7PG26 DAD

High Impedance Relays

Document Release History

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Pre release

02/2010	Document reformat due to rebrand

Software Revision History

Contents

1. INTRODUCTION

The relay can be used for high impedance busbar zone protection and circulating current protection of auto transformers, motors, and generators, and restricted earth fault protection. A simplified scheme is shown in figure 1.

Transient stability under through fault conditions is a problem with many forms of differential protection due to variations in CT magnetizing characteristics. As saturation is approached, the CT output current waveforms become increasingly distorted with high percentage of 3rd and other higher odd harmonics. These problems can be overcome by either using biased differential protection, or more elegantly by the use of high impedance schemes. In the latter case the relay settings are calculated with known stability margins. Intermediate conditions, where a CT is only partially saturated, increases the stability margin. This approach enables schemes to be engineered using CTs with relatively low knee point voltages.

The DAD relay also incorporates supervision of CT secondary circuits. This supervision provides a desirable safety feature particularly where the CTs are switched for different busbar arrangements. When carrying load current an open circuit CT will cause unbalance in any current balance group. As this can cause instability it is normal practice to use a sensitive relay to detect this condition. In addition to initiating an alarm after a time delay, zone switched relays, when they are required, can be energized to switch out the affected zone. This integration of protection, CT supervision and associated timers considerably simplifies system design and secondary wiring.

High impedance busbar protection is recommended for all switchgear applications where faults must be cleared in the shortest possible time. High impedance schemes can provide lower fault settings and better through fault stability than most other schemes.

The stability of a current balance scheme using a high impedance relay circuit depends upon the relay voltage setting being greater than the maximum voltage which can appear across the relay under a given fault condition. A setting resistor or resistors, and non linear resistor, per phase, complete the scheme and are mounted externally to the relay. The resistor value is determined by the voltage level required for stability and the value of relay current calculated to provide the required primary fault setting. Non linear resistors protect the CTs and relay from the excessively high voltages which may occur e.g. for high values of in-zone fault current.

2. THEORY OF HIGH IMPEDANCE CURRENT BALANCE PROTECTICE SCHEMES AND THEIR APPLICATION

2.1 Determination of Stability

The stability of a current balance scheme using a high impedance relay circuit is based on the fact that for a given through fault condition, the maximum voltage that can occur across the relay circuit is determined by means of a simple calculation. If the setting voltage of the relay is made equal to or greater than this voltage, then the protection will be stable.

In calculating the required setting voltage of the relay it is assumed that one current transformer is fully saturated and that the remaining CTs maintain their ratio. In this condition, the excitation impedance of the saturated CT is negligible and the resistance of the secondary winding, together with leads connecting the CT to the relay terminals, constitute the only burden in parallel with the relay as shown in figure 2.

Thus the voltage across the relay is given by:

$$V = I \times (X1 + Y1) \text{ for CT1 saturated}$$
$$V = I \times (X2 \times Y2) \text{ for CT2 saturated}$$

X1 and X2	= the secondary winding resistances of the CTs
Y1 and Y2	= the value of the pilot loop resistance between the relative CT and the relay circuit terminals
I	= the CT secondary current corresponding to the maximum steady state through fault current of the protected equipment
V	= the maximum voltage that can occur across the relay circuit under through fault conditions

For stability, the voltage setting, Vs, of the relay must be made equal to or exceed, the highest value of V calculated above.

Experience and extensive laboratory tests have proved that if this method of estimating the relay setting voltage is adopted, the stability of the protection will be much greater than the value of I used in the calculation. This is because a CT is normally not continuously saturated and consequently any voltage generated by this CT will reduce the voltage appearing across the relay circuit.

The DAD is a low burden, current operated relay and the stability voltage setting is achieved by employing a series resistor of appropriate ohmic value (e.g. depending on the current setting chosen) and power dissipation rating.

2.2 Current Transformer Requirements

For high impedance schemes it is necessary to establish characteristics of the CT in accordance with Class 'X' to BS 3938 and that where the CTs are specifically designed for this protection their overall size may be smaller than that required for an alternative current balance protection. The basic requirements are:

All CTs should, if possible have identical turns ratios.

The knee point voltage of each CT, should be at least 2 x Vs. The knee point voltage is expressed as the voltage applied to the secondary circuit with the primary open circuit which when increased by 10% causes the magnetizing current to increase by 50%.

CTs should be of the low leakage reactance type. Most modern CTs are of this type and there is no difficulty in meeting this requirement. A low leakage reactance CT has a joint less ring type core, the secondary winding evenly distributed along the whole length of the magnetic circuit and the primary conductor passes though the appropriate centre of the core.

2.3 Overvoltage Protection

The maximum primary fault current in the protected zone 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. Thus it is necessary to suppress the voltage with a non linear resistor in a shunt connection which will pass the excess current as the voltage rises. The type of non linear resistor required is chosen by its thermal ring.

2.4 Fault Setting

The fault setting of a current balance protection using a high impedance relay circuit can be calculated in the following manner.

Primary fault setting = N (I + I1 + I2 + I3 + I_{sh})

I	= the relay operating current
I1, I2, I3	= the excitation currents of the CTs at the relay setting voltage
N	= the CT ratio
I_{sh}	= other shunt circuits where provided e.g. non linear resistor etc.

The fault setting of the protective scheme depends upon the protected equipment and the type of system earthing. For a solidly earthed power transformer a fault setting of 10 to 60% of the rated current of the protected winding is recommended. If the power transformer is earthed through a resistor rated to pass a earth fault current of 100% of more the rated current of the protected winding, a fault setting of 10 to 25% of the rated current of the earthed resistor is recommended.

In the case of feeders terminating in a power transformer, it may be necessary to increase the basic fault setting to ensure that the capacitance currents of the feeder do not impair the stability of the protection. For stability during an external fault on the system to which the feeder is connected, the fault setting should preferably be greater than three times the residual capacitance current of the feeder. The maximum residual capacitance current is equal to the capacitance current to earth per phase at normal voltage in the case of a feeder in a solidly earthed system. Higher fault settings can be obtained as described in the following section.

2.4.1 To give required current setting

The primary fault current setting required can usually be obtained by employing the appropriate DAD current settings. Alternatively , when the required fault setting is large, the correct result can be obtained by connecting a resistor in parallel with relay circuit, thereby effectively increasing the value of primary current setting. The DAD minimum current setting is 5mA and this is normally sufficient to achieve the most onerous requirement for sensitivity. However where a very high sensitivity is required the CT magnetisation current at the relay circuit operating voltage must be kept to a low value in order to reduce the primary operating current further.

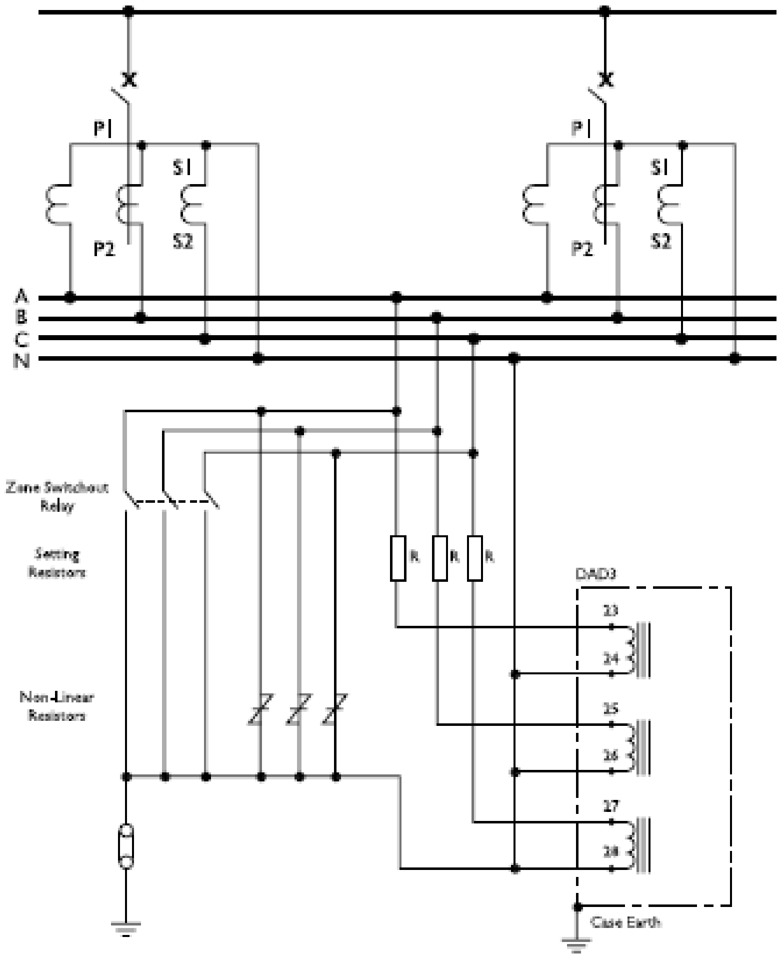

Figure 1 Simplified Typical A.C. Schematic Diagram for Bus Zone Protection

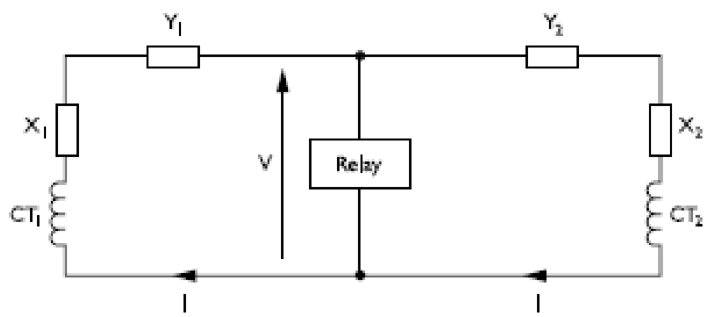

Figure 2 Basic Circulating Current Scheme