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Computations of Relay Settings and Development of Programmable Scheme Logic for a Numerical Distance Relay

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Abstract: In power system protection, relays play a very important role in monitoring the system parameters and separating the faulty sections of the system from the healthy system. Transmission lines are most frequently prone to faults and so their protection is of great importance. With the advances in the technology, transmission line protection is being achieved by using numerical distance relays. This paper concentrates on the protection of transmission lines using numerical distance relays. Calculation of zonal settings and development of programmable scheme logic(PSL) for a numerical distance relay are being discussed.

Keywords: Numerical Relay, Zonal Reach, PSL, P444, PSL Editor.

I. INTRODUCTION

Electrical energy is available to the user at the correct voltage and frequency, and exactly in the amount that is needed. This remarkable performance is achieved through careful planning, design, installation and operation of a very complex network of generators, transformers, and transmission and distribution lines. To the user of electricity, the power system may appear to be in steady state; imperturbable, constant and infinite in capacity. Yet, the power system is subject to constant disturbances created by random load changes, by faults created by natural causes and sometimes as a result of equipment or operation failure. In spite of these constant perturbations, the power system maintains its quasi-steady state because of two basic factors: the large size of power system in relation to the size of individual loads and generators, and correct and quick remedial action taken by the protective relaying equipment. Protective relaying is governed by correct diagnosis of trouble, quickness of response and minimum disturbance to power system. The response must be automatic and response times of the orders of a few milliseconds are often required. Numerical relaying provides a good solution for meeting the needs of protection of the power systems. It provides features such as dependability, security and immunity to variation in parameters of individual components. They are more flexible because of the programmable capability. This paper concentrates on computation of relay settings and the development of programmable scheme logic(PSL) for AREVA make P444 type of numerical distance relay. The PSL will be developed using MiCOM PSL editor and will be validated by testing it on universal numerical relay testing kit (OMICRON make).

A. Zonal protection of transmission lines

To facilitate speedy removal of disturbance from a power system, the system is divided in to protective zones and relays monitor the system quantities appearing in these zones. Numerical relays generally provide 4 or 5 zones of protection depending on the manufacturer. All zones are identical in terms of settings. However, zone 1 has extra adaptive mechanisms built-in to enhance the transient reach accuracy even when the voltage signals are supplied from poor quality voltage sources such as capacitive voltage transformers (CVTs). Ground zones 2 through 5, in turn, have an extra zero-sequence directional supervision implemented for their time-delayed operation after the memory expires. Consequently, zone 1 is recommended as an under-reaching element, and zones 2 through 5 are recommended as overreaching elements and for time-delayed tripping. Since the distance relays are fed from the secondary of line CTs and bus PTs/line CVTs, the line parameters are to be converted into secondary values to set the relay as per requirements.

$$Z_{secy} = Z_{pri}/IR; \quad (1)$$

Where, impedance ratio

$$(IR) = P.T\ ratio/C.T\ ratio \quad (2)$$

Note:

1. Where a three zone relay only is available, the zone 3 will be set to cover the adjacent longest line.
2. The zonal timings will be carefully selected to properly grade with the relays on adjoining sections.

B. Zonal settings logic

Case 1: Zsal < 40% of Zpl

Zone 1=80% of Zpl ; T1=0 sec
Zone 2=120% of Zpl; T2=0.3 sec
Zone 3=100% of Zpl + 50% of Zlal ; T3=0.6 sec
Zone 4=100% of Zpl + 120% of Zlal ; T4=0.9 sec

Case 2: Zsal > 40% of Zpl

Zone 1= 80% of Zpl; T1=0 sec
Zone 2= 100% of Zpl + 50% of Zsal; T2=0.3 sec
Zone 3= 100% of Zpl + 120% of Zsal; T3=0.6 sec
Zone 4= 100% of Zpl + 120% of Zlal; T4=0.9 sec

Case 3: Line ending with power transformer

Zone 1= 110% of Zpl; T1=0 sec
Zone 2= 100% of Zpl + 50% of Zt; T2=0.3 sec
Zone 3= 100% of Zpl + 80% of Zt; T3=0.6 sec
Zone 4= 100% Zpl + 120% of Zt; T4=0.9 sec

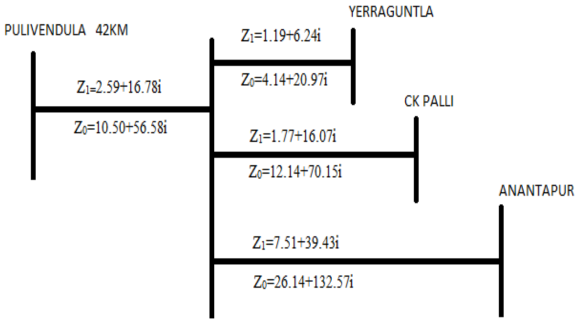
Where, Zpl → impedance of the protected line.
Zsal → impedance of the shortest adjacent line.
Zlal → impedance of longest adjacent line.
Zt → impedance of transformer in ohms.

To account for the effect of fault resistance on zonal settings the arc resistances calculated using Van Warrington's empirical formula are added to the zonal reaches. The values of arc resistances added for different voltage levels are as follows

	132 kv	220kv	400kv
Ground fault	20 ohms	30 ohms	40 ohms
Phase faults	5 ohms	10 ohms	15 ohms

II.CASE STUDY

Based on the above zonal setting logic, settings for the following system are being calculated. The protected line is of 42 kms, has three adjacent lines and the relay is located at pulivendula station. The settings for both primary side and secondary side are calculated. Here P.T ratio=220kv/110v and C.T ratio=800A/1A.



1. Primary reaches:

zone1=2.072000+13.424000i; RG1=32.072000; RP1=12.072000; t1=0 secs
zone2=3.185000+19.900000i; RG2=33.185000; RP2=13.185000; t2=0.3 secs
zone3=4.018000+24.268000i; RG3=34.018000; RP3=14.018000; t3=0.6 secs

zone4=4.821600+29.121600i; RG4=34.821600; RP4=14.821600; t4=0.9secs

2. Secondary reaches:

zone1=0.828800+5.369600i; RG1=12.828800; RP1=4.828800; t1=0 secs

zone2=1.274000+7.960000i; RG1=13.274000; RP1=5.274000; t2=0.3 secs

zone3=1.607200+9.707200i; RG3=13.607200; RP3=5.607200; t3=0.6 secs

zone4=1.928640+11.648640i; RG4=13.928640; RP4=5.928640; t4=0.9 secs

Where, RG is ground reach and RP is the phase reach of the respective zone with the inclusion of arc resistance values.t1 to t4 are the tripping times in each zone.

III. P444 RELAY DESCRIPTION

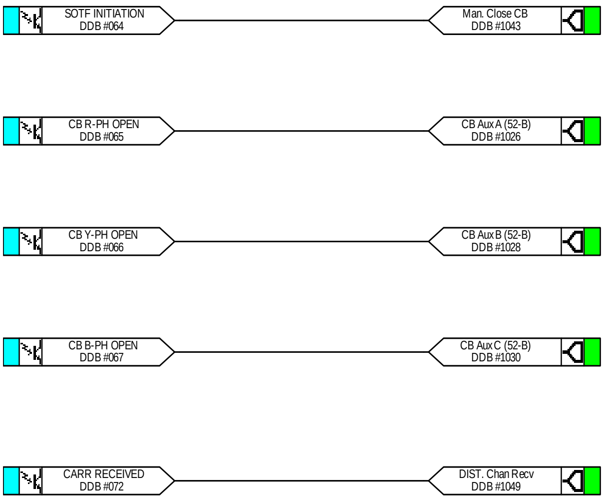
P444 is an advanced numerical distance relay manufactured by AREVA. In addition to the distance protection it also provides some additional protection functions. The relay front panel consists of LED indicators, some for fixed purpose and some programmable and user interface LED screen. In addition it has function keys which are also programmable for different functions. The communication with the relay can be achieved using RS232 communication port. The relay settings can be made using the front panel keys or by communicating with the relay using RS232 port. MiCOM Studio S1 is the software that interfaces the relay with a computer. The relay back panel has terminals for all current and voltage signals, digital logic input signals and all output contacts. Once communication with the relay is established the relay logic can be developed using PSL editor in MiCOM Studio S1.

A. Programmable Scheme Logic (PSL)

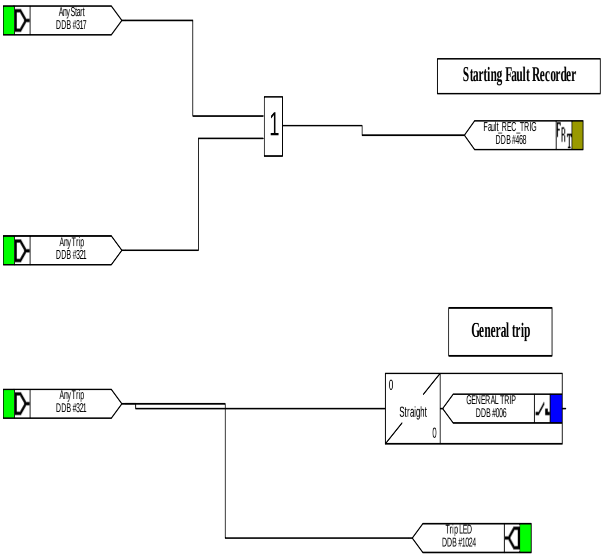
The purpose of the programmable scheme logic (PSL) is to allow the relay user to configure an individual protection scheme to suit their particular application. This is achieved through the use of programmable logic gates and delay timers. The input to the PSL is any combination of the status of opto inputs. It is also used to assign the mapping of functions to the opto inputs and output contacts, the outputs of the protection elements, e.g. protection starts and trips, and the outputs of the fixed protection scheme logic. The fixed scheme logic provides the relay's standard protection schemes. The PSL itself consists of software logic gates and timers. The logic gates can be programmed to perform a range of different logic functions and can accept any number of inputs. The timers are used either to create a programmable delay, and/or to condition the logic outputs, e.g. to create a pulse of fixed duration on the output regardless of the length of the pulse on the input. The outputs of the PSL are the LEDs on the front panel of the relay and the output contacts at the rear. The execution of the PSL logic is event driven; the logic is processed whenever any of its inputs change, for example as a result of a change in one of the digital input signals or a trip output from a protection element. Also, only the part of the PSL logic that is affected by the particular input change that has occurred is processed. This reduces the amount of processing time that is used by the PSL; even with large, complex PSL schemes the relay trip time will not lengthen.

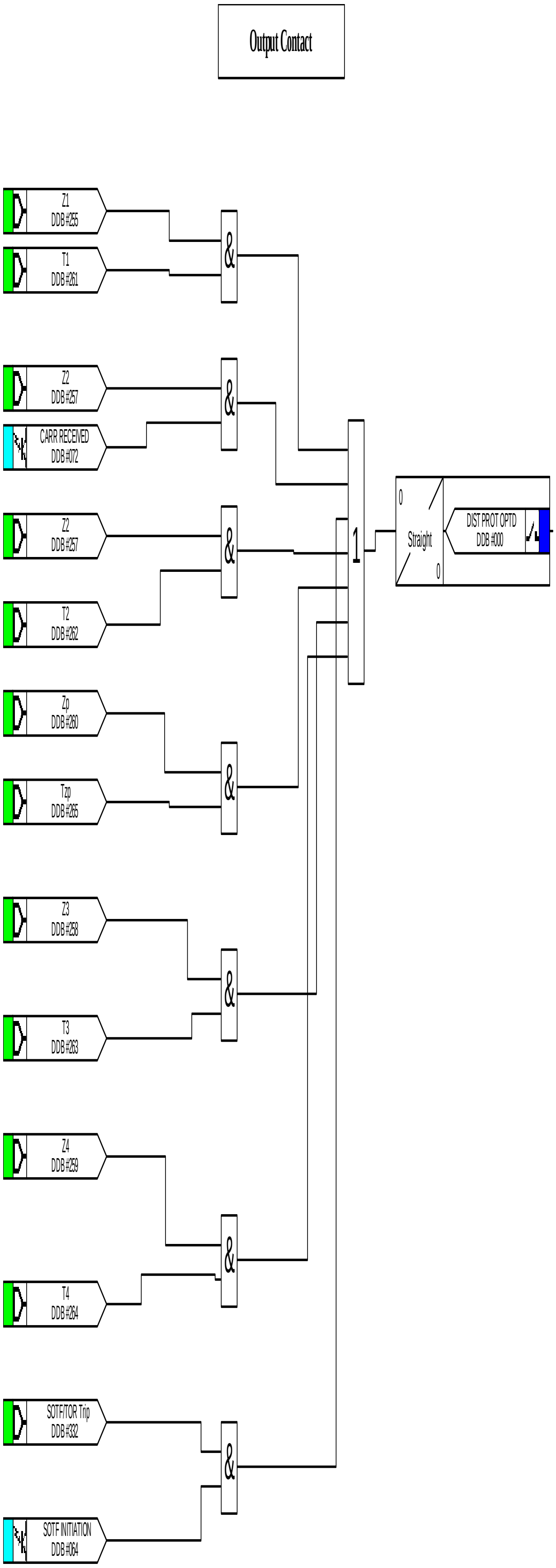
B. PSL scheme for 4 zones of protection

1. Input output couplers:

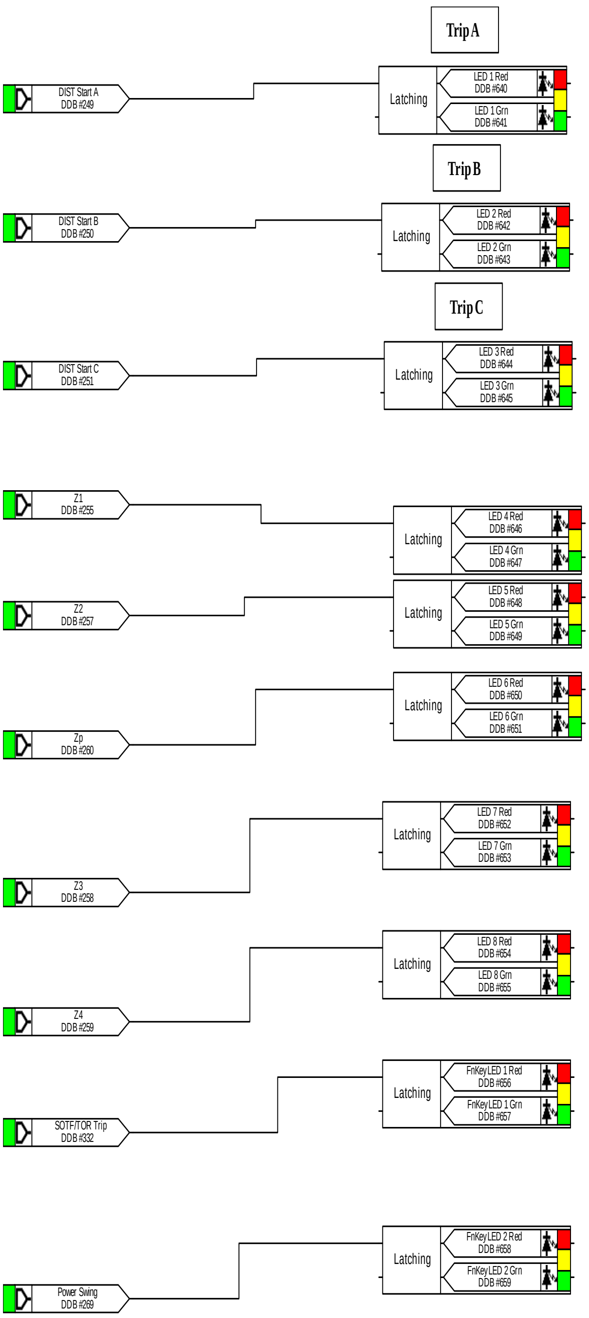


2. Output contact:





3. LED front panel:



IV. TESTING OF THE LOGIC

Once the logic is developed, it is to be sent to the relay and has to be tested before it is finally employed. The testing of the logic will be done using OMICRON make universal relay testing kit. The testing kit will have dedicated interface software to create various conditions of test cases. The relay is connected to the testing kit and the inputs for various conditions are fed from the interface software. The settings of the above test case are fed to relay and testing is carried out with various test cases. The results of the test are as follows:

Zone1:

Fault	R	X	Trip time (m sec)	Location of fault(kms)
L1-G	4.7	2.7	21	17.4
L2-G	8.3	5.1	25	32
L3-G	18.9	3.8	23	24.82
L1-L2	1.8	5	25	31
L2-L3	1.2	5	20	31.25
L3-L1	4.3	4.7	23	29.83
L1-L2-L3	0.3	5.3	21	33.46

Zone2:

Fault	R	X	Trip time (m sec)	Location of fault(kms)
L1-G	5.1	10	306	62
L2-G	8.6	9.3	305	59
L3-G	1	9.7	310	61
L1-L2	1.7	8.7	318	54.7
L2-L3	6.3	9.6	317	60
L3-L1	6	8.2	320	51.7
L1-L2-L3	3.1	9.5	312	59

Zone3:

Fault	R	X	Trip time (m sec)	Location of fault(kms)
L1-G	3.7	13.5	615	84.94
L2-G	9.6	14.2	609	89.75
L3-G	1	14.2	614	89.5
L1-L2	5	14.6	615	91.5
L2-L3	11	14	611	87
L3-L1	1.12	15.16	609	94.5
L1-L2-L3	2.6	12.7	611	79.6

Zone4:

Fault	R	X	Trip time (msec)	Location of fault(kms)
L1-G	5.5	18.8	908	118
L2-G	1	18.8	906	117.7
L3-G	7	18.4	913	115.7
L1-L2	1.3	18.5	918	115.6
L2-L3	1.12	17	910	107.7
L3-L1	5.7	16.3	913	101.7
L1-L2-L3	10	18.4	909	115.2

V. CONCLUSION

This paper has discussed the protection of the transmission lines using numerical distance relays. Zonal reaches of the numerical relay are discussed and reaches of the relay are calculated for a test case with the inclusion of effect of fault resistance. PSL is developed for a AREVA make P444 relay using

MiCOM S1 Studio PSL editor. The logic is tested using a OMICRON make universal relay testing kit. Time of operation of the relay and location of the fault are noted from the relay after its trip signal.

VI. REFERENCES

[1] S. H. Horowitz, A. G. Phadke, Power System Relaying, Taunton, Research Studies Press.

[2] Russel. C. Mason, The Art and Science of Protective Relaying, GE series.

[3] Numerical Relay Application Guide, AREVA.

[4] P44x Technical Guide, Schneider Electric.

[5] Electrical Transmission & Distribution Guide, Westinghouse Electric.

[6] Protective Relaying Application Guide, GEC measurements.

[7] Paul. M. Anderson, Analysis of Faulted Power Systems, IEEE Press.