



APPLICATION OF NUMERICAL DISTANCE RELAYS

A PRESENTATION BY
OS DEPARTMENT
ER-II, KOLKATA



FOREWORD

- Gazette Notification from GOI dated 09.03.2007 regarding Grid connectivity standards applicable to Transmission lines & substation- Part-III(3) stipulates that:

“Two Main Numerical Distance protection scheme shall be provided on all the Transmission Lines of 220KV & above for all new substations. For existing substations, this shall be implemented in a reasonable time frame”

POWERGRID's compliance

- “Technology made large populations possible; large populations now make technology indispensable
- POWERGRID is extensively using Numerical relays for protection schemes of all new Lines & substations.
- All regional OS departments have undertaken retrofitting of old relays with New generation Numerical relays.
- POWERGRID, ER-II has completed 1st stage of retrofitting of Numerical distance protection. The work for the 2nd stage is presently being executed.
- Old static type differential relays for all EHV Transformers are also being retrofitting with New Numerical differential protection.





ADVANTAGES

- Improves dependability as well as security
- Has Self checking facility
- Offers Very low burden
- More flexible because of programmable capability
- Adaptive relaying schemes
- Permit Historical data storage

ADVANTAGES...Contd.

- Fiber optical communication with substation LAN
- Allow GPS (Geographical Positioning System) Time stamping
- Numerical relays simplify interfacing with CTs and VTs
- Separate connection is not required, zero sequence voltages and currents can be derived inside the processor





ENGINEERS CHOICE

- Numerical relays represent best compromise between:
 - a) Economy and performance
 - b) Dependability and security
 - c) Complexity and simplicity
 - d) Speed and accuracy
 - e) Credible and conceivable

COMPARISON STATEMENT



| | Numerical | Solid State | Electro-Magnetic |
|--|-----------|-------------|------------------|
| Cost | ✓ | ✓ | ✓ |
| Self Checking and Reliability | ✓ | ✓ | ✗ |
| System Integration and Digital Environment | ✓ | ✗ | ✗ |
| Functional Flexibility and Adaptive Relaying | ✓ | ✗ | ✗ |

Numerical Distance Relay main functions

A single Numerical distance relay has:

- **Distance protection**
- **Power swing Blocking**
- **Switch on to fault**
- **Phase-fault (highset) overcurrent protection**
- **Directional earth-fault protection**
- **Sensitive earth-fault protection**
- **Overvoltage and undervoltage protection**



SPECIAL FUNCTIONS

- **Broken conductor detection** - To detect network faults such as open circuits, where a conductor may be broken but not in contact with another conductor or the earth.
- **Circuit breaker failure protection** - Generally set to back-trip upstream circuit breakers, should the circuit breaker at the protected terminal fail to trip.





Numerical Distance protection Other functions

Control

- Autoreclose
- Check synchronising

Monitoring

- Voltage transformer supervision

System data

- Sequence of event records
- Fault records
- Disturbance recorder

Existing Numerical Distance protection in POWERGRID-ER-II



REL-670



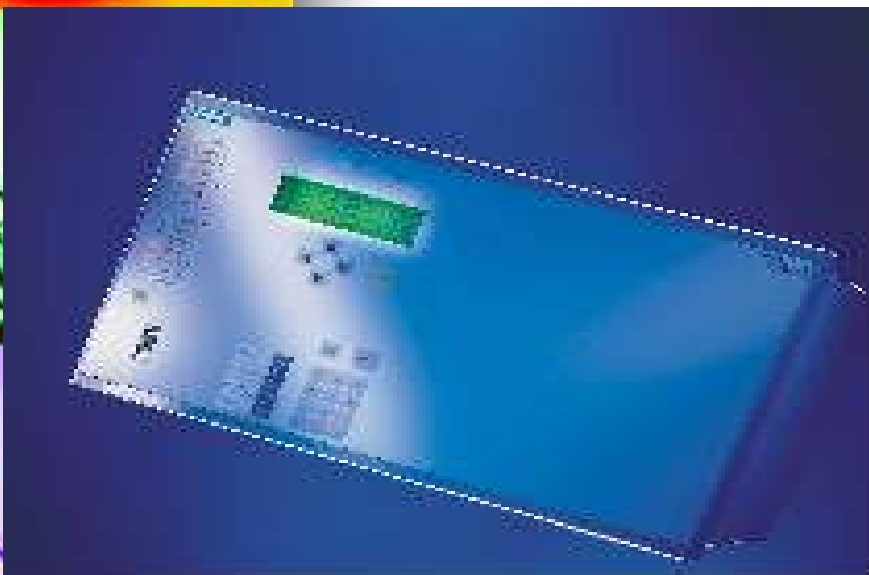
P444 in 80TE



P442 in 60TE



P441 in 40TE



7SA522



SEL-321-5



SEL-421





Numerical Differential relay main functions

A single Numerical differential relay
has:

- DIFFERENTIAL PROTECTION

- ... Matching to the vector group

- ... Stabilization under inrush

(eg:based on the presence of second harmonic components)

- ... Stabilization under overfluxing conditions

(eg:based on the ratio of the fifth harmonic to the fundamental wave)

- RESTRICTED EARTH FAULT PROTECTION

- DEFINITE TIME AND INVERSE TIME OVERCURRENT PROTECTION

Numerical Differential protection main functions...Contd.

- THERMAL OVERLOAD PROTECTION
- OVER-/UNDERVOLTAGE PROTECTION
- OVER-/UNDERFREQUENCY PROTECTION
- OVEREXCITATION PROTECTION

...Overexcitation protection detects impermissible high magnetic flux density in the iron core of power transformers in case of increase in voltage and/or decrease in frequency. Flux density above the rated value saturates the iron core & result in power transformer overheating due to large iron losses.





Numerical Differential protection: Other functions

Monitoring

- Voltage transformer supervision

System data

- Sequence of event records
- Fault records
- Disturbance recorder

Existing Numerical Differential protection in POWERGRID-ER-II



MICOM P-633



RET-670



7UT613

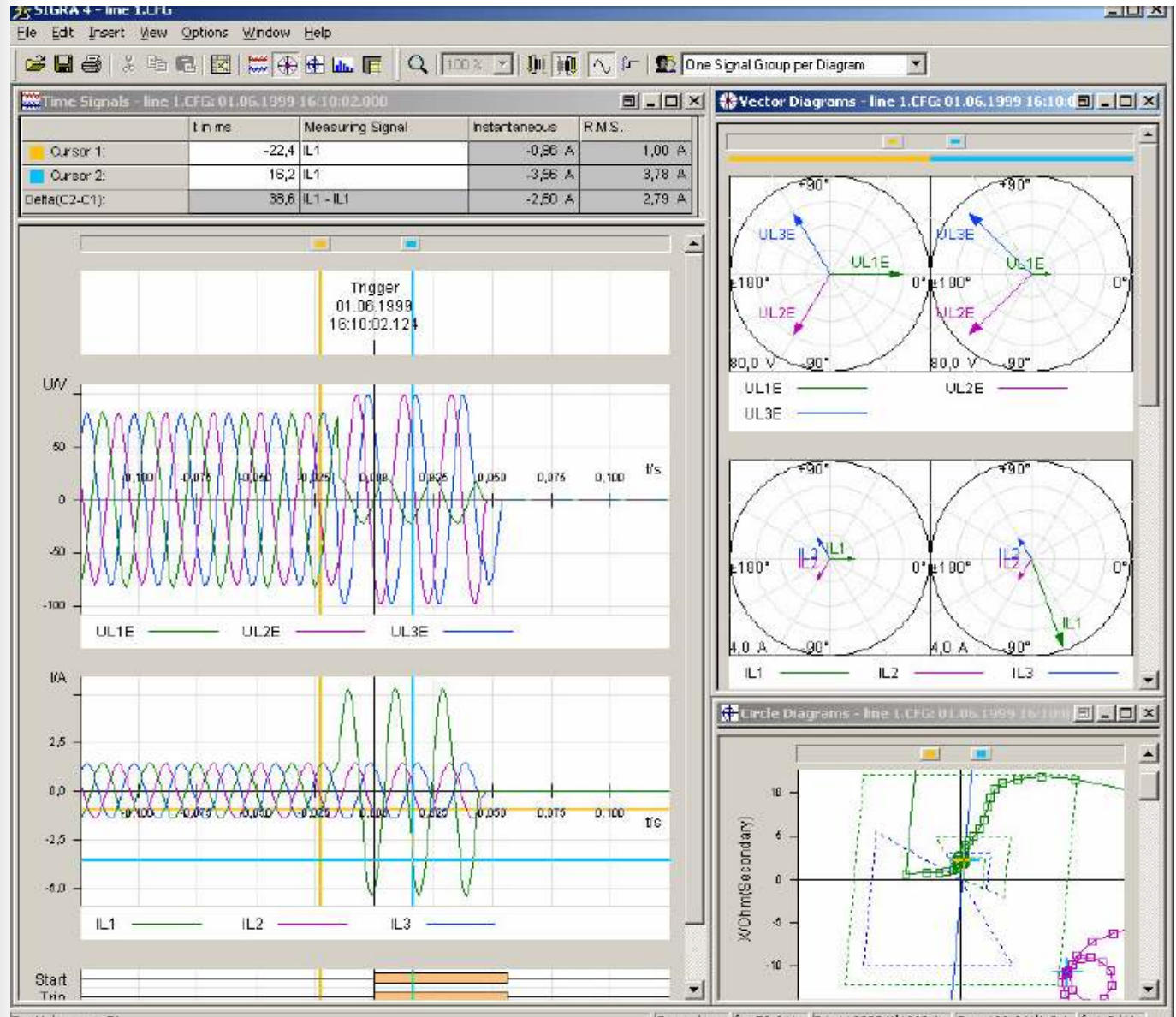


A TOOL TO SYSTEM ENGINEERS

- Numerical relays provide comprehensive fault reporting data for the analysis of power system faults and relay operations.
- Valuable information from relays throughout their grid may be gathered.
- After a fault, most precise fault location can be reached to narrow the search for possible damage on the line and to cut the down time for restoration.
- Software system for relay fault records can provide the desired precision to the utility personnel.



FAULT STUDY





Disturbance report-1

- Complete and reliable information about disturbances in the primary and/or in the secondary system together with continuous event-logging is accomplished by the disturbance report functionality.
- The disturbance report, included in the IED, acquires sampled data of all selected analogue input and binary signals connected to the function block



Disturbance report-2

- Any change in Digital Inputs or Analog Thresholds function blocks may be set to trigger the disturbance recorder.
- All signals from start of pre-fault time to the end of post-fault time, will be in the recording.
- Every disturbance report recording is saved in the IED in the standard formats.

Event recorder

- Quick, complete and reliable information about disturbances in the primary and/or in the secondary system is vital e.g. time tagged events logged during disturbances.
- This information is used for different purposes in the short term (e.g. corrective actions) and in the long term (e.g. Functional Analysis).





Time synchronization

- Time synchronization source selector selects a common source of absolute time for the IED.
- This makes comparison of events and disturbance data between all IEDs possible.
- It is done now with the IRIG-B Protocol available with the GPS Clock.

STATION COMMUNICATION

- Each IED is provided with a communication interface, enabling it to connect to one or many substation level systems or equipment, either on the Substation Automation (SA) bus or Substation Monitoring (SM) bus.
- **IEC 60870-5-103 communication protocol**
A single glass or plastic port allows design of simple substation automation systems including equipment from different vendors. Disturbance files uploading is provided.
- **IEC 61850-8-1 communication protocol**
Single or double optical Ethernet ports for the new substation communication standard IEC61850-8-1 allows intelligent devices (IEDs) from different vendors to exchange information and simplifies SA engineering.





Return on Investment

- Investing on Numerical relays has greater return as it was not required to invest for discrete relays line OV/UV,LBB,AR, FL,DR etc.
- Failure Rate of Numerical relays in POWERGRID has been very small, requiring less maintenance cost.

Return on Investment

A simple example.

- As per the New tariff regime, Outage of a 420/220/33 KV 315MVA Autotransformer results a monetary loss of Rs. 2.5L per Day.
- Tripping in case of even for extraneous reasons & not on Transformer fault follows Health check test program, requiring a full day.
- DR print, if available may help detect the above & Transformers can be restored within 10-15 Minutes.
- A single event of that order may render saving of the amount invested for a new Numerical differential protection

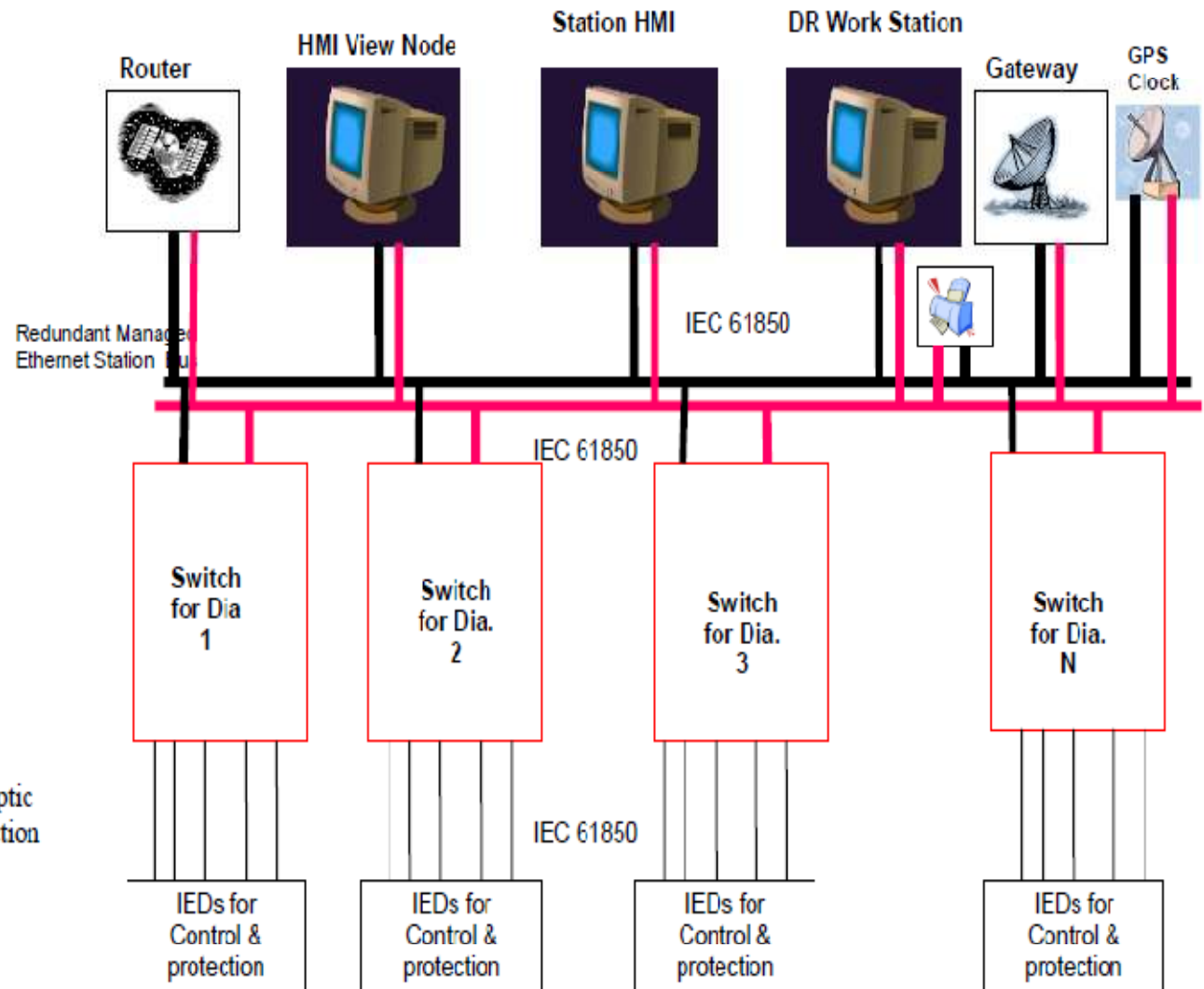


POWERGRID & NUMERICAL RELAYS

- **“Technology does not drive change -- it enables change**
- All new substations in POWERGRID are coming with Substation Automation, which inevitably comes with numerical relays with IEC61850 Communication protocol.
- Automation alongwith Numerical relays eventually results in cost effectiveness as well as Better grid security.



TYPICAL ARCHITECTURE SUBSTATION AUTOMATION SYSTEM IN POWERGRID



POWERGRID & NUMERICAL RELAYS.. Cond.

- “Once a new technology rolls over you, if you're not part of the steamroller, you're part of the road
- For Older stations, POWERGRID is replacing old & obsolete relays with numerical relays.
- Competitive bidding for Numerical distance relays has resulted an average cost of Rs. 1.5L per relay for the retrofitting work.
- In a few cases, repairing of old relays has been found costlier than retrofitting with a new numerical relays.



ADAPTATION

- “Our very survival depends on our ability to stay awake, to adjust to new ideas, to remain vigilant and to face the challenge of change”
- Control & relay schemes usually came from OEM’s like ABB,AREVA, SIEMENS,ER etc .
- POWERGRID has achieved expertise in adaptation of Numerical relay of Make say “X” to be installed in the C&R scheme of Make “Y”.
- However, problem of Lower Making capacity of the Numerical relays in comparison to the old distance relay had to be solved by incorporating CMR’s of suitable capacity.





LASTWORD

- “Science and technology revolutionize our lives, but memory, tradition and myth frame our response.”
- Numerical relays are here as the best available technology product as on date.
- The advantages are many & nobody can deny that the Numerical relays came to stay for years until a further better product replaces them.



Thank You!