CLASS Commissioning Report

CLASS Project

Produced by: Electricity North West
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CONTENTS

VERSION HISTORY

Version	Date	Author	Status (draft, etc)	Comments
V1	*19 April 2014*	*Electricity North West*	*Final*	

GLOSSARY OF TERMS

Abbreviation	Term
ASC	*Autonomous Substation Controller*
AVC	*Automatic Voltage Control*
CLASS	*Customer Load Active System Services*
GSP	*Grid Supply Point*
HV	*High Voltage*
Ofgem	*Office of the Gas and Electricity Markets*
PC	*Profile Class*
PLS	*Peak Load Share*
SDRC	*Successful Delivery Reward Criteria*
TCMK	*Transformer Compound Marshalling Kiosk*

All other definitions shown starting with a Capital letter are as per LCN Fund Governance Document v6.

1 EXECUTIVE SUMMARY

The Ofgem Project Direction issued on 21St December 2012 outlines certain Successful Delivery Reward Criteria (SDRC), against which the success of the Customer Load Active System Services (CLASS) project will be assessed. For each criterion, the Project Direction defines the evidence that is required to demonstrate successful delivery.

There are seven discrete SDRC evidence required for the Technology Build Work stream of the CLASS project (as per the list below).

This report is the document to deliver evidence 4 on the list.

1. Publish the design of the regulation scheme for substation Voltage Controllers by February 2014
2. Publish the site selection report including the methodology by August 2013
3. Network monitoring equipment installed and commissioned by March 2014
4. ***Publish the commissioning reports by April 2014***
5. Technology go-live by April 2014
6. ICCP installed and commissioned by March 2014
7. Publish the ICCP commissioning reports by April 2014

This report describes the methodology for the commissioning of the autonomous substation controllers (ASC)

2 INTRODUCTION

The CLASS project is funded via Ofgem's Low Carbon Network (LCN) second tier funding mechanism. Electricity North West received formal notification of selection for funding on 21 December 2012. The project is due for completion by 30 September 2015.

CLASS is investigating how reactive power flow and demand response change when voltage is varied through Primary transformer taps. It is assessing opportunities for:-

i. Reducing network peak demand and so defer network reinforcement
ii. Providing frequency control though demand response
iii. Managing National Grid network voltages through reactive power absorption

Extensive CLASS trials are planned to assess the relationship between voltage and demand. During these trials, tap positions of parallel primary transformers will be changed simultaneously and staggered to observe the response of loads at different times of the day and throughout the annual load cycle. Trial results will enable the evaluation of the application of the CLASS principles.

This report shows the methodology used when commissioning the ASC which are required on site for the above functions to work. The scope of the work is to prove that the new autonomous substation control system can communicate correctly with the tap change relay in order to execute all functions needed.

3 CLASS INSTALLATION TYPES

To enable the maximum amount of learning during the trial period the 60 selected sites were split up into different installation types.

3.1 Type 1

This substation type already had the required MicroTAPP relay so all that was required was the fitting of the Siemens ASC. The primary frequency response (below 49.7Hz) which trips one of the two transformer circuit breakers in service is not available on this type.
See figure 1

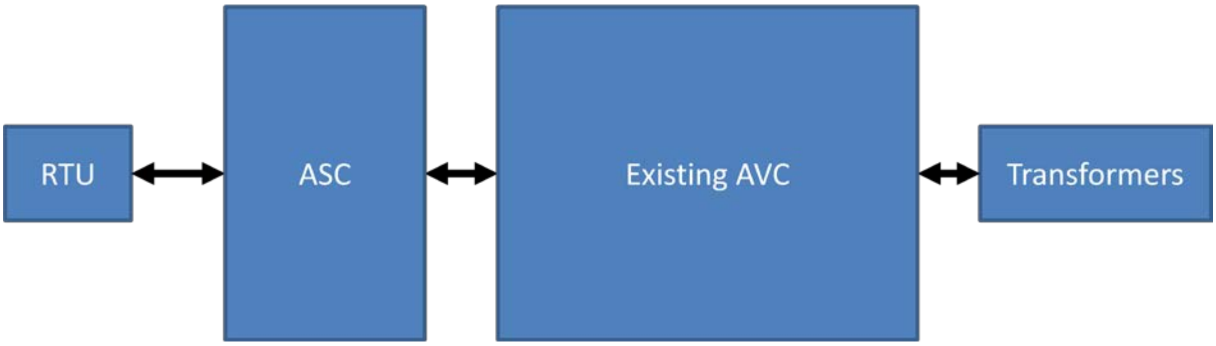

Figure 1 - Type 1 with existing MicroTAPP relay

3.2 Type 2

This substation type had legacy automatic voltage control relay (AVC) which had to be changed to a MicroTAPP relay in order for it to communicate with the ASC. The primary frequency response which trips one of the two transformer circuit breakers in service when the frequency falls below 49.7Hz at the selected primary is not available on this type. See figure 2

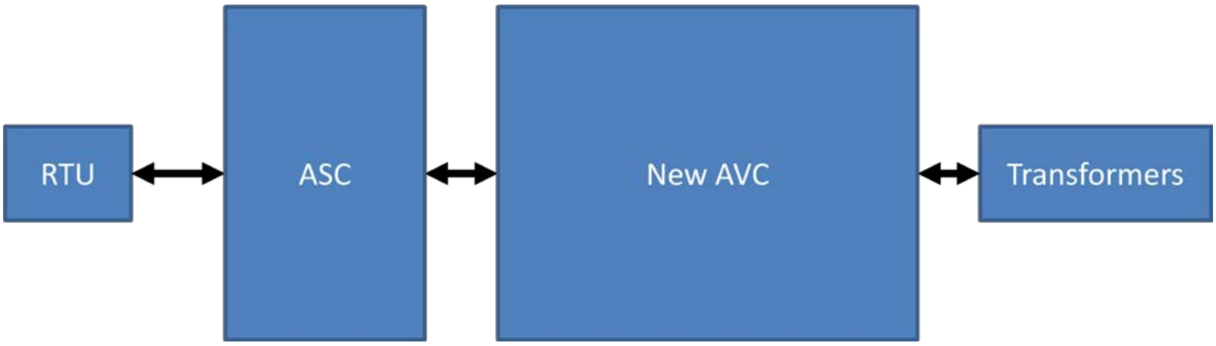

Figure 2 – Type 2 with new MicroTAPP relay

3.3 Type 3A & 3B

There are 10 substations of this type providing primary frequency response when the system frequency falls below 49.7Hz. These sites may have MicroTAPP (Type 3A) or Legacy AVC schemes (type 3B) with Argus8 interface relays fitted. See figures 3 & 4.

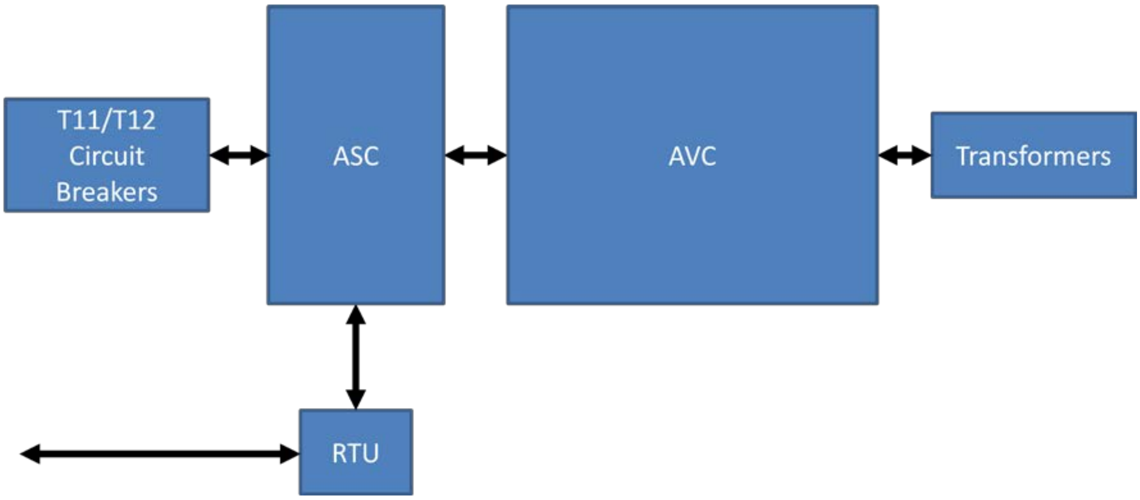

Figure 3 - Type 3A MicroTAPP solution with primary frequency response

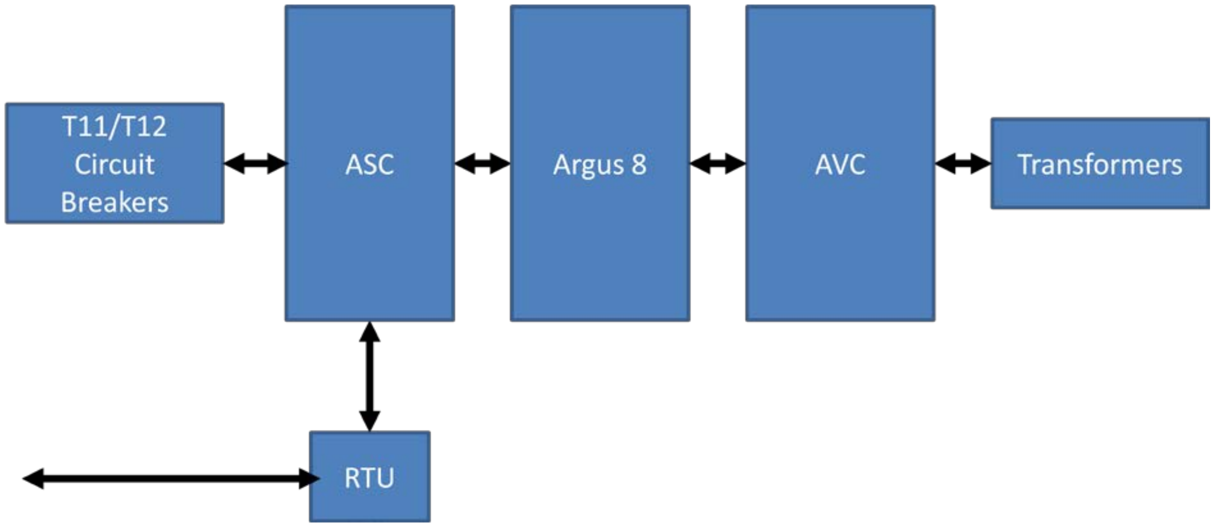

Figure 4 Type 3B Argus 8 Solution with primary frequency response

3.4 Type 4

This type uses an ARGUS 8 relay which acts as an interface between the ASC and a non MicroTAPP legacy AVC relay in order to test if the legacy AVC relays have to be changed to MicroTAPP for the CLASS functions to work. See figure 5

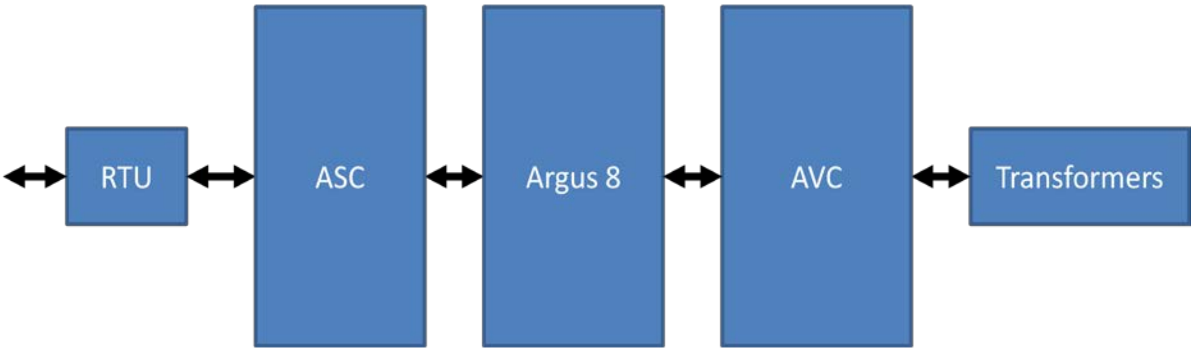

Figure 5 Type 4 Argus 8 Solution without primary frequency response.

4 COMMISSIONING TEST EQUIPMENT

The following calibrated and safety tested devices were used when commissioning the MicroTAPP relays, the Argus 8 relays and the Siemens ASC

OMICRON CMC 156

A PC-controlled test set which generates the test signals digitally (DSP technology), resulting in highly accurate testing signals even at small amplitudes.

Megger

Handheld insulation resistance and continuity tester

Multimeter

Handheld device with basic features such as the ability to measure voltage, current, and resistance

5 COMMISSIONING STRATEGY

No network outages were required for the commissioning of the ASC's and its communication path to the relevant tap change relay. The strategy was to initialise the ASC with a laptop using the toolbox software and upload the setting database for the primary in question. The existing MicroTAPP settings were saved as backup and new settings created which would allow it to receive commands from the ASC.

For all types of installation (Types1, 2, 3a, 3b, 4) the testing of the ASC to the AVC scheme was done under a Limitation of Access (LoA) safety document with the consent of the Control Engineer. Installation and testing of the 11/6.6kV T11/T12 circuit breaker tripping scheme was performed with circuit outages for the Type 3A and 3B sites.

Type 1

These sites had pre-exisiting MicroTAPP AVC relays. The ASC was installed under an LoA by a specialised installation team. This team also installed all multicores, multipairs and fibre optic wiring. The connection to 48v DC Power Supply for the ASC was made under personal supervision of an SAP in possession of an LoA. The local commissioning of the ASC to the MicroTAPP relays was performed by a Siemens Commissioning Engineer in possession of an LoA. The remote (telecontrol) commissioning was carried out by an SAP in possesion of an LoA with the consent of a Control Engineer.

Type 2

These sites had legacy AVC schemes which were replaced with MicroTAPP AVC relays. The ASC was installed under an LoA by a specialised installation team. This team also installed all multicores, multipairs and fibre optic wiring. The connection to 48v DC Power Supply for the ASC was made under personal supervision of an SAP in possession of an LoA. The local commissioning of the ASC to the MicroTAPP relays was performed by a Siemens Commissioning Engineer in possession of an LoA. The remote (telecontrol) commissioning was carried out by an SAP in possesion of an LoA with the consent of a Control Engineer.

The Type 2 sites required circuit outages to install and commission the new MicroTAPP AVC scheme. The work was performed under an LoA as part of a Control Engineer instructed pre-prepared switching programme. The Type 2 sites replaced the legacy AVC relays with a pair of MicroTAPP AVC relays. In order to commission the new MicroTAPP AVC scheme each tap changer had to be moved through every tap position. This was from tap 1 to tap 14 or 17, depending on the design of the transformer, and back down to tap 1. If the process had been performed live and on load very large circulating currents would have flowed and if taken off load the secondary side of the transformer would have easily exceeded UK statutory voltage limits.

MicroTAPP and the majority of legacy AVC schemes use line drop compensation (LDC) current transformers (CT) to assess the magnitude and power factor of the load in addition to the amount of circulating current between T11 and T12 primary transformers. The LDC CT is earthed on one side of its secondary wiring in order to prevent potentially dangerous voltages being induced or applied to that wiring. The commissioning engineer must therefore ensure that the CT is earthed on one side to ensure safety but not on both sides as this would prevent the scheme from operating correctly. The commissioning engineer also needs to ensure the integrity of the secondary wiring associated with the LDC CT. This was carried out by removing the LDC CT secondary wiring earth and insulation resistance testing the wiring before restoring this earth. To remove this earth and to have the possibility (during rewiring) of open circuiting the LDC CT secondary without the primary conductor being dead and off-load would be unsafe.

Type 3A

These sites had pre-existing MicroTAPP AVC relays. The ASC was installed under an LoA by a specialised installation team. This team also installed all multicores, multipairs and fibre optic wiring. The connection to 48v DC Power Supply for the ASC was made under personal supervision of an SAP in possession of an LoA. The local commissioning of the ASC to the MicroTAPP relays was performed by a Siemens Commissioning Engineer in possession of an LoA. The remote (telecontrol) commissioning was carried out by an SAP in possesion of an LoA with the consent of a Control Engineer.

The Type 3A sites required circuit outages to install and commission the new CLASS Frequency Trip Relay on T11 and T12 11/6.6kV circuit breaker (CB) trip wiring. The new CLASS Frequency Trip Relays for installation onto T11 and T12 11/6.6kV circuit breaker (CB) tripping schemes were bench tested. This was performed by secondary injection sets to check pick-up and drop off currents/ voltage and contact resistance prior to installation. The work was performed under an LoA as part of a Control Engineer instructed pre-prepared switching programme.

The Type 3A sites had pre-existing MicroTAPP AVC relays on each site. In order to install and commission the CLASS Frequency Trip Relay on the existing T11 11/6.6kV circuit breaker tripping scheme the circuit was previously reconfigured into an off load and dead state with the 33kV and 11/6.6kV CB closing disabled. Once the CLASS Frequency Trip wiring was commissioned with the 11/6.6kV T11 CB in an open state then an on load test was needed to fully commission the scheme. The T11 33kV CB and T11 11/6.6kV CB closing system was re-enabled. The T11 33kV CB and then the T11 11/6.6kV CB were closed via telecontrol. A live and on-load CLASS frequency trip was performed to to trip the T11 11/6.6kV CB. The Transformer was then confirmed as being off load but still energised as the 11/6.6kV CB is tripped but the associated 33kV CB remains closed for a CLASS frequency trip. T11 11/6.6kV CB was then closed to restore T11 to normal service. Once the T11 installation, commissioning and on load checking was finished the same process as stated above was performed on T12. Once both T12 and T11 CLASS frequency trips were commissioned the Control Engineer was informed that the CLASS Automatic Primary Frequency Response (APRF) and Manual Primary Frequency Response (MPFR) tripping functions were now available at this site.

The Type 3A and Type 3B sites required a permanent 48v DC supply to be available to cause the CLASS frequency trip relay to energise it's operate coil at anytime.

The Type 3A and Type 3B sites needed to continuously monitor the CB status of the T11/Bus-Section and T12 11/6.6kV CB. This was to provide local interlocking of the APFR and MPFR frequency tripping functions whereby if any of these three CB are 'OPEN' then those functions are automatically locally disabled in addition to the software interlocking on the GE PoF dashboard at the central control room. At some of the Type 3A sites this was achieved by monitoring unused auxiliary contacts in the CBs..

Due to the design and historic modifications to legacy switchgear some of the Type 3A and all of the Type 3B sites they did not have spare auxiliary contacts inside the CBs to provide the required CB status inputs to the ASC for the frequency tripping interlocking. Designs were proposed that changed the internal wiring of the CBs and utilised additional relays to provide status information to telecontrol (SCADA) and the ASC. This would have caused CB internal wiring to become non-standard increasing the risk of future operational issues/maintenance/interoperability and introducing increased complexity and risk by placing intermediate relays between the CBs and telecontrol (SCADA). In order to avoid these risks an innovation was tried where the ASC CB status inputs would be 'piggy-backed' off the existing telecontrol CB status wiring in the telecontrol RTU (SCADA outstation). The main concern with this approach was the potential increased burden on the telecontrol plant status outstation card and thus the risk of a DBI (double break indication) condition appearing on telecontrol. The input impedance of the CLASS ASC CB status inputs was found to be in the order of 50k Ohms and thus both in theory and practice caused no significant increase in burden (1mA).

Type 3B

These sites had legacy AVC schemes which used new ARGUS 8 relays to interface with the CLASS ASC. The ASC was installed under an LoA by a specialised installation team. This team also installed all multicores, multipairs and fibre optic wiring. The connection to 48v DC Power Supply for the ASC was made under personal supervision of an SAP in possession of an LoA. The local commissioning of the ASC to the MicroTAPP relays was performed by a Siemens Commissioning Engineer in possession of an LoA. The remote (telecontrol) commissioning (was done by an SAP in possesion of an LoA with the consent of a Control Engineer.

The Type 3B sites required circuit outages to install and commission the new CLASS Argus 8 interface relays, the load monitor transducers and the Frequency Trip Relay on T11 and T12 11/6.6kV circuit breaker (CB) tripping wiring. The new CLASS Frequency Trip Relays for installation onto T11 and T12 11/6.6kV circuit breaker (CB) tripping schemes were bench tested. This was performed by secondary injection sets to check pick-up and drop off currents/ voltage and contact resistance prior to installation. The work was performed under an LoA as part of a Control Engineer instructed pre-prepared switching programme.

The Type 3B sites first required circuit outages to install and commission the new ARGUS 8 AVC interface scheme. These acted as the interface between legacy AVC schemes and the CLASS ASC which used fibre optic communications routes. The work was performed under an LoA as part of a Control Engineer instructed pre-prepared switching programme. The Type 3B sites used the ARGUS 8 relays as a substitute for the MicroTAPP functionality. This did not however involve the Tap Stagger Function (TSF) as most of the Type 3B legacy schemes were Master/Follower or Circulating Current schemes that would have required major redesign and rewiring to prevent out-of-step/ lock-out situations arising in tap stagger mode especially where tap position information was not readily available from a second set of Tap Position Indication (TPI) resistors on each transformer. In order to commission the new ARGUS 8 AVC interface scheme each AVC scheme had to have its input voltage modified at each of the ARGUS 8 interposing VT tap positions. In order to provide transformer load information to the ASC a load current transducer was fitted in series with the transformer LDC CT. This transformer load information was required for a number of the CLASS functions but in particular Automatic Demand Reduction Function –Network Reinforcement Deferral (ADRF-NRD) and APFR required it to work effectively.

The LDC CT is earthed on one side of its secondary wiring in order to prevent potentially dangerous voltages being induced or applied to that wiring. In order to install the load current transducer the commissioning engineer requires the primary circuit to be off load or to have purpose designed CT shorting links to be available between the point of work and the LDC CT itself. Were such purpose built links are unavailable the commissioning engineer must therefore ensure the circuit is off load and that the LDC CT is shorted out so between the point of work and the LDC CT

Once the Type 3B sites had ARGUS 8 AVC interface relays on each site the CLASS frequency tripping relays could be installed (as the ASC needed to be in situ to be able to test the function). In order to install and commission the CLASS Frequency Tripping Relay on the existing T11 11/6.6kV circuit breaker tripping scheme the circuit was previously reconfigured into an off load and dead state with the 33kV and 11/6.6kV CB closing disabled. Once the CLASS Frequency Tripping wiring was commissioned with the 11/6.6kV T11 CB in an open state then an on load test was needed to fully commission the scheme. The T11 33kV CB and T11 11/6.6kV CB closing system was re-enabled. The T11 33kV CB and then the T11 11/6.6kV CB were closed via telecontrol. A live and on-load CLASS frequency trip was performed to to trip the T11 11/6.6kV CB. The Transformer was then confirmed as being off load but still energised as the 11/6.6kV CB is tripped but the associated 33kV CB remains closed for a CLASS frequency trip. T11 11/6.6kV CB was then closed to restore T11 to normal service. Once the T11 installation, commissioning and on load checking was finished the same process as stated above was performed on T12.

Type 4

These sites had legacy AVC schemes which used new ARGUS 8 relays to interface with the CLASS ASC. The ASC was installed under an LoA by a specialised installation team. This team also installed all multicores, multipairs and fibre optic wiring. The connection to 48v DC Power Supply for the ASC was made under personal supervision of an SAP in possession of an LoA. The local commissioning of the ASC to the MicroTAPP relays was performed by a Siemens Commissioning Engineer in possession of an LoA. The remote (telecontrol) commissioning was done by an SAP in possession of an LoA with the consent of a Control Engineer.

The Type 4 sites required circuit outages to install and commission the new ARGUS 8 AVC interface scheme. These acted as the interface between legacy AVC schemes and the CLASS ASC which used fibre optic communications routes. The work was performed under an LoA as part of a Control Engineer instructed pre-prepared switching programme. The Type 4 sites used the ARGUS 8 relays as a substitute for the MicroTAPP functionality. This did not however involve the Tap Stagger Function (TSF) as most of the Type 4 legacy schemes were Master/Follower or Circulating Current schemes that would have required major redesign and rewiring to prevent out-of-step/ lock-out situations arising in tap stagger mode especially where tap position information was not readily available from a second set of Tap Position Indication (TPI) resistors on each transformer. In order to commission the new ARGUS 8 AVC interface scheme each AVC scheme had to have its input voltage modified at each of the ARGUS 8 interposing VT tap positions. In order to provide transformer load information to the ASC a load current transducer was fitted in series with the transformer LDC CT. This transformer load information was required for a number of the CLASS functions but in particular Automatic Demand Reduction Function –Network Reinforcement Deferral (ADRF-NRD) and APFR required it to work effectively.

APPENDIX A – PRIMARY SUBSTATION CLASS TRIAL SELECTION

GROUP	Primary	Type
BOLD	ASHTON-Golborne	4
	GOLBORNE	3A
BREDBURY	WINIFRED RD	2
	FALLOWFIELD	3A
	LONGSIGHT	3B
	MOSS SIDE (Longsight)	4
	VICTORIA PARK	1
	LEVENSHULME	2
	ROMILEY	3B
CARRINGTON	GREEN LANE-Altrincham	4
	CHASSEN RD	4
	TRAFFORD PARK NORTH	2
	IRLAM	3A
	BAGULEY	3A
HARKER / HUTTON	EGREMONT	2
	KIRKBY STEPHEN	2
	CHATSWORTH ST	2
	ANNIE PIT	4
HEYSHAM	BURROW BECK	2
	WESTGATE	1
KEARSLEY	HARWOOD	2
	CHAMBERHALL	2
	BLACKFRIARS	3A
	TRINITY	1
	LOSTOCK	4
KEARSLEY LOCAL	CARR ST	1
	CAMPBELL ST	2
MACCLESFIELD	BOLLINGTON	2
	S.W. MACCLESFIELD	2
ROCHDALE / PADIHAM	KINGSWAY	1
	LITTLEBOROUGH	2
	HEADY HILL	2
	HYNDBURN RD	3A
PENWORTHAM EAST / ROCHDALE SGT1	AVENHAM	4
	DOUGLAS ST	4
	GRIFFIN	1
	BAMBER BRIDGE	1
PENWORTHAM WEST / STANNAH	BUCKSHAW	1
	TARLETON	1
	CECIL ST	1
	BLACKPOOL	1
	CLEVELEYS	2

GROUP	Primary	Type
SOUTH MANCHESTER	DICKINSON ST	2
	WILMSLOW	2
	BRIDGEWATER	2
	DIDSBURY	1
	WITHINGTON	2
STALYBRIDGE	DENTON EAST	2
	DROYLSDEN EAST	2
	OPENSHAW	2
	CENTRAL MANCHESTER	3A
	HYDE	2
	GOWHOLE	2
	STUART ST	2
WASHWAY FARM	SKELMERSDALE	2
	KITT GREEN	2
	UPHOLLAND	2
WHITEGATE	MIDDLETON JUNCTION	3A
	BELGRAVE	1
	WILLOWBANK	2

APPENDIX B – TYPE 1 COMMISSIONING REPORT - GRIFFIN

Method/Programme

Action		Complete
1.	IR test supply cable between 48Vdc battery and ASC.	✓
2.	Confirm correct polarity of the above cable inside ASC at mcb1.	✓
3.	Check wiring for continuity and ferruling in ASC panel	✓
4.	Confirm continuity and ferruling of the multi-pair cable from RTU to ASC with ASC and RTU terminal links open.	✓
5.	Switch mcb1 on. Verify that cable from SFC module is connected to SICAM port X7.	✓
6.	Initialize Autonomous substation control system using laptop with toolbox software. Verify that no error LED is on.	✓
7.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	✓
8.	Download setting group A from existing microTAPPs and save them.	✓
9.	Modify above setting A according to ENW requirements so as microTAPPs to be able to work with all functions. In order to do that Setting group A should be multiplied to three setting groups A,B,C and these to be uploaded back to microTAPPs.	✓
10.	Autonomous substation control system is ready to be tested.	✓
11.	Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.	✓
12.	Enable tap stagger function one ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	✓
13.	Enable tap stagger function two from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	✓
14.	Enable tap stagger function three from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. . Record the results to tables 2 and 3.	✓
15.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	✓

Page 3 of 9

16.	Connect test plugs to test sockets of the existing microTAPP panels in order to do secondary injection with omicron device. Before that terminals 1-2, 3-4, 11-12, 19-20, 21-22, 23-24,25-27 of the test plug should be linked otherwise MicroTAPPs will be switched off.	✓
17.	Connect omicron voltage outputs to terminals 6,8,10 and current outputs to terminals 26 and 28 of the test plugs.	✓
18.	Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.	✓
19.	Inject nominal voltage and current less than 98.5% of the nominal so as Power factor to be as in microTAPPs settings (i.e. for microTAPP PF 0.97 lagging change current phase B angle 14deg from -120 to -134). While performing TSF1, 2, 3 increase the substation load above upper limit that is 98.5%. Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.	✓
20.	While performing TSF1, 2, 3, drop the voltage below limit, 96% (60.97 Volts). Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.	✓
21.	Increase substation load (Two transformers load) beyond limit, above 98.5%, to simulate high load condition, and then apply TSF1, TSF2 and TSF3. Check that no operation is performed. Confirm to tables 2 and 3.	✓
22.	Activate demand boost full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 106% (67.32 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.	✓
23.	Activate demand boost half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 104.5% (66.37 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.	✓
24.	Enable demand reduction full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 98.8% (62.75 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function	✓

25.	**Activate demand reduction half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 100.9% (64 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function**	✓
26.	**Enable automatic demand reduction function ADRF-NRD from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Set the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %.) After red led HIGH flashes we decrease the injecting voltage from the omicron to 98.8% (62.75 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 6.**	✓
27.	**Decrease the voltage to 96% (60.97 Volts) check function is deactivated and that microTAPPs try to tap up. Record the results to table 6.**	✓
28.	**Set again the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %). After red led HIGH flashes we decrease the injecting voltage from the omicron to 98.8% (62.75 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Reduce the load to 90% and after 1 min expires verify that function is still activated. Record the results to table 6.**	✓
29.	**Drop the load below 85% and wait for 1 minute. Verify that ADRF deactivates. Record the results to table 6.**	✓
30.	**Temporary change setting of auxiliary voltage 2 at setting group 1 from 98.8% to 103.5%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs to 49,75Hz and see when function will be activated. Verify that correct BOs and LEDs are coming up in the ASC modules. Measure the time until ASFR is deactivated. Record the results to table 7.**	✓
31.	**Restore setting of auxiliary voltage 2 at setting group 1 from 103.5% to 98.8%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs until function will be activated. Record the results to table 7.**	✓
32.	**Verify all functions are disabled.**	✓
33.	**Remove microTAPPs from AUTO/REMOTE to LOCAL/MANUAL position and stop secondary injection.**	✓
34.	**Disconnect test plugs and remove back microTAPPs to AUTO/REMOTE position.**	✓

Table 2

TRAFO T11	Before	TSF1	TSF2	TSF3
Tap position	10	10	10	11
Load current	0.428 @ -9°	0.458 @ -9°	0.466 @ -8°	0.460 @ -10°
Transformer current	0.216 @ -8°	0.245 @ -17°	0.245 @ -16°	0.275 @ -30°
Circulating current	0.020	-0.015	-0.012	-0.078
Bus coupler current	No indication	NI	NI	NI
ASCS outputs activated: O07	✓	✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Table 3

TRAFO T12	Before	TSF1	TSF2	TSF3
Tap position	10	09	09	08
Load current	0.428 @ -9°	0.458 @ -9°	0.466 @ -8°	0.460 @ -10°
Transformer current	0.214 @ -9°	0.222 @ -0°	0.223 @ -0°	0.220 @ +15°
Circulating current	0.020	0.055	0.055	0.11
Bus coupler current	No indication	NI	NI	NI
ASCS outputs activated: O07	✓	✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Table 4

Action	Result	Pass/ Fail
DBF-FULL Activate the DBF-FULL function After first tap up inject with omicron voltage equal to upper limit in order microTAPPs to stop increasing the substation voltage	Check that both microTAPPs' voltage set points are set to upper safe limit (106%) Check that both transformers tap up to give maximum allowed load (MVA) boost. ASCS outputs activated: O05	✓
Set both transformer loads to maximum (i.e. 98.5%) and apply the DBF-FULL function	Check that no operation is performed	✓
Set nominal voltage to be above limit (i.e. above 110%)	Check that no operation is performed	✓
DBF-HALF Activate the DBF-HALF function	Check that the voltage set points are set to halfway the upper limit (i.e. 104.5%) Check that both transformers tap up to give half the available load (MVA) boost ASCS outputs activated: O06	✓
Change from one function to another (i.e. from DBF FULL to DBF HALF to DRF FULL to DRF HALF)	Check that target voltage doesn't change until it gets to new function	✓
Set voltage outside limit (i.e. above 110%) and apply DBF-HALF	Check that no operation is performed	✓
Set load outside limit (e.g. 100%) and apply DBF-HALF	Check that no operation is performed	✓

Table 5

Action	Result	Pass/ Fail
DRF-NGT FULL Activate the function After first tap up inject with omicron voltage equal to lower limit in order microTAPPs to stop decreasing the substation voltage	Check that voltage set points of both transformers set to lower limit (98.8%). Check that both transformers tap down to give maximum allowed load (MVA) reduction ASCS outputs activated: O010	✓
Set the voltage below the limit (i.e. below 96%)	Check that the function deactivates and returns back to nominal voltage (103.5%)	✓
DRF-NGT HALF Activate the function	Check that the voltage set points of both transformers set to halfway the lower limit (100.9%)	✓
	Check that both transformers tap down to give half the available load (MVA) reduction ASCS outputs activated: O011	✓
Set the voltage below the limit (i.e. below 96%)	Check that the function deactivates and returns back to nominal voltage (103.5%)	✓
Increase load to limit and activate the function	Check that the function is activated.	✓

Table 6

	Action	Result	Pass/Fail
	Enable the ADFR function	Check that the function is enabled ASCS outputs activated: O013	✓
ASC – microTAPP	Set the load to break the maximum load capacity (i.e. above 98.5%	Check that the voltage set points drop to lower limit (98.8%) and that both transformers try to tap down. ASCS outputs activated: O012	✓
	Reduce the voltage to 96%	Check that transformers tap up and ADRF deactivates.	✓
	Drop the load at 90% and wait for 1 minute.	Check that ADFR is not deactivated	✓
	Drop the load at 84% and wait for 1 minute.	Check that ADFR is deactivated	✓

Table 7

Action	Expected	Result	Pass/Fail
ASFR Pickup	49.8Hz	49,81Hz	√
Time before the transformers start to tap down.	<10sec	6	√
ASFR sustained time	32min for load<20%	√	√
Set the frequency back within limit (e.g. 49.9Hz) before voltage reduction time expires	No action	√	√
ASCS outputs activated: O03, O04	Yes	√	√

Page 9 of 9

APPENDIX C – TYPE 2 COMMISSIONING REPORT – DROYLSDEN EAST

Method/Programme

Action		Complete
1.	IR test supply cable between 48Vdc battery and ASC.	√
2.	Confirm correct polarity of the above cable inside ASC at mcb1.	√
3.	Check wiring for continuity and ferruling in ASC panel	√
4.	Confirm continuity and ferruling of the multi-pair cable from RTU to ASC with ASC and RTU terminal links open.	√
5.	Switch mcb1 on. Verify that cable from SFC module is connected to SICAM port X7.	√
6.	Initialize Autonomous substation control system using laptop with toolbox software. Verify that no error LED is on.	√
7.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	√
8.	Download setting group A from existing microTAPPs and save them.	√
9.	Modify above setting A according to ENW requirements so as microTAPPs to be able to work with all functions. In order to do that Setting group A should be multiplied to three setting groups A,B,C and these to be uploaded back to microTAPPs.	√
10.	Autonomous substation control system is ready to be tested.	√
11.	Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.	√
12.	Enable tap stagger function one ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	√
13.	Enable tap stagger function two from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	√
14.	Enable tap stagger function three from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. . Record the results to tables 2 and 3.	√
15.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	√

Page 3 of 9

16.	**Connect test plugs to test sockets of the existing microTAPP panels in order to do secondary injection with omicron device. Before that terminals 1-2, 3-4, 11-12, 19-20, 21-22, 23-24,25-27 of the test plug should be linked otherwise MicroTAPPs will be switched off.**	✓
17.	**Connect omicron voltage outputs to terminals 6,8,10 and current outputs to terminals 26 and 28 of the test plugs.**	✓
18.	**Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.**	✓
19.	**Inject nominal voltage and current less than 98.5% of the nominal so as Power factor to be as in microTAPPs settings (i.e. for microTAPP PF 0.97 lagging change current phase B angle 14deg from -120 to -134). While performing TSF1, 2, 3 increase the substation load above upper limit that is 98.5%. Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.**	✓
20.	**While performing TSF1, 2, 3, drop the voltage below limit, 92% (58.42 Volts). Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.**	✓
21.	**Increase substation load (Two transformers load) beyond limit, above 98.5%, to simulate high load condition, and then apply TSF1, TSF2 and TSF3. Check that no operation is performed. Confirm to tables 2 and 3.**	✓
22.	**Activate demand boost full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 106% (67.32 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.**	✓
23.	**Activate demand boost half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 103% (65.41 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.**	✓
24.	**Enable demand reduction full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function**	✓

25.	**Activate demand reduction half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 97% (61.60 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function**	✓
26.	**Enable automatic demand reduction function ADRF-NRD from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Set the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %.) After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 6.**	✓
27.	**Decrease the voltage to 92% (58.42 Volts) check function is deactivated and that microTAPPs try to tap up. Record the results to table 6.**	✓
28.	**Set again the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %). After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Reduce the load to 90% and after 1 min expires verify that function is still activated. Record the results to table 6.**	✓
29.	**Drop the load below 85% and wait for 1 minute. Verify that ADRF deactivates. Record the results to table 6.**	✓
30.	**Temporary change setting of auxiliary voltage 2 at setting group 1 from 95% to 99.5%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs to 49,75Hz and see when function will be activated. Verify that correct BOs and LEDs are coming up in the ASC modules. Measure the time until ASFR is deactivated. Record the results to table 7.**	✓
31.	**Restore setting of auxiliary voltage 2 at setting group 1 from 99.5% to 95%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs until function will be activated. Record the results to table 7.**	✓
32.	**Verify all functions are disabled.**	✓
33.	**Remove microTAPPs from AUTO/REMOTE to LOCAL/MANUAL position and stop secondary injection.**	✓
34.	**Disconnect test plugs and remove back microTAPPs to AUTO/REMOTE position.**	✓

Table 2

TRAFO T11	Before	TSF1	TSF2	TSF3
Tap position	05	06	06	07
Load current	0.473@ -2°	0.545@ -4°	0.545@ -4°	0.555@ -4°
Transformer current	0.232@ -4°	0.274@ -11°	0.274@ -11°	0.292@ -19°
Circulating current	0.034	0.006	0.006	-0.029
Bus coupler current	No indication	NII	NII	NII
ASCS outputs activated: O07		✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Table 3

TRAFO T12	Before	TSF1	TSF2	TSF3
Tap position	05	05	05	05
Load current	0.473@ -2°	0.545@ -4°	0.545@ -4°	0.555@ -4
Transformer current	0.248@ -1°	0.276@ 6°	0.276@ 6°	0.282@ 11°
Circulating current	0.056	0.095	0.095	0.123
Bus coupler current	No indication	NII	NII	NII
ASCS outputs activated: O07		✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Page 6 of 9

Table 4

Action	Result	Pass/ Fail
DBF-FULL Activate the DBF-FULL function After first tap up inject with omicron voltage equal to upper limit in order microTAPPs to stop increasing the substation voltage	Check that both microTAPPs' voltage set points are set to upper safe limit (106%) Check that both transformers tap up to give maximum allowed load (MVA) boost. ASCS outputs activated: O05	√
Set both transformer loads to maximum (i.e. 98.5%) and apply the DBF-FULL function	Check that no operation is performed	√
Set nominal voltage to be above limit (i.e. above 110%)	Check that no operation is performed	√
DBF-HALF Activate the DBF-HALF function	Check that the voltage set points are set to halfway the upper limit (i.e. 103%) Check that both transformers tap up to give half the available load (MVA) boost ASCS outputs activated: O06	√
Change from one function to another (i.e. from DBF FULL to DBF HALF to DRF FULL to DRF HALF)	Check that target voltage doesn't change until it gets to new function	√
Set voltage outside limit (i.e. above 110%) and apply DBF-HALF	Check that no operation is performed	√
Set load outside limit (e.g. 100%) and apply DBF-HALF	Check that no operation is performed	√

Page 7 of 9

Table 5

Action	Result	Pass/ Fail
DRF-NGT FULL Activate the function After first tap up inject with omicron voltage equal to lower limit in order microTAPPs to stop decreasing the substation voltage	Check that voltage set points of both transformers set to lower limit (95%). Check that both transformers tap down to give maximum allowed load (MVA) reduction ASCS outputs activated: O010	√
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	√
DRF-NGT HALF Activate the function	Check that the voltage set points of both transformers set to halfway the lower limit (97%)	√
	Check that both transformers tap down to give half the available load (MVA) reduction ASCS outputs activated: O011	√
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	√
Increase load to limit and activate the function	Check that the function is activated.	√

Table 6

	Action	Result	Pass/Fail
	Enable the ADFR function	Check that the function is enabled ASCS outputs activated: O013	√
ASC – microTAPP	Set the load to break the maximum load capacity (i.e. above 98.5%	Check that the voltage set points drop to lower limit (95%) and that both transformers try to tap down. ASCS outputs activated: O012	√
	Reduce the voltage to 92%	Check that transformers tap up and ADRF deactivates.	√
	Drop the load at 90% and wait for 1 minute.	Check that ADFR is not deactivated	√
	Drop the load at 84% and wait for 1 minute.	Check that ADFR is deactivated	√

Page 8 of 9

Table 7

Action	Expected	Result	Pass/Fail
ASFR Pickup	49.8Hz	49,81 Hz	√
Time before the transformers start to tap down.	<10sec	5 sec	√
ASFR sustained time	32min for load<20%	32min	√
Set the frequency back within limit (e.g. 49.9Hz) before voltage reduction time expires	No action	√	√
ASCS outputs activated: O03, O04	Yes	√	√

Page 9 of 9

APPENDIX D – TYPE 3A COMMISSIONING REPORT – HYNDBURN ROAD

Method/Programme

Action		Complete
1.	IR test supply cable between 48Vdc battery and ASC.	√
2.	Confirm correct polarity of the above cable inside ASC at mcb1.	√
3.	Check wiring for continuity and ferruling in ASC panel	√
4.	Confirm continuity and ferruling of the multi-pair cable from RTU to ASC with ASC and RTU terminal links open.	√
5.	Switch mcb1 on. Verify that cable from SFC module is connected to SICAM port X7.	√
6.	Initialize Autonomous substation control system using laptop with toolbox software. Verify that no error LED is on.	√
7.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	√
8.	Download setting group A from existing microTAPPs and save them.	√
9.	Modify above setting A according to ENW requirements so as microTAPPs to be able to work with all functions. In order to do that Setting group A should be multiplied to three setting groups A,B,C and these to be uploaded back to microTAPPs.	√
10.	Autonomous substation control system is ready to be tested.	√
11.	Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.	√
12.	Enable tap stagger function one ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	√
13.	Enable tap stagger function two from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. Record the results to tables 2 and 3.	√
14.	Enable tap stagger function three from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Write down from the microTAPP menu new tap positions load and transformer currents and circulating current. . Record the results to tables 2 and 3.	√
15.	Remove MicroTAPPs from AUTO/REMOTE to LOCAL/MANUAL position	√

Page 3 of 13

16.	Connect test plugs to test sockets of the existing microTAPP panels in order to do secondary injection with omicron device. Before that terminals 1-2, 3-4, 11-12, 19-20, 21-22, 23-24,25-27 of the test plug should be linked otherwise MicroTAPPs will be switched off.	✓
17.	Connect omicron voltage outputs to terminals 6,8,10 and current outputs to terminals 26 and 28 of the test plugs.	✓
18.	Remove microTAPPs from LOCAL/MANUAL back to AUTO/REMOTE.	✓
19.	Inject nominal voltage and current less than 98.5% of the nominal so as Power factor to be as in microTAPPs settings (i.e. for microTAPP PF 0.97 lagging change current phase B angle 14deg from -120 to -134). While performing TSF1, 2, 3 increase the substation load above upper limit that is 98.5%. Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.	✓
20.	While performing TSF1, 2, 3, drop the voltage below limit, 92% (58.42 Volts). Check that the ASC suspends the tap staggering action. Confirm to tables 2 and 3.	✓
21.	Increase substation load (Two transformers load) beyond limit, above 98.5%, to simulate high load condition, and then apply TSF1, TSF2 and TSF3. Check that no operation is performed. Confirm to tables 2 and 3.	✓
22.	Activate demand boost full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 106% (67.32 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.	✓
23.	Activate demand boost half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led LOW flashes we increase the injecting voltage from the omicron to 103% (65.41 Volts) that is the new target voltage of the microTAPPs in order to stop taping. After NORMAL led lights deactivate function Record the results to table 4.	✓
24.	Enable demand reduction full function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function	✓

25.	Activate demand reduction half function from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. After red led HIGH flashes we decrease the injecting voltage from the omicron to 97% (61.60 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 5. After NORMAL led lights deactivate function	✓
26.	Enable automatic demand reduction function ADRF-NRD from ASC. Verify that correct BOs and LEDs are coming up in the ASC modules. Set the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %.) After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Record the results to table 6.	✓
27.	Decrease the voltage to 92% (58.42 Volts) check function is deactivated and that microTAPPs try to tap up. Record the results to table 6.	✓
28.	Set again the load to break the maximum load (Two transformers load) capacity (i.e. above 98.5 %). After red led HIGH flashes we decrease the injecting voltage from the omicron to 95% (60.33 Volts) that is the new target voltage of the microTAPPs in order to stop taping. Reduce the load to 90% and after 1 min expires verify that function is still activated. Record the results to table 6.	✓
29.	Drop the load below 85% and wait for 1 minute. Verify that ADRF deactivates. Record the results to table 6.	✓
30.	Temporary change setting of auxiliary voltage 2 at setting group 1 from 95% to 99.5%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs to 49,75Hz and see when function will be activated. Verify that correct BOs and LEDs are coming up in the ASC modules. Measure the time until ASFR is deactivated. Record the results to table 7.	✓
31.	Restore setting of auxiliary voltage 2 at setting group 1 from 99.5% to 95%. Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs until function will be activated. Record the results to table 7.	✓
32.	Connect APFR reset activated, T11 and T12 LV interpose open signals to omicron device inputs then test APRF function according to Table 8.	✓
33.	Connect MPFR activated, T11 and T12 LV interpose open signals to omicron device inputs then test MPRF function according to Table 8.	✓
34.	Verify all functions are disabled.	✓
35.	Remove microTAPPs from AUTO/REMOTE to LOCAL/MANUAL position and stop secondary injection.	✓

36.	**Disconnect test plugs and remove back microTAPPs to AUTO/REMOTE position.**	✓

Table 2

TRAFO T11	Before	TSF1	TSF2	TSF3
Tap position	06	06	07	07
Load current	0.420 @ -12°	0.420 @ -12°	0.414 @ -11°	0.422 @ -11°
Transformer current	0.223 @ -18°	0.223 @ -18°	0.233 @ -25°	0.25 @ -29°
Circulating current	-0.019	-0.019	-0.047	-0.069
Bus coupler current	65.93A	65.93A	124.5A	175.8A
ASCS outputs activated: O07		✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Table 3

TRAFO T12	Before	TSF1	TSF2	TSF3
Tap position	05	05	05	04
Load current	0.420 @ -12°	0.420 @ -12°	0.414 @ -11°	0.422 @ -11°
Transformer current	0.203 @ -4°	0.203 @ -4°	0.202 @ 3°	0.2 @ 12°
Circulating current	0.031	0.031	0.063	0.085
Bus coupler current	65.93A	65.93A	124.5A	175.8A
ASCS outputs activated: O07		✓	✓	✓
Increase the load above upper limit suspends the tap stagger		✓	✓	✓
Drop the voltage below limit suspends the tap staggering		✓	✓	✓
High load condition blocks TSF		✓	✓	✓

Page 7 of 13

Table 4

Action	Result	Pass/ Fail
DBF-FULL Activate the DBF-FULL function After first tap up inject with omicron voltage equal to upper limit in order microTAPPs to stop increasing the substation voltage	Check that both microTAPPs' voltage set points are set to upper safe limit (106%) Check that both transformers tap up to give maximum allowed load (MVA) boost. ASCS outputs activated: O05	✓
Set both transformer loads to maximum (i.e. 98.5%) and apply the DBF-FULL function	Check that no operation is performed	✓
Set nominal voltage to be above limit (i.e. above 110%)	Check that no operation is performed	✓
DBF-HALF Activate the DBF-HALF function	Check that the voltage set points are set to halfway the upper limit (i.e. 103%) Check that both transformers tap up to give half the available load (MVA) boost ASCS outputs activated: O06	✓
Change from one function to another (i.e. from DBF FULL to DBF HALF to DRF FULL to DRF HALF)	Check that target voltage doesn't change until it gets to new function	✓
Set voltage outside limit (i.e. above 110%) and apply DBF-HALF	Check that no operation is performed	✓
Set load outside limit (e.g. 100%) and apply DBF-HALF	Check that no operation is performed	✓

Page 8 of 13

Table 5

Action	Result	Pass/ Fail
DRF-NGT FULL Activate the function After first tap up inject with omicron voltage equal to lower limit in order microTAPPs to stop decreasing the substation voltage	Check that voltage set points of both transformers set to lower limit (95%). Check that both transformers tap down to give maximum allowed load (MVA) reduction ASCS outputs activated: O010	✓
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	✓
DRF-NGT HALF Activate the function	Check that the voltage set points of both transformers set to halfway the lower limit (97%)	✓
	Check that both transformers tap down to give half the available load (MVA) reduction ASCS outputs activated: O011	✓
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	✓
Increase load to limit and activate the function	Check that the function is activated.	✓

Table 6

	Action	Result	Pass/Fail
	Enable the ADFR function	Check that the function is enabled ASCS outputs activated: O013	✓
ASC – microTAPP	Set the load to break the maximum load capacity (i.e. above 98.5%	Check that the voltage set points drop to lower limit (95%) and that both transformers try to tap down. ASCS outputs activated: O012	✓
	Reduce the voltage to 92%	Check that transformers tap up and ADRF deactivates.	✓
	Drop the load at 90% and wait for 1 minute.	Check that ADFR is not deactivated	✓
	Drop the load at 84% and wait for 1 minute.	Check that ADFR is deactivated	✓

Table 7

Action	Expected	Result	Pass/Fail
ASFR Pickup	49.8Hz	49,82Hz	√
Time before the transformers start to tap down.	<10sec	2,7 sec	√
ASFR sustained time	32min for load<20%	32 min	√
Set the frequency back within limit (e.g. 49.9Hz) before voltage reduction time expires	No action	√	√
ASCS outputs activated: O03, O04	Yes	√	√

Table 8

Action	Result	Pass/Fail
Set the frequency measured by microTAPP to a value below the APFR's limit(i.e. below 49.7Hz), to simulate network's frequency drop	Check that the ASC receives the low frequency signal and is activated	√
	Check that one of the closed circuit breakers opens to trip its transformer.	
	Check that the voltage set point is lowered and that voltage drops	√
	Check that time delay starts to count down (30 ~~minutes~~ sec)	√
		√
Measure the time it takes before the transformer trips	Check that it's within 2 seconds	√
Let the timer expire (30 ~~minutes~~ sec) after the trip	Check that alarm and flag signal is not raised (APFR-RESET not activated) whilst timer counts down i.e. within 30 ~~minutes~~. sec	√
	Check that APFR RESET is activated after timer expires	√
Before timer expires, set the frequency measured by microTAPP back to a value within the APFR's limit (e.g. to 49.9Hz)	Check that alarm and flag signal is not raised (APFR RESET not activated) until after time expires	√
After timer expires, set the frequency measured by microTAPP back to a value within the APFR's limit (e.g. to 49.9Hz)	Check that APFR RESET is activated	√
Simulate a transient disturbance by bleeping the frequency for 900ms (45 cycles)	Check that the APFR function is not activated	√
Manually close the circuit breaker (To simulate control engineer's intervention)	Check that the voltage set point increases, and that voltage rises (back to nominal)	√
While the frequency is still below limit and a breaker is opened, simulate a voltage reduction below the lower limit (i.e. below 94%) and let timer expire	Check that ASC suspends action by raising alarm to control engineer to close breaker (APFR RESET activated)	√ √
Open T1 then drop the frequency below 49.7	Check that APFR is not activated	√

Open T2 then drop the frequency below 49.7	Check that APFR is not activated	✓
Set total loads (MVA) above the limit and apply APFR function	Check that APFR is not activated.	✓
Set the total load below the limit	Check that APFR activates.	✓
Set the microTAPPs' voltage to be above the limit (i.e. above 110%) then set the frequency below lower limit (i.e. below 49.7Hz)	Check that the ASC does not perform any function	✓
Set the microTAPPs' voltage to be below the limit (i.e. below 92%) then set the frequency below lower limit (i.e. below 49.7Hz)	Check that the ASC does not perform any function	✓
Drop the frequency below 49.7Hz and simulate that CB does not open to trip a transformer (as would normally be expected)	Check that ASC immediately disables APFR, function and that it goes back to nominal.	✓

Page 12 of 13

Table 9

Action	Result	Pass/Fail
Manually activate the MPFR function	Check that the ASC receives the low frequency signal and is activated	✓
	Check that one of the closed circuit breakers opens to trip its transformer.	✓
	Check that the voltage set point is lowered and that voltage drops	✓ ✓
Measure the time it takes before the transformer trips	Check that it's within 2 seconds	✓
Manually close the circuit breaker (To simulate control engineer's intervention)	Check that the voltage set point increases, and that voltage rises (back to nominal)	✓
Set total loads (MVA) above the limit and apply APFR function	Check that MPFR is not activated.	✓
Set total loads (MVA) below the limit and apply APFR function	Check that MPFR activates.	✓
Set the microTAPPs' voltage to be above the limit (i.e. above 110%) then activate the MPFR function	Check that the ASC does not perform any function	✓
Set the microTAPPs' voltage to be below the limit (i.e. below 92%) then activate the MPFR function	Check that the ASC does not perform any function	✓
Activate MPFR and simulate that CB does not open to trip a transformer (as would normally be expected)	Check that ASC immediately disables MPFR function and that it goes back to nominal.	✓
Open the bus section of CB to ensure there is no action of both APFR and MPFR	Check that both APFR and MPFR are not activated	✓

Page 13 of 13

Type 3 CLASS T11/T12 11/6.6kV Transformer Opening Relay Commissioning Results

Engineer: S.J.Stott Date: 07/03/2014

Site: Hyndburn Rd S/S 400013

Voltage of Transformer Circuit Breaker: 6.6kV

Relay Manufacturer: Siemens Relay Type: 7PA27220AA002

Relay Voltage Range: 60V DC Relay Lot Number: 1400555601

Transformer name: T11 Relay Serial Number: 140055560122

Pick-Up (PU) & Drop-Off (DO) Values On Relay Pins 1 & 2

PU Voltage = 36.1v DO Voltage = 24.0v

Pre PU Input Current = 2.19mA Pre DO Input Current = 32.50mA

Post PU Input Current = 21.80mA Post DO Input Current = 2.11mA

Output Contact Resistance Across Relay Pins 6 & 10

Closed Contact Resistance Measured = 0.08ohms

Measuring Instrument Lead Resistance = 0.06ohms

Closed Contact True Resistance = 0.02ohms

Open Contact Resistance = >10Mohms

Transformer name: T12 Relay Serial Number: 140055560124

Pick-Up (PU) & Drop-Off (DO) Values On Relay Pins 1 & 2

PU Voltage = 36.7v DO Voltage = 24.9v

Pre PU Input Current = 2.23mA Pre DO Input Current = 34.60mA

Post PU Input Current = 23.30mA Post DO Input Current = 2.13mA

Output Contact Resistance Across Relay Pins 6 & 10

Closed Contact Resistance Measured = 0.08ohms

Measuring Instrument Lead Resistance = 0.06ohms

Closed Contact True Resistance = 0.02ohms

Open Contact Resistance = >10Mohms

Method/Programme

Action		Complete
1.	IR test supply cable between 48Vdc battery and ASC.	✓
2.	Confirm correct polarity of the above cable inside ASC at mcb1.	✓
3.	Check wiring for continuity and ferruling in ASC panel	✓
4.	Confirm continuity and ferruling of the multi-pair cable from RTU to ASC with ASC and RTU terminal links open.	✓
5.	Switch mcb1 on. Verify that cable from SFC module is connected to SICAM port X7.	✓
6.	Using a laptop with Reydisp program or via the keys of ARGUS 8 confirm that they have the correct settings.	✓
7.	Using a laptop with the internet explorer and an Ethernet cable, configure the two transducers.	✓
8.	Initialize Autonomous substation control system using laptop with toolbox software. Verify that no error LED is on.	✓
9.	Autonomous substation control system is ready to be tested.	✓
10.	Connect voltage outputs of the omicron to the ARGUS 8 and current outputs to the Transducers.	✓
11.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then activate demand boost full function from ASC. Verify that correct BOs of Of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 [illegible] drops to 95.5 % Record the results to table 2.	✓
12.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand boost half function from ASC. Verify that correct BOs of Of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 [illegible] drops to 97% Record the results to table 2.	✓
13.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand reduction full function from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 [illegible] rises to 106% Record the results to table 3.	✓

Page 3 of 10

14.	**Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand reduction half function from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3** [illegible] rises to 104.5% **Record the results to table 3.**	√
15.	**Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then enable automatic demand reduction function ADRF-NRD from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals** rises to 104.5% [illegible] **Record the results to table 4.**	√
16.	**Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs to 49,75Hz and see when function will be activated. Verify that correct BOs and LEDs are coming up in the ASC modules. Measure the time until ASFR is deactivated. Record the results to table 5.**	√
17.	**Enable automatic primary frequency response APFR from ASC. Reduce frequency below 49.7Hz and verify that one of the transformers trips. Record the results to table 6.**	√
18.	**Enable manual primary frequency response MPFR from ASC. Verify that one of the transformers trips. Record the results to table 7.**	√
19.	**Verify all functions are disabled and stop secondary injection to Argus 8s' and transducers.**	√

Page 4 of 10

Table 2

Action	Result	Pass/ Fail
DBF-FULL Activate the DBF-FULL function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 [redacted] drops to 95.5% ASCS outputs activated: O05	✓
Set system group capacity load to maximum (i.e. 98.5%) and apply the DBF-FULL function	Check that no operation is performed	✓
Set nominal voltage to be above limit (i.e. above 110%)	Check that no operation is performed	✓
DBF-HALF Activate the DBF-HALF function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 [redacted] drops to 97% ASCS outputs activated: O06	✓
Set voltage outside limit (i.e. above 110%) and apply DBF-HALF	Check that no operation is performed	✓
Set load outside limit (e.g. 100%) and apply DBF-HALF	Check that no operation is performed	✓

Table 3

Action	Result	Pass/ Fail
DRF-NGT FULL Activate the function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 [redacted]. ASCS outputs activated: O010 rises to 106%	✓
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	✓
DRF-NGT HALF Activate the function	Check that the voltage set points of both transformers set to halfway the lower limit (97%) Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 [redacted] ASCS outputs activated: O011 rises to 103%	✓
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%)	✓
Increase load to limit and activate the function	Check that the function is activated.	✓

Table 4

	Action	Result	Pass/Fail
	Enable the ADRF function	Check that the function is enabled	✓
ASC – Argus 8	Set the load to break the maximum load capacity (i.e. above 98.5%	Check that both Argus 8s' energize their outputs and that voltage to terminals ~~[illegible]~~ rises to 104.5%	✓
	Apply a time delay (e.g. 1 minute) when the voltage is at lower limit (95.5%)		✓
	Drop the load below 85% and apply time delay (1 minute)	Check that the ADRF is still activated and timer starts to countdown.	✓
	While load is below 85%, allow timer (1 minute) to expire	Check that transformers tap up after time delay expires	✓
	Simulate that after transformers tap up, the load increases back beyond limit (above 98.5%)	Check that ASC starts the ADRF function again (i.e. voltage set point drop, then transformers tap down)	✓
	Simulate that after transformers tap up the load remains within limit e.g. 96%	Check that ASC continues with the function (i.e. ADRF still activated) until the function is switched off.	✓
	Apply a time delay when the load is at lower limit (85%) and before the timer expires, interrupt with a high load (i.e. set load above 98.5%)	Check that ASC performs no action and that voltage remains at lower limit (i.e. no tap up)	✓
	Increase load above limit (above 98.5%) then reduce voltage below limit	Check that ASC performs no action	✓
	Open CB1 and press the ADRF function	Check that transformer 2 taps down to perform the function	✓
	Open CB2 and press the ADRF function	Check that transformer 1 taps down to perform the function	✓

Page 6 of 10

Check that both Argus 8s' energize their outputs and that Voltage to terminals rises to 104.5%

Argus of T1 energize it's outputs and that Voltage to terminals rises to 104.5%

Argus of T2 energize it's outputs and that Voltage to terminals rises to 104.5%

Table 5

	Action	Result	Pass/Fail
ASC-Argus 8	Set the frequency measured by both Argus 8s to a value below the ASFR's limit(i.e. below 49.8Hz) but higher than 49.7Hz, to simulate network's frequency drop 49.80Hz	Check that the ASC receives the low frequency signal and is activated	✓
		Check that the parallel transformers tap down to lower voltage set point (95.5%)	✓
	Open CB1 and set Transformer 2 frequency below 49.8 (to simulate that only one transformer is online)	Check that there is no load on transformer 1 and that transformer 2 taps down to lower voltage set point (95.5%)	✓
	Open CB2 and set Transformer 1 frequency below 49.8 (to simulate that only one transformer is online)	Check that there is no load on transformer 2 and that transformer 2 taps down to lower voltage set point (95.5%)	✓
	Measure the time it takes before the transformers start to tap down	Check that it's within 10 seconds	✓
	Measure how long the voltage reduction is sustained before or after frequency improves to ensure voltage reduction period is time dependent (e.g. 30 seconds) and not frequency dependent	Check that the voltage reduction time is up to [illegible] minutes 32	✓
	Set the frequency back within limit (e.g. 49.9Hz) before voltage reduction time (30 seconds) expires	Check that no action	✓
	Set the frequency back within limit (e.g. 49.9Hz) after voltage reduction time (30 seconds) expires	Check that voltage set point increases	✓
		Then check that transformers tap up sequentially in increasing order of loading condition (i.e. lightly loaded tap up first)	✓
	Set Transformer 1 to a higher load than transformer 2 (to simulate different substation loading)	Check that transformer 2 starts to tap up first [illegible] then transformer 1 (after 2 minutes)	✓
	Drop the frequency further below 49.70Hz	Check that APFR function starts (circuit breaker opens)	N/A

Table 6

	Action	Result	Pass/Fail
ASC-Argus 8	Set the frequency measured by both Argus 8s to a value below the APFR's limit(i.e. below 49.7Hz) , to simulate network's frequency drop	Check that the ASC receives the low frequency signal and is activated	✓
		Check that one of the closed circuit breakers opens to trip its transformer	✓
		Check that the voltage set point is lowered and that voltage drops	✓
		Check that time delay starts to count down (30 minutes)	✓
	Measure the time it takes before the transformer trips	Check that it's within 2 seconds	✓
	Let the timer expire (30 minutes) after the trip	Check that alarm and flag signal is not raised (APFR-RESET not activated) whilst timer counts down i.e. within 30 minutes.	✓
		Check that APFR RESET is activated after timer expires	✓
	Before timer expires, set the frequency measured by Argus 8 back to a value within the APFR's limit (e.g. to 49.9Hz)	Check that alarm and flag signal is not raised (APFR RESET not activated) until after time expires	✓
	After timer expires, set the frequency measured by Argus 8 back to a value within the APFR's limit (e.g. to 49.9Hz)	Check that APFR RESET is activated	✓
	Simulate a transient disturbance by bleeping the frequency for 500ms (25 cycles)	Check that the APFR function is not activated	✓
	Manually close the circuit breaker (To simulate control engineer's intervention	Check that the voltage set point increases, and that voltage rises (back to nominal)	✓

Page 8 of 10

	While the frequency is still below limit and a breaker is opened, simulate a voltage reduction below the lower limit (i.e. below 95.5%) and let timer expire	Check that ASC suspends action by raising alarm to control engineer to close breaker (APFR RESET activated)	✓
	Open T1 then drop the frequency below 49.7	Check that APFR is not activated	✓
	Open T2 then drop the frequency below 49.7	Check that APFR is not activated	✓
	Set total load (MVA) above firm load and apply APFR function	Check that APFR is not activated	✓
	Set total load (MVA) below firm load and apply APFR function)	Check that APFR activates.	✓
	Set the Argus 8s' voltage to be above the limit (i.e. above 110%) then set the frequency below lower limit (i.e. below 49.7Hz)	Check that the ASC does not perform any function	✓
	Set the Argus 8s' voltage to be below the limit (i.e. below 92%) then set the frequency below lower limit (i.e. below 49.7Hz)	Check that the ASC does not perform any function	✓
	Drop the frequency below 49.7Hz and simulate that CB does not open to trip a transformer (as would normally be expected)	Check that ASC immediately disables APFR, ASFR and ADRF functions and that it goes back to nominal.	✓

Table 7

	Action	Result	Pass/Fail
	Manually activate the MPFR function	Check that the result is as in APFR above	✓
	Increase the load above firm load and activate the MPFR function	Check that the MPFR does not activate and ASC performs no function	✓
	Open the bus section of CB to ensure there is no action of both APFR and MPFR	Check that both APFR and MPFR are not activated	✓

Page 10 of 10

Method/Programme

Action		Complete
1.	IR test supply cable between 48Vdc battery and ASC.	200+. ✓
2.	Confirm correct polarity of the above cable inside ASC at mcb1.	✓ 54.74.
3.	Check wiring for continuity and ferruling in ASC panel	✓
4.	Confirm continuity and ferruling of the multi-pair cable from RTU to ASC with ASC and RTU terminal links open.	✓
5.	Switch mcb1 on. Verify that cable from SFC module is connected to SICAM port X7.	✓
6.	Using a laptop with Reydisp program or via the keys of ARGUS 8 confirm that they have the correct settings.	✓ Manual
7.	Using a laptop with the Internet explorer and an Ethernet cables configure the two transducers.	✓ 2000/1, 6.6KV.
8.	Initialize Autonomous substation control system using laptop with toolbox software. Verify that no error LED is on.	✓
9.	Autonomous substation control system is ready to be tested.	✓
10.	Connect voltage outputs of the omicron to the ARGUS 8 and current outputs to the Transducers.	✓
11.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then activate demand boost full function from ASC. Verify that correct BOs of Of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 rises to 106% Record the results to table 2.	6.22 6.22 ✓ R4
12.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand boost half function from ASC. Verify that correct BOs of Of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 rises to 103% Record the results to table 2.	✓ 6.42 6.42. RS
13.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand reduction full function from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 drops to 95.5% Record the results to table 3.	✓ 6.263 6.263 RS26.

Page 3 of 7

14.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then Activate demand reduction half function from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals TB2,3 : 1,3 drops to 97%. Record the results to table 3. 3%.	✓ 6.22 6.75
15.	Inject nominal voltage to ARGUS 8 and current to transducers so as not to exceed the firm load then enable automatic demand reduction function ADRF-NRD from ASC. Verify that correct BOs of ARGUS 8 are energized and that the voltage at terminals drops to 95.5%. Record the results to table 4.	P. 6.861 6.861. R5e6,
16.	Enable automatic secondary frequency response ASFR from ASC. Reduce frequency to both microTAPPs to 49,75Hz and see when function will be activated. Verify that correct BOs and LEDs are coming up in the ASC modules. Measure the time until ASFR is deactivated. Record the results to table 5.	P 6.874 6.874 R5e6.
17.	Verify all functions are disabled and stop secondary injection to Argus 8s' and transducers.	

Table 2

Action	Result	Pass/ Fail
DBF-FULL Activate the DBF-FULL function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 rises to 106% ASCS outputs activated: O05	P ✓
Set system group capacity load to maximum (i.e. 98.5%) and apply the DBF-FULL function	Check that no operation is performed 23 MVA ✓	✓ P
Set nominal voltage to be above limit (i.e. above 110%)	Check that no operation is performed 69.52V.	✓ P
DBF-HALF Activate the DBF-HALF function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 rises to 103% ASCS outputs activated: O06	P ✓
Set voltage outside limit (i.e. above 110%) and apply DBF-HALF	Check that no operation is performed 23 MVA.	P ✓
Set load outside limit (e.g. 100%) and apply DBF-HALF	Check that no operation is performed 70V. 69.52	P ✓

Table 3

Action	Result	Pass/ Fail
DRF-NGT FULL Activate the function	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 drops to 95.5%. ASCS outputs activated: O010	P.
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%) 58V	P.
DRF-NGT HALF Activate the function	Check that the voltage set points of both transformers set to halfway the lower limit (97%) 3%	P
	Check that both Argus 8s' energize their outputs and that voltage to terminals TB2,3 : 1,3 drops to 97% ASCS outputs activated: O011	P ✓
Set the voltage below the limit (i.e. below 92%)	Check that the function deactivates and returns back to nominal voltage (99.5%) 58V.	P ✓
Increase load to limit and activate the function	Check that the function is activated. 23 MVA.	✓ P

Page 5 of 7

Table 4

	Action	Result	Pass/Fail
	Enable the ADFR function	Check that the function is enabled	P ✓
ASC – Argus 8	Set the load to break the maximum load capacity (i.e. above 98.5%	Check that both Argus 8s' energize their outputs and that voltage to terminals drops to 95.5%	P. ✓
	Apply a time delay (e.g. 1 minute) when the voltage is at lower limit (95.5%)	R set — 4.5%.	P ✓
	Drop the load below 85% and apply time delay (1 minute)	Check that the ADRF is still activated and timer starts to countdown.	P ✓
	While load is below 85%, allow timer (1 minute) to expire	Check that transformers tap up after time delay expires	P ✓
	Simulate that after transformers tap up, the load increases back beyond limit (above 98.5%)	Check that ASC starts the ADRF function again (i.e. voltage set point drop, then transformers tap down)	P ✓
	Simulate that after transformers tap up the load remains within limit e.g. 96%	Check that ASC continues with the function (i.e. ADRF still activated) until the function is switched off.	P
	Apply a time delay when the load is at lower limit (85%) and before the timer expires, interrupt with a high load (i.e. set load above 98.5%)	Check that ASC performs no action and that voltage remains at lower limit (i.e. no tap up)	P. ✓
	Increase load above limit (above 98.5%) then reduce voltage below limit	Check that ASC performs no action 23MW/52V.	P. ✓

Page 6 of 7

Table 5

	Action	Result	Pass/Fail
ASC-Argus 8	Set the frequency measured by both Argus 8s to a value below the ASFR's limit(i.e. below 49.8Hz) but higher than 49.7Hz, to simulate network's frequency drop	Check that the ASC receives the low frequency signal and is activated 49.77	P. ✓
		Check that the parallel transformers tap down to lower voltage set point (95.5%) 45%	P. P ✓
	Measure the time it takes before the transformers start to tap down	Check that it's within 10 seconds 10sec	✓
	Measure how long the voltage reduction is sustained before or after frequency improves to ensure voltage reduction period is time dependent (e.g. 30 seconds) and not frequency dependent	Check that the voltage reduction time is up to 30 minutes 32 mins	✓ P.
	Set the frequency back within limit (e.g. 49.9Hz) before voltage reduction time (30 seconds) expires	Check that no action 30sec	P ✓
	Set the frequency back within limit (e.g. 49.9Hz) after voltage reduction time (30 seconds) expires	Check that voltage set point increases	P. ✓
		Then check that transformers tap up sequentially in increasing order of loading condition (i.e. lightly loaded tap up first)	

Page 7 of 7