一种判断金属性短路的方法

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【摘要】　文中针对大多数单端测距算法, 在金属性短路、或过渡电阻不大时短路都能得到准确故障距离的实际, 提出了一种判断金属性短路的方法, 并利用 EMTP 仿真数据对方法进行了验证, 结果证明方法是正确的。

【关键词】　故障　高压输电线路　短路

引言

实际中, 过渡电阻是影响精确故障测距算法精度的主要因素, 所有的单端测距算法都是围绕此进行讨论的, 大多数算法在金属性短路、或过渡电阻不大时短路都能得到准确的故障距离, 但如何确定此时的测距结果就是准确故障距离(即算法所得故障距离的可信度有多高), 或如何估计故障点过渡电阻的大小, 下文对此进行了定性的讨论:

1　判断金属性短路的基本原理

如图 1 所示线路的 R—L 参数模型:

假设输电线路的分布电容可以忽略, 由故障点到测量点的输电线路可以用一电阻和电感(R、L)串联电路来表示, 于是下列微分方程成立:

$$U = X(R_1 i + L_1 \mathrm{d}i/\mathrm{d}t) + U_f \qquad (1)$$

写成离散形式为:

$$U_K = L_1 X D_K + U_{fk} \qquad (2)$$

其中:

相间短路时:

$$+ \ i_K * (RD/L \mp)\ (i_{K+1} - i_{K-1})/(2 \times T_S) + \qquad (3)$$

单相短路时:

$$D_K = [i_{K+1} - i_{K-1} + 3K_1(i_{0k+1} - i_{0k-1})]/(2 \times T_S) + (i_k + K_r 3 i_{0k})(R_1/L_1) \qquad (4)$$

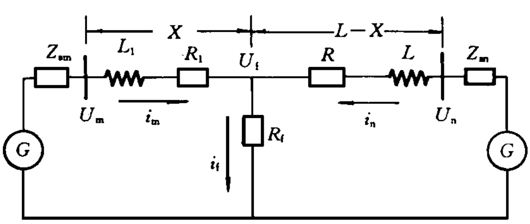

图 1　线路的 R—L 参数模型

R_1、L_1: 为输电线路每公里的正序电阻和电感。

X: 为输电线路上故障点至测量点的距离(即为所求故障距离)。

T_s: 为采样周期

U_K: 测量点 K 时刻的电压采样值。I_k: 测量点 K 时刻的电流采样值。

U_{fk}: 故障点 K 时刻的电压采样值。(未知量)

对于相间短路, 取故障相的线电压、线电流, 如 AB 相短路, U、I 取 U_{ab}, I_{ab}。

收稿日期: 1996—04—22

对于单相接地短路, 两相接地短路, 取故障相的相电压、相电流, 加零序补偿电流, 如A 相接地短路, U、I 分别取 U_a, $I_a + K_r 3i_0 (I_a + K_1 3i_0)$。

K_r, K_1: 为零序电流补偿系数, 其值为: $K_L = \frac{L_0 - L_1}{3L_1}$, $K_r = \frac{R_0 - R_1}{3R_1}$

利用 2 式可以判断金属性短路和非金属性短路:

(1) 当金属性短路时, 对于任一采样时刻 U_{fk} 始终等于 0, 如果令 U_{fk} 始终等于 0, 用 2 式计算出的 X 是一不随采样点 K 而变化的定值, 而且, 此时的 X 对应故障的真实距离。

(2) 当非金属性短路时, U_{fk} 呈一定(正弦或余弦) 规律变化, 此时如果令 U_{fk} 始终等于 0, 用 2 式计算出的 X 是随采样点 K 而变化的值, 且相邻的两个值之差越大, 说明过渡电阻越大; 反之, 说明过渡电阻越小。

2 EMTP 仿真结果

下面用 EMTP 仿真进一步证明上述结论的正确性:

线路模型一如图 2 所示, 是 102km 长的 500kV 超高压输电线路。线路参数如下: (标幺值)

	L km	$R1$ PU/km	$WL1$ PU/km	$WC1$ PU/km	$R0$ PU/km	$WL0$ PU/km	$WC0$ PU/km
L	102	0.000098	0.0011	0.00118	0.00071	0.00252	0.000788

基准值 $S_b = 1000MVA$, $U_b = 525kV$。

仿真结果:

表 1 $D = 31km$ AN 故障类型: AN 实际故障距离: $L = 31km$, $Em = 1.1En\angle 30°$

Rg (Ω)	$k1$	$k2$	$k3$	$k4$	$k5$	$k6$	$k7$	$k8$	$k9$	$k10$	$k11$	$k12$	$k13$	$k14$	$k15$	$k16$	$k17$	$k18$	$k19$	$k20$
0.0	29.92	32.03	31.71	31.62	31.57	31.54	31.51	31.47	31.28	33.82	31.70	31.59	31.42	31.54	31.51	31.48	31.45	31.41	31.35	31.20
0.1	32.26	31.78	31.66	31.60	31.56	31.53	31.50	31.45	31.32	32.21	31.62	31.55	31.52	31.49	31.47	31.44	31.40	31.33	31.18	30.21
0.25	24.94	29.14	30.19	30.71	31.05	31.33	31.61	32.00	33.02	25.78	30.61	31.19	31.49	31.72	31.94	32.20	32.54	33.12	34.44	43.48
0.5	18.26	26.62	28.78	29.86	30.58	31.16	31.76	32.60	34.82	18.93	29.54	30.79	31.43	31.92	32.40	32.95	33.68	34.90	37.76	58.96
1.0	6.60	21.94	26.14	28.28	29.73	30.93	32.18	33.95	38.72	4.28	27.21	29.89	31.25	32.28	33.27	34.40	35.93	38.48	44.60	99.39

表 2 $D = 71km$ AN 故障类型: AN 实际故障距离: $L = 72km$, $Em = 1.1En\angle 30°$

Rg (Ω)	$k1$	$k2$	$k3$	$k4$	$k5$	$k6$	$k7$	$k8$	$k9$	$k10$	$k11$	$k12$	$k13$	$k14$	$k15$	$k16$	$k17$	$k18$	$k19$	$k20$
0.0	71.37	66.11	73.10	72.53	72.35	72.24	72.16	72.09	72.01	71.87	76.22	72.58	71.50	72.32	72.21	72.14	72.00	71.91	71.76	72.07
0.1	68.19	73.40	72.63	72.41	72.29	72.20	72.13	72.05	71.92	71.57	74.09	72.46	72.27	72.17	72.11	72.04	71.98	71.88	71.73	71.36
0.25	98.55	65.21	69.53	70.81	71.47	71.91	72.28	72.64	73.14	74.43	65.82	71.48	72.20	72.59	72.90	73.21	73.58	74.09	74.97	77.22
0.5	136.20	57.67	66.59	69.30	70.71	71.67	72.47	73.29	74.43	77.47	57.07	70.41	72.08	72.96	73.66	74.35	75.16	76.28	78.22	83.22
1.0	247.06	44.23	61.13	66.49	69.35	71.33	73.00	74.75	77.25	84.06	38.53	68.00	71.71	73.62	75.10	76.56	78.27	80.64	84.76	95.66

注: (1) 在求 X 时, 应对所采样数据进行数字滤波, 消除其所含高频分量。这里我们采用了 Tukey 低通滤波器[1] 消除高频分量。

(2) 由于在求导数时, 是用差分运算代替导数运算, 因此对于个别点会导致算法不稳定, 求出的 X 很大, 此时可将数据窗向后移动一点, 重新计算。

(3) 对于高压远距离输电线路, 分布电容较大, 1 式应改写如下:

$$u = xR_1 i - xR_1 C \frac{du}{dt} + xL_1 \frac{di}{dt} - xL_1 C \frac{d^2 i}{dt^2} + u_f$$

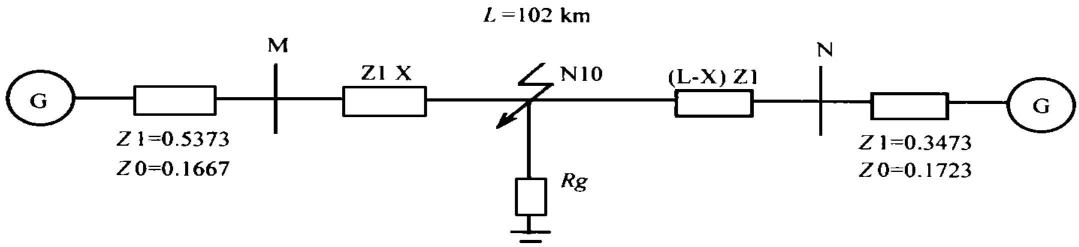

图 2　模拟系统结线图

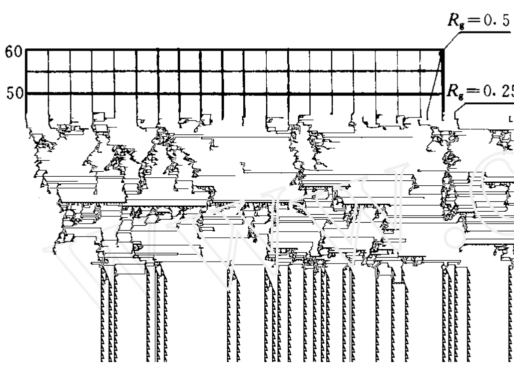

图 3

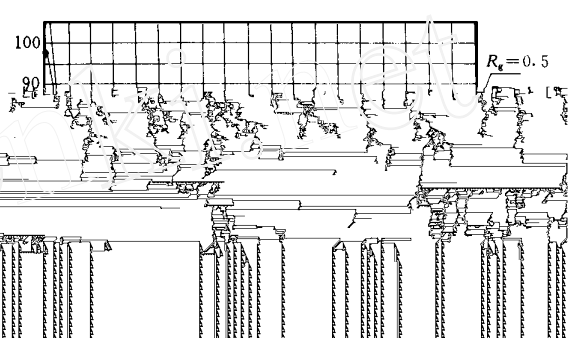

图 4

3　结论

数字仿真结果与理论是一致的。如图 3、4 所示, 当金属性短路时, 计算出的 X 随采样时刻 K 在真实的故障距离附近有较小的波动, 是一水平线, (此时计算出的 X 可认为就是真实的故障距离); 当非金属性短路时, 计算出的 X 是随采样时刻 K 而有较大的变化不再是一定值。

因此, 对于 2 式, 如果令 U_{fk} 始终等于 0, 计算出的 X: 如果是一不随采样点 K 而变化的定值, 则对应金属性短路和准确故障距离。如果是随采样点 K 变化而变化的值, 则对应非金属性短路, 且相邻两点 X 之差越小, 故障点过渡电阻也越小, 反之, 说明过渡电阻也越大。(采样频率一定)。

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RELAY

Vol. 25 No. 5 Oct. 1997

CONTENTS AND ABSTRACTS (Partial)

THEORETICAL STUDY AND APPLICATION

Applying expert system theory and intelligent program designing method and combining conventional setting calculation of zero- sequence current protection, an expert system of setting calculation for zero- sequence current protection has been developed. The system better realizes the effective combination of value calculation and logic inference and is easy for realization of the expert system's behaviour. By practical calculation, its result can satisfy the requirement.

Keywords: Setting calculation of protective relay Expert system

This paper discusses when parallel multiloop transmission lines may result in induced voltage and circulating current. The EMTP program is used to compute model system. The method for compensation of circulating current is discussed and the method is effective for distortionless operation of protective relays.

Keywords: Multiloop transmission line Parallel Circulating current Compensation

After analyzing the problems of analog phase- comparison pilot relays that run in our power system, this paper discusses some difficulties when realizing digital phase- comparison relay according to the approach of realizing analog phase- comparison relay. In the same time, the paper analyzes the existing problems of power line carrier and provides the corresponding resolving method. Some foundation viewpoints for the design of new type digital phase- comparison relay are presented.

Keywords: Phase- comparison pilot relay Microprocessor- based protective device Power line carrier communication system

A new approach of evaluating phasor mode is presented in this paper. Contrasting with other methods, the approach is of higher approaching accuracy, and in four subdivisions its maximum error is less than 7.87510^{-3}%. Thus it is of higher practical value in microprocessor- based protective and control devices.

Keywords: Evaluating phasor mode Approach

A kind of approach for judging metal- fault is presented basing on the practical case that majority of locating algorithms from single- end can evaluate accurate fault distance at metal fault or short- circuit with less transient resistance. The approach is tested using EMTP and its result proves the approach is correct.

Key words: Fault HV transmission line Short- circuit

NEW TECHNIQUE AND SCHEME

A kind of HF protection communication- - "transmitting audio protection signal on PLC in multi- purpose mode" is discussed in this paper. Because of increasing shortage of carrier frequency on power network, demand on using channel in multi- purpose mode is increasing strongly. Using PLC to transmit protection signal is an economic and reliable transmission mode, no matter now or in the future. Transmitting audio protection signal on PLC in multi- purpose mode belongs in 'edge science' between communication field and protection field and needs engineers of the two fields to make research together.

Keywords: PLC Teleprotection Simultaneous multi- purpose Alternative multi- purpose