Detected!

A vote of confidence for ABB's high impedance fault detection system

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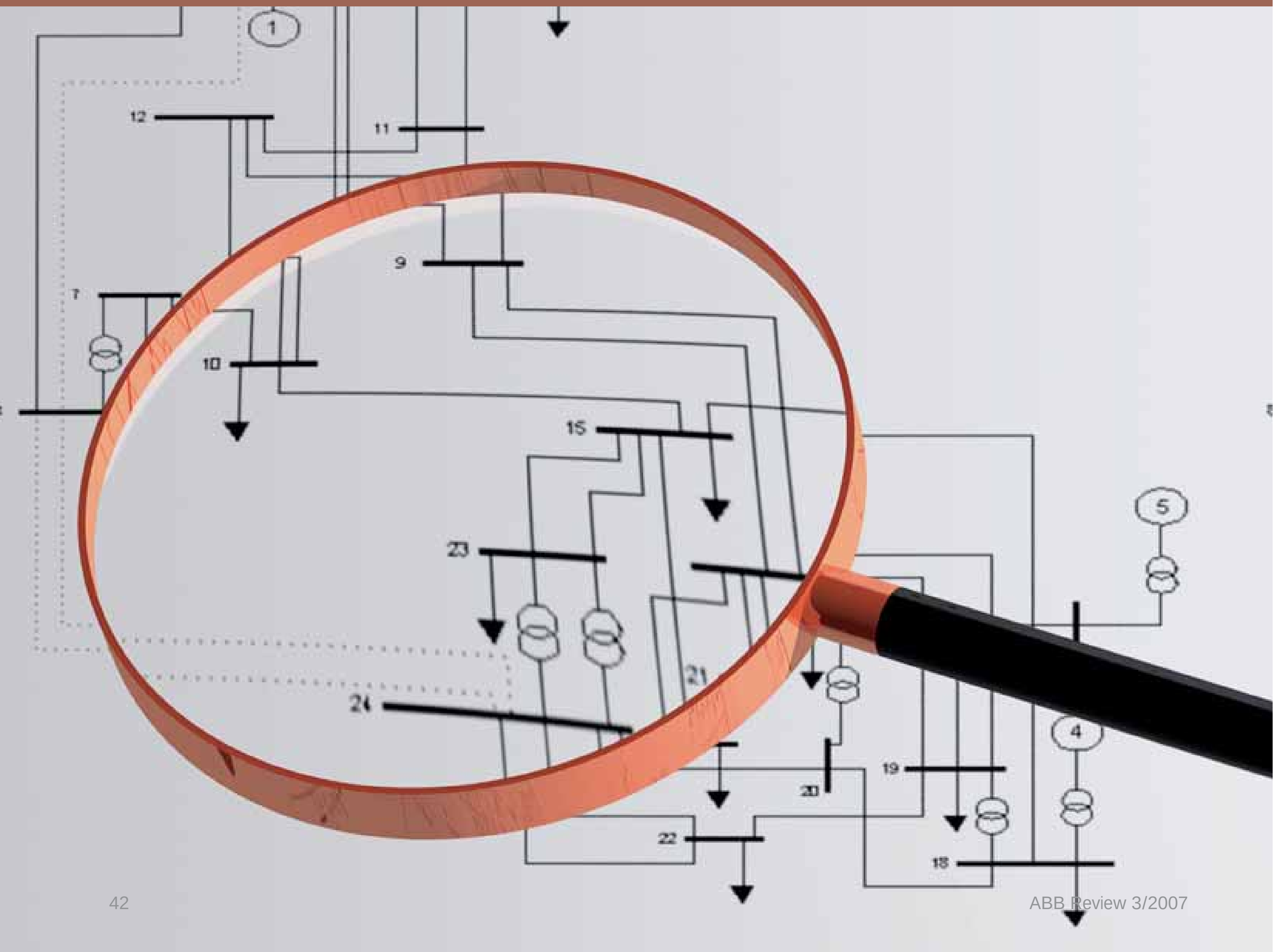
They are practically invisible to conventional fault detection methods, are dangerous to the unsuspecting public and have created unique challenges for many a protection engineer. However, the days where high-impedance faults evaded complete detection are now numbered or are even over thanks to an innovative high-impedance fault detection system from ABB. Known as *HIF Detect™*, it uses a multi-algorithm approach to identify downed conductors on soil, gravel, concrete, sand and other surfaces. Not only does it increase overall electrical system safety, but it also offers improved system reliability through better outage management control.



Most of the faults on power systems result in a substantial increase in current flow towards the fault point and conventional overcurrent protection schemes are used to detect and protect against these “low impedance” faults. High impedance faults (HIFs), on the other hand, do not produce enough detectable fault current to trigger conventional overcurrent relays or fuses 1. A high impedance ground fault results when a primary conductor makes unwanted electrical contact with a non-conducting foreign object, for example overgrown vegetation, a road surface or a sidewalk, to name a few. In general, HIFs do not threaten power system equipment, but an energized conductor on the ground surface is a serious public safety hazard. Non-conducting objects present high electrical impedances therefore allowing only small amounts of current through them. So, as far as conventional protection schemes are concerned, there isn’t a problem.

High impedance faults (HIFs) do not produce enough detectable fault current to trigger conventional overcurrent relays or fuses.

Two characteristics of HIFs are the low fault currents and arcing. Typical HIF currents on a distribution system can range anywhere from zero amperes for contact with asphalt and dry sand to 50 A for contact with wet grass or 75 A for contact with reinforced concrete [1]. Arcing is the result of air gaps due to the poor contact made with the ground or a grounded object and can start fires. Also, there may be air gaps in the ground (soil) or grounded object (concrete, tree, etc.). These air gaps create a high potential over a short distance, and arcing is produced when the air gap breaks down. The sustainable current level in the arc is not sufficient to be reliably detected by conventional means [2].

ABB, under the *Engineered for Safety*™ program, has come up with a HIF detection solution that is now an integral part of its power protection devices, an example of which is shown in 2. This economical and reliable innovation, known as *HIF Detect*™, is the result of years of research and development. Utilities around the globe are enthusiastic about this solution and some have already partnered ABB to test it in a live power system network.

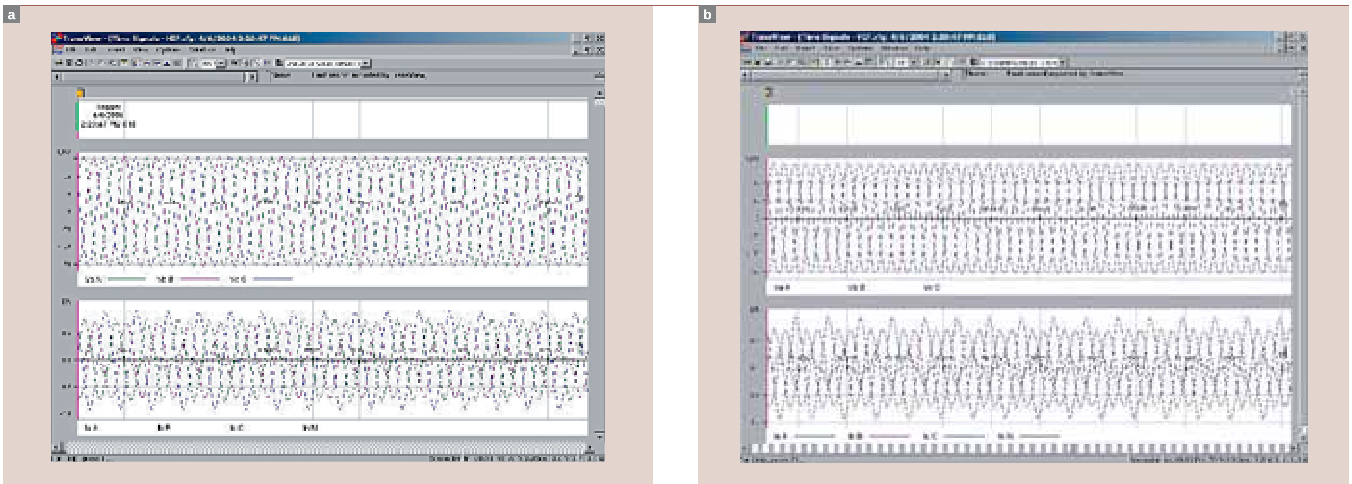
Field tests provided utilities with a welcome opportunity to participate in the testing of a new and innovative technology.

HIF Detect™ system – an overview

A schematic diagram of an electrical power system equipped with ABB’s *HIF Detect*™ system is shown in 3.

HIF Detect™ is based on patented advanced signal processing techniques and includes a multi-algorithm ap-

1 a No-fault voltage and current waveforms and b High Impedance Fault (HIF) voltage and current waveforms



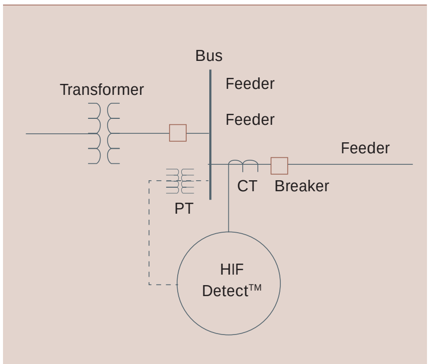
proach. Each algorithm uses various features of ground currents to detect a high-impedance fault. In other words, ground current signatures can be non stationary, temporally volatile, and of various burst durations.

With reference to 4, power system signals are acquired, filtered, and then processed by individual high impedance fault detection algorithms. The individual algorithm outputs are further processed by decision logic[1] to provide the detection decision, ie, whether or not a HIF has occurred.

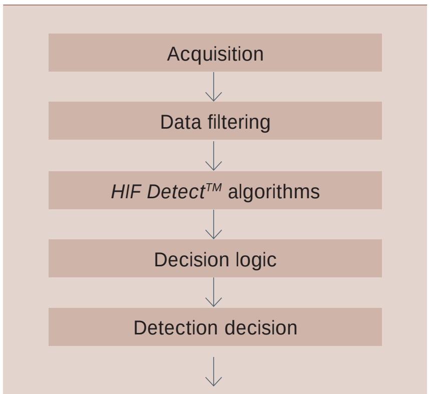
All harmonic and non-harmonic components within the available filter data window can play a vital role in HIF detection. A major challenge is to develop a data model which acknowledges that HIFs could take place at any time within the observation window of the signal, and which could be delayed randomly and attenuated substantially. Such a model is motivated by extensive research, actual experimental observations in the laboratory, field testing, and what traditionally represents an accurate depiction of a non stationary signal with a time dependent spectrum.

2 ABB's REF550 feeder protection device

3 An electrical power system equipped with ABB's *HIF Detect™* system



4 Signal processing in *HIF Detect™*



5 IEDs equipped with *HIF Detect™* and data collection system

As well as being hazardous to the public, HIFs result in service interruptions which reduce system reliability, dependability and continuity.

The proof is in the pudding

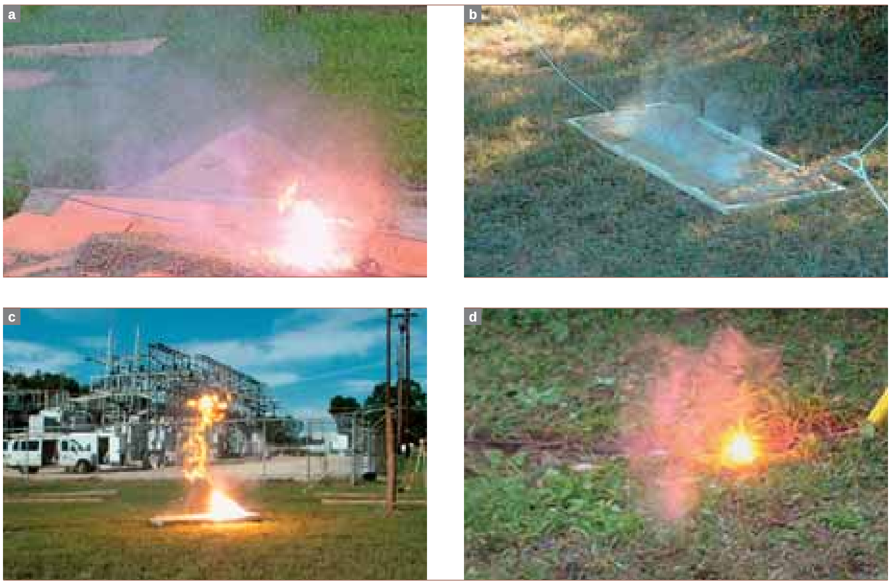
ABB's *HIF Detect™* system has undergone extensive and successful laboratory testing (between 1998 and 2000) producing correct detection rates of around 80 percent while false detection rates remained close to zero. Having completed these tests, the technology was implemented in an embedded platform so that HIF detection could be integrated into Intelligent Electronic Devices (IEDs) used for the protection and control of feeders. In 2002, additional HIF field data was obtained from an independent research laboratory after it conducted its own set of tests in a distribution system. To perform satisfactorily with the laboratory and acquired field data, the implemented *HIF Detect™* system was successfully adapted and modified.

In addition to the IEDs equipped with ABB's *HIF Detect™*, a separate Data Acquisition System (DAS) for HIF field testing was also developed 5. This DAS is independent of the HIF detection units[2] and is based on LabVIEW software from National Instruments.

Footnotes

[1] The decision logic can be modified depending on the application requirement.

[2] The HIF detection units are subject to continuous development and further enhancements.



6 Validation of *HIF Detect™* on gravel a, sand b, concrete c and grass d

DAS assembly and system software development was carried out by ABB.

Field testing of the IEDs was done while collecting data from staged HIF testing, and was conducted together with utilities in North America, Latin America and the Middle East. Using active feeders, the tests were completed without any interruption to the utility concerned or its customers. Testing on various surfaces is shown in 6. *HIF Detect™* successfully detected HIFs on gravel, sand, concrete, soil and grass, and it proved to be very secure when presented with various load conditions that resemble HIF situations. From a utility point of view, these field tests provided a welcome opportunity to participate in the testing of a new and innovative technology that is destined to become the most reliable HIF detection method available.

ABB's High Impedance Fault (HIF) detection solution is now an integral part of its power protection devices.

ABB has implemented *HIF Detect™* as a standard feature in one of its feeder protection devices, the REF550[3]. One of the hallmarks of ABB's solution is its user-friendly design. There are only two settings, the first being the level of security in the HIF detection system. A very intuitive setting, called HIF level, can be set anywhere between 1 (least secure) and 10 (most secure) in steps of 1, with a default setting of 5. The second setting is related to the grounding system; the user can select between a grounded and ungrounded system, with a choice to disable the feature.

Currently field testing of the commercially available unit is continuing.

Safety is the reason

For electric utilities, public safety must always take top priority. However, as well as being hazardous to the public, HIFs result in service interruptions which reduce system reliability, dependability and continuity. Arcing faults result in energy waste and can damage property. Because they have proved evasive in the past, utilities need an economic solution that not only reliably detects them, but also ensures against false detection. Reliable detection can also prevent fires and minimize property damage.

Innovative technology for HIF detection has been developed and proven by ABB with its *HIF Detect™* system and backed up by outstanding results from many field tests.

HIF detection requires a different approach than that for conventional low impedance faults. Innovative technology for HIF detection has been developed and proven by ABB with its *HIF Detect™* system and backed up by the outstanding results from many field tests.

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Footnote

[3] REF550 was released onto the market in January 2005. More information about this device can be found at www.abb.com (May 2007).

References

[1] Stoupis, J., Maharsi, M., Nuqui, R., Kunsman, St. A., Das, Ratan, Ground Alert – reliable detection of high-impedance faults caused by downed conductors, ABB Review 1/2004, pp. 28–31.

[2] Russell, B. D., Benner, C. L., Arcing Fault Detection for Distribution Feeders: Security Assessment in Long Term Field Trials, IEEE Transactions on Power Delivery April 1995 Volume 10, Number 2, pp. 676–683.