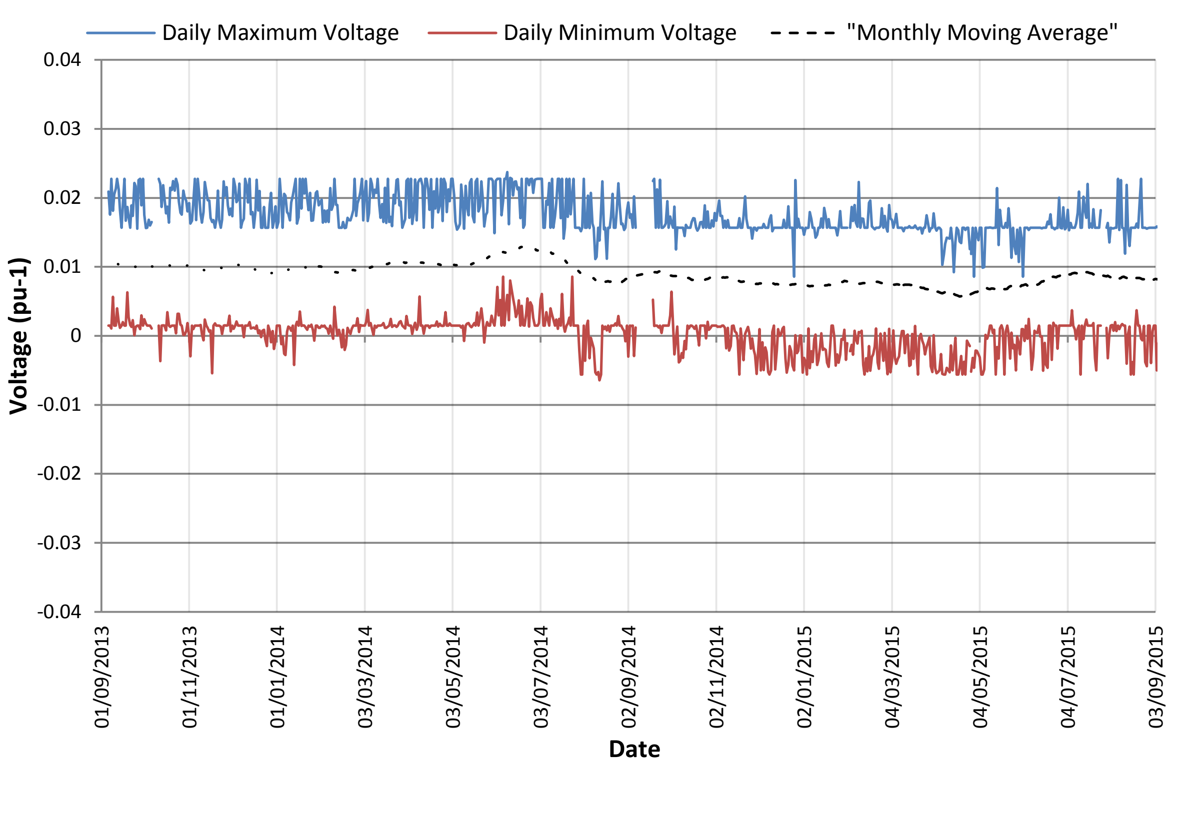


Figure 3-1: Historic voltage profile at Taunton Main

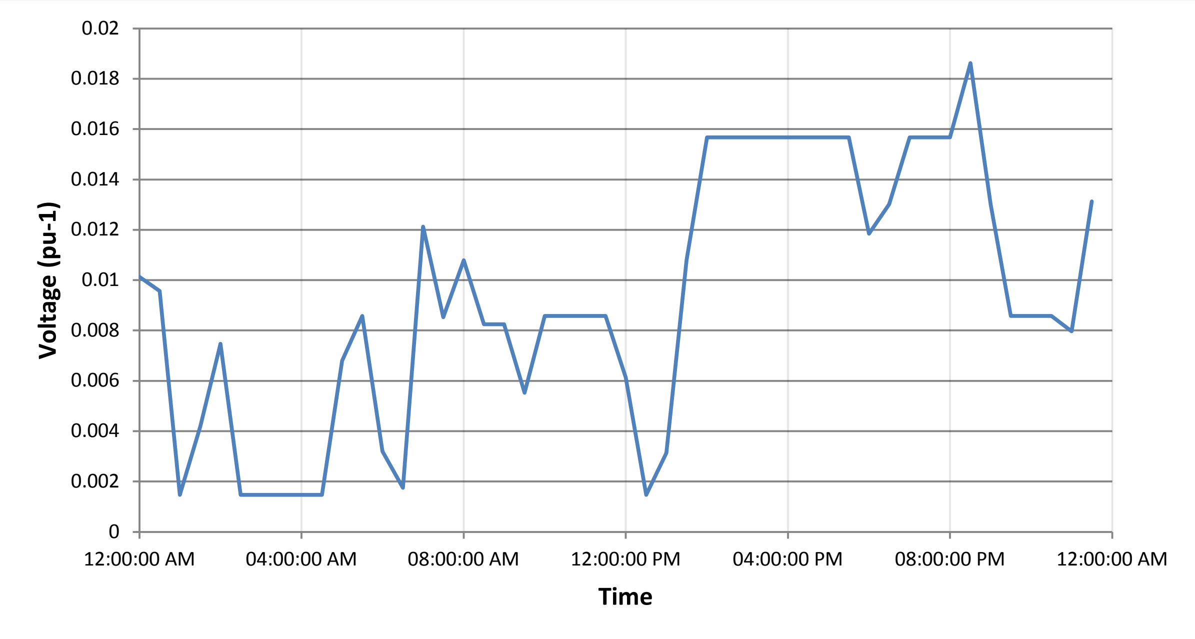


Figure 3-2: 1/7/15 Voltage profile at Taunton Main

3.2.3 Results

The study results show that for Taunton Main BSP, the voltage can be reduced by 0.022pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.018pu and be within the statutory limits.

The historic voltage profiles shows the voltage was initially stable around 0.01pu above nominal however has recently started to show a pronounced fluctuation. The typical daily variation in voltage has remained around 0.017pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Taunton Main BSP the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing panels are front access swing door frame that contain suitable room to accommodate a new AVC relay. Therefore the current relays will be removed and the panels adapted to fit the new relays. This will also involve a replacement of internal control wiring and additional terminal blocks to accommodate the new communication requirements.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Taunton Feeder measurement locations

Taunton Main BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Exebridge 11kV	YES	YES
Lydeard St Lawrence 11kV	YES	YES
Priorswood 11kV	NO	YES
Staplegrove 11kV	NO	YES
Taunton Local 11kV	NO	YES
Wellington 11kV	NO	YES
Wellington Town 11kV	NO	YES

3.3.4 SCADA

Modifications are required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring and communications cards.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Taunton Main BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Taunton Main BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

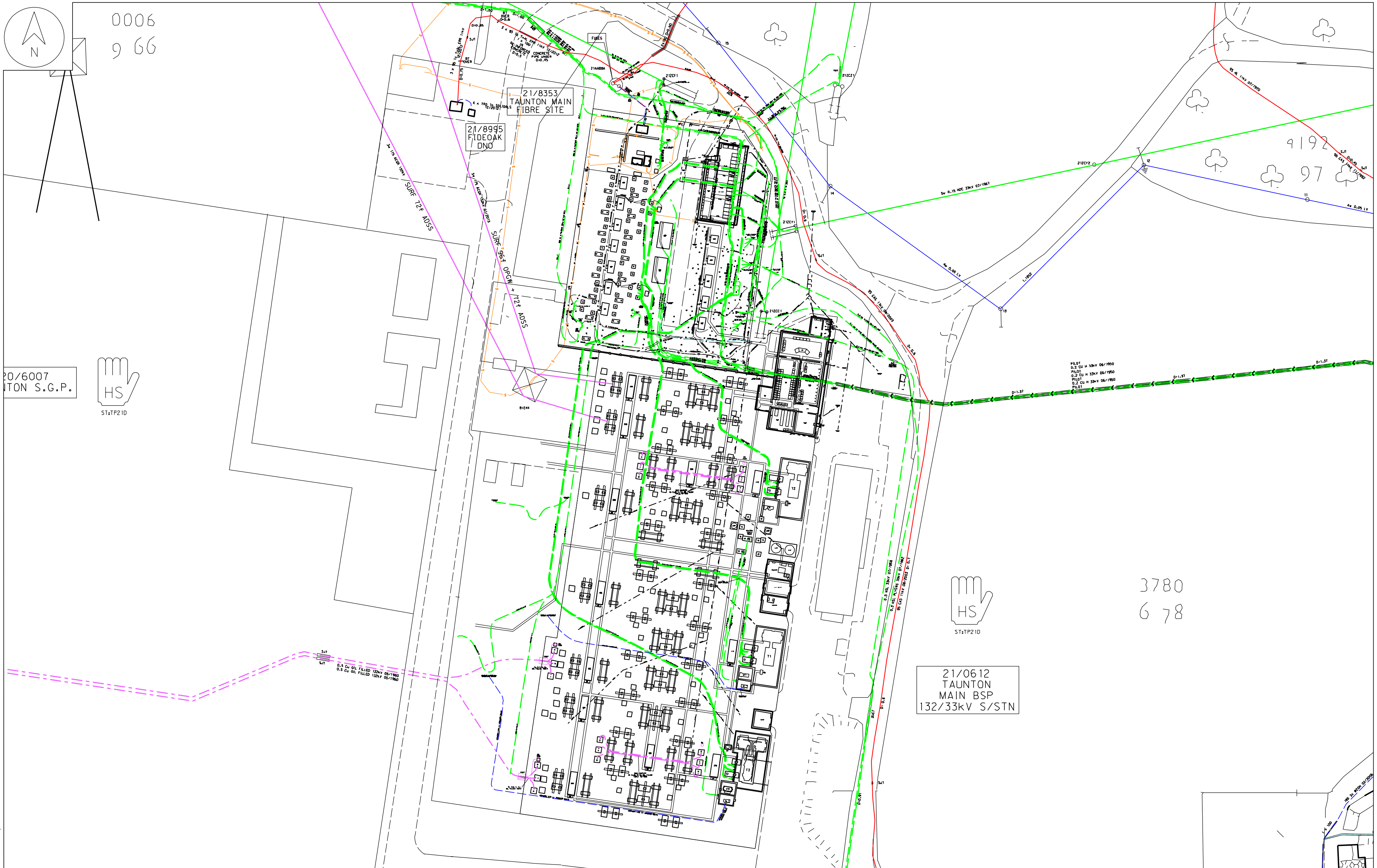
Table 4-1: Site specific risks

Risk	Effect	Action
Cutting Panels will cause vibrations.	The vibrations can transmit to adjacent panels. If these house old mechanical relays they may be triggered by the vibrations causing unwanted changes in voltage. This can lead to trips occurring.	Remove the door and modify off the panel if possible. Ensure all live panels are labelled clearly. Ensure WPD approved methods are used for cutting existing panels.
One of the remaining two transformers trip when working on one transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution. Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.



SURF TELECOMS APPARATUS

PILOT CABLES

OVERHEAD LINE / UNDERGROUND CABLE: PL, SERVICE, LV, HV (11kV), HV (33kV), HV (66kV), HV (132kV)

PME Earth

Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

* ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: TAUNTON MAIN BSP
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:1000 @ A3
PLOT CENTRE: 319230.586,124833.398

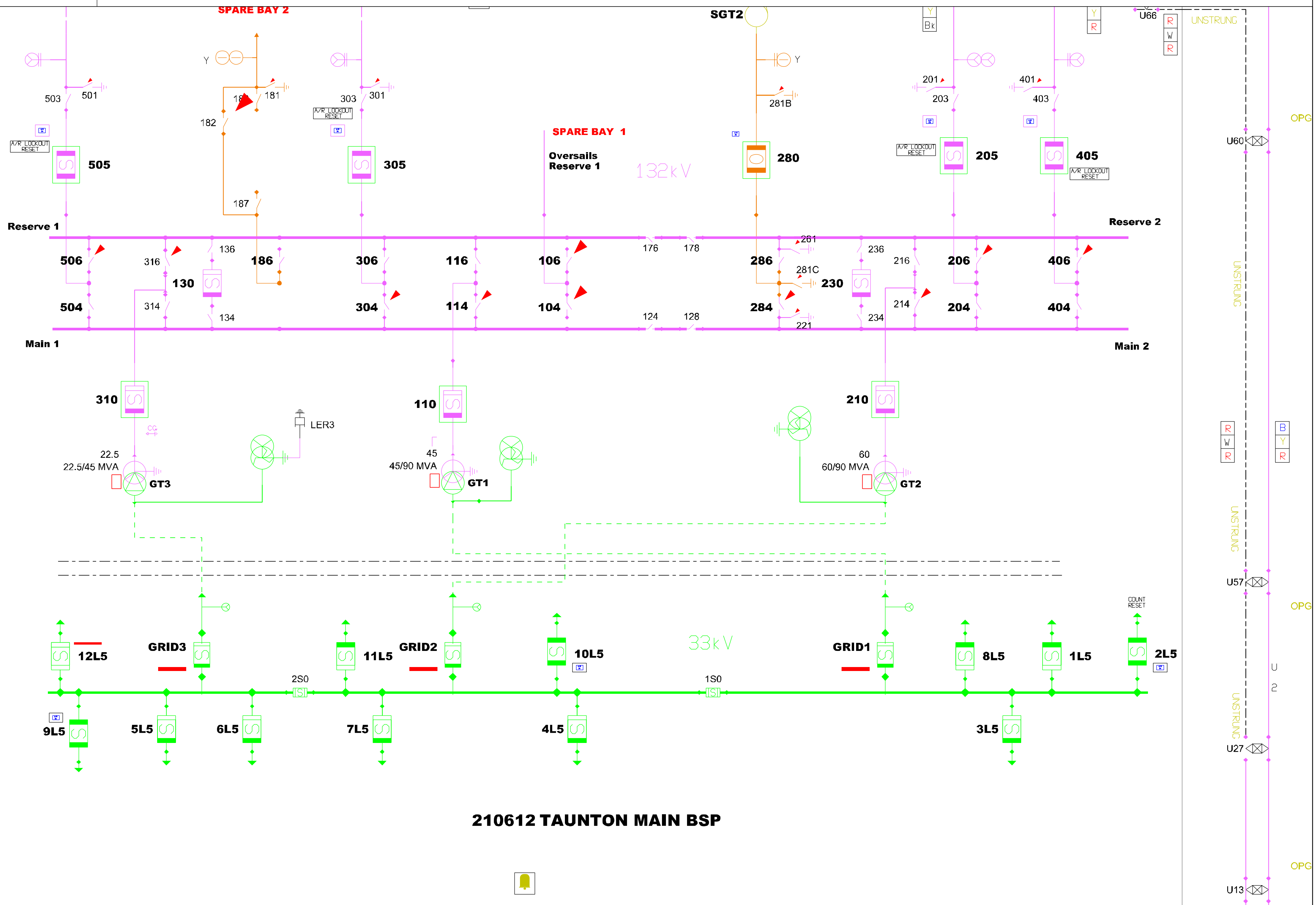
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



210612 TAUNTON MAIN BSP

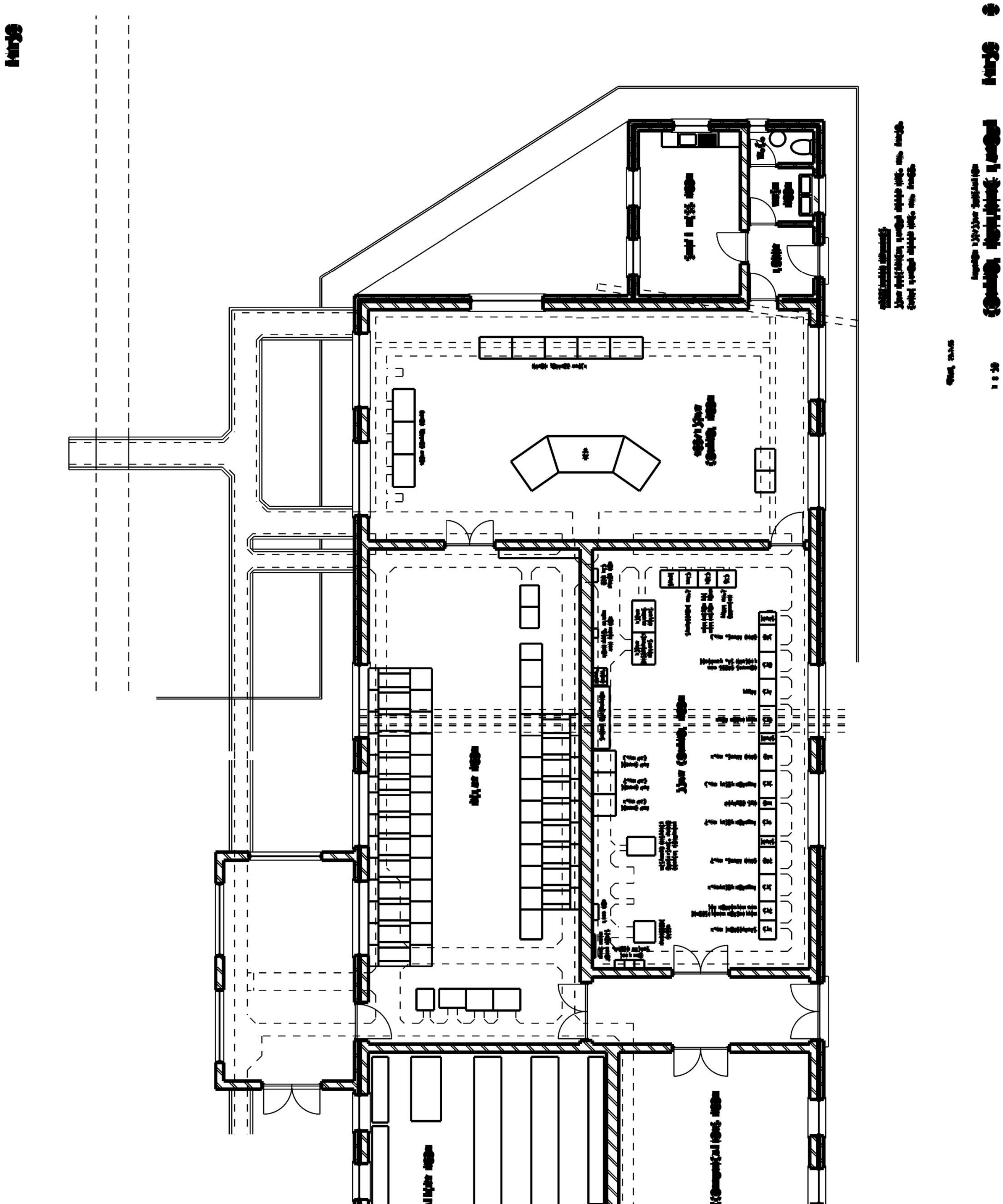
Tiles: 39, 40

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT



APPENDIX D - SITE PHOTOS


MVGC
VOLTAGE REGULATING RELAY
ALARM
TAP
VOLTS LOW
TEST VOLTS ADJUST
VOLTAGE MONITOR
INTER-TAP sec
INITIAL TIME sec

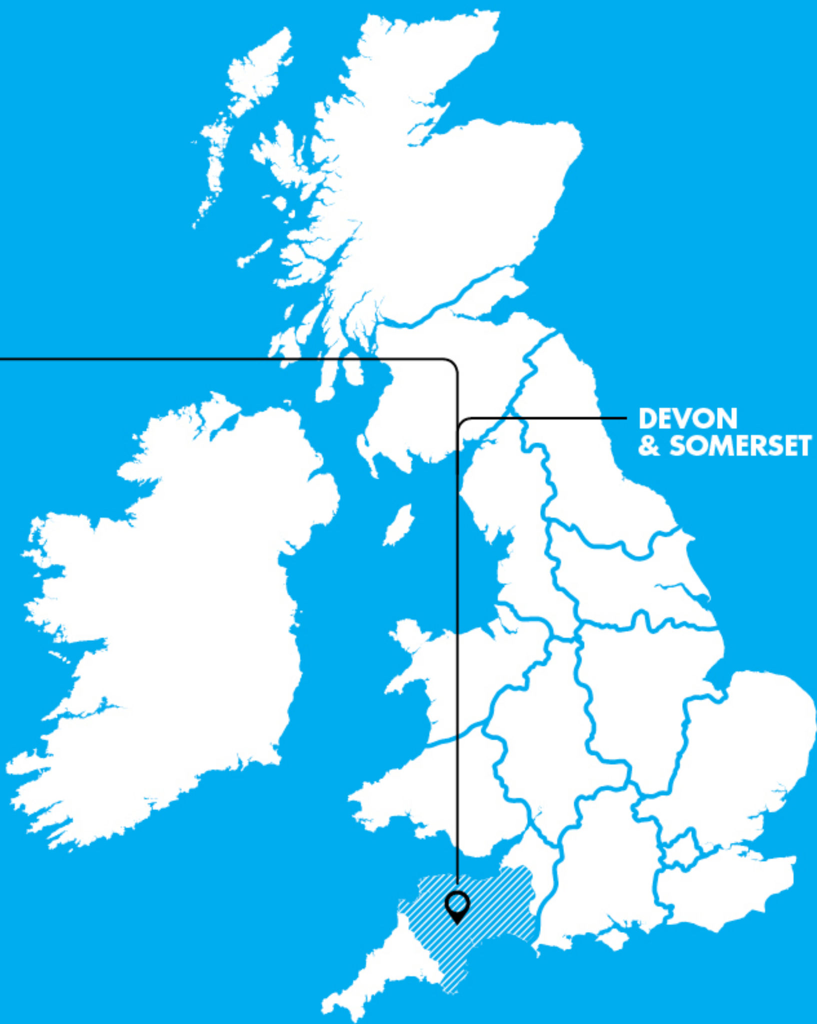

132/33kV Transformer No 1
GRID 1
A
Mvar
FAULT - TRIP OPERATIONS

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Tiverton 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Tiverton Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Tiverton 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring the BSP sites to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Tiverton 132/33kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 132 kV circuits from Exeter Main GSP. It has two 22.5/45MVA 132/33kV transformers operating with the bus section normally closed. The substation was originally constructed in the early 1960's with the 33kV switchgear replacement works completed in 2015.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

Work is currently in progress to change the 132kV circuit breaker as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected increase by 2.74MVA over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Tiverton 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Tiverton	132/33	0.98	56.91	58.42	58.31	58.92	59.01	59.65	67.5

2.4 Customers

2.4.1 Number of Customers

Tiverton BSP supplies a total of ten primary substations with a total number of customers of 48,000.

2.4.2 Type of Loads

The primary substations supplied from Tiverton Main are located in a mixture of urban and rural areas with a mixture of domestic, commercial and industrial loads. None of the customers are specified as voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Tiverton network is 21.28MW of three phase generation. Connected to the 33kV network is 4.55MW with 16.73MW of generation connected to the 11kV networks.

The 33kV connection is made up of a single solar PV site (4.55MW) at Ayshford Court. Four further solar PV sites are committed to in the future (18MW). There is 16.73MW of generation connected to the 11kV primary networks fed from Tiverton BSP, this is made up of solar PV and gas generation.

Overall the future generation will add 18MW of embedded generation giving a total of 39.28MW [2015 LTDS table 5]. Figure 2-1 shows the division of capacity between the generation sources found in the network.

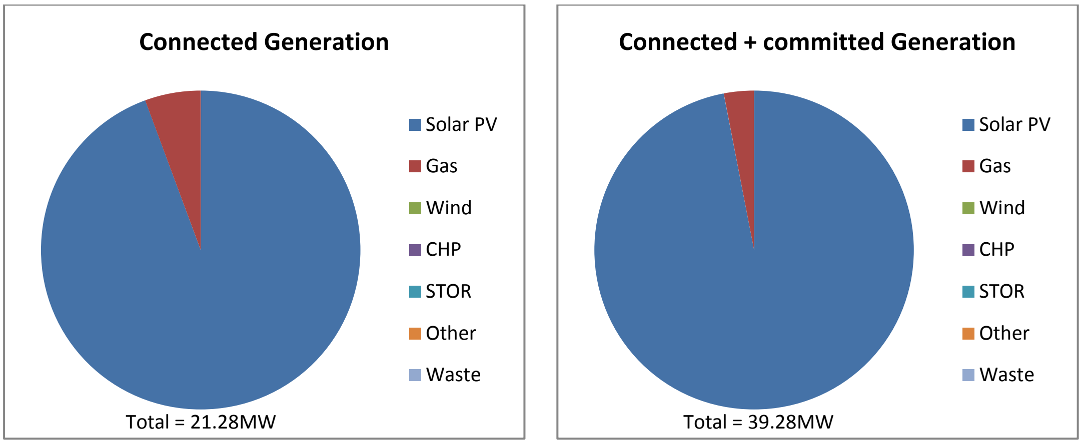


Figure 2-1: Pie charts of the networks connected generation (left), connected and committed generation (right)

2.5 Voltage Control Equipment

2.5.1 Transformers

The two transformers at Tiverton BSP were manufactured by Brush transformers in 1964 and have 19 position tap changers.

2.5.2 Automatic Voltage Control Relays

The AVC relays were updated alongside the replacement of the 33kV switchboard to Fundementals SuperTAPP N+ relays.

2.5.3 Auxiliary Systems

The substation contains an 110V battery that was installed in 2015 alongside the replacement of the 33kV switchgear. The D20 SCADA communications system was also installed alongside the 33kV switchgear replacement works.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trail will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Tiverton Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.027	**0.964**
2	**1.031**	0.986
3	**1.031**	0.986
4	1.030	0.985
5	1.030	0.985

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Tiverton BSP over a three month period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

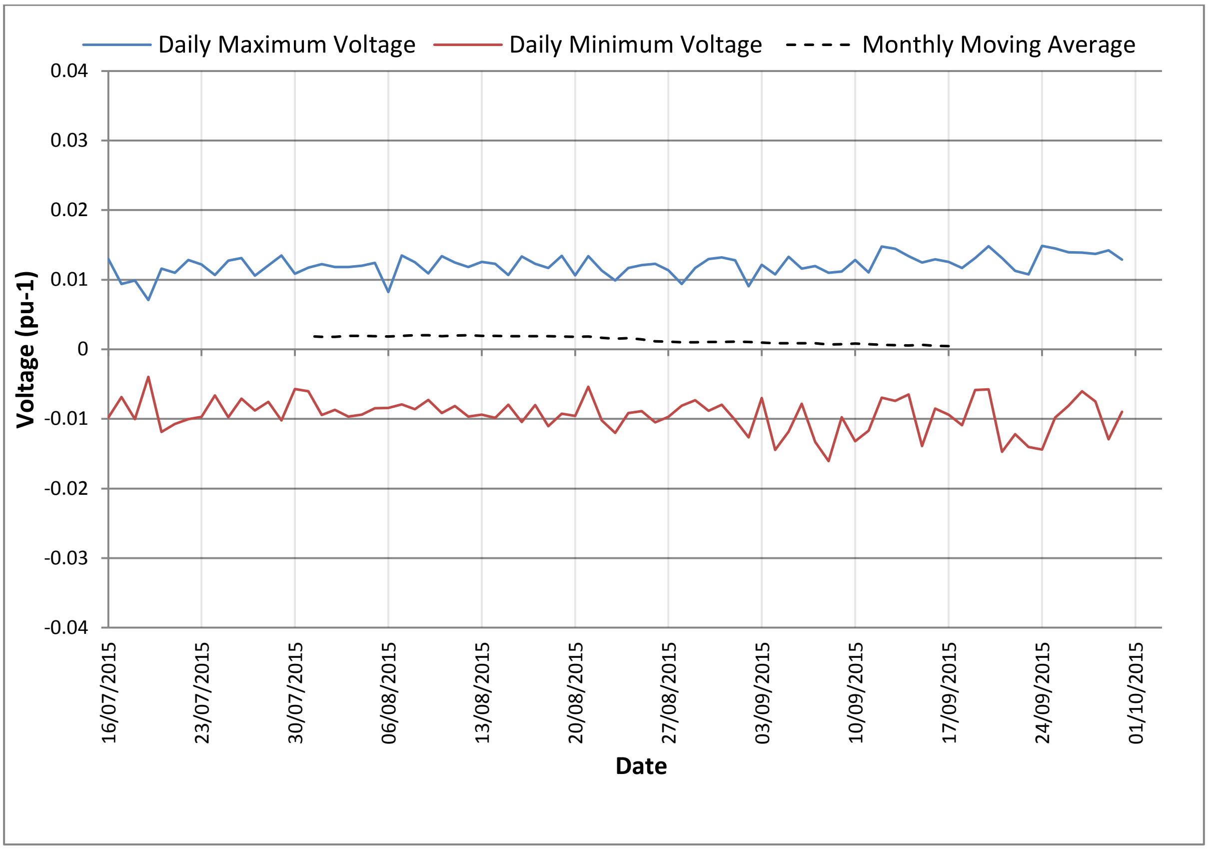


Figure 3-1: Historic voltage profile at Tiverton BSP

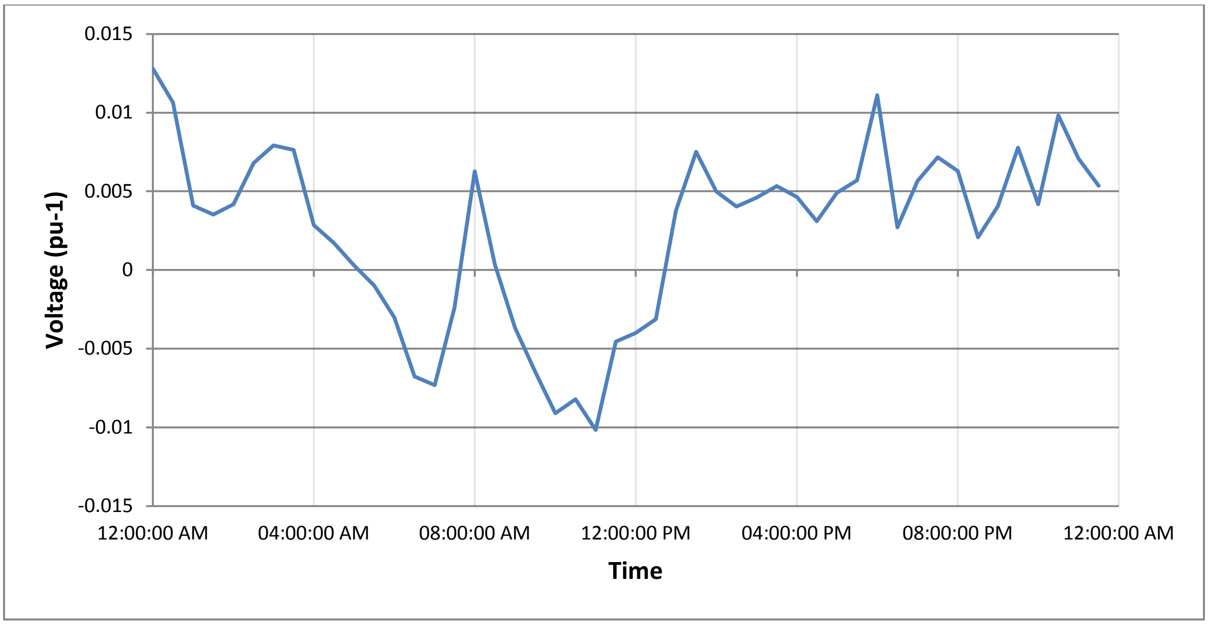


Figure 3-2: 01/09/15 Voltage profile at Tiverton BSP

3.2.3 Results

The study results show that for Tiverton BSP, the voltage can be reduced by 0.024pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.029pu and be within the statutory limits.

The historical voltage profiles show that the voltage has remained steady over the period analysed at nominal voltage with an average daily fluctuation in voltage of 0.022pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The current relay is suitable for the use with the SVO method.

3.3.2 AVC Panel

The existing panel will require additional terminal blocks to be installed to facilitate communications between the relay and SCADA interface.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Tiverton BSP Feeder measurement locations

Tiverton BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Bridge Mills 11kV	YES	YES
Burlescombe 11kV	YES	YES
Cullompton 11kV	YES	YES
Dunkeswell 11kV	YES	YES
Hemyock 11kV	YES	YES
Tiverton Moorhayes 11kV	YES	YES
Tiverton South 11kV	YES	YES
Tiverton Junction 11kV	NO	YES

3.3.4 SCADA

Minor modifications will be required to the existing SCADA interface to accommodate the relay specific control signals. The existing communications scheme is sufficient but will require the installation of extra wiring.

3.3.5 Auxiliary systems

The existing battery systems at the substation have sufficient spare capacity for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Tiverton BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Tiverton BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

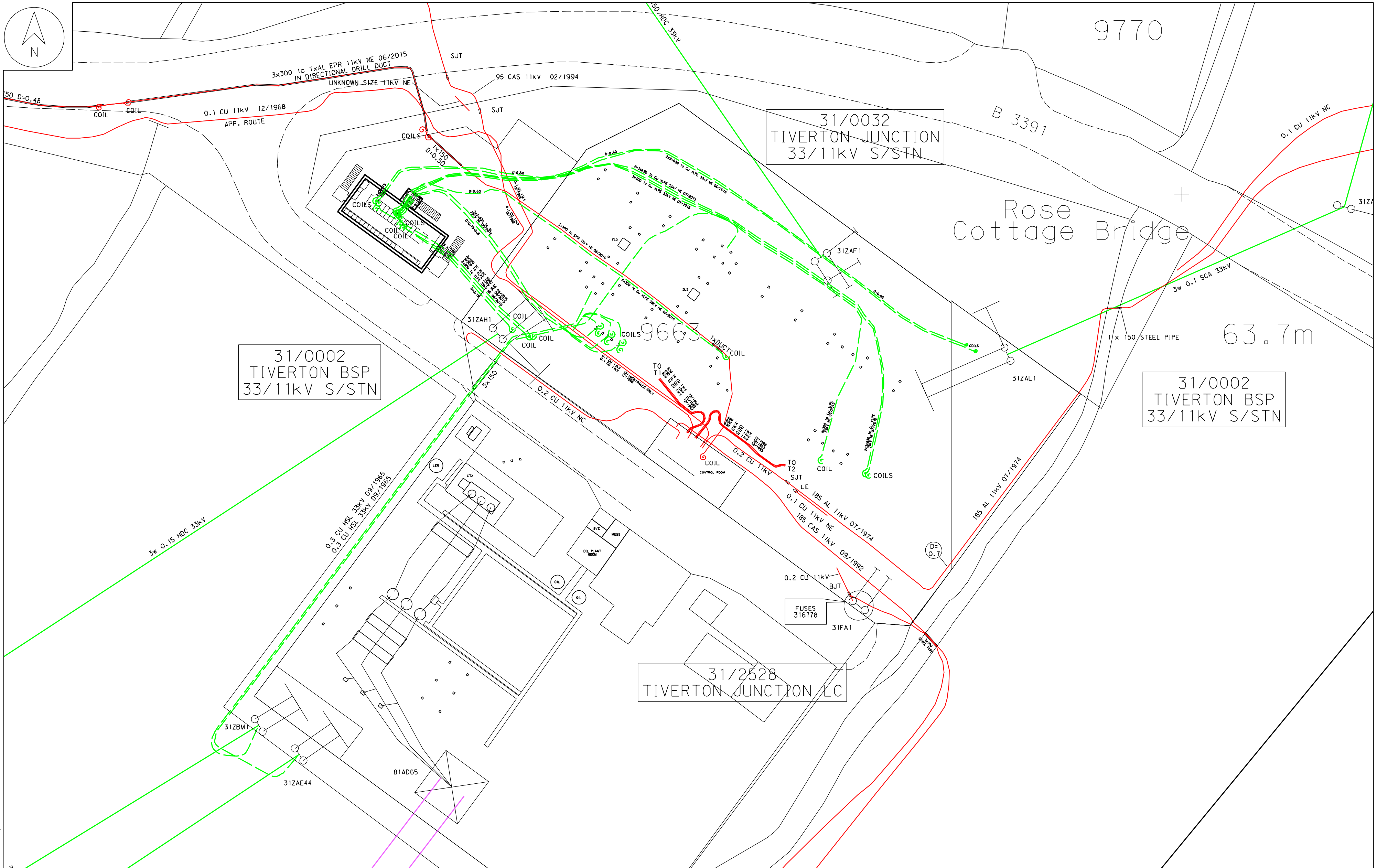
4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

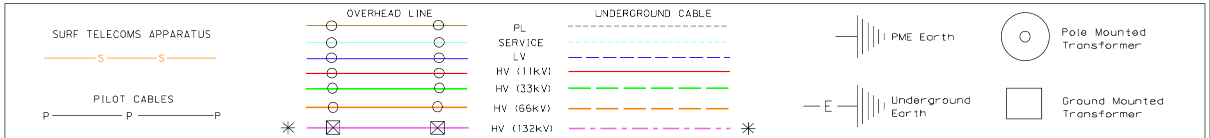
Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
Old transformer degrades at a faster rate due to stricter voltage control requiring more frequent tap changes.	The lifetime of the transformer tap changer reduces.	Aim to install at the sites were the transformers are younger and in better condition. Expect to replace the transformer sooner than anticipated.

APPENDIX A - OVERALL NETWORK DIAGRAM



Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.



✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: TIVERTON
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 302962.075,111630.037

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

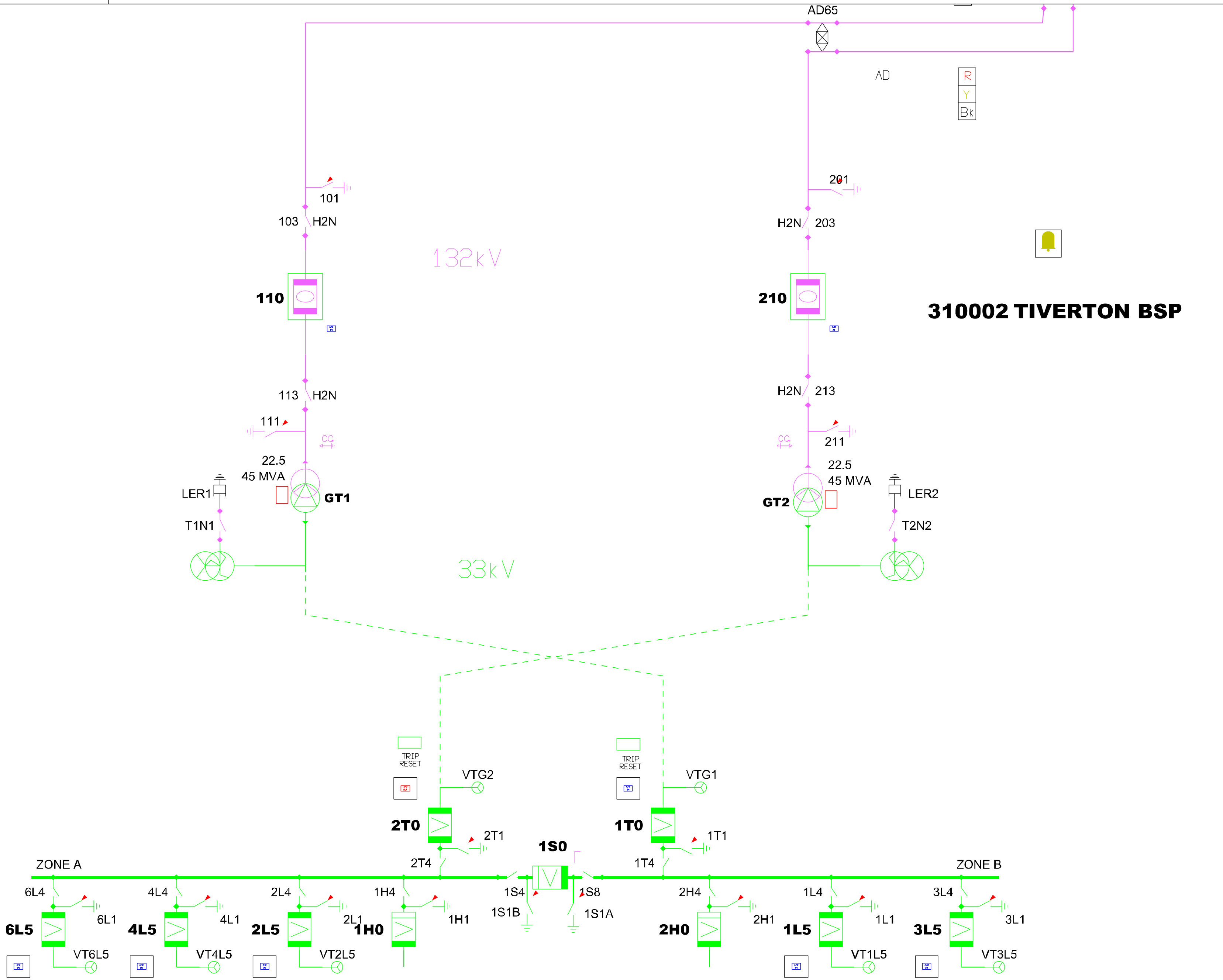
APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.

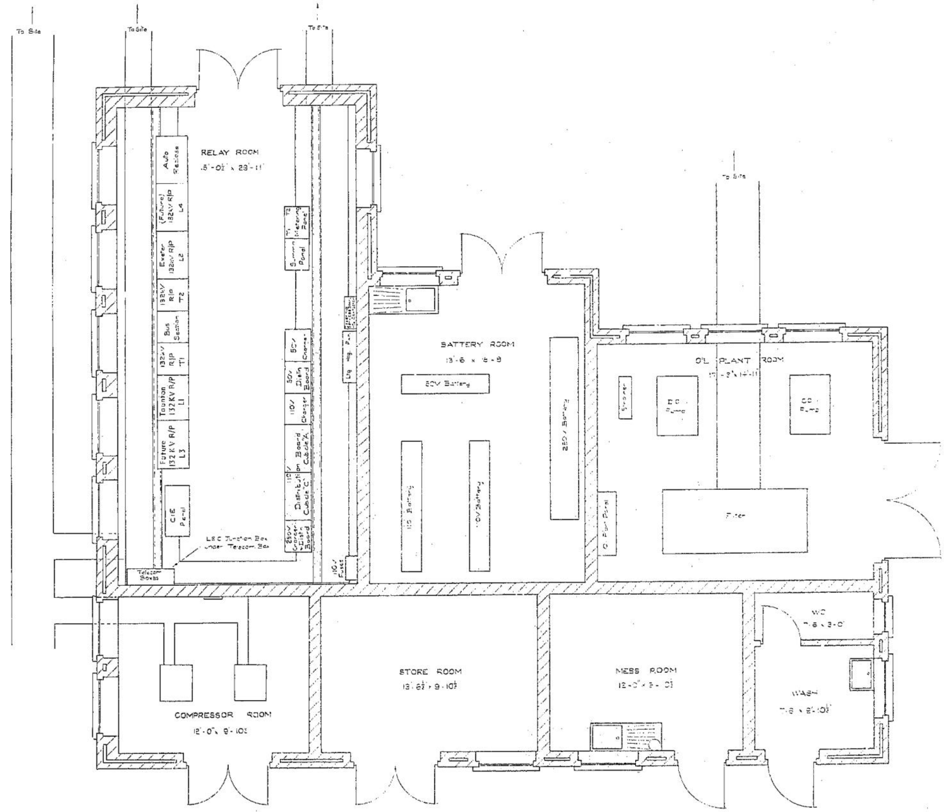
310002 TIVERTON BSP



IMIT
A

APPENDIX C - CONTROL ROOM LAYOUT

THIRD ANGLE PROJECTION



Notes
Oil Plant supplied direct to CEGB
Battery Bds supplied direct to CEGB
L.V.A.C. Bds supplied Switchboard Mfg Co.

Control & Relay Panels A2312478
DAR Panel A231247

A2311883	Layout of Multicore Cables on Site
B3214110	Multicore Estimated Lengths
B3214118	BOM No 6 - Multicore Cables
B3214108	Elevations of 33kV Switchgear
A2311080	Elevations of 132kV Switchgear
A2311879	Plan View of 132/33kV Outdoor Substation
DRAWING REFERENCE	

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ASSOCIATED ELECTRICAL INDUSTRIES LTD.
SWITCHGEAR DIVISION
MANCHESTER 17, ENGLAND.

TRAFFORD PARK
MANCHESTER 17

DRAWN
CH'D
APP'D
PRINTS TO

RELAY & PLANT BUILDING
TIVERTON 132/33kV OUTDOOR SUBSTATION
CONTRACT Nº 4/TRANS/TIVERTON/S23
FOR
C.E.G.B. SOUTH WESTERN REGION

SCALE 3/8" - ONE FOOT | ORDER No CB20058/ | A2311888

REV 1 | REV 2 | REV 3 | REV - | REV 5 Relay Panel Layout Revised due to removal of T.d. Equipment. SWEB MOD 15 (JAC)

A2311888

CONTRACT Nº 4/TRANS/TIVERTON/S23.

T612 -R 21/17194

APPENDIX D - SITE PHOTOS


GRID TRANSFORMER 1


Record all fault-trip operations above
MAINTENANCE DUE - REPORT TO PLANT MAINTENANCE DEPT.
FIGURE NOT TO BE EXCEEDED UNLESS AGREED WITH CONTROL ENGINEER.
OFF
ON
STATUS
O.C.B. OPEN
TRIP RELAY OPERATED
O.C.B. CLOSED
15 MVA TRANSFORMER 2
2HO
SWEDAT
CONTROLLED
EQUIPMENT
HEALTHY TRIP
CIRCUIT BREAKER
FREE
LOCKED
TRIP
CLOSE
REMOTE
SUPV
CB CONTROL
REMOTE / SUPERVISORY
HEALTHY TRIP
R110
R111

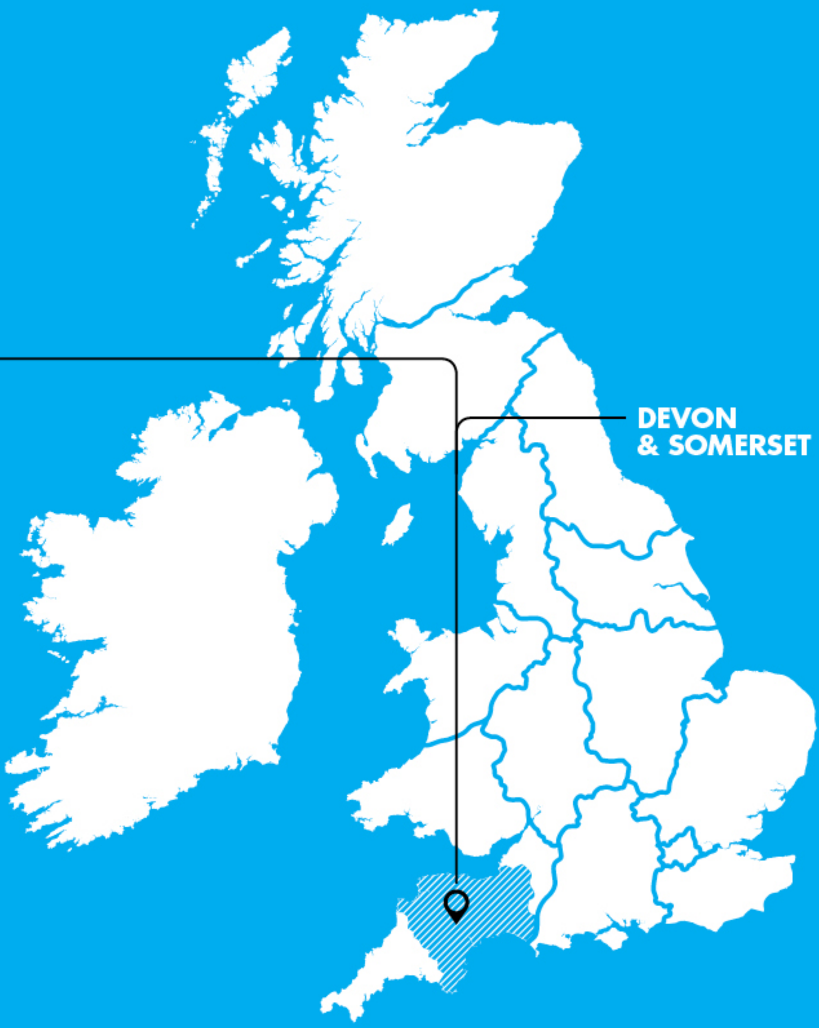

GRID TRANSFORMER 1

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Tiverton Junction 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Tiverton Junction Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

WESTERN POWER DISTRIBUTION (WPD) IN CONFIDENCE
This is an internal WPD document. Recipients may not pass this document to any person outside the organisation without written consent.

1 Introduction

The following report details the findings from the investigation of Tiverton Junction 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Tiverton Junction 33/11kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed from Tiverton BSP. It has two 15/18.75MVA 132/33kV transformers operating with the bus section normally closed. The substation was constructed in the late 1950s with the 11kV switchgear installed in the mid 1970s.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

As part of RIIO-ED1 Investment plans work is currently in progress to install a new 11kV board.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to increase by 1.84MVA over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Tiverton Junction 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Tiverton Junction	33/11kV	0.98	12.16	13.24	13.42	13.85	13.87	14.00	15.24

2.4 Customers

2.4.1 Number of Customers

Tiverton Junction currently supplies 4,700 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

The substation supplies a mainly rural area and therefore the customers are domestic and small industrial.

2.4.3 Generation

The total amount of embedded generation feeding into the Tiverton Junction 11KV network is 7MW. This is supplied by two solar PV sites (5.8MW). A single solar PV site (1.2MW) is committed for future connection. This will increase the embedded generation to 7MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

Both of the 33/11kV transformers at the substation were manufactured in 1956 and had 15 position tap changers installed.

2.5.2 Automatic Voltage Control Relays

The substation currently utilises two GE AVE5 relays for voltage control. These were installed alongside the switchgear in the 1970's.

2.5.3 Auxiliary Systems

The substation has an 110V battery and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Tiverton Junction feeder voltages using WPD IPSA models determined that there is no voltage reduction available at Tiverton Junction whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Tiverton Junction over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

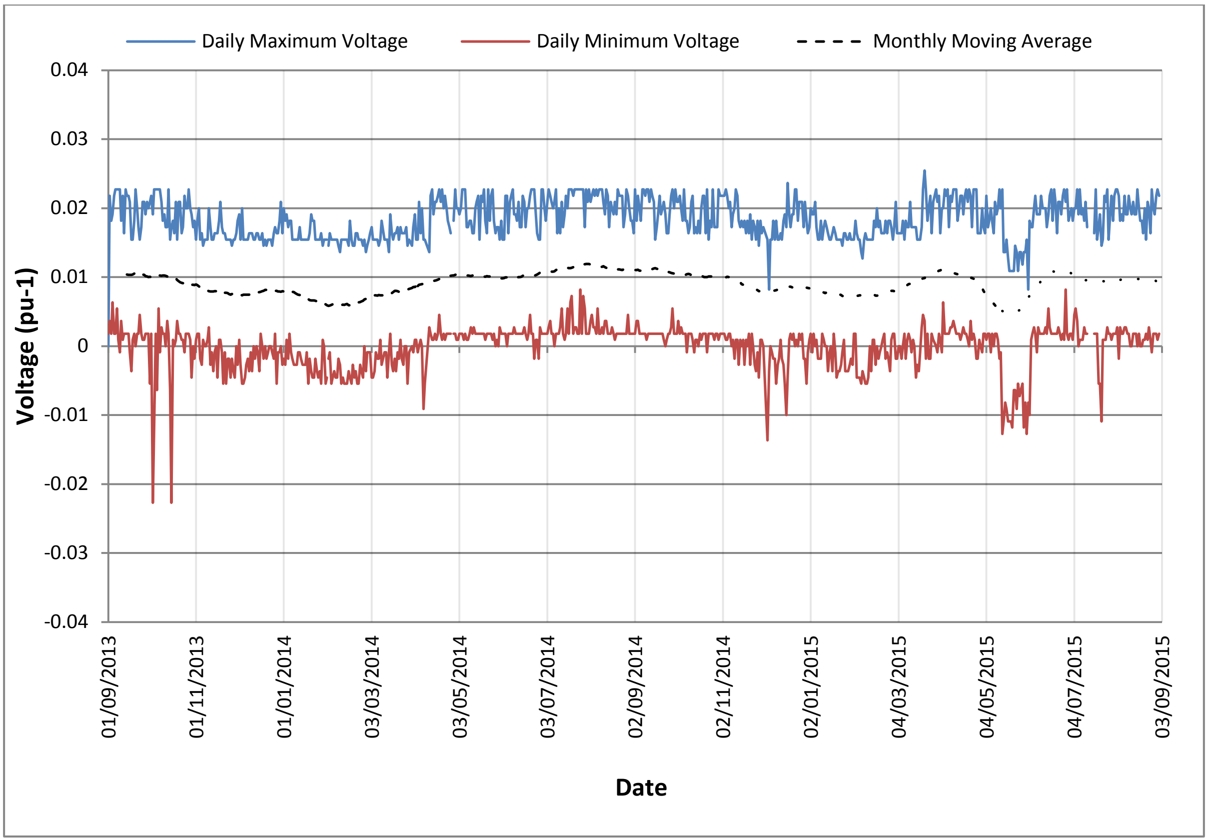


Figure 3-1: Historic voltage profile at Tiverton Junction

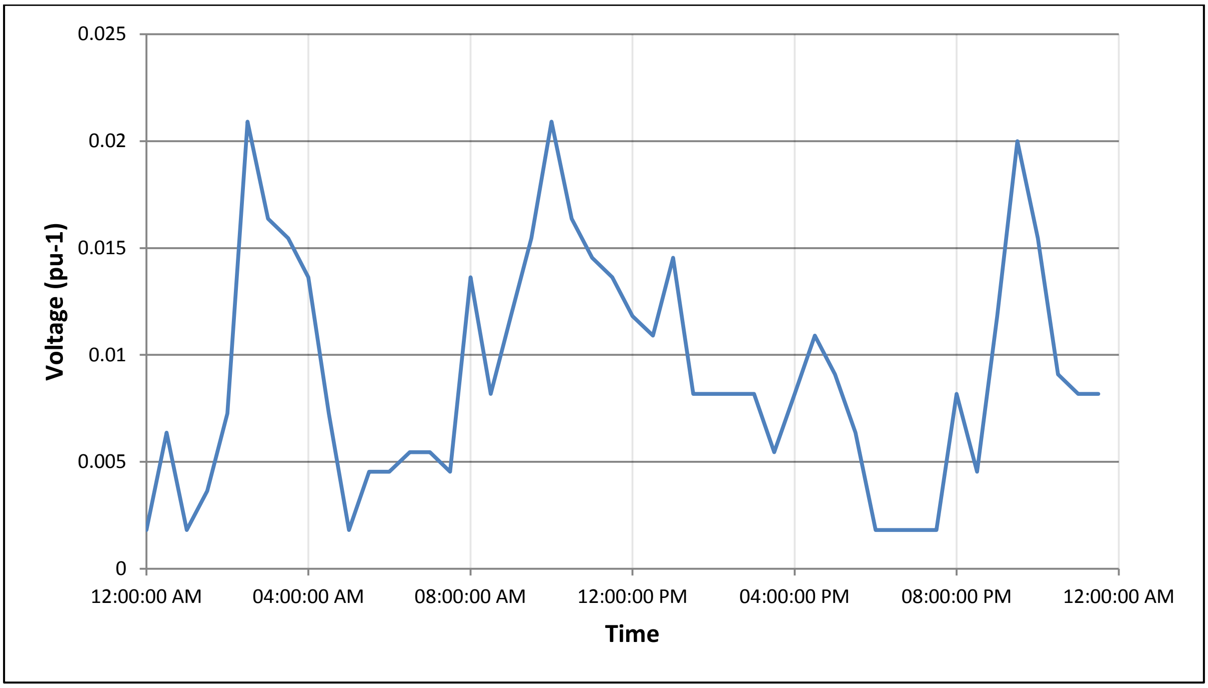


Figure 3-2: 01/06/15 Voltage Profile at Tiverton Junction

3.2.3 Results

The voltage studies have shown that the voltage cannot be reduced below 1pu and remain within statutory limits.

The historical voltage profiles show that the moving average has fluctuated over the two years between 0.005pu and 0.012pu with an average of 0.009pu. The daily fluctuations in voltage are roughly constant with an average of 0.019pu.

With the substation operating at around 0.01pu above nominal it may be possible to achieve some voltage reduction.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Tiverton Junction the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

Due to the complexity of change from mechanical to numerical relays, it is proposed to install a new AVC panel at this substation. This would require the removal of now redundant equipment still inside the 11kV switchroom.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, six potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

The change from mechanical to numerical relays for voltage control will require a large number of new interfaces. The existing SCADA equipment has capacity to accept new signals, however wiring and communications cards will be required.

3.3.5 Auxiliary systems

The existing substation auxiliary systems are suitable for any modifications required to operate new equipment for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Tiverton Junction. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Tiverton Junction will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

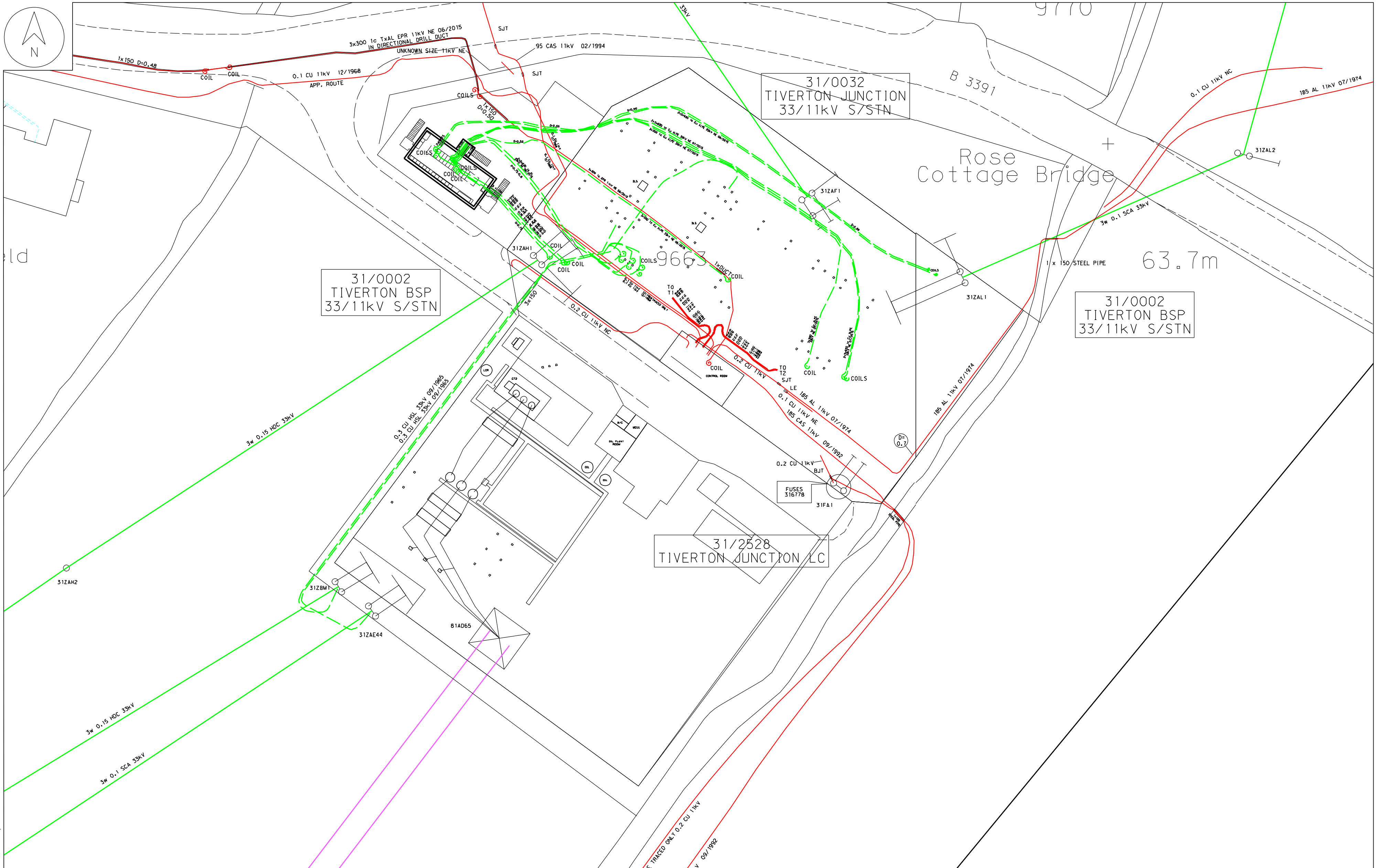
Table 4-1: Site specific risks

Risk	Effect	Action
Asbestos in the fuse casing can release dust particles if moved.	If inhaled asbestos can cause harm/injury.	Carry out an asbestos survey. Hire a specialist to remove the asbestos if it is found.
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
The old transformer and the new relay may not be compatible.	This may restrict the level of control that can be applied	Check the functionality of the transformer before choosing the relay to be used. Select an alternative site if necessary.
Old transformer degrades at a faster rate due to stricter voltage control requiring more frequent tap changes.	The lifetime of the tap changer reduces.	Aim to install at the sites were the transformers are younger and in better condition. Expect to replace the transformer sooner than anticipated.
The space allocated for a new panel is taken up by other equipment.	No room for the panel, the design needs to be redrawn.	Communication is required once the approved designs are in place to agree what the space is reserved for.

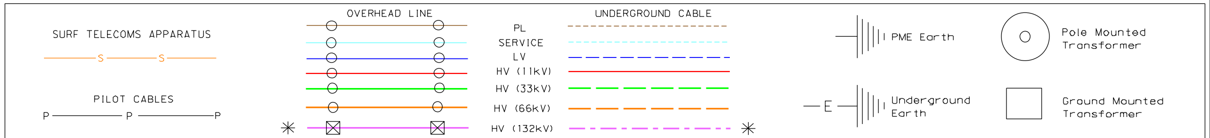
APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.



✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: TIVERTON JUNCTION
DRAWN BY: S. SHIANGOLI
DATE: 14/01/2016
SCALE 1:600 @ A3
PLOT CENTRE: 302960.314,111614.187

WESTERN POWER DISTRIBUTION
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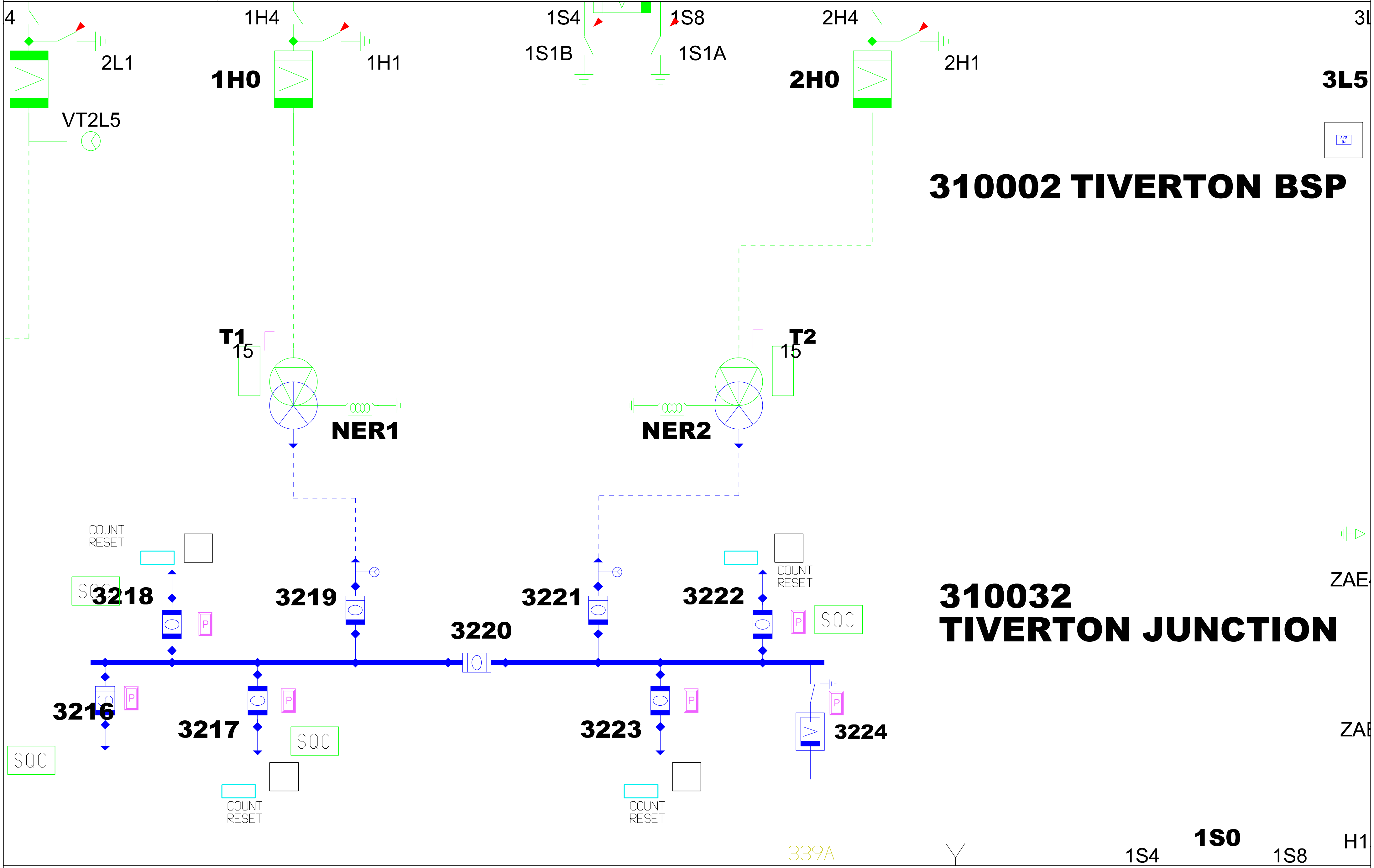
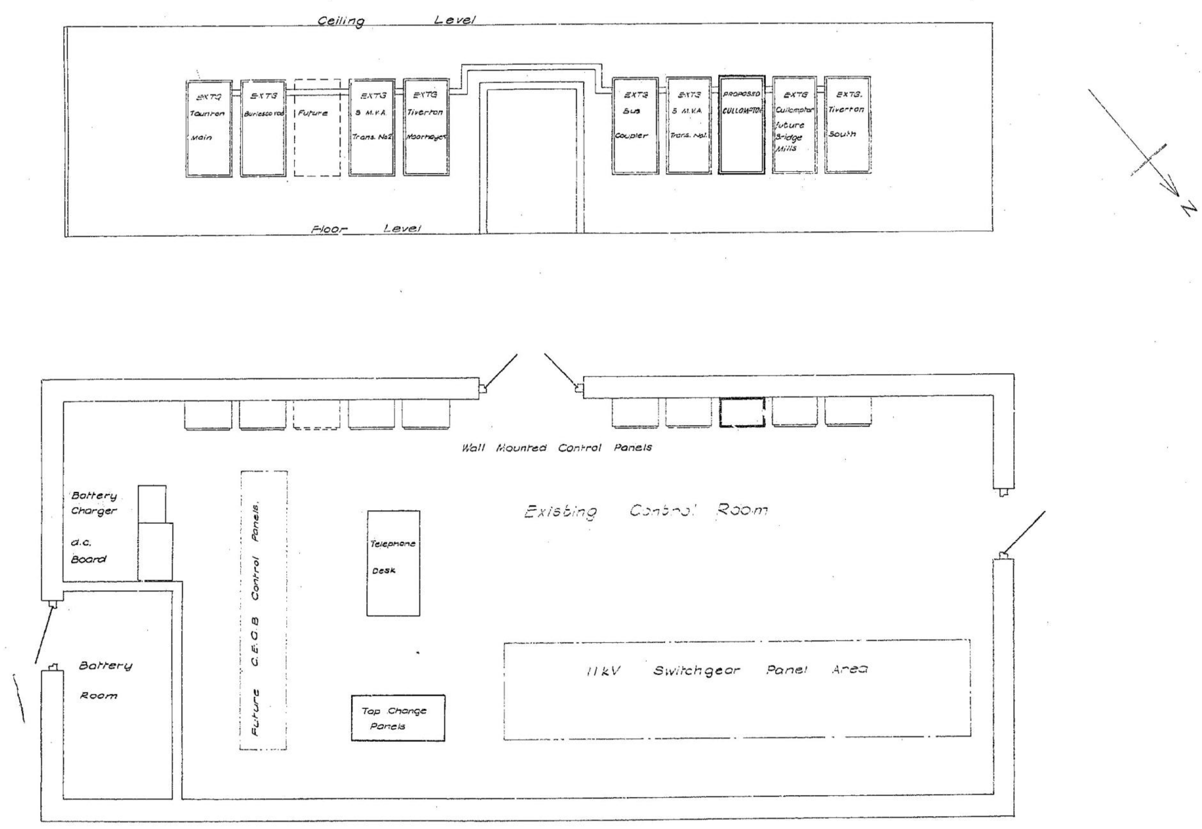
APPENDIX B - SINGLE LINE DIAGRAM


4
1H4
1S4
1S8
2H4
3L
2L1
1H1
1S1B
1S1A
2H1
1H0
2H0
3L5
VT2L5
310002 TIVERTON BSP
T1
15
T2
15
NER1
NER2
COUNT RESET
3218
3219
3220
3221
3222
COUNT RESET
SQC
ZAE
310032
TIVERTON JUNCTION
3216
3217
SQC
3223
3224
ZAE
SQC
COUNT RESET
COUNT RESET
339A
1S0
1S4
1S8
H1

APPENDIX C - CONTROL ROOM LAYOUT

TIVERTON JUNCTION BSP PANEL LAYOUT IN CONTROL ROOM 03/45/1096



T545-R

SCALE: $\frac{1}{8}$" to 1'-0"	DATE	SOUTH WESTERN ELECTRICITY BOARD AREA HEADQUARTERS, BRISTOL
DRAWN:	12-3-64	TITLE TIVERTON JUNCTION B.S.P.
CHECKED:	16-4-64	Proposed Cullompton Feeder Bay
APPROVED: R.O.	17-4-64	Proposed Panel Layout in Control Room.

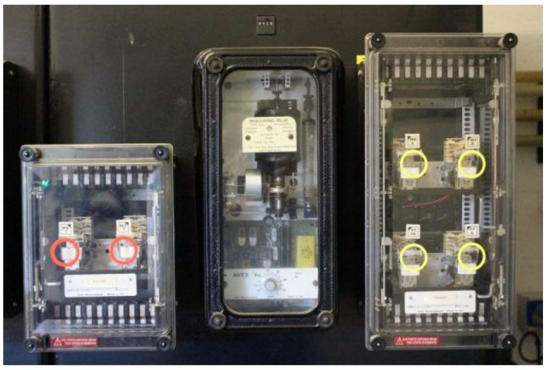
DRAWING NUMBER 03/45/1096

No.	REVISION	SIG./DATE	No.	REVISION	SIG./DATE
			1	Proposed Bridge Mills Fdr. Bay	

APPENDIX D - SITE PHOTOS


15 MVA 33/11KV
TRANSFORMER Nº1
15 MVA 33/11KV
TRANSFORMER Nº2


AVE 5
Made in UK



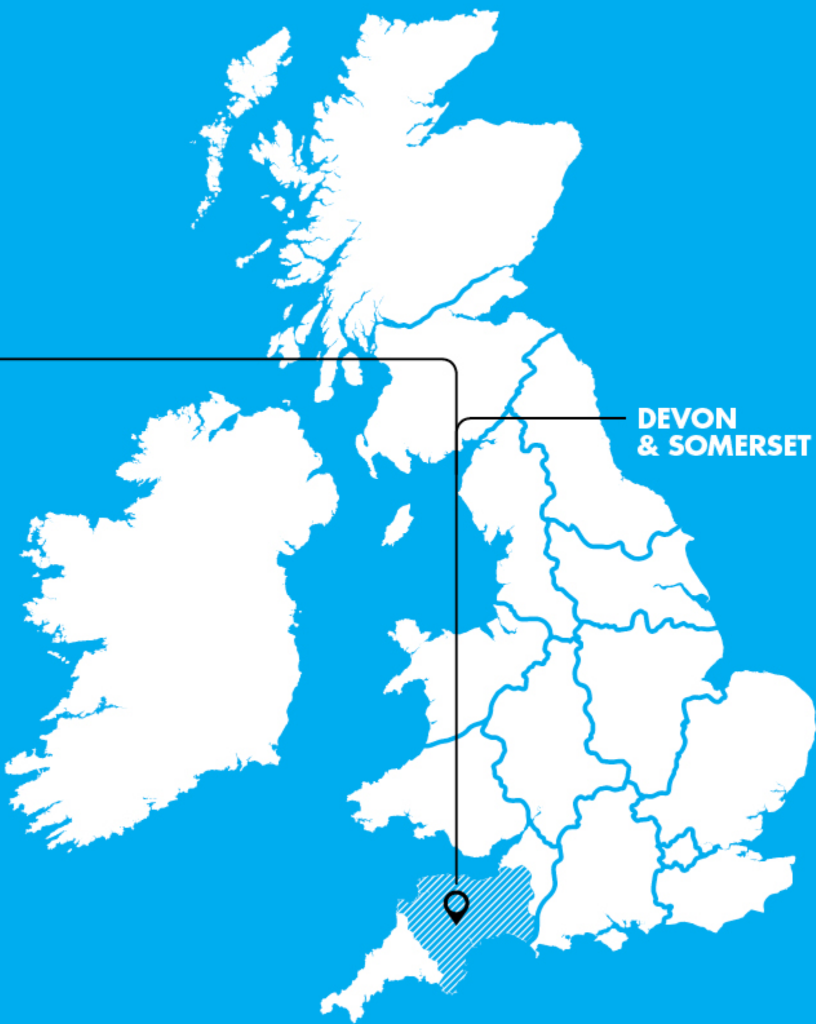

GRID TRANSFORMER 2
CAUTION! Fuse carriers on this panel may contain asbestos. Please refer to Asbestos File for safe working procedure.

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Tiverton Moorhayes 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Tiverton Moorhayes Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	S Shiangoli	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

WESTERN POWER DISTRIBUTION (WPD) IN CONFIDENCE
This is an internal WPD document. Recipients may not pass this document to any person outside the organisation without written consent.

1 Introduction

The following report details the findings from the investigation of Tiverton Moorhayes 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Tiverton Moorhayes 33/11kV substation belongs to the Abham-Exeter-Landulph Grid Group and is normally fed via two 33kV circuits from Tiverton BSP. It has two 7.5/15MVA transformers operating with the bus section normally closed. The transformers and switchgear were both replaced in 2006.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

As part of RIIO-ED1 Investment plans modifications are currently being carried out on the incoming 33kV circuits.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to decrease by 0.16MVA over the next five years.

Table 2-1: Load forecast for Tiverton Moorhayes 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Tiverton Moorhayes	33/11	0.98	6.68	6.55	6.48	6.43	6.44	6.52	14

2.4 Customers

2.4.1 Number of Customers

Tiverton Moorhayes currently supplies 5,600 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

The substation is the main supply point for Tiverton Town therefore the primary loads are domestic with some industrial and commercial loads.

2.4.3 Generation

The total amount of embedded generation feeding into the Tiverton Moorhayes 11KV network is 2.66MW. This is supplied by two solar PV sites. There are currently no connections committed for in the future above 1MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

Both of the 7.5/15MVA transformers at the substation were manufactured in 2005 by Brush Transformers. Both transformers have 17 position AT 317 44/300L tap changers installed.

2.5.2 Automatic Voltage Control Relays

Tiverton Moorhayes currently utilises two KVGC202 relays for Voltage Control of its transformers. The existing scheme was installed in 2006 alongside the replacement of the transformers.

2.5.3 Auxiliary Systems

The substation has an 110V battery supply and D20 SCADA system, installed in 2006 in conjunction with the change in switchgear.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Tiverton Moorhayes feeder voltages using WPD IPSA models determined that there is no voltage reduction available at Tiverton Moorhayes whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Tiverton Moorhayes over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

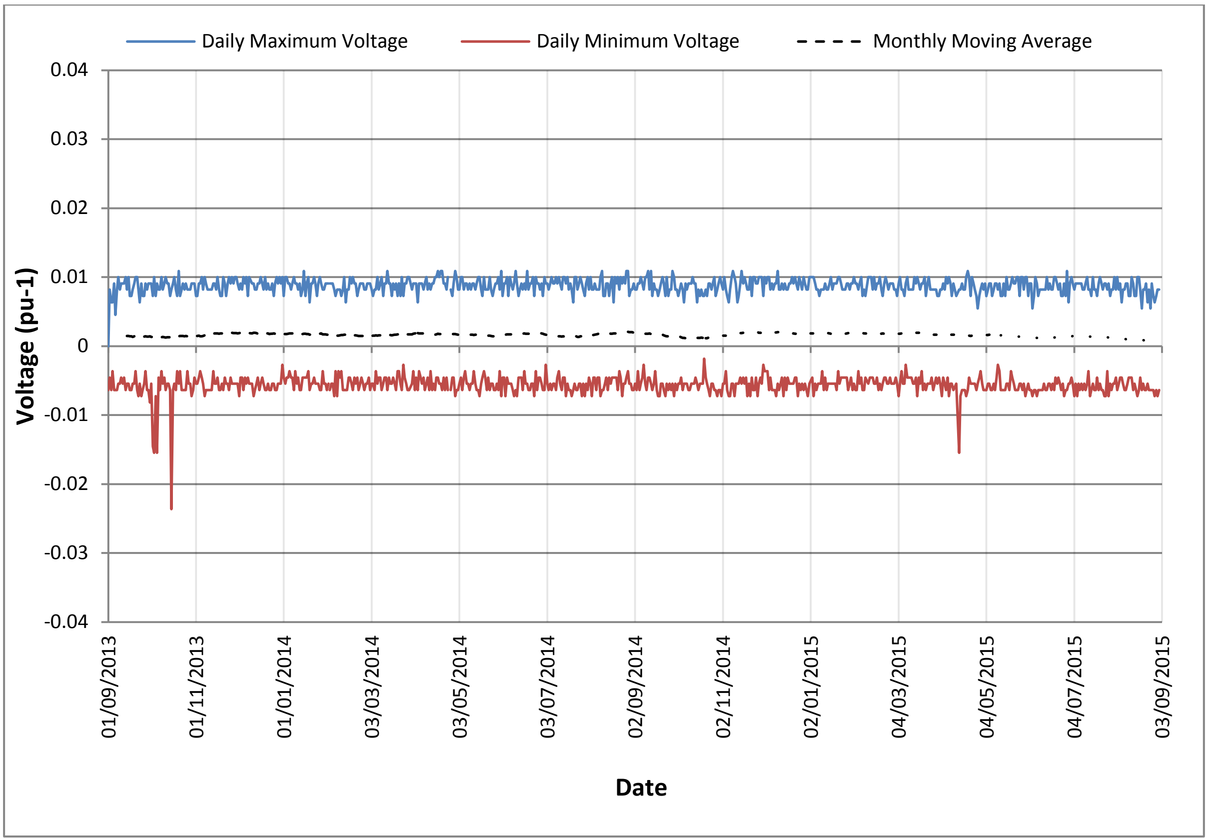


Figure 3-1: Historic voltage profile at Tiverton Moorhayes

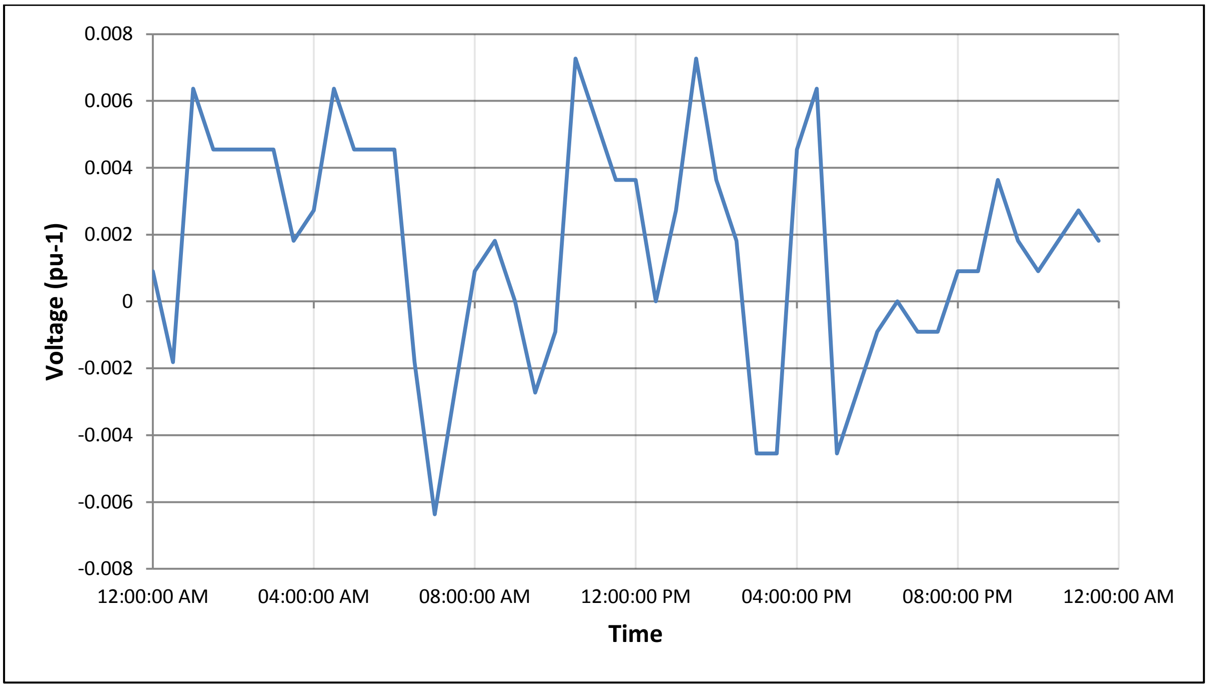


Figure 3-2: 01/06/15 Voltage profile at Tiverton Moorhayes

3.2.3 Results

The voltage studies have shown that the voltage cannot be reduced below 1pu and remain within statutory limits.

The historical voltage profiles show that the moving average has remained roughly constant over the two years at 0.0016pu. The daily fluctuations in voltage are approximately constant at an average of 0.014pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Tiverton Moorhayes the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

The existing AVC panel has room available for a new relay once the existing relay is removed. The panel wiring will require replacement due to the change in relay type and additional controls.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, six potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable the full operational capability required for the SVO.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Tiverton Moorhayes. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Tiverton Moorhayes will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

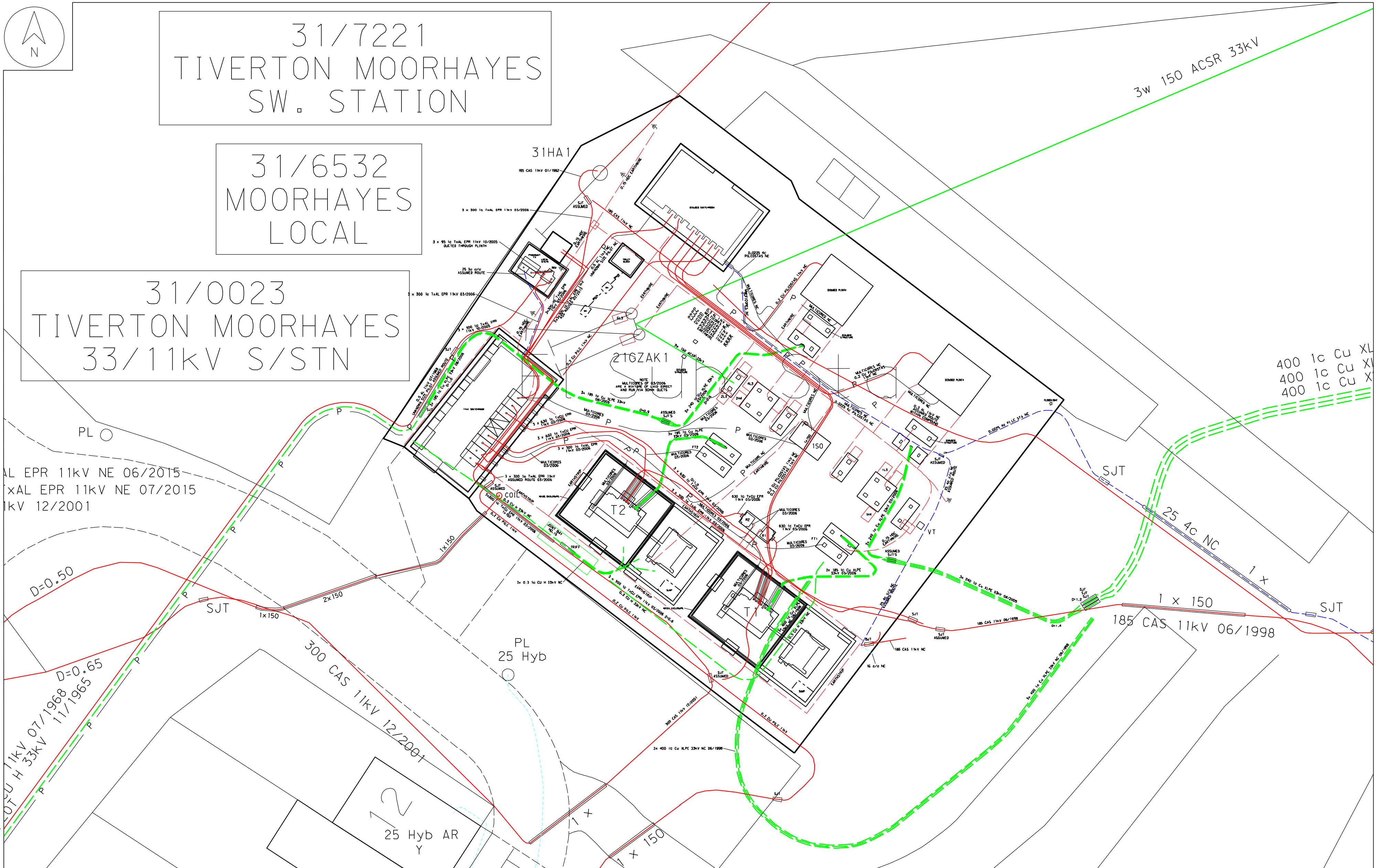
Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
If in doubt, contact your local WPD office.

Information is given as a guide only and it's accuracy cannot be guaranteed.



PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS	OVERHEAD LINE		UNDERGROUND CABLE		
——S——S——		PL		PME Earth	Pole Mounted Transformer
		SERVICE			
PILOT CABLES		LV		Underground Earth	Ground Mounted Transformer
P——P——P		HV (11kV)			
		HV (33kV)			
		HV (66kV)			
	*	HV (132kV)	*		

* ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: TIVERTON MOORHAYES
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:250 @ A3
PLOT CENTRE: 296053.733,114089.984

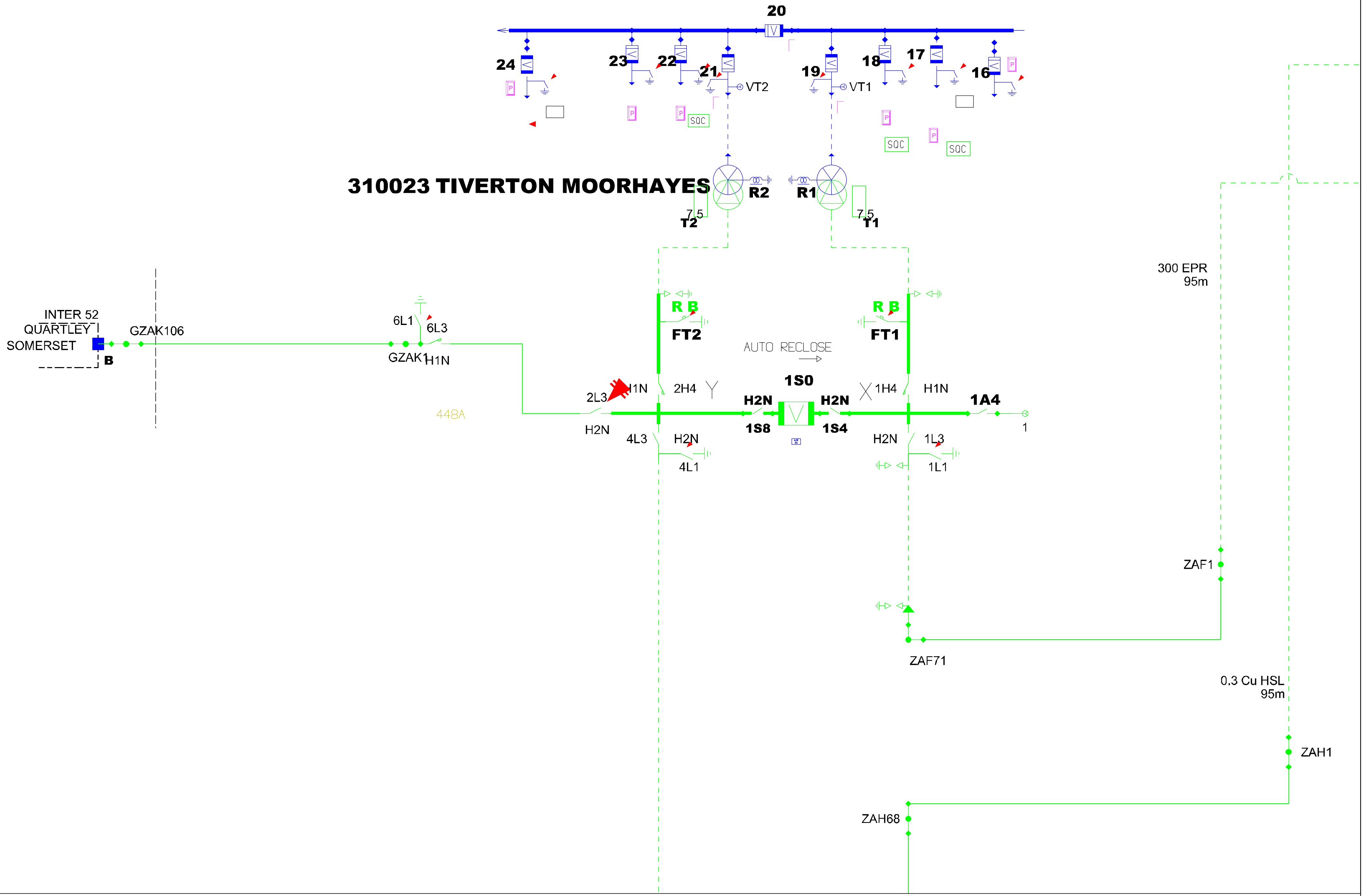
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

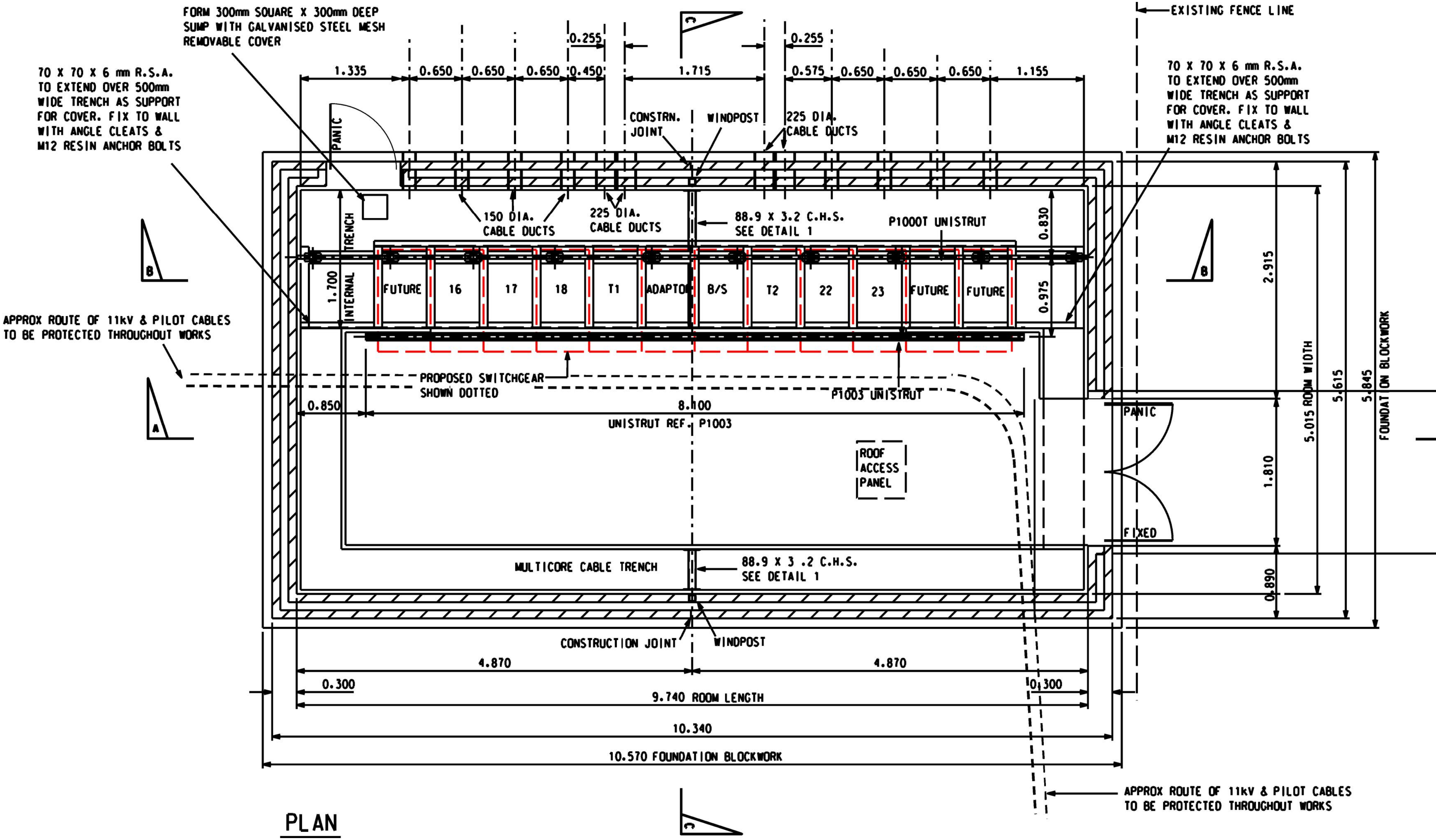
WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



Tiles: 285, 298 Date: 13/01/2016 FOR INTERNAL USE ONLY *A3*

APPENDIX C - CONTROL ROOM LAYOUT



FORM 300mm SQUARE X 300mm DEEP SUMP WITH GALVANISED STEEL MESH REMOVABLE COVER
70 X 70 X 6 mm R.S.A. TO EXTEND OVER 500mm WIDE TRENCH AS SUPPORT FOR COVER. FIX TO WALL WITH ANGLE CLEATS & M12 RESIN ANCHOR BOLTS
EXISTING FENCE LINE
70 X 70 X 6 mm R.S.A. TO EXTEND OVER 500mm WIDE TRENCH AS SUPPORT FOR COVER. FIX TO WALL WITH ANGLE CLEATS & M12 RESIN ANCHOR BOLTS
0.255
0.255
1.335
0.650
0.650
0.650
0.450
1.715
0.575
0.650
0.650
0.650
1.155
PANIC
CONSTRN. JOINT
WINDPOST
225 DIA. CABLE DUCTS
150 DIA. CABLE DUCTS
225 DIA. CABLE DUCTS
88.9 X 3.2 C.H.S. SEE DETAIL 1
P1000T UNISTRUT
0.830
0.975
INTERNAL TRENCH
1.700
FUTURE
16
17
18
T1
ADAPTOR
B/S
T2
22
23
FUTURE
FUTURE
B
B
A
C
C
APPROX ROUTE OF 11kV & PILOT CABLES TO BE PROTECTED THROUGHOUT WORKS
PROPOSED SWITCHGEAR SHOWN DOTTED
P1003 UNISTRUT
0.850
8.100
UNISTRUT REF. P1003
ROOF ACCESS PANEL
PANIC
FIXED
2.915
1.810
0.890
5.015 ROOM WIDTH
5.615
5.845 FOUNDATION BLOCKWORK
MULTICORE CABLE TRENCH
88.9 X 3 .2 C.H.S. SEE DETAIL 1
CONSTRUCTION JOINT
WINDPOST
4.870
4.870
0.300
0.300
9.740 ROOM LENGTH
10.340
10.570 FOUNDATION BLOCKWORK
APPROX ROUTE OF 11kV & PILOT CABLES TO BE PROTECTED THROUGHOUT WORKS

PLAN

APPENDIX D - SITE PHOTOS


33/11kV TRANSFORMER No.1
33/11kV TRANSFORMER No.2


33/11kV TRANSFORMER No.1
TAP POSITION INDICATOR
kV

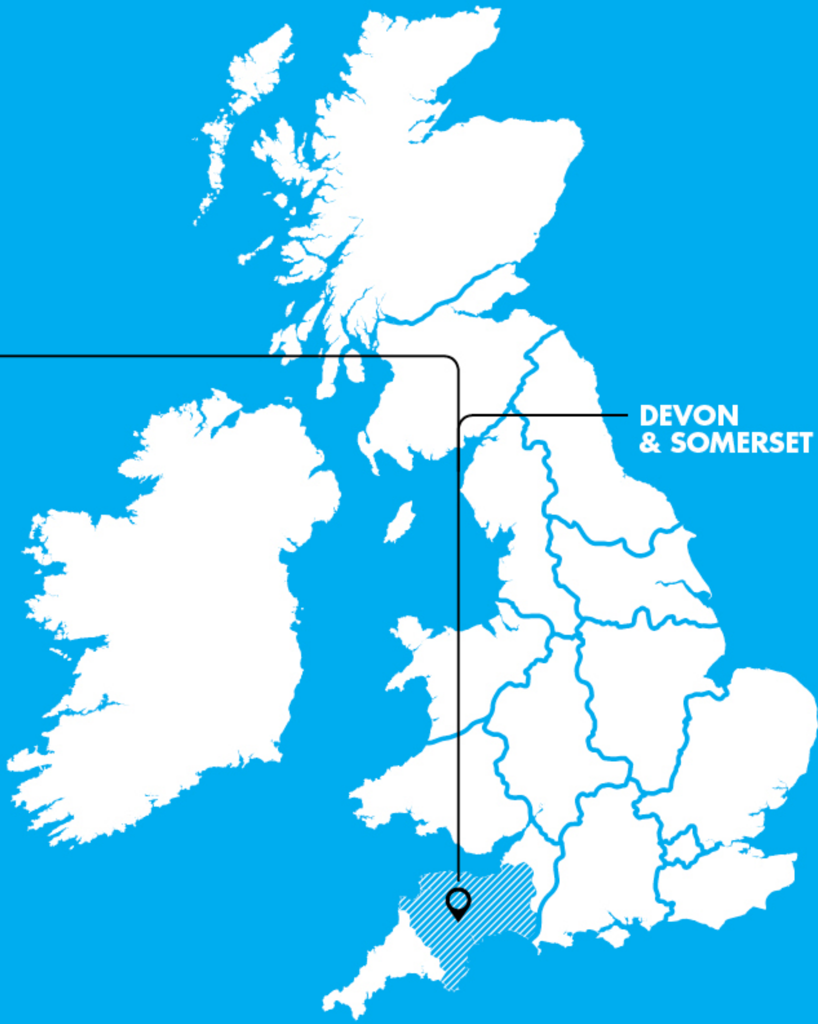

T1

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Totnes 132/33kV BSP



LCN Fund
Low Carbon Networks

Report Title	:	Totnes Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control		
	Name	Date
Prepared by:	P Edwards	08.02.2016
Reviewed by:	J Berry	15.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History		
Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Totnes 132/33kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Totnes 132/33kV substation belongs to the Abham, Exeter and Landulph Grid Group and is normally fed via two 132kV circuits from Abham GSP. It has two 22.5/45MVA 132/33kV transformers operating with the bus section normally closed.

The control, single line and EMU diagrams are provided in Appendices A-C of this report.

2.2 Investment under RIIO-ED1

As part of RIIO-ED1 Investment plans the 132kV Circuit Breaker will be replaced in 2017.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to increase by 1.2MVA over the next five years. However, the firm capacity will not be reached.

Table 2-1: Load forecast for Totnes 132/33kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Totnes	132/33	0.96	45.76	45.84	45.96	46.10	46.45	46.96	50.29

2.4 Customers

2.4.1 Number of Customers

Totnes BSP supplies seven primary substations with a total of 36,400 customers supplied.

2.4.2 Type of Loads

The primary substations supplied from Totnes are mainly located in rural areas with a domestic and light industrial load. None of the customers are specified as being voltage sensitive.

2.4.3 Generation

The total amount of embedded generation feeding into the Totnes network is 36.17MW all of which is connected to the 33kV network. All generation is provided by six solar PV sites with another three solar PV sites committed for future connection adding a further 17.76MW of generation. This will give a total generation on the Totnes BSP network of 53.93MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

The first transformer GT1 was manufactured by Yorkshire electric and commissioned in 1961. The second transformer GT2 was manufactured by Crompton Parkinson and commissioned in 1965.

2.5.2 Automatic Voltage Control Relays

The substation currently utilises two GE AVE5 relays for voltage control.

2.5.3 Auxiliary Systems

The substation has an 110V battery system and a D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

The feeder voltages calculated through PSS/E studies are shown in Table 3-1 below with the maximum and minimum voltages across the whole network highlighted in bold.

Table 3-1: Totnes Feeder voltage analysis

Feeder	Feeder Max Voltage (pu)	Feeder Min Voltage (pu)
1	1.030	0.999
2	1.031	0.983
3	1.041	0.969
4	1.039	**0.966**
5	1.019	0.974
6	1.030	0.999
7	**1.046**	0.994

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Totnes BSP over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

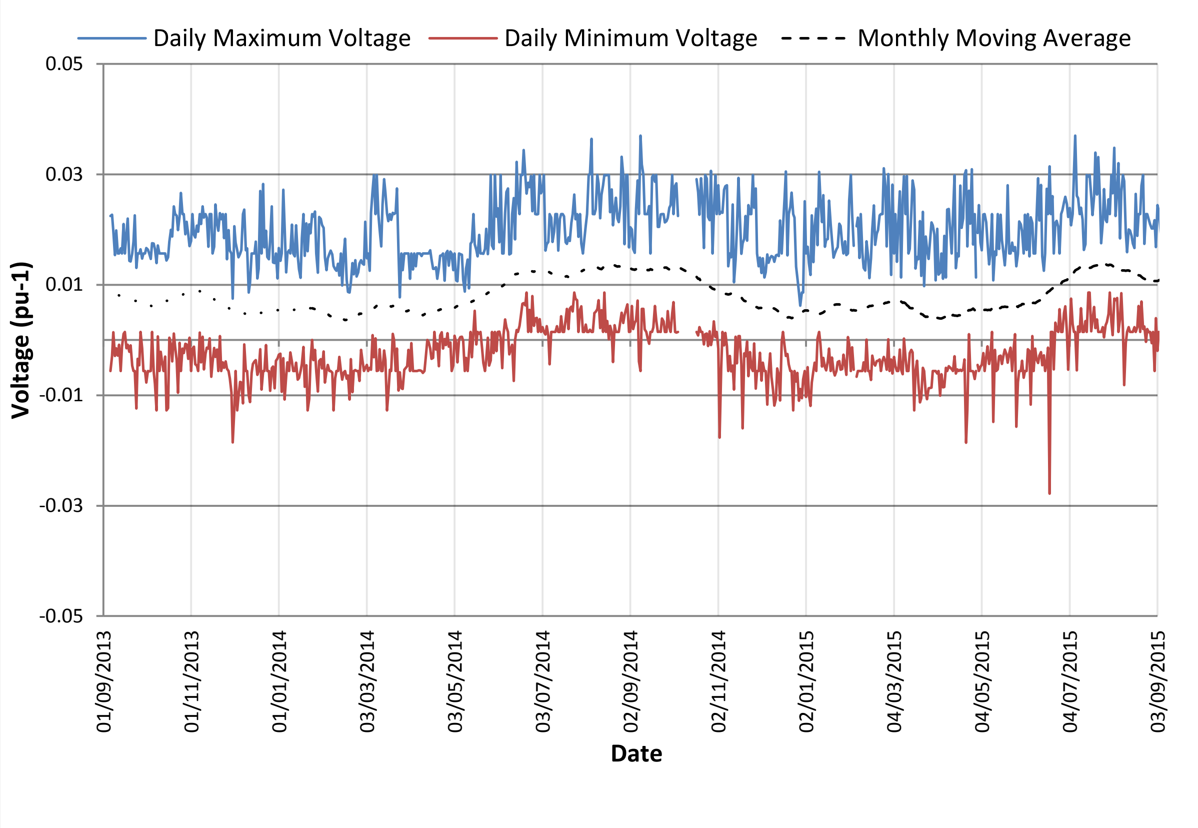


Figure 3-1: Historic voltage profile of Totnes

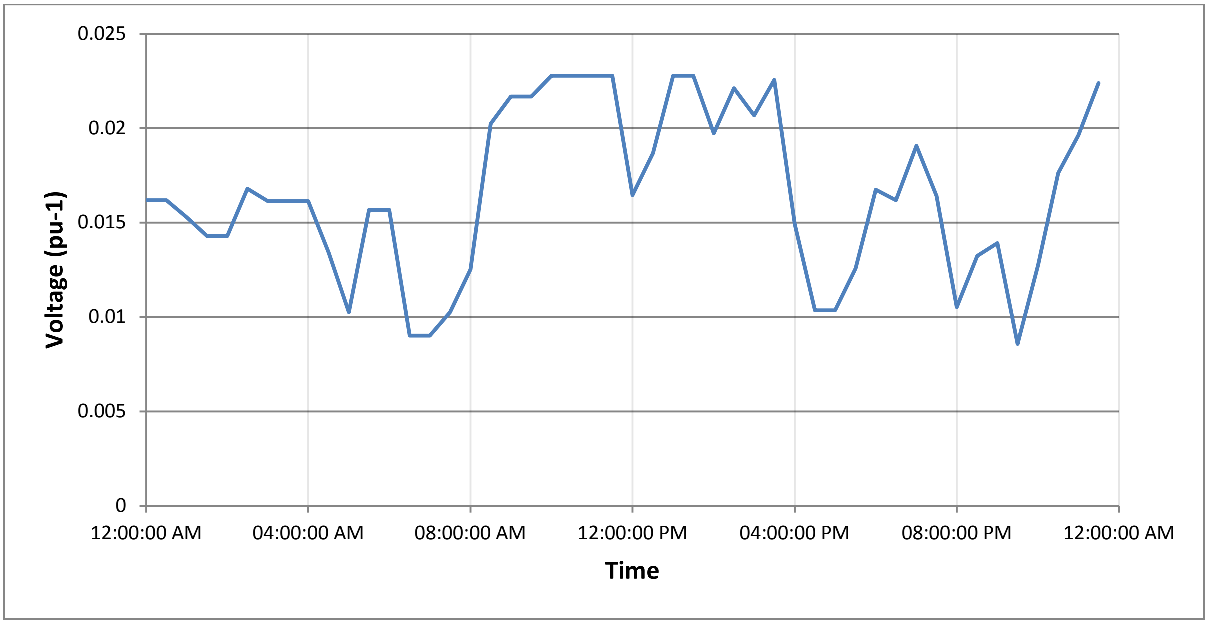


Figure 3-2: 01/08/15 Voltage profile of Totnes

3.2.3 Results

The study results show that for Totnes BSP, the voltage can be reduced by 0.026pu and still keep all parts of the 33kV network within statutory limits. It is possible to increase the voltage by 0.014pu and be within the statutory limits.

The historical voltage profiles show the moving average has fluctuated between 0.003pu and 0.014pu with an average of 0.008pu above nominal. These fluctuations are caused by the use of a mechanical relay. The daily fluctuations in voltage on average have been at 0.022pu.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

The existing AVC relays are not suitable for use with the SVO method. In order for the SVO method to be applied at Totnes BSP the relays must be replaced with one of the recommended relays.

3.3.2 AVC Panel

Due to the complexity of change from mechanical to numerical relays, it is proposed to install a new AVC panel at this substation. This will require new multicore cables to be run between the transformer and new panel.

3.3.3 Monitors

The following existing measurement points can be utilised by the SVO method for verification purposes.

Table 3-2: Totnes Feeder measurement locations

Totnes BSP Feeder Measurement Locations	33 kV VT	11 kV VT
Ashburton 11kV	NO	YES
Buckfastleigh 11kV	YES	YES
Kingsbridge 11kV	NO	YES
Marldon 11kV	NO	YES
Salcombe 11kV	YES	YES
South Brent 11kV	NO	YES
Totnes 11kV	NO	YES

3.3.4 SCADA

The change from mechanical to numerical relays for voltage control will require a large number of new interfaces. The existing SCADA equipment has capacity to accept new signals, however wiring and communications cards will be required.

3.3.5 Auxiliary systems

The existing auxiliary systems at the substation are sufficient for any new equipment installed for the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Totnes BSP. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Totnes BSP will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Asbestos in the fuse casing can release dust particles if moved.	If inhaled asbestos can cause illnesses.	Carry out an asbestos survey. Hire a specialist to remove the asbestos if it is found.
Second transformer trips when working on the other transformer.	Customers lose supply. Fines may be incurred depending on the outage time.	Consider surveying the overhead line. Stage the work to meet the Emergency Return To Service (ERTS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.
The old transformer and the new relay may not be compatible.	This may restrict the level of control that can be applied	Check the functionality of the transformer before choosing the relay to be used. Select an alternative site if necessary.
Old transformer degrades at a faster rate due to stricter voltage control requiring more frequent tap changes.	The lifetime of the transformer tap changer reduces.	Aim to install at the sites were the transformers are younger and in better condition. Expect to replace the transformer sooner than anticipated.
The space allocated for a new panel is taken up by other equipment.	No room for the panel, the design needs to be redrawn.	Communication is required once the approved designs are in place to agree what the space is reserved for.

APPENDIX A - OVERALL NETWORK DIAGRAM

CARE SHOULD BE EXERCISED TO ENSURE THE PRECISE POSITION OF THE WPD APPARATUS IF WORK IS TO BE EXECUTED IN ITS VICINITY.
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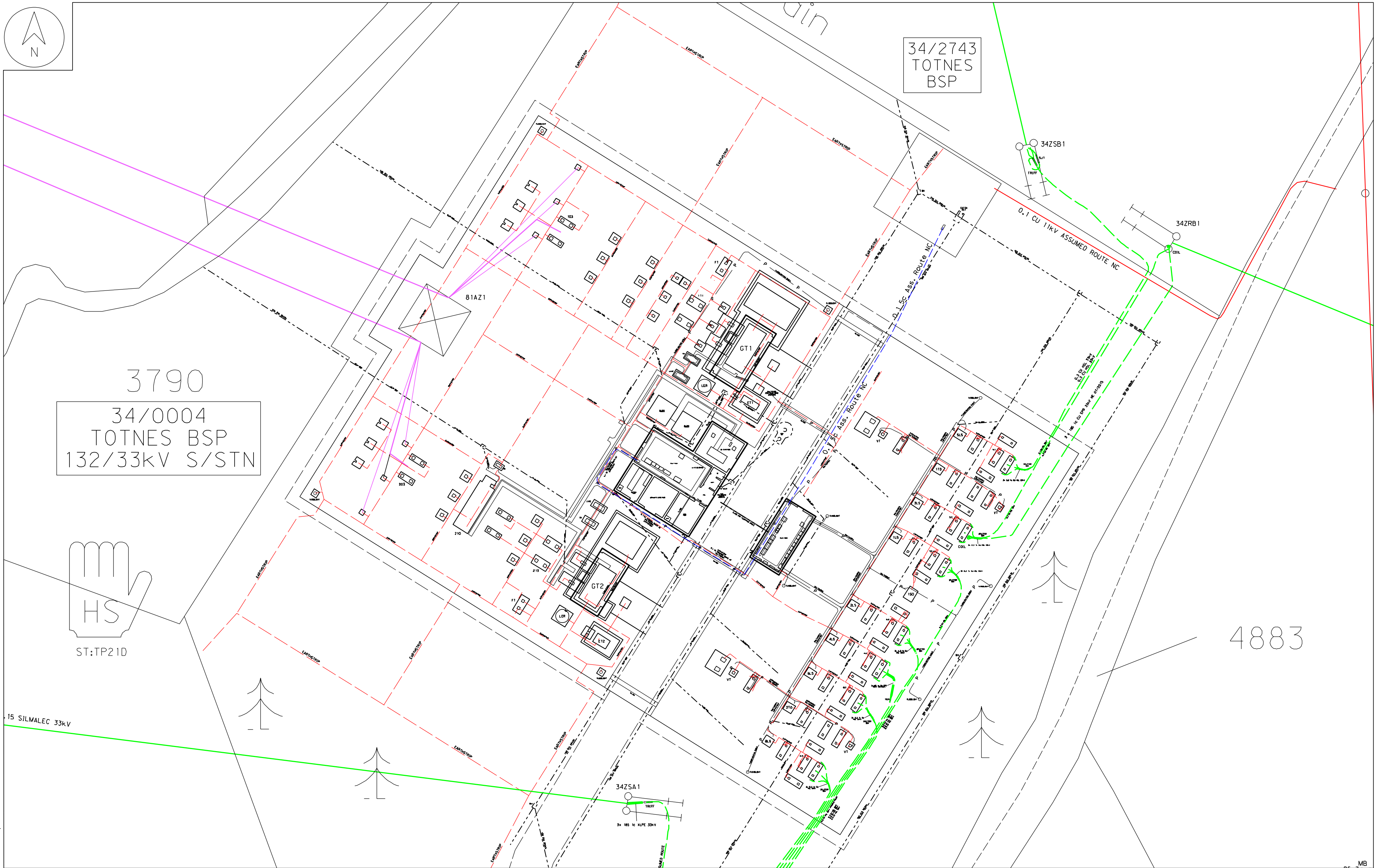


Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution.
Electricity assets owned by IDNO's (Independent Network Operators)
MAY be present in this area.

SURF TELECOMS APPARATUS
PILOT CABLES
OVERHEAD LINE
UNDERGROUND CABLE
PL
SERVICE
LV
HV (11kV)
HV (33kV)
HV (66kV)
HV (132kV)
PME Earth
Underground Earth
Pole Mounted Transformer
Ground Mounted Transformer

✳ ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: TOTNES
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:500 @ A3
PLOT CENTRE: 277434.061,061881.099

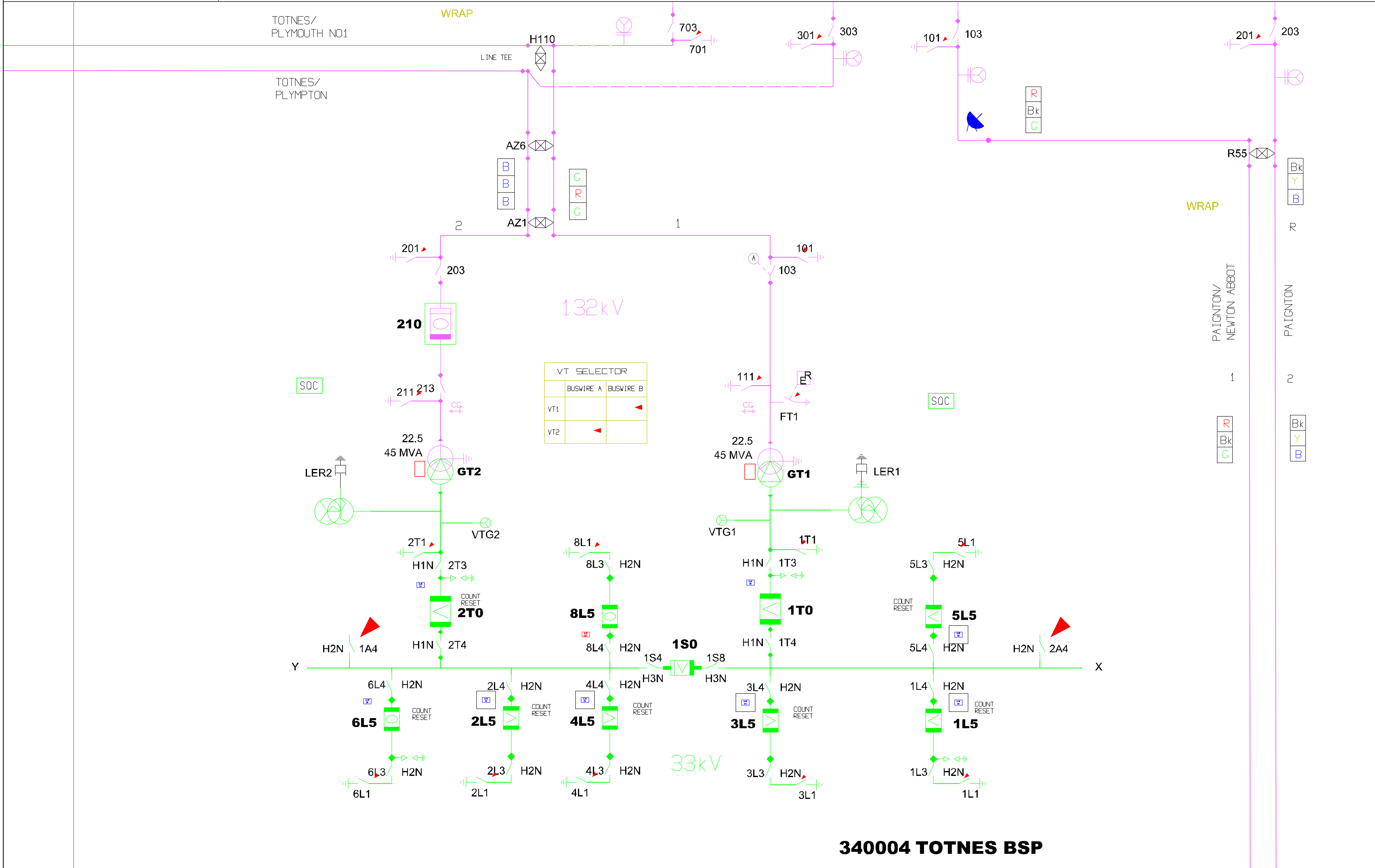
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



340004 TOTNES BSP

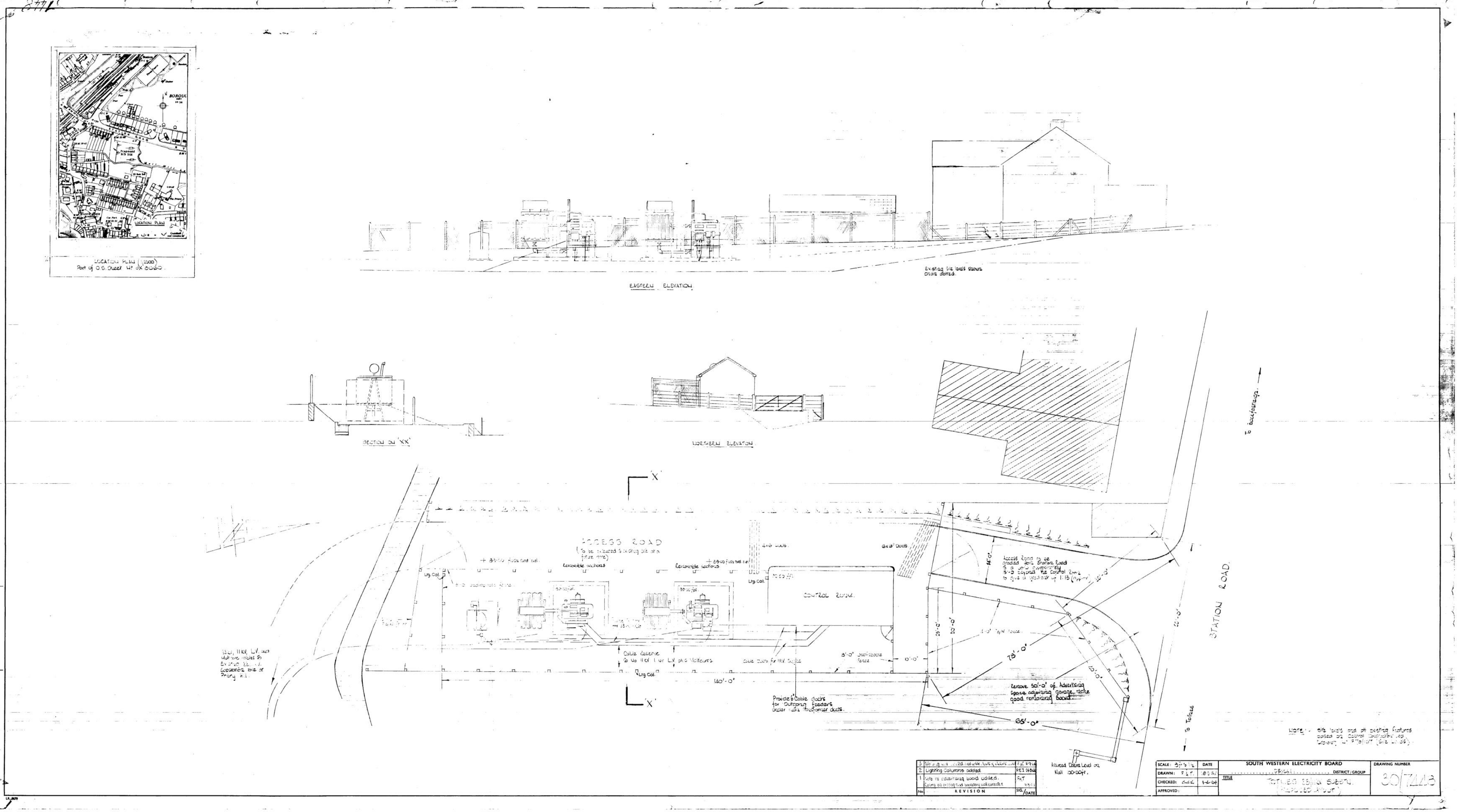
Tiles: 48, 49

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT



LOCATION PLAN (1/2500)
Part of O.S. Sheet
EASTERN ELEVATION
Existing site levels shown dotted.
SECTION ON 'XX'
NORTHERN ELEVATION
ACCESS ROAD
CONTROL ROOM
STATION ROAD
To Totnes
Cable Reserve
140'-0"
65'-0"
73'-0"
Remove 50'-0" of Advertising space adjoining garage, make good remaining board.
Provide 6 Cable ducts for outgoing feeders under the transformer ducts.
Assumed Datum Level on Wall 100·00ft.
Note:- Site levels and all existing features based on
No.
REVISION
SIG./DATE
Lighting Columns added
Note re advertising board added.
SCALE:
DATE
DRAWN:
CHECKED:
APPROVED:
SOUTH WESTERN ELECTRICITY BOARD
DISTRICT/GROUP
TITLE
DRAWING NUMBER
30/7448

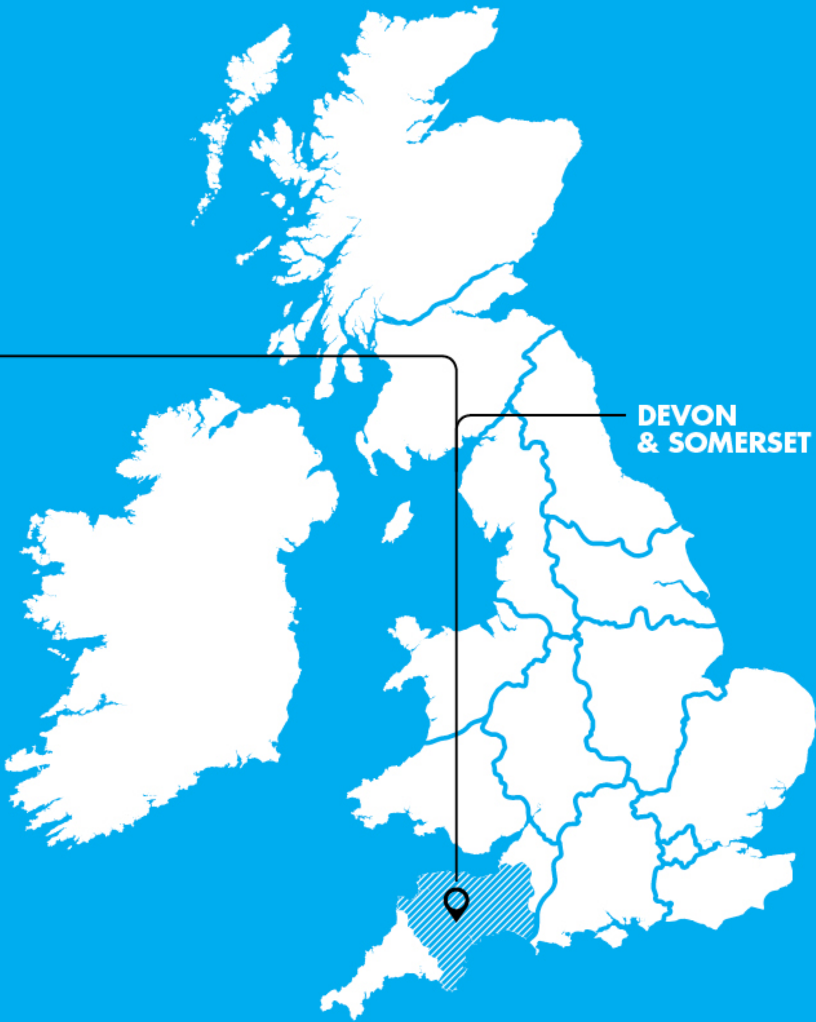
APPENDIX D - SITE PHOTOS

WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND

SVO Substation Investigation
Waterlake 33/11kV



LCN Fund
Low Carbon Networks

Report Title	:	Waterlake Substation Investigation Report
Report Status	:	Final
Project Ref	:	Equilibrium
Date	:	23.02.2016

Document Control

	Name	Date
Prepared by:	S Shiangoli	09.02.2016
Reviewed by:	J Berry	16.02.2016
Approved (WPD):	M Dale	23.02.2016

Revision History

Date	Issue	Status
23.02.2016	1	Final

Contents

1 Introduction

The following report details the findings from the investigation of Waterlake 33/11kV Substation for the inclusion of SVO technology. The report will provide an overview of the substation, including existing customer information and installed equipment, and provide details of the work required to successfully integrate the SVO technology at the substation.

The information presented will form the basis of scoring each substation to select the most suitable for trialling the SVO Method.

2 Substation Overview

2.1 Description

Waterlake 33/11kV substation belongs to the Axminster Grid Group and is normally fed via two 33kV circuits from Woodcote BSP. It has two 7.5/15MVA 33/11kV transformers operating with the bus section normally open. The substation was originally constructed in the late 1960's with the 11kV switchgear installed in 1980 and both transformers installed over the last 2 years.

The control, single line and EMU diagrams, plus a selection of photographs are provided in Appendices A-D of this report.

2.2 Investment under RIIO-ED1

There are currently no plans to carry out investment works at this site as part of RIIO-ED1.

2.3 Generation and Load Forecast

Table 2-1 below shows the load forecast for the substation. The load is expected to decrease by 0.13MVA over the next five years.

Table 2-1: Load forecast for Waterlake 33/11kV substation [2015 LTDS table 3]

Name	Voltage (kV)	Power Factor	Actual Peak (MVA)	Load Forecast (MVA)					Firm Capacity (MVA)
			2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	
Waterlake	33/11	0.97	5.19	5.09	5.03	4.99	5.00	5.06	28

2.4 Customers

2.4.1 Number of Customers

Waterlake currently supplies 3,000 customers and has no voltage sensitive customers connected.

2.4.2 Type of Loads

The substation supplies a mainly rural area with only a single town. The majority of the loads supplied are domestic with only a few light industrial and commercial loads.

2.4.3 Generation

The total amount of embedded generation feeding into the Waterlake 11KV network is 4.344MW. This is supplied by two solar PV sites. There are currently no connections committed for in the future above 1MW. [2015 LTDS table 5]

2.5 Voltage Control Equipment

2.5.1 Transformers

Both transformers at the substation were manufactured by Brush Transformers in 2013 and contain a 17 position AT 317 44/300L tap changer.

2.5.2 Automatic Voltage Control Relays

The substation contains two MicroTapp relays in a single swing frame panel for voltage control. These were installed in 2013 alongside the replacement of the 33/11kV transformers.

2.5.3 Auxiliary Systems

The substation has a 110V battery supply and D20 SCADA system installed.

3 SVO Suitability

3.1 Overview

This section describes the current voltages at the site and the theoretical change in voltage that is possible from system models. A description of the works required to make the site suitable for inclusion in the SVO method trial will also be provided.

3.2 Substation Voltage Range

3.2.1 Study

Analysis of Waterlake feeder voltages using WPD IPSA models determined that a 0.016pu voltage reduction was available whilst remaining within statutory limits.

3.2.2 Measured Values

Figure 3-1 below shows the historic voltage profile at Waterlake over a two year period. Figure 3-2 shows the fluctuation in the voltage seen at the substation in a typical day.

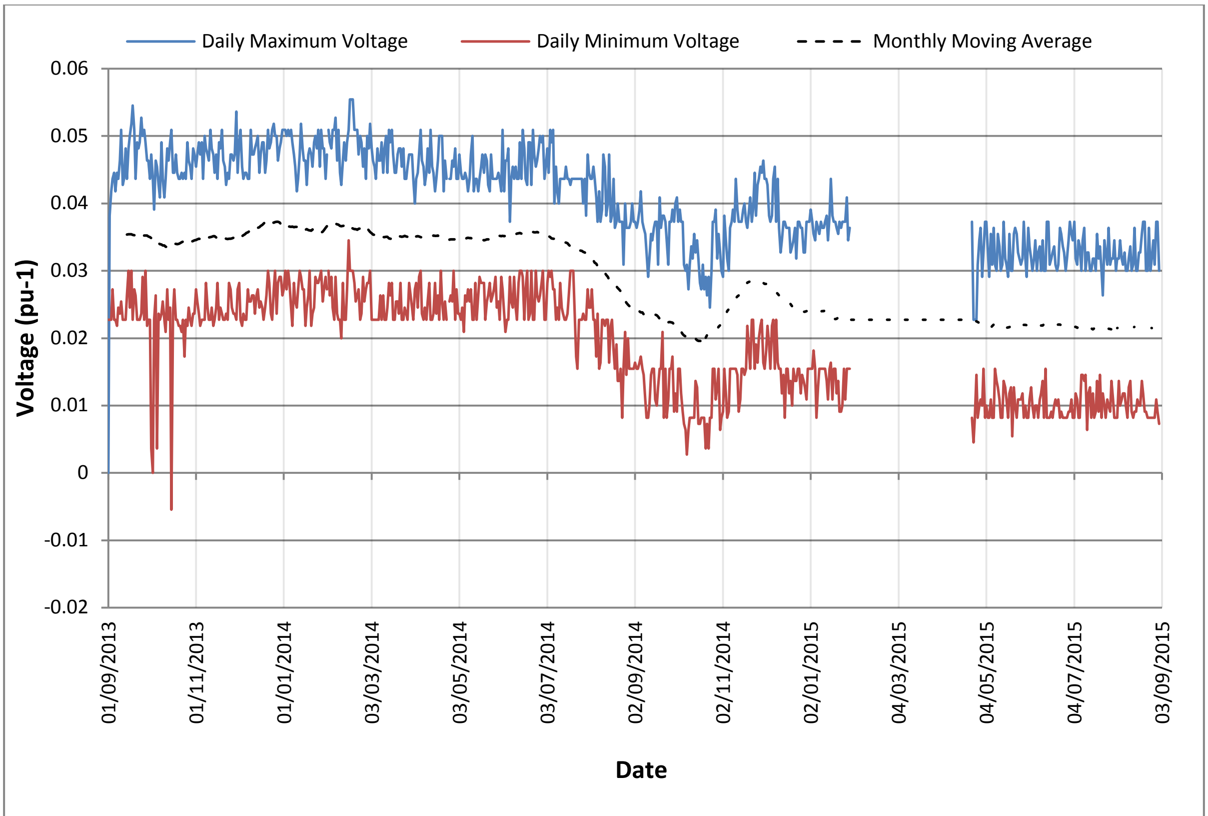


Figure 3-1: Historic voltage profile at Waterlake

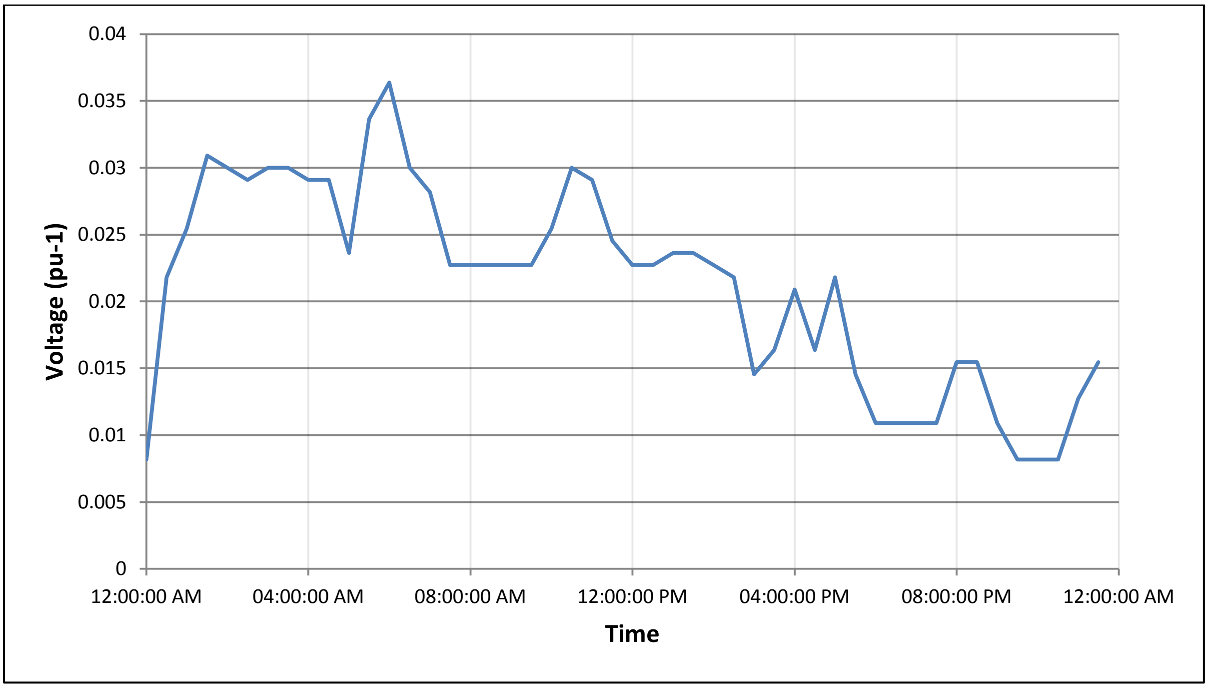


Figure 3-2: 01/06/15 Voltage profile at Waterlake

3.2.3 Results

The voltage studies have shown that the voltage can be reduced by 0.016pu below nominal and remain within statutory limits.

The historical voltage profiles show that the moving average has decreased from 0.035pu to 0.022pu over the two years with their being some large fluctuations prior to February 2015. Following completion of all replacement works the voltage has settled at 0.022pu. The daily fluctuations in voltage are approximately constant at an average of 0.022pu.

With the substation operating at around 0.022pu above nominal it may be possible to achieve a 0.038pu voltage reduction.

3.3 Scope of work to enable SVO

3.3.1 AVC Relay

As the existing MicroTAPP relays have the function to control group settings, it is planned to utilise them as part of the SVO method and enable them for use via the installation of interposing relays. The relay will require minor wiring modifications and commissioning with new settings.

3.3.2 AVC Panel

Each AVC panel will be modified to include the required number of interposing relays internally. These will be mounted to the existing internal rail with all additional wiring utilising the existing cable containment within the panel.

3.3.3 Monitors

Following analysis of the 11kV network in IPSA, eight potential locations have been identified across all feeders from the substation to have voltage monitoring equipment installed for SVO verification purposes.

3.3.4 SCADA

Minor modifications are required to the existing SCADA system to enable selection of the different AVC settings groups.

3.3.5 Auxiliary systems

No modifications are required to the substation auxiliary systems to enable the SVO method.

4 Health and Safety

4.1 Overview

Safe operation and continuity of supply shall be the main considerations for WPD, nominated working parties and manufacturers involved with any works to install SVO equipment at Waterlake. The *Health and Safety at Work Act 1974* and *Electricity at Work Regulations 1989* shall be fully implemented with a view to making the equipment safe to install, operate and maintain.

4.2 CDM

The works at Waterlake will fall under the *Construction Design and Management Regulations 2015*. WPD will be the Principal Contractor during all phases of the works.

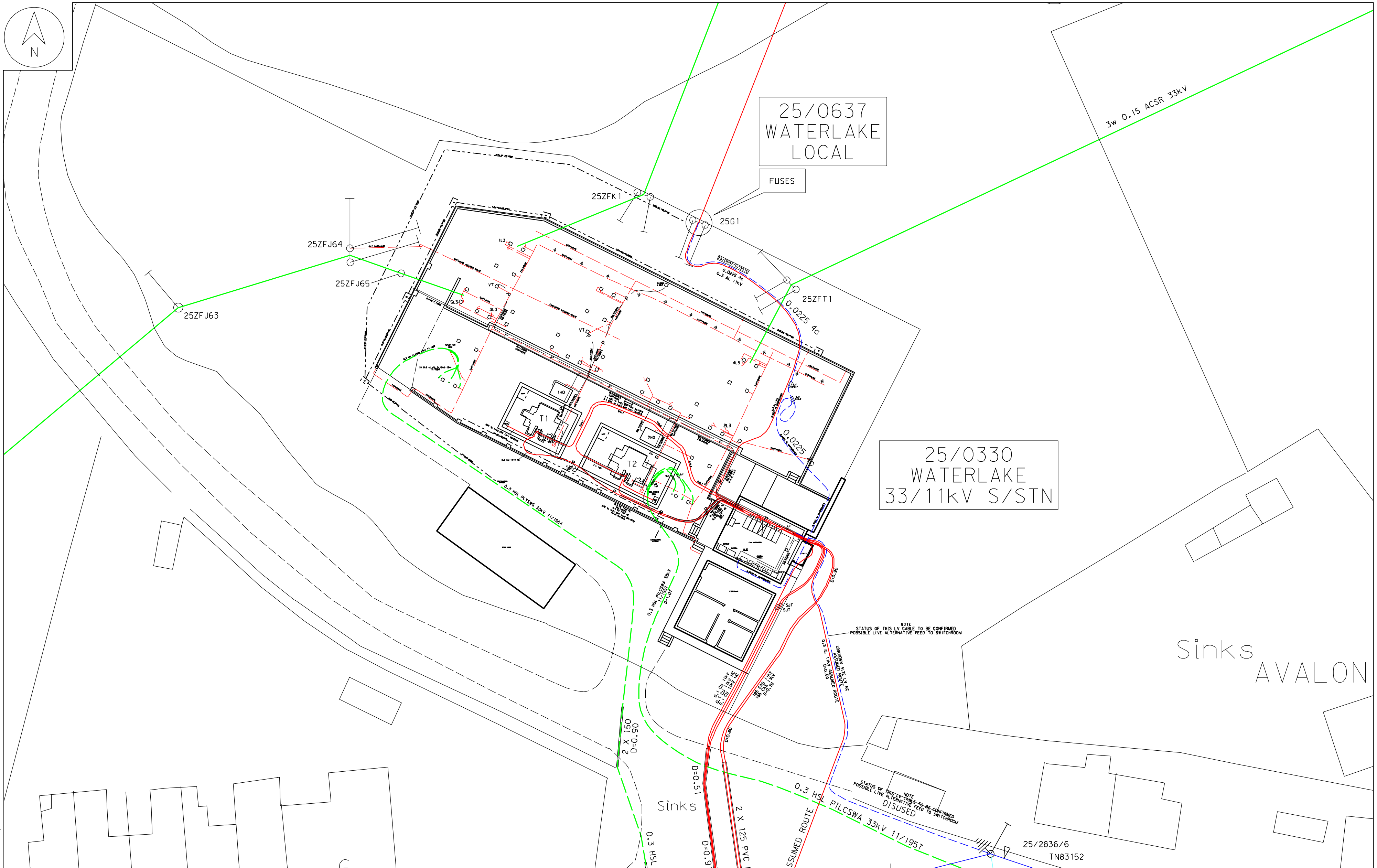
4.3 Risk Register

Table 4-1 below highlights the site specific risks when carrying out the proposed modifications to the substation.

Table 4-1: Site specific risks

Risk	Effect	Action
Second transformer trips when working on the other transformer.	Customers loose supply. Fines may be incurred depending on the outage time.	Consider surveying the Overhead Line. Stage the work to meet the Emergency Return To Service (ETRS). Ensure the two transformers are serviced before the work is carried out to ensure they are in good condition.

APPENDIX A - OVERALL NETWORK DIAGRAM



Information is given as a guide only and it's accuracy cannot be guaranteed.

PLEASE NOTE: This plan ONLY shows assets owned by Western Power Distribution. Electricity assets owned by IDNO's (Independent Network Operators) MAY be present in this area.

SURF TELECOMS APPARATUS

PILOT CABLES

	OVERHEAD LINE	UNDERGROUND CABLE
PL		
SERVICE		
LV		
HV (11kV)		
HV (33kV)		
HV (66kV)		
HV (132kV)		

PME Earth

Underground Earth

Pole Mounted Transformer

Ground Mounted Transformer

* ADVICE SHOULD BE SOUGHT FROM THE WESTERN POWER DISTRIBUTION CONTACT CENTRE S.WEST (0845 601 2989) FOR ANY WORK THAT IS TO TAKE PLACE IN PROXIMITY TO 132kV UNDERGROUND CABLES AND 132kV OVERHEAD LINES

TITLE: WATERLAKE
DRAWN BY: S. SHIANGOLI
DATE: 13/01/2016
SCALE 1:400 @ A3
PLOT CENTRE: 333161.567,105715.161

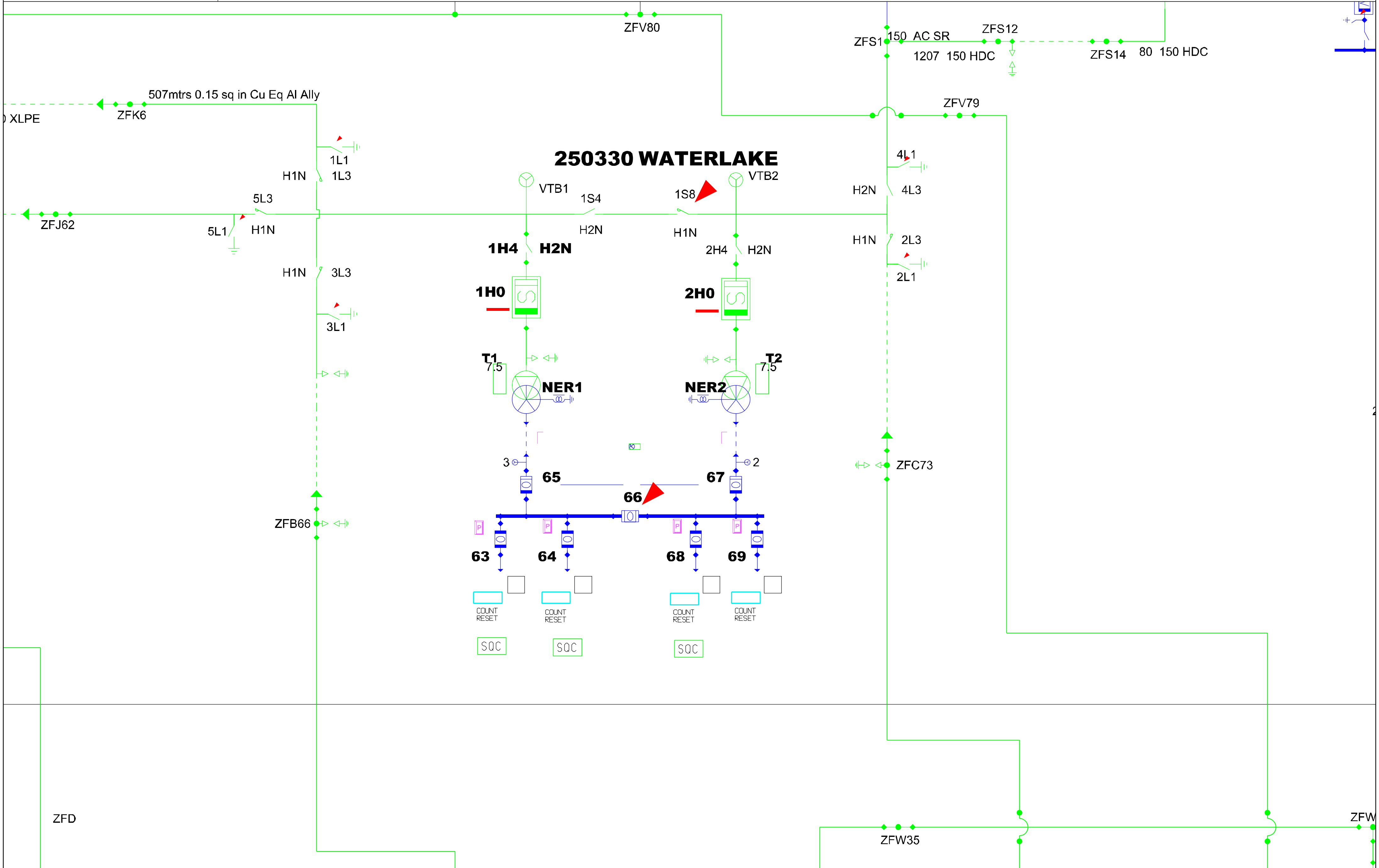
WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

APPENDIX B - SINGLE LINE DIAGRAM

WESTERN POWER DISTRIBUTION
Serving the Midlands, South West and Wales

WARNING: This a copy of the Enmac Diagram extracted on a monthly Refresh cycle.
Please refer to the live Enmac system for all operational matters

Information is given as a guide only
and it's accuracy cannot be guaranteed.



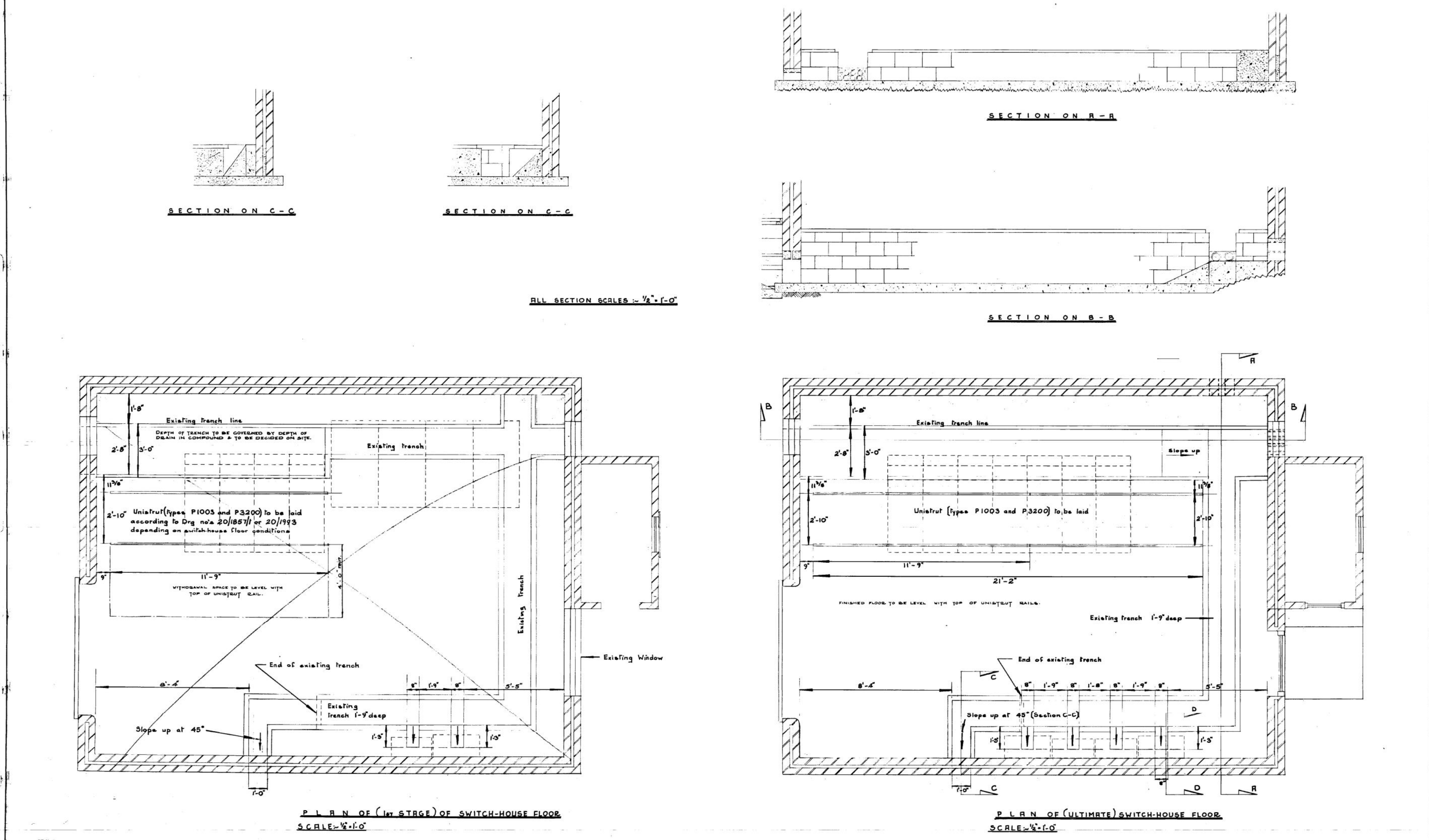
Tiles: 204. 217

Date: 13/01/2016

FOR INTERNAL USE ONLY

A3

APPENDIX C - CONTROL ROOM LAYOUT



No.	REVISION	SIG./DATE	No.	REVISION	SIG./DATE				
			2	As Erected	RAB 29/1/80	SCALE: AS SHOWN	DATE	SOUTH WESTERN ELECTRICITY BOARD SOMERSET DISTRICT/GROUP	DRAWING NUMBER
			1.	Depth of trench revised. Withdrawal space added	KB 16-2-67	DRAWN: R.A.B.	25/7/66	TITLE Floor Layout for Switch-House at Waterlake 33/11kV S/S	20/2005
						CHECKED:			
						APPROVED:			

APPENDIX D - SITE PHOTOS


33/11kV TRANSFORMER No.1
33/11kV TRANSFORMER No.2


T2


33/11kV TRANSFORMER No.1

SDRC2 Appendix G - SVO Technical Specification

Equilibrium project: System Voltage Optimization (SVO)

Specification_ScopeWorks V2.0

Project reference	P-014407; Oppt-AEMA-QTQRPI 299007 Equilibrium
Date	June 2015
Prepared and Edited by	EM SG Olamayowa Olabisi
Office address	Monkton Business Park South, Hebburn, UK
Phone	+44 (0)191 / 495 - 3658
Fax	+44 (0)191 / 495 - 3693

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Revision History

Version	Date	Changes
V01	June 2015	Initial Version
V02	Feb 2016	

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Anyone contravening this provision will be liable to pay damages.

Table of Contents

1 Solution Description

1.1 SVO Base Solution Technology

Our technology, Spectrum Power, will carry out real-time state estimation, modeling and management functions as part of an integrated solution for the SVO. It will address the needs for expedition of the time to connect distributed generation (DG) to the network, thus reduce the cost of connections through the adoption of revised Distribution System State Estimation methodologies.

Connection of DGs often causes a significant rise in voltage levels which goes over the limits of the existing equipments. Spectrum Power Component Distribution Network Applications (DNA) which includes Distribution System State Estimation (DSSE) and Voltage Var Control application (VVC), are used for the voltage constraint analysis and optimization in the network both in real-time and study modes.

The DSSE application provides a solution for real-time monitoring, control, and base for optimization of the network. It utilizes available current magnitude and measured voltage and power values. It consistently corrects incoming mismatched information during the estimation process, including topology analysis, load data, and measured values. DSSE calculates the state of the distribution network elements to detect potential equipment loading and voltage limit violations.

The VVC application performs the optimization of the network by providing recommendations for the control of transformer tap changers and shunt devices (e.g. capacitors), in order to keep distribution feeder equipment loading and voltages within defined limits.

The application will be utilized in automatic closed-loop model while an open-loop mode is also available for implementation and test purposes.

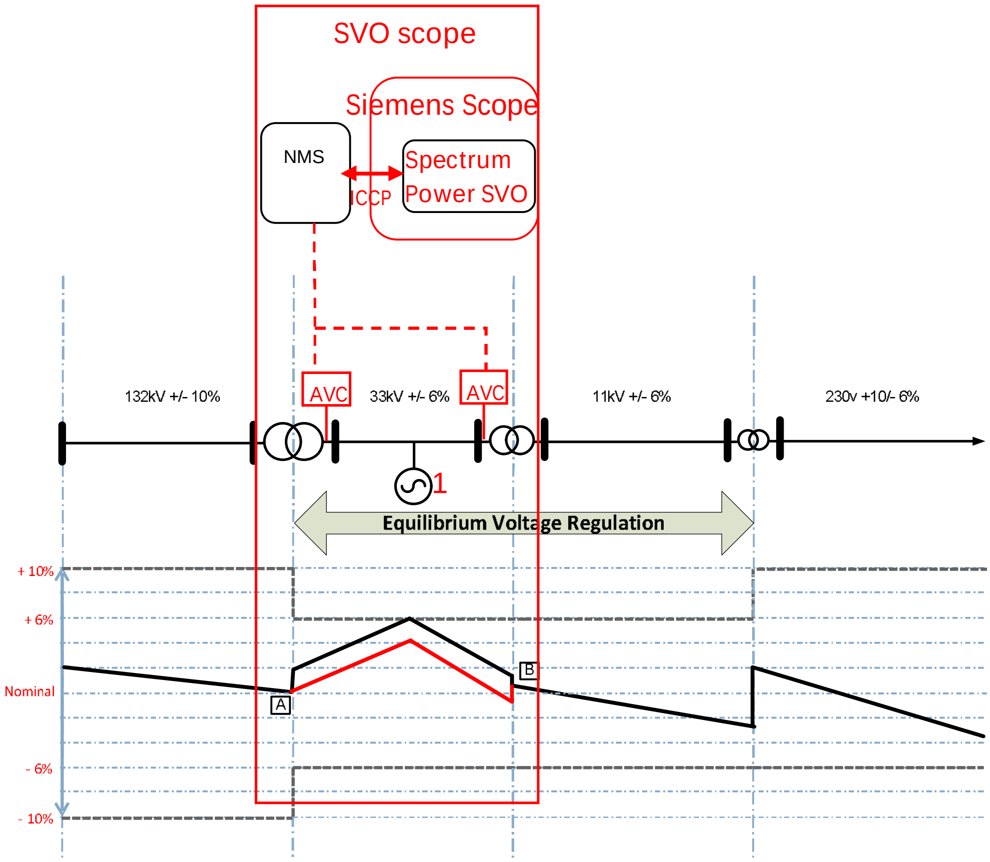


Figure 3: SVO solution concept

Connection of Generator 1 to the 33KV network as shown in figure 1 above causes the 33KV transformer voltage to rise thereby hitting its +6% upper voltage limit. Consequently, the SVO system will optimize the network voltage within the relevant substations by reducing the voltage setpoints of the AVC relays at the 33KV substations (e.g. at point A) such that the voltage at that level is optimally reduced back within limits; while simultaneously maintaining the 11KV transformer voltage level by retaining the existing voltage setpoint target at point B (which has different setpoint to that of point A). Though with the same optimization targets/aims, this application of separate optimisation setpoints at different system voltage levels will allow additional generations to be connected on WPD's networks.

As depicted in figure 1 above, Siemens Spectrum Power SVO (through WPD's NMS) will effectively send separate voltage setpoint targets to AVC 1(33KV) and AVC 2(11KV) such that an overall optimal system voltage is achieved. This voltage optimization will directly be achieved using the VVC application (detailed in section 3) within the DNA suite that is contained in our Spectrum Power platform.

1.2 SVO Solution Architecture

Siemens has reviewed WPD's technical requirements of schedule 3 of the ITT and has opted for option 2 within its system layout as our preferred solution, as shown in figure4 below. The main element of the SVO system is the real time analysis and control which will be delivered through the "Spectrum Power SVO" system, as shown below. The solution uses a central intelligence to deliver flexible, scalable and expandable intelligence.

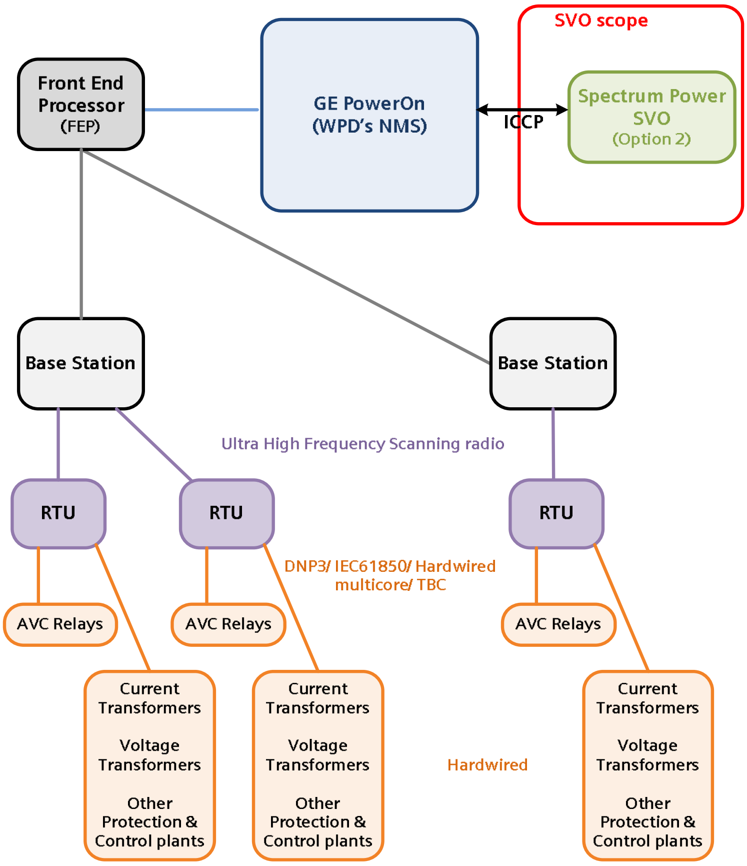


Figure 4: Siemens solution architecture (Option 2)

The solution allows our Spectrum Power SVO to directly and securely communicate with the PowerOn in order to receive and send real time data necessary to make its decision to and from the PowerON though ICCP link. Under normal and abnormal running arrangements, Spectrum Power will evaluate network configuration, voltage measurements and current measurements across the trialled networks and calculate the optimal voltage set-points which will be sent to the AVCs, based on real time data it gathers from PowerON through the ICCP link.

When Spectrum Power decides to optimize the voltage set-points of the relevant AVC relays at the 16 trial substations, consequent upon its calculations and other information received from PowerOn, it will simultaneously issue the set-point control signals through ICCP to PowerOn. PowerOn will then pass the control signal through Front End Processor (FEP), through the Base station, through the RTUs, to the AVCs, using its existing communications networks.

The communication between the NMS and the SVO is assumed to be ICCP. However, the Spectrum Power SVO system could retrieve required real time data directly from the RTUs in the event of any failure (e.g. due to maintenance) or delay from the PowerOn. In essence, when necessary, the optimal setpoint control may be directly issued to the RTUs without having to pass the command through PowerOn. This may allow greater flexibility and ensure optimal operation of the SVO system. If required by WPD, this alternative direct access and communication with the RTUs can be achieved using the Spectrum Power's CFE application (see section Error! Reference source not found. for further details).

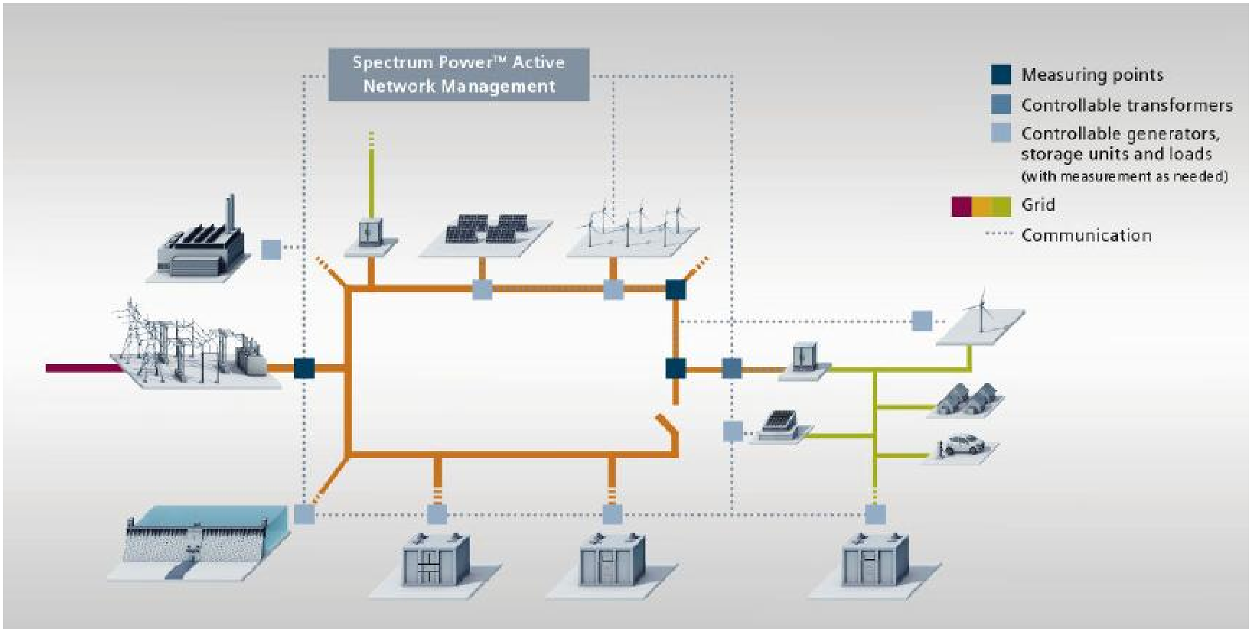
As earlier described in section 2.1, the optimization is achieved using the DSSE and VVC functionalities for the calculations, by considering the most recent state of the trial area network topology.

2 Detailed Technology Description

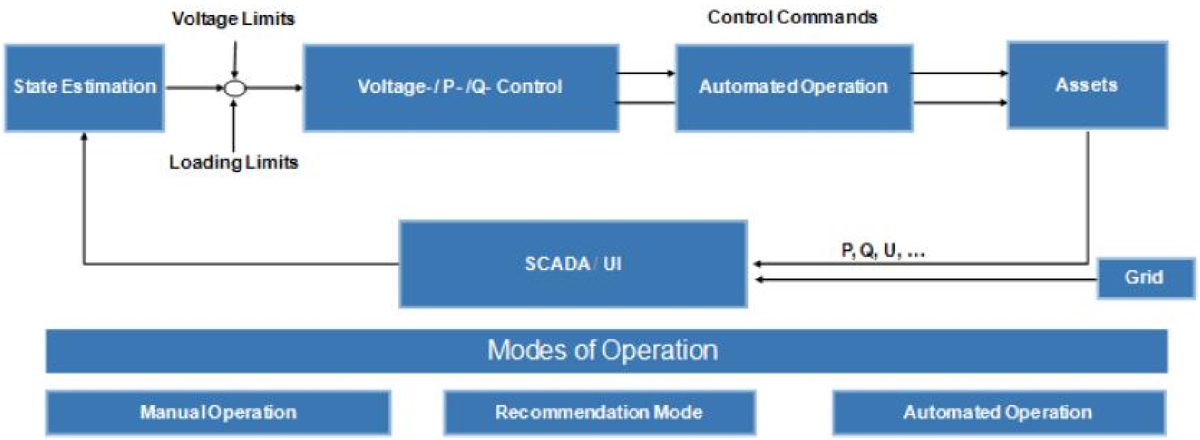
2.1 Overview

This section provides some details on the Spectrum Power SVO architecture and functionality. Spectrum Power 5 will be centrally positioned within the SVO project and will be responsible for voltage optimisation (33KV and 11KV networks) within the trial substation.

The Spectrum Power Active Network Management (ANM), is a smart tool for distribution grids which supports a wide range of equipment – from transformer tap changers and capacitor banks to controllable loads including battery storage.
The Spectrum Power ANM displays the current load flow directions and calculated load values as well as voltage range violations and overload situations. This also includes integrated analysis and archiving functions, allowing automatic result validation and comparison as well as reports and facilitating meaningful short-term and longterm views.
The Spectrum Power ANM also provides functions for convenient voltage range and capacity utilization management. This makes it easier to predict voltage violations and equipment overloads, and substantially reduce them in connection with control algorithms. Additionally losses can be minimized by distinct voltage, reactive power and active power control and Spectrum Power ANM is a reliable basis for making these decisions, whether automatically or in manual mode. Economic and secure operation is the focus of this platform.

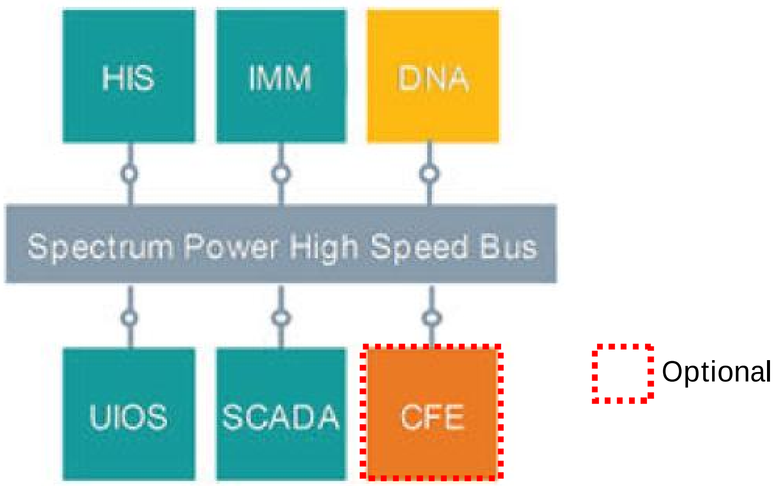


Power flow values and power flow directions are reliably monitored. Voltage violations and equipment overloads are detected quickly and accurately.
• Balancing measures primarily for maintaining grid stability and for protecting equipment can be initiated at an early point.
• Distribution losses can be effectively reduced.
• An optional automatic mode of the Volt/VAr and Volt/Watt optimization allows transformer tap changers, capacitor banks, loads including battery storages also to be controlled without operator intervention.



Siemens standard Spectrum Power ANM solution which will be used as the SVO control system, is a preconfigured solution based on Spectrum Power 5 applications forming an integrated approach for the optimization of distribution grids. Our standard Spectrum Power ANM comprises the following Spectrum Power 5 applications:

- Distribution Network Applications (DNA)
- Supervisory Control And Data Acquisition (SCADA)
- User Interface and Operator Support (UIOS)
- Information Model Management (IMM)
- Historical Information System (HIS)
- Communication Front-End (CFE)[1]



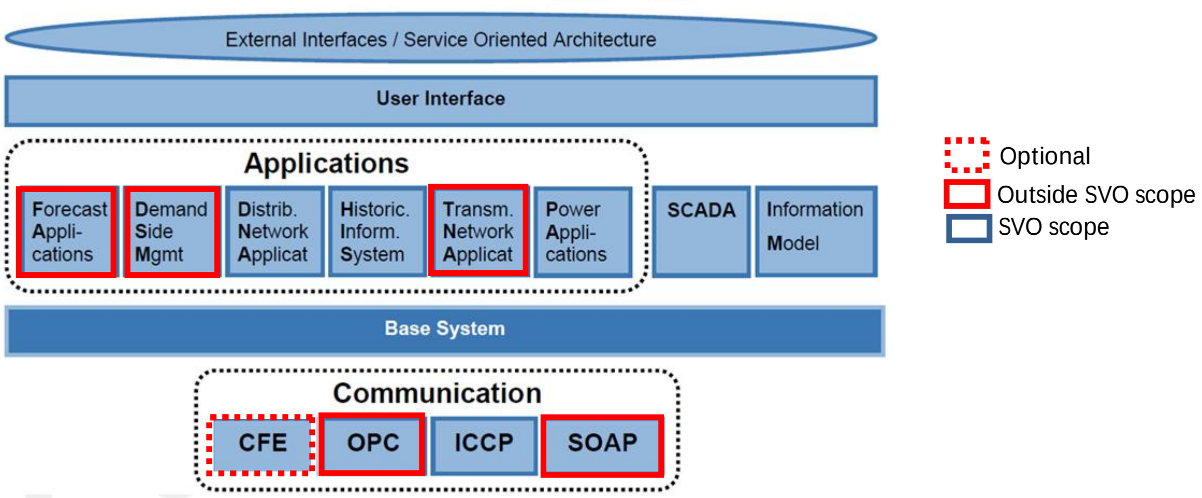
As Spectrum Power 5 provides modular system architecture, other standard components can also be added if required.

[1] For the purpose of SVO, this application will optionally be used if direct access/communication is required to the RTUs. The standard communication option for the SVO is ICCP (see section 2.3.1)

2.1 Distribution Network Applications (DNA)

The Spectrum PowerTM Distribution Network Applications (DNA) form a critical component in the Smart Grid transformation of distribution networks and it is the principal area for delivering the required SVO functionality to WPD as;

- It increases the observability of the distribution network and provides the user with a fast and complete real-time view of the current network status (monitoring).
- It provides optimization of the distribution network control in closed loop operation.
- It implements dynamic optimization of the distribution network.



All applications are designed and developed to take into account the characteristics of distribution networks (very large radial and weakly meshed structure, balanced, symmetrical and asymmetrical). Distribution network models and the amount of data needed for network analysis can be very large. In addition, the quality of data has significant impact in the feasibility of results. Hence, our user friendly data validation tool will be used for the SVO solution to help detect and resolve errors.

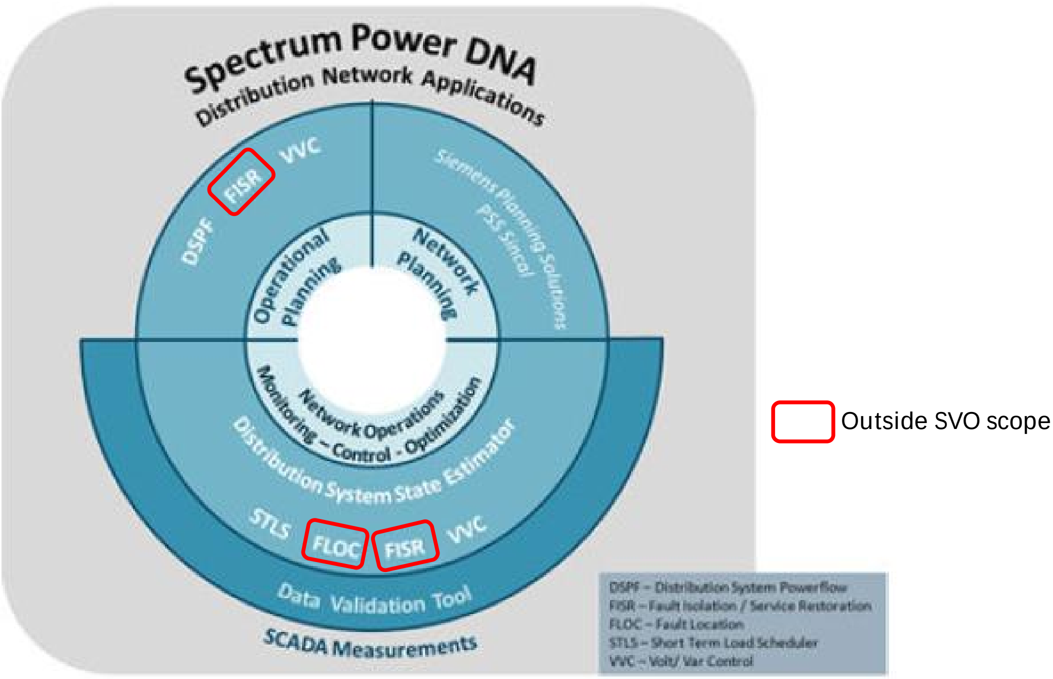
DNA subsystem is divided into various applications which can be utilized to match the tasks and the structure of WPD's system so as to improve the observability of its network. With this modular structure the system can be expanded with little effort to meet the diverse abd growing needs of WPD's networks. In addition to real-time operation, DNA also supports operational planning (study mode). The DNA provides the following features for the ANM solutions which shall revantly be used for the SVO solution:

- Automatic verification of quality and completeness of relevant data.
- Complete and consistent calculation of the current state of the distribution network.
- Detection of erroneous measurements.
- Calculation of optimal resources settings to optimize the state of the network.
- Working in different modes (open loop, closed loop, and study mode).

Our Spectrum Power's DNA provides a comprehensive suite of applications to support increased distribution network reliability and efficiency, some of which will be used for the SVO project. Within the scope of the SVO, the following DNA applications will be used:

- Distribution System Power Flow (DSPF)
- Distribution System State Estimator (DSSE)
- Short-Term Load Scheduler (STLS)
- Volt/VAr Control (VVC)

Data Validation is provided to check the input data for completeness, consistency, and quality.
Other standard DNA applications which are outside the scope of the SVO solution are:
- Fault Management
- Fault Location (FLOC)
- Fault Isolation and Service Restoration (FISR)



Spectrum Power DNA

2.1.1 Distribution System Power Flow (DSPF)

DSPF is used to calculate the network status under different load conditions and configurations including look-ahead.

Main DSPF Features

- Handles symmetrical balanced powerflow in radial, looped, and meshed topology.
- Handles balanced conforming and non-conforming loads and load-to-voltage dependency.
- Includes multi-phase local control of tap changers and shunts.
- Supports PQ and PV generators.

• Calculates networks with single-phase switching and jumpers added on demand.

• Provides Switch Results even for Complex Substation Busbar Connections.

Power Flow Solution

DSPF calculates voltages (magnitudes and angles) for all nodes (busbars), active/reactive powers for slack buses, and reactive power/voltage angles for nodes with PV generators. Other power flow output is calculated from the node voltages and branch impedances/ admittances. The most important result values are flows (kW / kVArs and currents) through lines and transformers, and active and reactive power losses.

DSPF calculates the network status to detect potential limit violations. The results are also used for further analysis (for example, what if scenarios) and further optimization processes.

2.1.2 Distribution System State Estimator (DSSE)

DSSE provides a solution for real-time monitoring, control, and optimization of the network. Unlike DSPF, it utilizes available current magnitude and measured power values. It consistently corrects incoming mismatched information during the estimation process, including topology analysis, load data, and measured values. DSSE statistically estimates the most probable active and reactive power values of the loads using existing measured values, switching positions, and initial active and reactive power consumption of the power system loads.

State Estimation

DSSE performs the following:

• Estimates loads matching measurements using weighting factors for measurements and loads.

• Detects obviously wrong measurements.

DSSE calculates loads so that their values, initialized from load curves, scheduled loads and/or measured loads, best fit existing measurements and actual network topology. The adaptation of loads uses an optimization process which minimizes the deviation between measured and calculated values. It takes into account measurements, load curves, and rated outputs as weighted information.

DSSE integrates this optimization process together with a power flow engine to calculate nodal voltages and branch flows. DSSE results are used to monitor the real-time network operating state, including transformer loading, voltage profiles and overloads, and as input to other applications, for example, VVC and related potential operational improvements.

Determination of Load Base Values

Different sources are used for determining load base values, including:

• Load rating values, load curve values, and STLS values.

• Measurements DSSE adapts system loads in such a way that the calculated values fit the measured values and load information (on the basis of their respective weighting factor) as closely as possible.

Trust Factors

Trust factors mirror results and load flow information.

Load Adaptation

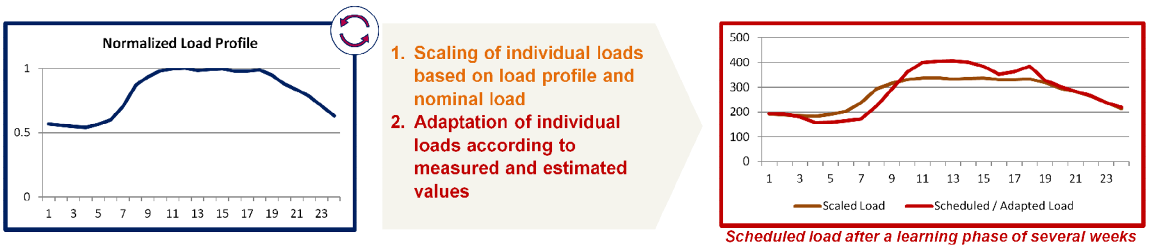
Load Adaptation adapts loads to conforming measurements as accurate as possible. It minimizes the residuals between measurements and their calculated values taking into account their respective weighting factors.

2.1.3 Short-Term Load Scheduler (STLS)

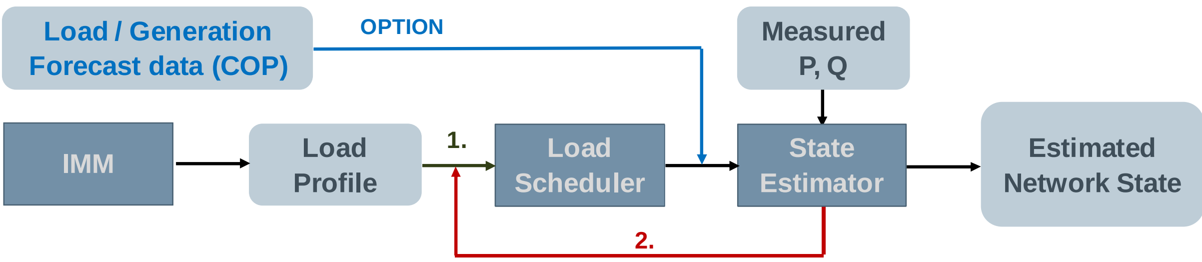
STLS maintains scheduled active and reactive power consumption of power system loads for a short time range (one week - configurable granularity). STLS also maintains the active and reactive power consumption of the power system loads for each load in the distribution network in the appropriate database. The scheduled active and reactive power consumption of the power system loads is maintained using the existing values, and continuously adjusted to the latest DSSE results.

Load Schedule Management

STLS maintains a database of load schedules over a one-week time range (up to seven days). Load values are maintained for predefined day types and hourly resolution. An STLS load schedule is updated with the results of DSSE. Scheduled load values are used in DNA applications which require load data.



Scheduled load after a learning phase of several weeks



STLS maintains load values for each load in the distribution network in appropriate storage. STLS updates load models using real-time DSSE results. This update is done using a recursion algorithm which smoothes out random or unusual load changes to produce more accurate load pattern.

Upon request, STLS returns active and reactive load values of specific loads for a given time.

Note: Generation is considered as negative load.

STLS as described above is part of the main offer. Optional scope is the usage of available Forecast data (see OPTION blue in the picture above). In this case DNA would use Load/ Generation Forecast data where available.

Project experiences shows that Load models calculated with standard STLS algorithm, already provides good results. Additional usage of accurate Forecast data as optionally offered might improve result especially in case the network is heavily penetrated by wind generation.

Hence, where accurate forecast data is not available, the standard STLS algorithm will be applied which considers the initial load/ generation profile from WPD with the SE running estimations and interative tuning to improve result.

2.1.4 Volt/VAr Control (VVC)

Volt/VAr Control (VVC) determines control actions of transformers with an on-load tap changer, phase-to phase voltage controllers and/or shunt capacitor banks to improve network operations. The optional Volt- Watt module allows including the determination of control actions for active power control of battery storage systems and/or flexible loads (as interface to Demand Response Management Systems). These control actions are the result of a network optimization performed by the VVC application to achieve, for example, loss minimization.

The basic goals of VVC are to improve reliability and quality as well as energy conservation.

VVC Optimization

The optimization performed by VVC consists of minimizing an objective function that is user-selectable among the following subobjective functions:

- Minimize limit violations
- Minimize power losses and limit violations
- Minimize active power consumption (power demand) and limit violations
- Minimize reactive power consumption and limit violations
- Maximize power revenue and minimize limit violations

The optimization is subject to network constraints, for example, power flow equations and operational voltage limits. Establishing these constraints in the system ensures that optimal benefits are reached.

VVC provides a centralized coordinated control of the network regulating controllers. It provides distribution network optimization (including subtransmission) by using control devices. Control devices used to control voltage and reactive power flow in the target distribution system can be divided into different types:

- Transformer with on-load tap changer
- Phase-to-phase voltage controllers
- Shunt capacitor bank
- Battery storage systems

The additional Volt/ Watt module adds the capability to control voltage and active power flow in the target distribution system by two different types of control devices:

• Battery Storage System

• Flexible Load

VVC application provides the following two operating modes:

• Open Loop

The optimal setting/switching orders calculated from VVC are not automatically executed, but available for review in the user interface.

• Closed Loop

The optimal setting/switching orders calculated from VVC are immediately executed after VVC calculation.

While providing a complete view of the network state the main benefit of the DSSE is the provision of initial voltages for the VVC component.The outputs of the DSSE applications provide Spectrum Power VVC (also within the DNA) with the information it needs to be able to optimize the selected feeders of the trial network, using the adjustments under its control: the 32 AVCs (or whatever quantity as may later deemed fit). T

2.1.5 Data Validation

In all types of distribution networks, the volume of the data needed in Distribution Management System is large. As a consequence, the data validation process is an important and challenging task. The Data Validation tool verifies in an automated way the quality and the completeness of the data necessary to execute all DNA functions. The validation can be performed on network elements (lines, switches, and so on), network parameters (impedances, reactances, and so on) and SCADA parameters (connectivity). The appropriate equipment for this tool can be selected on the user interface.

2.1.6 Supervisory Control and Data Acquisition (SCADA)

Spectrum Power 5 is a state of the art and market-proven network control system, based on the established international IT standards, with uniform and windows-oriented handling of all operational workflows. Spectrum Power 5 provides:

• Source Value Selection (SVS) - To monitor incoming values and to detect data changes, including the possibility to select values from multiple sources.
• SCADA calculations - For example, Visual Basic Scripts, predefined, and common calculations.
• Quality code processing - To indicate the status and the reliability of a value.
• Marking and tagging - To execute special processing on field devices.
• Manual updating - To override and update system measurements manually.
• Limit value monitoring - To apply and configure limits to analog values and accumulator values.
• Topology processing - To execute network status processing and network coloring.

• Supervisory control - To submit control requests for any device, with different types of interlocking checks, which are taken into account before control requests are sent.
• Event and alarm monitoring - To handle incoming alarms.
• Switching Procedure Management (SPM) - To define and execute switching sequences.
• Temporary network elements - To handle jumpers, cuts, and grounds that are inserted by field crews as a temporary problem solution.
• External data interfaces using Inter-Control Center Communications Protocol (ICCP), OLE for Process Control (OPC), ELCOM, or Communication Front End (CFE) components for communication.

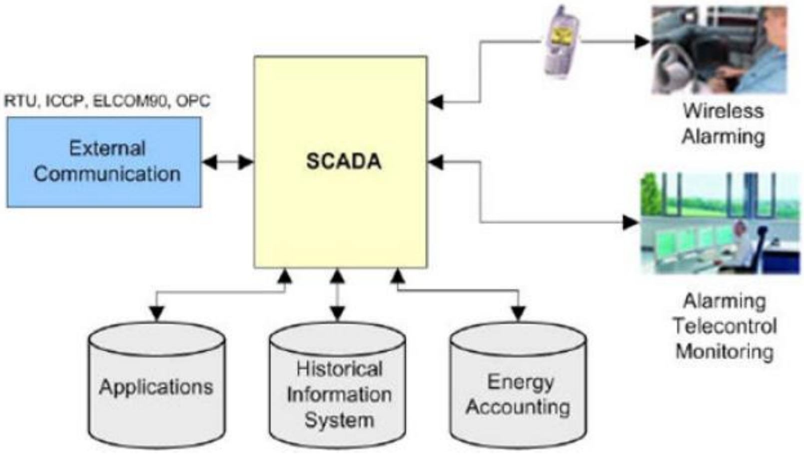


Figure 7: Spectrum Power 5 SCADA Components and its Main Interfaces

2.1.7 Context Management

Spectrum Power 5 provides easy and clear context management. You can switch from a real-time context to a study context. For example, to test a switching procedure. Furthermore, a test mode is available to perform telemetry test for selected data points.

2.1.7.1 Real-time Context

The real-time context is used to monitor, control, and manage the network through the connected process interfaces. It is the most accurate and up-to-date image of the real world.

2.1.7.2 Study Context

Typically, the study context is used to support the operators during different analysis and operational activities. The study context is decoupled from the real-time process. In study context, no commands are issued to the field but rather their effects are simulated. To issue commands to the real-time process, you can switch back to the real-time context at any time by clicking the mouse. The System provides the possibility to run different Save cases simultaneously.

There are three possibilities to initialize the study context:

- Snapshot from real time
  The current real-time situation is taken as basis for the study.
- Save case
  A previously stored save case is used as starting point for the study.
  The System will store up to 50 Save cases.

- Normal states
  Reset of all study values to defined normal states of the equipment
- Historical values
  Load all values of a certain time in the past into the study.

2.1.7.3 Test Mode

The test mode is a working environment where parts of the network are controlled through the connected process interfaces and the remaining under real-time context control. The test mode can be used for point-to-point tests of an RTU without affecting the remaining real-time operators.

2.2 User Interface and Operator Support (UIOS)

Spectrum Power 5 will provide a clear network representation for WPD within its control room which will present it with real time visibility of the network status.

The Spectrum Power 5 User Interface provides clear and easy handling. It allows fast and reliable work in network operation with:

- Access rights to ensure system security
- Power 5 Application Toolbar (PAT)
  - Central navigation and alarming unit
  - All applications at a glance
- Familiar user interface elements and navigation for intuitive and fast operation
- Siemens Energy Automation Style Guide compliance to assure a consistent behavior of all
- Spectrum Power 5 user interface components
- Integrated plausibility checks for secure handling
- A choice of graphical displays for easy visualization and analysis of data. For example, worldmap and summary.
- The generic Runtime Explorer allows all SCADA network operations and monitoring without the necessity of having a graphical display available
- Context management
  - Clearly distinguishable environments (real-time context, study context, or test mode)
- Workflow-oriented operation
- Remote and web-based operation and viewing
- Consistent and intuitive handling of temporary network elements
- Easy display of application results in single-line diagrams

The VVC optimization will send setpoint controls through ICCP to the NMS system . Logging of VVC actions will be provided to the NMS system through ICCP as well.

2.3 Communication Options

Spectrum Power 5 receives process information from external systems or has to transmit own information to external systems. Depending of the type of information exchange different solutions are provided:
· CFE for telecontrol communications with remote terminal units (RTU's)
· ICCP for information exchange with other or foreign operation control centers
· OPC for information exchange, mainly with automation equipment

2.3.1 ICCP

Communication Overview

ICCP is part of the Spectrum Power 5 (SP5) Communication Domain used for real-time data exchange between control centers. Some of the different types of control centers that the Spectrum Power 5 ICCP protocol can communicate with are shown in the following figure 8.

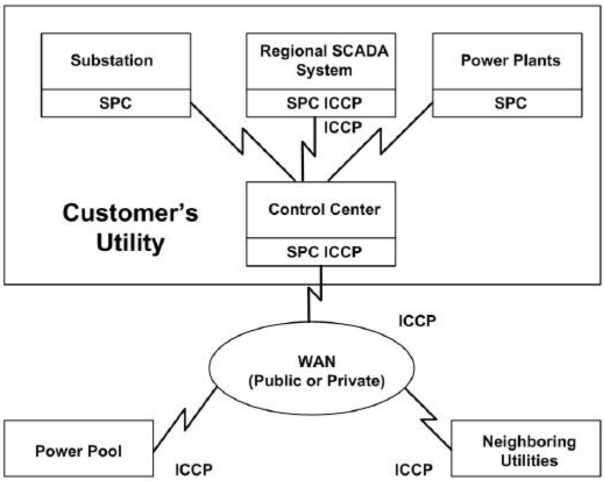


Figure 8: ICCP data exchange between control centers and power systems

ICCP is designed to support power system data exchange via a network (WAN, LAN, ISDN etc.) between a local utility control center and other utilities, power pools, regional control centers and non-utility generators. The ICCP standards are "companion standards" of the Manufacturing Message Specification (MMS). ICCP is a user of MMS services.

2.3.1.1 ICCP Security Features

Secure communications are required to support confidentiality, integrity and availability. ICCP provides

the following security standards and features:

- Secure communication using the ICCP PKI security standard (SSL protocol).
- Digital Certificates are used for authentication and data encryption cipher selection.
- Works with or without an external Certificate Authority.
- Makes use of the X.509 standard.

- Supports secure and non-secure connections simultaneously.
- Security status shown on the status display.

The secure mode can be configured on a link by link basis. This is a Public Key Infrastructure (PKI) approach to secure each connection using the Secure Sockets Layer (SSL) technology. When a secure link is designated, both sides must work securely for the connection to work.

2.4 Data Model – Information Model Management (IMM)

Spectrum Power Information Model Management (IMM) gives you the ability to enter and maintain all power system related engineering data for use within Spectrum Power control center systems within a CIM-based central repository. Engineering data consists of domain data like equipment, measurements and topology, as well as single line displays and configuration data of the Spectrum Power control center system like hardware and software deployment and application configuration. A set of editors allow data access and data definition optimized for the different engineering workflows a data engineer needs to perform. Complete, partial, and incremental import and export of engineering data is provided through CIM-RDF and XDF formats based on the W3C standard XML. IMM also controls the activation of data changes to the Spectrum Power control center runtime databases. The Information Model Management is based on an object-oriented data model using a Relational Database Management System (RDBMS).

The IMM features:

2.4.1 Common Information Model (CIM)

- The Data Model is based on IEC 61970 (EMS Application Program Interface) and its extensions according to IEC 61968 (System Interfaces for Distribution) and IEC 62325 (Energy Market Communication)
- Allows easy enterprise integration and data exchange between control centers and applications of different suppliers.
- Is the base for vertical and horizontal integration.
- Allows easier, faster, and lower-risk upgrade or even migration of existing data.
- CIM data remains stable, and data model expansions for example, additional types or attributes, are easy to implement.
- NIST (National Institute of Standards and Technology) recently identified CIM as key standard for Smart Grid interoperability.

2.4.2 Job Management

- A job is an organized set of data changes. The user is in control of which changes are collected into a job. Multiple jobs are allowed at any time.
- Allows multiple and concurrent users to make data modifications at the same time without any impact on the operational database within a secure environment.
- Provides life-cycle management for data modifications.
- Automatic change detection allows tracing of all changes done by users at any time.
- Job activation provides the ability to transfer the incremental data changes online to the operational system without interrupt of process control, including the ability to undo changes.
- Choice between interlock-based job model or time-based job model to support different business logics regarding data maintenance.

2.4.3 System and Data Integrity

- Multilevel security service
- User authorization, User access rights, Instance level access rights.
- Audit records of every change made to graphical or domain data.
- Powerful validation means to secure the integrity of the model.
- IT security checks as part of the system test (Red Team Vulnerability Assessment).
- Secure installation procedure according to Siemens CERT guidelines.
- Patch management for Microsoft operating system and 3rd party products.

2.4.4 IMM Archive

- Data version management and automatic data model archiving facilities.
- A history of model changes enables retrieval of the data model at any point in past times.

2.4.5 User Interface

- One common user interface for data entries covering all aspects of data engineering.
- Domain data topology can be derived from the graphic model (single line diagrams).
- Can be viewed and accessed using Microsoft Internet Explorer.
- Multi-screen and multi-window data entry sessions (MS Windows look and feel).
- Report generator function included.
- Online help.

SDRC2 Appendix H - SVO DNO Workshop Minutes

Date: 27/01/2016

Time: 09:00 – 14:30

Venue: IET Austin Court Birmingham

Meeting Title: Network Equilibrium System Voltage Optimisation Workshop

Purpose: Share knowledge and detailed specifications of System Voltage Optimisation.

Attendees:

WPD	**Jonathan Berry**	**JB**
WPD	**Mark Dale**	**MD**
WPD	**Yiango Mavrocostanti**	**YM**
WPD	**Karen McCalman**	**KM**
Scottish Power Energy Networks	**Kevin Smith**	**KS**
Northern Power Grid	**Alan Creighton**	**AC**
SSE	**Simon Killoran-Codling**	**SKC**
PB	**Paul Edwards**	**PE**

1 Minutes

MD: Introductions
YM: SVO overview
JB: Detailed design of spectrum 5 and SVO application

AC: How would SVO account for OC6 voltage reduction? The tap position would need to have enough room to still administer OC6 if needed. How does SVO take into consideration outage conditions?

KS: Regarding OC6 potentially it would mean the trial could do one or the other. How would this work operationally? Can WPD discuss this position with National Grid that if you are running SVO then OC6 would not apply?
If SVO was deployed as business as usual (BAU) solution then what would the consequences be for National Grid in OC6 occurrence? This would need clarification and agreement before it could become BAU application. If intelligent voltage control was being used would that negate the need for OC6?
WPD Response: The project outcomes will need to address this issue once it is understood how SVO will affect the steady state network. In the case of an OC6 request then SVO would probably need to be disabled. There have been no recent occurrences of OC6 requesting 6% drop, only 3% has been requested. The discussion needs to be had around the SVO already providing the optimal voltage and what this means in terms of OC6.

KS: Would the system use 'add ons' to help with voltage drop on long feeders etc.?
WPD Response: The point of the project is just to use SVO independently and see what benefits it produces.

AC: Envisages SVO to be part of a planners 'tool box' rather than standard BAU solution. If the problem is wide spread across an area then SVO deployed to solve the problem, however if small localised issue then smaller bespoke solutions can be used.
How does SVO work with line drop compensation? Would this be used instead and be more accurate?
WPD Response: The Advanced Planning Tool will be in the planners' tool box, SVO will be a plug in within this modelling tool. It is not thought that LDC would be used in conjunction with SVO

Detailed design

KS: Tap positions -ABB have ability to measure tap positon as does the Siemens Microtapp via a fibre optic port.

AC: Fundamentals Supertapp N+ & MR TapCon have intelligent tap change and monitors positions which will validate the SVO, either less tap changes or more.
Response: WPD will review the scope of the project re tap positions. New Relay selection process is underway and this will be included in the investigations

AC: Investigate PIE data to see what network is doing, it is possible to add at tag to collect the frequency of operation and tap position. Actual data would be needed not half hourly averages, so there be some amendments needed to collect the data.
SVO has the Potential to optimise for losses in the future although perhaps not highest priority at this point.
When the signal is sent from Spectrum Power 5 do you want that to initiate tap change or where possible just change target voltage? How would this work practically, particularly on AVC with a range of settings rather than exact voltage data.
Why have local control and not send centrally?
Response: The signal is to send optimal target voltage set point, not individual tap positions. We would not want centralised system as it would be reliant on communications and is a risk if they are unavailable.

KS: Voltage optimisation – Is the project going to install all new AVC'S? Can any of the existing ones be used?
Response: Network Equilibrium plans to make use of existing relays wherever possible and install new ones where the existing relays are too old and have no setting control at all e.g. MVGO1. Currently we are investigating SuperTapp SG, MR Tapp Con and A-Eberle REG-D.

KS: What is minimum requirement for measurement points? How do you choose the right points to monitor the effect on LV customers?
It isn't safe to assume the end substation is the worst; a suggestion would be to evaluate the feeders and look volts mid-point as well as the end to check where the weakest point is.
Response: Monitoring is a key issue and requires some thought. The idea would be to maybe heavily monitor one circuit and then trial how much or little data is required to optimise the system.

AC: After the smart meter roll out some of this information can be determined from the data collected.
Some customers could show outside of limits but it is not having any noticeable effect.

KS: SPN have trialled alterative voltage setting point on 11kV – moved to 10.8kV with the option of a control engineer pressing a button and moving back to 11kV when needed.

A two pronged approach was taken dependant on the amount of generation:
Adjust the settings and monitor min and max then adjust the transformer setting.
It has the potential to change in line with demand, max demand 11kV middle of the day 9am- 5pm 10.8kV and then 5pm onwards back to 11kV.
For The SVO method would it be worth putting additional monitoring past the 11kV bars?
Response: This will be considered and investigated

AC: Within NPG control engineers are not able to change tap positions.

KS: The tap position is also dependant on the range i.e. 10 taps in either direction or 15 taps upwards and only 5 taps down, this could lead to running out of taps as one end.

KS: Monitoring of pole mounted closers – NOJA's communicates with IHost and has a VT inside. This could be used as part of SVO monitoring. Also GE Line sensor.
Response: Fitting a recloser in order to capture voltage data seems a little expensive. Alternate solutions are being looked at.

AC: Additional monitoring will need robust justification after smart metering is live and rolled out as this should provide a wealth of information.

Policies & Operation

AC: Currently tap changers are maintained on an operational basis not timed.

KS: SP use timed maintenance but does have operational readings to confirm the transformer is generally working ok.
Response: ENW, UKPN will be asked how they maintain theirs.

KS: Older transformers may actually perform better if increased taps as stronger units/ contacts etc. than new ones. It may be worth monitoring performance of both types of transformers and comparing results at the end of the trial.
Response: It is hoped that we will not see a significant increase in Tap changer activity.

KS: Is there a risk of SVO giving corrupted data and wrong values, can the SVO or the AVC be given set boundaries as a backstop to stop this. IE Max and Min values that are acceptable. Can this be set within the new relays being investigated or existing ones?
Response: Failsafe's and communication issues are a key consideration.

AC: There is a risk of setting lower volts for the connection of DG generators but the knock on effect means that volts could drop low enough for LV customers to have complaints. It would uncover any issues with the modelling.
Will the SVO operation be 'active' or have programmed settings?
If active and PV farms have intermittent cloud cover it could tap up and down in excess? Will the SVO wait for '**X** 'amount of time and access the situation before moving?
Possible different ways to model the SVO:
Lowest Voltage the more DG that can be connected, also less volts =less power so cheaper customer bills
Highest Voltage = Less losses
Optimal = highest voltage that reduces losses but still facilitates more DG connections.

How is the system balanced when SVO is not working?

If DG are connected based on SVO what happens if it is not operational? Customer turned off? Does this mean they would need Alternative Connection Agreement? Also Different Generators would need different attributable settings?
Response: There will have to be a 'Return to safe position' for when SVO is unavailable. This would require constraining the generators that have used the created capacity.

AC: Ideally would have a relay that had an export limiting device as part of its settings (Idea for a new project?)

2 Actions

Action SVO	Actionee	Due Date

3 Agreements

Agreement SVO	Requested by

Distribution: Attendees

SDRC2 Appendix I - Risk Register

1 Risk Register

Table 7-1 below details the high level project risks associated with implementation of SVO across the BSPs and Primary substations.

Table 7-1: High level risk register for SVO

Ref	Risk	Effect	Action
R1	Working in live substations	Potential harm / injury to personnel	All works to be carried out in accordance with CDM regulations and Distribution Safety Rules
R2	Selected substation is no longer available	SVO cannot be implemented at 8 BSPs and 8 Primary substations	Have 'reserve' substations that can be swapped with others if they become unavailable (due to a fault for example)
R3	AVC relays don't receive group or fine control settings	AVC relay has a setting that is not suitable for network operation	Ensure AVC relay has a fail-safe function that can revert to original settings in the event that communication is lost
R4	Voltage set points cannot be accurately determined	Spectrum Power 5 does not have a high confidence factor	For the first installation deploy as many voltage monitors as possible to achieve high confidence factor. Refine number and position of monitors for remaining substations
R5	Customer is sensitive to voltage variation	Customer is unable to operate as normal and submits complaints to WPD	Identify sensitive customers so that any constraints can be addressed before implementation of SVO.
R6	SVO relays aren't approved	Unable to have fine control for relays	Obtain approval for one or more SVO relays
R7	Substation equipment is not suitable for SVO implementation	SVO cannot be implemented at 8 BSPs and 8 Primary substations	Detailed installation reports carried out for all considered BSPs and Primaries