1. SCOPE

This document details the application of overhead line switchgear and protection systems and is referred to as the Overhead Protection and Switchgear Standard (OHPSS). This document was previously known as the Overhead Protection Policy (OHPP).

2. ISSUE RECORD

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Issue Date	Issue No.	Author	Amendment Details
December 2017	6	Ewan Gilliland	Revision of time delay for fast operating reclosers with re-settable smart links down circuit (e.g., Noja). Inclusion of guidance for ABSD design criteria from ESDD-02-015 (now archived)
November 2018	7	Ewan Gilliland	Updated to include requirement to install auto-sectionalising disconnector in place of 63A and 100A ASLs. Included the requirement to install tele control at standard.
January 2019	8	Ewan Gilliland	Updated to clarify wording on ABSD installation and requirement to cease installing 63A and 100A ASLs regardless of fault count settings.
June 2024	9	Charlie Dodds Jamie McDonald	Minor updates throughout. Change of title to reflect this is a standard. Review period set to 3 years to allow major review.

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
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4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative change but at a period of no greater than 3 years from the last issue date.

5. DISTRIBUTION

This document is part of the SP Distribution (DOC-00-206) and SP Manweb (DOC-00-310) System Design Virtual Manuals maintained by Document Control but does not have a maintained distribution list. It is also published to the SP Energy Networks website.

6. CONTENTS

7. REFERENCE AND RELATED DOCUMENTS

PROT-01-006	33kV Protection and Control Application Policy
PROT-01-012	11kV Protection and Control Application Policy
OHL-01-008	Construction Policy for Distribution Overhead Lines
OHL-03-002	PROCUREMENT SPECIFICATION 11kV Overhead Line Expulsion Fuse Units
OHL-03-003	PROCUREMENT SPECIFICATION 11kV Overhead Line Auto-Sectionaliser Links
OHL-25-007	Earthing and Bonding Pole Mounted Equipment

8. INTRODUCTION

Overhead lines in the distribution system are prone to interference and damage which result in both transient and persistent faults. These incidents are often weather related (in the form of lightning, windblown debris, and clashing conductors) or due to bird strikes.

Typically, 80% of all such incidents affecting overhead lines are of a transient nature.

This standard shall be applied to all overhead line construction and refurbishment work, and existing circuits which are known to have a poor performance.

This standard outlines the application of overhead line apparatus which provides protection against transient and persistent faults. It also sets out guidelines to be considered when determining the positioning of overhead protection equipment.

9. 33KV AUTO-RECLOSING

As per PROT-01-006, overhead line circuits shall be protected using a circuit breaker with Delayed Automatic Reclosing (DAR)
In addition, any single transformer Primary substation should have a load transfer scheme installed as per PROT-01-012, in the associated 11kV network.

As an alternative to this, single shot auto-reclosing of the 33kV circuit on High Set Overcurrent only should be considered. This will be accompanied by automatic re-closing of any 11kV incomers which have tripped due to a back energised 33kV fault.

10. 11KV OVERHEAD SYSTEM PROTECTION

10.1 Design Requirements

The following sections describe the methodology of overhead protection design. Guidance on the location and selection of the devices is given in Appendix 2.

10.1.1 Ground Mounted Auto-Reclosers

Circuit-breakers controlling overhead line feeders shall incorporate multi-shot auto-reclosing features as standard on all new switchboards in accordance with PROT-01-012.

Protection shall normally be 2 pole overcurrent and 1 pole earth fault having both instantaneous and IDMT elements. Sensitive Earth Fault (SEF) protection with a definite time setting shall also be provided. The “normal” setting to be selected for SEF delay shall be 3 seconds at 20 Amps.

Where necessary, existing single shot ground mounted auto-reclosers shall be converted to multi-shot operation by the installation of an approved multifunction protection relay to meet the requirements of this standard, where the motorised spring charging time is less than 10 seconds.

In a retrofit situation, where the spring charging time is greater than 10 seconds, the switchgear modification costs, and maintenance requirements may prove uneconomic. Consideration shall then be given to the installation of a PMAR at the first suitable location on the circuit.

10.1.2 Pole Mounted Auto-Reclosers (PMAR)

The proximity of the connections and jumpers on a PMAR can cause flashovers due to wildlife which can damage the bushings. Suitable shrouding shall be fitted to the terminations, arrester connections and the jumper connections.

PMARs shall be purchased with relays providing Standard Inverse protection characteristics with 2-pole Overcurrent and 1-pole Earth Fault. A Sensitive Earth Fault element shall also be provided. The “normal” setting to be selected for Sensitive Earth Fault delay shall be 3 seconds at 20 Amps.

A “Protection Disable” facility shall be fitted to render all automatic features inoperative when required (e.g., the line is being fed abnormally).

A “Live Line”, “One Trip to Lockout”, or “Non-Auto” facility shall also be provided to comply with operational requirements.

All new PMARs shall be fitted with approved surge arresters across both incoming and outgoing bushings or as specified by the manufacturer.

All new PMARs shall be equipped with telecontrol, where practicable. Where telecontrol cannot currently be achieved, it may still be appropriate to install a PMAR to provide protection to the overhead line.

PMARs shall be solidly connected to earth using a site-specific earth system design, in accordance with OHL-25-007.

10.1.3 Auto-Sectionalising Disconnectors (PMSWs)

Pole Mounted Metal Enclosed Switches (PMSW) e.g. “Soule” switches, can also be utilised as auto-sectionalising disconnectors, when fitted with a relay with auto-sectionalising functionality enabled. The auto-sectionalising function can discriminate between transient and persistent faults in the same manner as auto-sectionalising links (ASLs). When called upon to operate during the dead time of an upstream auto-recloser, all three phases open simultaneously to disconnect the faulty section in the same manner as an Air Break Switch Disconnector (ABSD).
Due to the height and pole installation position, and the vertical arrangement of the HV bushings, the Ensto Auguste (Soule) cannot easily be installed at a tee-off pole. These will require to be installed on a suitable pole at one of the optional points, in preference order:

1. An additional pole in the first span on the spur or
2. The first pole on the spur

PMSWs have current transformers (CTs) on each phase which communicate to the control box via an umbilical cable. Typically, standard settings will be applied, i.e., 100A O/C; 20A EF and 3 bursts of fault current to initiate a trip.

All PMSWs shall be equipped with telecontrol, where practicable. Where telecontrol cannot currently be achieved, it may still be appropriate to install a PMSW to provide protection to the overhead line.

PMSWs, operating as auto-sectionalising disconnectors, can be utilised on three-phase overhead lines where design criteria previously required 63 or 100A ASLs. The earth fault detection capability of these units, down to 20A, greatly improves grounded conductor detection when compared to the performance of 63 and 100A ASLs.

PMSWs shall be utilised at network open points (NOPs) and where automation schemes require telecontrol.

PMSWs shall be solidly connected to earth using a site-specific earth system design, in accordance with OHL-25-007.

Due to the hazards associated with ferroresonance, any new cable connected spur lines shall, where practicable, be installed with either a PMSW, PMAR, or an ABSD with ASLs. This enables ganged switching operations which reduces the risk of the effects of ferroresonance. Auto-sectionalising disconnectors shall be installed when feeding HV generation substations. It may be required to construct an additional span of overhead line to accommodate a new PMSW / PMAR.

10.1.4 Auto-Sectionalising Links (ASLs)

Auto-Sectionalising links (ASLs), previously referred to as smart links or sectionalisers, discriminate between a transient and persistent fault by counting the passage of fault current during the auto-reclose sequence. They operate during the dead time of the auto-reclose sequence after a pre-determined number of passages of fault current. They shall only be fitted to circuits protected by a multi-shot auto-recloser with the minimum number of trips to lock-out being one more than the highest ASL count.

ASLs are available with an operating sequence of 1, 2 or 3 “counts” of fault current. The selection of the number of “counts” of the ASL shall be as detailed in Section 11.3 and in Schemes AR1 to AR8 of APPENDIX 1 – AUTO-RECLOSE SCHEMES.

Re-settable ASLs (no actuator) were introduced in 2017 and have the same basic principle in their operation as the chemical actuator type.

Installation of ASLs with a 63A or 100A rating on three-phase overhead lines shall be avoided where practicable. A PMSW / PMAR shall be installed instead.

ASLs, or any form of HV fuse units, shall not be installed on spurs with more than 500kVA aggregate transformer capacity or more than 500m of cable. A PMSW / PMAR shall be installed.

10.1.5 Air Break Switch Disconnectors (ABSDs)

Main line ABSDs shall, where reasonably practicable, be installed on the network such that one or more of the conditions below are met:

a) There are no more than 30 to 45 customers.
b) 5 spurs
c) 4km (30 to 50 spans) between ABSDs

They shall also be installed, as close as practicable, to HV cable dips/terminal poles to provide suitable points of isolation.

Note: The requirements above may not be considered reasonably practicable for circuits with flexible jumpers at comparable or suitable alternative locations to ABSDs.

New ABSDs shall be hook stick in operation, have polymeric insulators and can be installed on unearthed poles, or poles with an earthing system which complies with OHL-25-007.

ABSDs shall be installed at the most appropriate place for ease of operational access.

All new ABSDs shall have interrupter heads fitted making them Category 1 or Category 0 and all insulators shall be of a polymeric type of material.

Existing ABSDs with porcelain insulators shall be removed from earthed poles. ABSDs with polymeric insulators, which are hook stick operated, can only be retained on earthed poles where the earthing arrangements can be proven to comply with OHL-25-007.

Existing ABSDs with frayed flexible connections, stiff operating mechanisms or in poor condition shall be entirely removed from the system and replaced.

All existing ABSDs situated above the cross arm as “masthead” units shall be removed.

Legacy “Bypass ABSDs” installed on the same pole as a PMAR, or other plant, shall be removed.

New 11kV ABSDs Approved for use by SPEN have two fault make ratings:

- Category 1: 3kA$_{rms}$ for dependant manual units (up to 60MVA)
- Category 0: 10kA$_{rms}$ for independent manual units (spring-assisted) (up to 190MVA)

3kA units shall only be employed in locations where the fault level is below 60MVA.
Spring-assisted 10kA units can be employed where the fault level is below 190MVA.

10.1.6 Fault Recorders

Fault Recorders shall be fitted in new and replacement Primary Substation switchboards containing reclosing circuit-breakers. These will enable an assessment of system performance to be made and provide information on the operating duty and condition of the circuit breakers.

11. APPLICATION

11.1 Application Summary

When applying approved protection equipment, reference shall be made to the schemes shown in Appendix 1 when building or refurbishing overhead lines to comply with this standard. These schemes, SCHEME AR1 to SCHEME AR8, represent typical overhead circuit layouts and indicate the associated protection requirements to comply with this standard in general:

a) No overhead fuses shall be installed beyond a multi-shot auto-recloser.

b) Spurs with cable sections shall be protected by ASLs, or PMSW / PMAR on three-phase overhead lines. Where a spur comprises of only cable (no spans of overhead line) a 1 “count” (S1) setting shall be installed. Auto-sectionalising disconnectors shall not be installed on single phase spur lines.

c) Single shot ASLs (S1) shall not be rated at less than 40Amps.

d) ASLs count “bursts” of fault current and shall therefore be controlled by a multi-shot auto-recloser.

e) Multi-shot auto-reclosers shall have a minimum of three trips to lock-out.

f) Where an auto-recloser controls downstream fused switchgear (e.g., RMU), then the instantaneous protection shall be “delayed” e.g., 150msec.

g) Where PMARs control ASLs, then the instantaneous protection shall be delayed by 30msec.

h) When auto-reclosers are positioned in series, the instantaneous protection on the source side recloser shall be “delayed.” Recommendations as follows:

Type	d1	d2
ESR	160msec	320msec
PMR3	200msec	300msec
GVR	150msec	300msec
OSM (Noja)*	150msec	300msec

*PMARs with instantaneous settings shall have a 30ms delay added.

i) The “One Trip to Lock-out” or “Live Line Mode” feature on PMARs shall be set to “instantaneous.”

11.2 Protection Settings

The protection settings at source may need adjusted to accommodate the proposed downstream PMAR settings.

	Mainline	Spur
Overcurrent	240A	120A
Earth fault	30A	30A
SEF	20A	20A

The overcurrent setting may be increased (to no more than the primary protection value) where load current is likely to exceed 70% of the proposed setting above. A setting based on 1.5 times load should be adopted and consideration given to the prospective load of an abnormal feeding arrangement.

11.2.1 Instantaneous Protection

Series auto-reclosers shall provide the appropriate discrimination and this shall be applied as indicated in Section 11.1 and the AR Schemes of Appendix 1.

It has been identified that PMARs can operate quicker than the time required for down circuit ASLs to register a fault count. It is therefore required to install a 30ms delay on instantaneous PMARs to ensure successful ASL operation.

A delayed instantaneous protection setting should be retained in the non-auto mode to allow for the decay of large magnetisation inrush currents where there is a large, connected load capacity controlled by the auto-recloser.

Some PMARs require a background protection setting based on IDMT characteristics (PMR3 and GVR). The appropriate settings for this are for the “current” setting to be the same as the instantaneous (INST) setting (e.g., 240A with the time multiplier set to 0.2). This will ensure that tripping will always be carried out by the INST protection on the PMAR.

11.2.2 Sensitive Earth Fault (SEF) Protection

In order to maintain protection co-ordination at low fault currents the SEF shall perform an auto-reclose sequence. This will ensure correct operation of 20A and 25A ASLs with permanent faults beyond them.

Where discrimination is required between series PMARs then the SEF time delay should be set appropriately to either 3, 5 or 7 seconds. See AR5 in Appendix 1 for guidance.

11.3 Auto-sectionalising Links (ASLs) (previously Smart Links)

ASLs used in SP Energy Networks shall be of an Approved type, complying with OHL-03-003.

Five actuating current ratings are available, and the minimum rating shall be chosen to comply with Table 1 (for 11kV circuits) with due consideration given to possible future additional load.

SECTIONALISER RATING	MAXIMUM CONNECTED TRANSFORMER CAPACITY	
	3 Phase	1 Phase
PMSW / PMAR – see 11.3.1	>380kVA	>380kVA
40 A	380 kVA	220 kVA
25 A	240 kVA	140 kVA
20 A	195 kVA	115 kVA

Table 1

11.3.1 Calculation of the appropriate ASL (smart link) rating

For spurs with a mix of single and three-phase transformers, assume that the single-phase transformers are connected to the same two phases. Calculate the total full load current of these transformers then add the full load line current of the three-phase transformers. Use a factor of safety of 2 (for mag inrush). Therefore, double this total full load line current and select the ASL rating above the calculated figure e.g., 15A full load requires 40A ASL (2x15=30; next S2 up is 40A).

PMSWs, or PMARs, shall where practicable be utilised on three-phase overhead lines, where design criteria previously required 63A or 100A, 2 or 3-shot ASLs. The earth fault detection capability of these units, down to 20A, greatly improves grounded conductor detection when compared to the performance of 63A and 100A ASLs.

Where the design of a spur necessitates the use of a PMSW or PMAR at the tapping point and the spur consists of more than 10 spans, the spur should be further considered for alternative and additional

protection measures. Consideration should be given to the use of additional lower rated ASLs (20A preferred) for sub-spur sectionalising.

Where ASLs, PMSWs or spur PMARs are set to three shots, all upstream auto-reclosers controlling the spur shall be set to 4 trips to lockout. Appendix 1, Scheme AR8 indicates the options.

Where sub-spur protection of a cable tee-off with S1 ASLs is considered, this should only be carried out where the transformer is not in the vicinity of the cable tee-off/terminal pole.

Single shot (S1) ASLs shall not be rated at less than 40 Amps, to avoid maloperation for low voltage faults on a lightly loaded spur.

12. ADDITIONAL DESIGN REQUIREMENTS FOR LOW FAULT LEVELS

Due to low fault levels and network arrangements, there are some additional design considerations when applying this standard to all networks in Wales and to other networks with less than 50MVA source fault level and more than 20km of effective circuit length (see 12.2.2 for effective circuit length).

Additional consideration is required, where necessary, for source protection to be modified and for careful application of protection settings to address abnormal feeding arrangements.

12.1 Source Protection Replacement

It may be necessary to modify existing source protection schemes to allow application of this standard. Most existing protection schemes on SPM overhead line circuits use extreme inverse (EI) relay characteristics (CDG34 relays) to give optimum grading with HV fuse characteristics.

Existing electromechanical auto-reclose schemes have no facility to introduce delays into the instantaneous trip times and are, therefore, incompatible with downstream PMARs and must be set to non-auto.

Where source protection has this EI characteristic, the protection must be changed to a standard inverse (SI) characteristic using new or recovered relays (e.g., PBO or CDG31 relays). These schemes will have a PMAR placed as close to the source of supply as possible.

12.2 Overcurrent Protection Setting Assessment

12.2.1 Fault Current Levels on Overhead Line Circuits

Studies to identify typical fault current values on the SPM network produced the data in the following table. These figures are also appropriate for SPD networks where the source fault level is below 50MVA.

	Main line Distance-to-Fault								
Fault type	**0km**	**5km**	**10km**	**15km**	**20km**	**25km**	**30km**	**35km**	**40km**
Three-phase	2246A	1142A	721A	523A	408A	335A	284A	246A	217A
Phase-phase	1945A	989A	625A	453A	354A	290A	246A	213A	188A
E/F 0 Ohms	2452A	867A	526A	378A	295A	241A	204A	177A	156A
E/F 80 Ohms	79A	76A	73A	70A	67A	65A	62A	60A	58A

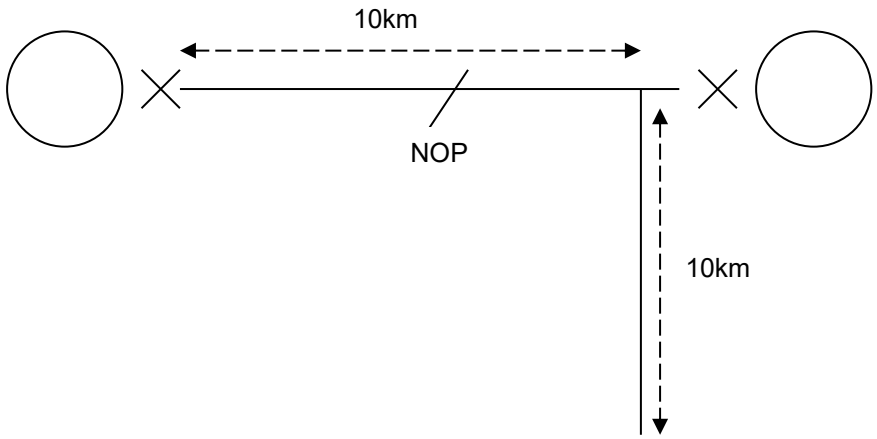
Table 2: Fault Currents on OHL Circuits

From Table 2, it can be shown that the three-phase fault figures show that the standard overcurrent setting of 225 Amps will not detect phase-phase faults beyond 30km of main line and with a 50% safety margin this will reduce to 20km. SEF provides adequate network coverage for all network lengths.

12.2.2 Calculating the "Effective" Length of Overhead Line Circuits

It is necessary to calculate the protection "reach" in terms of main line kilometres to include abnormal feeding arrangements. This must take account of the different conductor sizes for main lines (50mm^2 AAAC) and spurs (25mm^2 ACSR) by using an equivalence factor of 1.73 for the spurs in terms of main line length. E.g., 10km main line + 10km spur equates to 27.3km main line [10 + (10 x 1.73)]

From a calculation of the maximum effective length of a circuit, including abnormal feeding arrangements and spurs near the extremities, the overcurrent protection setting can be calculated and



guidance for this is given in the following table. The table includes the range of PMAR settings.

	Effective circuit length					
	<19km	**<20km**	**<27km**	**<33km**	**<42km**	**<51km**
GAD or ESR		225A O/C		150A O/C	120A O/C	100A O/C
PMR3 / GVR	240A O/C		180A O/C		120A O/C	
NOJA	240A O/C		180A O/C		120A O/C	
Max. Circuit loading	160A	150A	120A	100A	80A	65A

Table 3: Overcurrent Setting Selection

Where circuit loading presents a problem for source protection settings then consideration should be given to an additional PMAR on the circuit beyond the load centre. This can be set to a lower overcurrent setting to "see" through to the source of the adjacent circuit beyond the Normal Open Point (NOP).

13. LOCATION OF EQUIPMENT

Fuse mounts and ASLs (smart links) shall, where practicable, be mounted at the tee-off pole.

Jumper connections should be positioned to avoid the risk of arc transfer from ejected gases or fuse tails, and they should approach the terminals slightly from the rear. The lower side of the fuse/ASL unit should be connected to the protected line.

13.1 Auto-Sectionalising Links (ASLs)

The location of ASLs on an overhead circuit selected for auto-reclosing shall comply with the following guidelines but, when applying them, consideration must be given to local conditions affecting access.

i) New fuse mounts shall be a C-type design rated at 8kA (150MVA) minimum, complying with OHL-03-002.
ii) Spurs more than 5 spans long shall be group protected with ASLs, or a PMSW / PMAR.
iii) Due to network design and application of the “five spans” rule, some circuit designs have shown few ASLs to be fitted making the circuit almost entirely solidly connected. In this circumstance only, the “five spans” rule will be relaxed to an extent that permits 40% of the spurs (not including main-line transformers) to be fitted with ASLs.
iv) If a spur supplies more than 30% of the customers controlled by the associated recloser then the spur shall be solidly connected to the main line, where the line construction is suitable as per OHL-01-008, and the sub-spurs protected by ASLs.
v) Spurs less than 5 spans long shall be solidly connected to the main line except where the spur contains a section of cable or has environmental risks e.g., trees. In this case the spur should be protected with ASLs (<500m cable), or PMSW / PMAR (>500m cable).
vi) ASLs will only operate in series where the “count” of the device is used as a means of discrimination, NOT the current rating. This is clarified in Scheme AR8 of this document.

13.2 Expulsion Fuses

The preferred method of protecting overhead circuits is by the use of multi-shot reclosers and auto-sectionalising disconnectors or links.

However, the following guidelines shall be used for determining the location of expulsion fuses on circuits with no multi-shot auto-reclose facilities. When applying them, consideration must be given to local conditions affecting access.

i) Spurs more than 5 spans long shall be group protected with a Minimum of 25A fuses.
ii) If the spur supplies more than 30% of the customers controlled by the associated circuit breaker, then the spur shall be solidly connected to the main line and the sub-spurs protected by fuses.
iii) Spurs less than 5 spans long shall be solidly connected to the main line except where the spur contains a section of cable. In this case the spur should be protected with 30A fuses (<500m cable), or PMSW / PMAR (>500m cable).
iv) Single pole mounted transformers on a line shall not normally be fused.
v) On very long spurs subgroup fusing may be necessary. This situation is likely to arise where the 11kV fault level is under 4MVA and in these instances 15 Amp fuses may be used.

13.3 Heavily Loaded Spurs

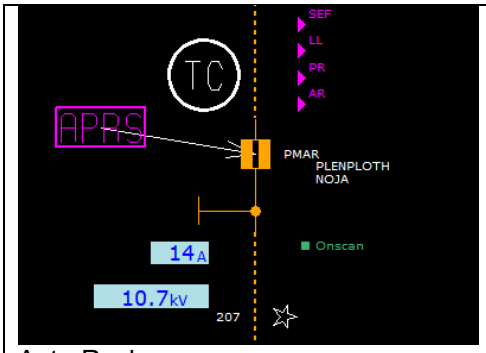
PMSWs / PMARs shall be fitted in order to improve fault detection for low-level earth fault currents on heavily loaded three-phase spurs, previously requiring 63A or 100A ASLs. These units will be set to detect 20A earth fault currents. See 10.1.4 for further details.

PMSWs / PMARs shall be installed on three-phase spurs with more than 500kVA of aggregate transformer capacity or more than 500m of cable.

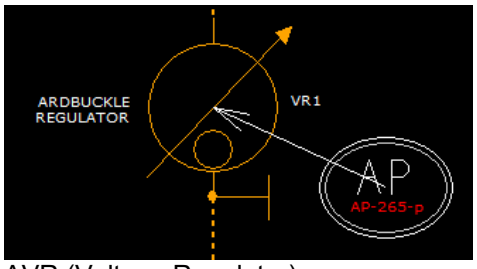
14. SYMBOLS

The location of PMARs, ASLs and PMSWs shall be clearly marked on PowerOn.

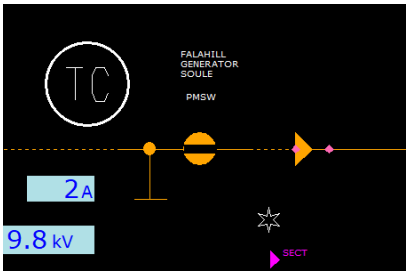
Overhead line equipment shall be identified on PowerOn using the following symbols:



Auto-Recloser



AVR (Voltage Regulator)

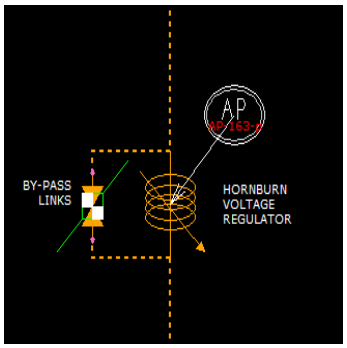


Auto-sectionalising Disconnector

Sectionaliser (ASL)


Expulsion Fuse

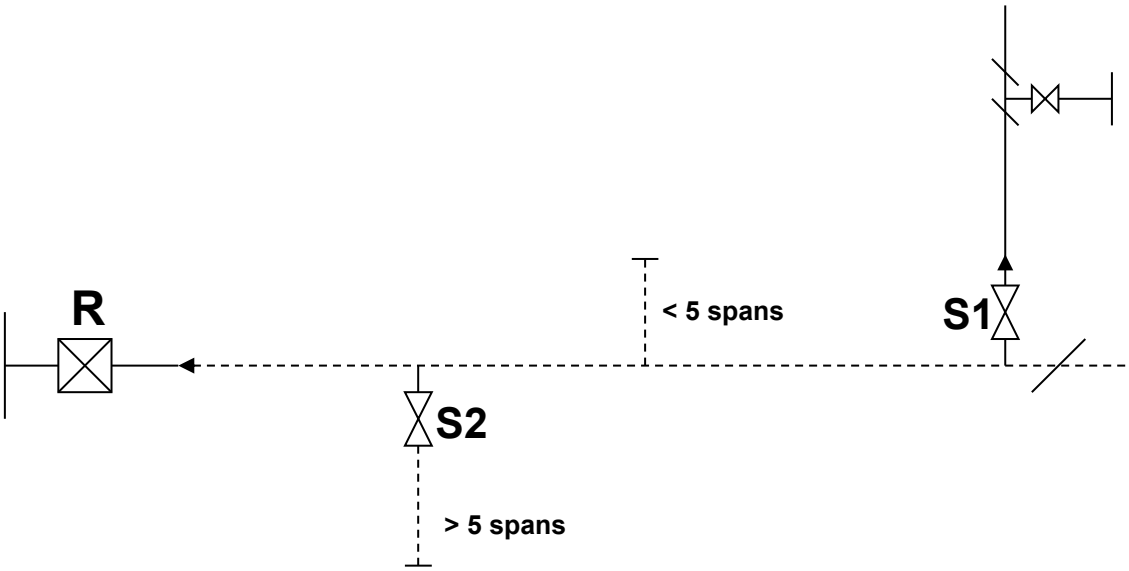

Solid link



Voltage Regulator

15. APPENDIX 1 – AUTO-RECLOSE SCHEMES

SCHEME AR1 : Predominantly Overhead Circuit
Multi-Shot Auto-recloser at Source



	R	
Trip Sequence	3I: 240A 3I: 30A 3 x 3sec	O/C E/F SEF (20A)
Reclose Time	10seconds	
Reclaim Time	15seconds	

Notes: No fuses on overhead system.

If existing single shot auto-recloser at source, change protection relay to provide multi-shot scheme as above. [see 10.1.1].

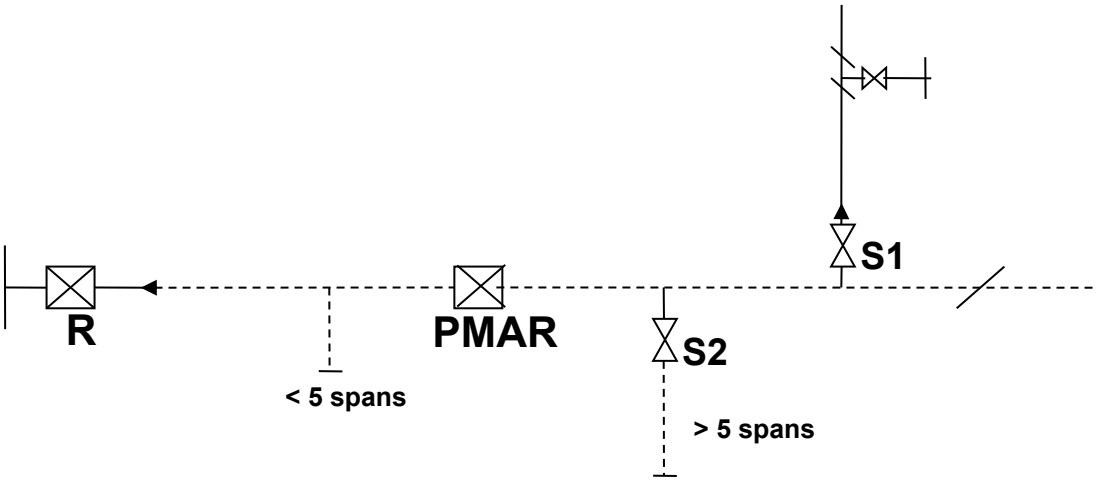
If relay change is not practical (e.g., spring charge time too slow) see SCHEME AR2 and AR3.

If grading with switchgear fuses is required, e.g., RMU, then PMAR instantaneous protection shall be set to "delayed," see 11.1(h).

Due to network design and applying the "five spans" rule, some circuit designs have shown few ASLs to be fitted making the circuit almost entirely solidly connected. In this circumstance only, the "five spans" rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - "delayed" Instantaneous D - Delayed (IDMT)

SCHEME AR2 : Predominantly Overhead Circuit
No suitable spring charging mechanism on source C.B.
[O/H Line Fault Level <230 MVA]



	PMAR	
Trip Sequence	3I: 240A	O/C
	3I: 30A	E/F
	3 x 3sec	SEF (20A)
Reclose Time	10seconds	
Reclaim Time	15seconds	

Notes: No fuses on overhead system.

Convert source single shot auto-recloser to “Non-Auto; Delayed” operation.

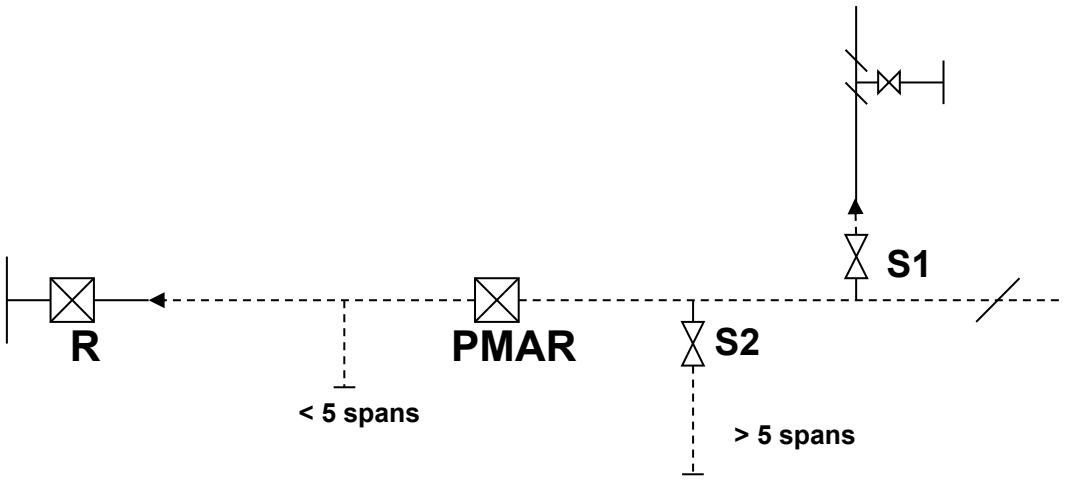
Install PMAR on first suitable pole.

If grading with switchgear fuses is required, e.g., RMU, then PMAR instantaneous protection shall be set to “delayed,” see 11.1(h).

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR3 : Predominantly Overhead Circuit
Single Shot Auto-recloser at Source
Multi-shot Auto-recloser online



	R	PMAR	
Trip Sequence	1I + 1D	3I: 240A	O/C
		3I: 30 A	E/F
	1 x 5sec	3 x 3sec	SEF (20A)
Reclose Time	10	10	seconds
Reclaim Time	15	15	seconds

Notes: No fuses on overhead system.

No Sectionalisers between R and PMAR.

May require fuses on overhead system between R and PMAR, if any connected spur >5 spans in length. In this situation, source SEF protection should be set to 15 seconds.

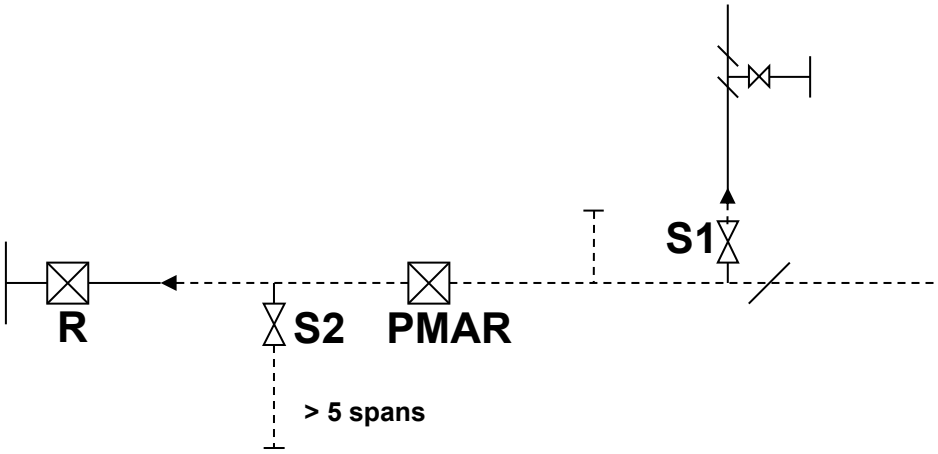
If switchgear fuses are required beyond the PMAR then there will be no discrimination with the PMAR.

The source circuit breaker may also trip for a fault beyond the PMAR due to lack of grading with instantaneous protection.

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR4 : Predominantly Overhead Circuit
2 Auto-reclosers in Series
Multi-Shot Auto-recloser at Source



	R	PMAR	
Trip Sequence	3Id1	3I: 240A	O/C
	3Id1	3I: 30 A	E/F
	3 x 5sec	3 x 3sec	SEF
Reclose Time	10	10	seconds
Reclaim Time	15	15	seconds

Notes: No fuses on overhead system.

Instantaneous protection on R shall be set to “delayed,” see 11.1(h), to ensure co-ordination with PMAR.

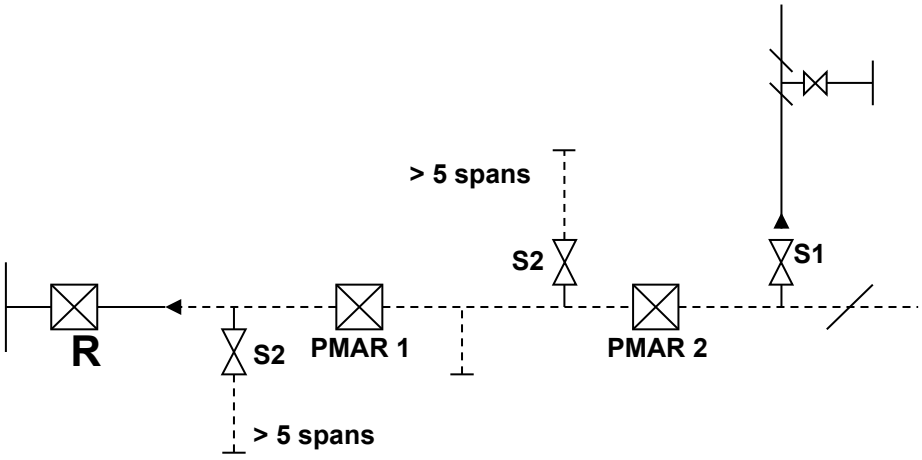
If grading with switchgear fuses is required, e.g., RMU, then PMAR instantaneous protection shall be set to “delayed,” see 11.1(h).

For Single Shot Auto-recloser at source see SCHEME AR3.

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR5 : Predominantly Overhead Circuit
3 Auto-Reclosers in Series
Multi-Shot Auto-recloser at Source



	R	PMAR 1	PMAR 2	
Trip Sequence	3Id2 3Id2 3 x 7sec	3Id1: 240A 3Id1: 30A 3 x 5sec	3I: 240A 3I: 30 A 3 x 3sec	O/C E/F SEF (20A)
Reclose Time	10	10	10	seconds
Reclaim Time	15	15	15	seconds

Notes:

No fuses on overhead system.

Instantaneous protection on R shall be set to “delayed,” see 11.1(h), to ensure co-ordination with PMAR1.

PMAR1 instantaneous protection shall be set to “delayed”, see 11.1(h), to ensure co-ordination with PMAR2.

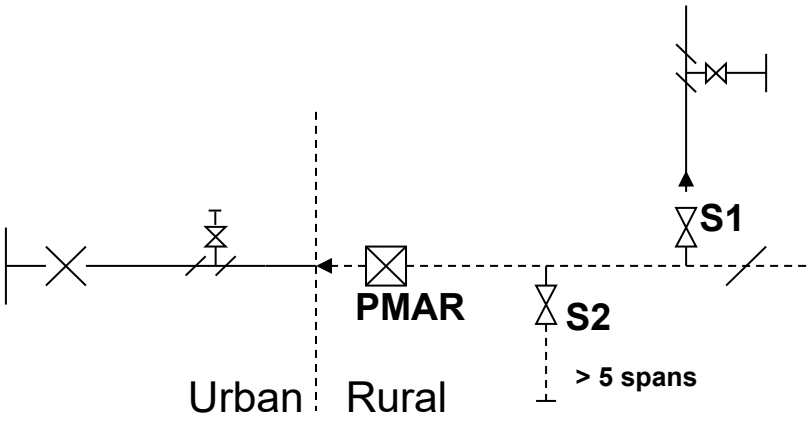
There will be no discrimination with RMU fuses beyond PMAR2.

For Single Shot Auto-recloser at source see SCHEME AR3.

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR6 : Mixed Urban / Rural Circuit
Multi-Shot Pole Mounted Auto-Recloser



	PMAR	
Trip Sequence	3Id1: 240A	O/C
	3I: 30A	E/F
	3 x 3sec	SEF (20A)
Reclose Time	10seconds	
Reclaim Time	15seconds	

Notes: No fuses on overhead system.

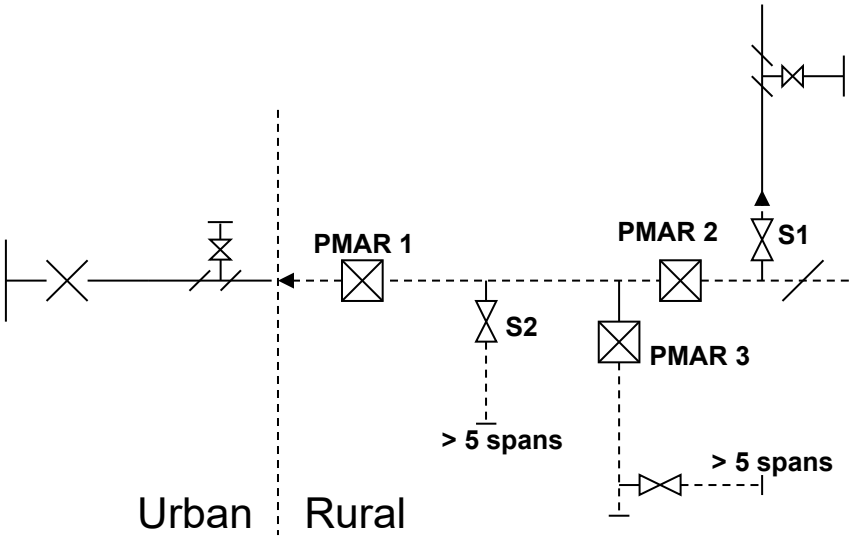
Source circuit breakers controlling extensive underground networks shall be non-reclosing.

If grading with switchgear fuses is required, e.g., RMU, then PMAR instantaneous protection shall be set to “delayed,” see 11.1(h).

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR7 : Mixed / Urban Rural Circuit
Auto-Reclosers in Series



	PMAR 1	PMAR 2	PMAR 3	
Trip Sequence	3Id2: 240A 3Id: 30A 3 x 7sec	3Id1: 240A 3Id: 30A 3 x 5sec	3I: 120A 3I: 30A 3 x 3sec	O/C E/F SEF
Reclose Time	10	10	10	Seconds
Reclaim Time	15	15	15	Seconds

Notes: No fuses on overhead system.

Overcurrent setting on mainline PMARs is typically 240A and spur PMARs is 120A.

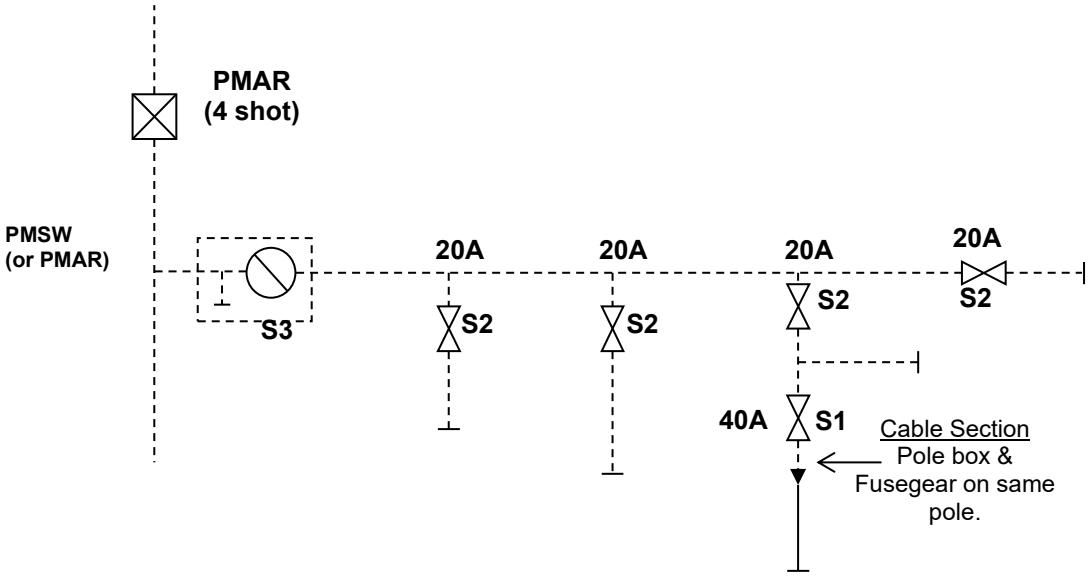
PMAR1 instantaneous protection shall be set to “delayed”, see 11.1(h), to ensure co-ordination with PMAR2 and PMAR3.

PMAR2 instantaneous protection shall be set to “delayed”, to allow grading with switchgear fuses, e.g., RMU, see 11.1(h).

In applying the “five spans” rule, some circuit designs have shown few ASLs to be installed. In this circumstance only, the “five spans” rule will be relaxed to an extent which permits 40% of the spurs (not including main-line transformers) to have ASLs fitted.

Where:
I - Instantaneous Id - “delayed” Instantaneous D - Delayed (IDMT)

SCHEME AR8 : Auto-sectionalising Disconnector (or PMAR) and sub-spur ASLs



Where the design of a three-phase spur necessitates the use of 63A, or 100A ASLs, a PMSW / PMAR, shall be installed where practicable. If the network lends itself to further treatment, then consideration should be given to the use of additional 20A 2-shot ASLs for sub-spur sectionalising.

All auto-reclosers upstream of this tapping must then be set to 4 trips to lockout. **Note that this also applies to the SEF protection on the mainline auto-reclosers.**

Sub-spurs comprising only cable may be protected by S1 ASLs (minimum 40A) where the transformer is not in the vicinity of the cable tee-off/terminal pole.

16. APPENDIX 2 – GUIDANCE FOR SELECTION OF OVERHEAD DEVICES

Table 4: Location of Overhead Line Equipment - Main Line Length	POSITION OF R2/R3 (PMAR)													
	KM	2	4	6	8	10	12	14	16	18	20	22	24	26	28
	30	87	94	101	110	122	135	153	173	202	243	303	404	607	1212
	28	94	101	110	122	135	153	173	202	243	303	404	607	1212	
	26	101	110	122	135	153	173	202	243	303	404	607	1212		
	24	110	122	135	153	173	202	243	303	404	607	1212			
	22	122	135	153	173	202	243	303	404	607	1212				
	20	135	153	173	202	243	303	404	607	1212					
	18	153	173	202	243	303	404	607	1212						
	16	173	202	243	303	404	607	1212							
	14	202	243	303	404	607	1212								
	12	243	303	404	607	1212									
	10	303	404	607	1212										
	8	404	607	1212											
	6	607	1212												
	4	1212													
	Number of customers on Live side of PMAR														

As an example of application of **Table 4**, on a 24km line, a PMAR can be justified at 12km distance if there are 202 customers on the Live side.