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OPTIMUM OVERCURRENT RELAY'S COORDINATION USING MULTIPLE STANDARD RELAYS CHARACTERISTICS

Preet Shah, Shanker D. Godwal, Soumesh Chatterjee, Akhilesh A. Nimje
E-Mail Id: 20bee092@nirmauni.ac.in
Electrical Engineering Department, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India

Abstract- Relay Coordination is very crucial task as it required coordination of primary and backup relays. in past various authors have proposed modification in standard overcurrent relays characteristic, modification in objective function to achieve optimum results of operating time of primary as well as backup relays. In this paper, considering normal inverse, very inverse and extremely inverse standard relays characteristic, optimized results are obtained using PSO, GA, HAS. Further these results have been validated on radial distribution system.
Keywords: Overcurrent relays, relay coordination, particle swarm optimization, Plug setting

1. PROBLEM FORMULATION

The theory of overcurrent relay coordination state that the aggregate of the operating times of all overcurrent relays must be minimum when they operate as primary relays. Most of the researchers used the objective function given as in eq. (1).

$$\mathbf{OF_1} = \sum_{i=1}^{m} \mathbf{t_{i,k}} \qquad (1)$$

where, m is the total number of relays in the system; $t_{i,k}$ - operating time of the relay Ri, for fault at bus k. By considering below four constraints defined in eq.(2) to eq.(5), the optimum value of the said objective function can be achieved. To obtain viable and optimum relay coordination, these constraints are necessary.
The following are the relay coordination constraints

$$t_{ik} - t_{jk} - CTI \geq \Delta t \qquad (2)$$

$$t_{i,min} \leq t_i \leq t_{i,max} \qquad (3)$$

$$TMS_{i,min} \leq TMS_i \leq TMS_{i,max} \qquad (4)$$

$$PS_{i,min} \leq PSi \leq PS_{i,max} \qquad (5)$$

where, tik and tjk are the operating time of primary and backup relays, CTI is the coordination time interval, ti,min and ti,max are minimum and maximum possible operating time of individual relay, TMSi,min, and TMSi,max are the minimum and maximum value of TMSi and PSi,min and PSi,max is the minimum and maximum plug setting of an individual relay.

Table-1.1 Constants for various 7 common standardized Tripping Curves

CCs type	A	B	C
IEC (NI)	0.140	0.020	0.0
IEC(VI)	13.50	1.000	0.0
IEC(EI)	80.00	2.000	0.0

2. TEST SYSTEMS

2.1 Test system 1

In this system one radial feeder is considered. In this system four relays are kept. This system is shown as per fig. 2.1. Four overcurrent relays are IDMT and non direction overcurrent relays Relay R1 will protect section AB, Relay R2 will protect section BC Relay R3 will protect section CD and relay R4 will protect region beyond D. on each bus individual load is connected. Each load having 1 MW capacity. Further fault level at bus A is 10000 A, at bus B 8000 A, at bus C 6000 A and at bus D 5000 A respectively. Each relay is associated with CT ratio 800/1.

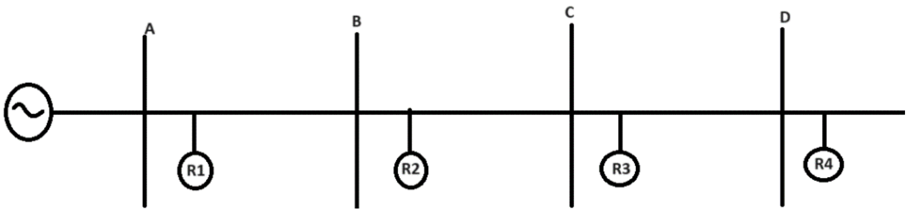

Fig. 2.1 Four bus Radial Distribution System

3. RESULTS AND DISCUSSION

Table 3.1 show the plug setting (PS) and time multiplier setting (TMS) of test system-1 considering normal inverse, very inverse and extremely inverse. The PS and TMS are obtained using genetic algorithm. Table 3.2 depicts the PS and TMS of test system-1 considering very inverse, very inverse and extremely inverse. The PS and TMS are obtained using particle swarm optimization algorithm. Table 4 show the plug setting (PS) and time multiplier setting(TMS) of test system-1 considering normal inverse, very inverse and extremely inverse. The PS and TMS are obtained using Harmonic search algorithm. It is found that PS and time setting range are between 0.5 to 2.5 of rated CT secondary current in all three cases.

Table-3.1 PS and TMS for test system 1 considering GA optimization

PR	NI		VI		EI	
	PS	TMS	PS	TMS	PS	TMS
R1	1.65	0.87	1.45	0.92	1.34	0.79
R2	2	0.63	1.23	0.56	1.85	0.99
R3	2.1	0.43	1.93	0.52	1.56	0.51
R4	1.5	0.34	1.86	0.41	1.78	0.45

Table-3.2 PS and TMS for test system 1 considering PSO Optimization

PR	NI		VI		EI	
	PS	TMS	PS	TMS	PS	TMS
R1	1.45	0.85	1.39	0.76	1.59	0.92
R2	1.74	0.72	1.95	0.72	1.22	0.35
R3	0.67	0.4	1.45	0.36	2.01	0.44
R4	1.45	0.28	1.8	0.38	1.3	0.1

Table-3.3 PS and TMS for test system 1 considering HSA Optimization

PR	NI		VI		EI	
	PS	TMS	PS	TMS	PS	TMS
R1	2.03	0.79	1.23	1	1.49	0.84
R2	1.09	0.56	1.09	0.61	1.53	0.48
R3	1.67	0.41	1.67	0.46	2.17	0.42
R4	1.49	0.24	1.49	0.34	1.89	0.12

Table 3.4 show the sum of operating time of primary and backup relays of test system-1 considering normal inverse, very inverse and extremely inverse. These operating times are calculated using genetic algorithm. The operating time are in acceptable range. Table 3.5 present the sum of operating time of primary and backup relays of test system-1 considering normal inverse, very inverse and extremely inverse. These operating times are calculated using particle swarm optimization algorithm. The operating time are in acceptable range. Table 3.6 show the sum of operating time of primary and backup relays of test system-1 considering normal inverse, very inverse and extremely inverse. These operating times are calculated using harmonic search algorithm. In this case also, the operating time is found in acceptable range. It can be noted that Harmonic search algorithm more superior as compared to both GA and PSO considering normal inverse relays characteristic whereas PSO is much better if very inverse relay characteristic is adopted for overcurrent relays coordination. Similarly, it is observed that for extremely inverse overcurrent relays HSA delivers optimum results.

Table-3.4 Sum of operating time for test system 1 considering GA

	NI	VI	EI
$\sum OTp$	5.48s	2.44s	1.05s
$\sum OTb$	4.84s	2.47s	1.20s

Table-3.5 Sum of operating time for test system 1 considering PSO

	NI	VI	EI
$\sum OTp$	6.29s	2.14s	0.60s
$\sum OTb$	6.01s	2.11s	0.86s

Table-3.6 Sum of operating time for test system 1 considering HSA

	NI	VI	EI
$\sum$ OTp	5.10s	2.86s	0.56s
$\sum$ OTb	4.80s	3.00s	0.78s

Table-3.7 Operating time for test system-1 considering GA optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	1.95	--	--
R2	R1	1.43	2.11	0.58
R3	R2	1.06	1.58	0.42
R4	R3	1.04	1.14	0.00

Table-3.8 Operating time for test system-1 considering PSO optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	1.99		
R2	R1	1.71	2.17	0.35
R3	R2	1.71	1.91	0.11
R4	R3	0.87	1.93	0.96

Table-3.9 Operating time for test system-1 considering HSA optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	1.66		
R2	R1	1.60	1.78	0.08
R3	R2	1.11	1.83	0.62
R4	R3	0.74	1.20	0.36

Table-3.10Operating time for test system-1 considering GA optimization and VI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.73		
R2	R1	0.67	0.92	0.15
R3	R2	0.52	0.92	0.30
R4	R3	0.52	0.63	0.01

Table-3.11 Operating time for test system-1 considering PSO optimization and VI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.63		
R2	R1	0.53	0.80	0.17
R3	R2	0.49	0.71	0.12
R4	R3	0.50	0.60	0.00

Table-3.12 Operating time for test system-1 considering HSA optimization and VI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.94		
R2	R1	0.83	1.19	0.26
R3	R2	0.54	1.15	0.51
R4	R3	0.55	0.66	0.01

Table-3.13 Operating time for test system-1 considering GA optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.23		
R2	R1	0.23	0.35	0.02
R3	R2	0.30	0.41	0.01
R4	R3	0.29	0.43	0.04

Table-3.14 Operating time for test system-1 considering PSO optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.19		
R2	R1	0.19	0.29	0.00
R3	R2	0.16	0.34	0.08
R4	R3	0.12	0.22	0.00

Table-3.15 Operating time for test system-1 considering HSA optimization and NI relay characteristics

PR	BR	OTp	OTb	CTI
R1	--	0.19		
R2	R1	0.16	0.30	0.04
R3	R2	0.13	0.29	0.07
R4	R3	0.07	0.18	0.01

CONCLUSION

In this paper, considering three overcurrent standard relays characteristic namely normal inverse, very inverse and extremely inverse the optimum operating time of overcurrent relays are obtained. Further to obtained optimum time of relays, three soft computing techniques are used. These soft computing techniques are genetic algorithm, particle swarm optimization and harmonic search algorithm. It is found that for very inverse overcurrent relays characteristic particle swarm optimization produce much better results.

But for normal inverse overcurrent relays characteristics and extremely inverse overcurrent relays characteristic, harmonic search algorithm produce better results.

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