Contents *Page*

1 REQUIREMENTS AND BASIC TECHNICAL DATA - REL 551

1.1 Transformer requirements

The operation of a differential and distance protection measuring function is influenced by distortion, and measures need to be taken in the protection to handle this phenomenon. One source of distortion is current transformer saturation. In this protection terminal, measures are taken to allow for a certain amount of CT saturation with maintained correct operation. This protection terminal can allow relatively heavy current transformer saturation.

Distance protections are also affected by transients caused by capacitive voltage transformers (CVTs) but as this protection terminal has a very effective filter for these transients, the operation is hardly affected at all.

1.2 Requirements on voltage instrument transformers

Magnetic or capacitive voltage transformers can be used.

Capacitive voltage transformers should fulfil the requirements according to IEC 186A, Section 20, with regard to transients. According to the standard, at a primary voltage drop down to zero, the secondary voltage should drop to less than 10% of the peak pre-fault value within one cycle.

The protection terminal has an effective filter for this transient, which gives secure and correct operation with CVTs.

1.3 Requirements on current instrument transformers

1.3.1 Choice of current transformers

The current transformer should be of type TPX or TPY with an accuracy class of 5P or better. The characteristic of the linearised current transformer type TPZ is not well defined as far as the phase angle error is concerned, and we therefore recommend that ABB Relays is contacted for confirmation that the type in question can be used.

The current transformer ratio should be selected so that the current to the protection is higher than the minimum operating value for all faults that are to be detected.

The minimum operating current for the differential protection function in REL 551 is 20% of the nominal current multiplied with the CTFactor setting. The CTFactor is settable 0,40-1,00.

The current transformer resulting ratio must be equal in both terminals. The resulting current transformer ratio is the primary current transformer ratio multiplied with the CTFactor. The CTFactor is used to equalise different primary current transformer ratio in the two terminals or to reduce the resulting current transformer ratio to which the minimum operating current is related.

Different rated secondary current for the current transformers in the two terminals is equalised by using REL 551 with the corresponding rated current.

The minimum operating current for the distance protection is 20% of the nominal current, and for the earth-fault overcurrent protection it is 5%.

1.3.2 Conditions for the CT requirements

The requirements for this protection terminal are a result of investigations performed in our network simulator. The tests have been carried out with an analogue current transformer model with a settable core area, core length, air gap and number of primary and secondary turns. The setting of the current transformer model was representative for current transformers of type TPX and TPY. The results are not valid for TPZ.

The performance of the protection was checked at both symmetrical and fully asymmetrical fault currents. A source with a time constant of about 120 ms was used at the tests. The current requirements below are thus applicable both for symmetrical and asymmetrical fault currents.

Both phase-to-earth, phase-to-phase and three-phase faults were tested in fault locations backward, close up forward and at the distance protection zone 1 reach. The protection was checked with regard to dependability, security, directionality and overreach.

All testing was made without any remanence flux in the current transformer core. The requirements below are therefore fully valid for a core with no remanence flux. It is difficult to give general recommendations for additional margins for remanence flux. They depend on reliability and economy requirements.

When current transformers of type TPY are used, practically no additional margin is needed due to the anti-remanence air gap.

For current transformers of type TPX, the small probability of a fully asymmetrical fault, together with maximum remanence flux in the same direction as the flux generated by the fault, has to be kept in mind at the decision of an additional margin. Fully asymmetrical fault current will be achieved when the fault occurs at zero voltage (0°). According to Van Warrington, over 95% of the faults occur within 40° before the voltage maximum, i.e. the peak value of the voltage wave.

1.3.3 Fault current

The current transformer requirements are based on the maximum fault current for faults in different locations. Maximum fault current will occur either for three-phase faults or for single-phase-to-earth-faults. The current for a single phase-to-earth-fault will exceed the current for a three-phase fault when the zero sequence impedance in the total fault loop is less than the positive sequence impedance.

When calculating the current transformer requirements, maximum fault current should be used and therefore both fault types have to be considered.

1.3.4 Cable resistance and additional load

The current transformer saturation is directly affected by the voltage at the current transformer secondary terminals. This voltage, for an earth-fault, is developed in a loop containing the phase and neutral conductor, and relay load. For three-phase faults, the neutral current is zero, and only the phase conductor and relay phase load have to be considered.

In the calculation, the loop resistance should be used for phase-to-earth-faults and the phase resistance for three-phase faults.

1.3.5 Current transformer requirements for the differential protection

The current transformer secondary limiting emf (E_{2max}) should meet the four requirements below. The requirements according to the formulas below are valid for fault currents with a dc-timeconstant less than 120 ms.

Requirement 1:

$$E_{2max} > \frac{I_{kmax} \cdot I_{sn}}{I_{pn}} \cdot 0,5 \cdot \left(R_{CT} + R_L + \frac{0,5}{I_R^2}\right)$$

I_{kmax}	The highest primary **fault current for an internal close-up fault**
I_{pn}	Primary nominal CT current
I_{sn}	Secondary nominal CT current
I_R	REL 551 nominal current
R_{CT}	CT secondary winding resistance
R_L	CT secondary cable loop resistance and additional load

Requirement 2:

$$E_{2max} > 0,12 \cdot f \cdot I_{sn} \cdot \left(R_{CT} + R_L + \frac{0,5}{I_R^2} \right)$$

f	Nominal frequency
I_{sn}	Secondary nominal CT current
I_R	REL 551 nominal current
R_{CT}	CT secondary winding resistance
R_L	CT secondary cable loop resistance and additional load

Requirement 3:

$$E_{2max} > \frac{I_{kmax} \cdot I_{sn}}{I_{pn}} \cdot 2 \cdot \left(R_{CT} + R_L + \frac{0,5}{I_R^2} \right)$$

I_{kmax}	The highest **through fault current for an external fault**
I_{pn}	Primary nominal CT current
I_{sn}	Secondary nominal CT current
I_R	REL 551 nominal current
R_{CT}	CT secondary winding resistance
R_L	CT secondary cable loop resistance and additional load

Requirement 4:

$$E_{2max} > IMinSat \cdot CTFactor \cdot I_R \cdot \left(R_{CT} + R_L + \frac{0,5}{I_R^2} \right)$$

IMinSat	Set saturation detector min current (100 - 1000% I_r)
CTFactor	Set current scaling factor (0,4 - 1,0)
I_R	REL 551 nominal current
R_{CT}	CT secondary winding resistance
R_L	CT secondary cable loop resistance and additional load

1.4 Requirement on the differential protection remote end data communication

REL 551 is designed to work with digital communication systems. A data message, 22 bytes long, is sent every 5 ms. The protocol used is HDLC with a 16 bit Cyclic Redundancy Check (CRC). To ensure compatibility with a wide range of communication equipment and media, the relay is designed to work within the signalling bandwidth of a standard CCITT PCM channel at 64 kbits/s and during some conditions the North American EIA PCM systems working at 56 kbits/s.

REL 551 communicates continuously and requires a permanent communication circuit. The call control and handshaking features specified for some interfacing recommendations are therefore not provided.

During normal conditions, the bit error rate (BER) should not be higher than 10^{-6} and under no circumstances higher than $4x10^{-4}$ in order to ensure the reliable operation of the protection.

There are four different types of communication modules available, two for optical fibre connection and two for galvanic connection. The first intended for operation on dedicated fibres or to be use together with equipments of type FOX6Plus (for connection to multiplexers according to CCITT standard G.703) or FOX20. It is designed to work both with 9/125 µm single-mode fibres and 50/125 or 62,5/125 µm multimode fibres at 1300 nm wavelength. The connectors are of type FC-PC. With an attenuation in fibres of 0,4 dB/km and additional attenuation due to installation of 0,1 dB/km a maximum distance of 32 km can be obtained with single-mode fibres.

For details on the short range modems, refer to chapter 1MRK 580 039-XEN.

The communication module of galvanic type is intended for use together with multiplexers or other communication equipment. The requirement for this is that the protection is within the same building as the communication equipment, within a distance less than 100 m, and that the environment is relatively free from noise. In this case the protection may be connected directly to the multiplexer via shielded and properly earthed cables with twisted pairs.

Equipment is available for the following interfacing recommendations, specifying the interconnection of the digital equipment to a PCM multiplexer:

- V.35/36 co-directional galvanic interface
- V.35/36 contra-directional galvanic interface
- X.21 galvanic interface
- RS530/422 co-directional galvanic interface
- RS530/422 contra-directional galvanic interface

For the signals used by REL 551, the communication module for V.36 also fulfils the older recommendation for V.35.

The connection is established by DSUB connectors, 15 pins for X.21 and 25 pins for V.35/36 and RS530.

1.5 Demands on communication links for remote communication

The optical fibres that can be bought from ABB Relays AB fulfil all the requirements for the communication in the station. Both plastic fibres and glass fibres can be used. For distances up to 30 m, plastic fibres and for distances up to 500 m, glass fibres are suitable. Glass and plastic fibres can be mixed in the same loop.

For communication on longer distances, telephone modems are used. The modems must be Hayes-compatible using “AT” commands with automatic answering (AA) capability. The telephone network must comply with the CCITT standards.

For connection of the optical fibre loop to a PC or a telephone modem, an opto/electrical converter is required. The converter uses RS232 and it has a D25 connector on the electrical side. The converter is supplied by ABB Relays AB.

1.6 Demands on PC for local man machine interface (MMI)

The PC shall comply with the following requirements:

- 100% IBM compatible running with DOS 5.0 or higher
- 640 kb RAM or more (at least 450 kb available)
- VGA screen and floppy disk drive 3 1/2” (1,44 Mb)
- 3 Mb disk space required for the local MMI program SM/REL 551 for communication to the front port
- Additional disk space required depends on the application, see 1MDB11021-EN SMS 200 or 1MDB11019-EN SMS 010.
- one serial port (COM) available

1.7 Technical data

Table 1: Energizing quantities, rated values and limits

Quantity	Rated value	Nominal range
Current Operative range Burden	I_r = 1 or 5 A (0,2-4) × I_r cont. (0,2-100) × I_r for 1 s *) < 0,25 VA at I_r	(0,2-30) x I_r (0,2-15) x I_r for line differential function
Frequency	f_r = 50/60 Hz	± 5 %
Auxiliary dc voltage EL power consumption basic terminal each I/O-board Comm board each output relay	U_r = (48/60) V U_r = (110/125) V U_r = (220/250) V ≤ 14 W ≤ 1 W ≤ 2 W ≤ 0,1 W	± 20 % ± 20 % ± 20 %
Binary input circuits dc voltage RL power consumption U_r = (24/30)V U_r = (48/60)V U_r = (110/125)V U_r = (220/250)V	 U_r = (24/30) V U_r = (48/60) V U_r = (110/125) V U_r = (220/250) V max. 0,05 W/input max. 0,1 W/input max. 0,2 W/input max. 0,4 W/input	 ± 20 % ± 20 % ± 20 % ± 20 %
Ambient temperature	20° C	-5° C to +55° C
Ripple in dc auxiliary voltage	max. 2 %	max. 12 %
Relative humidity	(10-90) %	(10-90) %

*) max. 350 A for 1 s when COMBIFLEX test switch included together with the product

Table 2: Influencing factors, Permissible influence

Dependence on:	Within nominal range	Within operative range
Ambient temperature	0,01 % / °C	Correct function
Ripple in auxiliary dc voltage	Negligible	Correct function
Interruption in auxiliary dc voltage without resetting correct function restart time	 < 50 ms 0 - ∞ < 45 s	 < 50 ms 0 - ∞ < 45 s

Table 3: Electromagnetic compatibility tests

Test	Type test values	Reference standards
1 MHz burst disturbance For short range galvanic modem For galvanic interface *) - differential mode - common mode	2,5 kV 2,5kV 1 kV 0,5 kV	IEC 255-22-1, Class III IEC 255-22-1, Class III Class II Class II
Electrostatic discharge For short range galvanic modem For galvanic interface *)	8 kV 8 kV -	IEC 255-22-2, Class III IEC 255-22-2, Class III
Fast transient disturbance For short range galvanic modem For galvanic interface *)	4 kV 4 kV 1 kV	IEC 255-22-4, Class IV IEC 255-22-4, Class IV Class II, level 2
Radiated electromagnetic field disturbance	10 V/m, (25-1000) MHz	IEC 255-22-3, Class III Draft IEEE/ANSI C37.90.2

*) Applicable for the differential communication module and FOX6Plus only, for the following standards:
- V.36/V11 Co-directional according to CCITT
- V.36/V11 Contra-directional according to CCITT
- X21/X27 according to CCITT
- RS530/RS422 Co-directional according to EIA
- RS 530/RS422 Contra-directional according to EIA
- G.703 according to CCITT

Table 4: Insulation tests (reference standard: IEC 255-5)

Test	Type test values
Dielectric test For short range galvanic modem For galvanic interface *)	2,0 kV ac, 1 min 2,5 kV ac, 1 min 1,0 kV ac, 1 min
Impulse voltage test For short range galvanic modem For galvanic interface *) For other circuits	 5 kV, 1,2/50 µs, 0,5 J 1 kV, 1,2/50 µs, 0,5 J 5 kV, 1,2/50 µs, 0,5 J
Insulation resistance	>100 MΩ at 500 V dc

*) Applicable for the differential communication module and FOX6Plus only, see comments under table 3.

Table 5: Mechanical tests

Test	Type test values	Reference standards
Vibration	Class I	IEC 255-21-1
Shock and bump	Class I	IEC 255-21-2
Seismic	Class I	IEC 255-21-3

Table 6: Contact data (reference standard: IEC 255)

Function or quantity	Trip and Signal relays	Fast signal relays
Max system voltage	250 V ac, dc	250 V ac, dc
Test voltage across open contact, 1 min	1000 V rms	800 V dc
Current carrying capacity continuous 1 s	 8 A 10 A	 8 A 10 A
Making capacity at inductive load with L/R>10 ms 0,2 s 1,0 s	 30 A 10 A	 0,4 A 0,4 A
Breaking capacity for ac, cos φ>0,4	250 V/8,0 A	250 V/8,0 A
Breaking capacity for dc with L/R<40 ms	48 V/1 A 110 V/0,4 A 220 V/0,2 A 250 V/0,15 A	48 V/1 A 110 V/0,4 A 220 V/0,2 A 250 V/0,15 A
Maximum capacitive load	-	10 nF

Table 7: Additional General Data

Weight approx.	8,5 kg
Dimensions width height depth	 223,7 mm 267 mm 245 mm
Storage temperature	-40° C to +70° C