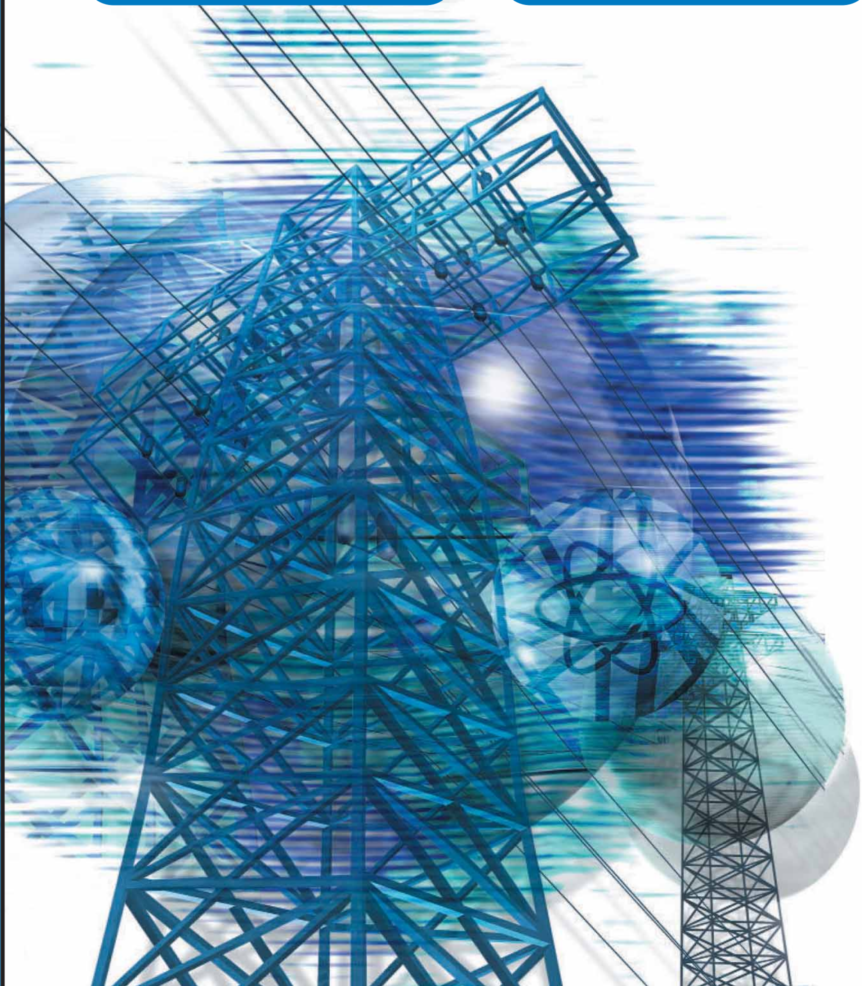
High Impedance Protection

RMS 2V73
Restricted Earth Fault

RMS 2V75
Metrosil Module

Reyrolle DAD-N
Numeric High Impedance Differential



- Applications include auto-transformers, busbars, reactors, motors, generators, capacitors & individual transformer windings
- DAD-N provides high impedance differential protection with CT supervision, plus offers all the advantages of a numeric relay including communications, programmable LED's, expandable input/output, fault, event, and waveform records
- 2V73 is a cost effective single pole relay ideal for restricted earth fault applications or can be used on a per phase basis for three phase high impedance differential protection
- 2V75 provides a compact, simple & cost effective means of fitting a pre-wired three phase Metrosil & resistor combination into protection panels
- 1M123, 1M124 are single tier 4U high racks, factory assembled and pre-wired with the above components to form complete three phase busbar protection schemes

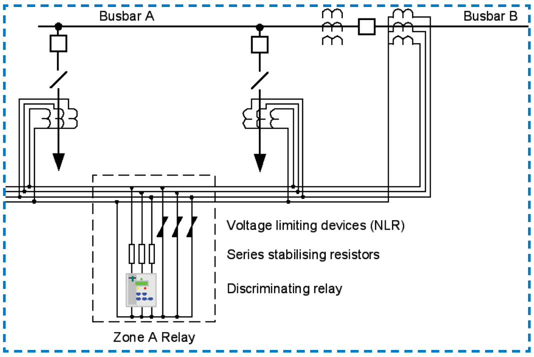
leading the way in high impedance differential solutions

Relay Monitoring Systems Pty Ltd
6 Anzed Court Mulgrave Victoria 3170
Telephone: 61-3-9561 0266
Facsimile: 61-3-9561 0277
Email: gavin.ogorman@rmspl.com.au
Web Site: www.rmspl.com.au

rms

Guidelines for the Setting Calculations required for…

HIGH IMPEDANCE PROTECTION



The stability of a high impedance differential scheme depends upon the relay circuit setting voltage being greater than the maximum voltage which can appear across the relay circuit under a given through fault condition (i.e. external fault). This voltage can be determined by means of a simple calculation which makes the following assumptions:

a) One CT is fully saturated making its excitation impedance negligible;
b) The resistance of the secondary winding of the saturated CT together with the leads connecting it to the relay circuit terminals constitutes the only burden in parallel with the relay;
c) The remaining CT's maintain their ratio.

Thus the minimum stability voltage is given by:

$$Vs = \frac{If}{N} \times (Rct + Rl)$$

Vs = relay circuit setting voltage (stability voltage)
If = the maximum primary through fault current
N = CT turns ratio
Rct = CT secondary winding resistance
Rl = the maximum lead loop resistance

For stability, the relay circuit setting voltage should be made equal to or exceed this calculated value. No factor of safety is necessary because this is built into the assumptions made above.

CURRENT TRANSFORMER REQUIREMENTS

Current transformers for high impedance protection should be specified in accordance with IEC60044 (part 5), class PX, or with AS1675, class PL. The basic requirements are:

a) All the current transformers should have identical turns ratios;
b) The knee point voltage Vk of the current transformers should be at least twice the relay voltage setting. The knee point voltage is expressed as the voltage at fundamental frequency applied to the secondary circuit of the current transformer which when increased in magnitude by 10% causes the magnetizing current to increase by 50%;

$$Vk > 2Vs$$

c) The current transformers should be of the low leakage reactance type.

SETTING RESISTOR

If the relay used in the scheme has a low burden, then a series setting resistor will be required to provide the relay circuit setting voltage for stability. Assuming the relay burden is very small and the CT's do not have very low knee point voltages (less than 25V), the relay burden can be neglected and the setting resistor value is then given by:

$$Rs = Vs / Is$$

The stabilising resistor is an important component in the scheme and should be selected to ensure that it performs reliably for all operational conditions. The thermal withstand for any possible continuous spill current and for the fault condition need to be considered, as well as the voltage withstand.

SETTING RESISTOR CONTINUOUS POWER RATING

The continuous power rating of a resistor is defined as:

$$Pcon = Is^2 \times Rs$$

Pcon= resistor continuous power rating
Is = the operating current of the relay
Rs = resistance of setting resistor

SETTING RESISTOR HALF-SECOND POWER RATING

The rms voltage developed across a resistor for maximum internal fault conditions is defined as:

$$Vf = 1.3 \times (Vk^3 \times Rs \times Ifs)^{1/4}$$

Vf = rms voltage across resistor
Ifs = maximum secondary fault current

Thus the half-second power rating is given by:

$$Phalf = Vf^2 / Rs$$

NON LINEAR RESISTOR (METROSIL)

The previous calculations produced a voltage setting for through fault stability, now the case for an internal fault needs to be considered. The maximum primary fault current will cause high voltage spikes across the relay at instants of zero flux since a practical CT core enters saturation on each half-cycle for voltages of this magnitude.

A formula in common use, which gives a reasonable approximation to the peak voltage produced under internal fault conditions, is expressed as:

$$Vpk = 2 \times (2Vk \times [Vfs-Vk])^{1/2}$$

Vpk = peak value of the voltage waveform
Vfs = value of voltage that would appear if CT did not saturate
Vfs = Ifs x (Rr + Rs)
Rr = relay resistance

To protect the CT's, the secondary wiring, and the relay from damage due to excessively high voltages, a non-linear resistor is connected in parallel with the relay circuit if the peak voltage would exceed 3kV. If the calculated peak voltage is less than 3kV it is not necessary to employ a non-linear resistor.

The type of non-linear resistor required is chosen by:

a) Its thermal rating as defined by the empirical formula:

$$P = 4/pi \times Ifs \times Vk$$

There are two types of Metrosil available the 3 inch type with a maximum rating of 8kJ/s and the 6 inch type with a maximum rating of 33kJ/s.

b) Its non-linear characteristic i.e. $V = CI^B$, where C and B are constants.

A resistor with C and B values is selected which ensures the peak voltage cannot exceed 3kV and in the region of the relay circuit setting voltage, the current shunted by the non-linear resistor is very small (e.g. $<$10mA).

FAULT SETTING

The primary operating current or fault setting may be calculated from:

$$Iop = (n.Ie + Is + Inlr) \times N$$

Iop = primary fault setting
n = number of CTs in parallel
Ie = excitation current of each CT at the relay circuit setting voltage
Inlr = current in metrosil at the relay circuit setting voltage

If the calculated Iop is lower than a specified minimum then a shunt setting resistor is required in order to raise the fault setting.

For further information please contact Relay Monitoring Systems at www.rmspl.com.au