ELEKTROINŠTITUT MILAN VIDMAR

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Monitoring of the high-voltage circuit breakers condition based on number of operations and sum of breaking short-circuit currents

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INTRODUCTION

- CB (Circuit Breaker) ensures safe and reliable operation of the power system.
- CB in operation undergoes a lot of mechanical and electrical stress.
- CB is strategically important device that comes with high financial maintenance costs.
- This costs can be optimized using on-line monitoring.
- IED-Q0 monitors: sum of breaking short-circuit currents and number of operations for three CBs (one for each phase).
- This enables real-time monitoring, CBM (Condition Based Maintenance) and integration with AMS (Asset Management System).

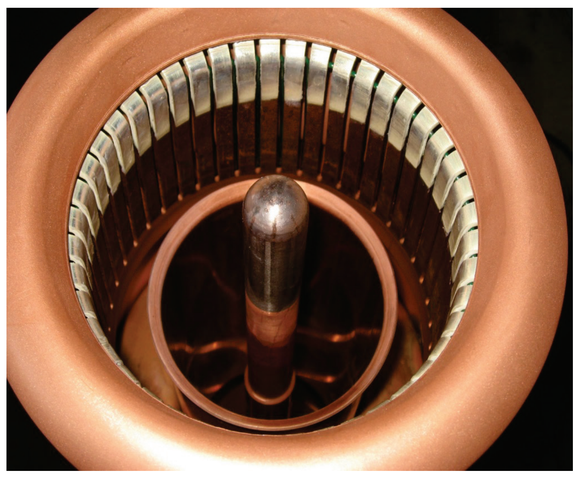

Figure 1: New contact system.

Figure 2: Damaged contact system.

DEVICE PROTOTYPING

- Main requirement: already existing wiring infrastructure of the relay protection, must be preserved.
- A non-invasive method of measuring currents with current clamps was used.
- Trigger signals that indicate manipulation status from relay protection were galvanically isolated from IED-Q0 using optical isolators.
- Based on trigger signals measurements of CB currents take place.
- Algorithm extracts maximum values and number of manipulations are increased.
- Data are shown on local LCD and also sent over Ethernet to a remote client.
- Measurements and algorithm runs on Arduino based µC (microcontroller). Data are send using Ethernet shield.

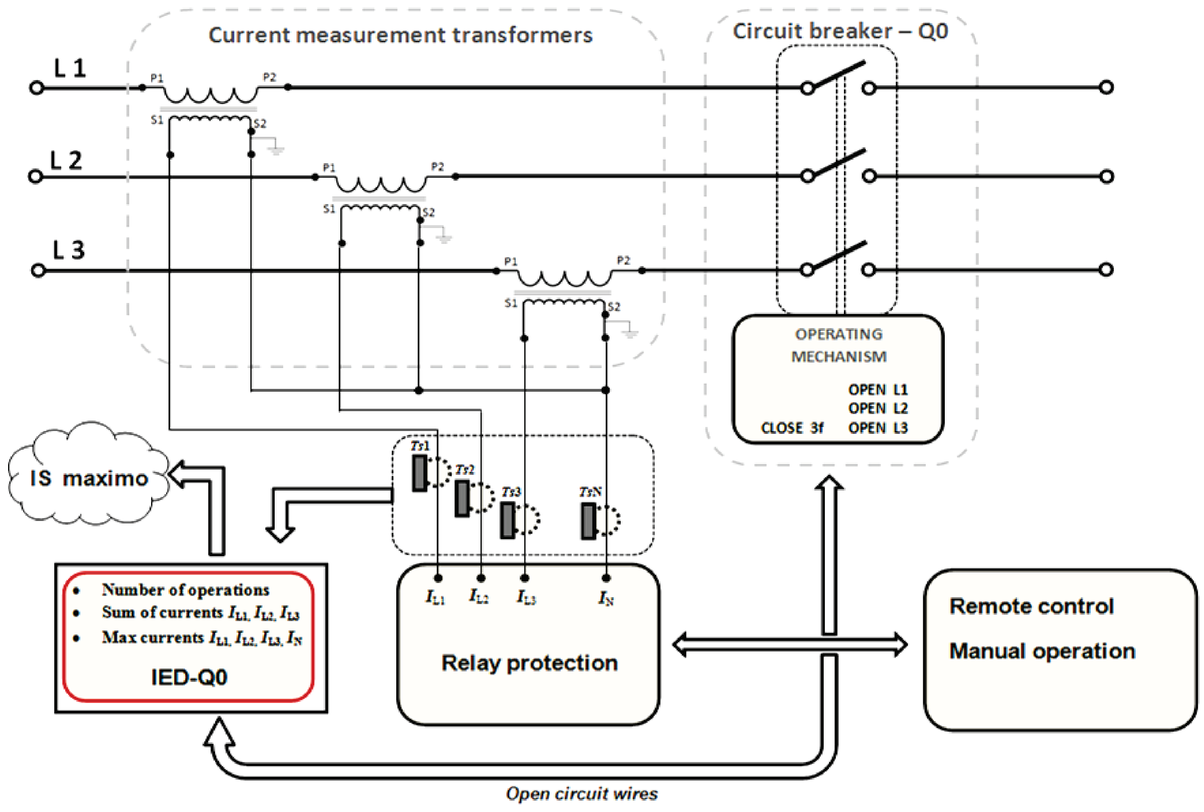

Figure 3: Integration of IED-Q0 into measuring system with relay protection.

SOFTWARE DESCRIPTION

- During the fault relay protection needs approximately 60 ÷ 80 ms to sense and characterize the fault and output the trigger signal. During this time DC component of the fault current is already damped.
- The process of switching off takes another 20 ÷ 60 ms (this is where IED-Q0 measures the fault currents - for 300 ms).
- µC algorithm uses in-time filtering for maximum values of the breaking currents.
- Since current clamps bring non-linearity into the measurement, values of the currents are linearized by the algorithm.

INTEGRATION WITH ASSET MANAGEMENT SYSTEM

- IED-Q0 uses TCP/IP based communication protocol to send the measured data to the Data Concentrator (DC) located in the substation.
- DC can be integrated with an Asset Management System (e.g. IBM Maximo) using web services (SOAP).
- This architecture enables safe and reliable integration of state-wide online monitoring of CBs.

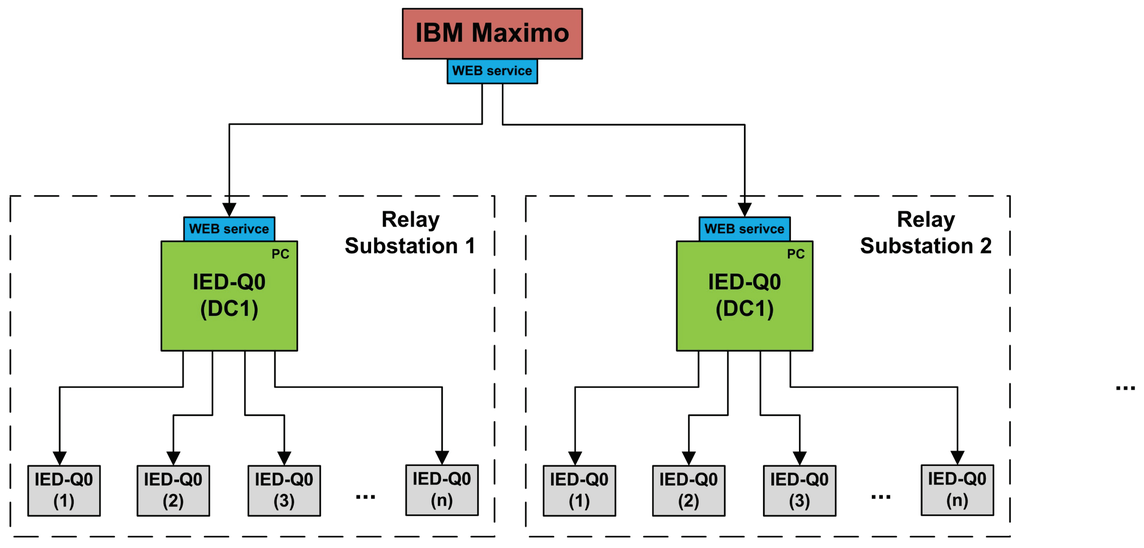

Figure 4: Integration with IBM Maximo Asset Management System.

TESTING

- Successful laboratory testing took place using CB and relay protection simulator.
- Measurements of trigger signals showed high voltage spikes, that could damage optical isolators. For that matter a special protection circuit was implemented to avoid damaging the device.
- IED-Q0 can successfully measure breaking currents up to 20 kA.
- Field test took place in RTP Podlog, where IED-Q0 was exposed to real environment.
- Device was tested for worst case scenario EM disturbances (it was placed under 110 kV CBs while doing manipulations).
- All tests were successful.
- A real integration into a substation suggests mounting of IED-Q0 inside relay houses where they are protected from EM disturbances.

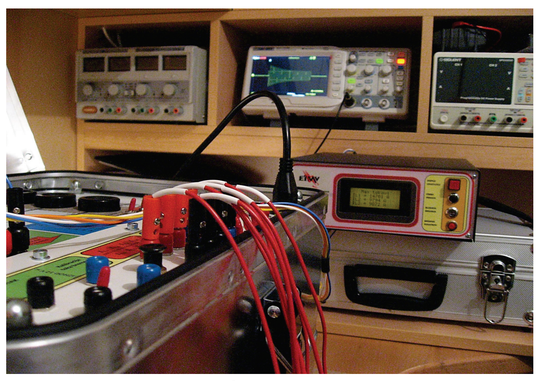

Figure 5: Laboratory testing.

Figure 6: Relay substation testing.

CONCLUSIONS

- This type of real-time on-line monitoring presents the base for integrating CBs into Asset Management.
- CBM methods must be included in AMS.
- IED-Q0 is universal and can be used for all types of CBs from different manufacturers.
- IED-Q0 is flexible due to its ability to be re-programmed depending on type of CB it is monitoring.
- Additional information about CB‘s condition can be acquired if time parameters of the driving mechanism are also measured.
- IED-Q0 will be further developed and upgraded in that direction.
- IED-Q0 is the product of domestic knowledge.