P03

Advanced Fault Current Indicators for MV Overhead Lines

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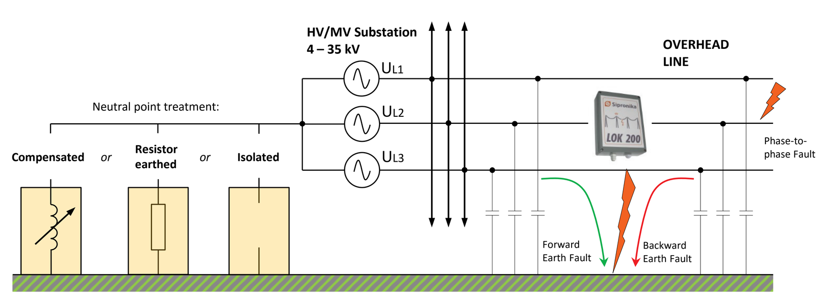
Introduction

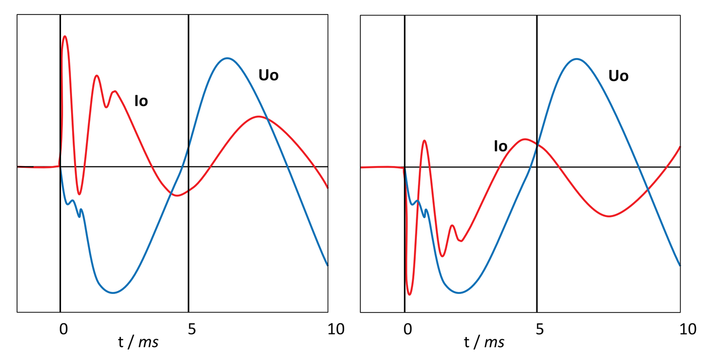
- Elektro Ljubljana, the largest Slovenian DNO, utilizes a Distribution Automation System, where Fault Indicators are one of key elements in fault location and network restauration process
- Changed operation conditions (resonant-earthed neutral point, high degree of distributed generation) require a new approach for reliable fault detection
- A need for future-proof solution
- Installation of latest generation of Fault Indicators with advanced detection techniques, system integration flexibility and disturbance analysis tools
- Basic requirement: reliable detection of Phase-to-Phase and Phase-to-Earth faults in resonant-grounded MV network, fault-type classification, data integration into existing SCADA, high-resolution disturbance data logging

Fault Detection Method

- Based on the measuring of the resultants of the magnetic and electric field, generated by the feeder currents and voltages.
- The dominant component of the magnetic field is directed horizontally.
- The dominant component of the electric field is directed vertically and curves from the vertical towards the horizontal direction in the vicinity of the pole.
- Measured values of magnetic and electric field are digitally processed, the amplitudes and phases of the measured signals – phasors – are taken into account.



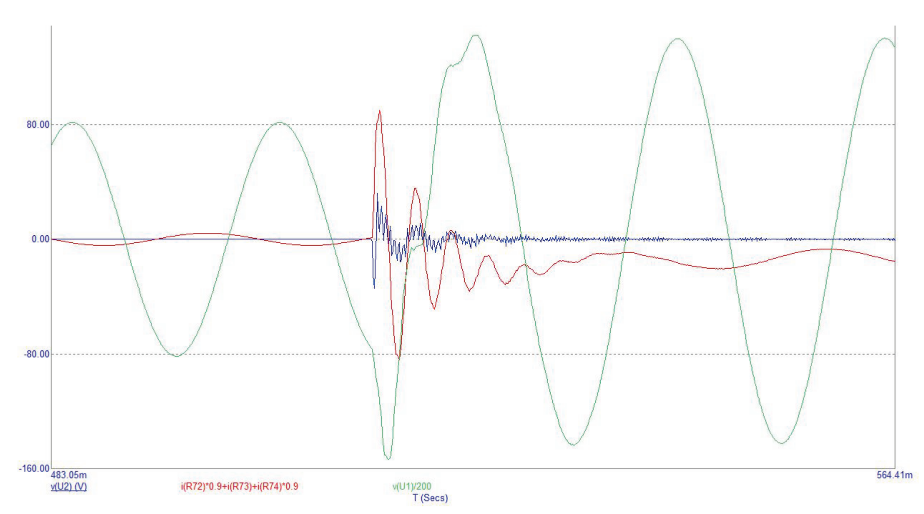
- Measuring of the resultants of the steady state magnetic (H) and electric (E) field phasors
- Evaluation of E and H field phasor change
- calculation/evaluation of I0 and U0 values
- Measuring and evaluation of 5-th harmonic component in I0
- Evaluation of transient polarity in I0 for directional Earth-fault detection



Forward direction:
- Io transient is in opposite phase to Uo

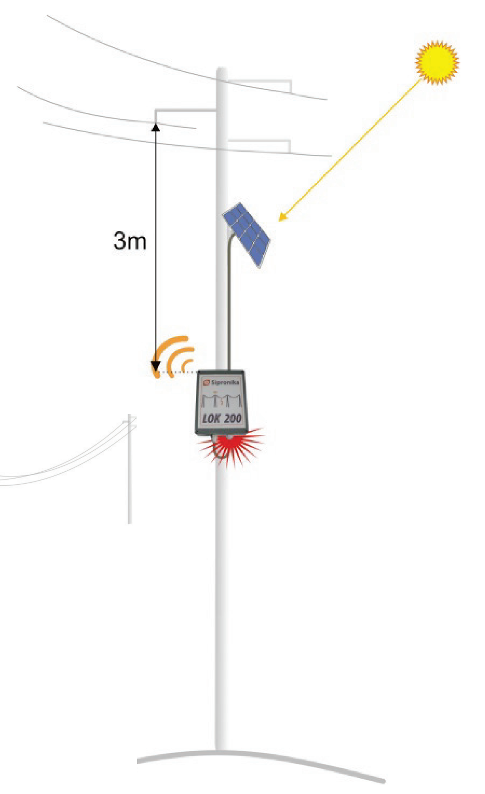
Backward direction:
- Io transient is in phase to Uo

In the development process we used a simulation on a three-pole model of a resonant-earthed network, in which we converted the response to an earth fault into electric signals in order to simulate an electric and magnetic field.



Highlights

Project:
- Installed at Elektro Ljubljana d.d. – the largest Slovenian DNO
- 20 kV network, mostly resonant-earthed
- Installed quantity: 80 devices
- 10 HV/MV substations involved
- Integrated into SCADA (IEC 60870-5-104)
- Total 1.920 events detected between January 2015 and April 2016
- Total 351 fault disturbances
- Total 72 permanent faults



Equipment:
- Pole Mounted Device LOK 200
- P-to-P- and Earth-fault Detection and Classification
- Remote Fault Signalling and MV line Monitoring
- Time-Tagged Fault Data Logging
- Indicative Line-Load Monitoring
- SCADA Gateway, configuration and MV line disturbance analyses server

Disturbance Recording and Analyses

- Measured (E, H field) and calculated electrical values (fault currents) during disturbances are being recorded and stored in the device's local memory.
- Recorded disturbances data give the operator a detailed insight into the operation of the line and events resulting from short-term electrical breakdowns that can develop into a permanent fault.
- Time-resolution is 20 ms during disturbance and 1 to 15 min. at normal line operation.
- Recorded values are time-stamped, which enable precise comparison with the data captured from protection relays at the outgoing feeders or from the remote-controlled reclosers on the network.

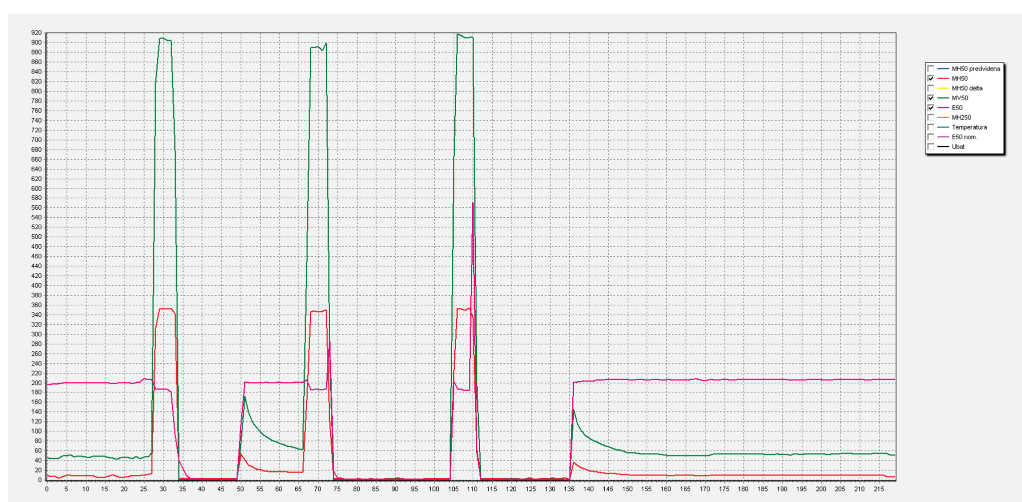


Fig.: Diagram of a Phase-to-Phase Fault and Reclosing Operations, Captured by an Indicator

Diagram curves:
- E-field;
- horizontal H-field – 50 Hz; horizontal H-field – 250 Hz component;
- calculated fault current I0;
- calculated phase-to-phase fault current;
- battery voltage and device temperature;

Fig.: Diagram of Transient Faults and Reclosing Operations, Captured by an Indicator

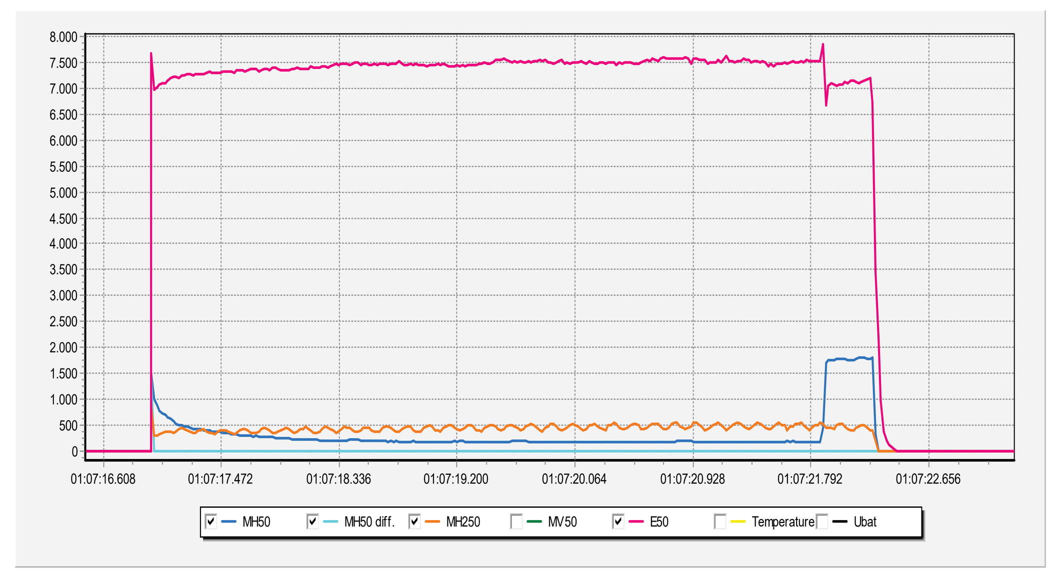


Fig.: Recording of a typical earth-fault in a resonant-earthed network, with a distinct fifth harmonic component (orange) in the fault current which exceeds the basic harmonic component (blue) in amplitude.

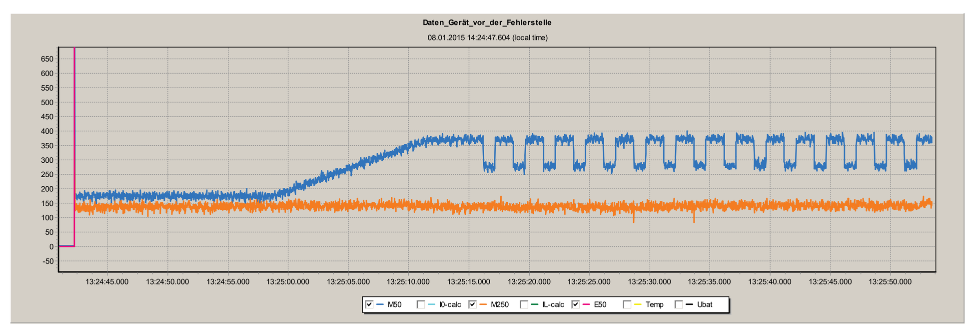


Fig.: Recording of a Fault in a Resonant-Earthed Network with Pulsation of the Fault Current.

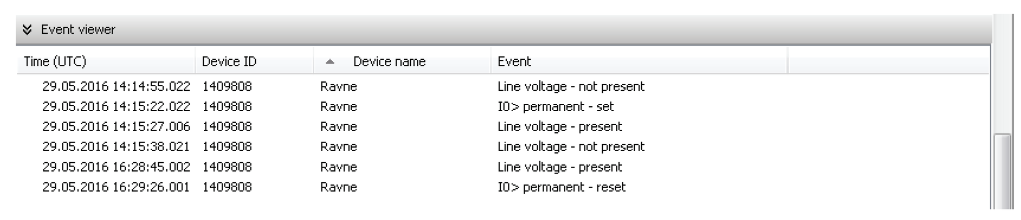
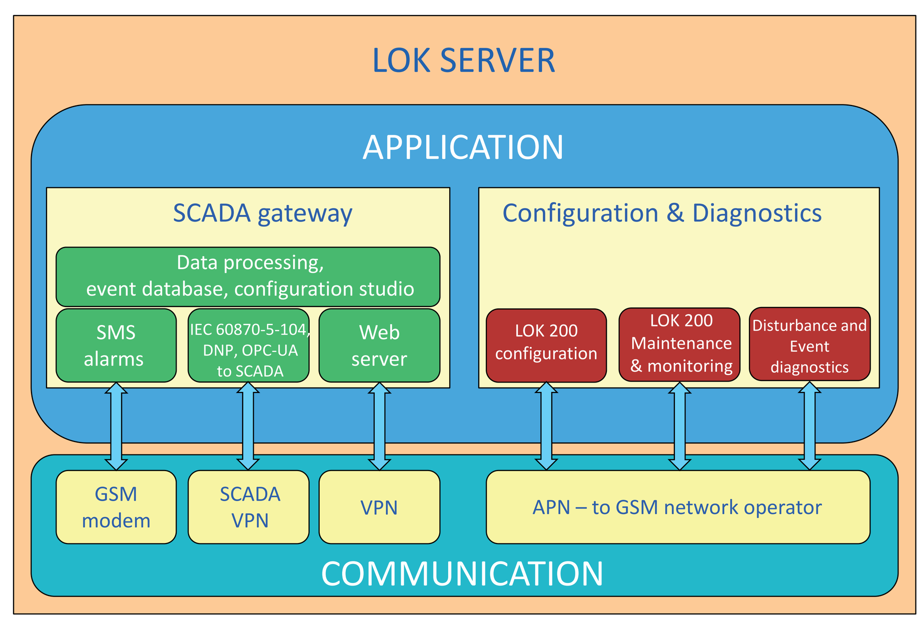


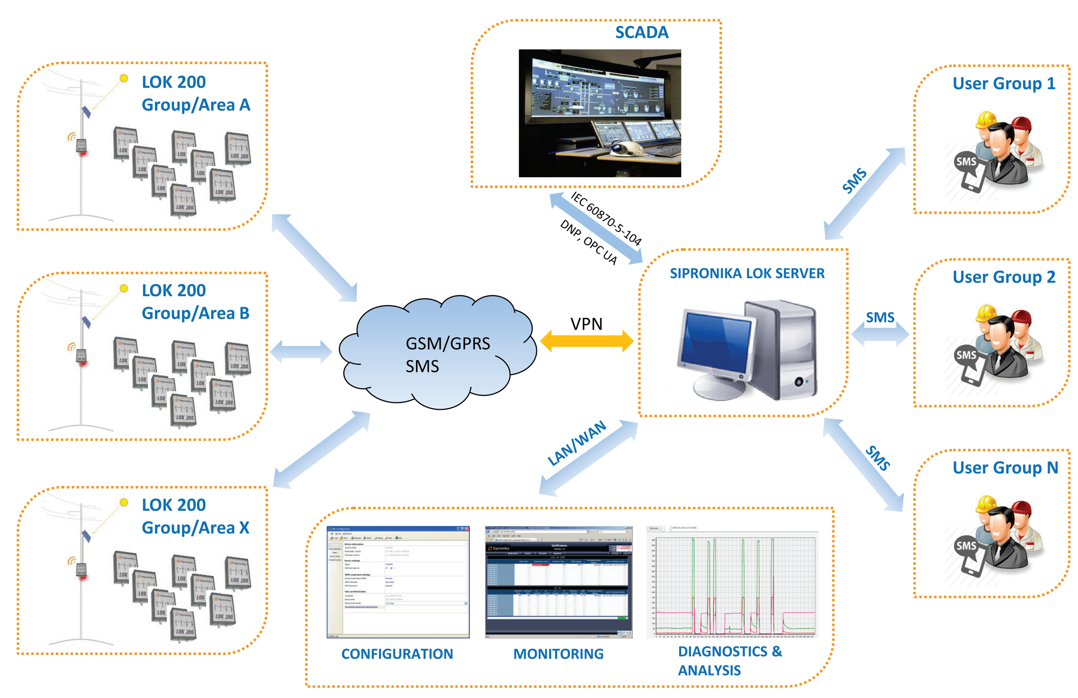
Fig.: List of Recorded Events, Stored in the Device's Local Memory

System Integration and Communication

The remote reporting system consists of a telecommunications infrastructure and a server with modularly designed software:

1. SCADA Gateway: receives SMS messages from the indicators and submits them to SCADA by using IEC60870-5-104 protocol. SMS messages can also be sent to the mobile devices of users.
2. Web server: access to basic status of indicators (indicator operation, current alarms, status of the GSM signal and battery)
3. Remote device monitoring: remote configuration of parameters, software updates of devices, transfer of diagnostic data on the device's operation and the transfer of recorded data on events occurring on the line via a GPRS connection.
4. Diagnostic data server: captures data on the measured values of the monitored electrical values of the line.





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