SANDC.COM

APPLICATION
GUIDE

# AUTOMATIC LOOP RESTORATION

## INTELLIRUPTER® PULSECLOSER® FAULT INTERRUPTER

# CUSTOMER CHALLENGES

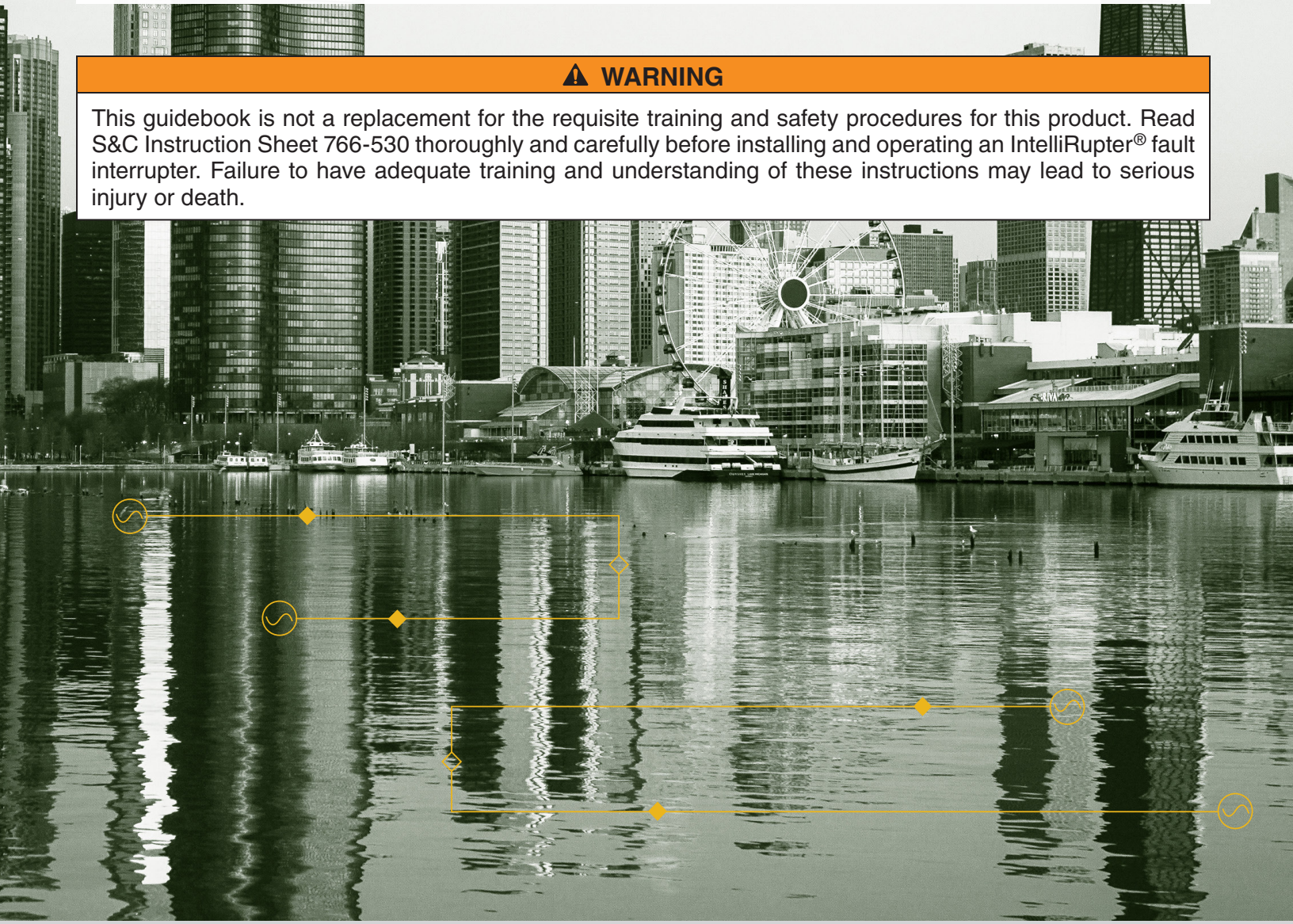
In today's technology-driven world, customers are increasingly less tolerant of power outages. When outages do occur, customers expect their power restored quickly. This puts pressure on utilities to advance their grid to provide better reliability and resilience.

One of the most common ways a utility can upgrade its system is through increased feeder segmentation. Increased segmentation can spare customers in unfaulted segments from experiencing unnecessary outages, but its effectiveness on radial circuits is largely dependent on the location of the fault.

To increase both reliability and resilience, tying radial feeders into loop circuits enables utilities to reroute power from an alternate source, ensuring only customers in the faulted segment experience a permanent outage. This solution offers significant benefits and can be achieved without implementing communications.

**⚠ WARNING**

This guidebook is not a replacement for the requisite training and safety procedures for this product. Read S&C Instruction Sheet 766-530 thoroughly and carefully before installing and operating an IntelliRupter® fault interrupter. Failure to have adequate training and understanding of these instructions may lead to serious injury or death.



# THE SHORTCOMINGS OF RADIAL CIRCUITS

Most distribution feeders were constructed as radial circuits, usually with a midline recloser. This configuration is adequate to provide fault-testing, but depending on the location of the fault it can leave large numbers of customers in unfaulted segments without power. See Figure 1.

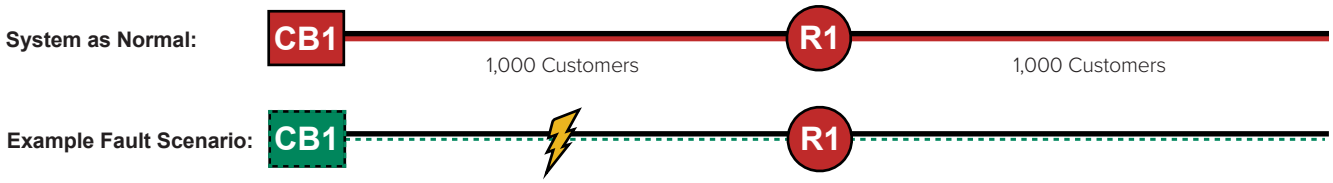



**Figure 1.** A line diagram of a permanent fault occurring on a radial circuit with one midline fault-testing device.

**RESULT:** Because this permanent fault occurred upstream of the midline testing device, the substation circuit breaker will trip and lock out, leaving all 2,000 customers on this feeder without power.

| **Device Key:** | Closed | Open |
|---|---|---|
| **Segment Key:** | With Power | Without Power |

# THE BENEFITS OF AUTOMATIC LOOP RESTORATION

In contrast to radial circuits, loop circuits enable service restoration for customers in unfaulted segments. When a fault occurs in a loop scheme, the devices can isolate the fault and automatically reroute power from an alternate source, greatly enhancing reliability and enabling quick restoration with no communications required.

In a loop circuit, two radial feeders are connected by a normally open device, commonly called the normally open tie point. The normally open device can close in response to a permanent fault, allowing the secondary source to pick up additional load and restore power to customers in unfaulted segments.

In Figure 2, two simple radial circuits with one midline IntelliRupter fault interrupter each have been connected through a normally open tie-point device. The same permanent fault as shown in Figure 1 occurs.

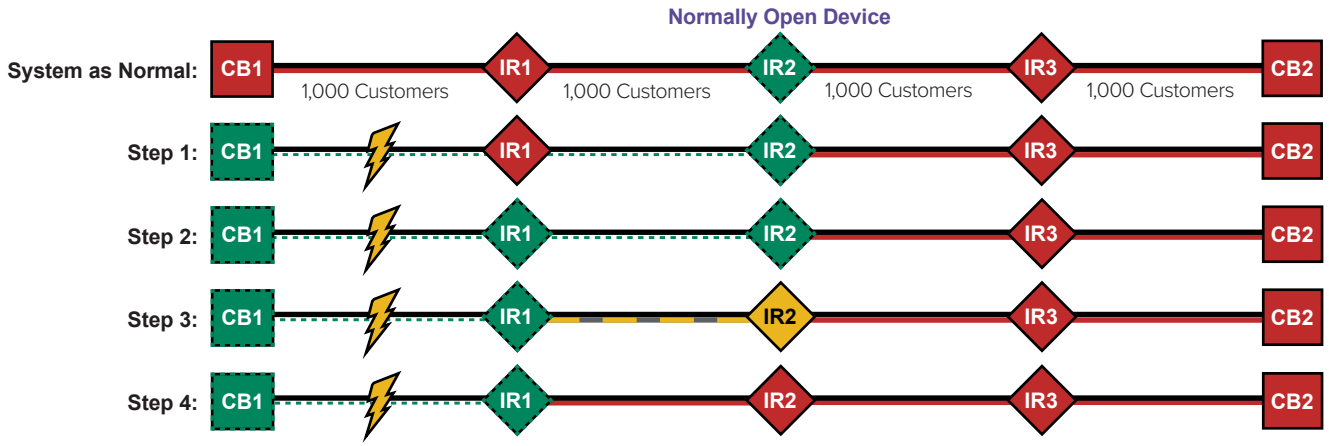



**Figure 2.** A line diagram of a permanent fault occurring on a simple loop circuit.

**RESULT:** When the fault occurs, the substation circuit breaker will trip as it did in Figure 1 using a conventional radial circuit. IntelliRupter 1 will then open and lock out because of loss of voltage, and the normally open device IntelliRupter 2 will close after a low-energy test in the direction of Substation 1 to confirm no fault is present. This restores power to the 1,000 customers in the unfaulted segment between IntelliRupter 1 and IntelliRupter 2.

| Device Key: | Closed | Open | Testing |
|---|---|---|---|
| Segment Key: | With Power | Without Power | Being Tested |

50% reliability improvement compared to the radial feeder example scenario.

# BIDIRECTIONAL PROTECTION: THE KEY TO AUTOMATIC LOOP RESTORATION

Changing your circuit design may seem daunting at first, but automatic loop restoration will benefit both you and your customers. All you need are fault-testing devices with bidirectional protection ability.

Bidirectional protection allows a device to monitor power flow from two sources. Because protection requirements may differ depending on the direction of power, bidirectional protection allows a device to automatically react with the appropriate tripping response. See Figure 3.

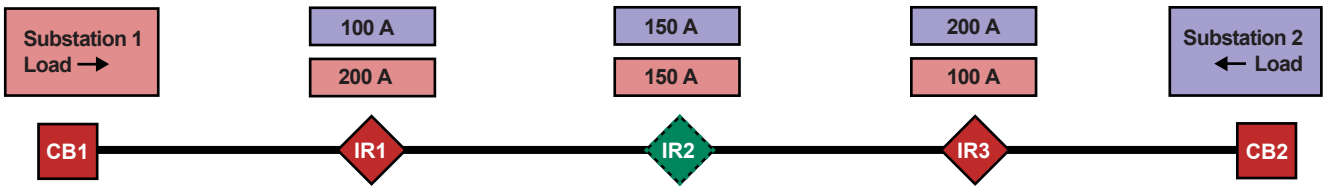



**Figure 3.** Line diagram showing the load profiles of each device in a loop restoration.

The type of device you choose impacts how easy it will be for you to set up a loop system, the effectiveness of it, and whether the devices can address other system challenges. While most conventional recloser controls can provide bidirectional protection, most require advanced configurable logic for this application.

Automatic loop restoration provides the best results with the least effort when the devices used have integrated simultaneously active bidirectional protection—a feature unique to S&C's IntelliRupter fault interrupter.

# LIMITATIONS OF CONVENTIONAL RECLOSERS

Conventional reclosers can achieve basic bidirectional protection, but the function is not inherent to these devices, so it requires significant financial and/or engineering capacity to coordinate effectively. Conventional reclosers also limit a utility's ability to deploy additional reliability-enhancing solutions, and they can create problems that will diminish the benefits of loop restoration. The four biggest challenges conventional reclosers create for loop circuits are:

## 1. CUSTOM LOGIC AND DEVELOPMENT

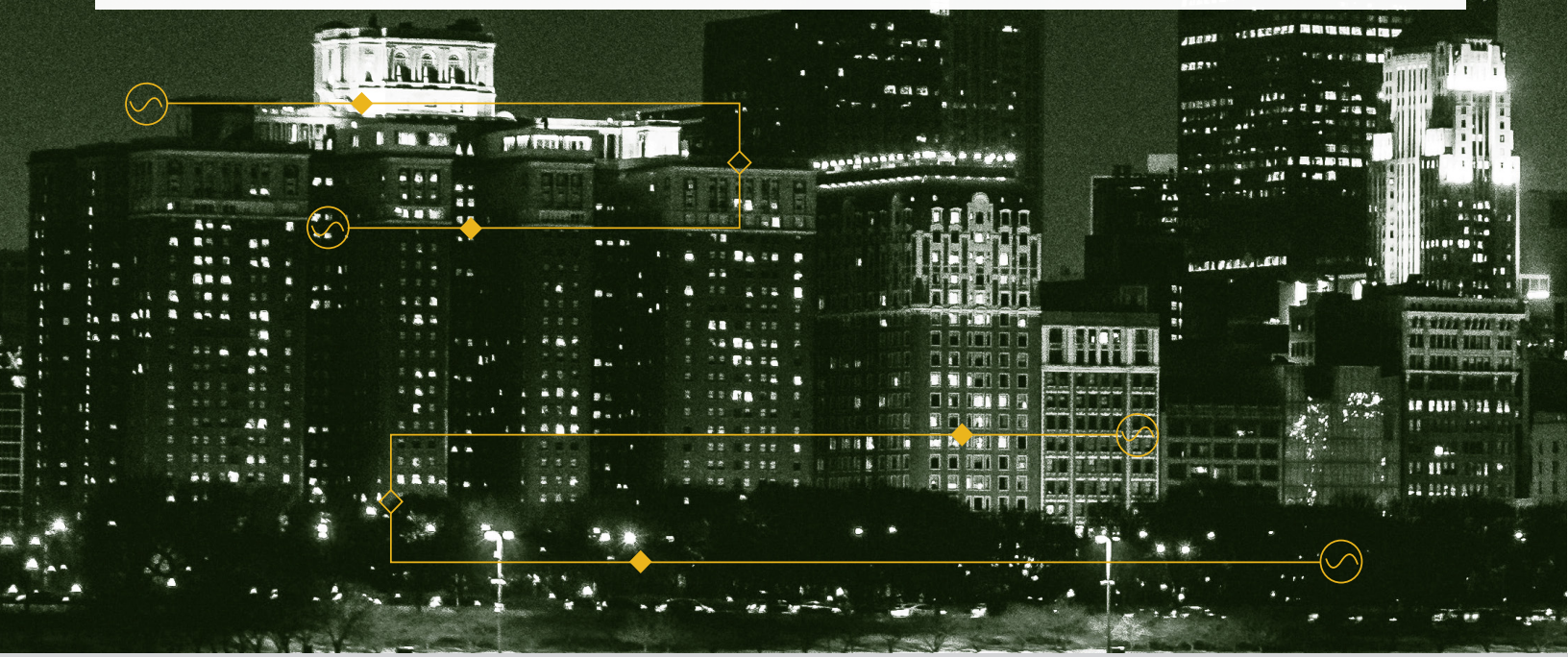
Although many conventional reclosers can achieve bidirectional protection, using them in a loop-restoration scheme requires developing custom coordination and protection logic. Though feasible, this is a time-consuming and challenging process that draws utility engineers away from other grid-modernization projects.

Alternatively, utilities can deploy communications to ease the engineering effort of achieving bidirectional protection with conventional reclosers. However, such a strategy is not as simple as it seems. Implementing communications is impractical for some utilities because of the nature of their territory. Long feeder distances or interference from dense vegetation, for example, can make communications nearly impossible to deploy successfully. For other utilities, implementing a widescale communications system is cost-prohibitive.

## 2. OVERTRIPPING

The lack of true bidirectional protection, where both directions are monitored simultaneously, also means conventional devices occasionally may fault-test in the wrong direction. In a loop circuit, this can create a scenario where the conventional recloser closes into the fault and may unwittingly trip, or re-trip, other devices on the circuit. This overtripping will typically leave additional unfaulted segments without power, defeating the purpose of automatic loop restoration.

*This topic continues on page 7.*



# LIMITATIONS OF CONVENTIONAL RECLOSERS (CONT.)

### 3. LIMITED COORDINATION

The reliability benefit of loop restoration is maximized for circuits with a high level of segmentation. However, this is usually not possible with conventional reclosers. If a utility is to maintain proper coordination, it typically can install very few (and often only one) conventional reclosers on each radial feeder.

If the utility adds additional devices, the coordination space is usually limited to the extent the time-current characteristic (TCC) curves for some devices overlap. This miscoordination can cause multiple devices to trip in response to a fault, commonly resulting in more customers than necessary experiencing an outage. See Figure 4.

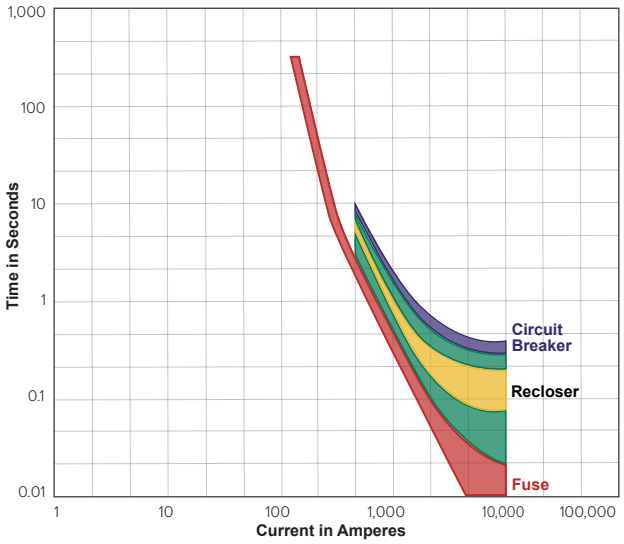



**Figure 4.** TCC curve chart showing the finite coordination space left available when using a conventional recloser does not allow for additional devices to be added without risking miscoordination.

### 4. VOLTAGE SAGS

During fault-testing, conventional reclosers subject the circuit to the full force of the fault current. In a loop-restoration scheme, this can result in voltage sags on the unfaulted portion of the loop circuit, potentially subjecting customers to avoidable momentary outages. See Figure 5.

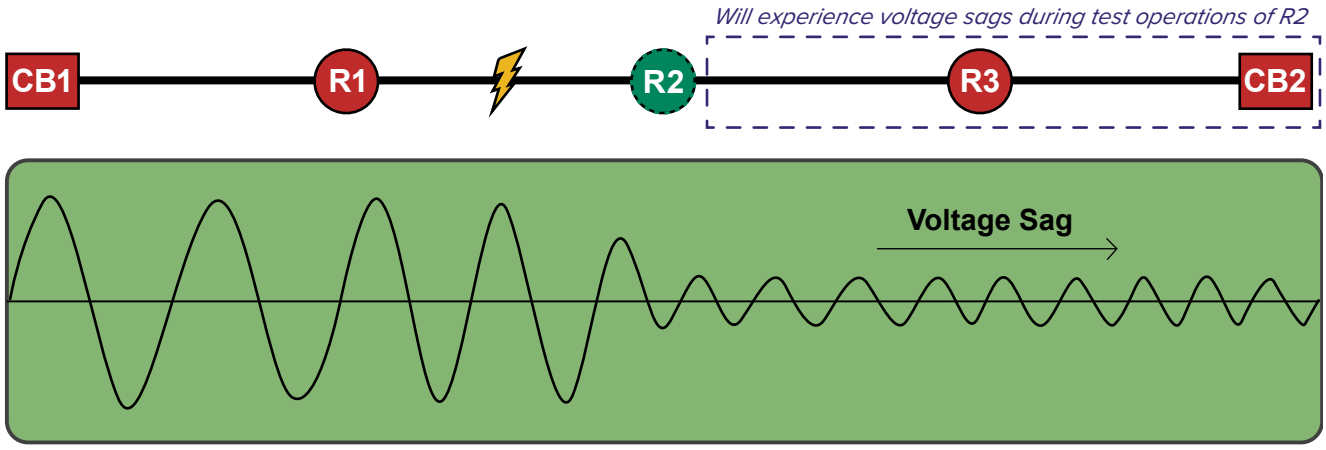


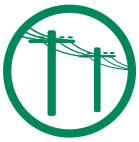

**Figure 5.** A line diagram (top) in which a fault occurs between Recloser 1 and the normally open Recloser 2. Use of conventional reclosing causes voltage sags on the unfaulted portion of the loop circuit, seen in the accompanying waveform (bottom).

# BENEFITS OF INTELLIRUPTER FAULT INTERRUPTERS FOR AUTOMATIC LOOP RESTORATION

In contrast, the IntelliRupter fault interrupter comes preprogrammed with the protection logic required for automatic loop restoration. Unlike conventional reclosers, these devices can simultaneously monitor power flow from both directions, easing the time and effort required to implement automatic loop restoration while enabling other benefits:

### UPGRADE WITH EASE

Simultaneously active directional protection is inherent to the IntelliRupter fault interrupter, and no custom logic or engineering is required. This feature significantly reduces the time and effort required to implement automatic loop restoration using IntelliRupter fault interrupters compared to conventional reclosers.



### INCREASE SEGMENTATION

IntelliRupter fault interrupters have 80% more accurate time and current tolerances than conventional reclosers. They also have additional sectionalizing features and make segmentation capabilities nearly limitless, including in loop-restoration schemes.

### PREVENT VOLTAGE SAGS

Using PulseClosing® Technology, the IntelliRupter fault interrupter uses 95% less energy to test for faults, which results in no voltage sags, blinks, or outages on adjacent feeders during testing.

### INCORPORATE EXISTING ASSETS

Existing feeders can undergo a significant reliability upgrade just by adding an IntelliRupter fault interrupter as the normally open tie point device to create a loop circuit—with little to no other upgrades or changes to existing equipment required.

### RESTORE WITH SPEED

Automatic loop restoration restores service to customers in unfaulted sections with no human intervention required, reducing restoration times from days or hours to just minutes—or even seconds.

### AUTOMATE WITHOUT COMMUNICATIONS

Utilities can use IntelliRupter fault interrupters on loop circuits as-is, with no communications required, making a reliable self-healing grid possible even for utilities unable to invest in communication systems.

### SIMPLIFY INSTALLATION

Automatic loop restoration is a standard feature in all IntelliRupter fault interrupters. No additional power source, extra sensing equipment, or add-on software licenses are required. A built-in power module and six voltage sensors on each device make the IntelliRupter fault interrupter the perfect all-in-one solution.

# SYSTEM SPOTLIGHTS

Automatic loop restoration can improve the reliability and resilience of nearly any circuit. No matter how your system is set up, there are a variety of ways to approach automatic loop restoration to tailor this application for your specific system and help you meet your goals.

The IntelliRupter fault interrupter offers the flexibility to achieve the benefits of automatic loop restoration on your present system with minimal engineering effort, and it provides you options to further enhance loop circuits throughout your grid-modernization journey.

# USING AN INTELLIRUPTER FAULT INTERRUPTER AS THE NORMALLY OPEN DEVICE FOR LOOP RESTORATION

If you're early in your grid-modernization journey, the most straightforward path to implementing automatic loop restoration without communications on your existing system is using an IntelliRupter fault interrupter as the normally open tie point.

By tying two existing radial circuits together, you can experience all the benefits of automatic loop restoration with very minimal effort. This is a simple and effective way to advance reliability and resilience without having to replace or re-coordinate existing assets.

The example in Figure 6 on page 11 shows a simple loop circuit. Two radial feeders, each with an existing midline conventional recloser, have been connected by an IntelliRupter fault interrupter as the normally open tie point.

# EXAMPLE: USING AN INTELLIRUPTER FAULT INTERRUPTER AS THE NORMALLY OPEN DEVICE FOR LOOP RESTORATION


| Description | Diagram |
|---|---|
| **#1.** A fault occurs between Substation 1 and Recloser 1, causing the circuit breaker for Substation 1 to open and lock out. |  |
| **#2.** Recloser 1 opens and locks out when its loss-of-voltage timer expires. |  |
| **#3.** Normally open tie point IntelliRupter 1 detects loss of voltage from Substation 1 while sensing normal voltage from Substation 2. This triggers the device to begin a low-energy PulseClosing Technology sequence in the direction of Substation 1 to begin restoration. |  |
| **#4.** After determining no fault is present, IntelliRupter 1 closes. |  |



**Figure 6.** An IntelliRupter fault interrupter serves as the normally open tie point to a circuit with existing midline conventional reclosers and restores power to unfaulted segments.

**RESULT:** 500 customers in the unfaulted line segment between Recloser 1 and normally open tie point IntelliRupter 1 have their power automatically restored with no human intervention required, and without creating a voltage sag on the healthy feeder.

| **Device Key:** | Closed | Open | Testing |
|---|---|---|---|
| **Segment Key:** | With Power | Without Power | Being Tested |

Creating a loop circuit with an IntelliRupter fault interrupter as the normally open tie point avoids a permanent outage for 500 customers.

## WHAT WOULD HAPPEN IF THE NORMALLY OPEN DEVICE WERE A CONVENTIONAL RECLOSER?

If the fault had occurred in the segment between Recloser 1 and the normally open device, a recloser serving as the normally open device could close into the fault during its testing sequence. This could result in an overtripping event where both Recloser 1 and the normally open recloser open and lock out—leaving 1,000 customers without power compared to the 500 customers left without power from using an IntelliRupter fault interrupter as the normally open tie point.

In addition, during each testing operation where the normally open recloser closes into the fault, all customers receiving power from substation Circuit Breaker 2 would experience a voltage sag—diminishing reliability for customers who otherwise would have been unaffected by the fault.

# ENHANCING LOOP RESTORATION WITH THE PULSEFINDING™ FAULT LOCATION TECHNIQUE

If you're also interested in easily increasing segmentation and improving overall reliability and resilience, using S&C's PulseFinding Fault Location Technique* in your loop circuit saves you from spending significant time and resources developing custom protection settings for each sectionalizing device.

With this technique, which uses intentionally overlapping TCC curve settings to overcome the limitations of conventional coordination, you can achieve automatic loop restoration alongside nearly unlimited segmentation, so devices isolate a fault to a smaller segment of customers.

Utilities can use this fault-isolation method with exclusively IntelliRupter fault interrupters on the line, which can also work alongside existing assets to significantly increase segmentation without complicating protection and coordination. See Figure 7.

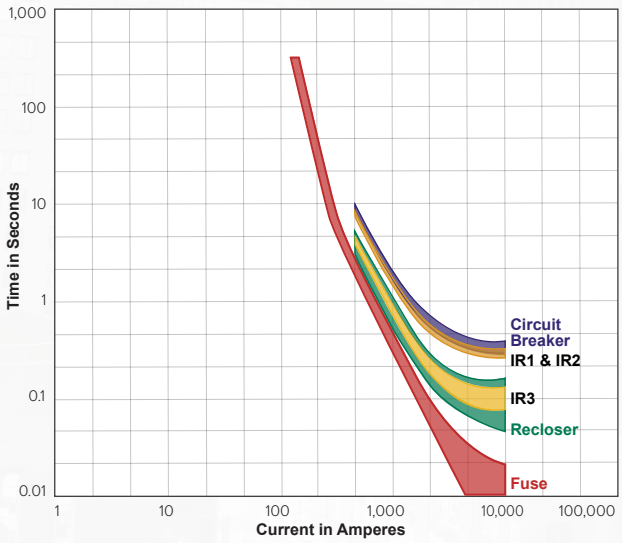



**Figure 7.** TCC curve chart showing how, when using the PulseFinding technique, utilities can program an IntelliRupter fault interrupter's coordination to either overlap or exactly match that of an existing asset, in this case overlapping the substation circuit breaker and exactly matching the midline recloser.

In the example shown in Figure 8 on page 13, half of a simple loop circuit has been upgraded with the addition of three IntelliRupter fault interrupters using the PulseFinding technique. Because the IntelliRupter fault interrupters share the same TCC curve settings as the existing substation circuit breaker or midline conventional recloser, the increased segmentation seen on this loop circuit is significantly simpler to achieve than doing so using conventional reclosers.

**For more information, refer to The PulseFinding Fault Location Technique: IntelliRupter Fault Interrupter Application Guide*

# EXAMPLE: ENHANCING LOOP RESTORATION WITH THE PULSEFINDING TECHNIQUE

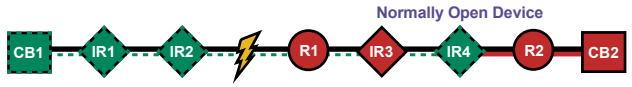
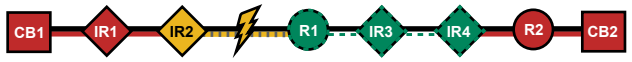
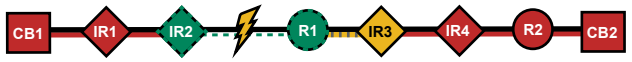
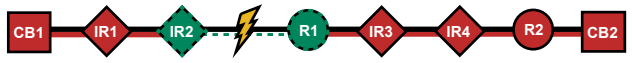
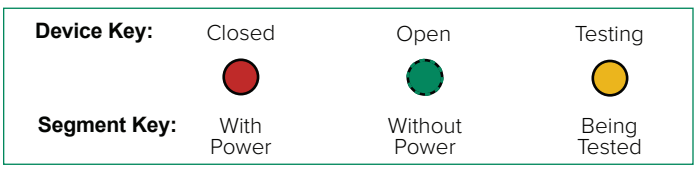

| Description | Diagram |
|---|---|
| **#1.** A fault occurs between IntelliRupter 2 and Recloser 1. Because the circuit breaker for Substation 1, IntelliRupter 1, and IntelliRupter 2 share the same TCC curve coordination, all three devices trip on their overcurrent settings. |  |
| **#2.** Recloser 1 and IntelliRupter 3 trip on loss of upstream voltage. |  |
| **#3.** The circuit breaker for Substation 1 tests for the fault, does not detect one, and closes back in. |  |
| **#4.** Upon return of voltage from Substation 1, IntelliRupter 1 begins a low-energy PulseClosing Technology sequence to test for the fault. |  |
| **#5.** Detecting no fault, IntelliRupter 1 closes. Upon return of voltage from upstream, IntelliRupter 2 begins a low-energy PulseClosing Technology sequence for the fault. |  |
| **#6.** IntelliRupter 2 identifies the fault and locks out. |  |
| **#7.** Normally open tie point IntelliRupter 4 detects loss of voltage from Substation 1 while sensing normal voltage from Substation 2. This triggers a low-energy PulseClosing Technology sequence in the direction of Substation 1 to begin restoration. |  |
| **#8.** IntelliRupter 4 detects no fault and closes. |  |
| **#9.** Sensing normal voltage from Substation 2, IntelliRupter 3 begins a low-energy PulseClosing Technology sequence in the direction of Substation 1. |  |
| **#10.** Detecting no fault, IntelliRupter 3 closes. |  |

**Figure 8.** Several IntelliRupter fault interrupters using the PulseFinding technique provide a high level of segmentation to half of a looped circuit, helping restore power to unfaulted segments.

**RESULT:** In this scenario, Recloser 1 is configured not to test in its alternate direction to avoid closing into the fault and re-tripping other devices. The device remains locked out, leaving only the 200 customers between IntelliRupter 2 and Recloser 1 without power.




The PulseFinding technique offers unlimited segmentation for loop circuits, with no re-coordination or replacement of existing assets required.

# USING INTELLIRUPTER FAULT INTERRUPTERS EXCLUSIVELY FOR LOOP RESTORATION

If you're looking for best-in-class reliability with your loop circuit, using IntelliRupter fault interrupters exclusively enables you to increase segmentation, avoid momentary interruptions for sensitive customers, and prepare your grid with advanced devices that can handle evolving energy needs.

For optimum reliability and resilience, maintaining devices' individual coordination settings is key. Because IntelliRupter fault interrupters have 80% more accurate time and current tolerances than conventional reclosers, these "skinny" TCC curves mean two to three IntelliRupter fault interrupters can typically be fully coordinated on each radial feeder of a loop circuit. This allows you to increase segmentation while maintaining coordination. See Figure 9.

Though this coordination method offers more limited segmentation than the PulseFinding technique, maintaining unique coordination settings spares customers in healthy feeder segments from experiencing avoidable momentary outages during the fault isolation process.

Especially if your existing assets are reaching end of life or you're building new circuits, standardizing on only IntelliRupter fault interrupters enables you to use the best protection for your system today and leverage more advanced features as you progress in your grid-modernization journey.

The example in Figure 10 on page 15 shows two radial feeders of 1,000 customers each connected by an IntelliRupter fault interrupter as the normally open tie point. Each radial feeder has three fully coordinated IntelliRupter fault interrupters segmenting the line to just 250 customers per segment.

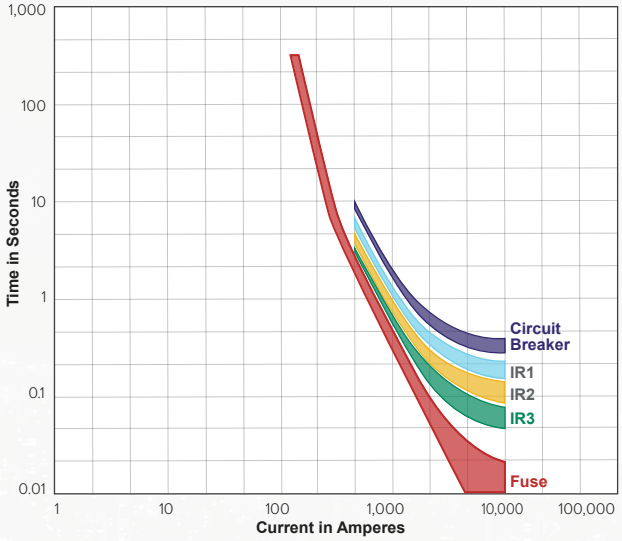



**Figure 9.** TCC curve chart showing how three normally closed IntelliRupter fault interrupters can be uniquely coordinated to achieve heightened segmentation on each radial portion of a loop circuit.

# EXAMPLE: USING INTELLIRUPTER FAULT INTERRUPTERS EXCLUSIVELY FOR LOOP RESTORATION


| Description | Diagram |
|---|---|
| **#1.** A fault occurs, causing IntelliRupter 2 to trip open and lock out. |  |
| **#2.** IntelliRupter 3 opens upon loss of voltage from Substation 1. |  |
| **#3.** Normally open tie point IntelliRupter 4 detects loss of voltage from Substation 1 while sensing normal voltage from Substation 2. This triggers the device to begin a low-energy PulseClosing Technology sequence in the direction of Substation 1 to begin restoration. |  |
| **#4.** After determining no fault is present, IntelliRupter 4 closes. |  |



**Figure 10.** Several IntelliRupter fault interrupters provide a high level of segmentation to a looped circuit and restore power to unfaulted segments.

**RESULT:** 250 customers in the unfaulted segment of line between IntelliRupter 3 and normally open tie point IntelliRupter 4 have their power automatically restored with no human intervention required. This leaves only the 250 customers in the faulted feeder section out of power.

| | Closed | Open | Testing |
|---|---|---|---|
| **Device Key:** |  |  |  |
| **Segment Key:** | With Power | Without Power | Being Tested |

Individually coordinating these IntelliRupter fault interrupters, instead of using shared TCC curve settings, spares some customers from momentary outages during the fault-isolation process.

# THREE-STEP SETUP

Straightforward protection setup, advanced coordination capabilities, and integrated simultaneously active bidirectional protection optimize the IntelliRupter fault interrupter for automatic loop restoration. Because the logic required for this application is inherent to the device, set-up requires just three steps.

**⚠ WARNING**

This guidebook is not a replacement for the requisite training and safety procedures for this product. Read S&C Instruction Sheet 766-530 thoroughly and carefully before installing and operating an IntelliRupter fault interrupter. Failure to have adequate training and understanding of these instructions may lead to serious injury or death.

# STEP 1: DIRECTIONALITY

*(INTELLILINK SOFTWARE NAVIGATION: SETUP > GENERAL > SITE-RELATED)*

Because loop restoration requires a normally open IntelliRupter fault interrupter feedable from either source (i.e., two different directions), utilities can program different protection settings based on the direction of power flow. This is important even for normally closed IntelliRupter fault interrupters in a loop-restoration scheme because these devices can be energized from their alternate source (i.e., the opposite direction) when the system is alternately configured during fault events.

The first step in programming directional protection settings for an IntelliRupter fault interrupter is knowing how the device was installed on the feeder, meaning which direction the X and Y terminals are facing in relation to the normal versus alternate source for the device. When this is determined, navigate to the ***Setup > General > Site-Related*** tab of the IntelliLink® Setup Software.

To distinguish between directional protection settings in the IntelliLink software, the directions are labeled Direction 1 and Direction 2 under each protection element for all IntelliRupter fault interrupters. They are not labeled as “preferred” and “alternate” directions because such terms don’t apply to normally open devices. On the ***Site-Related*** tab of the IntelliLink software, under “System Settings,” select the ***Direction 1/Direction 2*** drop-down option, which aligns with the orientation of the IntelliRupter fault interrupter’s terminals on the feeder so Direction 1 responds to power flow to the X terminal and Direction 2 responds to power flow to the Y terminal (Direction 1/Direction 2 = X/Y), or vice versa. See Figure 11.

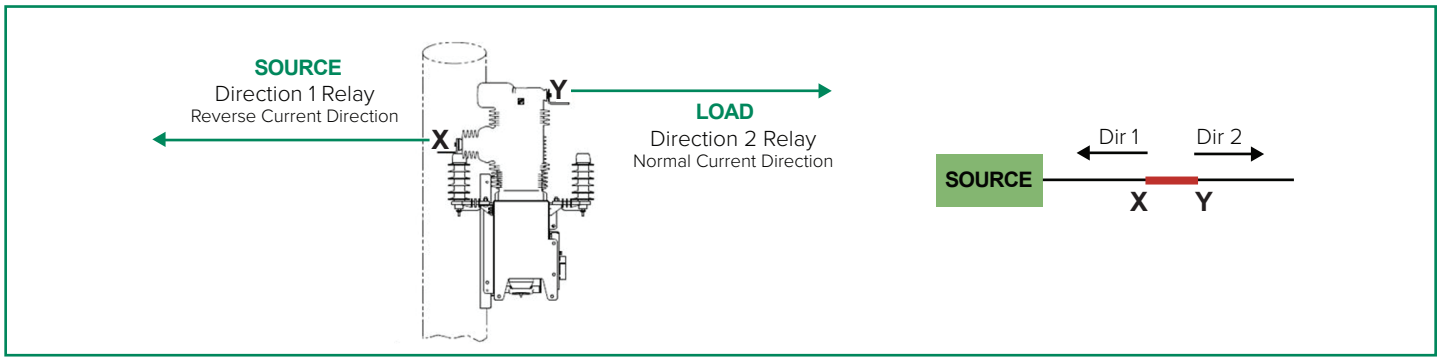


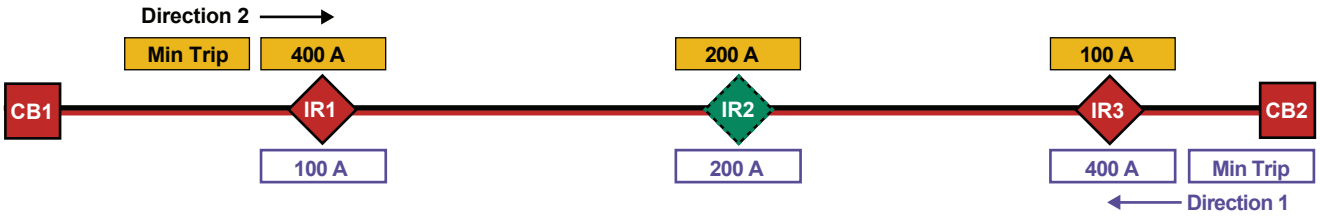

**Figure 11.** A schematic drawing (left) and a line diagram (right) show the correlation between the physical orientation of an installed IntelliRupter fault interrupter and the IntelliLink software directionality settings when left at the default of Dir 1/Dir 2 = X/Y.

When this setting is left at the default (Direction 1/Direction 2 = X/Y), the IntelliRupter fault interrupter will apply **Direction 2** protection settings when power is flowing from the X terminal to the Y terminal. Likewise, it will apply the **Direction 1** protection settings when power is flowing from the Y terminal to the X terminal.

If the physical orientation of a normally closed IntelliRupter fault interrupter is the X terminal facing your designated “normal” source and the Y terminal facing the “alternate” source, then IntelliLink **Direction 2** protection settings will be applied if a fault occurs when the system is in its normal configuration [normal power flow from preferred source (X to Y)]. Conversely, the IntelliLink **Direction 1** protection settings will be applied when the system is alternately configured and the IntelliRupter fault interrupter is being energized by the alternate source (Y to X).

# STEP 1 (CONT.): EXAMPLE AND SETUP TIPS

Figure 12 describes how utilities can apply directionality settings to a simple loop circuit composed of three IntelliRupter fault interrupters.



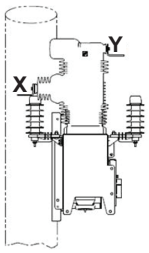
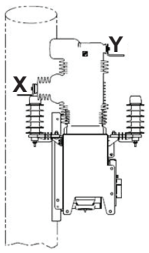
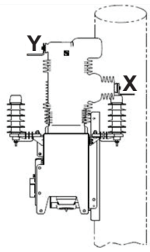

| | IR1 | IR2 | IR3 |
|---|---|---|---|
| **Normal State** | Closed | Open | Closed |
| **Physical Orientation** |  X terminal faces Substation 1 |  X terminal faces Substation 1 |  X terminal faces Substation 2 |
| **IntelliLink Dir 1/Dir 2=** | X/Y | X/Y | Y/X |

**Figure 12.** A line diagram accompanied by a chart displaying the normal state, physical orientation, and IntelliLink software directionality settings for three IntelliRupter fault interrupters on a loop circuit.

**NOTICE**

Settings provided are for the purposes of this example only; always conduct the proper protection and coordination studies to determine the minimum trip settings that apply to your specific system.

# STEP 1 (CONT.): EXAMPLE AND SETUP TIPS

## DIRECTIONALITY SETUP TIPS

**Maintaining Consistency for Ease of Coordination.** For all IntelliRupter fault interrupters on the same feeder, be consistent with which direction (1 or 2) is for normal power flow as opposed to alternate power flow. This allows you to easily compare or adjust protection settings across all IntelliRupter fault interrupters on the feeder.

**Fixing Incorrect Field Installation.** If your line crews accidentally install an IntelliRupter fault interrupter with the opposite orientation as intended in the field (with the Y terminal facing the preferred source, rather than the alternate), don't worry. You don't have to reinstall the IntelliRupter fault interrupter on the pole or switch all the protection settings. Simply change the Direction 1/Direction 2 selection on the ***Setup > General > Site-Related*** tab of the IntelliLink software to Y/X instead of the default X/Y.

**Programming First Device Outside the Substation.** When using IntelliTeam® SG Automatic Restoration System software, the first IntelliRupter fault interrupter outside the substation must have its source side set as Direction 1 (i.e., if the X terminal faces the source, set Direction 1/Direction 2 = X/Y). That said, consider adopting this as a best practice for the first IntelliRupter fault interrupter outside the substation of any loop-restoration scheme. This way, if you choose to use IntelliTeam SG system software later in your grid-modernization journey, you can avoid re-programming protection settings and streamline your implementation of communication-enhanced automatic loop restoration.

# STEP 2: PROTECTION PROFILES

*(INTELLILINK SOFTWARE NAVIGATION: SETUP > PROTECTION PROFILES – INITIAL TRIP)*

Utilities should program protection profiles for devices in a loop-restoration scheme the same as a radial circuit but consider the appropriate settings for both the normal state of the device and when the device is powered by its alternate source.

Below are the three profiles that must be configured with appropriate overcurrent and voltage-protection settings for all IntelliRupter fault interrupters in a loop scheme:

**GENERAL PROFILE 1.** General profiles contain the IntelliRupter fault interrupter's protection settings. Utilities can set up protection for phase, ground, negative sequence, and sensitive earth for both directions. They can also configure TCC curve coordination, voltage, frequency, and sectionalizing settings. Several additional features, including the PulseFinding technique, are also set up within general profiles.

**CLOSING PROFILE 1.** Closing profiles determine how an IntelliRupter fault interrupter will test, close, or lock out in response to feeder conditions. Utilities can configure closing profiles for phase, ground, negative sequence, and sensitive earth in both directions. They can also configure voltage and frequency settings for individual phases and three-phase tripping.

**HOT LINE TAG.** This feature provides more sensitive overcurrent protection settings and blocks test operations or close commands while line crews are working on a hot line.

### PROTECTION SETUP TIP

In a loop-restoration scheme where an IntelliRupter fault interrupter's settings for Direction 1 and Direction 2 are different, which is most often the case, utilities should not use instantaneous protection. This can result in the IntelliRupter fault interrupter tripping in the wrong direction because the device requires one cycle to determine current direction. Instead, they should apply a minimum response or definite time greater than two cycles to provide the IntelliRupter fault interrupter enough time to determine the direction of fault current before tripping.

### *NOTICE*

If you're going to alternately configure your system by opening and closing various switches, make sure to consider the ratings of conductors, switches, regulators, and other assets to avoid overloading equipment and to ensure your system will remain properly protected.

For more in-depth protection setup information, please reference S&C *Instruction Sheet 766-530*.

# STEP 3: LOOP RESTORATION

*(INTELLILINK SOFTWARE NAVIGATION: SETUP > RESTORATION > LOOP)*

When configuring automatic loop restoration for a simple loop circuit—one with a single fault-testing device between the normally open device and each source—you only need to configure loop restoration in the normally open IntelliRupter fault interrupter.

For loop circuits with segmentation beyond one midline fault-testing device per radial portion of the circuit, utilities can configure all normally closed IntelliRupter fault interrupters for loop restoration. During fault events, this allows the devices to incrementally restore power to unfaulted segments after the normally open device has been closed to provide power from the alternate source.

**NOTICE**

All protection settings must be programmed *before* enabling loop restoration or adjusting loop-restoration settings.

For in-depth protection and coordination instructions, please see the "Loop Restoration" section of the IntelliRupter Fault Interrupter Protection and Communication Setup document (*S&C Instruction Sheet 766-530*).

## KEY SETTINGS

1. **Enable:** Set the applicable general profile(s) to "Enabled" for loop restoration. This will make the following settings available for configuration.
2. **Direction:** When loop restoration has been enabled, select whether an IntelliRupter fault interrupter should respond only in Direction 1, only in Direction 2, or in both directions.

   **Additional Consideration:** While most IntelliRupter fault interrupters in a loop-restoration scheme are typically set to respond in both directions, there are special considerations for the IntelliRupter fault interrupter closest to each source. Often these are set to respond only in the normal direction, and not the alternate, to avoid fault-testing into the substation circuit breaker.
3. **Normal State**

   **Closed:** The **Normally Closed** state is for all IntelliRupter fault interrupters on the feeder that will not serve as the normally open tie point.

   **Open:** The **Normally Open** state is for an IntelliRupter fault interrupter serving as the tie point between two feeders.
4. **Protection:** Choose between "Voltage Trip" or "Sectionalizing Element" for triggering loop-restoration logic. This parameter is only available when an IntelliRupter fault interrupter has **Loop Restoration** mode enabled and has been set to a **Normally Closed** state.

   **Voltage Trip:** This option is usually selected.

   **Sectionalizing Element:** This option is used for IntelliRupter fault interrupters closest to the source when the source's substation circuit breaker does not have loss-of-voltage tripping. This prevents backfeeding the substation and transmission system during outage events.

# STEP 3: LOOP RESTORATION (CONT.)

*(INTELLILINK SOFTWARE NAVIGATION: SETUP > RESTORATION > LOOP)*

5. **Open-Source Sectionalizing:** When a normally closed IntelliRupter fault interrupter senses loss of voltage for a pre-specified period of time, the device will open based on this selection. This setting ensures all normally closed IntelliRupter fault interrupters necessary for proper fault isolation (and restoration using an alternate configuration) will open in response to a fault, even if they do not sense an overcurrent event.

   **Yes:** The IntelliRupter fault interrupter will open on all loss-of-voltage conditions.

   **Loops Only:** The IntelliRupter fault interrupter will only open when its **Loss of Voltage** timer expires and **Loop Restoration** mode is in the **Ready** state. This is the most common selection among utilities operating an automatic loop scheme without communications.

   **Additional Consideration:** If a loop circuit has a level of segmentation greater than one midline fault-testing device per radial portion of the circuit, all normally closed devices must be configured to isolate from the fault using loss-of-voltage settings. The normally closed devices' time to open on loss of voltage must be less than the normally open device's time to close.

6. **Time Delay Before First Test:** This setting determines how long a normally open IntelliRupter fault interrupter will wait before starting use of PulseClosing Technology or a closing sequence following a Loss of Voltage event. This setting must be a longer hold time than the time for all upstream device(s) to open following loss of voltage.

7. **Max Time Allowed for Restoration:** This setting allows utilities to designate how long it should take IntelliRupter fault interrupters to restore the circuit following a fault event. If restoration is not complete by this time, **Loop Restoration** mode will automatically disable. Protection elements will remain active, except those designated as "Loops Only."

**DON'T FORGET!**

After applying all these settings, an IntelliRupter fault interrupter's "mode of operation" must also be set to "Loop" for loop restoration to be active. To change the mode of operation of an IntelliRupter fault interrupter, navigate to the Setup > General > Site-Related screen of the IntelliLink software.

Utilities can verify **Loop Restoration** mode is active by navigating to the IntelliLink software's Operation screen. The Loop Restoration field should show a **Ready** state.

**WHAT IF WE NEED TO DISABLE LOOP RESTORATION?**

There are times when loop restoration will need to be disabled, such as planned switching events or when line crews will be completing repair work on the feeder.

To disable loop restoration: Within the IntelliLink software, turn the mode of operation from **Loop** to **Radial** for all devices in the loop-restoration scheme. When line crews are will be present, the Hot Line Tag must also be applied to all devices in the loop scheme to disable loop restoration. When the system returns to its normal state, mode of operation should be returned to **Loop**, and the Hot Line Tag should be disabled for all devices in the loop scheme.

# CONCLUSION

Utilities turning the radial feeders on their system into loop circuits can see dramatic reliability improvements. However, the ease and reliability benefits of this solution ultimately depend on the devices chosen.

The integrated simultaneously active bidirectional protection unique to S&C's IntelliRupter fault interrupter optimizes automatic loop restoration and makes it easy to implement. With no communications or custom protection logic required, IntelliRupter fault interrupters reduce the financial and engineering effort required for automatic loop restoration while maximizing reliability benefits.

To learn more about S&C's loop restoration and discover other unique applications of the IntelliRupter fault interrupter, visit *sandc.com/intellirupter*.

# NEED HELP?

| RESOURCE | DESCRIPTION | HOW TO ACCESS | RECOMMENDED FOR |
|---|---|---|---|
| General Training | Led by our application engineering team, S&C's *Distribution Automation Workshop:* IntelliRupter® Fault Interrupter covers a multitude of IntelliRupter Fault Interrupter applications, including a live demo of the PulseFinding technique, and places emphasis on hands-on learning exercises. | Visit *sandc.com/workshops* | Engineers |
| Customized Training | For utilities interested in educational resources catered specifically to their system needs, customized training is available on request. | Contact your sales representative | Operations, Line Crews, and Engineers |
| Protection & Coordination Study | For assistance determining parameters and optimal device locations, S&C's Consulting and Analytical Services team is available to conduct personalized protection and coordination studies. | Contact your sales representative | Engineers |
| Configuration Assistance & Hands-On Support | S&C's application engineering and field services teams are available to provide assistance with device settings and operation of IntelliLink software. | Submit a request at *sandc.com/tech-support* or call 1-888-762-1100 and an S&C representative will contact you. | Engineers |

For additional resources on S&C's IntelliRupter fault interrupter, such as installation and operation videos, product specifications, technical literature, utility case studies and more, visit *sandc.com/intellirupter.*

**CONTACT YOUR S&C REPRESENTATIVE FOR INFORMATION**

Learn more at sandc.com/intellirupter

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