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EFFICIENCY OF MODERN TYPES OF PROTECTION AGAINST DIRECTIONAL PHASE OVERCURRENT USING "EASERGY P3" RELAY IN MANUFACTURING ENTERPRISES ON THE EXAMPLE OF "FERGANA AZOT" JSC

Low-voltage lines are a consequence of the emergence of power supply to industrial enterprises, the article discusses the advantage and emergence of a new modern type of relay protection of the "Easergy P3" type, designed to limit the short-circuit current from the types of relay protection that were proposed instead of the existing old type of relay protection and automation as an example JSC "Ferganaazot"

Key words: power systems, phase-to-earth fault, polarization, relay, short-circuit protection, positive sequence current

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ЭФФЕКТИВНОСТЬ СОВРЕМЕННЫХ ВИДОВ ЗАЩИТЫ ОТ НАПРАВЛЕННЫХ ФАЗНЫХ МАКСИМАЛЬНЫХ ТОКОВ С ИСПОЛЬЗОВАНИЕМ РЕЛЕ «EASERGY P3» НА ПРОИЗВОДСТВЕННЫХ ПРЕДПРИЯТИЯХ НА ПРИМЕРЕ ОАО «ФЕРГАНА АЗОТ»

Низковольтные линии являются основным источником электроснабжения промышленных предприятий, в статье обсуждаются преимущества и недостатки нового современного типа релейной защиты типа «Easergy P3», предназначенного для ограничения тока короткого замыкания из типов релейной защиты, которые могут быть предложены вместо существующего старого типа релейной защиты и автоматики в пример ОАО «Ферганаазот».

Ключевые слова: энергосистемы, замыкание фазы на землю, поляризация, реле, защита от короткого замыкания, ток прямой последовательности

First let us consider why the directional phase o / c is protected in the enterprise supply networks mentioned above. Most distribution power systems in that plant are built and operated on radial configuration with a single source. The current protection of such a network is relatively simple. Also, relay coordination for selectivity is normally easy to obtain. For more sophisticated distribution schemes, directional protection is needed. Below (Fig.1) (like principle scheme of substation № 20-27 10/04 kV) depicts a simple radial distribution network [1].

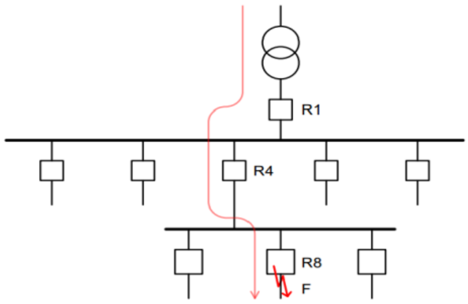


Fig.1 Principle scheme of radially-operated network

Protection coordination is obtained by using time grading. For example, fault-1 first leads to tripping of relay R8 and then successively relays R4 and R1 trip, if the fault is not cleared. It is evident that simple phase o/c protection provides selective protection for a basic radial network. A network with parallel current paths or a network with several sources cannot be protected this easily. Directional protection is often needed for proper protection coordination and selectivity. For example, the network shown in picture 2 has two parallel lines. Simple phase o/c protection does not suffice, as the fault current flows from both lines. Therefore, both lines will be tripped [2].

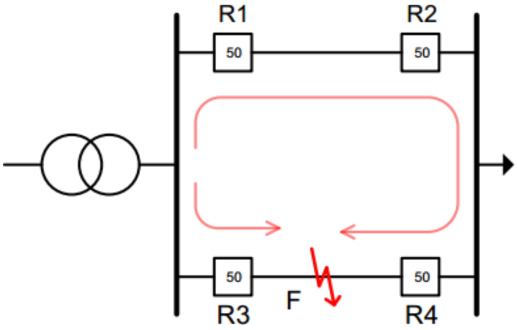


Fig.2 Two parallel lines protected lines non-directional phase o/c relays

Protection selectivity can be obtained by making relays R2 and R4 directional. When fault F occurs, relay R2 does not trip because the fault is considered reverse. Relay R4 trips because the fault is in forward direction. The tripping times of R2 and R4 must be faster than those of relays R1 and R3. Finally, the fault is cleared by the tripping of relays R3 and R4. The two examples above clearly show a need for directional discrimination in protection coordination [3].

Directional discrimination

For directional protection, simple current measurement is not enough. Instead, a polarization reference is needed. The most common directional protection is directional earth-fault (e/f) protection. In directional e/f protection, residual voltage is often used as a polarizing quantity, while residual current is an operating quantity. When the fault is in forward direction, the operating quantity falls to the designated trip area. For a reverse fault, the operating quantity falls to the restrain area (no-trip area).

Similarly, phase o/c protection can be made directional by introducing the polarizing quantity. The polarizing quantity can be phase-to-earth voltage, phase-to-phase voltage, positive-sequence voltage or some other suitable quantity [4].

Cross-polarization

The most common polarization method for today's directional phase o/c protection is cross polarization. Idea of the cross-polarization is to use a healthy phase-to-phase voltage as an angle reference for a faulted phase. Fig.3 depicts how a phase-to-earth fault on phase A falls to a tripping characteristic polarized by phase-to-phase voltage V_{BC}

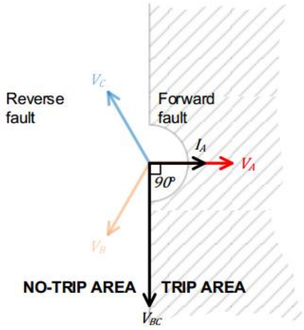


Fig.3 Forward phase-to-earth fault on phase A

As voltage V_{BC} is not affected by the fault, this polarization reference is always present for a phase to-earth fault on phase A. Similarly, phase B fault is polarized by using phase-to-phase voltage V_{CA}, and phase C fault is polarized by using phase-to-phase voltage V_{AB}. If phase voltage was used for polarization, a voltage drop on a nearby fault could cause polarization reference loss, thus endangering directional discrimination. A polarization method that uses faulted phase voltage as the polarization quantity is called self-polarized. Because of a possible loss of the polarization quantity, self-polarization is not commonly used. As explained above, the cross-polarization uses a different polarization reference for all phases. Therefore, especially in older literature, directional phase o/c protection is considered to consist of three separate protection elements, one for each phase. Modern relays typically combine all three phase elements in one directional phase o/c protection function, even if there is a different polarization source for each phase. Because of this historical background, some literature uses terminology such as 30˚, 60˚ or 90˚ connection.[5]

This terminology describes which polarization source is used. For example, 90˚ connection uses a polarization reference that is naturally 90˚ away from the operating quantity. The 90˚ connection (also called quadrature connection) is essentially the same as cross-polarization *(Fig.4)*.

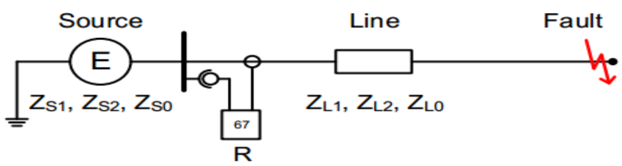


Fig.4 Faulted line

Positive-sequence polarization with different fault cases

The directional phase o/c protection should work for all possible fault cases:

- phase-to-earth fault
- phase-to-phase fault, with and without earth contact
- three-phase fault, with and without earth contact

Because the P3 directional phase o/c protection uses positive-sequence polarization only for phase-to-phase and three phase faults, those cases are studied. All faults involving earth are polarized by using cross-polarization. Because the relay measures essentially the source voltage, we can declare that the positive sequence voltage measured by the relay is equal to the source:

$V1=E\angle 0°$. The positive-sequence current need to be analysed (Fig.5) for all fault cases separately[6].

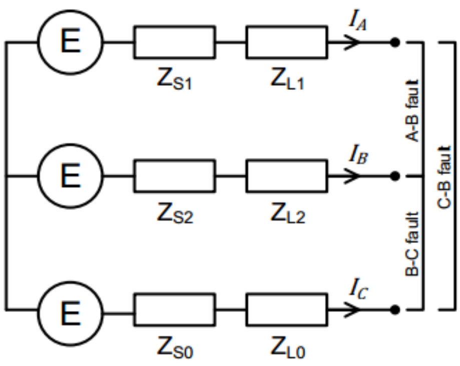


Fig.5. Phase-to-phase fault cases

Assumption, Z= X (inductive)

A-B fault: $I_k = \frac{V_A - V_B}{X} = |I_K| < -60^\circ$ (1)

B-C fault: $I_k = \frac{V_B - V_C}{X} = |I_K| < 180^\circ$ (2)

C-A fault: $I_K = \frac{V_C - V_A}{X} = |I_K| < 60^\circ$ (3)

Application example with relay settings. This simple example shows typical transformer protection by using directional phase o/c protection. Fig. 6 depicts a utility with two incoming feeders and power transformers. The fault situation is a short circuit in one transformer while fault current is fed from a healthy transformer to a faulty one.

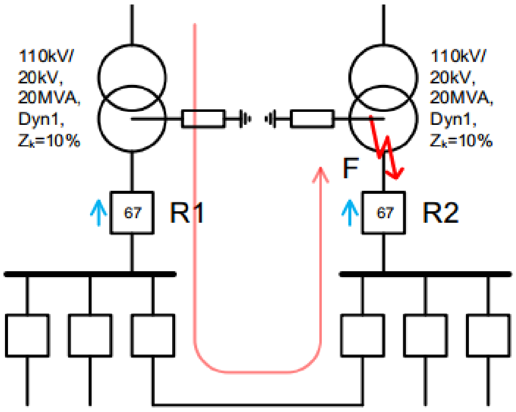


Fig.6.Transformer directional phase o/c protection

This fault case can be coordinated by using directional phase o/c protection. Additional time delay is not needed because of directional discrimination. Fig.7 depicts relay connections for protection settings presented [7].

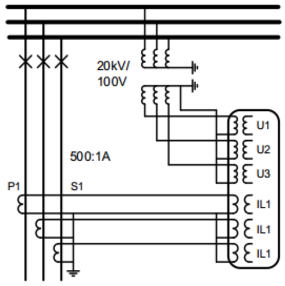
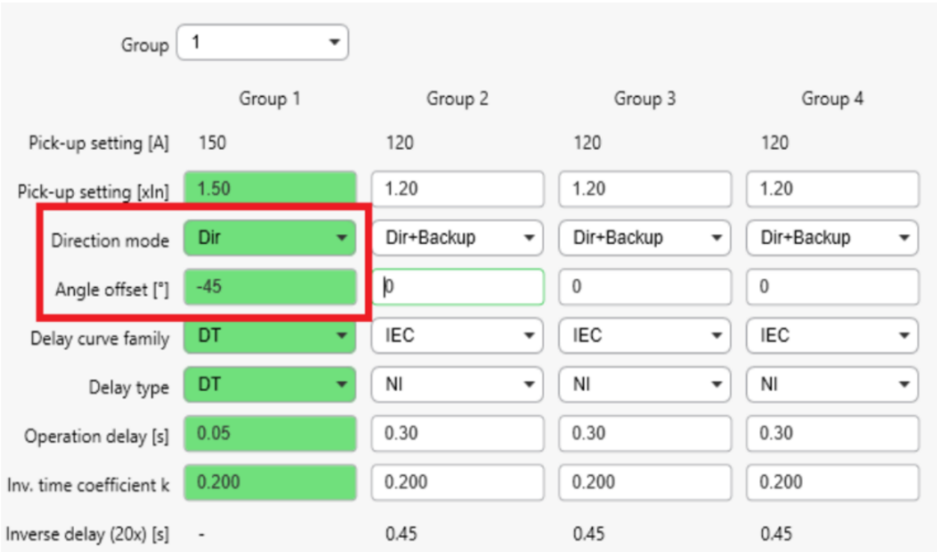


Fig.7.Relay connections for incoming feeder



Group: 1

	Group 1	Group 2	Group 3	Group 4
Pick-up setting [A]	150	120	120	120
Pick-up setting [xIn]	1.50	1.20	1.20	1.20
Direction mode	Dir	Dir+Backup	Dir+Backup	Dir+Backup
Angle offset [°]	-45	0	0	0
Delay curve family	DT	IEC	IEC	IEC
Delay type	DT	NI	NI	NI
Operation delay [s]	0.05	0.30	0.30	0.30
Inv. time coefficient k	0.200	0.200	0.200	0.200
Inverse delay (20x) [s]	-	0.45	0.45	0.45

Fig.8. Relay settings for the example case

General overview: The main task in the implementation of energy supply to industrial enterprises is always the supply of electricity in accordance with the requirements of quality indicators. The above issues of installation of modern Easergy P3 relays instead of electromagnetic relay protection devices designed to protect against various abnormal modes used in the power supply of “Ferganaazot” JSC are considered in detail. Easergy P3 is a complete range of protection relays for medium voltage applications, including feeder, motor, transformer, and generator protection. It embeds all the latest communication protocols on serial or Ethernet links. Based on more than 100 years of experience in network protection relays, Easergy P3 benefits from the reliability of Sepam, MiCOM and Vamp. Easergy P3 protection relay is based on proven technology concepts and developed in close cooperation with customers, so it’s built to meet your toughest demands. It’s available in two sizes to best fit. Based on the information reviewed, it may be recommended to replace these modern Easergy P3 type relay protection and automation devices with old electromagnetic type relays. I believe that this will serve to increase the reliability of the power supply of this enterprise. The above modern relay device can be recommended for inclusion in future modernization plans.

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