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APPLICATION
GUIDE

PROTECT UNDERGROUND CIRCUITS

WITH THE INTELLIRUPTER® PULSECLOSER® FAULT INTERRUPTER

INTRODUCTION

Weather has become more severe and frequent, and utilities are undergrounding lines to harden the grid and improve resilience. As the grid sees an increase in circuits with underground lines, utilities face a challenge of how to best protect them and maximize reliability.

MISCONCEPTIONS ABOUT UNDERGROUND CIRCUITS

Debunk the common misconceptions about underground circuits before you determine your protection strategy.

1. Undergrounding is more expensive than maintaining existing overhead lines.

Storms are becoming more frequent and severe. The cost to rebuild the grid after each storm can exceed the cost of undergrounding.

2. Temporary faults don't occur on underground lines.

Some utilities say up to 30% of underground faults on their systems are temporary, such as when animals creep near cables or into gear. Without fault-testing devices, these temporary issues create sustained outages.

3. Configuring protection devices for underground circuits is too complex.

Modern devices have flexible settings and built-in sensing capabilities to easily protect underground circuits. This technology can modernize any circuit and the increasingly complex grid with few or no settings changes.

4. Avoiding reclosing on underground circuits helps protect lines.

Utilities shy away from high-stress reclosers to minimize potential damage to cables. This leaves circuits unprotected or means that temporary faults will create an outage for the entire circuit. However, low-stress fault-testing makes it possible to fault-test on any line—whether it's underground or overhead.

THE PARADOX: OVERHEAD AND UNDERGROUND CIRCUIT PROTECTION

The protection philosophies for overhead and underground distribution systems contradict. This gives utilities a tough choice: fault-test and risk system damage or accept outages that could be avoided.

OVERHEAD
Reclosers and fuses interrupt faults on feeders to mitigate or minimize outages. Reclosers' high-stress fault-testing can damage cables and other assets.

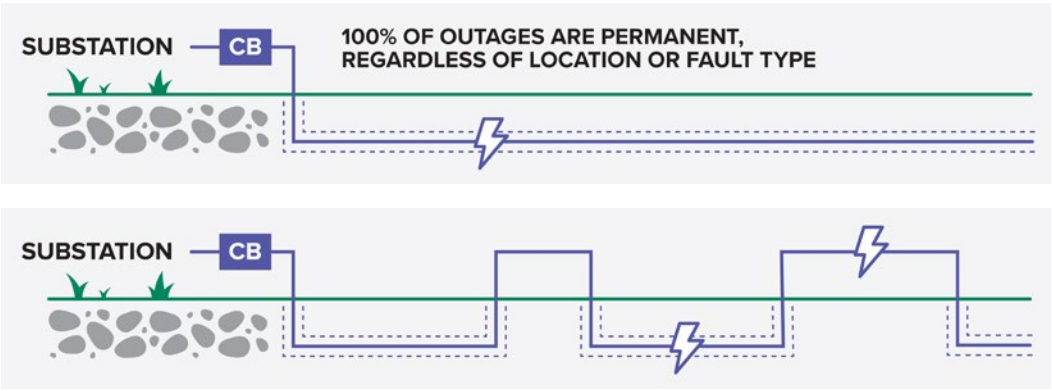
The protection schemes of these two circuits are designed to solve different problems and don't work well together.

UNDERGROUND
Pad-mounted gear distributes power. It is often used for sectionalizing, but not for fault interruption.

AN UNFORTUNATE COMPROMISE

Faced with protection trade-offs, many utilities choose the one-shot-to-lockout approach. When a fault occurs, the substation circuit breaker immediately opens and locks out. Underground lines are not exposed to high-stress fault-testing, but all customers on the circuit see a sustained outage, regardless of the fault location or whether it was temporary.

EXAMPLES OF TROUBLESOME CIRCUITS TO PROTECT



KEY CB SUBSTATION CIRCUIT BREAKER FAULT

THE SOLUTION: THE INTELLIRUPTER® PULSECLOSER® FAULT INTERRUPTER

S&C's IntelliRupter® fault interrupter eliminates the one-shot-to-lockout approach. Using PulseClosing® Technology, it tests for faults with 95% less energy than reclosers. This low-stress method mitigates damage, making it a universal protection solution for any circuit.

The device can also segment lines better than conventional reclosers and reroute power with its simultaneous bi-directional sensing. This isolates outages to the smallest segment possible. The device's time-current characteristic (TCC) curves are 80% more accurate than reclosers, so more of them can be installed to maximize segmentation.

PRODUCT INSTALLATION STYLES

Non-disconnect style

Disconnect style

Pad-mounted style

ADVANTAGES

Protect any circuit type

Mitigate outages

Improve segmentation

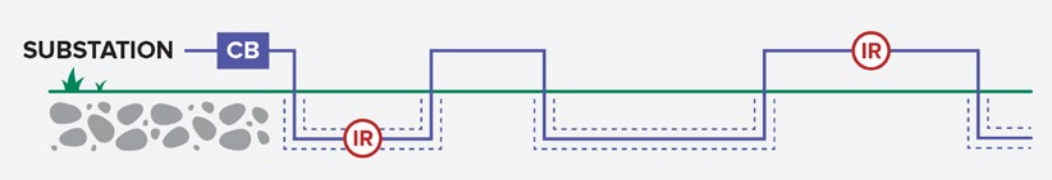
No new settings or complex logic

Low-stress fault-testing

COMMON APPLICATIONS

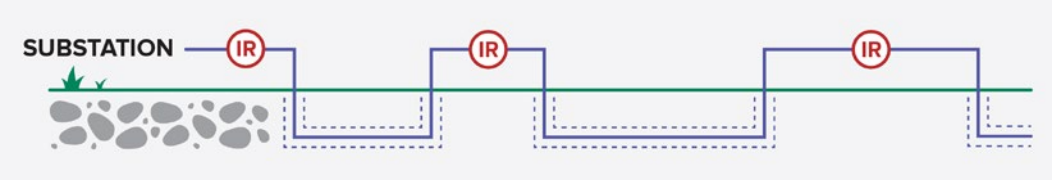
The IntelliRupter fault interrupter provides a universal protection strategy for all circuit types. The device's flexibility and installation styles make it ideal for any application. Here are a few examples of common circuits where utilities can apply IntelliRupter fault interrupters:

APPLICATION ONE: OVERHEAD AND UNDERGROUND CIRCUIT PROTECTION WITH OVERHEAD AND PAD-MOUNTED DEVICES



Every IntelliRupter fault interrupter is configured with the same testing sequence, regardless of installation style. The pad- or pole-mounted style versions will follow the same test pattern using low-stress fault-testing.

APPLICATION TWO: OVERHEAD AND UNDERGROUND CIRCUIT PROTECTION WITH ALL-OVERHEAD DEVICES



Increase segmentation with the IntelliRupter fault interrupter's highly accurate sensing, which allows more devices to be coordinated in series. This is helpful if there is no room for pad-mounted gear. Adding a device inside or directly outside substations also reduces stress on substation transformers and optimizes protection for the first segment.

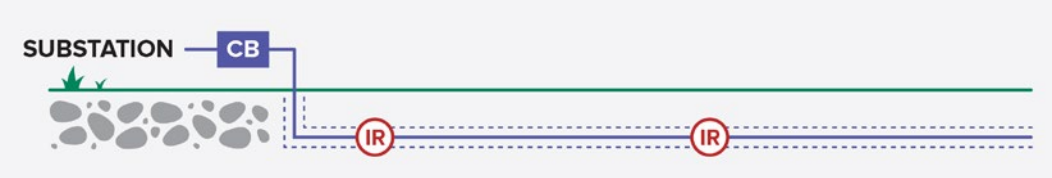
KEY

CB **SUBSTATION CIRCUIT BREAKER**

IR **CLOSED INTELLIRUPTER FAULT INTERRUPTER**

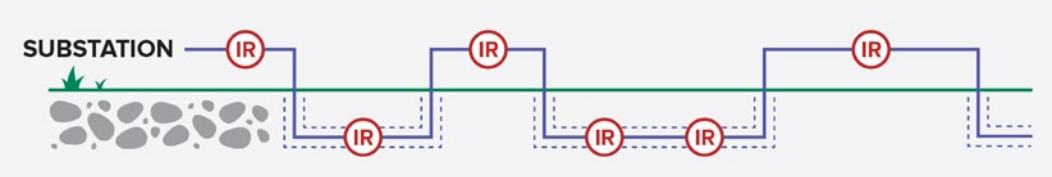
COMMON CIRCUIT APPLICATIONS (CONTINUED)

APPLICATION THREE: UNDERGROUND CIRCUIT PROTECTION WITH ALL PAD-MOUNTED DEVICES



Pad-mounted IntelliRupter fault interrupters can be installed without affecting switchgear already on the system. If a temporary fault occurs on an underground line, the device fault-tests to mitigate an outage. The devices also collect event data to inform line inspections.

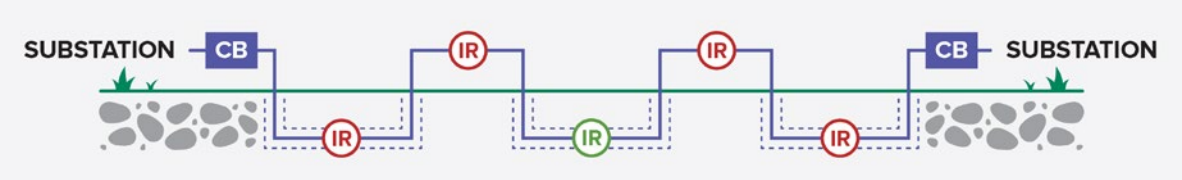
APPLICATION FOUR: UNLIMITED CIRCUIT SEGMENTATION



Overcome coordination limitations with the IntelliRupter fault interrupter's PulseFinding™ Fault Location Technique. This technique "hunts" down faults and isolates faulted segments. Intentionally overlapping TCC curves, this technique allows for an unlimited number of devices on a feeder for unlimited segmentation.

Read more in this application guide: The PulseFinding™ Fault Location Technique.

APPLICATION FIVE: LOOPED CIRCUITS



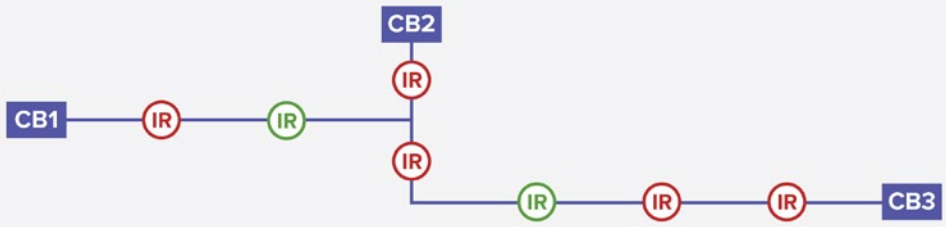
The IntelliRupter fault interrupter's built-in protection logic and simultaneous bi-directional sensing keep outages to the smallest segment possible. In a looped circuit, devices locate and isolate the fault and restore power from an alternate source. This can be done with or without communications.

Read more in this application guide: Automatic Loop Restoration.

KEY	CB SUBSTATION CIRCUIT BREAKER	IR NORMALLY OPEN INTELLIRUPTER FAULT INTERRUPTER	IR CLOSED INTELLIRUPTER FAULT INTERRUPTER

COMMON CIRCUIT APPLICATIONS (CONTINUED)

APPLICATION SIX: ADVANCED RESTORATION



A one-line diagram of an electrical system with three connected lines, each with its own circuit breaker.

Line 1 runs horizontally and contains two IntelliRupter fault interrupters. The device closest to the circuit breaker is closed. The other device is normally open.

Line 2 runs vertically and has two closed IntelliRupter fault interrupters. Line 1 connects to line 2 between the two closed IntelliRupter fault interrupters.

Line 3 runs horizontally and connects to Line 2 downstream of the second IntelliRupter fault interrupter.

Line 3 contains three IntelliRupter fault interrupters. The two closest to circuit breaker 3 are closed. The device furthest from circuit breaker 3 and closest to line 2 is normally open.

S&C's IntelliTeam® SG Automatic Restoration System uses distributed intelligence to isolate faults and restore power on highly complex circuits. Teams of IntelliRupter fault interrupters and other protective devices work together to reroute power in seconds.

KEY

- CB — SUBSTATION CIRCUIT BREAKER
- IR — NORMALLY OPEN INTELLIRUPTER FAULT INTERRUPTER
- IR — CLOSED INTELLIRUPTER FAULT INTERRUPTER

TIPS TO OPTIMIZE YOUR UNDERGROUND SYSTEM

1. Install an overhead IntelliRupter fault interrupter outside substations to manage overhead faults.

An IntelliRupter fault interrupter directly outside a substation relieves circuit breakers from dually protecting substations and feeders. The IntelliRupter device's low-stress fault-testing eliminates the one-shot-to-lockout approach while automatically resolving temporary faults.

2. Deploy fiber-optic networks and distribution automation devices simultaneously with undergrounding to advance the grid.

Although undergrounding, fiber deployment, and distribution automation plans may be considered separate initiatives, completing them simultaneously makes logistics easier and expedites improvements. The IntelliRupter fault interrupter is fiber-ready to advance the grid faster.

3. Use pad-mounted fault interrupters and underground switchgear to maximize reliability.

Overcurrent protection on underground feeders can be challenging to coordinate because underground cables have less impedance while fault currents are high, even at the end of the feeder. Pad-mounted IntelliRupter fault interrupters overcome these coordination challenges with highly accurate sensing and gently test for faults. S&C's **Vista® Underground Distribution Switchgear** also pairs with IntelliRupter fault interrupters to optimize power distribution.

4. Deploy distribution automation devices on feeders and laterals for end-to-end underground fault management.

S&C's **EdgeRestore® Underground Distribution Restoration System** identifies and isolates faults on looped underground residential circuits to reduce high-impact outages. Get comprehensive underground solutions—from feeders to the grid edge—using IntelliRupter fault interrupters and the EdgeRestore system.

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