Standard

Protection and Control of Network Transformers
Standard
R246242
Version 3.0, May 2018
Authorisations

<table>
<thead>
<tr>
<th>Action</th>
<th>Name and title</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared by</td>
<td>Anthony Januba, Senior Asset Strategy Engineer</td>
<td>17/05/2018</td>
</tr>
<tr>
<td>Reviewed by</td>
<td>Stewart Collins, Senior Asset Strategy Engineer</td>
<td>18/5/2018</td>
</tr>
<tr>
<td>Authorised by</td>
<td>Robert Smith, Secondary Asset Strategy Team Leader</td>
<td>24/05/2018</td>
</tr>
<tr>
<td>Review cycle</td>
<td></td>
<td>30 months</td>
</tr>
</tbody>
</table>

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

Please contact the Asset Strategy Leader with any queries or suggestions.

- Implementation All TasNetworks staff and contractors.
- Compliance All group managers.

Minimum Requirements

The requirements set out in TasNetworks’ documents are minimum requirements that must be complied with by all TasNetworks team members, contractors, and other consultants.

The end user is expected to implement any practices which may not be stated but which can be reasonably regarded as good practices relevant to the objective of this document.
# Record of revisions

<table>
<thead>
<tr>
<th>Section number</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>*Document transferred to new <em>TasNetworks</em> <em>template</em></td>
</tr>
<tr>
<td>1.4</td>
<td>Section modified for precedence of project specification over this standard</td>
</tr>
<tr>
<td>3.1</td>
<td>499A and 499B protection relays functional requirements</td>
</tr>
<tr>
<td>5.6</td>
<td>Table 1 for Network transformer thermal limits removed</td>
</tr>
</tbody>
</table>
# Table of contents

Authorisations..............................................................................................................................................2

Responsibilities...........................................................................................................................................2

Minimum Requirements...............................................................................................................................2

1.....................................................................................................................................................General 7

1.1..................................................................................................................................................Purpose 7

1.2..................................................................................................................................................Scope 7

1.3...................................................................................................................................................Objective 7

1.4...................................................................................................................................................Precedence 7

1.5..............................................................................................................................................Abbreviations 8

1.6..............................................................................................................................................References 8

1.7..........................................................................................................................................TasNetworks standards 8

1.8..........................................................................................................................................TasNetworks drawings 8

2....................................................................................................................................................Philosophy 9

2.1........................................................................................................................................Design philosophy 9

3....................................................................................................................................................Functional requirements 9

3.1.......................................................................................................................................Protection and control scheme arrangement 9

3.1.1........................................................................................................................................499A Protection relay 10

3.1.2........................................................................................................................................499B Protection relay 11

3.1.3.......................................................................................................................................590 AVR Device 11

3.2......................................................................................................................................Transformer protection functions 12

4....................................................................................................................................................Protection application 13
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>General application requirements</td>
<td>13</td>
</tr>
<tr>
<td>4.2</td>
<td>Tertiary winding earth fault protection application</td>
<td>13</td>
</tr>
<tr>
<td>4.2.1</td>
<td>Distance protection application</td>
<td>13</td>
</tr>
<tr>
<td>4.2.2</td>
<td>Biased transformer differential protection application</td>
<td>14</td>
</tr>
<tr>
<td>4.2.3</td>
<td>Over-fluxing protection application</td>
<td>14</td>
</tr>
<tr>
<td>4.2.4</td>
<td>Low impedance restricted earth fault protection application</td>
<td>14</td>
</tr>
<tr>
<td>4.2.5</td>
<td>Buchholz protection</td>
<td>14</td>
</tr>
<tr>
<td>4.2.6</td>
<td>Check Synchronisation</td>
<td>15</td>
</tr>
<tr>
<td>4.2.7</td>
<td>Over temperature protection</td>
<td>15</td>
</tr>
<tr>
<td>4.3</td>
<td>Circuit breaker failure (CBF) protection application</td>
<td>15</td>
</tr>
<tr>
<td>4.4</td>
<td>Automatic voltage regulator (AVR) application</td>
<td>15</td>
</tr>
<tr>
<td>4.5</td>
<td>Blocking of CB open and close commands</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Protection and control settings</td>
<td>16</td>
</tr>
<tr>
<td>5.1</td>
<td>Delta tertiary winding protection settings</td>
<td>16</td>
</tr>
<tr>
<td>5.2</td>
<td>Distance protection settings</td>
<td>16</td>
</tr>
<tr>
<td>5.3</td>
<td>Biased differential protection settings</td>
<td>16</td>
</tr>
<tr>
<td>5.4</td>
<td>Circuit breaker failure (CBF) protection settings</td>
<td>17</td>
</tr>
<tr>
<td>5.5</td>
<td>Over-fluxing protection settings</td>
<td>17</td>
</tr>
<tr>
<td>5.6</td>
<td>Thermal overload protection settings</td>
<td>17</td>
</tr>
<tr>
<td>5.7</td>
<td>Restricted earth fault protection settings</td>
<td>17</td>
</tr>
<tr>
<td>5.8</td>
<td>Check Synchronisation settings</td>
<td>17</td>
</tr>
<tr>
<td>5.9</td>
<td>Over temperature protection settings</td>
<td>17</td>
</tr>
</tbody>
</table>
5.10................................................................................Automatic voltage regulator (AVR) settings
17

Appendix 1 – Standard secondary equipment.................................................................19
1 General

1.1 Purpose

The purpose of this document is to define the requirements, philosophy and the application of protection and control schemes for network transformers in the Tasmanian interconnected power system under the responsibility of Tasmanian Networks Pty Ltd (hereafter referred to as “TasNetworks”).

1.2 Scope

This standard applies to all network transformer protection and control schemes under the responsibility of TasNetworks where the network transformer is connected to the following busbar configurations:

(a) Single busbar.
(b) Double or triple busbar.
(c) Double breaker in the diameter between two main busbars.
(d) Circuit breaker and a half in the diameter between two main busbar.

This standard contains requirements for design and is to be applied on new installations as well as redevelopment of part or all existing installations where the busbar arrangement may consist of a combination of the above mentioned configurations.

1.1 Objective

TasNetworks requires designs as covered in this standard to ensure:

(a) personnel and public safety;
(b) safety of TasNetworks’ assets;
(c) reliability and continuity of power supply to the power transmission network;
(d) that relevant Australian legal requirements are met;
(e) that the requirements of the National Electricity Rules are met;
(f) ease in operation and maintenance;
(g) minimum disruption to the EHV supply system following a fault;
(h) that the requirements of TasNetworks’ corporate plan are met; and
(i) that the exposure of TasNetworks’ business to risk is minimised.

1.1 Precedence

Any apparent conflict between the requirements of this standard and the law, mandatory requirements, industry standards, project specifications, non-statutory standards or guidelines, and any other associated documents should be brought to the immediate attention of TasNetworks for resolution and no action must be taken that might result in a breach of law or mandatory standard.

Where there may be a conflict between the requirements of this standard and any:

(a) law, mandatory requirement or industry standard, then that law or statutory requirements will prevail over this standard;
Protection and Control of Network Transformers Standard

(b) non-mandatory standard, or guideline, then this standard will prevail over that standard or guideline;
or
(c) project specification, then a deviation must be specifically requested and approved in writing by TasNetworks’ Asset Strategy Team Leader.

Approval for a deviation to this standard may only be accorded if it does not reduce the quality of workmanship, pose a safety risk to personnel or equipment and does not deviate from the intent of this standard.

1.1 Abbreviations

AVR Automatic Voltage Regulation
CB Circuit Breaker
CBF Circuit Breaker Failure
CT Current Transformer
DC Direct Current
EHV Extra High Voltage
I/O Inputs and Outputs
NER National Electricity Rules
OLTC On-Load Tap Changer
ONAN Oil Natural Air Natural
TCS Trip Circuit Supervision
VT Voltage Transformer

1.2 References

As a component of the complete specification for a system, this standard is to be read in conjunction with other standards and documents as applicable. In particular, this includes the project specifications and the standards mentioned below.

1.3 TasNetworks standards

SCADA Systems Standard (R246439)
Testing, Commissioning and Training Standard (R246497)
Commissioning and Recommissioning of Secondary Equipment Standard (R244782)
Protection of EHV Busbars Standard (R246414)
Extra High Voltage System Standard (R586386)
General Substation Requirements Standard (R522687)
Network Transformer Standard (R527893)

1.4 TasNetworks drawings
All project specific application design drawings shall be prepared using the appropriate TasNetworks standard protection scheme design template. This suite of standard design drawings for the network transformer protection scheme will be issued together with the project specification for each project.

New standard panel design drawings shall only be developed with prior approval from TasNetworks Asset Strategy Team Leader.

2 Philosophy

2.1 Design philosophy

The network transformer protection and control scheme shall be designed to ensure that:

(a) the protection scheme applied to the network transformer shall be adaptable and adequate for the protection of the entire transformer;

(b) all high current faults within the transformer protection zones shall be detected by at least two independent protection relays that have the capability of initiating fault clearance within the critical clearance times specified within clause S5.1a.8 of the National Electricity Rules (NER). Very low current and/or incipient faults are capable of detection only by the single Buchholz protection;

(c) the transformer protection scheme shall utilise EHV CT cores that are positioned to provide overlapping zones of protection with adjacent protection schemes;

(d) all tripping functions shall be hard wired from the protection relays to the respective trip coil on the associated circuit breakers;

(e) auto reclose facilities shall not be applied to the network transformer circuit breakers;

(f) the protection and control scheme shall consist of two independent protection relays that must be from different manufacturers or different models to achieve redundancy and diversity;

(g) control for each of the associated primary bays including status, interlocking, metering and signalling functions shall be integrated into the scheme. The 110 kV and 220 kV bay control functions shall be provided by different relays; and

(h) the location of protection and bay control functions within relays shall be arranged to meet the requirements above, with multifunction devices utilised to reduce the number of installed relays where possible.

3 Functional requirements

3.1 Protection and control scheme arrangement

The network transformer protection shall consist of independent protection relays designated ‘499A’ and ‘499B’, an independent AVR designated ‘590’ and transformer guard devices.

The 499A and 499B protection relays shall:

(a) be numerical multifunction devices capable of accepting more than two, three phase CT inputs;

(b) be capable of communicating all parameters including protection settings and recorded events to the substation SCADA system and shall be capable of being programmed and interrogated remotely;

(c) have inbuilt disturbance and event recorder with time and date tagging;

(d) be connectable for 1 Amp or 5 Amp current transformer secondary connections;
Protection and Control of Network Transformers Standard

(e) be connectable for VT secondary phase voltages of 110 V or 110/√3V;
(f) have heavy duty output contacts for direct tripping of both 220 kV and 110 kV circuit breakers;
(g) be capable of communicating on the SCADA network via Ethernet RJ45 or fibre connection;
(h) have configurable digital outputs for alarm, annunciation and external CBF initiation;
(i) be fed from independent CT cores on each side of the transformer and network shall use independent voltage transformer (VT) secondary circuits for voltage input to associated devices; and
(j) be configurable to accommodate required I/Os with 10 per cent spare capacity;
(k) Ability to provide Synchrophasor data;
(l) Be capable of multiple communications protocols with a minimum of DNP3 and IEC61850 GOOSE and MMS functionality; and
(m) Capable of time synchronisation via PTP (preferred option) or IRIG B.

The 590 AVR device shall:
(n) be a numerical device incorporating self-monitoring;
(o) accommodate multiple setting groups;
(p) be connectable for 1 Amp or 5 Amp current transformer secondary connections;
(q) be connectable for VT secondary phase voltages of 110 V or 110/√3V;
(r) be capable of regulating transformers operating in parallel or independent mode;
(s) have analogue inputs for connection of transformer winding and oil temperature transducers and circuit breaker SF6 transducers;
(t) have configurable voltage regulation settings;

3.1.1 499A Protection relay

The 499A protection relay shall provide the following functionality:
(a) Low impedance (87T) over all transformer biased differential protection.
(b) Low impedance (87N) phase segregated current differential protection for common and serial windings of the autotransformer where possible (also known as current node protection).
(c) Overcurrent and earth fault protection.
(d) Thermal overload protection.
(e) Over fluxing protection.
(f) Remote metering of individual circuit breakers for double breaker busbar arrangements.
(g) CT supervision including saturation detection.
(h) Trip circuit supervision for the ‘A’ trip coil.
(i) Circuit breaker failure for both 220 kV and 110 kV side circuit breakers when not available within the busbar protection scheme.
(j) Bay interlocking for 220 kV disconnectors.
(k) 220 kV side transformer metering.
(l) Remote/local open and close of circuit breakers and disconnectors of the 220 kV bay.
(m) Back-up distance protection for the 220 kV busbars.
(n) VT selection logic for the 220 kV bus VTs.
3.1.1 499B Protection relay
The 499B protection relay shall provide the following functionality:

(a) Low impedance (87T) over all transformer biased differential protection.
(b) Low impedance biased restricted earth fault protection with slope characteristics.
(c) Overcurrent and earth fault protection.
(d) Thermal overload protection.
(e) Over fluxing protection.
(f) CT supervision including saturation detection.
(g) Trip circuit supervision for the ‘B’ trip coil.
(h) Circuit breaker failure for both 220 kV and 110 kV side circuit breakers when not available within the busbar protection scheme.
(i) Bay interlocking for 110 kV disconnectors.
(j) 110 kV side transformer metering.
(k) Remote/local open and close for circuit breakers and disconnectors of the 110 kV bay.
(l) Back-up distance protection for the 110 kV busbars.
(m) VT selection logic for the 110 kV bus VTs.
(n) Check Synchronisation.
(o) Management of up to two 220 kV circuit breakers, refer to project specification for site specific requirements.

3.1.1 590 AVR Device
The 590 AVR device shall be capable of:

(a) initiating raising and lowering of network transformer tap position to maintain the 110 kV voltage within a set bandwidth including fast tap down;
(b) interpreting tap position of the transformer from a resistor chain, and transducer values;
(c) blocking its operation when the load current exceeds 1.2 times the value of the nominal rated current of the on-load tap changer or when voltages exceed upper or lower limits;
(d) detecting and minimising circulating current when transformers are connected in parallel;
(e) inter-AVR communications with similar model devices;
(f) communication of transformer temperature and circuit breaker SF6 analogue levels to SCADA;
(g) operating in manual, automatic or independent modes; and
(h) load drop compensation.
3.1 Transformer protection functions

The following functionality shall be provided by the network transformer protection scheme:

(a) Biased transformer differential protection shall provide:

(i) stabilised current differential protection to protect the winding from short circuit and inter-turn faults;
(ii) fast operation time even during partial saturation of associated current transformers;
(iii) stability for maximum through fault conditions;
(iv) restraint for transformer inrush current;
(v) unrestrained high set current differential element;
(vi) restraint for transformer over-excitation. The restraint level shall be configurable and shall be capable of being disabled; and
(vii) capability of catering for a wide range of current transformer ratios and vector corrections including the variation of the star point connection on the CT cores using numerical settings – please note that external matching or interposing CT will not be acceptable for these purposes.

(b) Restricted earth fault protection shall:

(i) operate on the low impedance biased principal and is added to supplement the biased transformer differential protection by detecting fault currents of a magnitude below that capable of being detected by the biased current differential protection.

(c) Delta tertiary winding earth fault protection shall:

(i) have selectable inverse time delayed and definite time delayed outputs.

(d) Distance protection shall:

(i) have an operating time not exceed 30 milliseconds for faults at the maximum reach setting and with system impedance ratios up to 50.

(e) Over-fluxing protection shall provide:

(i) two stage over-excitation protection. The first stage shall activate an alarm and the second stage shall provide protection tripping functionality.

(f) Thermal overload protection shall provide:

(i) selectable inverse time characteristics and a definite time characteristic for the construction of an inverse thermal characteristic to match the thermal characteristic supplied by the transformer manufacturer; and
(ii) two setting stages, one of which will provide an alarm and the second will provide a circuit breaker trip. The alarm shall be set at the value of maximum rated current and the trip function must match the transformer damage curve and shall be set to coordinate with upstream and downstream overcurrent protection.

(g) Buchholz and over temperature protection shall provide the following:

(i) The Buchholz relay shall be supplied with the network transformer and as such will be calibrated by the transformer manufacturer as stated in the Network Transformer Standard. The Buchholz relay must be able to provide as a minimum, two normally open contacts for trip and one normally open contact for alarm; and

(ii) The over temperature devices shall also be supplied with the network transformer and as such will be calibrated by the transformer manufacturer as stated in the Network Transformer Standard. The over temperature devices measure the temperature of the transformer.
spot’ and the temperature of the transformer oil. The over temperature devices shall be capable of two over temperature settings, stage one and stage two.

(h) Local emergency control switches shall:

(i) be provided for each 110 kV and 220 kV circuits breaker;
(ii) perform an emergency trip directly to the trip circuit of the respective circuit breaker;
(iii) perform a close directly to the close circuit of the respective circuit breaker;
(iv) have an additional contact of each control switch to be hard wired into the associated relay to record the operation of the switch; and
(v) have the switches associated with the 220 kV circuit breaker mounted on the Main A panel and the switches associated with the 110 kV circuit breaker mounted on the Main B panel.

Additional switches must be provided to enable the emergency contacts to by-pass the bay control functions of the protection scheme.

4 Protection application

4.1 General application requirements

The following arrangements shall be followed for the application of the main protection relays:

(a) The protection relays are to be connected to two independent cores on each side of the transformer.
(b) Separate DC supplies are derived from the ‘A’ and ‘B’ DC supply systems.
(c) Circuit breaker tripping is initiated via hard wiring direct to the ‘A’ and ‘B’ trip coils respectively.
(d) The protection scheme shall be housed within two panels designated ‘Main A’ and ‘Main B’ located directly beside each other within the Substation control room. The Main ‘A’ panel shall house the 499A relay and the Main ‘B’ panel shall house the 499B, and 590 devices.
(e) For information regarding to the integration of the protection relays to the SCADA system, refer to the SCADA System Standard.
(f) Protection functions that indicate an internal transformer fault shall latch with resetting facility via remote command.

4.1.1 Distance protection application

The following arrangement shall be implemented for the tertiary winding earth fault protection:

(a) The earth fault protection shall be connected to the secondary winding of the CT located in the delta tertiary – earth connection.
(b) The protection should be incorporated within the ‘499B’ protection device associated with the transformer.
(c) The output of the protection shall trip all circuit breakers associated with the transformer and initiate circuit breaker failure (CBF) protection. Trip and alarm indications shall be latched with remote reset capability.
The primary purpose of the distance protection is to provide back-up to bus faults in case of a failure or scheduled maintenance of a single busbar protection scheme. The following arrangement shall be implemented for the distance protection:

(a) The distance protection shall only be enabled to back-up a single busbar protection scheme.
(b) The distance protection shall be set to reach in the reverse direction to detect busbar faults.
(c) The output of the protection shall trip the circuit breakers of the network transformer connecting to the associated busbar and initiate CBF protection.
(d) If distance protection is required, it is to be derived from the busbar VTs, and voltage selection facilities are required.

4.1.1 Biased transformer differential protection application

The following arrangement shall be implemented for the biased differential protection:

(a) The CT ratios used shall be able to be accommodated by the low impedance differential protection.
(b) Use of auxiliary CTs is not permitted.
(c) The CT secondaries used for the low impedance differential protection may be used for other protection devices provided the CT can supply the burden without saturating during maximum offset through fault current conditions.
(d) The output of the transformer differential protection shall trip all circuit breakers associated with the network transformer and initiate CBF. Trip and alarm indications shall be latched with remote reset capability.

4.1.1 Over-fluxing protection application

(a) Unless directed otherwise in the project specification, the over-fluxing protection shall be disabled.
(b) If over-fluxing protection is required, it is to be derived from the busbar VTs, and voltage selection facilities are required.

4.1.1 Low impedance restricted earth fault protection application

The following arrangement shall be implemented for the low impedance restricted earth fault protection:

(a) The 499A relay shall be connected to CTs located before formation of the transformer neutral. This arrangement will provide protection against phase and earth faults. In case where phase segregated neutral CTs are not available then use of a single CT between neutral and earth connection should be used. This arrangement will provide protection against earth faults only.
(b) The 499B relay is only required to connect to a single phase CT located in the transformer neutral.
(c) The output for the restricted earth fault protection shall trip all circuit breakers associated with the network transformer and initiate CBF protection. Trip and alarm indications shall be latched with remote reset capability.

4.1.1 Buchholz protection

The following arrangement shall be implemented for the Buchholz protection:

(a) The Buchholz protection shall trip the ‘A’ trip coil of each circuit breaker via a separate trip relay.
(b) The alarm output shall be routed to SCADA via the 499A protection relay.
(c) The output of the relay shall trip all circuit breakers associated with the network transformer and initiate CBF protection – it should be noted that some fault conditions will exhibit very little fault
current and therefore will be beyond the capability of the overcurrent check to detect. The circuit breaker failure protection is unlikely to operate for an incipient fault on the transformer under no load or lightly loaded conditions. Trip and alarm indications shall be latched with remote reset capability.

4.1.1 Check Synchronisation

Check synchronisation for circuit breaker close commands issued by the protection relays is not required unless detailed in the project specification.

4.1.2 Over temperature protection

The following arrangement shall be implemented for the over temperature protection:

(a) The over temperature tripping function (if enabled) shall trip the ‘A’ trip coil of each circuit breaker.

(b) The stage two output of the over temperature devices shall be hard wired to binary inputs of the main protection relays (shared to minimise I/O usage) with logic configured to allow remote enabling or disabling of the trip function. Regardless of the trip enable status, the stage two temperature operations shall also be provided as an alarm.

4.1 Circuit breaker failure (CBF) protection application

For the application of CBF on network transformer circuit breakers, see the Protection of EHV Busbars Standard.

4.2 Automatic voltage regulator (AVR) application

The following arrangement shall be implemented for the AVR:

(a) Where voltage support is required for the 110 kV busbar, the AVR shall be configured for service using the 110 kV voltage as the reference voltage. The Contractor shall consult with TasNetworks to determine TasNetworks’ requirements for voltage support before placing the AVR into service following commissioning.

(b) The AVR of parallel transformers must be configured for inter-AVR communications for overall substation voltage control. The control functionality of the device must be configured to cater for the loss of inter-AVR communications or the opening of the 110 kV bus coupler so that the transformers can operate independently.

4.1 Blocking of CB open and close commands

The following functions shall be applied:

(a) CB trip commands should not be blocked on alarms from CB spring charge, SF6 and motor supply fail.

(b) CB close commands shall be blocked on alarms from CB spring charge, SF6 and motor supply fail.

(c) CB close commands shall be blocked if there are simultaneous operations of both ‘A’ and ‘B’ TCS.

(d) The operation of one TCS shall not block the close command.

(e) The operation of one TCS shall not block the open command.
5 Protection and control settings

The logic configuration of the relays shall incorporate the requirements stated in the application where appropriate.

5.1 Delta tertiary winding protection settings

The following settings are applicable for the delta tertiary winding earth fault protection:

(a) The current setting shall be set to detect low levels of earth fault current having a primary value of 50 Amps.

(b) In order to ensure the sensitivity of the protection, the associated CT ratio shall be as low as possible while still catering for the maximum phase to earth fault.

(c) The definite time characteristic shall be set for a time delay of 100 milliseconds.

5.1 Distance protection settings

The following settings are applicable for the distance protection:

(a) The reach of the reverse zone shall be set to 0.2 x zone 1 of the shortest transmission line from the EHV busbar.

(b) An appropriate zero sequence compensation factor K0 should be set.

(c) The time delay setting shall be 400 milliseconds.

5.1 Biased differential protection settings

The following settings are applicable for the biased differential protection:

(a) The relay differential pickup setting shall be set from 20 per cent to 25 per cent of the ONAN rated current of the transformer. This setting shall be checked if the range of transformer tapping is significant.

(b) The slope 1 bias characteristic settings shall be set to ensure that the relay remains stable under maximum loading condition with the transformer OLTC at the extreme ends of the tapping range and maximum CT error.

(c) The slope 2 bias characteristic settings shall be set to ensure that the relay remains stable for maximum through fault conditions with CT saturation.

(d) It is recommended that the manufacturer’s manual should be utilised for getting guidance on calculation of pickup and slope characteristic as applicable.

(e) The unrestrained high set differential element should be set above the maximum through fault current.

(f) Second harmonic restraint shall be set to 15 per cent of the fundamental current and where available, cross-blocking enabled for a time period of three cycles depending on transformer design.

(g) Where the fifth harmonic restraint setting is available and enabled, the setting shall be set to 30 per cent of the fundamental frequency.
5.1 Circuit breaker failure (CBF) protection settings
For setting requirements of CBF on network transformer circuit breakers, see the Protection of EHV Busbars Standard.

5.2 Over-fluxing protection settings
If enabled the following settings are applicable for the over-fluxing protection:
(a) The relay manufacturer’s manual must be used as a guide on how to set the over-fluxing protection.
(b) Information relating to the associated transformer manufacturer withstand values should be sought from the appropriate TasNetworks project representative.

5.1 Thermal overload protection settings
In the event that the overload protection is enabled the settings shall take into account the transformer operating regime as described in TasNetworks’ Network Transformer Standard. The setting parameters shall include the time constants for the oil and the transformer winding together with the full load current of the transformer and the maximum permissible current of the transformer. In addition the trip setting shall be coordinated with upstream and downstream overcurrent protection.

The output of the protection shall trip all circuit breakers associated with the transformer and initiate circuit breaker failure protection (CBF).

5.2 Restricted earth fault protection settings
The low impedance restricted earth fault protection shall:
(a) be set to operate at 10 per cent to 15 per cent of nominal current with appropriate bias/slope to prevent spurious operation due to CT saturation on a through fault;
(b) be set sensitive enough to pick up faults close to the neutral point; and
(c) in most applications, have a slope set to 40 per cent.

5.1 Check Synchronisation settings
Check synchronisation settings are to be requested from TasNetworks if required.

5.2 Over temperature protection settings
If enabled the following arrangement shall be implemented for the over temperature protection:
(a) The top oil temperature setting for the stage one function shall be 90°C.
(b) The top oil stage two setting shall be 100°C.
(c) The hot spot stage one function setting shall be 100°C.
(d) The hot spot stage two function shall be set to 120°C.

5.1 Automatic voltage regulator (AVR) settings
Generally system studies should be carried out to determine appropriate settings for the AVR. In the absence of these studies, the following philosophy shall be applied for setting of the AVR:
(a) AVR settings must be coordinated with any system capacitors installed at the site in order to avoid hunting.

(b) The voltage set point must be a value which can provide acceptable bus voltage under normal and contingency conditions.

(c) The dead band setting should be based on the voltage change produced by a single tap interval. This should preferably be set to 105 per cent of the voltage change produced by a single tap interval.

(d) The temporary voltage control range shall be set as 1.048 to 1.022 p.u with a target voltage of 1.035 p.u.

(e) the AVR shall be blocked when the voltage exceeds the following limits:
   (i) Lower limit shall be set to 80 per cent of nominal voltage.
   (ii) Upper limit shall be set to 135 per cent of nominal voltage.

(f) The AVR shall be blocked when the transformer capacity exceeds 150 per cent of nominal load.
### Appendix 1 – Standard secondary equipment

Where possible standard equipment must be used to ensure the most efficient maintenance practices are able to be undertaken. The following table shows the standard equipment types that are currently used by TasNetworks in network transformer protection installations.

<table>
<thead>
<tr>
<th>Device number</th>
<th>Manufacturer</th>
<th>Model</th>
<th>Order code</th>
<th>TasNetworks Standard drawings</th>
</tr>
</thead>
<tbody>
<tr>
<td>499A</td>
<td>Siemens</td>
<td>7UT86</td>
<td>P1F97574</td>
<td>TSD-DI-809-0080-001</td>
</tr>
<tr>
<td>499B</td>
<td>GE</td>
<td>T60</td>
<td>VE7-HLH-F8N-H6T-M8L-P6G-U6T-W6T</td>
<td>TSD-DI-809-0080-001</td>
</tr>
<tr>
<td>590</td>
<td>A-Eberle</td>
<td>REG-D</td>
<td>100-0030-835</td>
<td>TSD-DI-809-0080-001</td>
</tr>
</tbody>
</table>