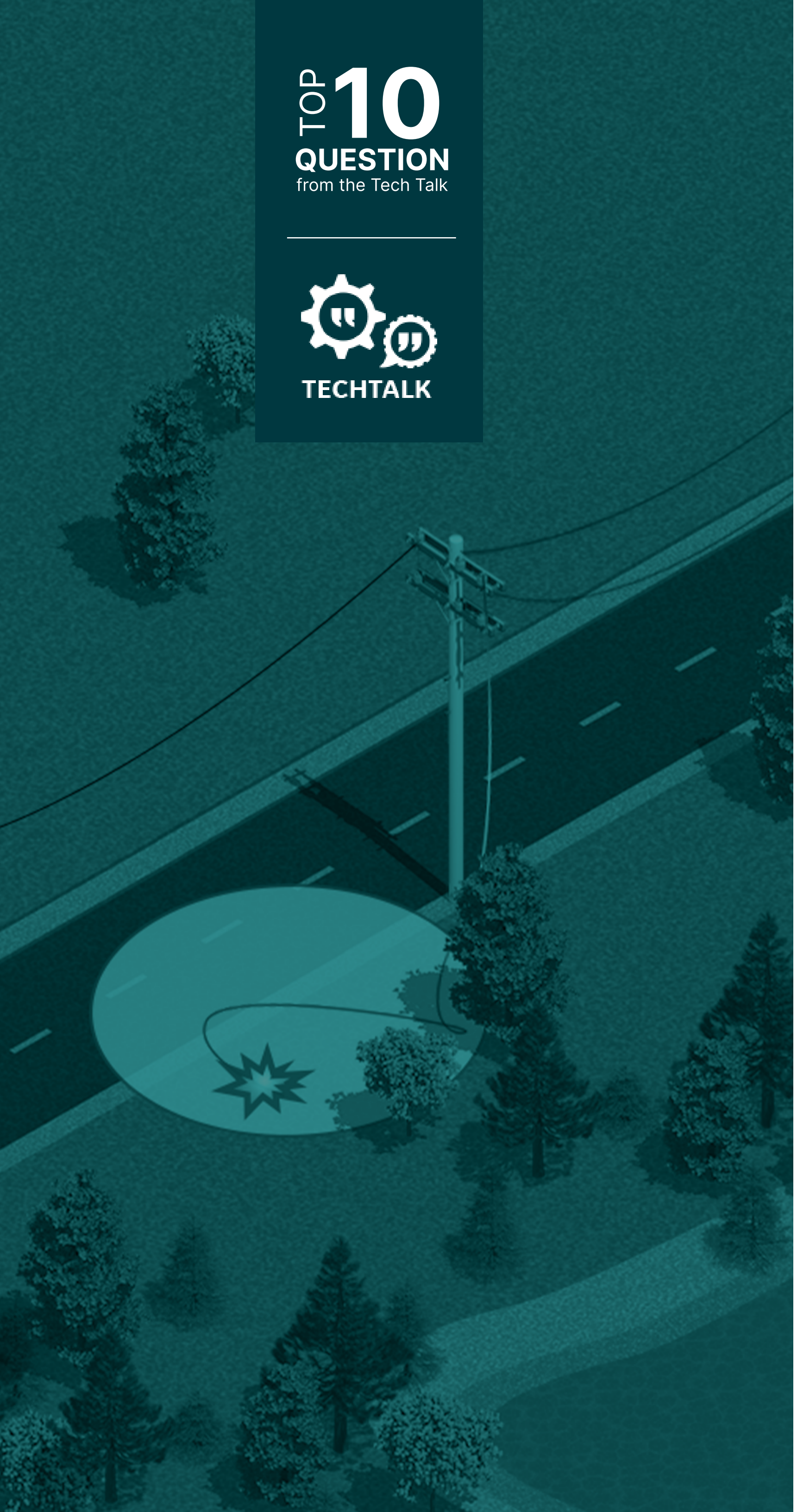

Fire Mitigation Using High-Impedance Fault Protection

In our Tech Talk, **Fire Mitigation Using High-Impedance Fault Protection**, learn how high-impedance fault (HIF) protection senses small currents from conductors lying on the ground and trips the circuit to remove power, reducing the chance of starting a fire. Get a refresher on the most common causes of high-impedance (Hi-Z) faults and techniques for identifying downed conductors. We also cover two arcing-detection methods and implementation strategies including special considerations for fire mitigation, recommendations for specific weather and soil conditions, as well as approaches for alarming and tripping for HIF events.

Need a recap of the webinar Q&A? Scan the top questions and answers from the session...

LET'S GO!

GE VERNOVA

Fire Mitigation Using High-Impedance Fault Protection

QUESTION	ANSWER
Is high-impedance fault (HIF) fire-mitigation protection different from arc-flash protection? What type of protection relay is used?	Yes, fire mitigation on distribution and transmission lines is different from arc-flash protection. Arc flash protection is for switchgear cubicles; we see this in industrial applications as well as utility applications. Both fire-mitigation HIF and arc-flash techniques use arc-detection methods, with arc-flash protection employing light sensing supervised by excess current. A relay with light-sensing inputs like the Multilin 8 Series 850 or the 3 Series 350 is required. HIF protection has similar overcurrent supervision. The relay senses arcing with the special current analysis measures we discussed in the webinar and monitors an overcurrent event to declare a downed conductor. Also, HIF protection supervises a downed-conductor declaration with a loss-of-load event (indicating a broken conductor).
Can this protection be implemented by negative sequence current detection/broken conductor protection?	Negative-sequence current detection is the I2/I1 or the traditional method of detecting a broken conductor; the relay measures the ratio of negative-sequence current, I2, to positive-sequence current, I1. It works on the principle that a broken phase conductor produces unbalanced current, I2. An advantage of this method is that modern, numeric protection relays calculate these sequence components; thus, the method is readily available at the point where the current transformers are applied in the power system. However, unbalance from line loading affects the sensitivity of the I2/I1 method. Typical I2/I1 settings are 0.2 per unit and greater to accommodate for system standing imbalance. Studies show that for a typical pickup setting ratio of 0.2, 50% of the single-phase load is required to drop for the I2/I1 element to assert. For three-terminal lines and distribution lines, there are other factors that affect the I2/I1 ratio measured at a protective relay. These factors include the network impedance, pre-fault load flow, break location, and distributed energy resource (DER) connections. Hi-Z arcing-detection methods work for these situations. A better broken conductor method is high-speed falling conductor protection (HFCP). This method detects an impedance change, which overcomes the limitations of the I2/I1 method. HFCP broken conductor detection senses the falling conductor more reliably and disconnects the line before it touches the ground. HIF (or Hi-Z) is different because it detects an arcing wire on the ground. When combining HIF and HFCP there is a very good probability of preventing a wildfire; both together make a robust wildfire prevention system.
What kind of testing tools are good for HIF detection?	Test HIF detection with COMTRADE file playback. Use a test set that plays COMTRADE files that are both simulated and actual recordings. You can contact your local Technical Application Engineer for these files.

Fire Mitigation Using High-Impedance Fault Protection

QUESTION	ANSWER
What current and time settings are recommended for HIF detection?	Settings for the HIF detection can be tuned for dependability or security, depending on the application. If you are concerned about wildfire prevention, it is best to adjust the settings for more operations and accept possible false alarms/tripping. You can make the settings more sensitive during weather and seasons that are more prone to wildfire, for example. Method F in the Multilin F60 feeder protection relay has arcing level and count-window settings. Among the settings that you can fine-tune is the overall ARCING SENSITIVITY. This establishes the belief-in-arcing confidence level at which the Hi-Z element recognizes arcing and the number of times the algorithm must conform its arcing confidence before it produces an output. The range is 1 to 10, where 10 is the most sensitive and 1 is the least sensitive setting. A larger setting is suitable for a very quiet, well-behaved power system. An initial setting of 5 to 7 is suggested, and you can monitor the Hi-Z element behavior and adjust from there. Other settings are the PHASE EVENT COUNT, the GROUND EVENT COUNT, and the EVENT COUNT TIME window. Hi-Z settings coordinate with the regular overcurrent protection and you can set the time to wait for this protection to operate from 1 second to 200 seconds. Along this same line is the definition of the Phase and Neutral OC minimum pickups, the levels at which the Hi-Z element considers a current to be the regular phase overcurrent and neutral overcurrent elements to operate—the HIF element works well when left at the default of 1.5 pu and 1.0 pu, respectively. You want these greater than the maximum load current for phase overcurrent, and greater than the maximum 3I0 residual current for unbalance loading for the neutral definition. There are rate-of-change settings for phase and neutral HI-Z PHASE RATE OF CHANGE and HI-Z NEUTRAL RATE OF CHANGE. Arcing has a small rate of change of current. An extremely large rate of change indicates a circuit-breaker closing, causing an associated inrush. The inrush current produces substantial variations in the harmonics used by the high-impedance algorithms. Therefore, these algorithms ignore all data for several seconds following a large rate-of-change event that exceeds these settings. Another type of inrush event is energizing a transformer. The Hi-Z element has even-harmonic restraint for this situation. The even-harmonic content is evaluated on each phase current as a percentage of the phase RMS current. It inhibits setting the overcurrent flags if the overcurrent is simply a surge caused by cold-load pickup or other inrush events. Just as we can tune overcurrent and rate of change, the Hi-Z element has a setting to determine what constitutes a loss of load. This is one of the conditions that supervises the “Downed Conductor” output. A loss-of-load flag is set if the Hi-Z algorithms detect a percentage drop in phase current between two successive, two-cycle root mean square (RMS) values that equals or exceeds the loss-of-load threshold. The amount the phase current that must decrease between successive two-cycle RMS values is based on this setting multiplied by the recent average phase current level. The range is 5% to 100%, with 5% being the most sensitive. The Hi-Z element can use voltage to block the loss-of-load flag when there is low voltage on the feeder—this can happen when there is a fault on an adjacent feeder because the drop in line voltage causes a subsequent drop in load current. There is a block time for this setting.

Fire Mitigation Using High-Impedance Fault Protection

QUESTION	ANSWER
What are the voltage levels for arcing fault detection techniques? Are there special CT requirements?	Hi-Z fault detection works at all distribution voltage levels. It is a current-analysis method where the relay evaluates the harmonics and randomness of the arcing current signature. Sensitivity is better when using smaller CT ratios. Hi-Z detection can work at 1200:5 CT ratios, and when using 600:5 and 300:5 ratios, the input signals to the relay are larger, so the sensitivity setting can be reduced.
Does a downed conductor have to be arcing for the HIF systems to sense it is on the ground?	Yes, these Hi-Z methods must have arcing input to sense if a conductor is on the ground. That is why there are advantages to employing both HFCP and high impedance "fallen" conductor protection in areas prone to wildfire.
How is the location of downed conductors determined?	The location of a downed conductor is nearby the installed HIF relay. Sensitivity is sufficient to locate the downed conductor within a few spans.
What is the cost of relays that include HIF protection?	The cost of implementing HIF is small. It is available in both the Method P, the Agile P14DZ, and in the Method F Multilin UR F60 relays. The hardware/relay cost is in line with regular protection relay prices. Note that you need one for each feeder. For installations with an existing F60 feeder relay you simply add the 8Z module. It is also important to consider the cost of engineering, settings, and commissioning. All in all, the cost is small compared to the damage and cost caused by a potential wildfire.
Will HIF protection be effective for detecting downed conductors on dry concreted aprons? Can safety be improved by including an area mat below the concrete apron?	Installing a grounding mat is one of the physical methods some have used in conjunction with regular overcurrent elements. It would give more arcing input which would help build arcing confidence for the Hi-Z methods. However, the cost of doing this can be prohibitive. Pavement concrete has steel reinforcing bars that are excellent conductors. HIF works well on concrete pavement because of conduction through the "rebar."
How long does it take for the HIF to operate? What is the learning period for the F60 load-subtraction algorithm?	Fault response time is at least one second, which is the minimum coordination time to allow the regular overcurrent elements to operate. The HIF algorithms are adaptive in nature. Internal thresholds adapt gradually to background noise on circuits with a moderate to large level of transient activity. In particular, for the F60 algorithm that subtracts learned system noise, the relay might identify some regular system noise and operate in the first three to five days after installation (or after being out-of-service for a significant period). It is important to take this into account when responding to alarms during the initial installation period.

GE VERNOVA

For more information, visit
gevernova.com/grid-solutions

FOLLOW US

GEA-N50668
English
250924