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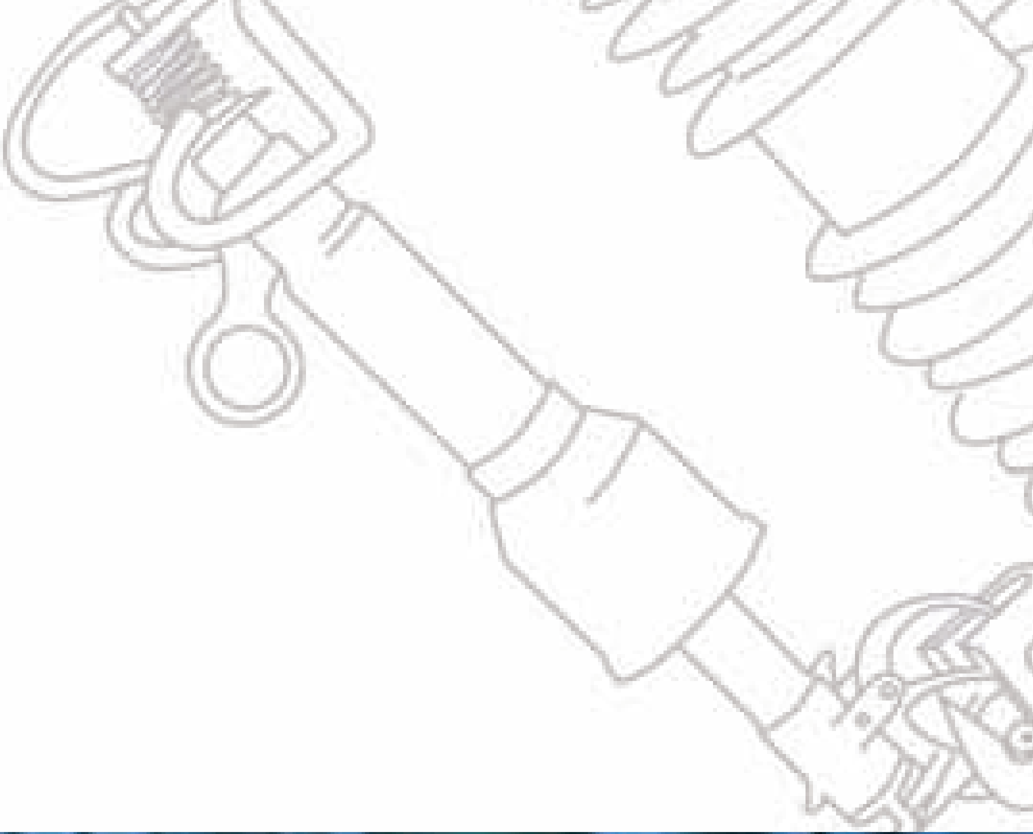

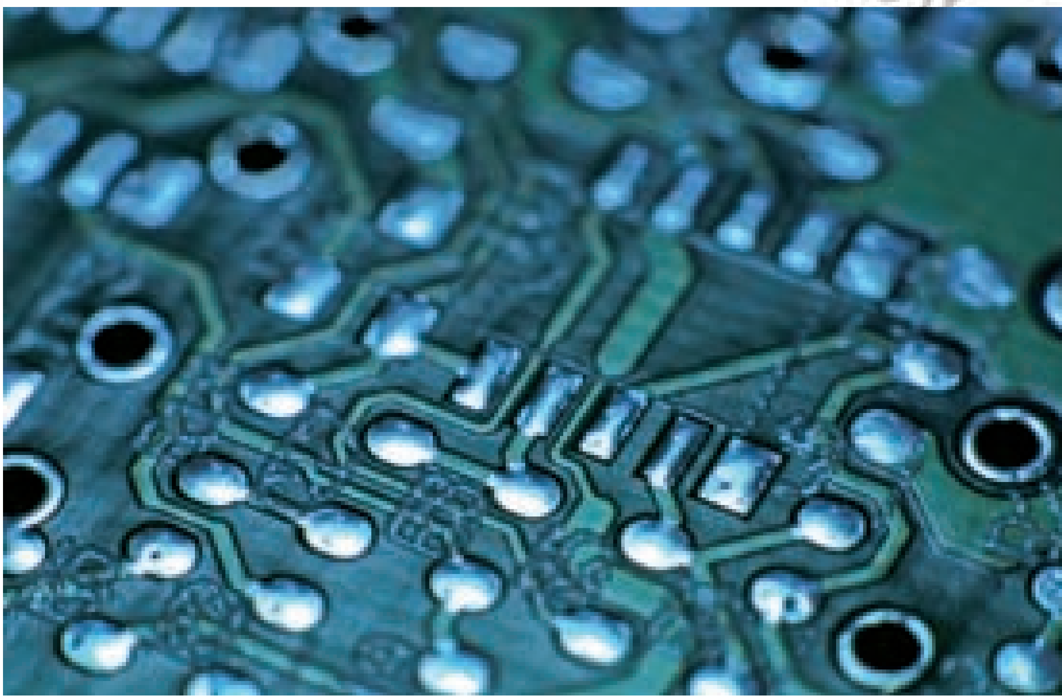

# Automatic Electronic Sectionalizing

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- OPTIMAL ELECTRONIC PROTECTION - NO REPLACEABLE ELEMENTS.
- FULLY COMPATIBLE WITH CERAMIC AND POLIMERIC BASES BY ANY MANUFACTURER.
- SINGLE-POLE AND ELECTRONIC THREE-POLE VERSIONS (NO MECHANICAL JUNCTIONS BETWEEN PHASES).
- REMOTE COMMUNICATION AND DIRECTIONAL FAULT DETECTION CAPABILITIES.

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**The Automatic Electronic Sectionalizer (AES)**: key element for improving service quality and operational profitability

The **AES** discriminates between permanent and temporary faults (faults that are spontaneously cleared without intervention and do not require opening of the line). It has been demonstrated that more than 90% of distribution network faults are self-clearing temporary faults (typically a tree branch short-circuiting one phase to ground and disappearing after the first reclosing operation). Today, these faults lead to fuse blow-up, unnecessarily opening the line and interrupting service, which causes service quality indicators to plummet. The AES is endowed with a local intelligence capable of deciding upon the nature of the fault: it only opens the line and interrupts service when, due to a permanent nature of the fault, this action is absolutely unavoidable.

The **AES** offers real solutions for real problems, generating true value for the users.

**90%**

FAULTS IN DISTRIBUTION NETWORKS ARE **TEMPORARY**

**Economic analysis show that AES cost is balanced in a very SHORT period against fuse replacement cost, energy non-supplied cost, and penalty costs.**

**The AES offers practical solutions to existing problems, both for conventional networks and for the forthcoming smart grids**

**Conventional grids: problems and cost-inefficiency during faults.**

Temporary self-clearing faults account for more than 90% of total faults in distribution electrical networks. These faults clear, without external intervention. In particular, there is no need to permanently trip the faulted line.

Typical examples are tree-branches touching the line, birds bridging insulation between phases (or phase-to-ground), high discharge currents from heavy lightning impulses, or insulation temporary flashover due to propagating overvoltages. None of these events require permanent interruption of supply. Therefore, fuse melting (leading to permanent opening of the line) is a highly inefficient event, implying a high cost due to:

- Labor cost (operators have to locate and replace the fused element)
- Replacement cost (typically the cost of a new fuse element)
- Cost of energy non-supplied during the interruption
- Penalties and reduction in service quality indicators.

## SMART GRIDS AND/OR GRIDS WITH DISTRIBUTED GENERATION: ADDITIONAL SPECIFIC PROBLEMS

Demand for stable and reliable supply

High penetration of distributed generation

Generator stability under voltage dips/sags

**GENERATION MUST BE PRESERVED DURING FAULTS**

Conventional protection schemes must be modified for the sake of:

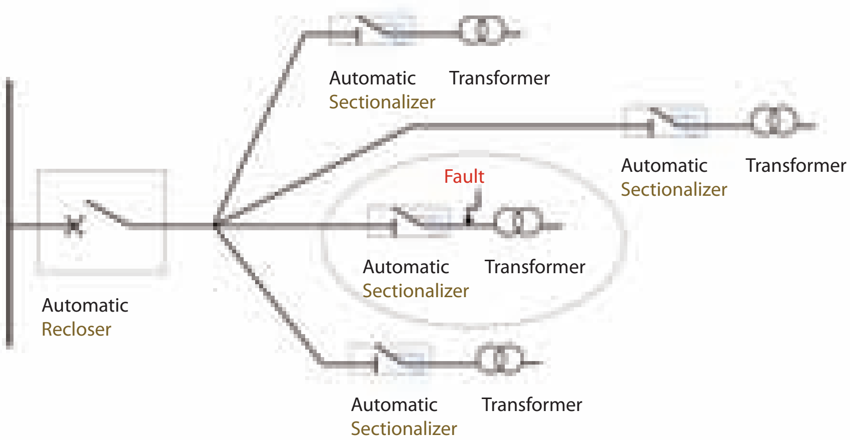
(1) Utilities
(2) Users
(3) Non-conventional Generation owners

GENERATION SHOULD **NOT** BE DISCONNECTED DURING TEMPORARY FAULTS

Advantages:

-Improvement on system safety
-Avoiding generation loss
-Increasing explotation benefits
-Improving service quality

Applying AESs allows for minimizing the disconnecting time of non-conventional generation systems under fault conditions. Disconnection only occurs when unavoidable, due to the existence of a permanent fault. This protection scheme implies relevant savings for the various actors (utilities, owners, and users), as well as relevant improvements in service quality, and grid safety/stability.



## NEW GENERATION OF INAEL AES: PUSHING THE LIMITS OF FUNCTIONALITY AND RELIABILITY

### THREE-PHASE AES WITH RADIO COMMUNICATION SYSTEM: A BREAKTHROUGH IN DISTRIBUTION LINE PROTECTION

### RELIABLE SIMULTANEOUS OPENING OF ALL THREE PHASES UNDER PERMANENT FAULTS

**Functional advantages**

INAEL new AESs, provide new solutions regarding FUNCTIONALITY, EFFICIENCY and RELIABILITY:

- THREE-PHASE operation under permanent faults. All three AESs operate simultaneously and open all htree phases of the circuit. Operation is safe and reliable, without any mechanical interconnections. It is enabled through a radio communication system that is fully EMC immune and has been tested under the most harassing electrothermal conditions. Three-phase models are named SIT and SITI.

- In addition, the SITI model is endowed with a novel local intelligence based on incremental algorithms. This model automatically adapts to the line load, avoiding the need for substitution in case of line repowering or load restructuring

## GSM Module (optional) Communicates line-opening and provides location of opened devices.

**As an option, a GSM module can be added to each three-pole set that allows information transfer towards the central dispatch, communicating an opening signal as well as detailed location of the actuated device. This way, the module enables a faster and more efficient maintenance service.**

**GSM**
communication
WITH CENTRAL
DISPATCH

**The main operational characteristics of INAEL three-phase AESs are:**

**1. THREE-POLE AUTOMATIC SECTIONALIZER.**

- Three phases simultaneous opening (only when the fault us permanent)
- Radio communication system betwen sectionalizers.
- Optional GSM module for communicating the fault to the central control
- Short distance transmission (betwen 5 and 10 meters)
- Eight differents codes to avoid interferences betwen nearby sectionalizers

Conventional AESs have been known to present a number of drawbacks that, on occasion, have prevented widespread use of these devices. These drawbacks are:

**OTHER manufacturers:**

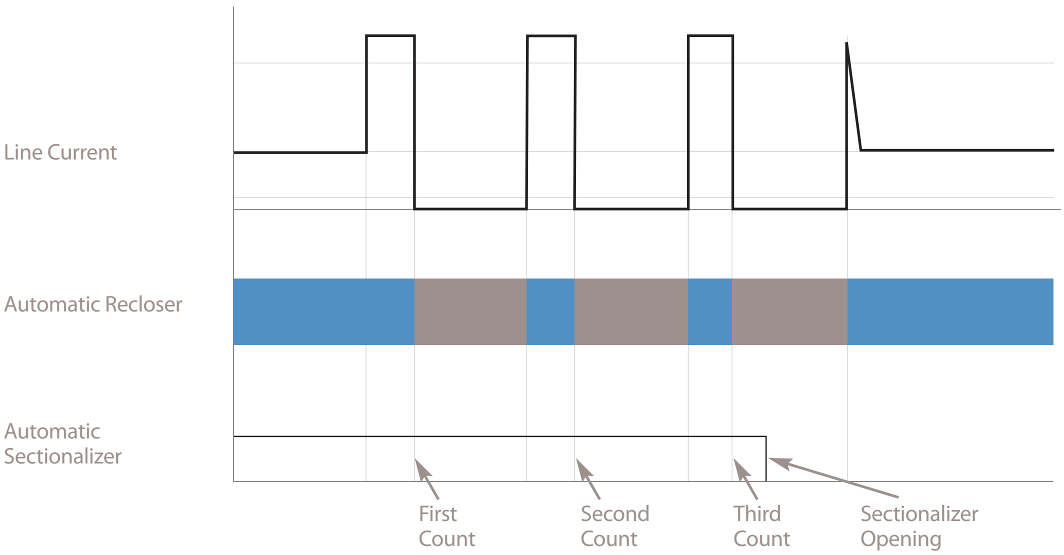
- Single phase
- Lack of reliability on proposed 3-phase solutions (mechanical systems)
- Variety of ratings: confussion arises and under re-powering, when changes are required
- Applicability restricted to grounded lines
- Lack of reliability of the mechanical actuator

INAEL offers reliable and innovative solutions for these problems, as well as extra-performance to increase functionality and applicability:

**INAEL Solutions and extra-perfomance:**

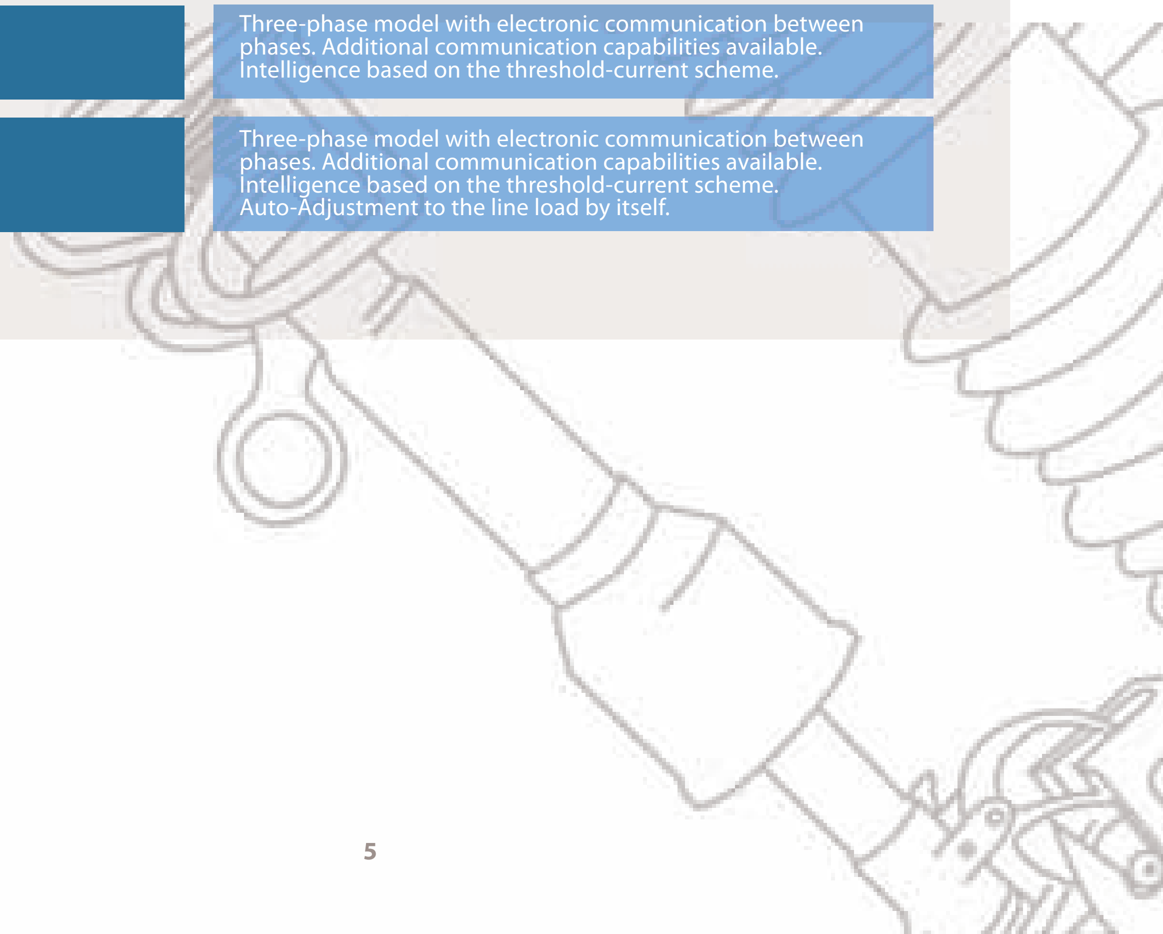
- Radio-communicated three-phase solution. Reliable and fully EMC-tested intercommunication system
- Incremental local intelligence allowing for an universal-model: no ratings required, zero confussions, no maintenance or updating requirements
- Full communication capabilities allowing accurate fault location.
- Shape -memory alloy- based actuator for improved cost-efficiency, miniaturization, and reliability
- Modular system: integration with proprietary pole-mounted electromagnetic fully directional Fault Passage Indicator for applications to ungrounded lines

## OPERATION WITH A PERMANENT FAULT (3 COUNTS)




## TABLE OF BASIC MODELS (TABLE 1)

| Model designation | Distinguishing features |
|---|---|
| **SEIN** | Basic model: single-phase, no communication capabilities, threshold-current based intelligence. |
| **SIT** | Three-phase model with electronic communication between phases. Additional communication capabilities available. Intelligence based on the threshold-current scheme. |
| **SITI** | Three-phase model with electronic communication between phases. Additional communication capabilities available. Intelligence based on the threshold-current scheme. Auto-Adjustment to the line load by itself. |



## Rated values, Parameters and Definitions:

**RATED VOLTAGE:** 15 kV, 24 kV, 36 kV

**RATED CURRENT:** maximum current allowed to permanently flow through the device. It is limited by thermal and dynamical behavior of the sectionalizer, and its value is 200A

**MAXIMUM THROUGH-FAULT:** short-circuit current (value and duration) that is guaranteed to not affect device performance in any way. Its tested value is 8 kA/1s.

**PICK-UP CURRENT:** Only applicable to SEIN and SIT models. It is the threshold value for the current above which the local intelligence within the sectionalizer assumes that a fault might be present in the system, and activates the internal fault-counting procedure. It is factory preset, and available values are as per Table 2.

**PICK-UP INCREMENTAL CURRENT:** Only applicable to SITI model. It is the threshold value for the rate of current increase (measured in A/s) above which the local intelligence assumes that a fault (as opposed to a simple load increase) might be present in the system, and activates the internal fault-counting procedure. It is factory preset, and allows for a single-model to be defined, needing no updates in case of line re-powering, and simplifying purchase and maintenance operations.

**RESPONSE TIME:** It is the time interval between the initiation of fault current and the reaction of the sectionalizer (in the form of fault recognition and fault-counting activation). It is below 50 ms.

**RECLAIM TIME:** It is the time between counting an event and reverting to the basic zero-state (i.e., re-initiating the count to zero). Typically 30 s.

**HOLD-OFF CURRENT:** The sectionalizer must ensure that mechanical operation (opening of the circuit) only happens off-load. The hold-off current is a security value, above which the local intelligence inhibits the sectionalizer mechanical operation. It is established as 300 mA, flowing through the line during, at least, 0.15 s.

**COUNT OF SHOOTING:** Number of counts before preparing to open the line. Can be adapted to client's needs.

**COMMUNICATION CODE:** Only applicable to SIT and SITI. One out of 8 communication codes that have to be configured on-site so as to guarantee that a certain three-pole set does not interfere with another three-pole set closer than 10m.

### TABLE 2:

| | | |
|---|---|---|
| Rated voltaje | kV | 15/17.5 20/24 30/36 |
| Rated current | A | 8, 15, 25, 38 ,60, 90 |
| Pick-up current (SEIN and SIT) | A | 12, 25, 40 , 63, 100, 140 |
| Pick-up incremental current (SITI) | A/s | 30/0.3 , 50/0.4 ,100/0.5 |
| Short-circuit withstand | | |
| 1 s | kA | 8 |
| 10 s | kA | 3 |
| Short-circuit withstand (peak value) | | |
| 1 s | kA | 20 |
| 10 s | kA | 7,5 |
| Response time | ms | <50 |
| Off-load time for hold-off current | ms | <150 |
| Reclaim time | s | 30 |
| Maximum time to de-latch | s | <0,1 |
| Hold-off current for 150 ms | mA | <300 |
| Counts before de-latch | | 1, 2* ó/or/ou 3 |
| Number of communication codes (SIT and SITI) | | 8 |

## OPERATION DESCRIPTION

The low-consumption printed circuit board (PCB) is powered by a sealed current transformer surrounding the current-carrying tube. Under normal load the PCB remains inert. Activation occurs in two modes, depending upon the sectionalizer model. For the SEIN and the SIT, a current increase above the pre-set value (the pick up current) must be measured. For the SITI, it is the current derivative, i.e., the rate of current increase, what it is measured, and activation requires a value (in A/s) above the pick-up incremental current.

If there is a true fault present on the line, the upstream recloser will open, temporarily removing the fault. The logic circuit stores the event for 30 seconds (the reclaim time). The upstream device will reclose 1-10 seconds later. If the fault current disappears, the seccionalizer will ignore the event, eventually reverting to an inert state after the reclaim time. However, if the fault condition is still present, the logic circuit will decide that this is a permanent fault on the line and will prepare to disconnect. The logic circuit is however, inhibited from operating the latch mechanism until the upstream recloser has tripped for the second time and the current has fallen to a value lower than 300 mA (the hold-off current) for a period of at least 0.15 second. The seccionalizer thus operates during the dead time of the upstream protective device and does so quietly without sparks or ionized gas emission and without contact erosion.

### TYPICAL SELECTION RULES (TABLE 3)

| Power | 50 kVA | 100 kVA | 160 kVA | 250 kVA | 400 kVA | 630 kVA | 1000 kVA | 1600 kVA | 2500 kVA |
|---|---|---|---|---|---|---|---|---|---|
| 15 kV | SEIN 8/12 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 15/25<br>SIT 15/25<br>SITI 30/0.3 | SEIN 15/25<br>SIT 15/25<br>SITI 30/0.3 | SEIN 25/40<br>SIT 25/40<br>SITI 30/0.3 | SEIN 38/63<br>SIT 38/63<br>SITI 30/0.3 | SEIN 60/100<br>SIT 60/100<br>SITI 50/0.4 | SEIN 90/140<br>SIT 90/140<br>SITI 100/0.5 |
| 20 kV | SEIN 8/12 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 15/25<br>SIT 15/25<br>SITI 30/0.3 | SEIN 25/40<br>SIT 25/40<br>SITI 30/0.3 | SEIN 38/63<br>SIT 38/63<br>SITI 30/0.3 | SEIN 60/100<br>SIT 60/100<br>SITI 50/0.4 | SEIN 90/140<br>SIT 90/140<br>SITI 100/0.5 |
| 30 kV | SEIN 8/12 | SEIN 8/12 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 8/12<br>SIT 8/12<br>SITI 30/0.3 | SEIN 15/25<br>SIT 15/25<br>SITI 30/0.3 | SEIN 25/40<br>SIT 25/40<br>SITI 30/0.3 | SEIN 38/63<br>SIT 38/63<br>SITI 30/0.3 | SEIN 60/100<br>SIT 60/100<br>SITI 50/0.4 |

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