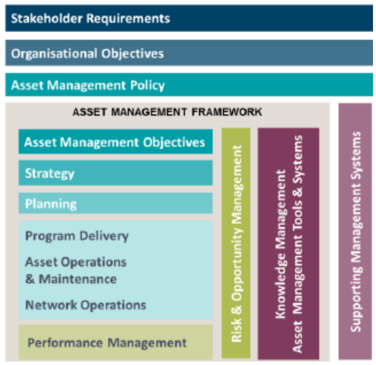
Electrical and Mechanical Interlocking

Design Standard



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RESPONSIBILITIES

Western Power's Engineering & Design Function is responsible for this document

CONTACT

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Contents

Revision Details[1]

Version	Date	EDM Version	Summary of change
0	May 2017	1.0	Original Issue
1	June 2019	2.0	Changed to AMS format. Added ARP policy (Section 9.1) as per Engineering Design Instruction Information Register.
2	October 2020	3.0	Added Section 8.1.2 items 4 & 8-12 as per Engineering Design Instruction Feedback Register items 13 & 14. Updated drawing references to logic diagrams in Section 10. General interlocking requirements added, Section 7. Updated SLD's to include cable connection disconnector on Type 2 switchboards.
3	Feb 2024	4.0	Formatting updated. Updated as per items 15, 16, & 17 of the Engineering Design Instruction Feedback Register.
4	Feb 2024	5.0	Standards Online Update

1 See Western Power Internal Document

1 Introduction

The purpose of this Engineering Design Instruction (EDI) is to assist engineers with the design and implementation of interlocking requirements for transmission substations.

Interlocking is necessary to:

- Ensure equipment is operated in the correct sequence.
- Prevent danger to personnel and damage to equipment from incorrect operation of equipment.

The presence of interlocks provides a higher level of reliability, even in the case of accidental error.

Interlocking can be achieved by electrical or mechanical methods.

1.1 Purpose and scope

This Engineering Design Instruction sets out the mechanical and electrical interlocking requirements for different equipment types within a substation, on both Greenfield and Brownfield sites.

1.2 Acronyms

Acronym	Definition

1.3 Definitions

Term	Definition
Interlocking device	A device that makes the operation of a switching device dependent upon the position or operation of one or more other pieces of equipment.
Key Interlocks	Key interlocks are important in interlocking units of the same switchgear, or of other low, medium and high voltage switchgear. For instance, the apparatus' racking-in/out operations and earthing switches' opening/closing can be prevented by means of key locks, which prevent insertion of the relevant operating levers.
Padlocks or deadbolts	Padlocks or deadbolts can lock the apparatus and feeder compartment doors into the closed or open position. These can be applied to either door closing versions – with screws or a central handle. The apparatus' racking-in/out and earthing switches' opening/closing can be prevented by applying the padlocks to the insertion slots of the relevant operating levers.
Locking magnets or blocking coils	Locking magnets or blocking coils are used to make automatic interlock logics without human intervention. The provision of auxiliary switches in earth switches by most manufacturers enables electrical interlocking among devices in switchgear. The apparatus racking-in/out and earth switch opening/closing operations can be prevented. The doors of the apparatus and feeder compartments can also be locked in the closed position. Doors can use magnets that operate with active logic, with a lack of auxiliary voltage making the lock become operative.
DIS	Disconnector

ES	Earth Switch
CB	Circuit Breaker

1.4 References

References which support implementation of this document

Table 1.1 References

Reference No.	Title

2 Supporting Documentation[2]

3 Compliance

The Engineering Design Instruction should encompass all requirements of the relevant Australian Standards which are current at the time. These relevant Standards and Guidelines are listed in below in Table 3.1. A period will be set when the standard needs to be reviewed. If significant changes occur on an Australian Standard which affects safety, then an out of cycle review can be completed.

Table 3.1: Standards and Guidelines

Standard Number	Standard Title
AS 2067 - 2016	AS 2067 - 2016 Substations and High Voltage installations exceeding 1kV AC
AS2650-2005	Common specifications for high-voltage switchgear and control gear standards (IEC60694, Ed.2.2(2002) MOD)
AS 62271.200-2005	High-voltage switchgear and control gear – A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV (IEC 62271-200, Ed. 1 (2003) MOD)
AS2467-2008	Maintenance of electrical switchgear
IEC 62271	High voltage switchgear and control gear (2007) part 1 common specifications – (supersedes IEC 60694 Ed 2.2)
IEC 62271-200–Ed 1. 2003	High-Voltage switchgear and control gear-part 200: AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV

2 See Western Power Internal Document

Compliance to this Engineering Design Instruction is necessary to provide a safe working environment within a substation. All interlocking requirements must be implemented where applicable to ensure full compliance.

4 Functional Requirements

The function of interlocks are to provide additional safety measures. The interlocking schemes acts as a last line of defence for operators in the event of an accidental error, but at the same time shouldn't act as a hindrance when following an operating program if the equipment has been proven safe.

The functional requirements for interlocking schemes shall conform with relevant Australian and IEC standards applicable to the equipment type and service voltage along with additional operational and safety requirements outlined below:

- The design of electrical / mechanical interlocking schemes should be "robust" so as to prevent the likelihood of being "bypassed" or having their operational function impaired – by persons employing "reasonable" operating force, whilst using the correct and appropriate operating tools, levers, bolt, handles or other actuators applicable to their operation.
- The electrical / mechanical interlocking design methodology shall deliver reliable and correct function throughout the operation service life of the equipment.
- In the event of the loss of power supplies, electrical interlocking schemes shall be designed to fail safely and not contribute towards an unsafe operating function.
- In the event of failure of springs, levers, magnets or any other mechanical stored energy device employed in the operation of interlocking schemes, the scheme shall be designed to fail safely and not contribute towards an unsafe operating condition.
- The correct operational of the function of the mechanical interlocking schemes shall be independent of the speed or travel interval at which the interlocking lever, bolt, handle, tool or other actuator is operated.
- Electrical and mechanical interlocking schemes shall be designed such that they require minimal, if any, ongoing maintenance or lubrication.
- If maintenance or lubrication of interlocking devices is required then the interval, nature and extent of this maintenance shall be clearly and separately described in the equipment operation and maintenance manual, along with a schedule of recommended lubricants.
- Electrical and mechanical interlocking schemes shall be designed with a "fixed point" operating system, with reliable operation not dependent upon correct adjustment, routine re-alignment or re-adjustment during their service life.
- Such schemes shall be robust and provide allowance for expected component wear during the service life of the equipment without functional "drift" or "creep", which could result in their mal-operation or impair their correct function.
- The point of interlock actuation shall be as near to the final "correct" operating position of the equipment as is required, to ensure safe and reliable interface between associated interlocked apparatus and correct apparatus performance.
- The operating sequence of electrical and mechanical interlocking schemes shall be designed such that at no point during their function or movement, a position could result where an unsafe or "illegal" equipment operation can be performed.

- The method of correct interlock function or use shall be unambiguously indicated using permanent labelling, adjacent to the relevant operating lever, handle, bolt, push button or other actuator.
- The final interlock operating position (e.g. "Locked" / "Free") shall be unambiguously indicated using permanent labelling adjacent to the relevant operating lever, handle, bolt, push button or other actuator.
- Interlocking provisions on metal enclosed switchgear and control gear shall conform to the requirements of AS 62271.200-2005 High-Voltage switchgear and control gear – part 200:AC metal-enclosed switchgear and control gear for rated voltages above 1kV up to and including 52kV (IEC 62271-200, Ed.1 (2003).
- The interlocking scheme must ensure a return to the original position after operation (particularly key exchange interlock schemes), to avoid logic steps being bypassed during the next operation.

5 Safety in Design[3]

Safety in Design (SID) is integral to interlocking design. It is an essential thought process that focuses on making the design safer and easier to understand, to eliminate or mitigate potential hazards during the design phase of a project.

Safety is already inherent within interlocking design to prevent danger to personnel and damage to equipment.

The implementation of site interlocking support the safety for all site personnel, and can have a varying influence depending on the type of work involved (switching, construction, maintenance etc.)

Some examples of SID within interlocking design include:

- Plant specification - Does the switchboard manufacturer provide all necessary status outputs to implement a standard interlocking design? Missing status outputs can lead to a more complex logic to maintain the interlocking standard.
- Brownfield sites - Do the existing disconnectors have the required auxiliary output contacts available? Is it possible to safely retrofit new ones to implement the proposed interlocking?
- Consider possible switching procedure shortfalls - Does the capacitor bank compound key need to be returned to the panel after maintenance? If the key is misplaced, is it possible to bypass logic steps i.e. earth switch close inhibition
- Consider standard switching procedures - Will the interlocking process be easy to follow? Where will the interlocking logic diagram be available on site for operators?
- Consider maintenance procedures on the equipment - Will the interlocking process hinder any future maintenance procedures? A complicated or difficult process may increase the likelihood of errors.

Interlocking is generally implemented during the "Secondary Design Stage" of the project, however it should be considered as early as the plant procurement stage. Risk Workshops are used to discuss potential interlocking issues with the project design.

All projects are required to have a SID Hazard Management Register to include evidence of all measures implemented to eliminate or reduce risks.

[3] See Western Power Internal Document

6 Overview of the Main Design Elements

This design instruction covers the following processes to ensure all interlocking requirements are established:

- Application of Interlocking Requirements and preparation of an Interlocking Checklist

  (Section 7 – Interlocking Requirements)
- Ensuring all Interlocking Requirements for the specific substation configuration are implemented

  (Section 8 – Greenfield Substations, Section 9 – Brownfield Substations)
- Development of an Interlocking Logic Diagram
  (Section 11 – Interlocking Logic Diagram)

7 Interlocking Requirements

The requirements of site interlocking are dependent on the substation configuration, layout and existing equipment.

In general, interlocking must meet the following requirements:

- Earth switches must not be able to close onto a live bus.
- Disconnectors must not be able to operate on load but may be operated on potential.
- Circuit breakers must be isolated before being maintained (local supply only enabled once isolated).
- Circuit breakers must not be able to close onto two live systems that are not synchronised.
- Busbars must have all sources isolated before a busbar earth switch can be closed.

7.1 Application of Interlocking Requirements (Principles)

The site classification (Greenfield or Brownfield) will determine the interlocking requirements. Standard interlocking requirements apply for Greenfield sites.

Interlocking with existing assets (Brownfield) shall be made practical where possible, by either matching with the existing site interlocking or by using a Greenfield interlocking approach.

All interlocking provided by the manufacturer shall be implemented and included in the equipment installation.

Interlocking between Western Power and 3rd party sites must be hard wired to ensure the integrity of the interlocking logic.

7.2 Interlocking Checklist[4]

For new switchgear installations, the designer must ensure that all interlocking requirements are implemented correctly. This can be checked by matching each site interlocking requirement with a compliant interlocking solution on a checklist table.

Different switchgear manufacturers offer varying degrees of interlocking functionality. This must be checked prior to contract acceptance to ensure all Western Power's interlocking requirements are fulfilled. Reduced switchgear interlocking functionality can increase the complexity of Western Power interlocking required to achieve compliance.

8 Greenfield Substations

Interlocking serves as an additional layer of protection against maloperation of assets. It assumes standard switching procedures; therefore, we do not interlock past the first isolation point.

Note: *The logic provided is a detailed clarification of the interlocking requirement. These are examples only and shall be applied as required.*

8.1 Breaker and a Half[5]

The following pieces of equipment are to be interlocked in a standard breaker and a half yard (refer to Appendix A, Figure A.1 and Figure B.1).

Table 8.1: Breaker and a half interlocking

Plant	Logic
930.7a Bus Earth Switch	Local/remote control enabled when: 1. Adjacent DIS status: 931.4, 921.0,…. status: Open OR 1. Bus no volt relay (NVR) status: No volts 2. Bus NVR MCB Status: MCB closed
931.4 Bay Disconnector	Local/remote control enabled when: 1. Associated CB status: 931.0 Open 2. Adjacent ES status: 930.7a and 931/7a Open
931.7b Bay Earthswitch	Local/remote control enabled when: 1. Adjacent DIS status: 931.4 Open 2. Adjacent CB status: 931.0 Open
931.0 Bay Circuit Breaker	Local close enabled when: 1. Adjacent DIS status: 931.4 Open 2. Adjacent DIS status: 931.3 Open

4 See Western Power Internal Document
5 See Western Power Internal Document

Plant	Logic
931.7b Bay Disconnector	Local/remote control enabled when: 1. Adjacent DIS status: 931.3 Open 2. Adjacent CB status: 931.0 Open
931.3 Bay Disconnector	Local/remote control enabled when: 1. Adjacent ES status: 931.7b Open 2. Adjacent ES status: 932.7a Open
932.7a Bay Earthswitch	Local/remote control enabled when: 1. Adjacent DIS status: 931.3 Open 2. Associated DIS status: 932.5 Open
932.5 Line Disconnector	Local/remote control enabled when: 1. Adjacent ES status: 932.7a Open 2. Adjacent ES status: 932.7 Open
932.7 Line Earthswitch	Local/remote control enabled when: 1. Adjacent ES status: 932.7a Open 2. Line NVR status: No volts 3. Line VT MCB status: MCB closed
933.3a Bay Disconnector	Local/remote control enabled when: 1. Adjacent ES status: 933.7a Open 2. Adjacent ES status: 932.7a Open
933.7a	Local/remote control enabled when: 1. Adjacent DIS status: 933.3a Open 2. Adjacent CB status: 933.0 Open
933.0	Local close enabled when: 1. Adjacent DIS status: 933.3a Open 2. Adjacent DIS status: 933.3b Open
934.5 Transformer Disconnector	Local/remote control enabled when: 1. Adjacent CB status: 933.0 Open 2. Adjacent CB status: 935.0 Open 3. Adjacent ES status: 934.7b Open 4. Adjacent ES status: 934.7 Open 5. Transformer LV ES status: Open
842.5 Transformer Disconnector	Local/remote control enabled when: 1. Adjacent CB status: 841.0 Open 2. Adjacent CB status: 843.0 Open 3. Adjacent ES status: 842.7b Open 4. Adjacent ES status: 842.7 Open 5. Transformer HV ES status: 934.5 Open
Capacitor and Reactor Bank	Refer to Protection Design Guidelines

8.2 Double Busbar

The following pieces of equipment are to be interlocked in a standard double busbar yard (refer to Appendix B, Figure B3):

Table 8.2: Double busbar interlocking

Plant	Logic
802.5 Line disconnector	802.5 close enabled when: 1. 802.0 status: Open 2. 802.7 status: Open
802.7 Line earth switch	802.7 close enabled when: 1. 802.5 status: Open 2. Line NVR status: No volts 3. NVR MCB status: Closed
801.4a Bay disconnector	801.4a close enabled when: 801.0a status: Open
803.5 Transformer disconnector	803.4 open enabled when: 1. 803.0 status: Open 2. 803.7 status: Open 3. HV earthswitch status: Open
803.7 Transformer HV earth switch	803.7 open/close enabled when 1. 803.5 status: Open 2. HV disconnector status: Open
804.0	804.0 open/close enabled when: 1. 804.4a status: Open 2. 804.4b status: Open 3. 804.5 status: Open

8.3 Ring Bus

The following pieces of equipment are to be interlocked in a standard ring bus arrangement. Refer to Appendix A - Figure A.2.

Table 8.3: Ring Bus Interlocking

Plant	Interlocking Logic
903.5 Line Disconnector	903.5 open/close enabled when: 1. 904.0 status: Open 2. 902.0 status: Open 3. 903.7 status: Open 4. 903.7a status: Open

Plant	Interlocking Logic
903.7 Line Earth Switch	903.7 close enable when: 1. 903.5 status: Open 2. NVR status: No volts 3. NVR MCB status: Closed
902.3b Bus Disconnector	902.3b open/close when: 1. 902.0 status: Open 2. 903.7a status: Open 3. 902.7b status: Open
903.7a Bus Earth Switch	903.7a close enable when: 1. 903.5 status: Open 2. 902.3b status: Open 3. 904.3a status: Open
901.5 Transformer Disconnector	901.5 open/close enabled when: 1. 902.0 status: Open 2. 912.0 status: Open 3. 901.7a status: Open 4. 901.7 status: Open 5. LV ES status: Open
901.7 Transformer Earth Switch	901.7 close enabled when: 1. 901.5 status: Open 2. LV DIS status: Open
908.0	908.0 open/close enabled when: 1. 908.3a status: Open 2. 908.3b status: Open

8.4 Zone Substation HV

The following pieces of equipment are to be interlocked in a standard zone substation HV arrangement. Refer to Appendix B - Figure B.2 and Figure C3.

Table 8.4: Zone Substation Interlocking

Plant	Logic
801.0 Line Circuit Breaker	801.0 local close enabled when: 1. 801.4 status: Open 2. 801.5 status: Open
802.0 Transformer HV CB (AIS)	803.0 local close enabled when: 1. 803.4 status: Open
Transformer HV CB (GIS)	803.0 close enable when: 1. 803.4 status: Open 2. 314.7 status: Open
Line Disconnector	Line disconnector can close when line earth switch is open. If a close solenoid is provided it should be supplied from the same battery supplying the circuit breaker control. 801.5 close enabled when 801.7 is open.
Line Earth Switch	Line earth switch can close when line disconnector is open. If a close solenoid is provided it should be supplied from the same battery supplying the circuit breaker control. 801.7 close enabled when 801.5 is open.

Notes:

8.5 Zone Substation MV Air Insulated Switchboards (AIS)

Circuit breakers must be mechanically interlocked and can only be withdrawn in "Open" state. Refer the Substation Design Drawing Register for examples of AIS interlocking logic.

The following pieces of equipment are to be interlocked in a standard AIS arrangement. Refer to Appendix C, Figure C.1 and Figure C.2.

Table 8.5: AIS Switchboard

Plant	Logic
506.0 Transformer LV Circuit Breaker	506.0 Close enabled when: Transformer HV Disconnector status: Open 506.7 ES status: Open
506.7 Transformer LV Earth Switch	506.7 close enabled when: Transformer HV Disconnector status: Open 506.0 status: Withdrawn
504.7 Feeder Earth Switch	504.7 close enabled when: 504.0 status: Withdrawn
509.7a1 Busbar Earth Switch	509.7a1 close enabled when source CBs are withdrawn1: 510.0 status: Withdrawn 506.0 status: Withdrawn PPG connections are treated as typical feeder connections and do not require additional interlocking for busbar isolation. Standard switching procedure requires all busbar connected circuit breakers to be withdrawn prior to closing the busbar earth switch.
501.7 Station Transformer CB	501.7 close enabled when: 501.1 status: Withdrawn (or 501.0 depending on switchboard manufacturer) Low voltage CFS / isolation point if applicable
502.7 Capacitor Earth Switch	502.7 ES close enabled when2: 502.0 has been withdrawn and open for 10 min

510.7a2 Cable Connection Earth Switch	510.7a2 close enabled when: 510.0 status: Open 515.4 status (from next switchboard): Withdrawn
515.4 Cable Connection Disconnector	515.4 can only be withdrawn when: 510.0 status: Open
510.0 Bus Section Circuit Breaker	510.0 can only be withdrawn when: 510.7a2 status: Closed
	CB closed enabled when: 510.7a2 status: Open
Circuit Breakers General	CB local and remote close is inhibited until: CB is fully and correctly wound, racked or selected to the appropriate in service, disconnected, removed, test or earthing position (whichever one is applicable) and robustly interlocked to this position.
	If a circuit breaker possesses an integral earth position (i.e., the circuit breaker is selected to an "earthing position") and then "Closed" again to apply an earth to the circuit) then the remote "Open" or "Trip" of the circuit breaker must be inhibited whilst in this state. Only local "Open" or "Trip" from the earthed position shall be possible.

8.6 Zone Substation MV Gas Insulated Switchboards (GIS)

Gas insulated switchboards have the circuit earth switch upstream from the circuit breaker. GIS switchgear is sealed in a gas compartment and cannot be withdrawn. Refer the Appendix C, Figure C.3.

9 Brownfield Substations

Existing brownfield substations often have specific interlocking schemes, and this should remain consistent where practical.

Brownfield design can include minor or major site modifications, and interlocking requirements should be applied accordingly.

The following requirements apply for minor brownfield design modifications:

- All interlocking to be hardwired.

- The method of correct interlock function or use shall be unambiguously indicated using permanent labelling adjacent to the relevant operating lever, handle, bolt, push-button or other actuator.
- The final interlock operating position (e.g., “Locked / “Free”) shall be unambiguously indicated using permanent labelling adjacent to the relevant operating lever, handle, bolt, push-button or other actuator.

The standard greenfield interlocking approach shall be applied to major brownfield design modifications. As an example, interlocking requirements shall conform to those of a greenfield site where a complete bay of new outdoor equipment is added, or a complete suite of additional indoor switchgear is added.

9.1 Asset Replacement[6]

Brownfield assets are often not interlocked or are part of an older interlocking scheme. When these assets are replaced, the associated primary and secondary equipment may need to be upgraded in order to comply with the current interlocking standard.

For the asset replacement program in Brownfield sites, the implementation of interlocking schemes shall be carried out as per Table 9.1 below.

Table 9.1 Implementation of interlocking schemes rules during Asset Replacement

Scenario	Rule
1	If secondary equipment is replaced and all auxiliary contacts are available on the associated primary plant (i.e., disconnectors and circuit breakers), and no additional civil works are required then implement the interlocking scheme.
2	If secondary equipment is replaced and all auxiliary contacts are available on the associated primary plant (i.e., disconnectors and circuit breakers), but additional civil works are required, discuss the requirement for an interlocking scheme with Operational Asset Performance team.
3	If primary equipment is replaced and the required interlocking contacts and secondary equipment are available, then update the scheme to the current design standard. (Do not add auxiliary contacts to primary plant or replace the secondary equipment).

In all other cases, assets shall be replaced like-for-like using the existing scheme and arrangement. Additional contacts shall not be added to existing primary equipment and secondary equipment shall not be replaced.

6 See Western Power Internal Document

10 Special Cases

10.1 Capacitor Banks

Table 10.1: Capacitor bank interlocking

Plant	Logic
502.0	502.0 close enabled when: 502.0 open for 10 minutes

Table 10.2: AIS Capacitor gate key interlocking

Plant	Logic
502.7 Capacitor Earth Switch	502.7 close enabled when: 502.0 withdrawn for 10 minutes
Capacitor Gate Key	Gate key released when: 502.7 status: Closed

Table 10.2: GIS Capacitor gate key Interlocking

Plant	Logic
342 Capacitor	342 gate key is released after the following sequence of events: 342.0 opened 342.4 opened 342.7 closed 342.0 closed (after it has been open for 10 minutes) (CB needs to be closed to earth the capacitor bank circuit) Gate key released

Notes:

(1) Capacitor banks require a 10-minute time delay to allow for discharging before applying the earth switch. Access to capacitor compound(s) is only available after earth switch is applied. A separate interlock (key system) is required to ensure the capacitor compound is only accessible when the earth switch is Closed. Once capacitor compound(s) access is available, the earth switch can be opened for testing purposes. However, the security of the capacitor compound(s) must be restored prior to closure of the circuit breaker. Refer to Protection Design Guidelines.

10.2 Reactor Banks[7]

Refer to Protection Design Guidelines.

10.3 Sync Check

The Sync Check function is to prevent closing of two out of sync systems.

Table 10.3: Sync check interlocking

Plant	Logic
801.0 Line Circuit Breaker (syncing with 802.0 line)	801.0 close enabled when: 1. System status: Synchronised 2. 801.4, 801.5,802.4,802.5 status: Closed 3. 801 VT MCB status: Closed 4. 802 VT MCB status: Closed

Notes:

(2) The 802.0 circuit breaker status is left out of the logic to allow black start closing.

11 Interlocking Logic Diagram

Many brownfield sites employ an interlocking scheme using hardwired signals for control, indication and alarms, which are reflected on our schematic drawings.

Greenfield sites now use the IEC61850 communication protocol, which allows some of these signals to be transmitted via optical fibre and network communications. Interlocking can be set using relay logic and will not necessarily be visible on the schematic drawings.

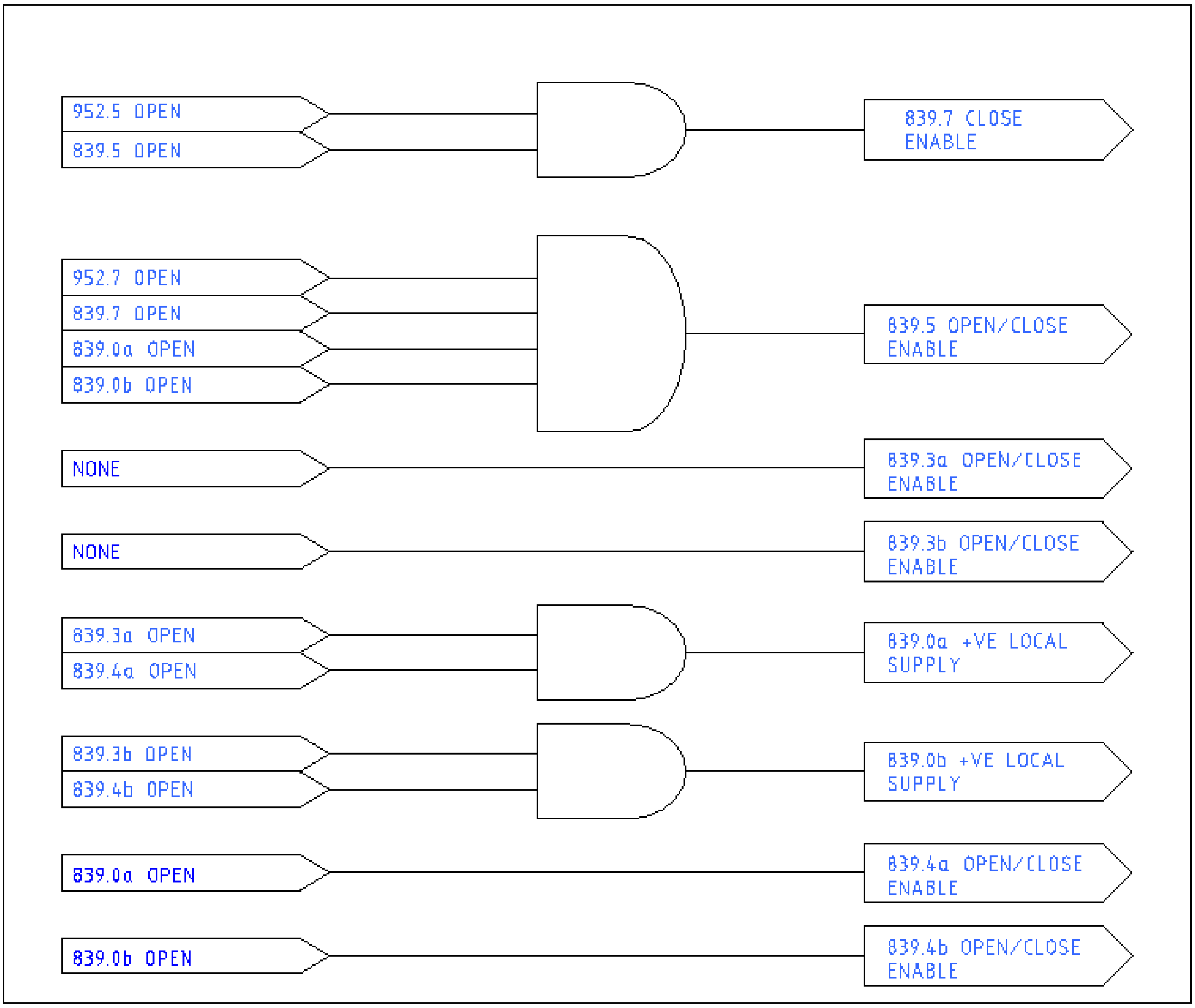
In order to ensure full compliance, a project must track all relevant interlocking types (mechanical, hardwire, relay logic) using an Interlocking Logic Diagram. This diagram is drawn in Microstation and includes all logic associated with the project interlocking design. Synchronism check must be included in the logic diagrams (refer to Protection Design Guidelines – Circuit Breaker Protection). Designers should refer to the interlocking logic diagram during schematic design and application of relay settings.

Field Commissioning will reference the interlocking logic diagram to ensure compliance with the interlocking requirements.

The interlocking logic diagram shall be converted to a CAD drawing and imported into the WP drawing system. This drawing shall be provided to the Protection team to allow them to implement the approved interlocking logic.

See the logic diagram below for an example.

[7] See Western Power Internal Document


952.5 OPEN
839.5 OPEN
839.7 CLOSE ENABLE
952.7 OPEN
839.7 OPEN
839.0a OPEN
839.0b OPEN
839.5 OPEN/CLOSE ENABLE
NONE
839.3a OPEN/CLOSE ENABLE
NONE
839.3b OPEN/CLOSE ENABLE
839.3a OPEN
839.4a OPEN
839.0a +VE LOCAL SUPPLY
839.3b OPEN
839.4b OPEN
839.0b +VE LOCAL SUPPLY
839.0a OPEN
839.4a OPEN/CLOSE ENABLE
839.0b OPEN
839.4b OPEN/CLOSE ENABLE

Appendix A: 330 kV Single Line diagrams

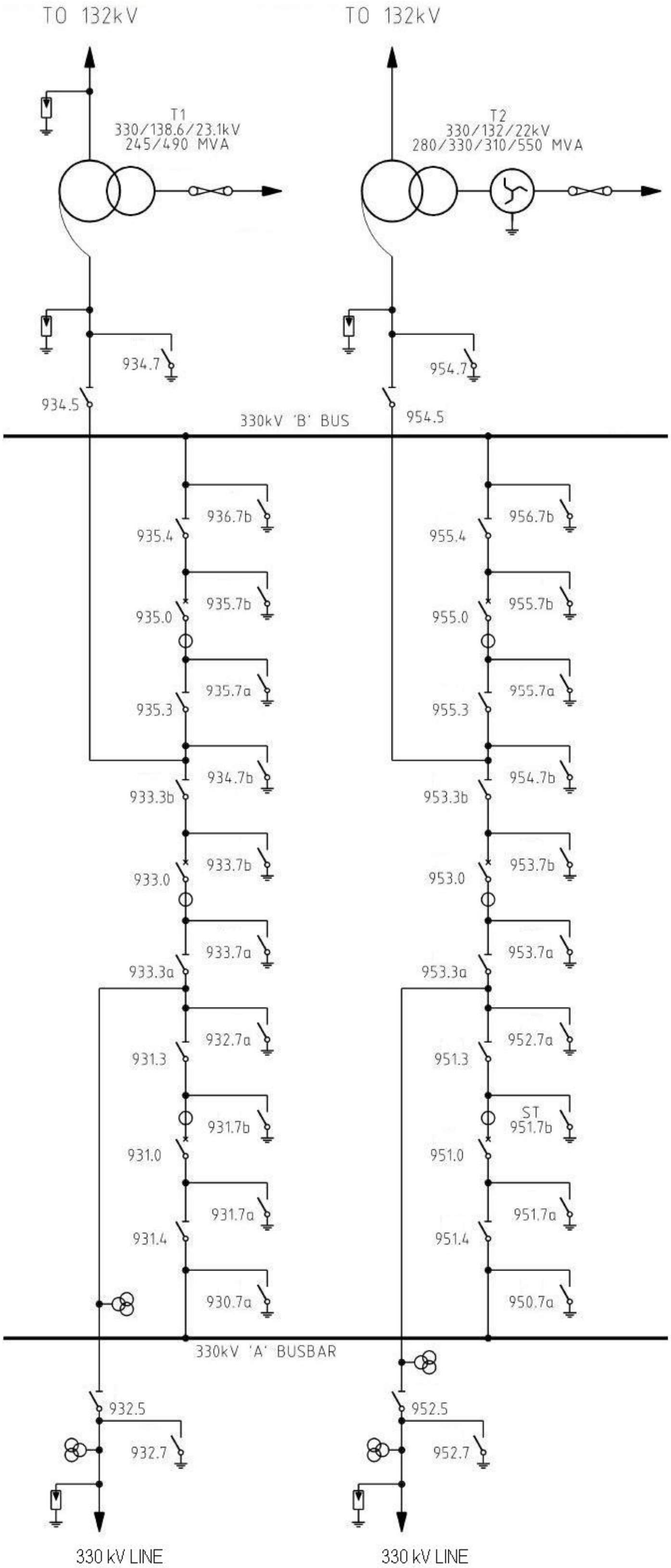


Figure A.1: Single line diagram of a typical 330kV breaker and a half yard

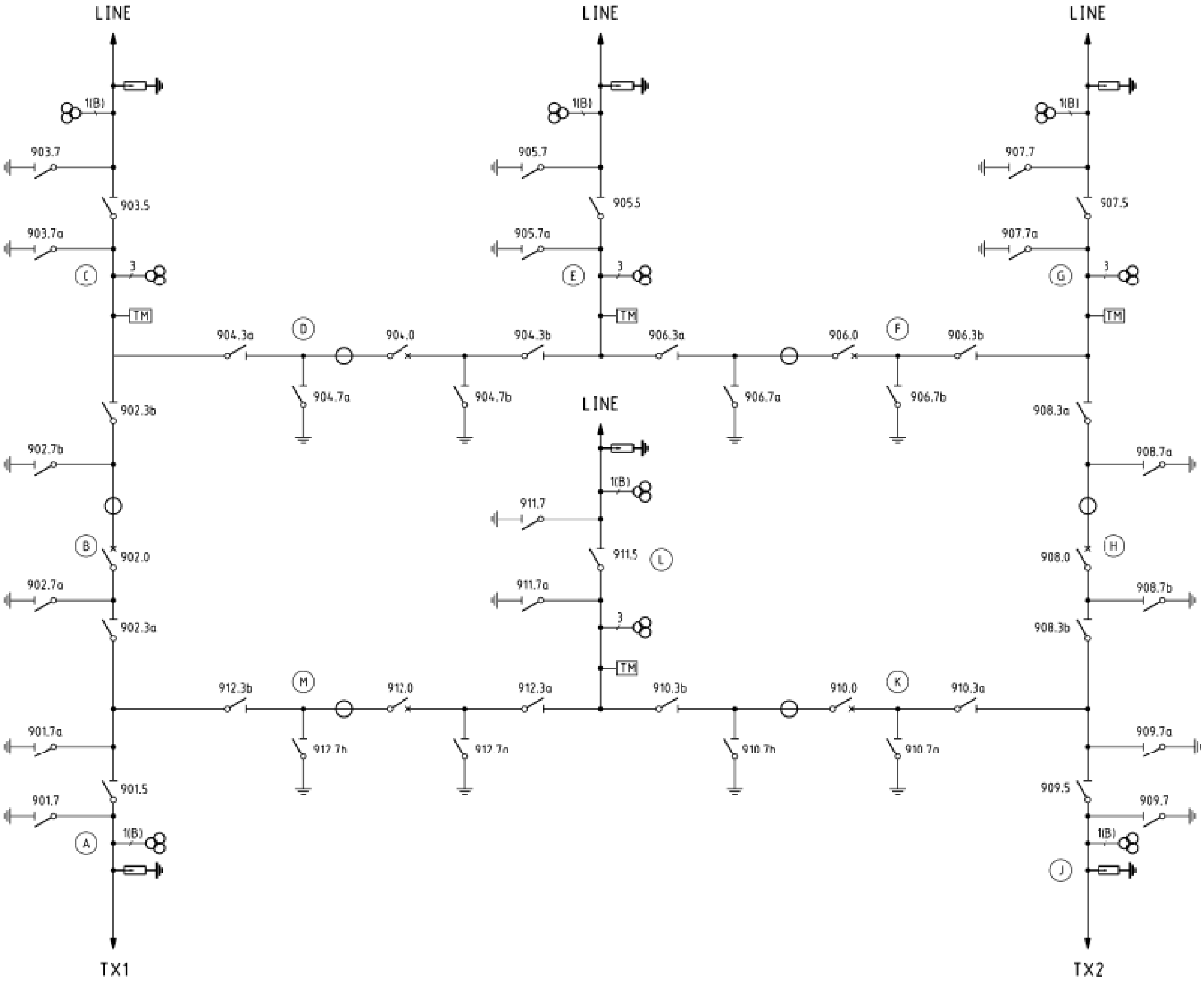


Figure A.2: 330kV ring bus system

Appendix B: 132 kV Single Line Diagrams

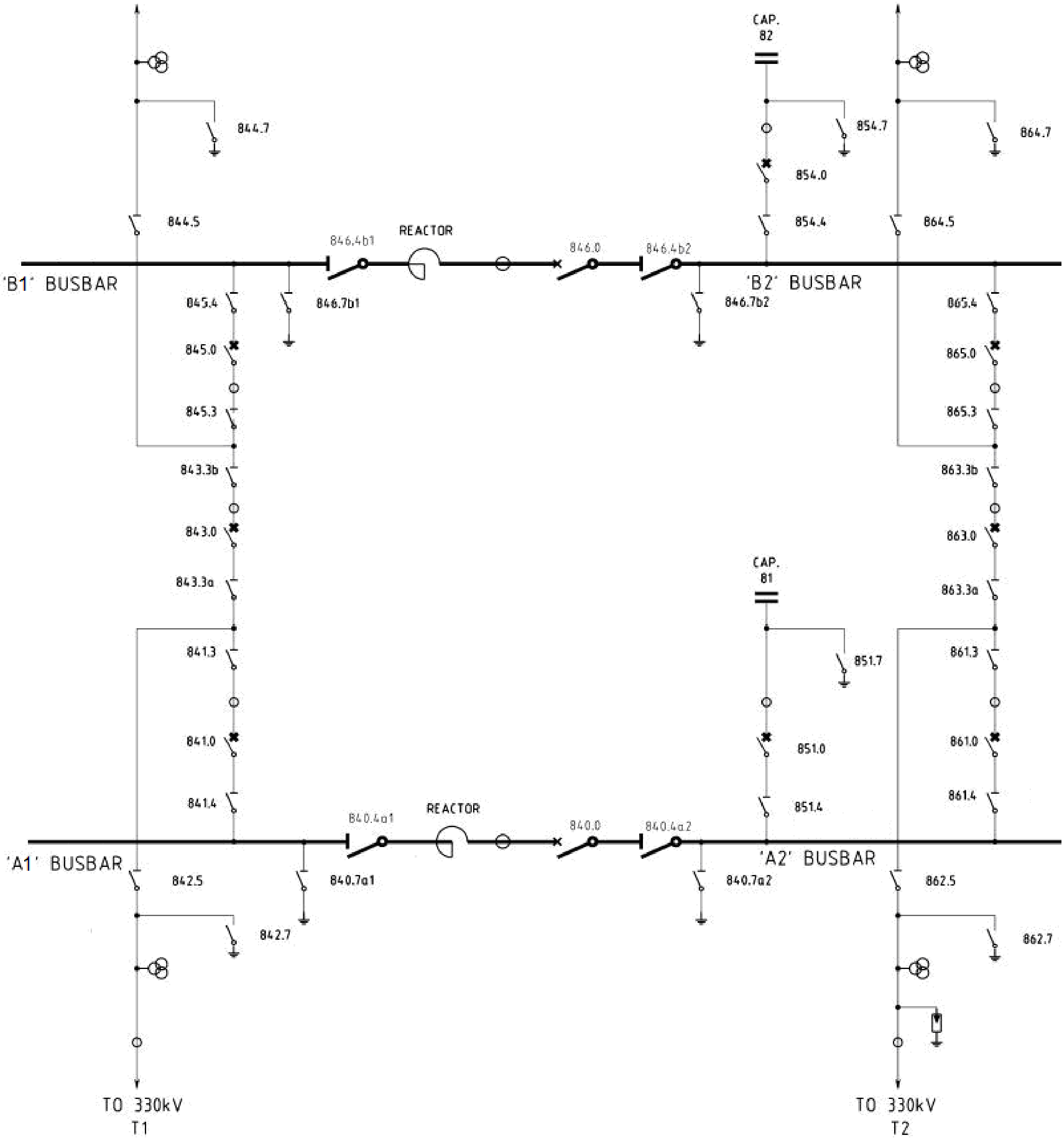


Figure B.1: Breaker and a half system

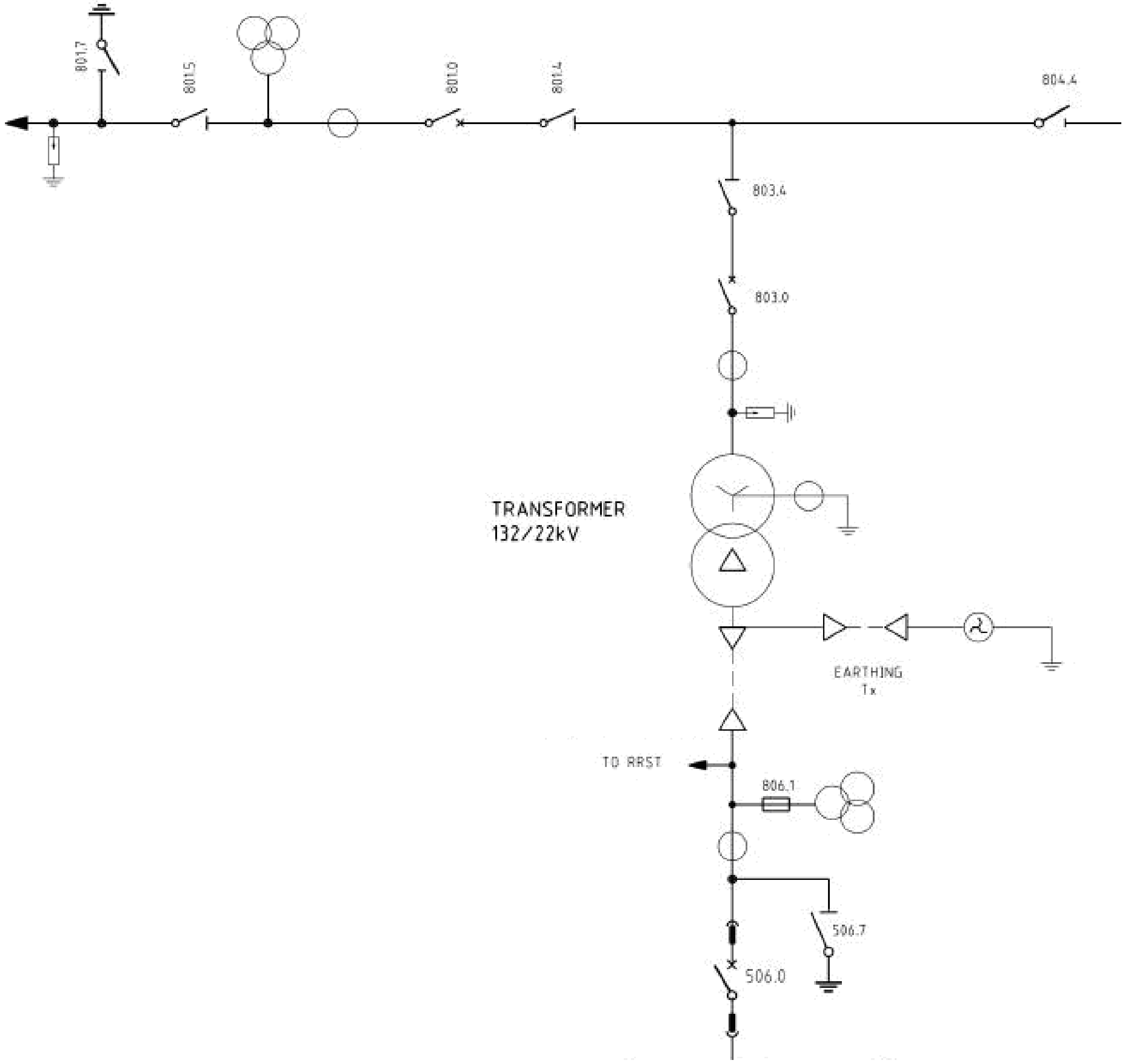


Figure B.2: 132kV transformer and line circuit

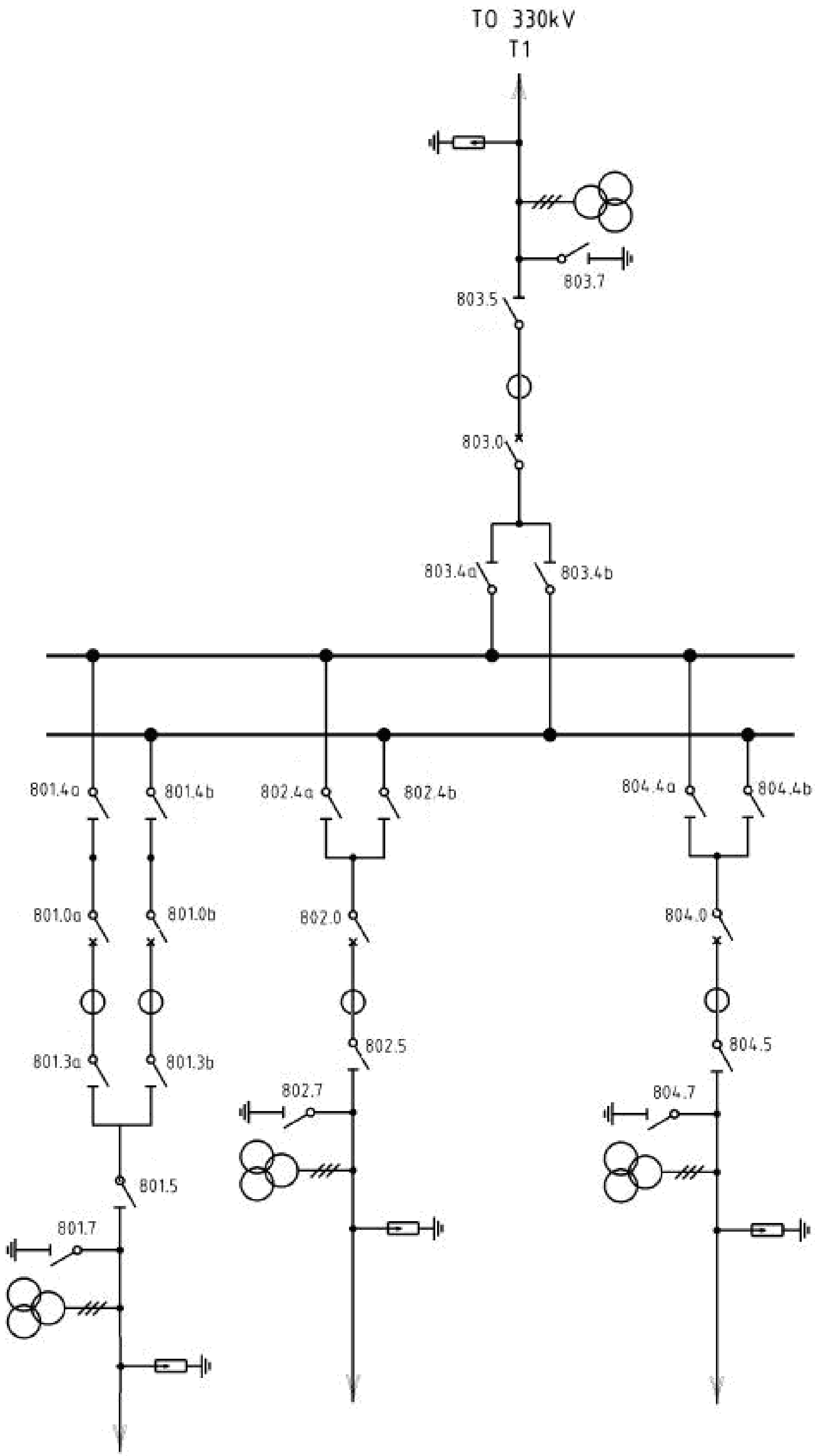


Figure B.3: 132kV double busbar system

Appendix C: Single Line Diagrams of Typical LV Switchgear

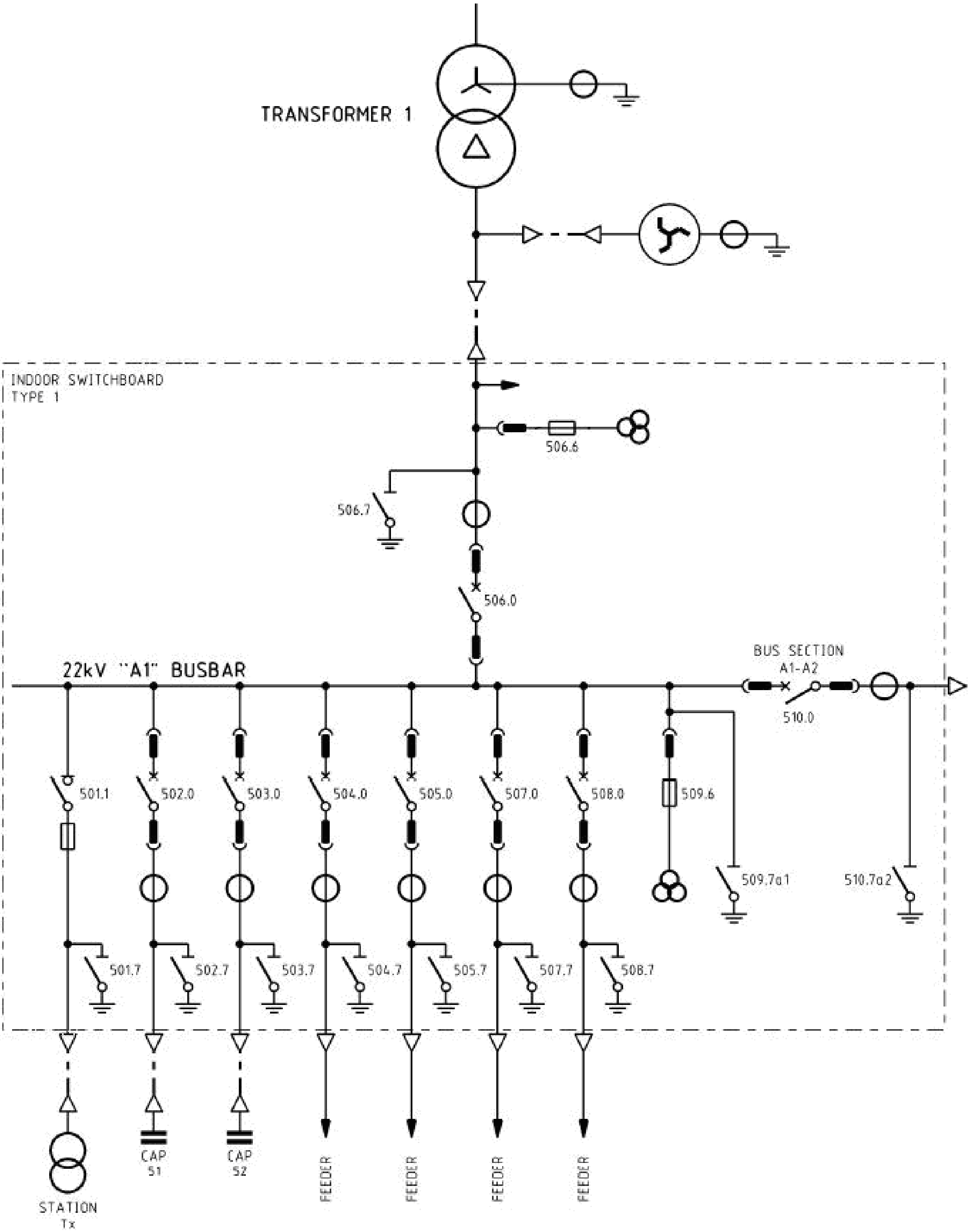


Figure C.1: AIS LV Single Bus Indoor Switchgear Type 1

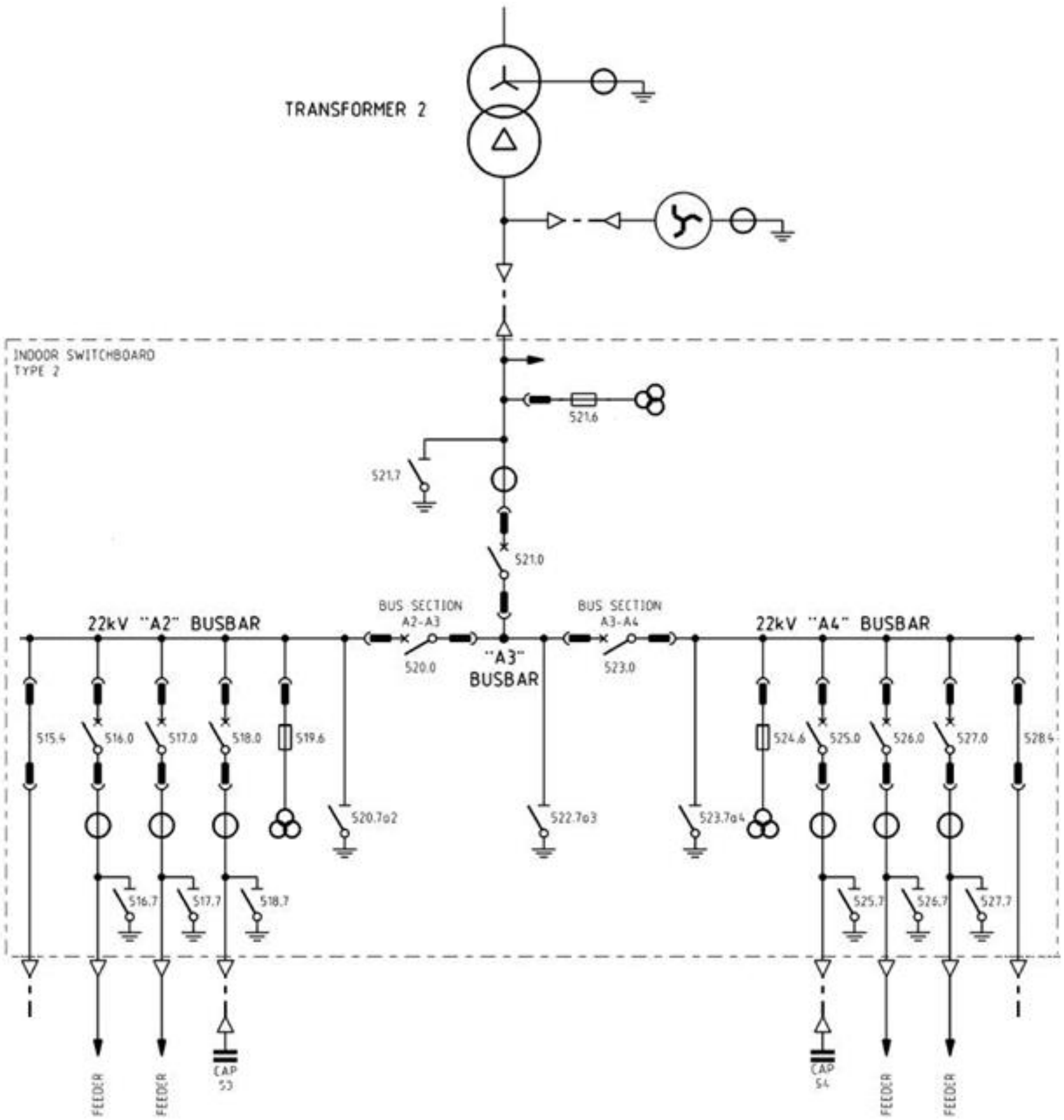


Figure C.2: AIS LV Single Bus Indoor Switchgear Type 2

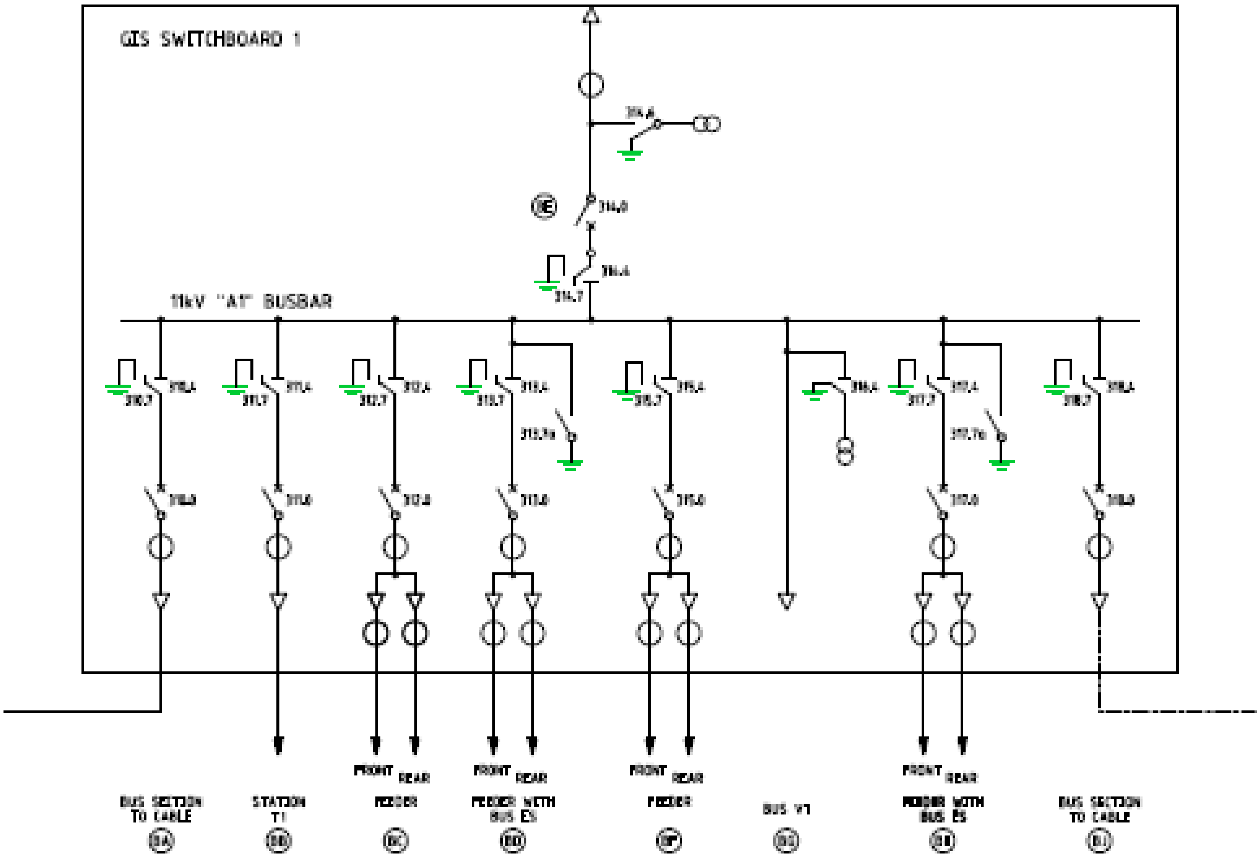


Figure C.3: GIS LV Single Bus Indoor Switchgear

Appendix D: Approval Record and Document Control[8]

[8] See Western Power Internal Document