Features of Implementation of Microprocessor Transformer Differential Protection

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OJSC "Belelektromontazhnaladka" is the leader among Belarusian companies in the development and manufacturing of microprocessor-based relay protection and automation. The system of relay protection and automation 6-110 kV substations can be completely realized on terminals which produced by "Belelektromontazhnaladka."

The terminal of the differential transformer protection MR801 is one of the recent developments. Production of MR801 was organized to ensure the Belarusian power system with modern domestic product, which reduces spending for buying expensive foreign equipment.

MR801 are provided with the following function package:
- differential current stage with restraining;
- differential current stage (cut-off) without restraining;
- 3 stages of differential zero-sequence current protection;
- 8 stages of directional overcurrent protection;
- 6 stages of directional zero-sequence or negative-sequence overcurrent protection;
- 4 stages of overvoltage and 4 stages of undervoltage protections;
- 16 stages of external protections which controlling external signals;
- automatic transfer of transformers supply;
- automatic reclosure of transformer;
- monitoring and operation automatic of one transformers breaker;
- breaker failure protection;
- user-defined logic.

The MR801 terminal has 16 analog and 26 discrete inputs. Input current and voltage signals are turned into the voltage signals which pass analog filtration. Then signals are digitized by means of a 16-bit ADC. Analog second-order filters with 1 kHz frequency cut-off in MR801 are applied.

Sampling rate of 1 kHz (20 samples across period) to provide required measurement accuracy and signal processing speed are chosen. The orthogonal components of analog signals are obtained by digital processing with the Goertzel algorithm. The Goertzel algorithm is special case of fast Fourier transformation. A RMS-value is calculated in 10-millisecond cycle on the basis of 20 samples. As a result of calculations currents of transformer windings, differential current (fundamental, second and fifth harmonics), bias current, phase and line voltages data arrays can be obtained. The operation of differential, overcurrent, zero-sequence and negative-sequence overcurrent, voltage protections, automatics and user-defined logic is implemented on the basis of those data.

The differential protection with restrained operate characteristic provides reliable transformer's protection against internal faults. Differential protection has absolute selectivity and supports tripping of internal faults with no time delay. However, there are some conditions when differential current is not accompanied with internal fault:
- magnetizing inrush current (MIC) at no-load switching on of transformer. MR801 has second harmonic restrain against maloperation of the differential protections during MIC;
- current transformer (CT) saturation during the external faults. The special algorithm of offsetting from external faults accompanied with CT saturation implemented in MR801 terminal;
- overexcitation of transformer. MR801 has fifth harmonic restrain against maloperation in this case;
- tap changer operations. MR801 settings calculations take into account imbalance of differential current which occurs due tap changer operations.

The disadvantage of the differential stage with restraining is delayed operation during internal faults accompanied with CT saturation. To overcome this problem MR801 provides fast tripping stage - differential cutoff without restraining. The differential cutoff setting is chosen more than the maximum current of external fault.

The terminal of the differential transformer protection MR801 passed complex laboratory tests as well as field testing on Belarusian power system. The results of tests showed that the differential protection unit MR801 reliably identifies internal faults. In addition MR801 did not form tripping signal during the process of external short circuit with CT saturation, and also when magnetizing inrush current occurred. MR801 is successfully operated in Belarusian power system now.