Loop Automation

Technical Manual for the ADVC Controller Range

Schneider Electric

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Acronyms

Acronym	Description
FDIR	Fault Detection, Isolation and Restoration
ACO	Auto-Changeover
ACR	Automatic Circuit Recloser
CB	Circuit Breaker
IOEX	Input/Output Expander
LA	Loop Automation
LBS	Load Break Switch
LOP	Loss of Phase
SCADA	Supervisory Control and Data Acquisition
SS	Single-Shot
SVIIS	Secondary Voltage Injection Interface Set
WSOS	Windows Switchgear Operating System

Symbols

Note

The note symbol indicates that the adjacent text contains information for your particular application.

The warning symbol indicates that the adjacent text contains a warning.

The caution symbol indicates that the adjacent text details a situation in which care should be taken.

[1] SCADA Supervisory Control and Data Acquisition system

Introduction

Loop Automation is Schneider Electric's Fault Detection, Isolation and Restoration (FDIR) system for overhead Automatic Circuit Reclosers (ACRs) and Automatic Sectionalisers. Loop Automation will restore supply to fault free sections of a ring network that has been disconnected because of a fault in another section of the network.

Note It is important to read this manual in conjunction with the Recloser and Sectionaliser specific technical manuals.

About This Manual

This manual describes the operation of Loop Automation and how overhead switchgear fitted with ADVC controllers are configured to implement the scheme. It is intended for use by the following personnel:

- system engineers
- system operators
- maintenance crews.

Warning **While every care has been taken in preparation of this manual, no responsibility is taken for loss or damage incurred by the purchaser or user due to any error or omission in this document.**

This manual is prepared in four important parts as follows:

- **Part 1 – Understanding Loop Automation**
  This part of the manual presents the basic concepts and principles of Loop Automation.
- **Part 2 – Configuring Loop Automation**
  This part of the manual explains all Loop Automation settings and provides configuration guidelines to ensure correct operation.
- **Part 3 – Loop Automation in Service**
  This part provides recommendations for installing and testing Loop Automation as well as advice on operational procedures.
- **Appendices - Application Examples**
  This part contains examples of Loop Automation on networks of different topologies.

Warning **As with any arrangement where automatic operation takes place, a danger exists that maintenance personnel may attempt to isolate a section of the network without realising that supply to the section may be automatically restored via an alternate supply path. It is therefore essential that Supply Authority personnel be fully trained in the operation and maintenance of the Loop Automation systems prior to their introduction.**

It is strongly recommended that each Recloser or Sectionaliser that is part of a Loop Automation scheme is fitted with a clearly visible external label, warning that the switchgear is part of a Loop Automation scheme and that it could automatically trip or close at any time.

ADVC Controller Firmware Versions

The firmware version determines the available functions of the ADVC controller. All ADVC controllers with firmware versions A44-04.50 or newer support Classic Loop Automation. Classic Loop Automation using Sectionalisers is supported in firmware version A45-19.02 and later. Intelligent Loop Automation for ACR's is supported in firmware version A45-27.01 and later.

WSOS Software Versions

The WSOS software version determines the available functions on WSOS. All WSOS releases with versions 5.02.44 or newer support Classic Loop Automation, WSOS releases with version 5.13.24 or newer support Classic Loop Automation with Sectionalisers. Intelligent Loop Automation for ACR's is supported in WSOS versions 5.13.29 and later.

Understanding Loop Automation

What Does Loop Automation Do?

Loop Automation reconfigures a network to return supply to fault free sections that have lost supply due to a fault condition on another section of the network. Loop Automation can be configured to operate according to either Classic or Intelligent logic.

Classic Loop Automation

Classic Loop Automation is the original implementation of Loop Automation. It operates the scheme without peer-to-peer communications and without operator intervention by using voltage detection and different timers. Utilities with or without SCADA communications can easily introduce Classic Loop Automation into most ring network configurations without any additional equipment.

Intelligent Loop Automation

An evolution of the Classic Loop Automation algorithm, Intelligent Loop Automation utilises peer-to-peer communications between devices to eliminate the possibility of a Device closing onto a fault while the network is being reconfigured.

Device Types

Loop Automation requires each Device in the scheme to be configured as a particular type depending on its position in the network. Each Device, whether a Recloser or Sectionaliser, will need to be configured as one of the following:

- Feeder Device - this Device is positioned closest to the substation or source of supply. A Loop Automation scheme would have a Feeder Device for each source i.e. at least two.
- Tie Device - this Device is used where two feeders meet and is normally the open point in the network.
- Mid-Point Device – this Device is positioned anywhere on the network between a Feeder and a Tie. A Loop Automation scheme can have multiple Mid-Point Devices.

Fault Isolation and Network Reconfiguration with Classic Loop Automation

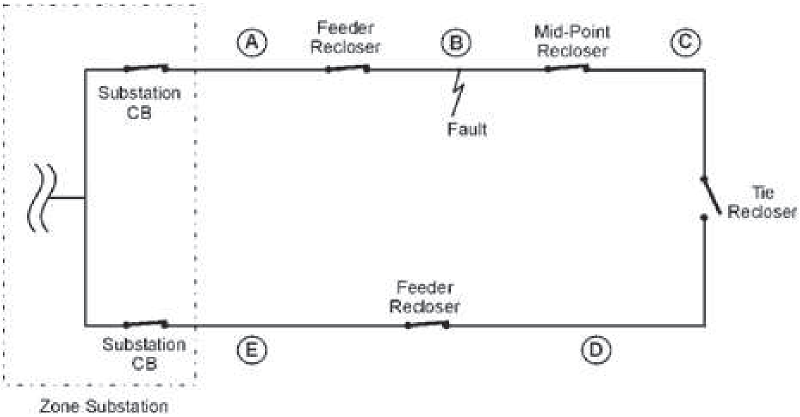


Figure 1. Example of a loop network shows a fault condition on Section B.

With Classic Loop Automation enabled, the following operational sequence is initiated:

- overcurrent protection trips the Feeder Device upstream from the fault. This is normal protection operation, not a Loop Automation function
- the Feeder Device may trip and Auto-Reclose several times in an attempt to clear the fault. It is only after the Auto-Reclose sequence has finished and the Device is locked out that the Loop Automation operation starts
- the Mid-Point Device changes to its alternate protection group i.e. reverse, and turns Auto-Reclose off
- Loop Automation then closes the Tie Device
- the Mid-Point Device trips from protection due to the re-energisation of the fault on section B and goes directly to lockout without an Auto-Reclose
- this action isolates section B and reconfigures the network to provide supply to section C.

The Tie Device detected the loss of supply in section C when the Feeder Device tripped and closed itself automatically after its Loop Automation Activation Delay timer expired. The Mid-Point Device also detected the same loss of supply and so was ready to trip straight to lockout prior to the Tie Device closing onto the fault.

Auto-Restore

The process of isolating the faulted section and re-configuring the network to bring supply back to the un-faulted sections is the primary function of Loop Automation.

In addition, Loop Automation can Auto-Restore the original network configuration when the fault on section B is removed. It does this by:

- detecting that section B has been re-energised by the linesperson who will have closed either the Feeder or Mid-Point Device after repairing the faulted section of the line.
- automatically closing the remaining open point (either the Mid-Point or Feeder Device) to close the network loop
- automatically opening the Tie Device
- the normal configuration is now restored.

Note Auto-Restore is an option – it is only available for the Classic Loop Automation application.

Warning **If the network cannot be run as a closed loop then auto-restore cannot be used and must be turned off.**

Fault Isolation and Network Reconfiguration with Intelligent Loop Automation

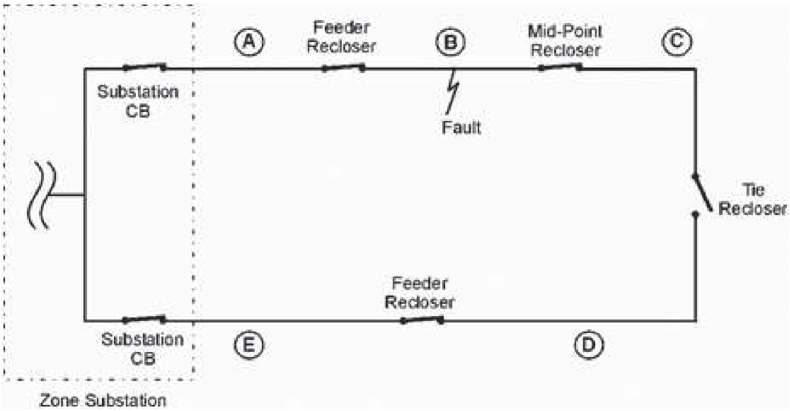


Figure 2. Example of a loop network shows a fault condition on Section B.

With Intelligent Loop Automation enabled, the following operational sequence is initiated:

- overcurrent protection trips the Feeder Device upstream from the fault. This is just the normal protection, not a Loop Automation function
- the Feeder Device may trip and Auto-Reclose several times in an attempt to clear the fault. It is only after the Auto-Reclose sequence has finished and the Device is locked out that the Loop Automation operation starts
- when it locks out, the Feeder Device will send a downstream trip request to the Mid-Point in order to isolate the fault before the Tie closes
- Loop Automation then closes the Tie automatically after its Loop Automation timer has expired, with an optional peer-to-peer close confirmation message by the Feeder
- this action isolates section B and reconfigures the network to provide supply to section C through the Tie.

Isolation and Reconfiguration

Overview – The Classic Rules

The rules of Loop Automation (the *Classic* rules) which cause Isolation and Reconfiguration are as follows:

(1) Feeder trips when it loses supply

(2) Mid-Point Device changes to the Alternate Protection Group and changes to single-shot mode for a short time when it loses supply

(3) Tie closes when it detects that supply to one side of the network has been lost but it still has supply available on the other side.

These simple rules can isolate and reconfigure the network for all possible faults.

Note The rules above are a simplification – the full rules are given in Appendix A. For Loop Automation with LBS rules, see Appendix H.

Intelligent Loop Automation Rules

Intelligent Loop Automation can operate in a more informed fashion due to communications between devices. It complements the Classic Loop Automation basic operation rules with the following Intelligent Loop Automation Rules:

(4) When either a Feeder or Mid-Point Device goes to lockout due to a protection operation it sends a trip request to its downstream Device if that Device is a Mid-Point.

(5a) A Feeder also sends a trip request to its downstream Device if that Device is a Mid-Point when it trips to lockout after losing its source supply (Classic Loop Automation Rule 1).

(5b) If the Device downstream from the locked out Feeder or Mid-Point is a Tie, the locked out Device will send a close inhibit request message to the Tie to prevent it from closing onto a fault.

(6) If Tie control mode is Message, and the Device downstream from the locked out Device is a Mid-Point, the locked out Device also sends a close request to the Tie in the scheme upon confirmation of the successful operation of its downstream Mid-Point Device. If this confirmation is not received, the locked out Device will not send a close request to the Tie.

(7a) If Tie control mode is Timer, a Tie will operate as per its basic Classic Loop Automation Rule 3 - regardless of receiving a close request or not. This mode maintains the availability of the scheme and enables an automatic attempt to restore supply regardless of the availability of the peer-to-peer communications.

(7b) If Tie control mode is Message, a Tie will operate only if it receives a Loop Automation close request.

Note The rules above are a simplification – the full rules are given in Appendix I.

Timer Tie Control

The Timer Tie Control option is based on a single message sent by a Feeder or Mid-Point Device which goes to lockout on a protection trip. The message is received either by a downstream Mid-Point or Tie. When a downstream Mid-Point receives the message it trips once to lockout to isolate an upstream fault. When a Tie Device receives the message it turns LA off to prevent closing onto a fault.

To prevent a Tie from closing onto a fault, the message needs to be sent before Tie's Loop Automation timer expires. The Loop Automation timer starts when the Device has lost the supply on the first trip of the protection sequence. The window for the message to be sent is: "Tie Loop Automation delay" minus "protection sequence time": typically, this is in the order of 5 seconds. The sending of the message can be attempted multiple times, and the attempt count and timeout are configurable.

Message Tie Control

In the Message Tie Control mode the closing of the Tie Device is controlled by a message.
When the Feeder or Mid-Point Device goes to a protection lockout it initially sends the same message to the downstream Device as described in the Timer Tie Control. The downstream Device also reacts to the message as described in the Timer Tie Control. If the downstream Device is not a Tie Device an additional "close" message is sent to the Tie Device. If the Tie Device does not receive a "close" message it does not close the switchgear when it has lost supply and the Loop Automation activation delay expires. If the "close" message is not received before the Loop Automation delay expires it will turn off Loop Automation. This also means that the total message retry period should be shorter than the Loop Automation activation delay.

Faults in Other Sections of the Network

Fault In Section A - Classic Loop Automation

In this scenario, the circuit breaker (CB) at the zone-substation will open and source supply will be lost to the Feeder Device, which will be then tripped by Loop Automation (Rule 1). Supply is also lost to the Mid-Point Device causing it to change to the Alternate protection group and go to Single-Shot mode (Rule 2). Similarly, supply is also lost to the Tie Device which now closes (Rule 3) and restores supply to the unfaulted B and C sections.

Note This time the Tie Device does not close onto a fault.

After a period of time the Mid-Point Device will come out of Single-Shot mode and be ready to Auto-Reclose if there are new faults on section B.

Fault In Section A – Intelligent Loop Automation

In this scenario, if the Tie Control mode is Timer, Intelligent Loop Automation will isolate the fault and restore power in the same way as Classic Loop Automation. If the Tie Control mode is Message, the Feeder will send a close request to the Tie Device after its Loop Automation Timer expires. The Tie Device will only close after it receives a close request from the Feeder Device.

Protection Groups

After the isolation and reconfiguration process the Mid-Point Device is now running on the alternate group of settings which must have been set up for correct coordination when the network is fed in this "reverse" direction.

Ensuring the Tie Device has the correct settings depends on which side is detected as having lost supply. If it was the Load side, it will close with the Forward group e.g. 'A' settings active but if it was the Source side it will close with the Alternate group e.g.'B' settings active.

Fault in Section C – Classic Loop Automation

In this scenario the Mid-Point Device will trip to lockout due to the fault and the Tie Device will sense the loss of supply and will close onto the fault (Rule 3). The Tie Device will have set Single-Shot mode before it closed so that when it closes onto the fault it immediately trips to lockout.

Note Since the fault is located on the last section of line before the open point, there is no section that can be restored by Loop Automation.

Fault in Section C – Intelligent Loop Automation

In this scenario the Mid-Point Device will trip to lockout and then send a close inhibit control to the Tie Device, preventing the Tie Device from closing onto the fault.

Note Since the fault is located on the last section of line before the open point, there is no section that can be restored by Loop Automation

Faults in Sections D and E – Classic and Intelligent Loop Automation

These are similar to sections A and C, in that they are isolated and re-configured in a similar manner.

Additional Intelligent Loop Automation Operation Information

Timer Tie Control operational sequence when the next switchgear Device is a Mid-Point Device

1. Protection sequence to lockout
2. Send the “Upstream Trip Request” message to the downstream Device
3. Log “Send Downstream Trip Request”
4. Log “Request Acknowledged” when confirmation is received from the downstream Device.
5. Turn LA off
6. Log “Loop Automation Off”
7. LA status:
   PROTECTION TRIP
   OPERATOR RESTORATION REQUIRED

Message Tie Control operational sequence when the next switchgear Device is a Mid-Point Device

1. Protection sequence to lockout
2. Send the “Upstream Trip Request” message to the downstream Device
3. Log “Send Downstream Trip Request”
4. Log “Request Acknowledged” when confirmation is received from the downstream Device.
5. Send the “close” message to the Tie Device
6. Log “Send Tie Close Request”
7. Turn LA off
8. Log “Loop Automation Off”
9. LA status:
   PROTECTION TRIP
   OPERATOR RESTORATION REQUIRED

Mid-Point Device receives “upstream lockout” message

When a Mid-Point Device receives an “upstream lockout” message the following sequence occurs:

1. Log “Upstream Trip Request Received”
2. Trip
3. Log “Trip Request”
4. Lockout
5. Turn LA off
6. Log “Loop Automation Off”
7. LA status:
   UPSTREAM LOCKOUT
   OPERATOR RESTORATION REQUIRED

Mid-Point Device loses the source supply and the source supply is restored after LA delay timer has expired.

Operational sequence for a Mid-Point Device in intelligent logic mode when the source supply is lost and then restored after the LA delay:

1. Log “Load Supply Off” and “Source Supply Off”
2. LA status:

   SOURCE SIDE NOW DEAD - TIMING OUT
   WILL CHANGE TO PROTECTION GROUP ‘B’

3. LA timeout
4. Turn LA off
5. Log “Loop Automation Off”
6. LA status:

   LOST SOURCE SUPPLY - PROT GRP ‘B’ ACTIVE
   LOOP AUTOMATION TURNED OFF

Tie Device receives “upstream lockout” message

When a Tie receives an “upstream lockout” message the following sequence occurs:

1. Log “Close Inhibit Request Received”
2. Turn LA off
3. Log “Loop Automation Off”
4. LA status:

   LOOP AUTOMATION CLOSE INHIBITED
   LOOP AUTOMATION TURNED OFF

Tie Device receives “close” message

When a tie loses supply and receives a “close” message the following sequence occurs:

1\. Log “Source Supply Off”
2\. Log “Loop Automation Upstream Close Request Received”
3\. LA timeout
4\. Closes switchgear
5\. Log “Loop Automation Close Request”
6\. Turns LA off
7\. Log “Loop Automation Off”
7\. LA status:

   CLOSED TO RESTORE SOURCE SUPPLY
   OPERATOR RESTORATION REQUIRED

Purpose of Feeder Device

The Feeder Device is always the Device closest to the source of supply and must never feed power in the reverse direction. This is the purpose of Rule 1: to isolate the source when it is lost so that Loop Automation does not try to feed power back into it. Conversely, a Mid-Point Device can feed power in both directions. Therefore, a network does not have to have a Mid-Point Device but must always have a Feeder Device for each source of supply. Ideally, the Device in the zone substation would be the Feeder Device in the Loop Automation scheme as this allows maximum coverage of the network by the scheme.

Asymmetric Tie Device Operation

It may not be desirable to reconfigure the network on both sides of the Tie point in some networks. To allow this, the Tie Device has an option to close automatically only if the Load Side Supply is lost. This is called the “Tie Restore One Way” setting. An example of this setting is given in Section 7.

Loss of Supply to the Zone Substation

This can happen with a transformer fault or a transmission network fault. In this case where both feeders originate from the same substation, the Feeder Devices will trip as for a fault in Section A (Rule 1). However, as the fault has caused loss of supply to both sides of the Tie Device it will not be closed by Loop Automation (Rule 3). This could be a problem when supply is restored to the feeder Device(s) because it is now tripped and will not supply the rest of the network. This possibility has been allowed for in the auto-restoration rules (see Understanding Auto- Restore - Rule A)

Loop Automation Activation Delay

Loop Automation is triggered by supply voltage being lost or restored on the power lines. Loss of power also occurs during a normal Auto-Reclose sequence. Therefore, to prevent Loop Automation from doing anything during the normal Auto-Reclose sequence, there is a time delay which must elapse before the Loop Automation algorithms start. The delay is set by the user to be of greater duration than the longest Auto-Reclose sequence that could occur, and is called the Loop Automation Activation Delay.

After supply is lost, the Feeder and Mid-Point Devices must obey rules 1 and 2 (isolation and re-configuration) before the Tie Device closes under Rule 3. The Loop Automation Activation Delay is set for a longer period in the Tie Device than the other Devices to achieve this coordination.

The Loop Automation Activation Delay may typically be set to 30 seconds in the Feeder and Mid-Point Devices and 40 seconds in the Tie Device.

Understanding Auto-Restore

Overview

The Auto-Restore feature is part of the Classic Loop Automation application. It closes the Feeder and Mid-Point Devices and opens the Tie Device to restore the normal network configuration after a fault condition has been cleared.

The basic rules of Auto-Restore are as follows:

A. a Feeder Device closes when its source supply is restored if it was tripped by Loop Automation, or when it has supply restored to both sides .
B. a Mid-Point Device closes when it has supply restored to both sides
C. a Tie Device trips when it detects a 50% reduction or a direction reversal in the power flowing through it.

These simple rules will restore the network to its normal operating configuration after a faulted section has been repaired

Note The above rules are a simplification - the full rules are given in Appendix A. For Loop Automation with LBS rules, see Appendix H.

Fault in Section A

In this scenario, the fault condition has initiated Loop Automation and supply is now restored through the closed Tie Device to Sections C and B up to the open Feeder Device. The Mid-Point Device has remained closed and the substation CB at A has tripped. When the fault condition is physically cleared and the substation CB at A is closed, the downstream Feeder Device will sense supply to both sides and close (Rule A, explained above). With the Feeder Device now closed, a substantial proportion of the Feeder load that was flowing through the Tie Device, would be taken up by the Zone Substation CB at A. The Tie Device would therefore detect a 50% drop in power flow and trip (Rule F, explained above) restoring the normal network configuration. Because Loop Automation has remained ON at the Tie Device there is no need to re-arm Loop Automation at that Device.

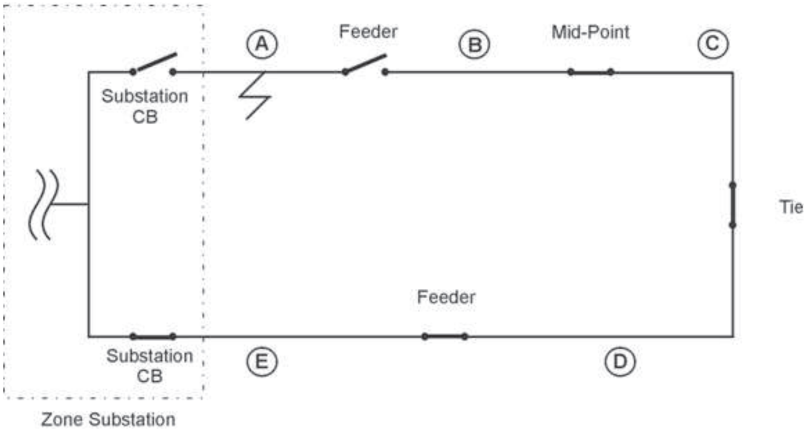


Figure 3. Auto-Restoration - Section A.

Fault in Section B

In this scenario, the fault condition has initiated Loop Automation and supply is now restored through the closed Tie Device to Section C to the Mid-Point Device (now open due to protection when Loop Automation closed the Tie Device). The Feeder Device is also now open because it tripped to clear the fault at B.

When the fault condition is physically cleared, Loop Automation is re-armed and the Feeder Device is closed, the Mid-Point Device will sense supply to both sides and close (Rule B). Alternatively, the linesperson may clear the fault condition and then close the Mid-Point Device. The Feeder Device will then sense supply at both sides and close (Rule A). The Tie Device will now detect either a 50% reduction or directional change of power flow through it and trip (Rule C) so as to restore the network to normal configuration.

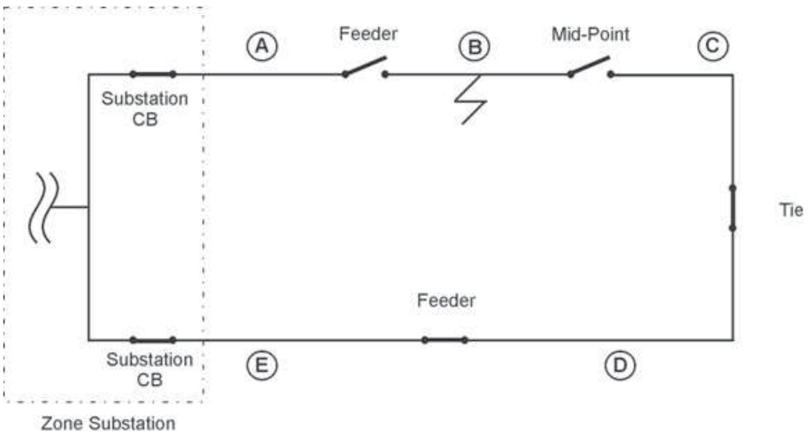


Figure 4. Auto-Restoration - Section B.

Fault in Section C

In this scenario, the fault condition has initiated Loop Automation and supply is lost to Section C. The Mid-Point Device is now open as it tripped to clear the fault. The Tie Device has gone to Single-Shot, closed and then tripped. The linesperson physically clears the fault condition and closes the Mid-Point Device before re-arming Loop Automation. The Tie Device will now detect supply at both sides and remain open. The linesperson must then re-arm Loop Automation at the Tie Device.

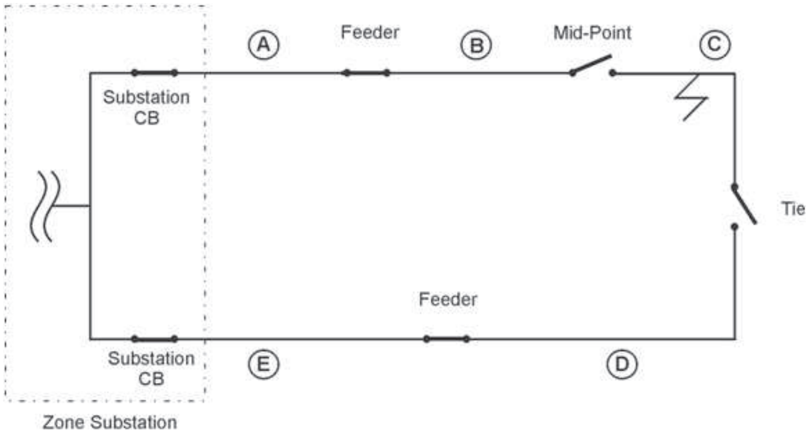


Figure 5. Auto-Restoration - Section C.

Supply Auto-Changeover

Overview

Loop Automation can also be used to ensure that a secure supply is provided to a critical load (e.g. a hospital) by implementing a 'make before break' Auto-Changeover (ACO) scheme that does not rely on communications between devices. This scheme ensures that the critical load will maintain supply providing either the normal or alternate supply is available.

Description

The following figure shows two Devices, one normally open (Tie Device) and the other normally closed (Feeder Device).

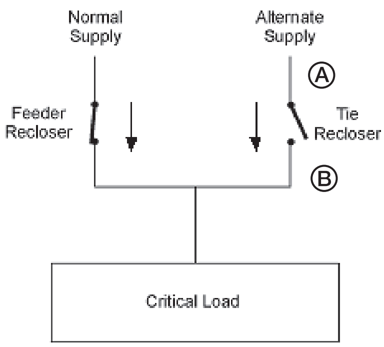


Figure 6. Loop Automation used as a Auto-Changeover scheme.

When using Loop Automation as a communications-free Auto-Changeover scheme, the Tie Device must be configured to "Tie Restore One Way" so that it will not close to back-feed the alternative supply if it is lost. For this to work correctly, the bushings on the side marked "A" must be configured as the Source Side and the bushings on the side marked "B" as the Load Side.

When the Feeder Device detects a loss of supply it trips (Rule 1) and the Tie Device closes (Rule 3), restoring supply to the critical load from the alternate source. This can only happen if the alternate supply is available.

If Auto-Restore is enabled:

- the Feeder Device will close (Rule A) when the normal power supply returns
- the Tie Device will trip provided that the power flow through the Tie reduces by 50% or more (Rule C).

Note If break before make functionality is mandatory (ie: incompatible supplies) Loop Automation cannot be used for Auto-Changeover. ADVC2 controllers have a separate ACO feature that caters for this requirement.

Loop Automation Configuration

Introduction

Loop Automation configuration involves setting up the type of switchgear (Feeder, Mid-Point or Tie), setting the Loop Automation Activation Delay timers and configuring Auto-Restore if required.

However, it must be strongly emphasised that Loop Automation relies on the basic protection being set correctly for both forward and reverse protection groups. If this is not the case, then Loop Automation will not operate as expected.

This part of the manual covers the following topics:

- Loop Automation Timing
- Determine the Loop Automation Settings (both Classic and Intelligent)
- Parameters affecting Loop Automation
- Configuring Loop Automation using the Operator Interfaces
- Configuring Loop Automation using the Windows Switchgear Operating System (WSOS5).

Loop Automation Timing

Overview

Devices in a Loop Automation scheme are primarily protection devices. They will trip when they detect a fault and attempt a number of Reclose operations as defined by the user.

Loop Automation only comes into effect after a set time has elapsed following the detection of a loss of power. This allows Devices to go through their normal protection sequence uninterrupted. Loop Automation is not triggered if the Device is successful in clearing the fault and restoring supply during this period.

Loop Automation will only be triggered after there is no possibility of the supply being restored by an Auto-Reclose from a Device. To ensure that this occurs the Loop Automation Activation Delay must be set for a period greater than the longest Auto-Reclose sequence possible, plus a safety margin of several seconds.

It is also important to set the Tie Device Loop Automation Activation Delay for a longer duration than the Loop Automation Activation Delay in the Feeder and Mid-Point Devices to make sure that it does not close before the other devices are ready.

What is done in practice is to decide a co-ordination time between the various stages of the Isolation and Reconfiguration sequence.

Classic Loop Automation Parameters

Overview

Loop Automation incorporates a number of parameters that must be correctly configured to ensure correct operation. These parameters may be set using either the Operator Control Panel or WSOS5.

Description of Parameters

All the parameters on the Loop Automation Setting Sheet are explained below whilst some others are further explained in the equipment-specific technical manual.

Parameter	Description
Live Line Threshold 2000-15000V Default 2000V	Determines the voltage level at which a terminal is considered to be "live". This value is used to generate Load/Source ON/OFF events that trigger Loop Automation. Must be the same value for all Devices in a Loop Automation scheme. Typical value is 2000V. Refer to equipment technical manual for further information. Set System Status: Phase Voltage and Power Flow: LIVE if >2000V Flex System Status: Phase Voltage and Power Flow: LIVE if >2000V Engineer Menu -> Configuration Menu -> System Settings -> Network Parameters -> LIVE if > 2000V
Supply Timeout (ST) 0.1-100s Default 4s	Determines the time between detecting a change of terminal live/dead status and generating the "Supply ON/OFF" event. It is this event that triggers the start of the Loop Automation timer and should be set to the same value in all Devices in a Loop Automation scheme. The value of this parameter is set by utility practices. A value of 0.5 to 5.0 seconds is typical. Refer to equipment technical manual for further information. Set System Status: Phase Voltage and Power Flow: Supply Timeout 0.5s Flex Engineer Menu -> Configuration Menu -> System Settings -> Network Parameters -> Supply timeout 0.5s
Coordination Time (T1)	There has to be a delay between the actions of each of the Loop Automation Devices. For example: the Mid-Point Device must change its protection group before the Tie Device closes. This is the coordination time. Typical time is 10 seconds. Minimum recommended time is 5 seconds.
Single-Shot Reset Time (2 x T1)	The single-shot facility is used by Loop Automation to force one shot to lockout in the Mid-Point and Tie Device prior to the Tie closing onto a faulted feeder. The Single-Shot timer must be set longer than the Loop Automation coordination time (T1), twice as long is recommended. Set Protection Setting 2: SS Reset Time 1s Flex Engineer Menu -> Protection Menu -> Protection Trip Settings -> Single-Shot -> Reset -> SS Reset Time 1s

Maximum Sequence Time (T2)	Loop Automation should only take control after there is no possibility of the supply being restored by an Auto-Reclose from a Device. Therefore the Loop Automation Time must be longer than the maximum time the Device will take to trip to lockout. This is called the Maximum Sequence Time. Maximum Sequence time is determined by the protection settings and the expected fault levels. It must include the Time To Trip and the Reclose time for each Reclose in the sequence. To limit the Time To Trip it may be desirable to set a maximum time to trip (refer equipment manual for protection parameters). For example, a typical Reclose sequence has an instantaneous trip, a 1 second dead time followed by a second inverse time trip with a max. time of 5 seconds. This sets the Maximum Sequence Time to be around 6 seconds. If there is the possibility of low level faults with long trip times (perhaps on fused spur lines) then these can take longer than the Maximum Sequence Time provided that they do not reduce the system voltage to a level where Loss of Supply events occur.
Auto Changeover Time (T1 + T2)	Determines the period of time that power (greater than 50 kW) must flow in the reversed direction before an automatic change of protection group takes place. Used in the Mid-Point Device to change protection settings when restoring the normal configuration, it is also used when power flows to the alternate source in a closed Tie Device and Loop Automation is turned off. In a Loop Automation scheme this must be long enough to allow an Auto-Reclose sequence to finish. Therefore it must be longer than the Maximum Sequence Time (T2). A time of T2 plus the Coordination Time is recommended. Consult your switchgear manual for further information.
Live Load Blocking ON/OFF	This setting takes priority over Loop Automation closing and should be turned OFF when Loop Automation is used. Consult your equipment technical manual for further information. *Factory default is* “OFF”
Loop Automation Available	Enables or disables the entire Loop Automation facility. This must be set to Available in all Devices used in the Loop Automation scheme. *Factory default is* “Not Available”
Dead Time ON/OFF This mode is only for Tie switchgear	Turns ON or OFF the Loop Automation Dead time function. **Note** By default, Dead Time is ON for a Tie on a LBS and for aTie on a Recloser it is Off.
Forward Dead Time Reverse Dead Time	This value is used to determine the allowable upstream Device dead time for forward or reverse Tie reconfiguration. This is a value e.g. 25 sec. ± a margin (see below). *Factory default is* 25.0 seconds
Forward Margin +/- Reverse Margin +/-	The margin is used with the Dead Time values above. This value is typically not more than the trip time of the upstream devices. *Factory default is* 2.0 seconds
Device Type	Determines whether the Device operates as a Feeder, Mid-Point or Tie Recloser Device or a Tie Device/Sectionaliser Device with Dead Time profile. Range: Feeder, Mid-Point, Tie. *Factory default is* “Tie”.

Power Direction	Designates which terminals of the ACR are the source and load sides in normal configuration. For the Feeder Device this is only important if auto-restore is used. For the Mid-Point Device this affects the selection of the protection group, which is set automatically by the direction of the power flow when the Tie Device is closed. Therefore if the direction parameter is not right the wrong protection group will be in service. For the Tie Device this affects the protection group selection as for the Mid-Point Device and, in addition will affect the Tie Restore One Way direction. If wrongly set, then the Tie will operate for loss of supply on the wrong side. This parameter can only be set after field installation when the installation details are known. Range: Source 1 or 2 - Load 2 or 1 in the N-Series and Source I or X - Load X or I in the U-Series Factory Defaults are: Source 1 - Load 2 for the N-Series Source I - Load X for the U-Series
Loop Auto Time (Activation Delay) (LA)	Determines the delay after a Supply ON/OFF event before the Loop Automation program takes action. The same timeout value is used both when supply is lost and during Auto-Restore operation. Range: 3 to 1800 seconds Factory Default is “30 seconds”
Auto-Restore Available	Enables or disables the Auto-Restore facility. This is a security feature and ensures the Auto-Restore features cannot be turned on unless this field is first set to “Auto-Restore Available”. **Note** The network must be able to operate closed if Auto-Restore is used. Range: Available, Not Available. *Factory default is* “Auto-Restore Not Available”
Auto-Restore ON/OFF	Turns on the Auto-Restore features. **Note** For U-Series, additional external voltage sensors must be fitted to units that require Auto-Restore. Range: Auto-Restore On, Auto-Restore Off *Factory default is* “Auto-Restore Off”
Tie Restore	Only applies to Tie Device. This field is only displayed if “Device Type” is set to Tie ACR. This field sets whether a Tie ACR reconfigures supply in both directions, or just from Source to Load. Set Tie Restore Both Ways if you want to restore symmetrically across the Tie Device. Range: One Way, Both Ways. *Factory default is* “Tie Restore One Way”
Loop Automation ON/OFF	Turns ON or OFF the Loop Automation function. Range: Loop Automation ON, Loop Automation OFF. *Factory default is* “Loop Automation OFF”

Arming Mode (Tie only)	Default mode causes LA to operate only when a loss of voltage occurs after there has been good voltage whilst LA is active. Alternate mode can be used by a Tie Device to allow LA to respond to logic conditions that exist when LA is turned on. (E.g. if LA is turned ON while the Tie Device is Live on the source and dead on the load, the LA timer would start.) Alternate mode may avoid the problem of manually closing a Tie, while an upstream Device is mid sequence. (A Tie Device with Live/Dead condition is closed while the upstream Device is in the middle of a Reclose sequence, causing potentially 2 out of phase networks to be connected. (Using the Alternate mode resolves this as the LA time of the Tie is always configured to be greater than the sequence time T2 of the upstream devices sequences) Warning: alternate mode may cause turning LA on to close the switch before any loss of supply events are generated.
LA Pickup	The default is changed to “Allows Trigger”. This causes Loop Automation to ignore any loss of supply events while still in pickup (also dependent on fault reset time, see below). Changing LA Pickup to “Allows Trigger” will allow loop auto to process loss of supply events during pickup. This would ensure protection operations can complete a protection sequence with Auto-Recloses at the same time as allowing LA to operate on Loss of Supply Triggers (i.e. without restoring power in a temporary fault situation). This mode is selectable only for Feeder and Mid-Point Devices on the network.
Loss of phase/Loop Automation Linked/Not Linked	If set to Linked, turning Loss of Phase (LOP) OFF will turn Loop Automation OFF and vice versa. (Only available for Classic Loop Automation).

Table 1. Description of parametres - Classic Loop Automation

Intelligent Loop Automation Parameters

Overview

Intelligent Loop Automation requires the configuration of parameters in addition to the Classic Loop Automation settings. These parameters may be set using either the Operator Control Panel or WSOS5.

Description of Parameters

All the parameters on the Loop Automation Setting Sheet are explained below whilst some others are further explained in the equipment-specific technical manual.

Parameter	Description
Ping Interval	This is the number of seconds between sending poll messages to determine the communications status of downstream devices. A ping message is sent every interval to the downstream and Tie. The communication status is Normal if ping succeeds, otherwise it is Failed.
Check IP Address	This setting is available on panel and also on WSOS. If Check IP Address setting is ticked, a connection from the upstream device will be accepted only if its IP address is in the allowed incoming IP address list, the list can be configured using WSOS under the Valid IP Addresses
Valid IP Addresses	This is the list of Valid IP addresses that will be used for poll and control messages.
Logic	Range: Classic, Intelligent Default Value: Classic Setting this option to Intelligent enables the communications based Loop Automation.
Tie Control	Range: Timer, Message Default Value: Timer This sets the Tie Control mode for the Intelligent Loop Automation. All devices in the Loop Automation scheme must be in the same mode.
Downstream Device IP	Range: “xxx.xxx.xxx.xxx” where “xxx” is a number from 0-255. Default Value: “0.0.0.0” This sets the IP address of the next controller device in the Loop Automation scheme. The first controller device in a Loop Automation scheme is a Feeder and the next can be either a Mid-Point or Tie. This is available only for a Feeder or Mid-Point.
Downstream Device TCP Port	Range: 1-65535 Default Value: 1502 This sets the TCP port of the next controller device in the Loop Automation scheme. This is available only for a Feeder or Mid-Point.
Downstream Device Type	Range: Mid-Point, Tie Default Value: Mid-Point This is available only for a Feeder or Mid-Point.
Downstream Device Function	Range: Load Break Switch, ACR Default Value: ACR This is available only for a Feeder or Mid-Point.
Tie Device IP	Range: “xxx.xxx.xxx.xxx” where “xxx” is a number from 0-255. Default Value: “0.0.0.0” This sets the IP address of the Tie Device in the Loop Automation scheme. This is available only when Downstream Device Type is Mid-Point and the Tie Control is Message.
Tie Device TCP Port	Range: 1-65535 Default Value: 1502 This sets the TCP port of the Tie controller in the Loop Automation scheme. This is available only when Downstream Device Type is Mid-Point and the Tie Control is Message.

Listening TCP Port	Range: 1-65535 Default Value: 1502 This sets the listening TCP port of a controller in the Loop Automation scheme. This is available only for a Mid-Point and Tie.
Message Timeout	Range: 1-999 seconds Default Value: 1 This specifies the timeout period for messaging. This is available only for a Feeder or Mid-Point.
Message Attempts	Range: 1-999 Default Value: 3 This specifies the maximum number of message sending attempts. This is available only for a Feeder or Mid-Point.

Table 2. Description of Parameters - Intelligent Loop Automation

Description of Status

All the parameters on the Loop Automation Setting Sheet are explained below whilst some others are further explained in the equipment specific technical manual.

Parameter	Description
Downstream Communications Status Type: Status Range: Normal/Failed	This indicates the communication status to the downstream Device. This is available only for a Feeder or Mid-Point.
Tie Communications Status Type: Status Range: Normal/Failed	This indicates the communication status to the Tie Device. This is available only for a Feeder or Mid-Point when the Downstream Device Type is Mid-Point and the Tie Control is Message.

Table 3. Description of Status Parameters - Intelligent Loop Automation.

Entering the Loop Automation Parameters

Overview

The Loop Automation Configuration page is located in the AUTOMATION display group in the Operator Control Panel. Loop Automation becomes available and adds additional display pages to the Automation display group when the setting is selected.

Set SYSTEM STATUS - OPTIONS - Automation - Loop Auto Available

Flex ENGINEERING - Configuration - Feature Selection - Automation

Loop Automation can be configured from the Loop Automation configuration screen.

Set Automation - Loop Automation Configuration 1

Flex Engineering Menu - Automation Menu - Loop Automation Menu

The above shown display page allows an engineer to set up the main Loop Automation parameters. A number of other parameters will also need to be set up for the scheme to work correctly, refer to Section 12.

Loop Automation Configuration Page

Loop Automation Configuration on setVUE

Navigation Tree

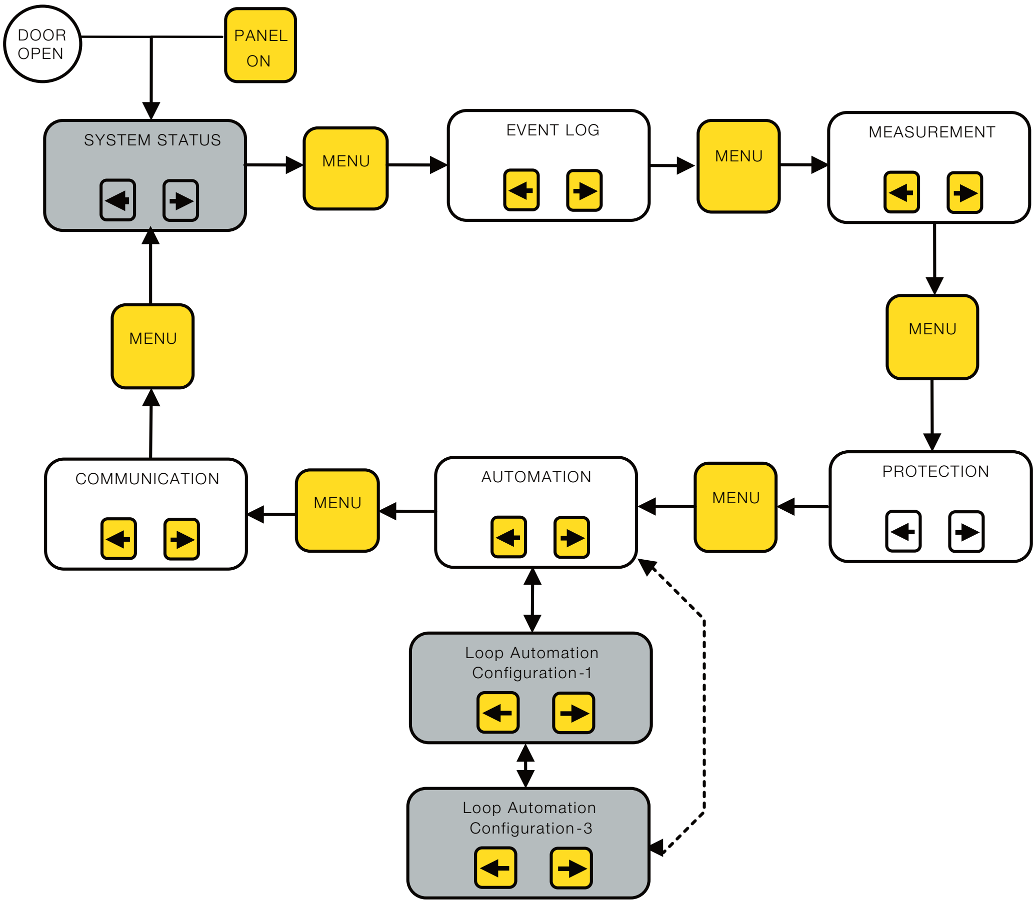


Figure 7. setVUE: Loop Automation Navigation Tree.

The parameters available on the Loop Automation Configuration screens are as follows:

- Type is Feeder, Mid-Point or Tie Device
- Auto-Restore is ON or OFF (If Auto Restore is Available)
- Arming Mode is Default or Alternate (Tie Device only)
- Pickup is Allows Trigger or Blocks Trigger (Feeder or Mid-Point Device only)
- Auto-Restore is Available or Not Available
- Tie Restore is set One Way or Both Ways (Tie ACR option only if Dead Time is Off)
- Loop Automation Activation Delay.
- LOP/Loop is Unlinked or Linked
- Logic is Classic or Intelligent
- Dead Time is Off or On (Tie Device only)
- Forward Dead Time is 25.0s (Configurable if Dead Time is On)
- Reverse Dead Time is 25.0s (Configurable if Dead Time is On)
- Forward Dead Time Margin is 2.0s (Configurable if Dead Time is On)
- Reverse Dead Time Margin is 2.0s (Configurable if Dead Time is On)

Loop Automation settings on the setVUE interface

-- LOOP AUTOMATION CONFIGURATION 1

Tie ACR	AutoRestore OFF
Arm Mode DEFAULT	TieRestore Bothways
	Delay Time 30s

Figure 8. setVUE: Loop Automation Configuration page 1.

-- LOOP AUTOMATION CONFIGURATION 2

Auto-Restore Avail

LOP/Loop Unlinked

Logic Classic

Figure 9. setVUE: Loop Automation Configuration page 2.

-- LOOP AUTOMATION CONFIGURATION 3 --A

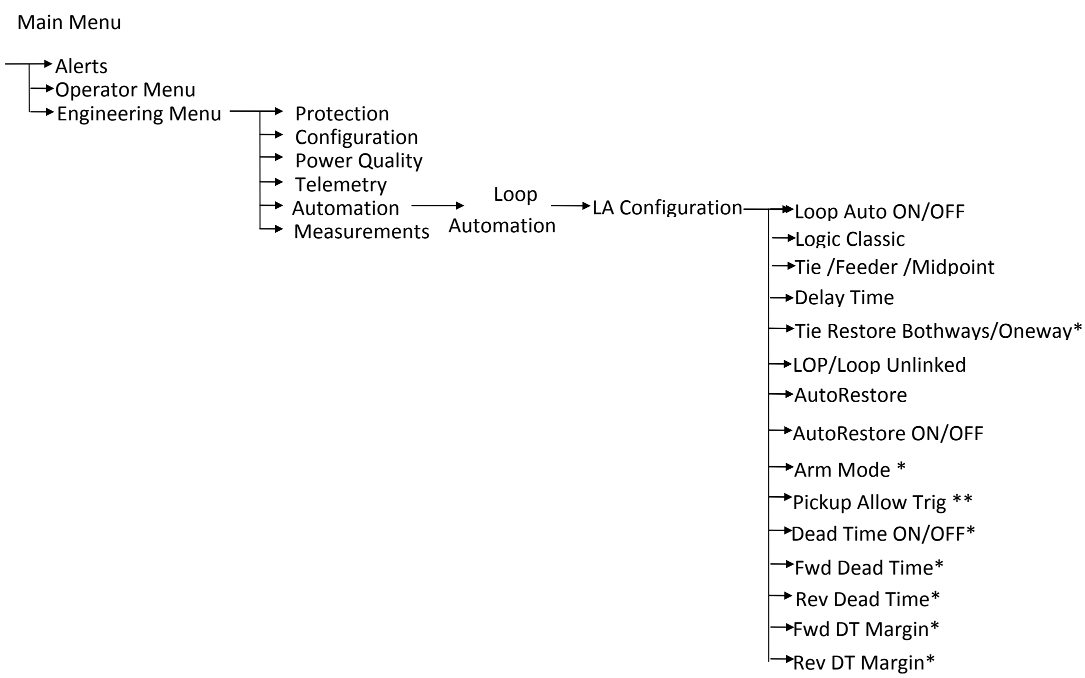
Dead Time ON

Fwd Dead Time 25.0s	Rev Dead Time 25.0s
Fwd DT Margin 2.0s	Rev DT Margin 2.0s

Figure 10. setVUE: Loop Automation Configuration page 3.

Loop Automation Configuration on flexVUE

Navigation Tree



*Applicable only for a Tie ACR, ** Applicable only for a Feeder and Mid-Point ACR.

Figure 11. flexVUE: Loop Automation Navigation Tree.

Windows Switchgear Operating System

Overview

Windows Switchgear Operating System (WSOS5) is a PC software package for configuring advanced controllers. Controller interface is via a local or remote serial USB or Ethernet port connection.

Loop Automation can be configured from WSOS5.

It is important to note that writing a WSOS5 File to the controller will automatically turn Loop Automation Off. This is so that a configuration which had Loop Automation set to "ON" when it was saved, does not inadvertently turn it "ON" when loaded into the controller.

Creating a New Loop Automation File

Loop Automation is not available when opening a new file. WSOS5 must be opened and then configured in OFF-LINE mode to create the file as follows:

- Loop Automation can be made available by checking the option Loop Automation Available in the Feature Selection window. The Feature Selection window can be opened in the Switchgear Explorer under Configuration.

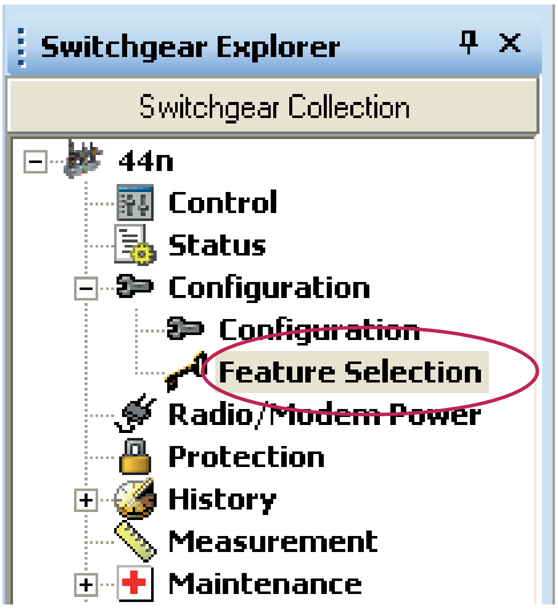


Figure 12. WSOS5 Feature Selection item on the Switchgear Explorer.

- At the following screen tick the Loop Automation Available option. (This action not required if a read file has been performed on an ADVC with Loop Automation already installed). Loop Automation and ACO features are mutually exclusive.

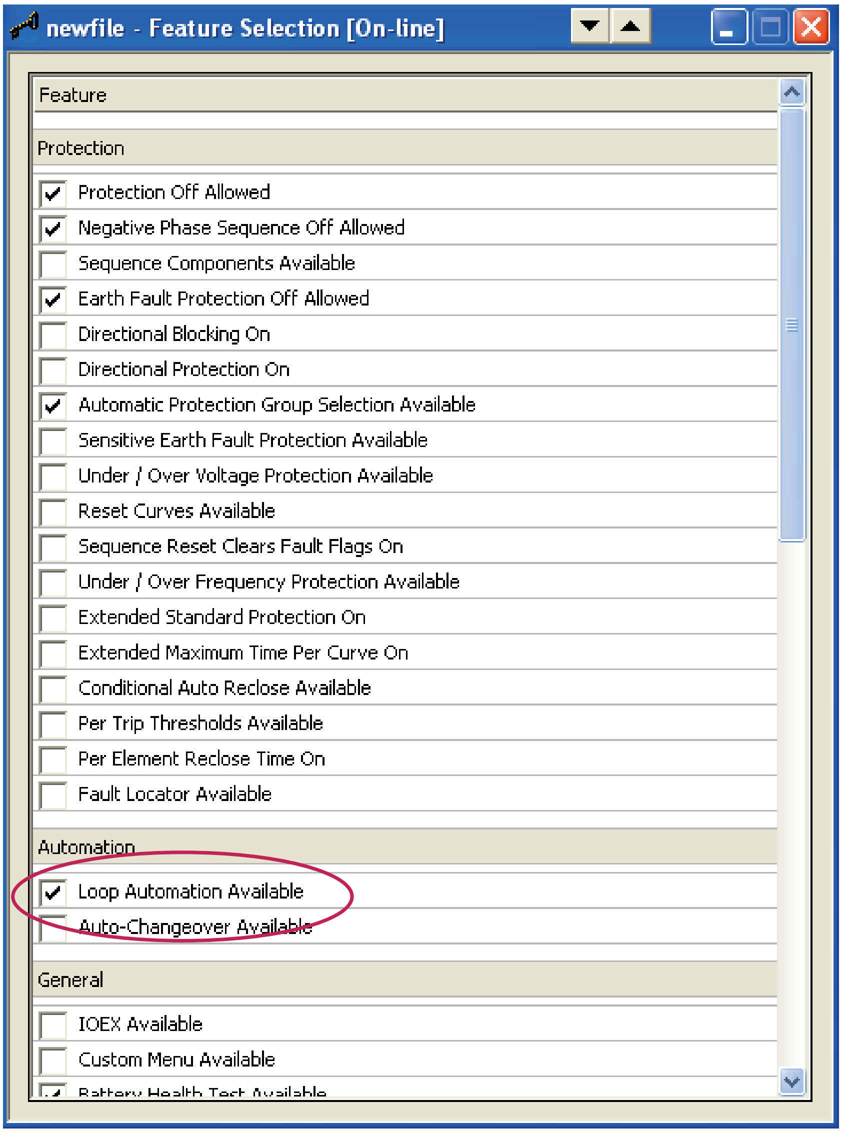


Figure 13. WSOS5 Feature Selection Window.

- Enter the password in the pop-up window.
- Then select 'OK'.

Configuring Loop Automation

- Display - Loop Automation.
- Once Loop Automation has been made available, the configuration pages can be opened from the Switchgear Explorer under Loop Automation.

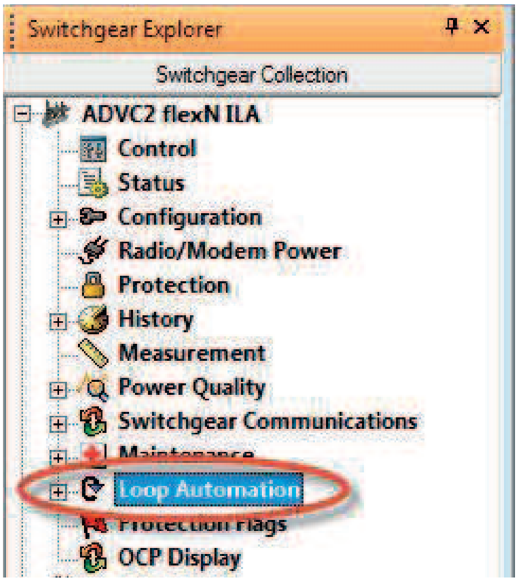


Figure 14. WSOS5 Loop Automation item on the Switchgear Explorer.

- The required parameters for Loop Automation configuration may now be entered.

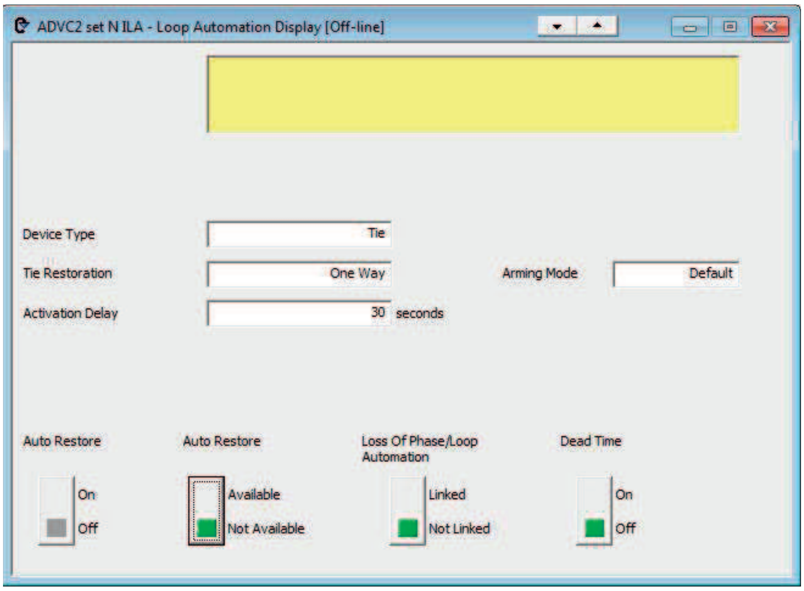
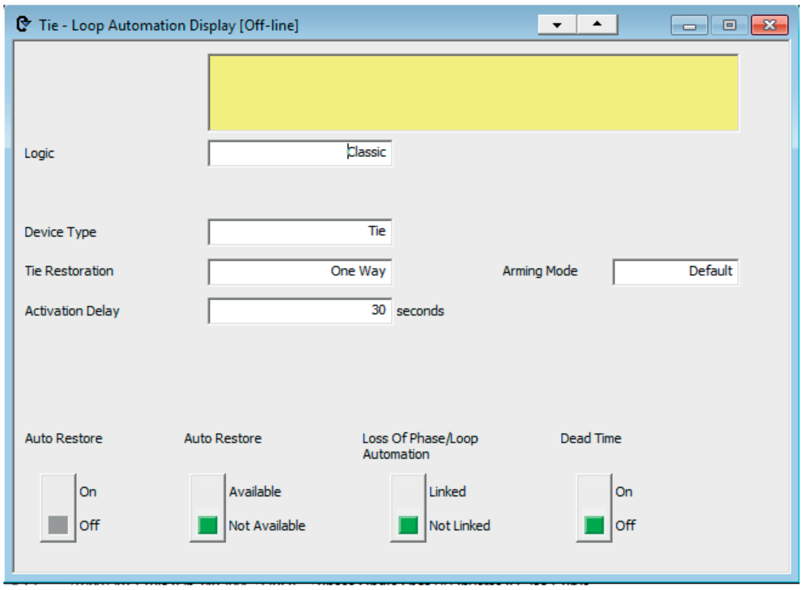


Figure 15. WSOS5 Loop Automation Configuration (Off Line).

Intelligent Loop Automation Settings in WSOS

The communications based Loop Automation mode can be enabled from the Loop Automation Configuration page by choosing Intelligent as the Loop Automation Logic. When the Intelligent Logic is chosen the "Configure" button is displayed. The Intelligent Loop Automation Communications settings page can be displayed by clicking the "Configure" button.



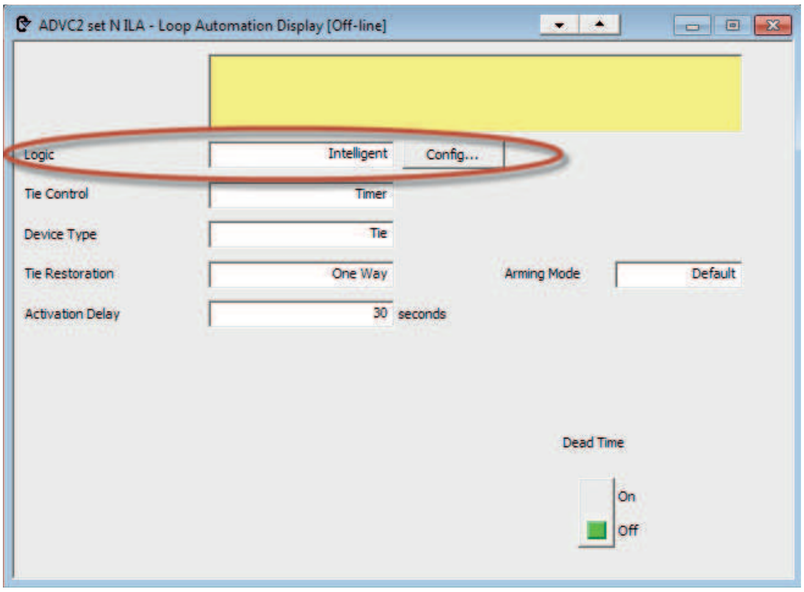
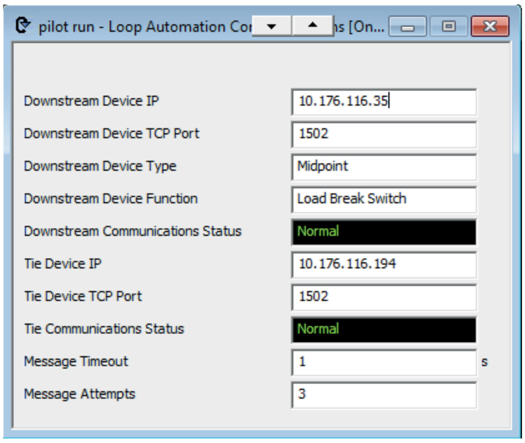


Figure 16. Loop Automation settings with Logic option.



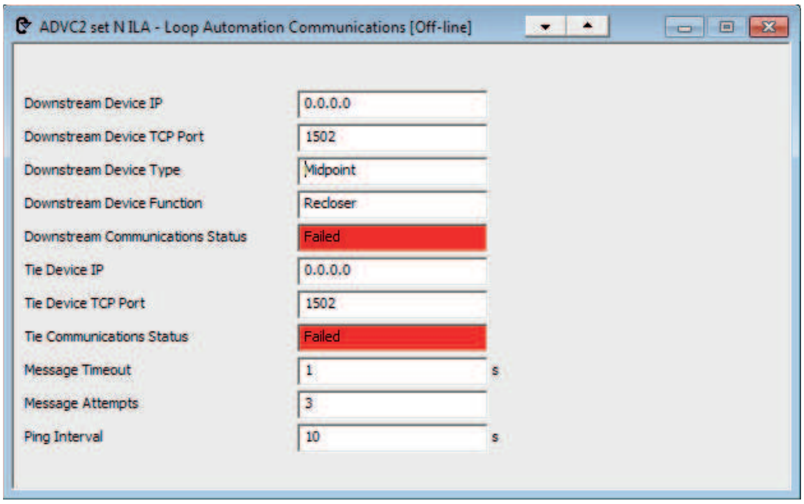


Figure 17. Intelligent Loop Automation Communications settings.

Determining Loop Automation Settings

Overview

There are four steps in the process of determining the required Loop Automation settings for a network. This section explains those steps and provides a working example of a network and how to determine the settings required.

When carrying out these steps it is strongly recommended that you record the settings on the template provided at Appendix C as well as entering them into the Windows Switchgear Operating System (WSOS5) configuration files.

As you work through the procedure, refer also to Section 12 for a detailed explanation of each of the parameters.

Procedure

Step 1

Sketch the network and identify each of the Devices.

Record general notes e.g.: Device 4 is normally open.

The dotted line feeder will supply the solid line feeder back to Device1 automatically.

The solid line feeder will supply the dotted line feeder back to Device 5 automatically.

There is no auto-restore on Device 2, 3 or 4 so restoration of normal configuration must be carried out manually after the fault condition is removed.

Auto-restore is ON for Device 1 and 5 so that if they lose Source Supply and trip due to the Loop Automation, they will close automatically when supply is restored.

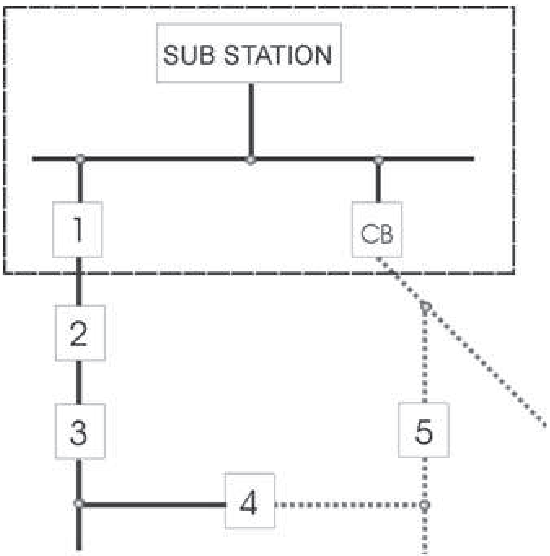


Figure 18. Example network.

Step 2

Decide the following global settings (refer also to Section 12 for explanation of parameters)

Live Terminal Voltage	- V	V = 2000V
Supply Timeout	- ST	ST = 1 second
Coordination Time	- T1	T1 = 10 second
Single-Shot time	- SS	SS = 2 x T1 (SS = 20 sec.)
Maximum Sequence Time	- T2	T2 = 30 sec.
Auto-changeover Time	- AT	AT = T1 + T2 (AT = 40 sec.)

Step 3

Determine the protection requirements for all devices in all network configurations:

Mid-Point Devices will need two protection groups to cater for forward and reverse power flow.

The Tie Device will also require two protection groups if set to Restore Both Ways.

When setting the protection groups, ensure that a fault can not cause a reclose sequence that would exceed the maximum sequence time.

Step 4

Determine the following for each Device:

Device Type must be either Feeder, Mid-Point or Tie depending on its position in the network.

Direction of power flow in the normal network configuration.

Auto-restoration Unavailable/ON/OFF.

Loop Automation (LA) time:

(a) Feeder or Mid-Point - LA time = T2 + T1

(b) Tie - LA time = (2 x T1) + T2

Loop Automation in Service

Introduction

The following topics are discussed within this section:

- Operator Control Panel Displays
- Turning ON Loop Automation
- Turning OFF Loop Automation
- Commissioning
- Post-Fault Condition Action

The preparation sequence required to be completed is as follows:

- load the correct software version into each controller as necessary (consult your distributor if required)
- load the correct Loop Automation and protection settings into each controller. This can be done manually or preferably using WSOS5. It is advisable to use the setting sheet template at Appendix C to record the settings for future reference
- turn on Loop Automation at each controller.

Warning

If switching is planned within the network, do not forget to turn off Loop Automation at any Devices which might be affected. If not turned off, they may operate due to Loop Automation.

After there has been a network fault, Loop Automation may have operated to isolate the faulted section and restore supply to the unfaulted sections. This must be taken into account when analysing the fault.

Event Log

The following events may be logged as a result of the operation of Loop Automation.

Event Text	**Explanation**
End of Sequence	Generated when a protection sequence has finished but Loop Automation may still cause an automatic close.
Lockout	Generated when Loop Automation changes state so that an automatic close will not be generated (only applicable if an end of sequence event has been generated previously).
Loop Auto Close Req	Loop Automation requests CLOSE
Loop Auto OFF	Loop Automation is turned OFF
Loop Auto ON	Loop Automation is turned ON
Loop Auto Trip Req	Loop Automation requests TRIP
Prot. Group A Active	Loop Automation has changed the Protection Group setting from B to A
Prot. Group B Active	Loop Automation has changed the Protection Group setting from A to B
Send Downstream Trip Req	Intelligent Loop Automation has sent a trip request to a downstream Device because the sending Device has gone to lockout following a protection operation.
Send Tie Close Inhibit Req	Intelligent Loop Automation has sent a close inhibit request to the Tie Device.
Req. Ack	Intelligent Loop Automation has received acknowledgement from the downstream Device that it received a trip or close inhibit request.
Upstream Trip Request Rcv	Intelligent Loop Automation has received a trip request from an upstream Device
Close Inhibit Request Rcv	Intelligent Loop Automation has received a close inhibit request from an upstream Device.
Downstream Failed to Operate	Intelligent Loop Automation did not receive confirmation that the downstream Device tripped following a trip request.
Upstream Close Request Rcv	Intelligent Loop Automation has received a close request from an upstream Device.

Table 4. Loop Automation event log.

“Lockout” and “End of Sequence”

For a Device without any automation facilities enabled, a permanent fault will cause the Device to go through a sequence of trips and Recloses, finally ending up with the Device open in the “Lockout” condition. The Device will not close whilst in this state without operator intervention.

Where automation facilities are enabled it is possible that, even though a Device has gone through its Reclose sequence to “Lockout”, the automation logic may command a close at some later time.

In this instance, the Device state cannot be described as “Lockout” as the word “Lockout” implies that the Device will not perform any further automatic operations until an operator intervenes. Instead of “Lockout” the term “End of Sequence” is used.

For the Loop Automation scheme, Lockout and End of Sequence work like this:

- The normal ‘Lockout’ event is generated if no automation logic is enabled in the Device which could cause an automatic close at some time in the future.
- Consequently, the following pages show “LOCKOUT” status:

Set — SYSTEM STATUS – OPERATOR SETTINGS 1 – LOCKOUT

Flex — Operator Menu – Operator Controls - Lockout

- The *End of Sequence* event is generated instead of Lockout if automation logic could at some time in the future generate an automatic close.
- If an automatic close is executed, the following page will show a blank field instead of advising the Lockout status:

Set — SYSTEM STATUS – OPERATOR SETTINGS 1

- If the automation system changes state so that it will not cause any future closes then the ‘Lockout’ event is generated. The following page shows “LOCKOUT” status.

Set — SYSTEM STATUS – OPERATOR SETTINGS 1 – LOCKOUT

Flex — Operator Menu – Operator Controls - Lockout

Turning Loop Automation On

Overview

Loop Automation is always turned on (made active) by a deliberate user action either from the Operator Control Panel status page, via WSOS5 or remotely using a SCADA system.

Limitations

Loop Automation ***cannot*** be turned on if any of the following conditions exist:

- Loop Automation is set to “Not Available” or “Maintenance Required”.
- the Trip or Close Isolate switches are set to isolate
- the switch mechanism has failed
- the switch is in Low Gas Lockout state
- switchgear data is invalid
- battery is abnormal
- trip/close capacitor charging has failed.

The three types of Devices must be in their normal operating state before Loop Automation can be turned on:

- Feeder Device closed
- Mid-Point Device closed
- Tie Device open.

Turning Loop Automation Off

Overview

Loop Automation can be turned off by a deliberate operator action, or automatically as detailed below. When Loop Automation is turned off the protection group selection defaults back to the primary protection group, unless the operator has explicitly changed it to another setting.

User Actions that Turn Off Loop Automation

Loop Automation turns off when:

- an operator manually closes or trips the Device. This can be from any control point, including a local operator, SCADA system or the IOEX inputs
- an operator changes SYSTEM STATUS – OPERATOR SETTINGS: Protection Auto to any other setting
- changes are made to the protection settings in either active or alternate protection groups
- an operator changes any Loop Automation settings
- an operator changes the active protection group.

Other Conditions that Turn Off Loop Automation

Loop Automation turns off when:

- the controller is powered up
- the Device trips to the end of its sequence and Auto-Restore is off
- any of the action conditions detailed in Section 17 that would prevent turning on Loop Automation occur.

After a Fault

Of course the first thing to do is to find and fix the fault. This will usually then be tested by closing one of the Reclosers on either side of the isolated section and seeing if it trips again.

What happens next depends on the Auto-Restore feature of Loop Automation.

Not Using Auto-Restore

In this case the sequence of actions is:

- locate and remove the fault condition
- close one of the open devices to test the faulted section. If the section is now unfaulted then restore the normal network configuration in the usual way, (for example close the other open devices and then open the Tie Device). This can be done either by visiting each Device individually or by using a remote control system (SCADA)
- turn on Loop Automation at each Device when it has been switched to its normal state.

Using Auto-Restore

In this case the sequence of actions is:

- locate and remove the fault condition
- close one of the open devices to test the faulted section. If the section is now unfaulted after the Loop Automation Timeout the other open device will be closed automatically by Auto-Restore

Note Loop Automation will still be ON at these devices.

- turn ON Loop Automation at the switchgear which was closed manually
- check that the Tie Device has been opened automatically by Auto-Restore (if Auto-Restore has been turned on at the Tie) and that supply is present on both sides of the Tie. If the Tie has not opened it may be because the change of load flow was insufficient to trigger the auto-restore. In this case open the Tie manually, check supply is present on both sides and turn Loop Automation back on
- if supply is not present on both sides then there is a network problem that needs to be investigated and fixed.

Analysing What Happened

If the actions of Loop Automation are not as expected, the likely cause is:

- one of the members of the scheme did not have Loop Automation turned on
- the settings were incorrectly coordinated between the different members of the Loop Automation Scheme. In this case recheck the settings method given in Section 11
- there was more than one fault on the network. In this case, protection will operate in one of the devices to isolate the faulted section. Due to the actions of Loop Automation, there should not be any increased outages
- there may have been communications failure if Loop Automation was being used in the Intelligent logic mode.

In all cases, it is suggested to examine the examples in Appendix B to increase your understanding of Loop Automation.

Commissioning

Overview

When Loop Automation is installed and configured it is possible to check its operation in the field on an energised feeder with the use of the Secondary Voltage Injection Interface Set (SVIIS).

Note The Recloser will trip and close as the test progresses.

Feeder Preparation

- A Feeder or Mid-Point Device should be closed at the start of the test and bypassed to prevent customer interruption.
- A Tie Device should be open at the start of the test and it must be acceptable for that Tie Device to close.

Test Sequence

The test sequence is as follows:

- Before bypassing the closed device check its measurement pages to ensure that the power flow is in the expected direction.
- Bypass the device, but leave it connected to the lines so that voltage signals are present. You may find that the device will now detect an Earth fault because the bypass impedance is not perfectly balanced. In this case turn Earth Fault protection off.
- Power down the Control Cubicle and connect the SVIIS between the control cubicle and the device. Set all the input switches on the SVIIS to “Switchgear”.
- Power up the Control Cubicle and check the System Status Live/Dead Display shows all terminals Live.
- Turn the three switches on the SVIIS that correspond to the source side terminals to “Input” – this will cause the controller to think that source supply has been lost. Observe the event log and check that a Source Supply OFF event takes place at the expected time. Then turn the switches back to “Switchgear” and check that a Source Supply ON event takes place. Do the same for the other three switches and check that Load Supply OFF/ON event occur. This check has confirmed that the source and load have been configured correctly.
- Now go to the Loop Automation status page and turn Loop Automation ON. Once again turn the three source side switches on the SVIIS to “Input” – this will cause the controller to think that source supply has been lost. Observe the Loop Automation status display and follow the messages on the screen. Check that the action and timing of Loop Automation is what you expect. In brief: a Feeder Device should Trip, a Tie Device should close and a Mid-Point Device should change protection group and go to Single-Shot for a period.
- Next, turn the switches back to “Switchgear”, this simulates the supply being restored. Observe the Loop Automation status display and follow the messages on the screen. Check that the action and timing of Loop Automation is what you expect. In brief: if auto-restore is ON then a Feeder Device should close and a Tie/Mid-point Device should not change.
- For a closed Tie Device check that the direction of power flow is as expected (it may not be easy to predict the direction of power flow).
- To finish turn off Loop Automation, turn OFF the controller. Remove the SVIIS and put the Devices into the required state. Turn ON the controller and remove any bypasses. Then turn Loop Automation ON.

Appendix A - Loop Automation Operating Rules

In the following tables the Sequence (Seq.) column indicates if the rule is applied during Isolation and Reconfiguration (**I**), or during Auto-Restoration (**R**).

Feeder Device

Rule No.	Switchgear State	Auto-Restore	Event	Action	Seq.
1	Closed	Off	Source Supply lost for longer than Loop Auto Time.	Switchgear opens and Loop Automation is turned off.	I
2	Closed	On	Source Supply lost for longer than Loop Auto Time.	Switchgear opens.	I
3	Closed	Off	Protection trip to Lockout.	Switchgear opens and Loop Automation is turned off.	I
4	Closed	On	Protection trip to end of sequence.	Switchgear opens and Loop Automation stays on.	I
5	Open	On	Source Supply is restored and ACR was initially tripped by Loop Automation.	Switchgear closes.	R
6	Open	On	Supply is restored to both sides of ACR. Either at the source then load or load then source.	Switchgear closes.	R

Table 5. Loop Automation operating rules - Feeder Device.

Mid-Point Device

Rule No.	ACR State	Auto-Restore	Event	Action	Seq.
7	Closed	On or Off	Source Supply lost for longer than Loop Auto Time.	Switch to Protection B.	I
8	Closed	Off	Protection trip to Lockout.	ACR opens and Loop Automation is turned off.	I
9	Closed	On	Protection trip to end of sequence.	ACR opens and Loop Automation stays on.	I
10	Open	On	Supply is restored to both sides of ACR.	Switch to Protection A and close ACR.	R

Table 6. Loop Automation operating rules - Mid-Point Device.

Tie Device

Rule No.	ACR State	Auto-Restore	Restore Both Ways	Event	Action	Seq.
11	Open	On or Off	On or Off	Supply to both sides is lost for longer than Loop Auto Time.	No Action.	I
12	Open	On	On or Off	Supply to load side is lost for longer than Loop Auto Time.	Switchgear closes if alternative supply is present.	I
13	Open	Off	On or Off	Supply to load side is lost for longer than Loop Auto Time.	Switchgear closes if alternative supply is present and turns Loop Automation off.	I
14	Open	On	On	Supply to source side is lost for longer than Loop Auto Time.	Activates Protection Group B and switchgear Closes.	I
15	Open	Off	On	Supply to source side is lost for longer than Loop Auto Time.	Activates Protection Group B, switchgear closes and turns Loop Automation off.	I
16	Open	On or Off	Off	Supply to source side is lost for longer than Loop Auto Time.	No Action.	I
17	Closed	On	On or Off	Protection trip to lockout.	Switchgear opens and Loop Automation is turned off.	I
18	Closed	On	On or Off	Power flow changes by 50% or more for Loop Auto Time.	Switchgear opens. (If supply is subsequently lost to either side then ACR closes and Loop Automation turns off.)	R
19	Closed	On	On or Off	Power flow changes by 50% or more but returns to previous level before Loop Auto Time expires.	Switchgear stays closed and Loop Automation is turned off.	R

Table 7. Loop Automation operating rules - Tie Device.

Appendix B - Network Configuration Examples

Overview

The flexible nature of the Loop Automation scheme allows it to be used in a wide range of network configurations. A number of simple configuration examples have been included to demonstrate how the system will operate in different situations. These examples use different fault scenarios to illustrate the operation of Loop Automation.

In all of the examples, a normally open Tie is located at the end of the Feeder with an alternate source of supply behind it. The alternate supply may be another feeder supplied from the same substation, or it may be from an entirely different substation.

Composition

The first two examples include an existing substation CB. Usually these cannot be programmed into the Loop Automation logic. Under these circumstances, there is a small limitation in the fault isolation sequence because the feeder section between the substation CB and the Feeder Device cannot be back-fed through the Tie Device. This limitation can be overcome by installing a Device fitted with an advanced controller in place of the substation CB.

Arrows shown next to each Device indicate the direction of positive power flow as configured in the advanced controller. This defines the source side and load side of each Device.

The different configurations in the examples in this appendix describe:

- how permanent faults at various points along the feeder are isolated
- how supply may be reconfigured to unfaulted feeder sections
- the restoration sequences for each fault scenario. For each scenario the description first covers the case where Loop Automation Configuration Auto-Restore is ON and then covers the case where Loop Automation Configuration Auto-Restore is turned OFF.

Configuration

In all cases Loop Automation relies on the protection settings of the substation Circuit Breaker (CB) and Loop Automation Devices being coordinated correctly so that the CB or Device closest to the fault trips first.

If this is not the case then Loop Automation will not be able to reconfigure supply to all unfaulted sections of the feeder. A Feeder Device can be used in place of a substation CB. This may permit substantial cost savings in some circumstances.

The Feeder Device is programmed to open when loss of supply is detected from the substation CB. This is necessary in order to prevent the substation being back-fed through the Tie Device from another source of supply. When supply is restored from the substation CB the Feeder Device can be configured to close automatically, restoring the normal configuration.

When loss of supply is detected on both sides of a Tie Device it will not close (to try and reconfigure supply). This is to cater for the case where both the main and alternate sources of supply have failed, e.g. where both supplies are fed from the same substation.

Network Example One – Feeder, Mid-Point and Tie

This example shows a Loop Automation scheme using a Device fitted with an advanced controller for the Feeder, Mid-Point and Tie.

The substation has its own circuit breaker. In the normal state the substation CB, Feeder and Mid-Point Devices are closed and the Tie Device is open with an alternative supply source behind it. The feeder sections are supplied through the substation CB, Feeder and Mid-Point Devices up to the Tie point.

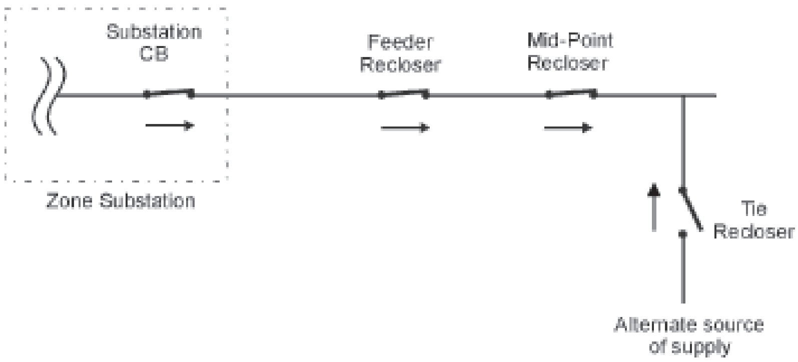


Figure 19. Example one - network configuration.

Default Settings Examples

Each of the fault isolation sequences are shown along with a sequence of events based on the event log.

In order to show the relevant timings between Device event logs, it has been assumed in all the examples that:

- the initial fault occurred at 12:30:00.00 on 01/04/99
- the Supply Timeout is set to 1 second
- the Loop Automation Configuration Loop Auto Time for the Feeder Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Mid-Point Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Tie Device is set to 39 seconds
- protection group A is active in the Mid-Point Device.

Fault Condition Before the Feeder Device

Using the configuration shown at Figure 19 as a starting point, a fault condition occurs on the section of feeder between the substation CB and the Feeder Device.

Device Actions

Step 1

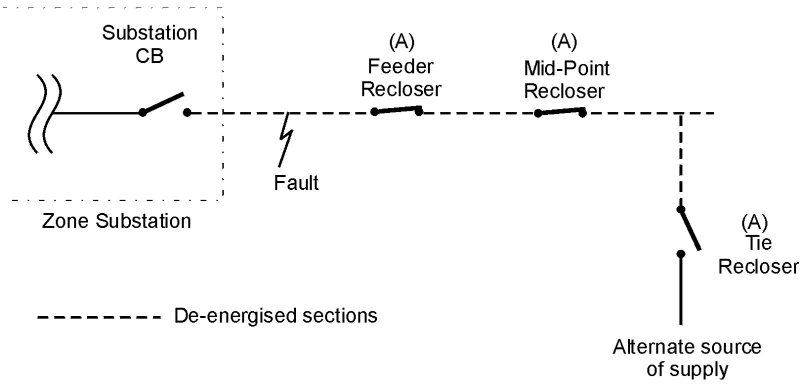


Figure 20. Fault occurs between Feeder Device and Substation CB.

The Substation CB trips to lockout and isolates the fault from the supply source.

Step 2

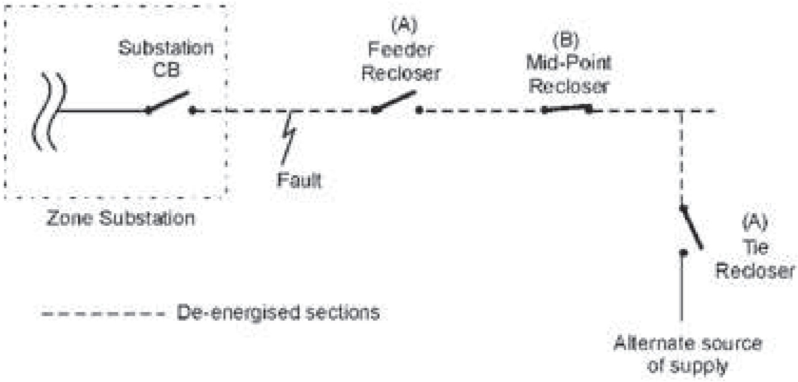


Figure 21. Feeder isolates fault.

30 seconds after the initial fault. The Feeder Device opens to isolate the fault from the alternate source of supply.

The Mid-Point Device changes to protection group "B" in preparation for a change in power flow direction.

Step 3

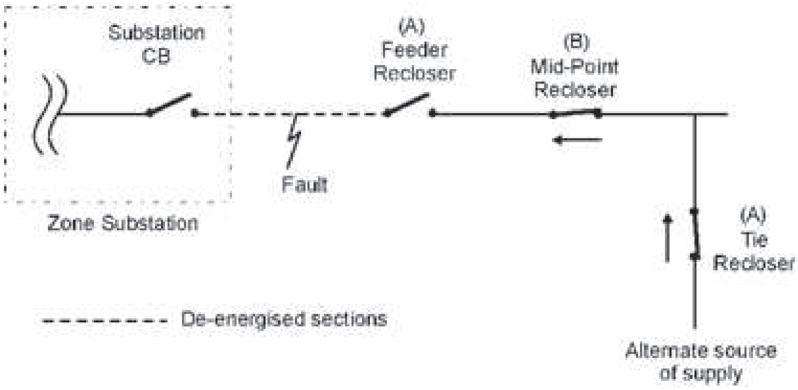


Figure 22. Tie reconfigures supply.

40 seconds after the initial fault the Tie Device closes, restoring supply to the unfaulted sections of the feeder.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
01.00 Source Supply OFF	**01.00 Source Supply OFF**	
01.00 Load Supply OFF	01.00 Load Supply OFF	**01.00 Load Supply OFF**
30.00 Loop Auto Trip Req.	30.00 Prot. Group B Active	
30.00 Loop Auto OFF [1]		
		40.00 Loop Auto Close Req.
		40.00 Loop Auto OFF [1]
	41.10 Source Supply ON	
41.10 Load Supply ON	41.10 Load Supply ON	**41.10 Load Supply ON**
Note 1: if Auto-Restore is OFF		**Note 1: if Auto-Restore is OFF**

Table 8. Sequence of events - fault condition before the Feeder Device.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is set to “ON”:

- linesperson clears fault
- linesperson closes substation CB
- Feeder Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

With the Feeder Device now closed a substantial proportion of the feeder load would be taken up by the Zone Substation. The Tie Device would therefore detect a significant drop in power flow and trip, restoring the normal feeder configuration.

Since Loop Automation remains on in the Tie Device the linesman would not need to travel to the Tie Device to re-arm Loop Automation. If Loop Automation Configuration Auto-Restore is set to “OFF”:

- linesperson clears fault
- if supplies can be connected together, linesman closes substation CB
- linesperson closes Feeder Device and re-arms Loop Automation
- inesperson opens Tie Device and re-arms Loop Automation in the Tie Device.

Fault Between Feeder Device and Mid-Point Device

In this example, a fault occurs on the section of the feeder between the Feeder Device and the Mid-Point Device.

Device Actions

Step 1

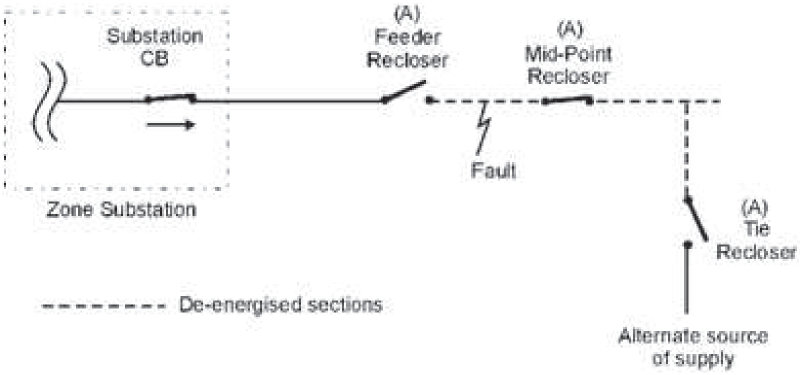


Figure 23. Fault between Feeder and Mid-Point Devices.

The Feeder Device trips to end of sequence to isolate the fault from the supply source.

Step 2

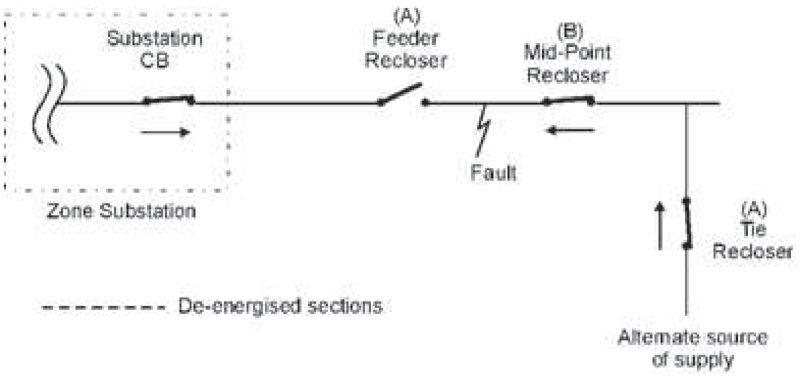


Figure 24. Tie Device closes.

30 seconds after the initial fault the Mid-Point Device changes to protection group 'B' in preparation for a change in power flow direction. 40 seconds after the initial fault the Tie Device closes to reconfigure supply to the feeder.

Step 3

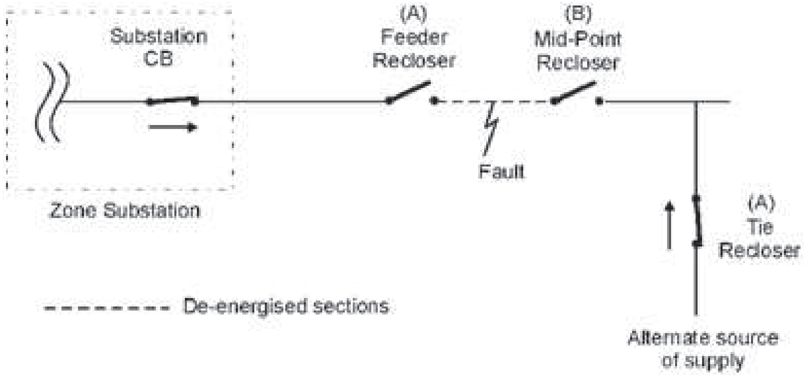


Figure 25. Mid-Point Device trips to isolate fault.

The fault has not been cleared and the Mid-point Device trips to lockout to isolate the faulted feeder section.

No Reclose operation takes place.

Supply is reconfigured to all the unfaulted sections of the feeder.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
00.00 Pickup 00.50 Prot. Group A Active 00.50 Phase Prot. Trip 00.50 Prot. Trip 1 00.60 B Max. 1200 AMP 01.00 Automatic Reclose 01.10 Pickup 01.60 Prot. Group A Active 01.60 Phase Prot. Trip 01.60 Prot. Trip 2 01.70 B Max. 1200 AMP 01.70 Lockout [1] 01.70 End of Sequence [2] 02.70 Load Supply OFF	 **02.70 Source Supply OFF** 02.70 Load Supply OFF 31.60 Prot. Group B Active 41.70 Pickup 42.20 Prot. Group B Active 42.20 Phase Prot. Trip 42.20 Single-Shot 42.40 B Max. 1050 AMP 42.40 Lockout [1] 42.40 End of Sequence [2] 43.20 Load Supply ON	 **02.70 Load Supply OFF** 41.60 Loop Auto Close Req. 41.60 Loop Auto OFF [1] 41.70 Pickup 42.40 B Max. 1050 AMP **42.70 Load Supply ON**
Note 1: if Auto-Restore is OFF Note 2: if Auto-Restore is ON	**Note 1: if Auto-Restore is OFF** **Note 2: if Auto-Restore is ON**	**Note 1: if Auto-Restore is OFF**

Table 9. Sequence of events - fault between Feeder Device and Mid-Point Device.

Restoration Scenarios

When Loop Automation Configuration Auto-Restore is turned ON:

- linesperson clears fault.
- linesperson closes Feeder Device and re-arms Loop Automation
- Mid-point Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

When Loop Automation Configuration Auto-Restore is turned OFF:

- linesperson clears fault
- linesperson closes Feeder Device and re-arms Loop Automation
- linesperson closes Mid-Point Device and re-arms Loop Automation
- linesperson opens Tie Device and re-arms Loop Automation in the Tie Device.

Warning

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before closing the Feeder Device.

Fault Beyond Mid-Point Device

In this example a fault occurs on the section of feeder between the Mid-Point and Tie Device.

Device Actions

Step 1

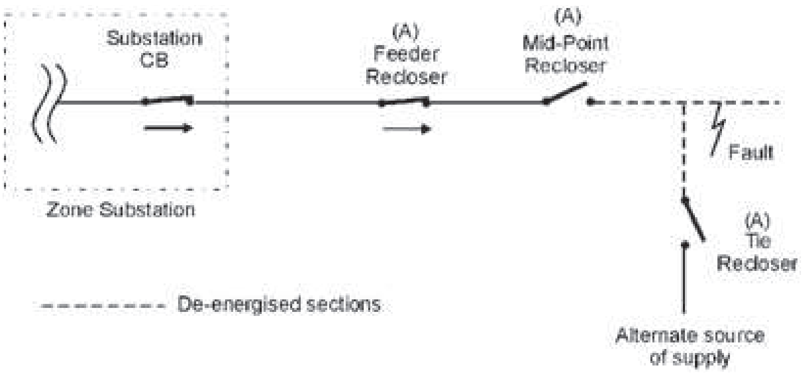


Figure 26. Fault occurs beyond Mid-Point Device.

The Mid-Point Device trips to end of sequence in order to isolate the fault from the supply source.

Step 2

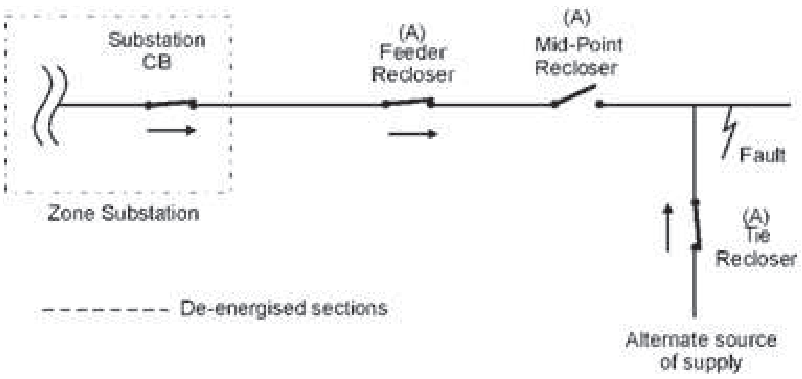


Figure 27. Tie Device closes onto the faulted section.

The Tie Device closes to reconfigure supply to the feeder 40 seconds after the initial fault.

Step 3

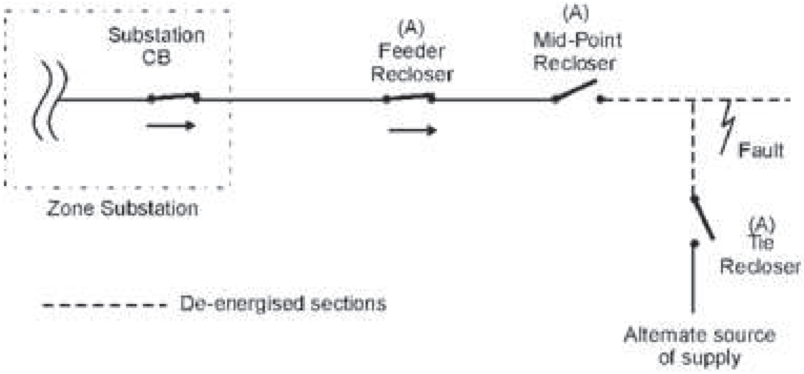


Figure 28. Tie Device trips and locks out.

The Tie Device immediately trips and locks out because the fault has not been cleared.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
00.00 Pickup	00.00 Pickup	
	00.50 Prot. Group A Active	
	00.50 Phase Prot. Trip	
	00.50 Prot. Trip 1	
00.60 B Max. 900 AMP	00.60 B Max. 900 Amp	
	01.00 Automatic Reclose	
01.10 Pickup	01.10 Pickup	
	01.60 Prot. Group A Active	
	01.60 Phase Prot. Trip	
	01.60 Prot. Trip 2	
	01.70 End of Sequence[1]	
	01.70 Lockout[2]	
01.70 B Max. 900 AMP	01.70 B Max. 900 AMP	
	02.60 Load Supply OFF	02.60 Load Supply OFF
		41.60 Loop Auto Close Req.
		41.60 Loop Auto OFF
		41.70 Pickup
		41.90 Prot. Group A Active
		41.90 Phase Prot. Trip
		41.90 Prot. Trip 1
		41.90 Lockout
		41.90 Loop Auto OFF[2]
		42.00 B Max. 850 AMP
	Note 1: if Auto-Restore is ON	**Note 1: if Auto-Restore is OFF**
	Note 2: if Auto-Restore is OFF	Note 2: if Auto-Restore is ON

Table 10. Sequence of events - fault beyond Mid-Point Device.

Restoration Scenarios

Restoration is the same whether {Loop Automation Configuration: Auto-Restore} is ON or OFF.

- Linesperson clears fault.
- Linesperson closes Mid-Point Device and re-arms Loop Automation .
- Linesperson re-arms Loop Automation in the Tie Device.

Loss of Zone Substation Supply

In this example the substation loses its supply.

Device Actions

Step 1

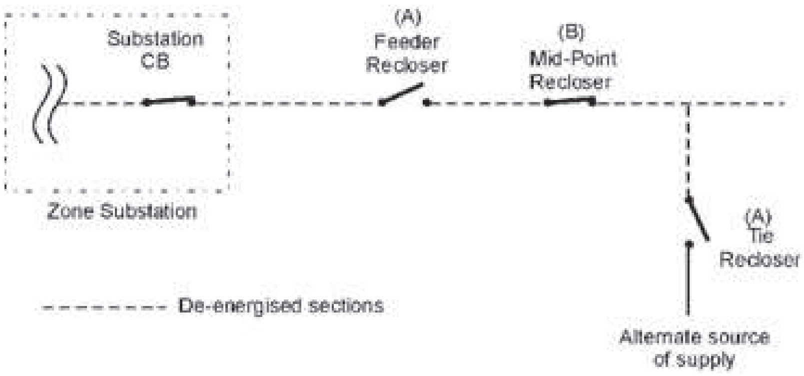


Figure 29. Loss of supply.

1 to 30 seconds after the zone substation supply is lost:

- the Feeder Device opens in order to isolate the substation from the alternate source of supply.
- the Mid-Point Device changes to protection group B in preparation for a change in power flow direction.

Step 2

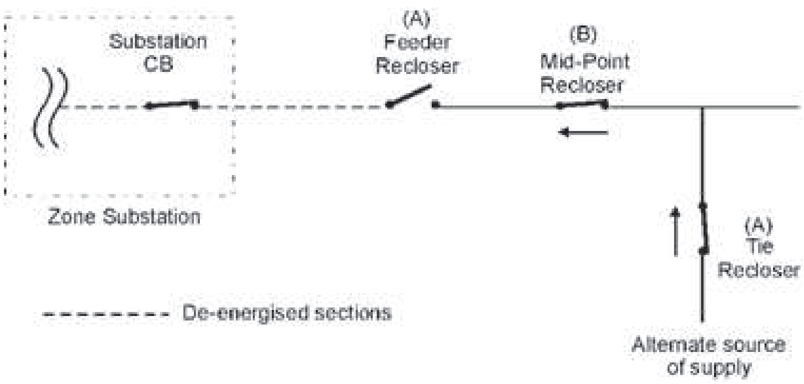


Figure 30. Tie Device reconfigures supply.

The Tie Device closes 40 seconds after losing supply on its load side.

Supply is reconfigured to the Feeder Device from the alternate source.

At the end of the sequence supply is reconfigured to all sections of the feeder except for the section between the substation CB and Feeder Device.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
01.00 Source Supply OFF	01.00 Source Supply OFF	01.00 Load Supply OFF
01.00 Load Supply OFF	01.00 Load Supply OFF	
30.00 Loop Auto Trip Req.	30.00 Prot. Group B Active	
		40.00 Loop Auto Close Req.
		40.00 Loop Auto OFF[1]
	41.00 Source Supply ON	
41.00 Load Supply ON	41.00 Load Supply ON	**41.00 Load Supply ON**
		Note 1: if Auto-Restore is OFF

Table 11. Sequence of events - loss of Zone Substation supply.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned “ON”:

- linesperson restores supply to the substation
- the Feeder Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

If Loop Automation Configuration Auto-Restore is turned “OFF”:

- linesperson restores supply to the substation
- linesperson closes Feeder Device and re-arms Loop Automation
- linesperson opens the Tie Device and re-arms Loop Automation.

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before restoring the substation supply.

Network Example Two – Substation CB, Feeder and Tie Devices

The second example is similar to the first, except there is no Mid-Point Device in the network. In its normal state, both the substation CB and Feeder Device are closed and the Tie Device is open with an alternate source of supply behind it.

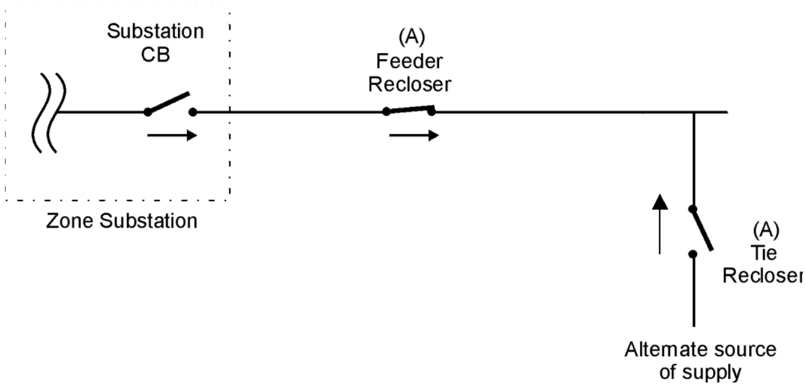


Figure 31. Example two - network configuration.

Examples of Default Settings

Each of the fault isolation sequences are shown along with a sequence of events based on the event log.

In order to show the relevant timings between Device event logs, it has been assumed in all the examples that:

- the initial fault occurred at 12:30:00.00 on 01/04/99
- the Supply Timeout is set to 1 second
- the Loop Automation Configuration Loop Auto Time for the Feeder Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Tie Device is set to 39 seconds.

Fault Before Feeder Device

The following example shows Loop Automation operating when a fault occurs on the section of feeder between the substaion CB and the Feeder Device.

Device Actions

Step 1

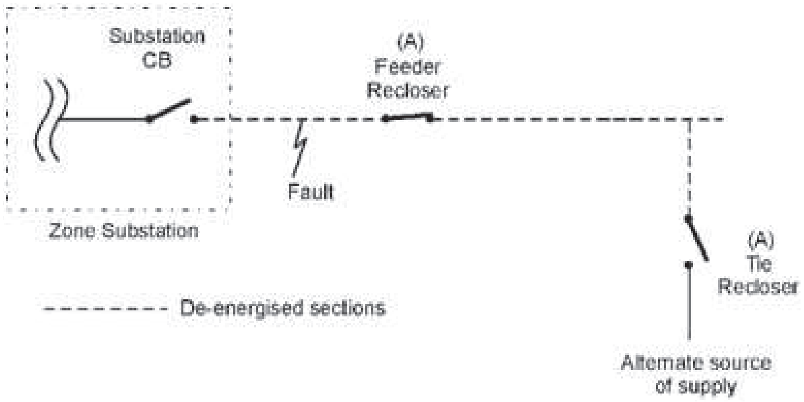


Figure 32. Fault occurs before Feeder Device.

Substation CB trips to lockout to isolate the fault from the source of supply.

Step 2

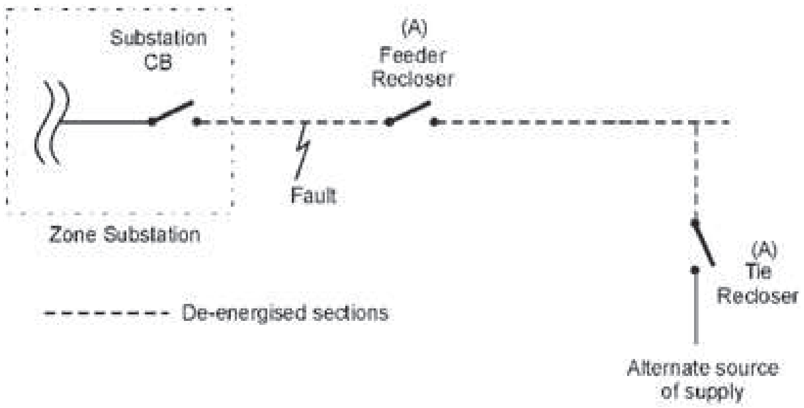


Figure 33. Feeder Device isolates the fault.

The Feeder Device opens 30 seconds after the initial fault isolating the fault from the alternate source of supply.

Step 3

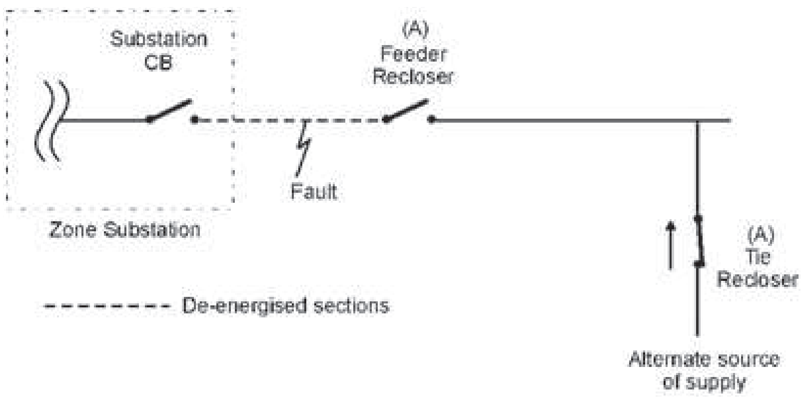


Figure 34. Supply is reconfigured.

Supply is reconfigured to the unfaulted sections of the feeder by the Tie Device 40 seconds after the initial fault. At the end of the sequence supply is reconfigured to the unfaulted sections of the feeder.

Sequence of Events

Feeder Device	Tie Device
01.00 Source Supply OFF	01.00 Load Supply OFF
01.00 Load Supply OFF	
30.00 Loop Auto Trip Req.	
	40.00 Loop Auto Close Req.
	40.00 Loop Auto OFF[1]
41.10 Load Supply ON	41.10 Load Supply ON
	Note 1: if Auto-Restore is OFF

Table 12. Sequence of events - fault before Feeder Device.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned "ON":

- linesperson clears fault
- linesperson closes substation CB
- Feeder Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

If Loop Automation Configuration Auto-Restore is turned "OFF":

- linesperson clears fault
- linesperson closes substation CB
- linesperson closes Feeder Device and re-arms Loop Automation
- linesperson opens Tie Device and re-arms Loop Automation.

Warning

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before closing the Substation Circuit Breaker.

Fault Between Feeder and Tie Device

In this example a fault occurs between the Feeder and Tie Devices.

Device Actions

Step 1

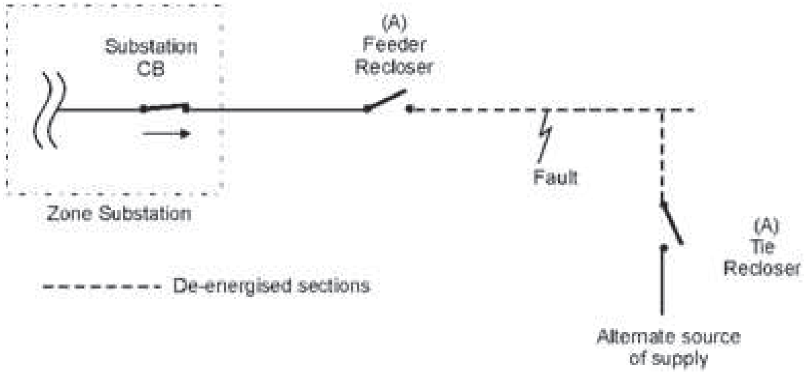


Figure 35. Fault between the Feeder and Tie Devices.

The Feeder Device trips to end of sequence and isolates the fault from the normal supply source.

Step 2

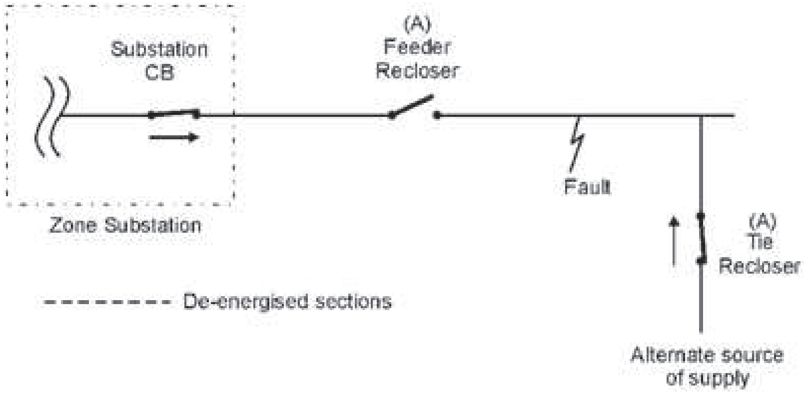


Figure 36. Tie Device attempts to reconfigure the supply.

The Tie Device closes 40 seconds after the initial fault to reconfigure supply to the feeder.

Step 3

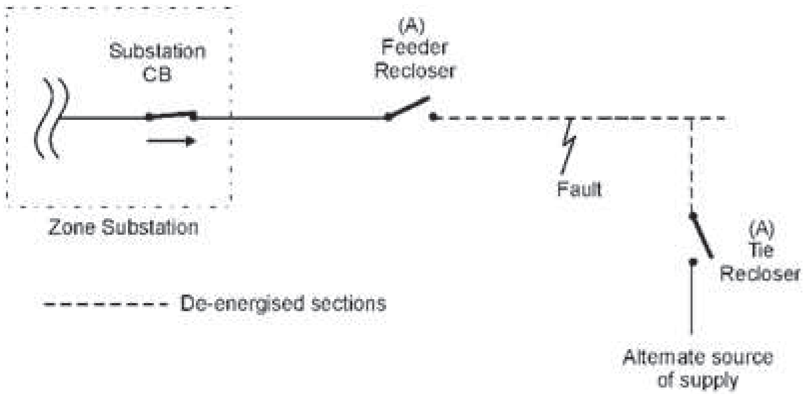


Figure 37. Tie Device trips and supply is not reconfigured.

The Tie Device trips and locks out because the fault has not been cleared.

Sequence of Events

Feeder Device	Tie Device
Pickup	02.70 Load Supply OFF
00.50 Prot. Group A Active	
00.50 Phase Prot. Trip	
00.50 Prot. Trip 1	
00.60 B Max. 1100 AMP	
01.00 Automatic Reclose	
01.10 Pickup	
01.60 Prot. Group A Active	
01.60 Phase Prot. Trip	
01.60 Prot. Trip 2	
01.70 B Max. 1100 AMP	
01.70 End of Sequence	
01.70 Lockout[1]	
02.70 Load Supply OFF[2]	41.60 Loop Auto Close Req.
	41.60 Loop Auto OFF[1]
	41.70 Pickup
	41.90 Prot. Group A Active
	41.90 Phase Prot. Trip
	41.90 Prot. Trip 1
	41.90 Lockout
	41.90 Loop Auto OFF[2]
	42.00 B Max. 850 AMP
Note 1: if Auto-Restore is ON	Note 1: if Auto-Restore is OFF
Note 2: if Auto-Restore is OFF	Note 2: if Auto-Restore is ON

Table 13. Sequence of events - fault between Feeder and Tie Device.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned “ON” or “OFF”:

- linesperson clears fault
- linesperson closes Feeder Device and re-arms Loop Automation
- linesperson re-arms Loop Automation in the Tie Device.

Network Example Three – Feeder, Mid-Point and Tie Devices

In this configuration, the substation CB has been replaced with a Device fitted with an advanced controller. This allows the user to backfeed the alternate source of supply right back to the substation Device if the substation loses supply. In normal operation, the Feeder and Mid-Point Devices are normally closed and the Tie Device is open with an alternate source of supply behind it.

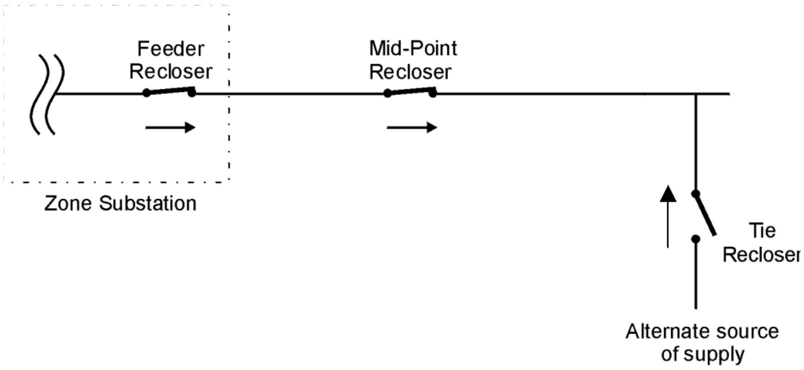


Figure 38. Example three - network configuration.

Default Settings for Examples

Each of the fault isolation sequences are shown along with a sequence of events based on the event log.

In order to show the relevant timings between Device event logs, it has been assumed in all the examples that:

- the initial fault occurred at 12:30:00.00 on 01/04/99
- the Supply Timeout is set to 1 second
- the Loop Automation Configuration Loop Auto Time for the Feeder Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Mid-Point Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Tie Device is set to 39 seconds
- protection group A is active in the Mid-Point Device.

Fault Between Feeder and Mid-Point Device

In this example a fault occurs between the Feeder and Mid-Point Devices.

Device Actions

Step 1

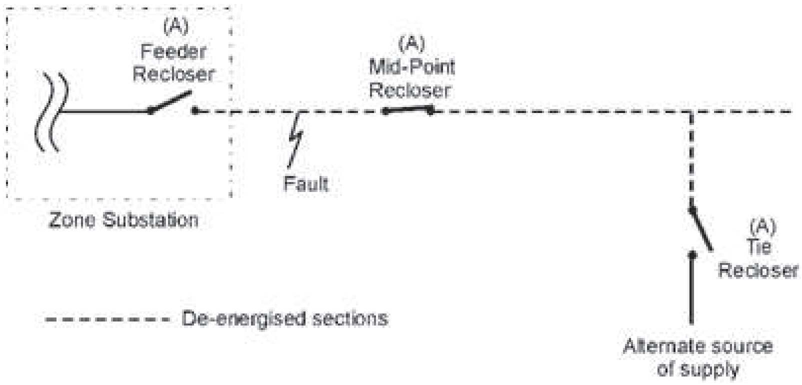


Figure 39. Fault occurs before the Mid-Point Device.

Fault is isolated from the normal source of supply when the Feeder Device trips to end of sequence.

Step 2

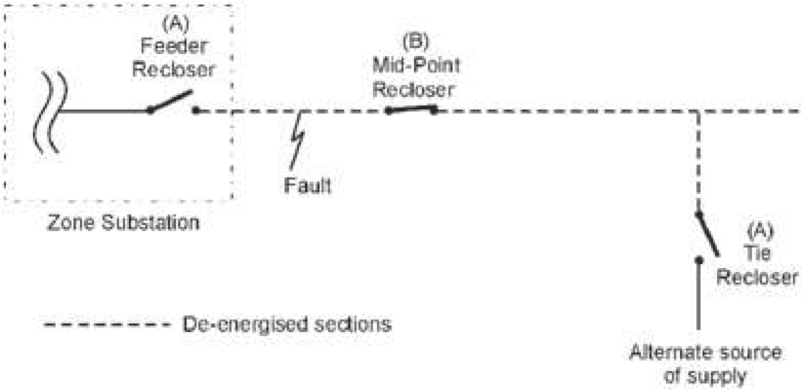


Figure 40. Mid-Point Device changes to protection group alternate source of supply.

The Mid-Point Device changes to protection group “B” 30 seconds after the initial fault to allow for the correct protection grading when the power direction changes.

Step 3

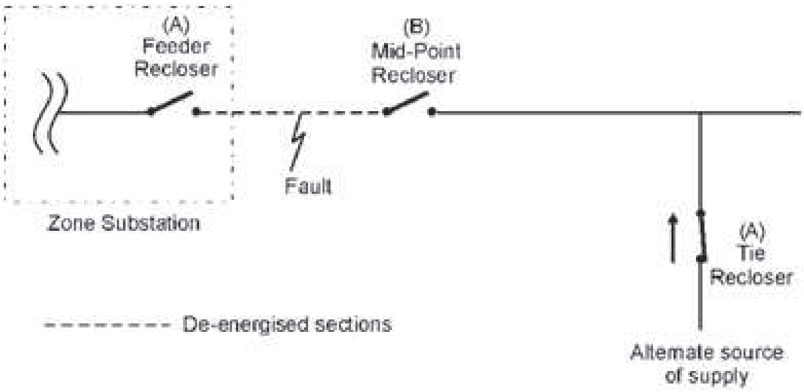


Figure 41. Tie Device reconfigures supply.

The Tie Device closes onto the fault 40 seconds after the initial fault.

The Mid-Point Device trips before the Tie Device, isolating the fault.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
00.00 Pickup		
00.50 Prot. Group A Active		
00.50 Phase Prot. Trip		
00.50 Prot. Trip 1		
00.60 B Max. 960 AMP		
01.00 Automatic Reclose		
01.10 Pickup		
01.60 Prot. Group A Active		
01.60 Phase Prot. Trip		
01.60 Prot.Trip 2		
01.70 B Max. 960 AMP		
01.70 End Of Sequence[1]		
01.70 Lockout[2]		
02.70 Load Supply OFF	02.70 Source Supply OFF	02.70 Load Supply OFF
	02.70 Load Supply OFF	
	31.60 Prot. Group B Active	
		41.60 Loop Auto Close Req.
		41.60 Loop Auto OFF[1]
		41.70 Pickup
	41.70 Pickup	
	42.20 Prot. Group B Active	
	42.20 Phase Prot. Trip	
	42.20 Prot. Trip 1	
	42.40 B Max. 730 AMP	**42.40 B Max. 730 AMP**
	42.40 End of Sequence[1]	
	42.40 Lockout[2]	
	42.70 Load Supply ON	
Note 1: if Auto-Restore is ON **Note 2: if Auto-Restore is OFF**	**Note 1: if Auto-Restore is ON** **Note 2: if Auto-Restore is OFF**	**Note 1: if Auto-Restore is OFF**

Table 14. Sequence of events - fault between Feeder and Mid-Point Device.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned "ON":

- linesperson clears fault
- linesperson closes Feeder Device at zone substation and re-arms Loop Automation
- Mid-point Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

If Loop Automation Configuration Auto-Restore is "OFF":

- linesperson clears fault
- linesperson closes Feeder Device at the zone substation and re-arms Loop Automation
- linesperson closes Mid-Point Device and re-arms Loop Automation
- linesperson opens Tie Device and re-arms Loop Automation in the Device.

Warning

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before closing the Feeder Device.

Fault Between Mid-Point and Tie Device

In this example a fault occurs between the Feeder and Mid-Point Devices.

Device Actions

Step 1

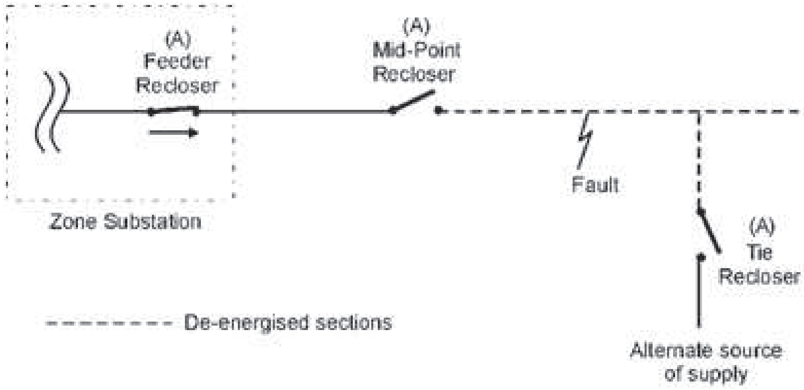


Figure 42. Fault occurs beyond the Mid-Point Device.

The fault is isolated from the normal supply by the Mid-Point Device tripping to end of sequence.

Step 2

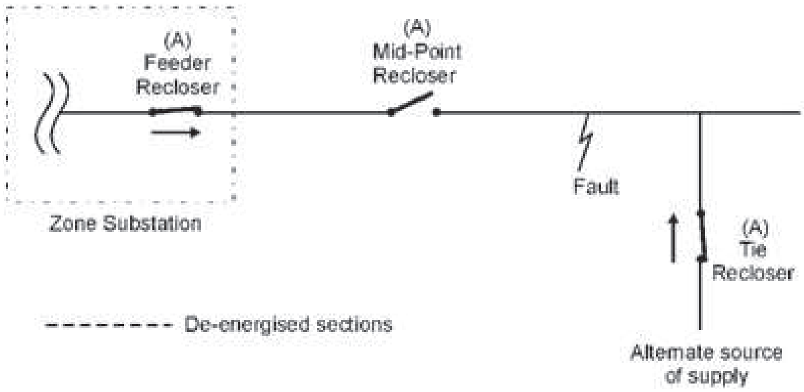


Figure 43. Tie Device attempts to reconfigure the supply.

Supply is reconfigured 40 seconds after the initial fault when the Tie Device closes.

Step 3

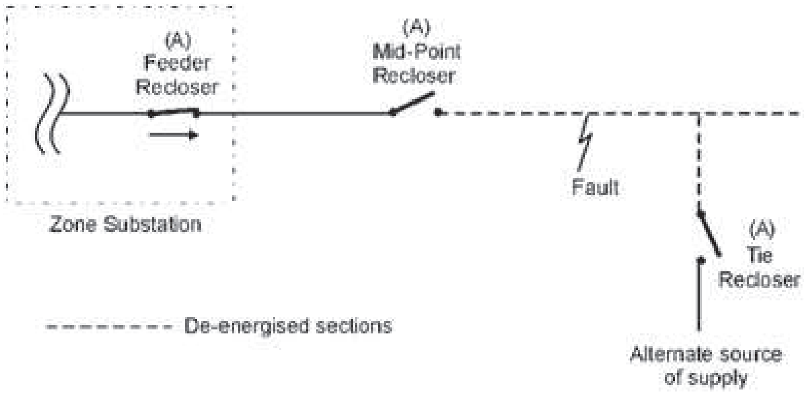


Figure 44. Tie Device trips.

The Tie Device trips and locks out because the fault has still not cleared.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
00.00 Pickup	00.00 Pickup	
	00.50 Prot. Group A Active	
	00.50 Phase Prot. Trip	
	00.50 Prot. Trip 1	
00.60 B Max. 960 AMP	00.60 B Max. 730 AMP	
	01.00 Automatic Reclose	
01.10 Pickup	01.10 Pickup	
	01.60 Prot. Group A Active	
	01.60 Phase Prot. Trip	
	01.60 Prot. Trip 2	
	01.70 End of Sequence[1]	
	01.70 Lockout[2]	
01.70 B Max. 960 AMP	01 .70 B Max. 900 AMP	
	02.70 Load Supply OFF	02.70 Load Supply OFF
		41.60 Loop Auto Close Req.
		41.60 Loop Auto OFF[1]
		41.70 Pickup
		41.90 Prot. Group A Active
		41.90 Phase Prot. Trip
		41.90 Single-Shot
		41.90 Lockout
		41.90 Loop Auto OFF[2]
		42.00 B Max. 730 AMP
	Note 1: if Auto-Restore is ON **Note 2: if Auto-Restore is OFF**	**Note 1: if Auto-Restore is OFF** **Note 2: if Auto-Restore is ON**

Table 15. Sequence of events - fault between Mid-Point and Tie Device.

Restoration Scenarios

Restoration is the same whether Loop Automation Configuration Auto-Restore is turned “ON” or “OFF”:

- linesperson clears fault
- linesperson closes the Mid-Point Device and re-arms Loop Automation
- linesperson re-arms Loop Automation in the Tie Device.

Loss of Zone Substation Supply

In this example the substation itself loses supply.

Device Actions

Step 1

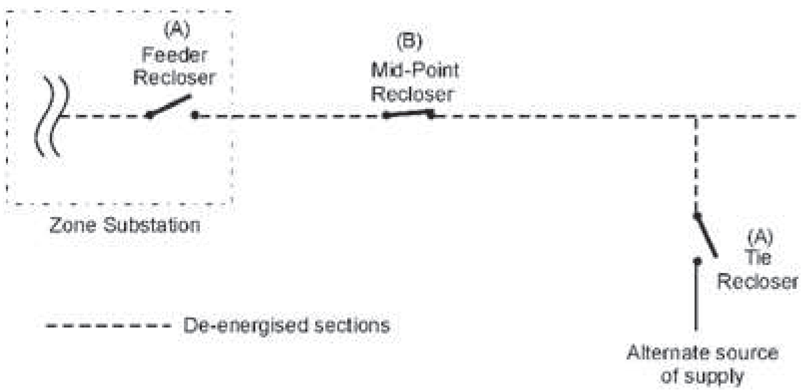


Figure 45. Loss of Zone Substation supply.

30 seconds after the zone substation loses its supply:

The Mid-Point Device changes to protection group “B” to provide correct grading when the power flow changes direction.

The Feeder Device opens to isolate the substation from the alternate supply source.

Step 2

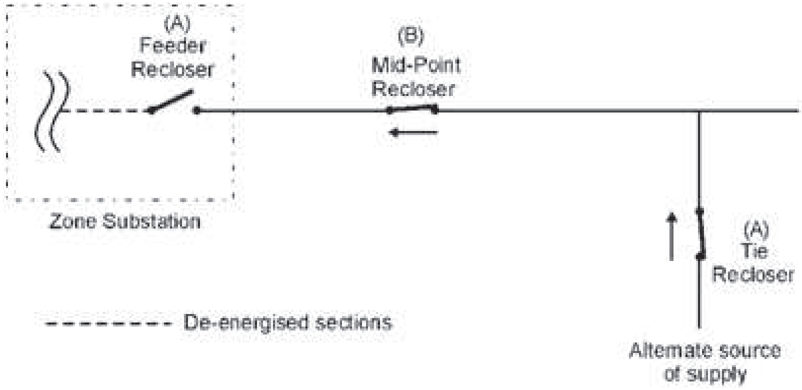


Figure 46. Tie Device reconfigures the supply.

The Tie Device closes 40 seconds after the initial fault restoring the supply to the feeder.

Supply is reconfigured to all sections of the feeder.

Sequence of Events

Feeder Device	Mid-Point Device	Tie Device
01.00 Source Supply OFF 01.00 Load Supply OFF 30.00 Loop Auto Trip Req. 41.00 Load Supply ON	01.00 Pickup 01.00 Load Supply OFF 30.00 Prot. Group B Active 41.00 Source Supply ON 41.00 Load Supply ON	**01.00 Load Supply OFF** 40.00 Loop Auto Close Req. 40.00 Loop Auto OFF[1] 41.00 Load Supply ON
		Note 1: If Auto-Restore is OFF

Table 16. Sequence of events - loss of Zone Substation supply.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned “ON”:

- linesman restores supply to the zone substation
- the Feeder Device senses the restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

If Loop Automation Configuration Auto-Restore is turned “OFF”:

- linesman restores supply to the zone substation
- linesman closes the Feeder Device and re-arms Loop Automation
- linesman opens the Tie Device and re-arms Loop Automation in the Tie Device.

Warning

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before closing the Feeder Device.

Network Example Four — Auto-Changeover

In this example, Loop Automation provides a secure supply to a critical load (e.g. Hospital). In the normal configuration the Feeder Device is closed and the Tie Device is open with an alternate source of supply behind it.

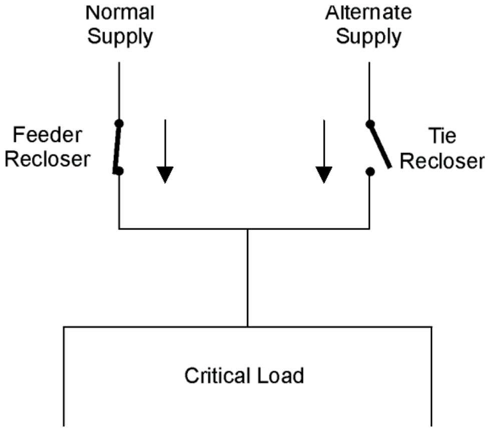


Figure 47. Example four - network configuration.

Default Settings

Each of the fault isolation sequences are shown along with a sequence of events based on the event log.

To show the relevant timings between Device event logs it has been assumed in the example that:

- the initial fault occurred at 12:30:00.00 on 01/04/99
- the Supply Timeout is set to 1 second
- the Loop Automation Configuration Loop Auto Time for the Feeder Device is set to 29 seconds
- the Loop Automation Configuration Loop Auto Time for the Tie Device is set to 39 seconds.

The following example shows Loop Automation operating when the Feeder Device loses supply.

Device Actions

Step 1

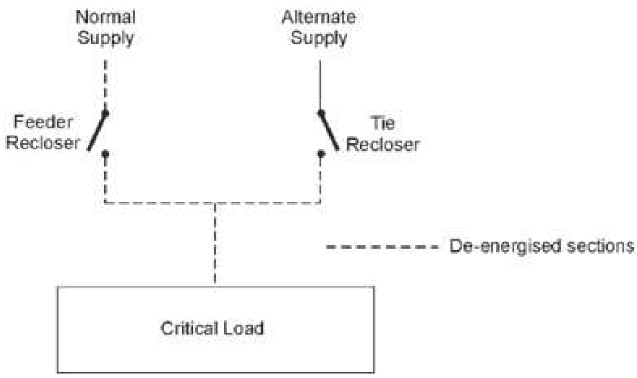


Figure 48. Feeder Device isolates the fault.

The Feeder Device opens 30 seconds after the supply is lost, isolating the preferred supply from the alternate source of supply.

Step 2

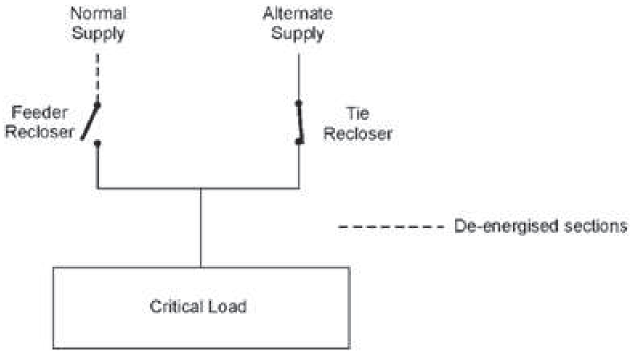


Figure 49. Supply is reconfigured.

Supply is reconfigured to the critical load by the Tie Device 40 seconds after the initial fault.

Sequence of Events

Feeder Device	Tie Device
01.00 Source Supply OFF 01.00 Load Supply OFF 30.00 Loop Auto Trip Req. 41.00 Load Supply ON	**01.00 Load Supply OFF** 40.00 Loop Auto Close Req. 40.00 Loop Auto OFF[1] 41.00 Load Supply ON
	Note 1: if Auto-Restore is OFF

Table 17. Sequence of events - Auto-Changeover.

Restoration Scenarios

If Loop Automation Configuration Auto-Restore is turned “ON”:

- linesperson restores supply to Feeder Device
- Feeder Device senses restoration of supply and closes automatically
- Tie Device senses the change in power flow and opens.

If Loop Automation Configuration: Auto-Restore is turned “OFF”:

- linesperson restores supply to Feeder Device
- linesperson closes Feeder Device and re-arms Loop Automation
- linesperson opens Tie Device and re-arms Loop Automation.

Where the alternate supplies cannot be connected together the linesperson must open the Tie Device before closing the Feeder Device.

Appendix C - Settings Record

The following template shows the range of information required when preparing a network for Loop Automation configuration. The template may be modified as required to suit individual requirements.

<table>
<tr><th colspan="10">Loop Automation SETTING SHEET</th></tr>
<tr><td colspan="7">GLOBAL PARAMETERS</td><td colspan="3">Loop Automation TIME</td></tr>
<tr><td colspan="3">Live Terminal Voltage</td><td></td><td colspan="2">Supply Timeout

(ST)</td><td></td><td colspan="3" rowspan="2">Feeder and Mid-Point Devices:

LA Time = T1 + T2

= ....</td></tr>
<tr><td colspan="3">Co-ordination time
(T1)</td><td></td><td colspan="2">Single-Shot Reset Time

(2 x T1)</td><td></td></tr>
<tr><td colspan="3">Max. Sequence Time
(T2)</td><td></td><td colspan="2">Live Load Blocking</td><td></td><td colspan="3" rowspan="2">Tie Device:

LA Time = 2 (T1 + T2)

= ....</td></tr>
<tr><td colspan="3">Auto-changeover
(T1 + T2)</td><td></td><td colspan="2">Loop Automation</td><td></td></tr>
<tr><td>DEV NO:</td><td>TYPE</td><td>SERIES</td><td>SER NO:</td><td>LOCATION</td><td>DIRECTION</td><td>LA TIME (sec.)</td><td>Auto-Restore AVAILABLE</td><td>AUTO-RESTORE ON - OFF</td><td>TIE RESTORE ONE / TWO WAY</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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</table>

Table 18. Loop Automation setting sheet.

Appendix D - Example Settings Record

The following record shows the range of information recorded whilst preparing a network for Loop Automation configuration.

Loop Automation SETTING SHEET

GLOBAL PARAMETERS				Loop Automation TIME
Live Terminal Voltage	2000V	Supply Timeout (ST)	10 sec.	Feeder and Mid-Point Devices: LA Time = T1 + T2 = 40 seconds
Co-ordination Time (T1)	10 sec.	Single-Shot Reset Time (2 x T1)	20 sec.	
Max. Sequence Time (T2)	30 sec.	Live Load Blocking	OFF	Tie Device: LA Time = (2 x T1) + T2 = 50 seconds
Auto-changeover (T1 + T2)	40 sec.	Loop Automation	Availa ble	

DEV NO:	TYPE	SERIES	SER NO:	LOCATION	DIRECTION	LA TIME (sec.)	AUTO-RESTORE AVAILABLE	Auto-Restore ON - OFF	TIE RESTORE ONE / TWO WAY
1	Feeder	N	ACR 7077	Whites Rd	Source 1	40	Available	ON	N/A
2	Mid-Point	U	ACR 7092	Lytton Rd Nth	Source 1	40	Not Available	N/A	N/A
3	Mid-Point	U	ACR 6999	Lytton Rd West	Source 2	50	Not Available	N/A	N/A
4	Tie	N	ACR 7078	Fisherman Island	Source 2	40	Not Available	N/A	BOTH
5	Feeder	N	ACR 7091	Hemnant substation	Source 2	40	Available	ON	N/A

Table 19. Loop Automation setting sheet example.

Note The information included within this example has no relevance to an existing network and is included for example purposes only.

Appendix E - Loop Automation Status List

Loop automation normal
Loop auto turned off by operator action. Must be on for automatic operation
Mechanism fail or swgear data invalid
Gas press low
Gas press invalid
Cap charge fail or battery abnormal
Loss of phase trip Will close when load supply restored/will close when source supply restored/operator restoration required/loop automation turned off
Protection trip - will close when Both source and load supplies come on
Protection trip/sectionaliser trip Operator restoration required/loop automation turned off
Worktag applied
Loop auto on request denied Trip/close circuit disconnected/mechanism fail or switchgear data invalid/cap charge fail or battery abnormal/gas low inhibit/invalid VT configuration/switch must be open/switch must be closed/currently not available/worktag applied
Currently not available
Source side now dead - timing out Will trip to isolate source/will change to protection group '#'/protection group '#' now active/will close to restore source supply/detected allow DT. Will close to restore
Tripped on loss of source supply Will close when source supply restored
Tripped on loss of source supply
Source and load now live - timing out Will close to restore normal state
Source side now live - timing out Will close to restore normal state/will close to restore load supply
Loss of phase trip Will close when source supply restored/will close when load supply restored/loop automation turned off
Lost source supply - PROT GRP '#' active Loop automation turned off
Load side now live - timing out Will close to restore normal state
Load side now dead - timing out Will close to restore load supply/detected allow DT. Will close to restore
Load side now dead Measuring dead time
Source side now dead Measuring dead time

Source and load sides dead
Closed to restore load supply
LA time expired - allow DT not detected Loop automation turned off
Loop automation normal Detected allow dead time
Closed to restore source supply
LA time expired - allow DT not detected Loop automation turned off
Normal FDR config. detected - timing out Will trip to restore normal FDR config.
Supply lost - loop auto turned off
Auto-restore unsuccessful
Unable to trip/close
Downstream operation failure Operator restoration required
Upstream lockout Operator restoration required
Communication error Operator restoration required
Loop automation close inhibited Loop automation turned off

Table 20. List of LA status display messages.

Appendix F – Intelligent Loop Automation Events

Each event has the following format:

Time_____________________Source_____________Group:Qualifier____________Event___________

Time is expressed as dd/mm/yy/ hh:mm:ss.ms with (dd: day, mm: month, yy: year, hh: hour, mm: minute, ss:second, ms: millisecond).

Group is a letter within [A...J] and specifies the active protection group.

Event	Source(s)	Group	Qualifier	Description
Logic Classic Logic Intelligent	User	No	Loop Automation	Logged when the Loop Automation logic is changed.
Tie Control Timer Tie Control Message	User	No	Loop Automation	Logged when the Tie Control mode is changed.
Downstream Device IP xxx.xxx.xxx.xxx	User	No	Loop Automation	Logged when the IP address of the downstream controller is modified.
Downstream Device TCP Port #	User	No	Loop Automation	Logged when the TCP port of the downstream controller is modified.
Downstream Device Type Tie Downstream Device Type Mid-Point	User	No	Loop Automation	Logged when the loop automation type of the downstream controller is modified.
Downstream Function Load Break Switch Downstream Function ACR	User	No	Loop Automation	Logged when the function of the downstream switchgear is modified.
Tie Device IP xxx.xxx.xxx.xxx	User	No	Loop Automation	Logged when the IP address of the Tie controller is modified.
Tie Device TCP Port #	User	No	Loop Automation	Logged when the TCP port of the Tie controller is modified.
Listening TCP Port #	User	No	Loop Automation	Logged when the listening TCP port of the controller is modified.
Downstream Communications normal		No	Loop Automation	Logged when the communication to downstream is normal
Downstream Communications failed		No	Loop Automation	Logged when the communication to downstream has failed
Tie Communications normal		No	Loop Automation	Logged when the communication to Tie is normal
Tie Communications failed		No	Loop Automation	Logged when the communication to Tie has failed
Message Attempts #	User	No	Loop Automation	Logged when the communication attempts count is changed
Message Timeout # seconds	User	No	Loop Automation	Logged when the communication timeout period is changed
Upstream Trip Request		No	Loop Automation	Logged when trip request message is received by a Mid-Point from an upstream Device
Upstream Close Request		No	Loop Automation	Logged when close request message is received by a Tie from an upstream Device
Upstream Close Inhibit Request		No	Loop Automation	Logged when close inhibit request message is received from an upstream Device by a Tie
Downstream Failed to Operate		No	Loop Automation	Logged by upstream Device when an downstream upstream Device fails to trip as requested
Send Tie Close Inhibit Request		No	Loop Automation	Logged by feeder or Mid-Point when it sends the close inhibit message to the Tie
Send Tie Close Request		No	Loop Automation	Logged by feeder or Mid-Point when it sends the close message to the Tie
Send Downstream Trip Request		No	Loop Automation	Logged by feeder or Mid-Point when it sends the trip message to the downstream Mid-Point Device
Request Acknowledged		No	Loop Automation	Logged when downstream Device received and acknowledged a message

Table 21. Intelligent Loop Automation Events.

Appendix G – Database Points

Digital Inputs

A.1.4 Distributed Automation Flags

Description	Mnemonic	Time Resolution	Default DNP Class	ACR	LBS	IOEX	Panel	Protocol	W-Series	CLT
Loop Automation ON This shows whether the Loop Automation facility is turned on or off	A_1_4_0	500	2	X	X	X	X	X		X
Loop Automation Device Type Feeder Device Type is set to Feeder.	A_1_4_3	500	2	X	X	X	X	X		X
Loop Automation Device Type Midpoint Device Type is set to Mid-Point.	A_1_4_4	500	2	X		X	X	X		X
Loop Automation Device Type Tie Device Type is set to Tie.	A_1_4_5	500	2	X	X	X	X	X		X
Loop Automation Trip Request Not suitable for poll oriented protocols.	A_1_4_8	500	10	X	X	X	X	X		X
Loop Automation Close Request Not suitable for poll oriented protocols.	A_1_4_9	500	10	X	X	X	X	X		X
Downstream Communications Status Intelligent Loop Automation downstream communications status normal/failed. Downstream communications is normal when the flag is set.	A_1_4_24	500	1	X		X	X	X		X
Tie Communications Status Intelligent Loop Automation Tie communications status Normal/Failed. Tie communications is normal when the flag is set.	A_1_4_25	500	1	X		X	X	X		X
Upstream Trip Request Intelligent Loop Automation trip was requested by an upstream Device.This point applies only to a Mid-Point Set when an Upstream Trip Request is issued. Cleared by: • any trip or close • "Reset Fault Flags" protocol command • "Reset fault flags and currents" control • Loop Automation is turned on.	A_1_4_26	500	1	X		X	X	X		X
Close Inhibit Intelligent Loop Automation close inhibit was requested by an upstream Device. This point applies only to a Tie. Set when a Close Inhibit request is issued. Cleared by: • any trip or close • "Reset Fault Flags" protocol command • "Reset fault flags and currents" control • Loop Automation is turned on.	A_1_4_27	500	1	X		X	X	X		X
Tie Control Intelligent Loop Automation Tie control mode Tie control mode is in the message mode when the flag is set and in the timer mode when the flag is not set.	A_1_4_28	500	0	X		X	X	X		X
Loop Automation Logic Intelligent Loop Automation logic mode The Loop Automation logic is the intelligent mode when the flag is set and the classic mode when the flag is not set.	A_1_4_29	500	0	X		X	X	X		X

Description	Mnemonic	Time Resolution	Default DNP Class	ACR	LBS	IOEX	Panel	Protocol	W-Series	CLT
Downstream Device Function Intelligent Loop Automation downstream Device function Downstream Device function is ACR when the flag is set and load break switch when the flag is not set.	A_1_4_30	500	0	X		X	X	X		X
Upstream Close Request Intelligent Loop Automation close was requested by an upstream Device. This point applies only to a Tie. Set when an Upstream Close Request is issued. Cleared by: • any trip or close • "Reset Fault Flags" protocol command • "Reset fault flags and currents" control • Loop Automation is turned on.	A_1_4_26	500	1	X		X	X	X		X

Table 22. Distributed Automation Flags.

A.2.9 Distributed Automation Analogue Points

Description	Mnemonic	Min.-Max.	Units	Dead band	Default DNP Class	ACR	LBS	IOEX	Panel	Protocol	W-Series	CLT
LA Remaining Time This is the Loop Automation timeout value while counting down prior to a Trip or Close action occurring. When no action is pending the value is zero.	A_2_9_0		2	X	X		X	X		X		
Loop Automation Ping Interval Loop Automation communications ping interval. Value 0 disables ping.	A_2_9_4	0 - 7200	Seconds	10	1	X			X	X		X
Downstream Device Type This is the downstream Device type. A Mid-Point is 2 and Tie 0.	A_2_9_5	0-2		1	0	X			X	X		X

Table 23. Distributed Automation Analogue Points.

B.2 Distributed Automation Analogue Control Points

Description	Mnemonic	Min.-Max.	Units	Default DNP Class	ACR	LBS	IOEX	Panel	Protocol	W-Series	CLT
Loop Automation Control Controls Loop Automation.	B_2_19		2	X	X	X	X	X		X	
Loop Automation Ping Interval Loop Automation communications ping interval. Value 0 disables ping.	B_2_37	0 - 7200	Seconds	1	X			X	X		X

Table 24. Distributed Automation Analogue Control Points.

Appendix H – Loop Automation LBS Support

Application note for the ADVC Controller range

Scope

General

This document covers the changes made in WSOS5 and the ADVC Controller to support LBS devices in Loop Automation schemes.

Warning

While all due care has been taken in the preparation of this application note, no responsibility is taken for loss or damage incurred by the purchaser or user due to any error or omission in this document.

Controller Firmware Version

This manual applies to the ADVC Controller Range controllers with firmware version A45- 19.02+.

Switchgear Series

The following switchgear may be used as an LBS Loop Automation Device:

- N-Series and U-Series switchgear with an ADVC controller in LBS mode
- RL-Series switchgear with an ADVC controller.

WSOS

Loop Automation LBS support is available in WSOS versions from 5.13.24+.

LBS Feeder

An LBS Feeder Device functions similarly to a Recloser Feeder Device for an upstream fault (section A – see Figure 46):

- substation CB trips to lockout from protection
- on detecting loss of source supply, the LBS Feeder Devices will trip after the Loop Automation time (which should be longer than the longest dead time in the upstream substation CB).

For a downstream fault (section B – see Figure 46):

- substation CB trips from protection
- if the Substation CB has reclosing capabilities and is graded with the LBS Feeder Device, the LBS Feeder Device will do a sectionalising trip after it reached the number of supply interrupts from the Substation CB reclosing sequence. If no reclosing capabilities are available in the Substation CB, the LBS Feeder Device will do a Loop Automation trip after there is a loss of supply and the Loop Automation Time expires.

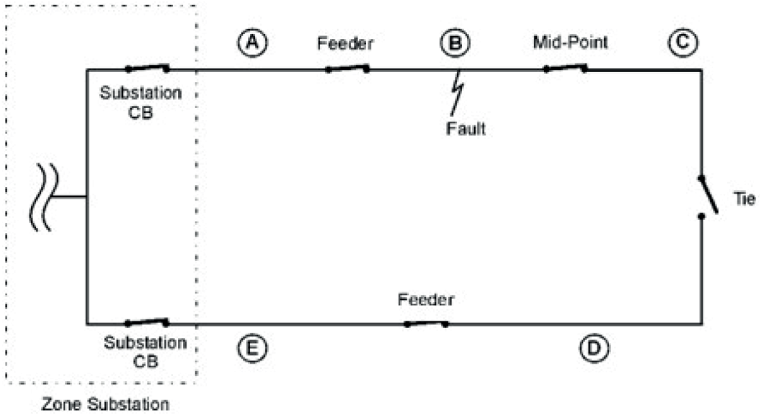


Figure 50. Example loop network.

LBS Tie Device

Overview

A Loop Automation scheme using an LBS Tie Device as the Tie (Normally Open Point) switch requires a trigger which, unlike the trigger for standard Loop Automation, utilizes the dead time set for the upstream Devices (their "signature") to identify which Device has tripped. The LBS Tie Device logic rules use the identification of the upstream Devices to reduce the possibility that the LBS Tie Device will close on to a fault.

Note	The Auto-Restoration option is not available if Loop Automation with Dead Time is in use.

Rule D. A Tie Device (Recloser or LBS) or Sectionaliser closes when supply is lost and it has detected an "Allow Loop Auto" dead time of an upstream Device.

Dead Time Detection

Dead time is the duration of voltage lost at the downstream devices and is measured from:

- When the voltages on all three phases fall below the Live Terminal Voltage level, until the voltage on one or more phases rises above the Live Terminal Voltage level.

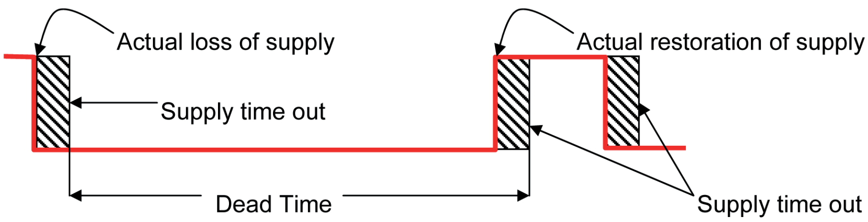


Figure 51. LBS Tie Device sectionaliser dead time diagram.

Dead Time Trigger

This trigger is called “Allow DT” in this document. This feature in Loop Automation is capable of recognising an “Allow” condition in the network. This is done by measuring the duration of the final dead time of upstream switchgear. For instances where this dead time equals a user configurable time, the switchgear will “Allow” Loop Automation actions to take place. Conversely, if the final dead time does not equal the “allow” dead time value, the LBS Tie Device will take no action. Power lost for the duration of the Loop Automation time in the LBS Tie Device will cause Loop Automation to abort. It is therefore necessary to set the normal “Loop Auto time” and also set the “Allow” dead time for the Tie Device.

- Loop Auto time is the delay after Loop Automation was triggered, before Loop Automation actions are taken (e.g. the Feeder Device opens or Tie Device closes). This delay ensures that all the protection sequences are finished before Loop Automation reconfigures the network and the value is set as a time, e.g. 40s. In the Tie Device this time is also used to determine a prolonged outage and will turn Loop Automation off should power be lost for longer than the Loop Automation time. Loop Auto time must therefore be greater than the “Allow DT” setting.
- The “Allow” dead time is the duration of the final upstream Reclose interval that will allow LA actions to take place. This value is set as a time with a margin, e.g. 25s ± 3s. When a value of zero (0s) is entered, Loop Automation will ignore all dead time durations. Examples:
- Allow DT = 25s ± 3s will describe the Reclose profile in Scenario A that will allow the Tie Device to close after Loop Auto time.
- The Tie Device can be used to restore power in both directions. Due to the possible different characteristics of Feeder 1 and Feeder 2, it is necessary to set the “Allow” dead time for both sides (Source and Load) of the Tie Device.
- When the Reclose sequence has successfully restored power after a temporary fault occurred, a Loop Automation sequence reset timer will be used in the Tie Device to reset the Loop Auto sequence. This LA sequence reset timer is equal to the Loop Auto time + the Forward or Reverse Margin. Forward is used when the dead time was detected on the Load side terminals. And when the Tie Device is configured to restore both ways, the Reverse Margin is used for a dead time detected on the Source side terminals.

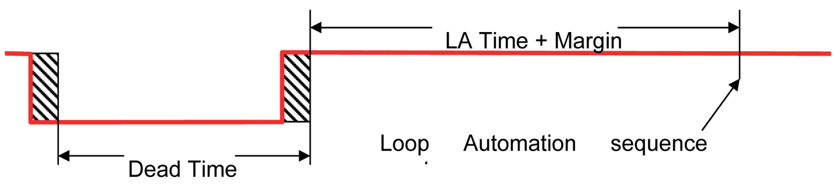


Figure 52. Dead time detection diagram.

Understanding Isolation and Reconfiguration with Dead Time

Standard Loop Automation uses the loss of voltage at the Device to trigger the specific actions to be taken by each Device. A specific time delay (Loop Auto Time) for each Device is set to ensure that the actions taken by Loop Automation to reconfigure the network occur in the correct sequence. For example if the power was lost at one of the substations, the Feeder Device opens first, then the Mid-Point Devices change direction of protection and finally the Tie Device closes to restore power. Loop Automation with dead time identifies a specific dead time and uses it to trigger the same loop automation reconfigurations as in the standard scheme but this can be used to reduce the possibility that the Tie Device will close on to a fault.

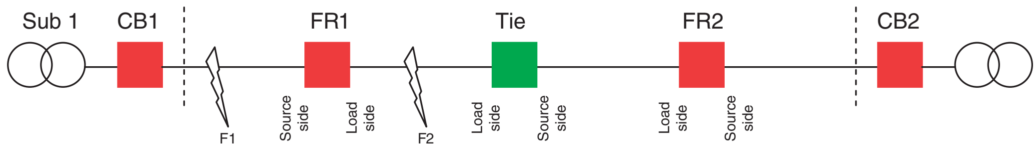


Figure 53. Example scenario with a potential Tie Device close on a fault.

The following table describes a few different Reclose possibilities that could be detected by the Tie Device. In this example the Tie Device is configured with an Allow DT = 25s ± 3s.

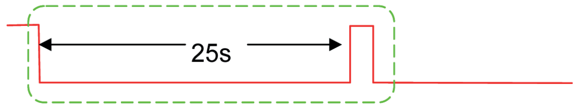
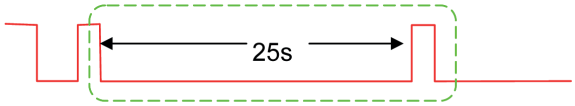
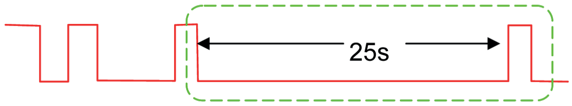
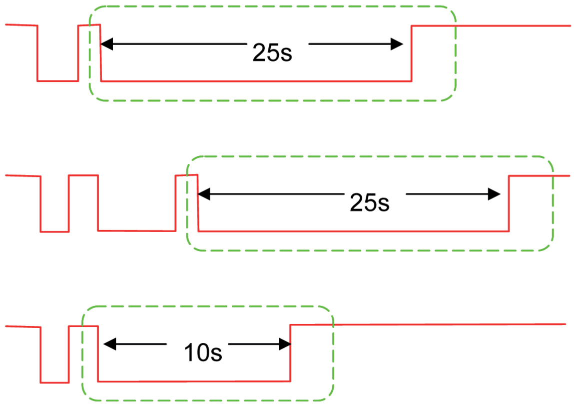
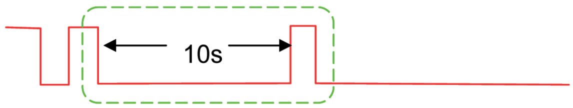
Voltage profile at Tie Device	Action	Comment
	Allow	Only one Reclose interval equals the “Allow DT”
	Allow	Second (last) Reclose interval equals the “Allow DT”
	Allow	Third (last) Reclose interval equals the “Allow DT”
	Ignore	Power is restored in the final Reclose attempt. Power restored by any auto-reclose action will cause Loop Automation to take no action. Loop Automation will reset if the power remains on for the duration of LA time.
	Ignore	Third (last) Reclose interval does not equal the “Allow DT”
	Ignore	Second (last) Reclose interval does not equal the “Allow DT”

Table 25. Voltage profile at Tie Device.

Appendix I - Intelligent Loop Automation - Network Configuration Examples

Overview

Intelligent Loop Automation can be used with the Tie Control setting as Timer or Message. The examples in this section describe how the functionality differs in response to various faults according to the setting used.

Composition

The first example describes how Intelligent Loop Automation handles permanent faults at different parts of the network when the Tie Control is set to Timer. The second example describes how Intelligent Loop Automation handles the same faults when the Tie Control is set to Message. The third example describes how a permanent fault between the Tie Device and the next Device upstream is handled the same way regardless of the Tie Control setting. All examples in this section describe the operation of Automatic Circuit Reclosers fitted with ADVC controllers for each Device in the scheme.

Coordination

Warning

As with the Classic version, Intelligent Loop Automation relies on the protection settings of the substation Circuit Breaker (CB) and Devices in the scheme being correctly coordinated so that the CB and/or Device closest to the fault always trips first.

Network Configuration

All of the examples in this section are based on the network configuration shown in Figure 54. The network consists of two feeders emulating from circuit breakers at the same substation. One feeder has three Devices configured as one Feeder Device and two Mid-Point Devices. The second feeder has two Devices configured as one Feeder Device and one Mid-Point Device. The two feeders are connected by a normally open Device configured as a Tie Device.

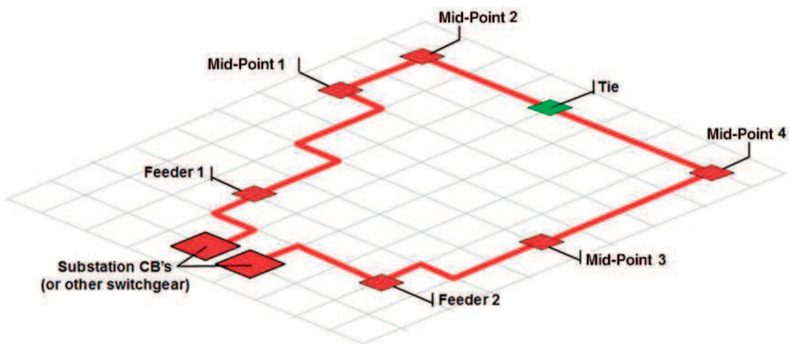


Figure 54. Loop Automation Network Configuration

Intelligent Loop Automation Example One – Timer Tie Control

When Intelligent Loop Automation is run with Tie Control set to Timer, a Tie Device will operate as per its basic Classic rules regardless of whether or not it receives a close request. This mode maintains the availability of the scheme and enables an automatic attempt to restore supply regardless of the availability of the peer-to-peer communications.

Fault Condition between the Substation CB and Feeder Device with Timer Tie Control

In the configuration shown at Figure 55 below, a permanent fault condition occurs on the section of feeder between the substation CB and the Feeder 1 Device.

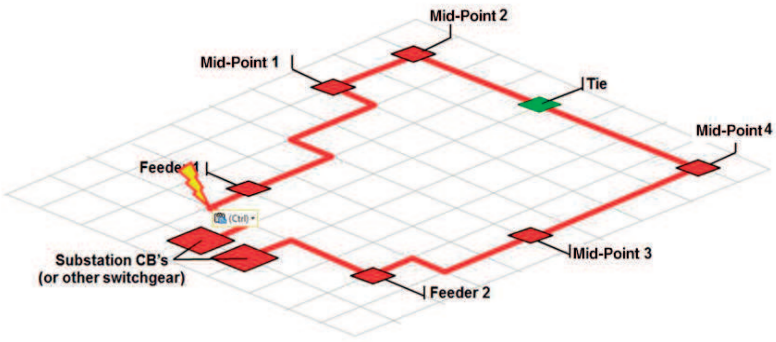


Figure 55. Fault between Substation CB and Feeder 1 Device

A protection pickup occurs at the substation CB which subsequently trips and goes to lockout. This will trigger the following sequence of Loop Automation events:

- the Feeder, two Mid-Point and Tie Devices detect a loss of supply and start their respective Loop Automation Activation Delay timers
- when the Feeder Device timer expires it trips and goes to lockout
- when the Mid-Point Device timers expire, they change to their alternate protection group in anticipation of a change of power flow direction and change to Single-Shot mode
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires

The network has now been reconfigured so that all sections are energised apart from the faulted section between the substation CB and the Feeder 1 Device as shown in Figure 56.

Note The substation CB was tripped by its protection due to the fault and the Feeder 1 Device was tripped by Loop Automation.

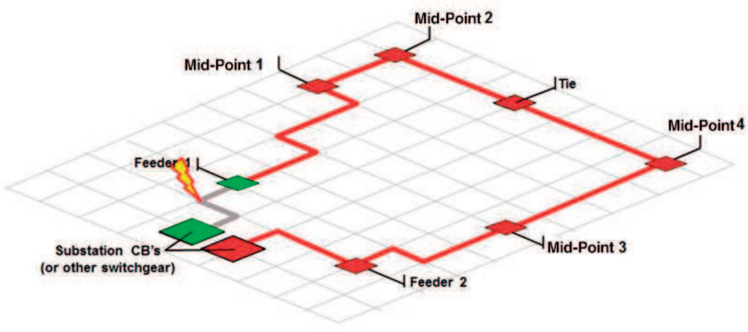


Figure 56. Reconfigured network following permanent fault between Substation CB and Feeder 1 Device

Fault Condition between Feeder and Mid-Point Devices with Timer Tie Control

In the configuration shown at Figure 57 below, a permanent fault condition occurs on the section of feeder between the Feeder 1 and Mid-Point 1 Devices.

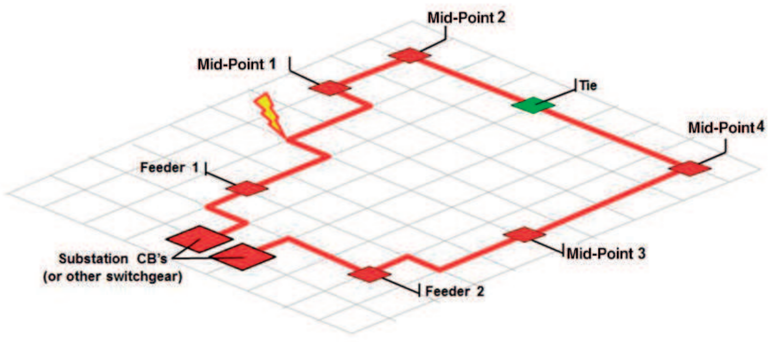


Figure 57. Fault between Feeder 1 and Mid-Point 1 Devices

The Feeder 1 Device detects the fault and may commence a reclose sequence if configured. Because the fault is permanent, the Device eventually goes to Lockout which triggers the following sequence of Loop Automation events:

- Feeder 1 Device sends a trip request to its downstream Device Mid-Point 1 Device using P2P communications.
- Loop Automation Activation Delay timers start at the two Mid-Point and Tie Devices due to a loss of supply caused by the Feeder 1 Device going to lockout.
- Mid-Point 1 Device changes its protection group in anticipation of a power flow direction reversal and goes to Single-Shot mode after its timer expires and trips upon receiving a Loop Automation trip request from Feeder 1 Device, which will also cause it to open.
- Mid-Point 2 Device also changes protection group and goes to Single-Shot mode after its timer expires.
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires.

The network has now been reconfigured so that all sections are energised apart from the faulted section between the Feeder 1 and Mid-Point 1 Devices as shown in Figure 58.

Note Feeder 1 Device was tripped by its protection due to the fault and the Mid-Point 1 Device was tripped by a trip request communications message received from Feeder 1.

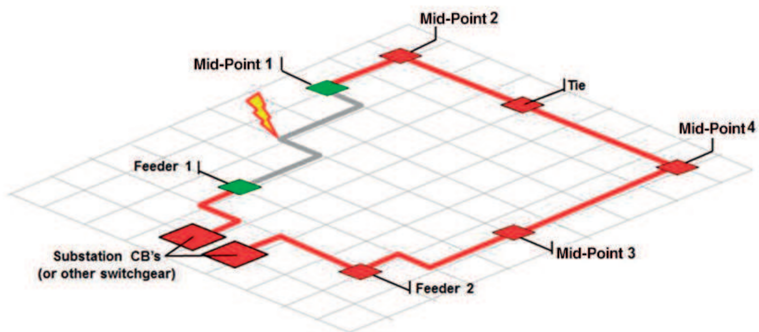


Figure 58. Reconfigured network following permanent fault between the Feeder 1 and Mid-Point 1 Devices

Fault Condition between Mid-Point 1 and Mid-Point 2 Devices with Timer Tie Control

In the configuration shown at Figure 59 below, a permanent fault condition occurs on the section of feeder between the Mid-Point 1 and Mid-Point 2 Devices.

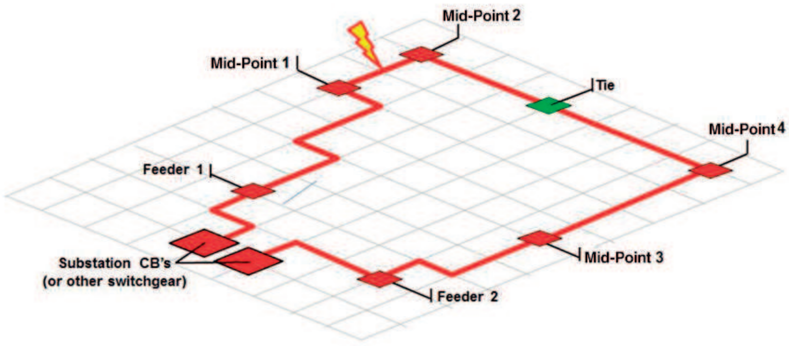


Figure 59. Fault between Mid-Point 1 and Mid-Point 2 Devices

The Mid-Point 1 Device detects the fault and may execute a reclose sequence before going to Lockout which triggers the following sequence of Loop Automation events:

- Mid-Point 1 Device sends a trip request to its downstream Mid-Point 2 Device using Modbus P2P communications.
- Loop Automation Activation Delay timers start at the Mid-Point 2 and Tie Devices due to a loss of supply caused by the Mid-Point 1 Device going to lockout.
- the downstream Mid-Point 2 Device changes protection group in anticipation of a change of power flow direction. It also goes to Single-Shot mode after its timer expires and upon receiving a Loop Automation trip request which also causes it to trip.
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires.

The network has now been reconfigured so that all sections are energised apart from the faulted section between the Mid-Point 1 and Mid-Point 2 Devices as shown in Figure 60.

Note The Mid-Point 1 Device was tripped by its protection due to the fault and the Mid-Point 2 Device was tripped by a trip request communications message received from Mid-Point 1 Device.

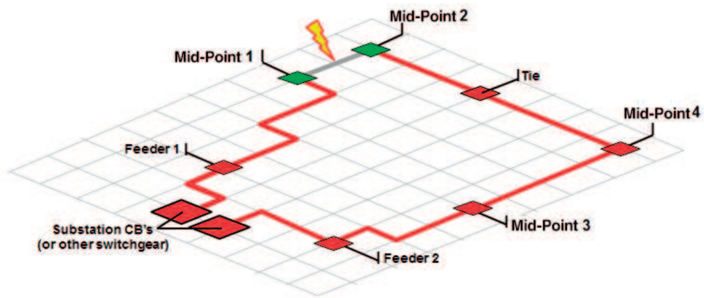


Figure 60. Reconfigured network following permanent fault between the Mid-Point 1 and Mid-Point 2 Devices

Intelligent Loop Automation Example Two – Message Tie Control

When Intelligent Loop Automation is run with Tie Control set to Message, the closing of the Tie Device is controlled by a communications message. When the Feeder or Mid-Point Device goes to a protection lockout it initially sends the same message to the downstream Device as described in the Timer Tie Control examples. The downstream Device also reacts to the message in the same way. If the downstream Device is not a Tie Device, an additional 'close' message is sent to the Tie Device. If the Tie Device does not receive a 'close' message, Loop Automation does not close the switchgear as it normally would when it has lost supply and the Loop Automation Activation Delay has expired. If the 'close' message has not been received when the Activation Delay timer expires, Loop Automation will turn off.

Fault Condition between the Substation CB and Feeder Device with Message Tie Control

In the configuration shown below in Figure 61, a permanent fault condition occurs on the section of feeder between the substation CB and the Feeder 1 Device.

A protection pickup occurs at the substation CB which subsequently trips and goes to lockout. This will trigger the following sequence of Loop Automation events:

- the Feeder, two Mid-Point and Tie Devices detect a loss of supply and start their respective Loop Automation Activation Delay timers
- when the Feeder Device timer expires it trips and goes to lockout, and then sends a close request to the Tie Device using Modbus P2P communications as shown in Figure 61

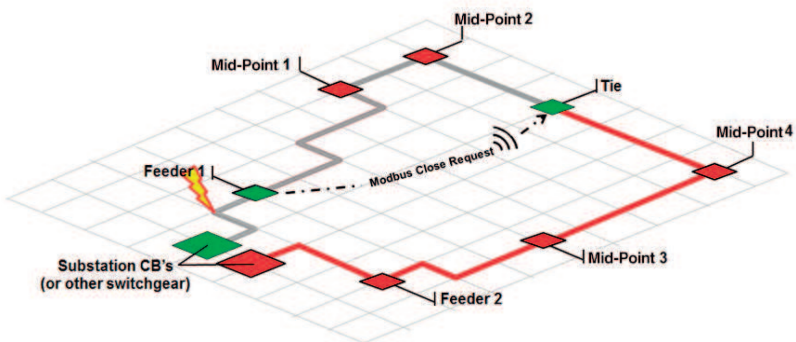


Figure 61. Fault between Substation CB and Feeder 1 Device with Message Tie Control

- when the Mid-Point Device timers expire, they change to their alternate protection group in anticipation of a change of power flow direction and change to Single-Shot mode
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires providing it has already received a close request message.

The network has now been reconfigured so that all sections are energised apart from the faulted section between the substation CB and the Feeder 1 Device as shown in Figure 56.

Note The substation CB was tripped by protection due to the fault and the Feeder 1 Device was tripped by Loop Automation. The Tie Device was closed by a close request message from Feeder 1 Device and its Activation Delay timer.

Fault Condition between Feeder and Mid-Point Devices with Message Tie Control

This example explains how Loop Automation with Message Tie Control handles a permanent fault between the Feeder and a Mid-Point Device as shown in Figure 62.

The Feeder 1 Device detects the fault and may execute a reclose sequence before eventually going to Lockout which triggers the following sequence of Loop Automation events:

- Feeder 1 Device sends a trip request to its downstream Mid-Point 1 Device and a close request to the Tie Device using Modbus P2P communications as shown in Figure 62

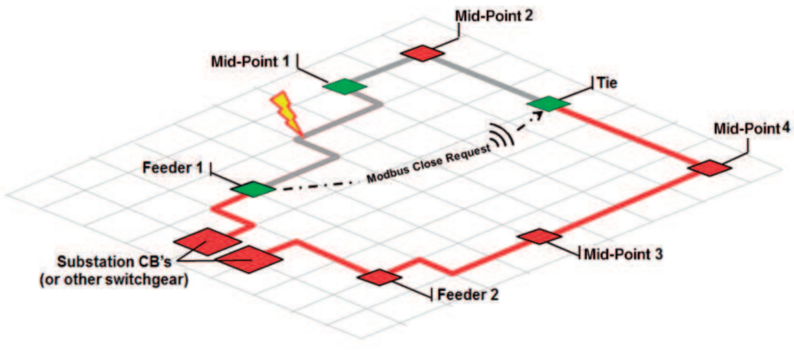


Figure 62. Fault between Feeder 1 and Mid-Point 1 Devices with Message Tie Control

- Loop Automation Activation Delay timers start at the two Mid-Point and Tie Devices due to a loss of supply caused by the Feeder 1 Device going to lockout
- Mid-Point 1 Device trips upon receiving a Loop Automation trip request from Feeder 1 Device
- Mid-Point 2 Device also changes protection group and goes to Single-Shot mode after its timer expires
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires providing it has already received a close request message.

The network will now have been reconfigured as shown in Figure 58 such that all sections are energised apart from the faulted section between the Feeder 1 and Mid-Point 1 Devices.

Note

Feeder 1 Device was tripped by its protection due to the fault and the Mid-Point 1 Device was tripped by a trip request communications message received from Feeder 1 Device. The Tie Device closed when its Activation Delay timer expired because it had already received a close request from Feeder 1 Device.

Fault Condition between Mid-Point 1 and Mid-Point 2 Devices with Message Tie Control

This example explains how Loop Automation with Message Tie Control handles a permanent fault between two Mid-Point Devices as shown in Figure 63.

The Mid-Point 1 Device detects the fault prior to executing a reclose sequence and eventually goes to lockout which triggers the following sequence of Loop Automation events:

- Mid-Point 1 Device sends a trip request to its downstream Mid-Point 2 Device and a close request to the Tie Device using Modbus P2P communications

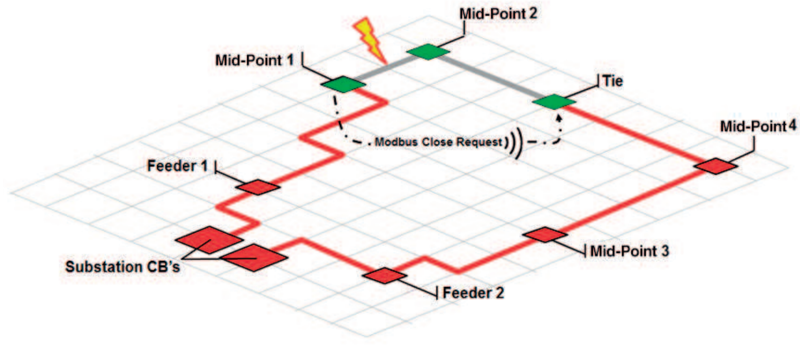


Figure 63. Fault between Mid-Point 1 and Mid-Point 2 Devices with Message Tie Control

- Loop Automation Activation Delay timers start at the Mid-Point 2 and Tie Devices due to a loss of supply caused by the Mid-Point 1 Device going to lockout
- Mid-Point 2 Device trips when it receives a trip request from Mid-Point 1 Device
- finally the Tie Device may change its protection group if required depending on the anticipated power flow direction, then go to Single-Shot mode and close after its timer expires providing it has already received a close request message.

The network has now been reconfigured so that all sections are energised apart from the faulted section between the Mid-Point 1 and Mid-Point 2 Devices as shown in Figure 60.

Note

The Mid-Point 1 Device was tripped by its protection due to the fault and the Mid-Point 2 Device was tripped by a trip request communications message received from Mid-Point 1 Device. The Tie Device closed when its Activation Delay timer expired because it had already received a close request from Mid-Point 1 Device.

Intelligent Loop Automation Example Three – Timer and Message Tie Control

Intelligent Loop Automation will operate in the same way for a fault between the Tie Device and upstream Device regardless of the Tie Control being set for Timer or Message. When a permanent fault occurs in this part of a network as shown in Figure 64 there is no possibility of any part of the faulted feeder being back fed. Intelligent Loop Automation can however prevent the Tie Device from closing onto the fault.

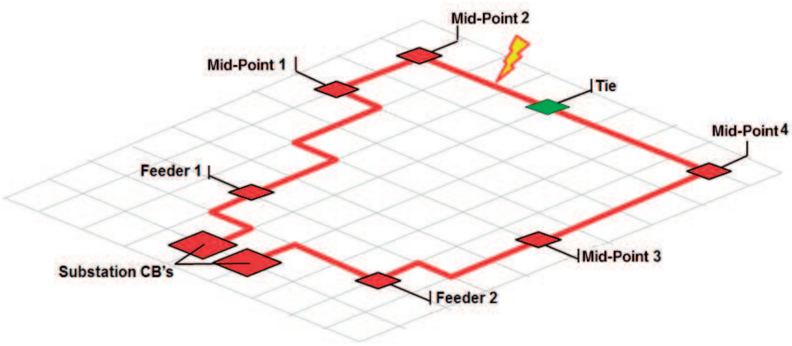


Figure 64. Fault between Mid-Point 2 and Tie Devices

The permanent fault in Figure 64 will cause a protection pickup at the Mid-Point 2 Device which will cause it to trip and eventually go to lockout. This will trigger the sequence of Loop Automation events detailed below:

- when the Mid-Point 2 Device goes to lockout it will send a close inhibit request to the Tie Device using Modbus P2P communications
- the Loop Automation Activation Delay timer will start in the Tie Device due to a loss of supply caused by the Mid-Point 2 Device going to lockout
- the Tie Device will be prevented from closing when its Activation Delay timer expires because it will have received a close inhibit request message from the Mid-Point 2 Device.

The network configuration will remain as shown in Figure 65 with only the faulted section between the Mid-Point 2 and Tie Devices isolated.

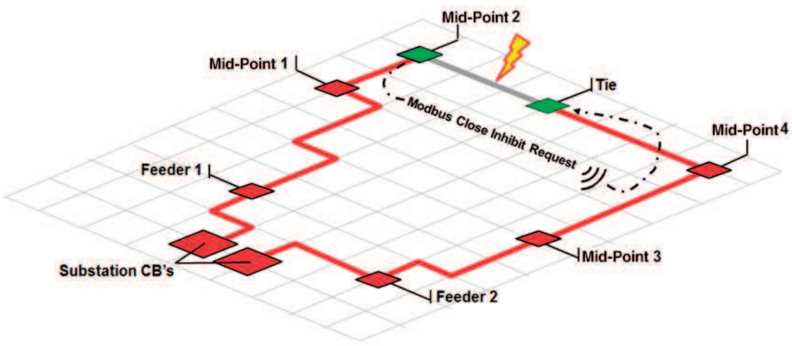


Figure 65. Fault between Mid-Point 2 and Tie Devices with Timer and Message Tie Control

Note The Mid-Point 2 Device was tripped by its protection due to the fault. The Tie Device did not close as it normally would due to a loss of supply on one side because it had received a close inhibit request message before its Activation Delay timer expired.

REFERENCES

Contact your local distributor if you need more information on this application.

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