Protection Zones at the Sub-Transmission Edge

TECHNICAL BRIEF

Applying the Viper®-HV Recloser for Tap Protection, Transmission Corridor Sectionalizing and Localized Fault Isolation on Sub-Transmission Lines

Overview

The Viper-HV recloser allows utilities to add fault detection, interruption, reclosing, and isolation at sub-transmission tap and mid-line locations that have traditionally provided switching only. These locations are typically served by gang-operated air-break switches (GOABs) or motor-operated air-break switches (MOABs), which can isolate a de-energized line but cannot detect a fault or interrupt fault current. Viper-HV recloser converts the location from a switching point into a protected zone, effectively establishing a protection zone without requiring a new substation.

The Protection Problem

Sub-transmission tap points are common sources of reliability exposure on overhead lines up to 72.5kV. The locations are often served by GOAB or MOAB switches, which provide isolation and, in some cases, remote operation. However, these devices do not detect or interrupt fault current, so a fault that originates on a tap is typically cleared upstream at the substation breaker rather than at the tap itself.

A temporary fault on a tap initiates the substation breaker's full reclose sequence, producing a momentary interruption for every customer served from the transmission corridor. A permanent fault results in a sustained outage until the affected tap is identified and isolated through patrol and switching.

In fire-prone areas, open-air arcing during load-break switching can also constrain restoration practices during fire weather conditions, when switching activity itself may need to be limited or avoided.

Protecting the Tap

The Viper-HV recloser changes the tap point from a switching-only location to a protected location. Installed at the tap, the recloser monitors current, detects overcurrent conditions, and interrupts fault current inside sealed vacuum interrupters, establishing a local protection point between the transmission corridor and the downstream tap.

The same protection-zone principle can also be applied inline on the transmission corridor. A mid-line Viper-HV® recloser can sectionalize a long sub-transmission line into independently protected segments, reducing the portion of the line affected by a transmission corridor fault and improving restoration focus after lockout.

This is not a one-for-one replacement of a switching device with a recloser. It introduces protection at a location where none previously existed, moving fault detection and interruption to the tap itself rather than leaving it centralized at the substation. See Figure 1 for an example of this configuration applied to a multi-tap line.

How Localized Protection Zones Work

Defining the protection boundary

A protection zone is created when the device responsible for detecting, interrupting, reclosing, and isolating a fault is placed at a defined electrical boundary. On tapped sub-transmission lines, that boundary may be the tap, where downstream load or substations connect to the transmission corridor. It may also be an inline location on a long transmission corridor where sectionalizing improves reliability and restoration options.

Temporary and Permanent Fault Behavior

For a temporary fault on a protected tap, the Viper-HV recloser detects and interrupts the fault within the zone of protection, then recloses according to the utility's protection philosophy. If the fault clears, the tap is restored while the transmission corridor remains energized. For a permanent fault, the recloser completes the configured sequence and locks out, isolating the affected tap or line segment.

Tap Protection and Transmission Corridor Sectionalizing

Tap protection localizes response to faults on lateral connections, downstream load-serving taps, or remote substation feeds. Transmission corridor sectionalizing applies the same principle to long sub-transmission corridors, dividing the line into independently protected sections to reduce the number of customers affected by a transmission corridor fault.

Viper®-HV Recloser as a Sub-Transmission Protection Terminal

The Viper-HV is a pole-mounted, solid-dielectric recloser rated up to 72.5kV. Magnetically actuated vacuum interrupters, internal current measurement, and voltage sensing make the device a self-contained field platform for protection and automation at selected sub-transmission locations.

At a tap, the recloser becomes the local interrupting and isolation point for the tap protection zone. Inline on the transmission corridor, the recloser becomes a sectionalizing terminal that can isolate a defined line segment. In both cases, placement, reach, timing, reclosing behavior, and lockout behavior should be coordinated with the upstream substation protection philosophy.

System-Level Validation

Conventional transmission protection is built from independently qualified components. Circuit breakers are tested as standalone devices under breaker standards such as IEEE C37.04, C37.06, and C37.09. Protection relays are tested independently under relay-specific standards such as the IEEE C37.90 series. Those standards verify how each component performs on its own, not how the interrupter, control, protection logic, and wiring behave once they are wired together. That combined behavior is usually confirmed late, during site acceptance testing or field commissioning, which is also the most schedule-constrained part of a project.

Viper-HV recloser is engineered, assembled, and validated as one system before it leaves the factory. The interrupter, control, protection logic, and wiring are tested together rather than qualified separately and integrated later. One example of this is Simulated Surge Arrester Operation testing under IEEE C37.60, which applies a simulated lightning-induced surge to the assembled recloser and control and confirms the control does not misoperate and that the system retains full function afterward. This type of system-level validation helps reduce the installation risks that might otherwise be discovered later during site acceptance testing or field commissioning of separately sourced equipment.

This matters most at taps and mid-line locations, which are often remote, difficult to access, and constrained by limited outage windows. Validating the system before shipment moves integration risk out of the field, where a return visit is expensive and slow, and into the factory, where it is not.

Viper®-HV Recloser as an Automation Platform

Beyond protection, the same field device supports remote operability and system visibility. Current, voltage, status, lockout, and fault event data can be integrated into supervisory control and data acquisition systems where required by the utility automation architecture.

When a permanent fault results in lockout, recloser status and fault information can help direct patrol and restoration activity to the affected tap or line segment. The same field platform can also support planned switching, operating practice changes during fire weather conditions, and future automated restoration logic where the application requires remote operation.

Ideal Applications

Viper-HV recloser is well suited to tapped 46kV to 72.5kV sub-transmission lines where lateral faults currently trip the upstream substation breaker. It is especially relevant where taps feed downstream substations, industrial load, critical customer load, or remote load-serving connections, and where local fault isolation can improve reliability performance.

The same architecture applies to long radial sub-transmission trunks, where inline sectionalizing can reduce the portion of the line interrupted by a transmission corridor fault. Corridors with limited field visibility may benefit from current, voltage, status, lockout, and fault event data at selected line locations. Fire weather operating areas may also benefit where utilities are reviewing operating practices that involve open-air switching during restricted conditions.

For reliability improvement projects, the strongest fit is where the utility is targeting momentary interruption performance, sustained interruption performance, restoration focus, and more deterministic response on tapped lines.

Customer Value

The primary benefit of establishing protection zones is keeping tap faults from affecting more of the line than necessary. By limiting interruption exposure to the faulted tap or line segment, utilities may reduce the number of customers affected by fault events and improve system reliability performance.

The Viper-HV recloser also improves restoration focus. Lockout at the recloser provides a confirmed isolated section, allowing crews to respond directly to the affected tap or line segment instead of patrolling a fully de-energized transmission corridor line to locate the fault.

FIELD APPLICATION

A 69kV Line with Four Protected Taps

A utility operates a 69kV radial sub-transmission line that is approximately 52 miles long and serves four downstream substations through lateral taps along the transmission corridor. Each tap represents a point where exposure to faults is introduced onto the line.

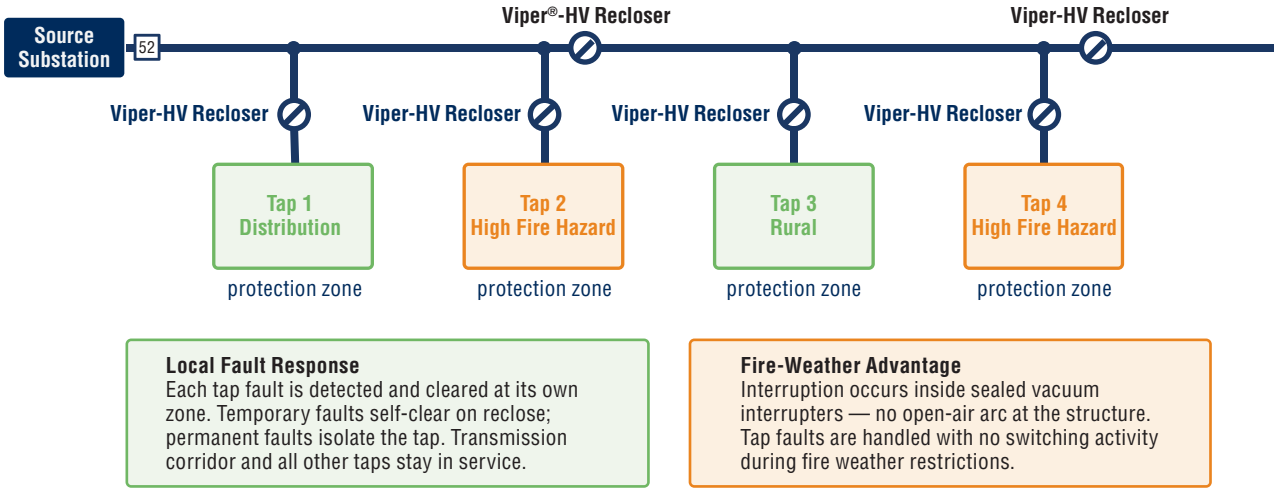
In the prior configuration, these tap points were not protected locations. Faults originating on any tap were detected upstream at the substation, where the protection system responded at the breaker. Temporary faults on lateral taps initiated the full breaker reclose sequence, producing momentary interruptions for all customers on the transmission corridor. Permanent faults resulted in sustained outages until the affected tap was identified and isolated through patrol and switching.

Two of the taps pass through high fire hazard terrain, where operating practices restrict switching activity during fire weather conditions, further extending restoration times when faults occurred under the prior configuration.

Each tap point is converted from a switching location to a protected location through the placement of a Viper®-HV recloser at the tap head, establishing a defined zone of protection at each tap. With protection present at the location, fault detection and interruption occur at the tap rather than at the substation. The system response becomes local to the point of fault rather than applied across the full line. The function introduced at the tap point is not switching. It is fault detection, interruption, and isolation within a defined protection zone.

Distributed Protection — Protection Zones at Every Tap on a 69kV Line

69 kV Radial Sub-Transmission Transmission Corridor — 52 miles, 4 protected taps, 2 sectionalizing points



Distributed protection architecture: fault response applied at the location of exposure rather than centralized at the substation breaker.

Figure 1

Event 1: Temporary Fault on a High Hazard Tap During Fire Weather

A temporary fault occurs on one of the taps during fire weather conditions.

Because the tap point is within a defined protection zone, the fault is detected and cleared locally. Interruption occurs within sealed vacuum interrupters, and the arc is contained entirely within the interrupter. The fault self-clears during the reclosing interval, and service at the tap is restored automatically.

The transmission corridor line remains in service throughout. No system-level interruption is propagated from the event. No switching activity is required at the structure during fire weather conditions, and no exposure of the environment to arc byproducts occurs at the tap location.

Event 2: Permanent Fault on a Rural Tap

A permanent fault occurs on a separate tap because of conductor contact with vegetation.

The fault is detected at the tap location and interrupted within the protection zone. Reclosing attempts confirm the fault remains present, and the tap is isolated from the transmission corridor.

All other portions of the line remain energized. The system response is confined to the faulted section rather than applied to the entire line. Because the faulted tap is already isolated, restoration activity is focused and directed: the location of the event is known, and field response is limited to the affected section.

Reliability and Deployment Value

With protection zones established at each tap, temporary faults are cleared locally without affecting the transmission corridor line, and permanent faults are isolated to the tap where they occur. System-wide interruptions are eliminated for tap-originated events, and restoration activities are directed to a defined and isolated location rather than a full-line patrol. Interruption at the tap occurs within a sealed environment, eliminating external arc exposure at the structure.

Tap points on sub-transmission lines represent where faults can originate, but in typical system configurations they sit outside any protection zone, so fault response is applied upstream at the substation and local events are treated as system-level disturbances. Establishing a protection zone at the tap shifts that response from centralized at the substation to distributed along the line, with fault detection, interruption, and isolation occurring where the fault originates.

This change is the result of placing protection where it does not exist today. For utilities operating tapped sub-transmission lines, establishing protection zones at tap points provides a direct path to improved reliability, reduced operational exposure, and controlled interruption behavior at each point of fault exposure.

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