ABB
ASEA BROWN BOVERI

ABB Relays

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User's Guide
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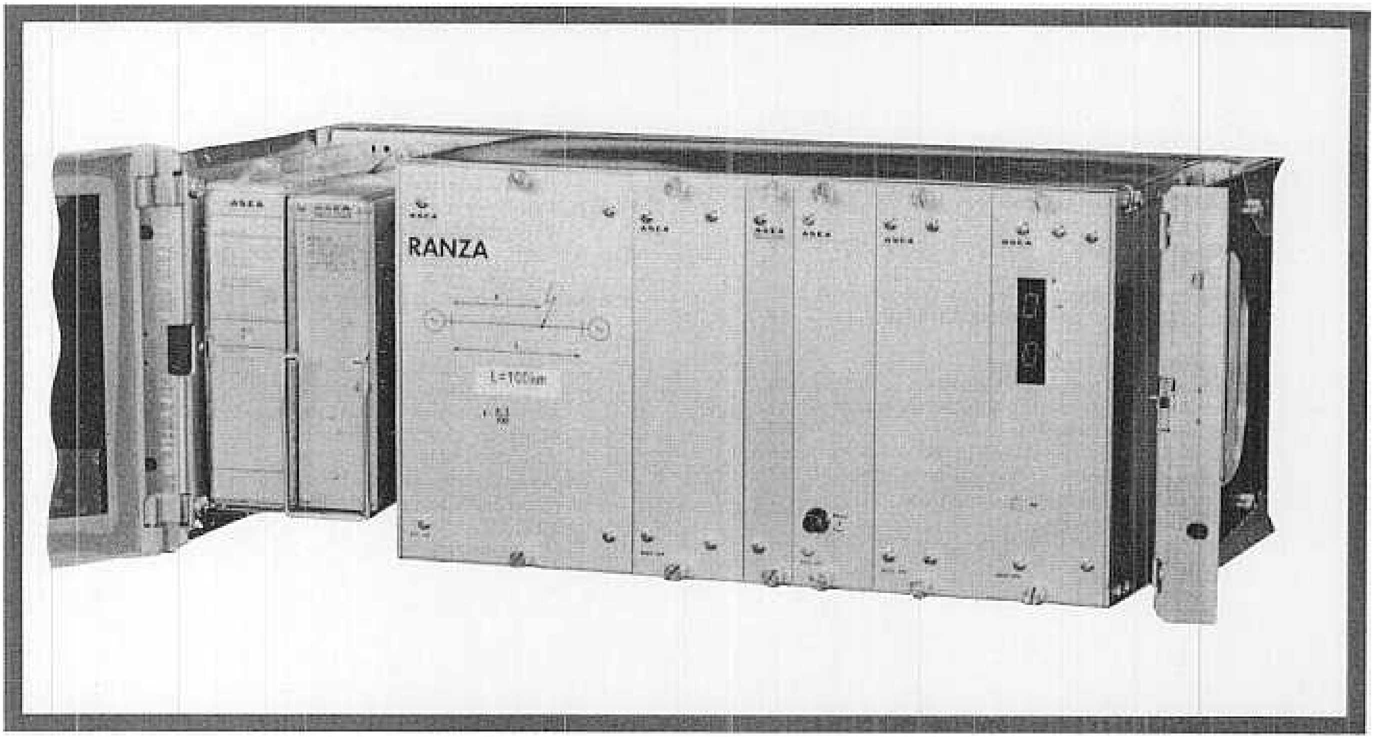
Type RANZA
Fault locator



ABSTRACT

- Uses measuring quantities of one of the line-section ends
- Connects to existing current and voltage transformers
- A microprocessor-based system determines, with great accuracy, the distance to the fault after receiving the starting signal from the protective relay
- The distance to the fault is presented as a percentage of the line-section length on a front-mounted display
- The applicable algorithm is not influenced by:
  - infeed of fault current from the remote end of the line
  - load current of the line
  - magnitude of fault resistance
- Outputs for telemetry and local printout of the distance to fault and the filtered measured values both prior to and after the fault
- Printouts of filtered measured values can be obtained even during normal operation of the line
- Can be used with compensation for mutual impedance from a parallel line
- The phase selection feature can be built-in as option.
- Built-in feature for testing the electronic circuits
- Printers are available as optional extras

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APPLICATION

The RANZA-type fault locator is an essential complement to protective relays of transmission lines, since it measures with great accuracy and indicates the distance to the fault. The calculation is executed by a microprocessor and memory circuits in which the stored measuring information and the measured current and voltage values are used for the purpose of compensating for the influence which the infeed current from the remote end of the line may have on determining the distance, particularly where high fault resistance is involved. The distance to the fault is indicated, by a front mounted display, as a percentage of the line-section length. The indicated distance to the fault can also be transferred via relay outputs for telemetric transmission to another place. The fault can then be rapidly located for repairs.

The RANZA works in co-operation with the line protection and receives the required phase-selection and starting information from this. However, it can also be provided with built-in phase selection equipment and then only requires starting information from the line protection.

The RANZA can also be combined with a printer for documenting the distance to the fault and the fundamental components both prior to and after the fault. This information could be very useful for further fault analysis. The printer can also be used for recording load data during the normal operation of the line, and to document the setting values.

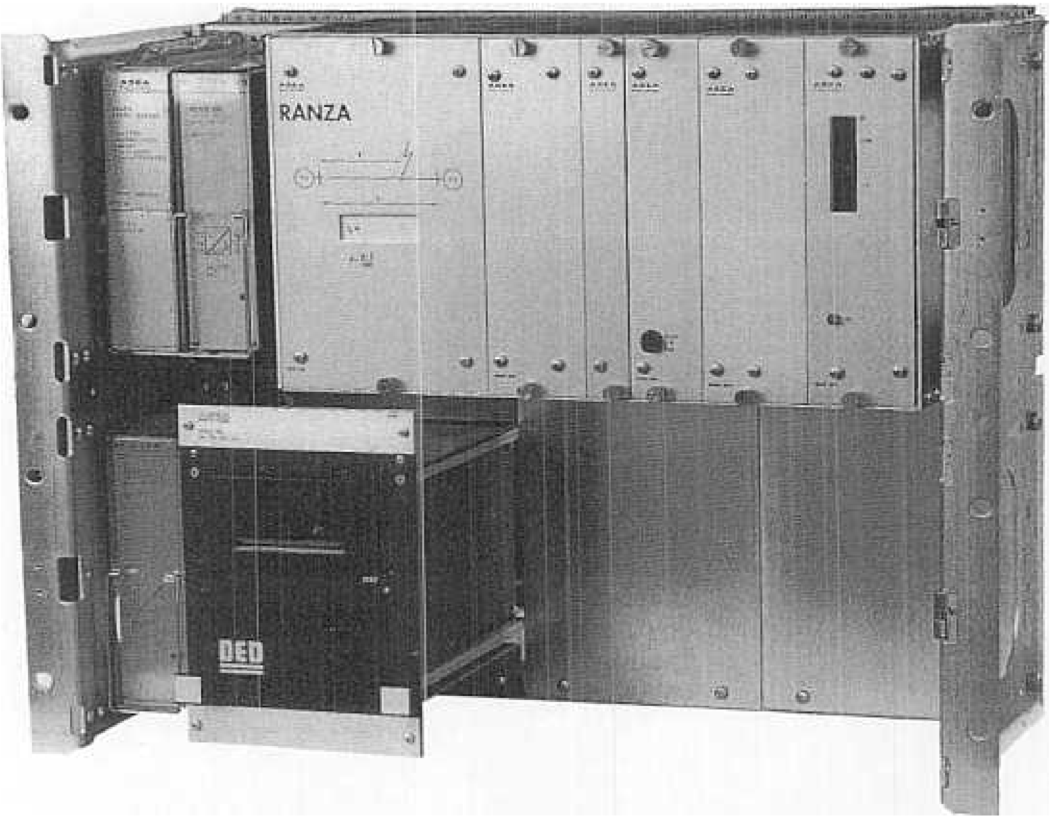

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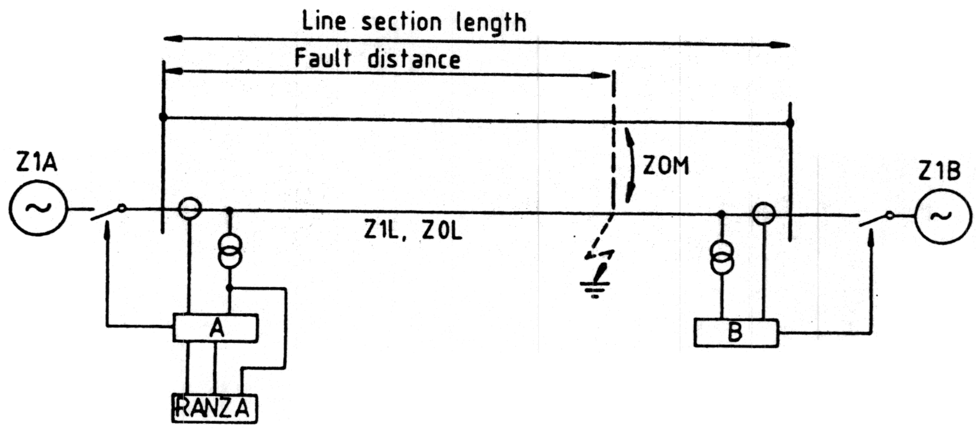
Fig. 1 RANZA incorporating a printer for documentation purposes.

In cases when RANZA is used in lines which incorporate ABB's distance relays, the phase-selection and starting information can be obtained from the distance relay. In those cases when the phase-selection information cannot be obtained from the starting relay, a version of RANZA with a built-in software phase selection is available.

The RANZA is connected to the current and voltage transformers of the line, in principle as shown in Fig. 2. The figure also shows the line data which is utilized when setting the RANZA.



A, B = Line protection
Z1L, Z0L = Positive sequence and zero sequence values of line impedance
Z1A, Z1B = Positive sequence values of source impedance
Z0M = Mutual zero sequence impedance

Fig. 2 Principle diagram showing the connections of RANZA.

Since the RANZA stores information from the voltage and current transformers of the line and, after starting for determining the distance to the fault, uses the measured values which are obtained immediately before and during the fault, the requirements imposed on the current transformers are very liberal. The distance to the fault is determined with great accuracy if the current transformers fulfill the same requirements as those imposed on the distance protection transformers, i.e., without being saturated in the case of faults which occur in the far end of the line.

To enable the RANZA to calculate the distance to a fault and to compensate for the influence which an infeed fault current, from the remote end of the line, can have on the determination of the distance, the starting relay must issue the start signal to RANZA within about 9 cycles after the fault occurred.

VERSIONS

The RANZA is available in the following versions:

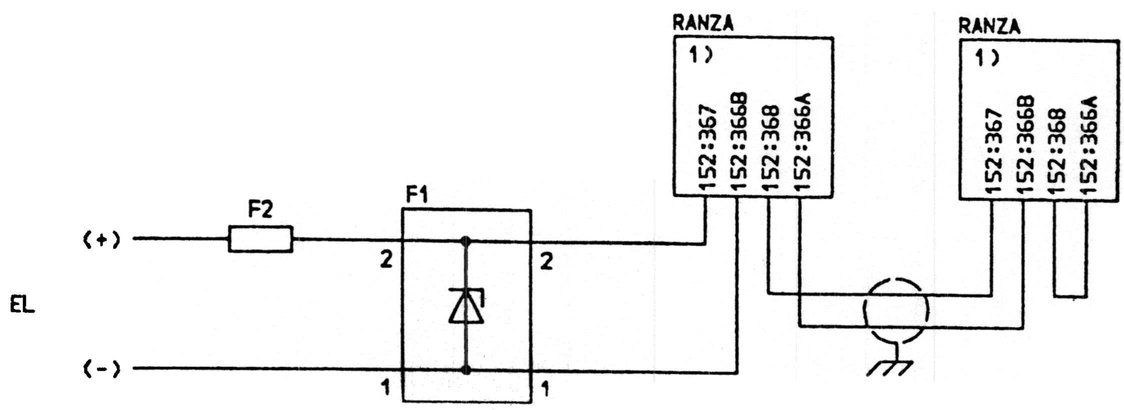
1. Mounted on bars (60C, 4S) and with input relays for external phase selection
2. Mounted on bars (60C, 4S) and with built-in phase selector

Both can be used for as well single as parallel lines and are programmed, in conjunction with commissioning, to compensate for mutual impedances of parallel lines during the calculating stage.

Compensation with respect to parallel lines

When compensation is to be used, a fault locator must be used for each line.

The influence, which the mutual impedance has on the measurements, is compensated for by transferring to RANZA, in the faulty line, a portion of the zero sequence current which, during an earth fault, is measured in the healthy line. The transfer is executed in binary mode with ASCII-coded signals in the current loop between the two RANZAs after the starting signal has been obtained by the RANZA in the healthy line and the RANZA in the faulty line, from the protective relay of the faulty line. The loop, which can also be used for connecting a printer, is routed through screened cables. When a printer is used the loop must be supplied from a separate supply unit.



F1. DIODE UNIT 5653 303-C
U_Z =12V

F2. RESISTOR

EL	R	P ≥
48V	1kΩ	5W
110-125V	3,3kΩ	10W
220-250V	6,8kΩ	25W

Fig. 3 Communication between RANZAs in parallel lines.

Printer for documentation

The printer which can be connected to the RANZA must be adapted to, or have a matching circuit for, a 20mA current loop which can decode ASCII-coded signals (for further information refer to Appendix 3). As an optional extra, ABB Relays can offer a printer incorporating a supply unit and a transient protection for the series loop, see Fig. 4a.

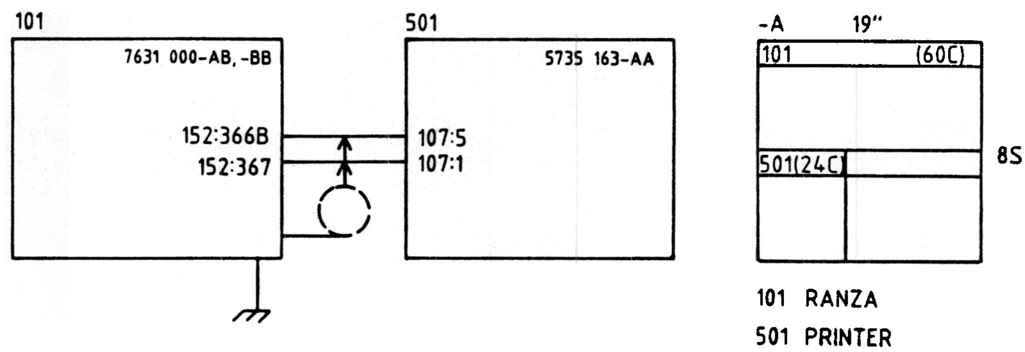


Fig. 4a Connection of printer type RTRS 180 to RANZA

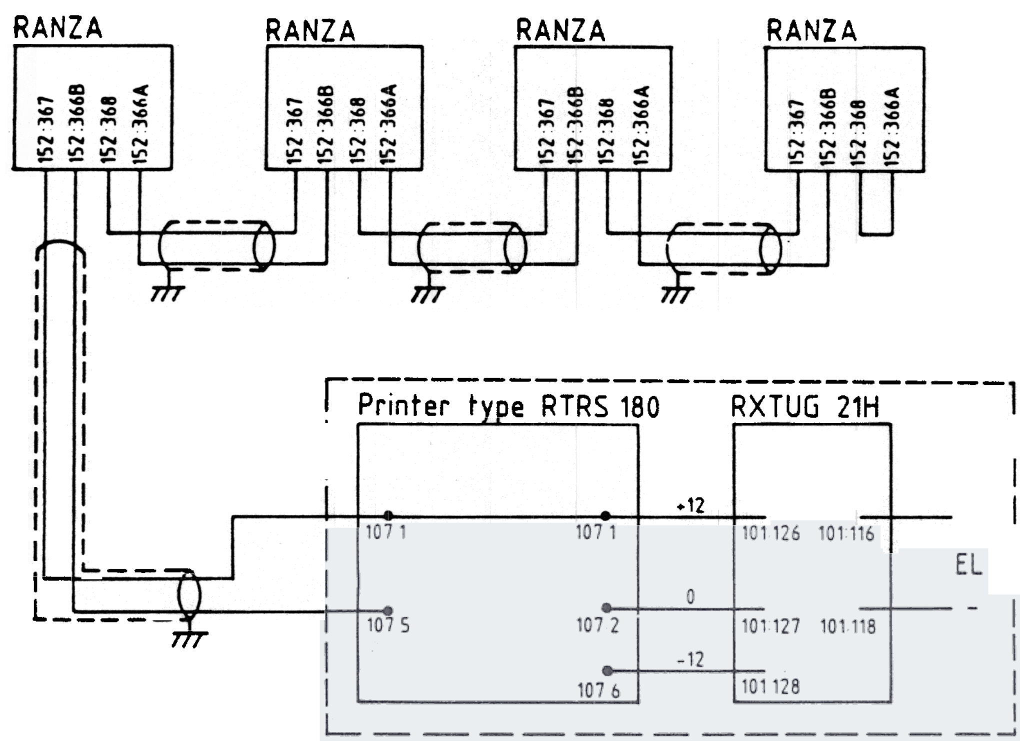


Fig. 4b Four RANZAs with separate printer

Up to four RANZAs can be interconnected in a current loop and can be served by a common printer which is connected in the loop. When four RANZAs are used for a common printer, the presentation can be delayed in the event that faults occur simultaneously in several lines. Furthermore, the RANZA is blocked for measuring until the complete presentation has been executed on both the display and the printer. A separate printer with its own supply unit can be connected as shown in Fig. 4b. The screened cable is earthed as shown in the figures. This connection is also applicable for 2 RANZAs in parallel lines.

Printers, which are intended to be fed with voltage pulses can also be used if the inputs of these are provided with an interface unit which converts the current signals, of the 20mA-loop, to voltage pulses. In addition, the RANZA must be programmed with a special printout code in order to execute the printout and the line feed. Refer to section entitled "Settings". Interface units for converting 20mA current-loop signals to RS-232-C transmission, are normally marketed by suppliers of printers. Printer type RTRS 180 includes a clock with battery back-up.

DESIGN

Fig. 5 shows the units which are included in the RANZA. The test switch, transformer unit and shunt board part are screwed directly to and held together by two apparatus bars. The other units are of the plug-in type and are connected to a motherboard, with the exception of the supply unit which has its own terminal base screwed to the bars.

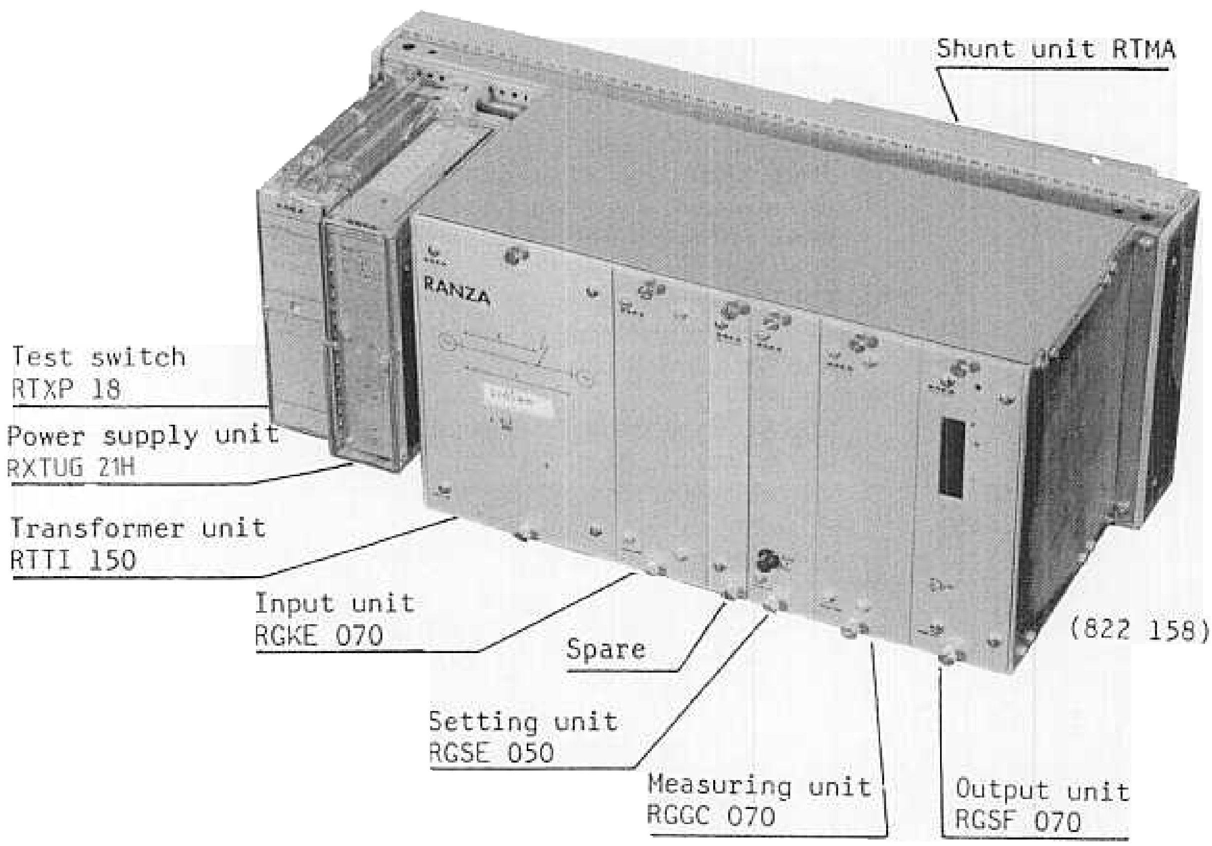


Fig. 5 Units included in the RANZA.

Test switch

The signals from the line's measuring transformers are routed to the fault locator via the test switch; refer to Fig. 13 and 14. When a test plug handle is inserted in the test switch, the points in the fault locator, which are required for functional checking, will be accessible via the test plug handle.

Supply unit

The supply unit provides the RANZA with the requisite auxiliary D.C. voltage, ± 24V, and issues a signal if the D.C. supply should fail. The voltage is stabilized in each included unit that requires auxiliary voltage. The supply unit can be reconnected to provide standard voltages of 24-36V, 48-60V, 110-250V.

Transformer unit

This unit includes isolating transformers, for currents and voltages, with a screen between the primary and secondary side. By means of this a protection against transients, and a signal level adapted to the subsequent electronics, are obtained.

Shunt board part

In this part, which is mounted on the rear of the fault locator, is included shunt resistors and protective circuits against overvoltages. The signals from this part are transmitted via flat ribbon cable to the motherboard.

Input unit

This unit has inputs, for external signals, each furnished with a dry-reed relay for galvanic separation. One input is intended for starting the RANZA in the event of a fault in the line to which it is connected, and another input is intended for starting the RANZA in the event of a fault in the parallel line, in order to compensate for the influence of the mutual impedance when determining the distance to the fault according to Figs. 13 and 14. When a RANZA is ordered for external phase selection, four input relays are included which provide information about the faulty phase; as shown in Fig. 13.

Setting unit

This unit contains 5 thumbwheel switches, mounted behind the unit's front plate, and a pushbutton. The line parameters are set with the thumbwheel switches and the set parameters are transmitted, by means of the pushbutton, to the data memory of the fault locator.

During normal operation, the pushbutton is also used for initiating test programs, making directional tests when a printer is connected and for turning off the display.

Measuring unit

The principal parts of this unit are:

- A/D converter
- microprocessor
- memory for operation program
- interface for input and output signals
- memory for storing of set parameters

The A/D converter converts the analog input signals from the instrument transformers to digital signals which are continuously stored in the memory during 13 $^{13}/_{24}$ successive cycles. This storage proceeds as long as the line is healthy and for a few cycles thereafter.

The microprocessor executes the following control and calculating functions:

- Collection of measured values (among other things, from the RANZA in the parallel line when compensating for I_o)
- Processes the measured values and calculates the distance to the fault
- Presents the percentual distance to the fault on an indicator
- Feeds out the calculated result to a printer (if such is included)
- Returns to normal measuring after a line fault
- Determines the type of fault when a built-in phase selector is used

The fault locator memories consist of:

- PROM (Programmable Read Only Memory) for the control and calculation programs
- RWM (Read Write Memory) for storing measured data and part results during the distance-determining sequence
- EEPROM (Electrical Erasable PROM) parameter setting memory.

The interface contains a drive stage for adapting input and output signals.

Output unit

This includes 2 front-mounted displays which, in the event of a line fault, show the distance to the fault as a percentage of the supervised length of the line.

The unit has binary coded outputs, for connection to telemetric equipment, and a current-loop output for connection of an alpha-numeric printer. There is also an output for alarm in the event of a fault in the microprocessor.

CALCULATION ALGORITHM

Fig. 6 shows a single-line diagram of a single transmission line fed from both ends and with the source impedances Z_A and Z_B. The fault is assumed to occur at a distance F from terminal A on a line of length L and with impedance Z_L. The fault resistance is defined as R_F. A single line model has been used to give a better clarification of the algorithm.

Calculated from one measuring point, terminal A, a equation is written by the aid of Ohms and Kirchoff's laws. This equation gives the relationship between measured currents and voltages at rated frequency. These are different for each type of fault and vary with the line impedances.

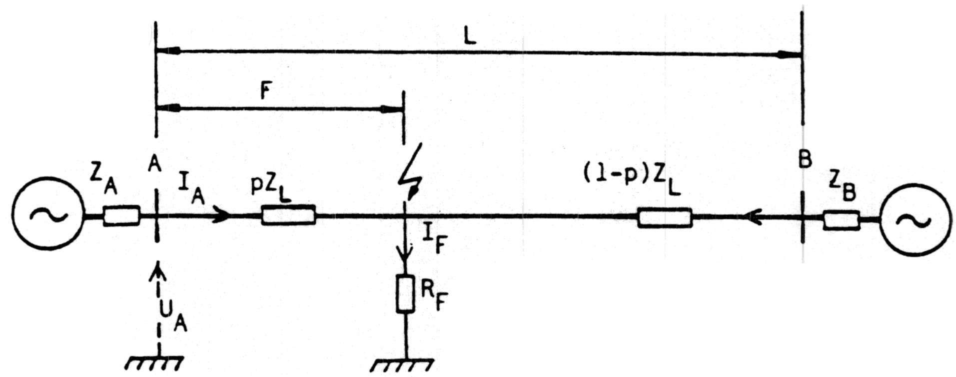


Fig. 6 Transmission line fed from both ends

With reference to Fig. 6, the following expression is applicable:

$U_A = I_A \times pZ_L + I_F \times R_F$

where p = relative distance to fault

It is essential and should be noted, that consideration is also taken to the voltage drop over fault resistance R_F, which otherwise would cause considerable error in the determination of the distance to the fault.

The fault current I_F is expressed in measurable quantities by

$$I_F = \frac{I_{FA}}{D_A}$$

where I_{FA} is the change in current at the point of measurement, terminal A, due to the fault and where D_A, the distribution factor (fault current distribution), in the case of a single line, is:

$$D_A = \frac{(1-p)\ Z_L + Z_B}{Z_A + Z_L + Z_B}$$

In the case of a short circuit, the change in the differential current is used directly while, during a ground-fault, it is advisable to eliminate the contribution of the zero sequence current in order to execute the subsequent calculations with the better-defined positive sequence quantities of the network. By utilizing the change in current, the influence imposed by the load current on the result will be eliminated.

The general fault-location equation will then be, for a single line:

$$U_A = I_A \times pZ_L + \frac{I_{FA}}{D_A}\ R_F \qquad (4)$$

The expressions for U_A, I_A and I_{FA}, for different types of fault, are given in table 1 below.

Table 1: Measuring quantities for different types of fault

Type of fault	U_A	I_A	I_{FA}
RN	U_{RA}	$I_{RA} + K_N \times I_{NA}$	$3/2\,(\Delta I_{RA} - I_{0A})$
SN	U_{SA}	$I_{SA} + K_N \times I_{NA}$	$3/2\,(\Delta I_{SA} - I_{0A})$
TN	U_{TA}	$I_{TA} + K_N \times I_{NA}$	$3/2\,(\Delta I_{TA} - I_{0A})$
RST RS RSN	$U_{RA} - U_{SA}$	$I_{RA} - I_{SA}$	ΔI_{RSA}
ST STN	$U_{SA} - U_{TA}$	$I_{SA} - I_{TA}$	ΔI_{STA}
TR TRN	$U_{TA} - U_{RA}$	$I_{TA} - I_{RA}$	ΔI_{TRA}

where the complex quantity K_N, for zero sequence compensation, is:

For a single line $$K_N = \frac{Z_{0L} - Z_L}{3Z_L}$$

I_{0A} = zero sequence current $= I_{NA}/3$

ΔI_{RA}, ΔI_{SA}, ΔI_{tA} = change in line current

ΔI_{RSA}, ΔI_{STA}, ΔI_{TRA} = change in differential current

To simplify the understanding of the above, use has been made of a single-line model. Since the RANZA can be used for both single and double lines, another set of equations are applicable in the general case.

The general fault-location equation will then be:

$$U_A = I_A \times pZ_L + \frac{I_{FA}}{D_A} R_F + I_{0P} \times Z_{0M} \qquad (5)$$

where I_{0P} = zero sequence current of the parallel line

Z_{0M} = mutual zero sequence impedances

D_A = the distribution factor of the parallel line, which is

$$= \frac{(1-p)(Z_A + Z_L + Z_B) + Z_B}{2Z_A + Z_L + 2Z_B} \qquad (6)$$

The compensating factor K_N for the general case will be

$$K_N = \frac{Z_{0L} - Z_L}{3Z_L} + \frac{Z_{0M}}{3Z_L} \times \frac{3I_{0P}}{3I_{0A}} \qquad (7)$$

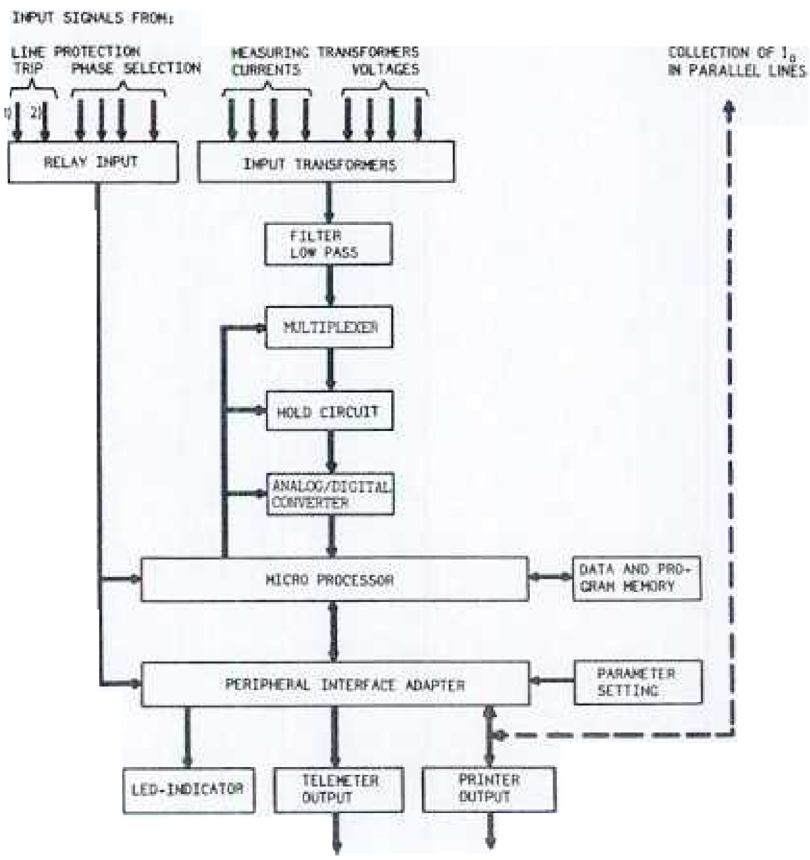
From these expressions, it can be seen that if $Z_{0M} = 0$, the general fault-location equation for a single line will be obtained. Only the distribution factor differs in the two cases.

MODE OF OPERATION

The operation of the fault locator can be described in the following steps:

- Data collection
- Starting of fault locator
- Sorting of measured instantaneous values
- Filtering of measured signals
- Determination of type of fault
- Collection of zero-sequence current in any existing parallel line
- Solution of fault location equation
- Presentation of the result

The block diagram, Fig. 7, illustrates the operating principle of the fault locator.



1) From line protection of appurtenant line

2) From line protection of parallel line (for transmitting of measured I_0)

Fig. 7 Operating principle of the fault locator

Data collection

The analog signals from the instrument transformers of the line are converted to a suitable level and are filtered in a low-pass filter having a frequency limit of 500 Hz.

After filtering, the signals are routed to a multiplexer, controlled from the microprocessor. The multiplexer, in successive order, transmits the signals (measured values) via a holding circuit to the A/D convertor. The purpose of the holding circuit is to retain the signals for the period of time required by the A/D convertor to convert the signals to digital form. The rate of measurement is chosen so that 24 measurements per cycle are made on each current and voltage signal.

The measured digital values are routed by the microprocessor to the correct addresses in the memory capsules. In these the values measured during the $13^{13}/24$ cycles are stored (325 samples).

Starting the fault locator

The tripping signal of the protective relay, which also constitutes the starting signal for the fault locator, interupts the collection of measured values. Two cycles of information are stored after start pulse. The measured values from the cycles immediately before and during the fault are then stored in the memory.

Sorting of measured instantaneous values

When the collection of measured values is interrupted, the memory is scanned for the purpose of localizing the actual time when the fault ocurred. The measured values, during 1.5 cycles before and after this instant of time, are adjusted, multiplied by the requisite scale factors and stored again for later use in the digital filter.

Filtering of measured values

This is done in a manner whereby the vector quantities of the fundamental harmonic are extracted from the distored measured signal. A Fourier-correlation method is used for this, i.e., the respective measured values are multiplied by a sine and cosine reference respectively and are integrated during one cycle, whereupon the measured values for current and voltage are expressed in real and imaginary portions. These current and voltage values are later used for determining the type of fault with the built-in phase selector, when this is incorporated, and for inclusion in the fault localizing equation.

Determination of the type of fault

To determine the type of fault for selecting the measuring loop, information from either the built-in phase selector or from the input-relays, is used. The input relays are to obtain information, regarding the type of fault, from the protective relay which started the RANZA or from another external logic phase selector.

On the operation of one or more measuring elements in the built-in phase selector, or of one or more input relays, the RANZA selects a measuring loop in accordance with table 2 below for determining the distance to the fault.

Table 2: Measuring loop during the operation of different phase-selector elements.

	Operation of input relay or measuring element in the phase selector									
	R	S	T	RN	SN	TN	RSN	STN	TRN	RSTN
	TR	RS	ST							RST
Measuring loop at normal phase selection	TR	RS	ST	RN	SN	TN	RS	ST	TR	RS
Measuring loop at cyclic phase selection (RTSR)	TR	RS	ST	RN	SN	TN	SN	TN	RN	RS
Measuring loop at acyclic phase selection (RTS)	TR	RS	ST	RN	SN	TN	RN	TN	RN	RS

Phase selection from input relays

When the phase is selected by external equipment, e.g., from a distance protection, information about the faulted phase and information as to whether or not it is a ground-fault, is supplied to the input relays. The input relays are of the dry-reed type and must be supplied with a continuous signal during at least the time interval for 0.75 cycles of the network frequency. This continuous signal is to be accommodated latest 1 1/2 cycle after start pulse. This implies that the phase selection need not necessarily be completed before the start of RANZA. Should the fault be one which has developed from another, the RANZA selects the fault loop which was indicated by the first phase selection information.

Phase selection from built-in phase selector

The phase selection part has an impedance measuring function per phase and a selectable operating characteristic, circular as in Fig. 8 or modified lens as in Fig. 9. The measuring principle is the same as that for ABBs RXZK type relay.

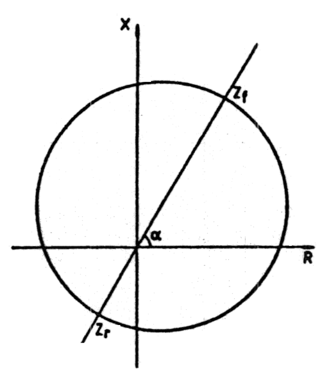


Fig. 8 Circular characteristic

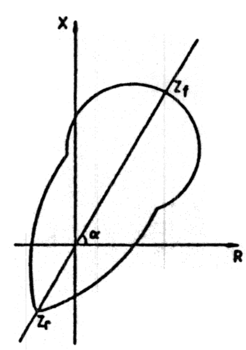


Fig. 9 Modified lens characteristic

The backward reach Z_r of the characteristic can be set as a multiple of the reach in the forward direction Z_f. The measuring direction Z_f is referred to as the characteristic angle of the characteristic, and is approximately 60° for ground-faults and 2-phase short circuits, in order to provide adequate resistive coverage for such faults. In the case of 3-phase conditions, the characteristic angle of the measuring units will be approximately 90°. The rotation of the characteristic in the impedance plane depends on the choice of measuring current and voltage to the operating conditions of the measuring units. The measuring quantities used for the respective phase elements during different types of fault, are shown in table 3. During all faults where the neutral sequence current ($3I_o$) exceeds the set threshold value, the measuring elements will measure the ground-fault loop.

Setting of built in phase selector

The impedance measuring units are set to operate in the forward direction for a measuring loop Z_s $60° = \text{Re } Z_s + \text{Im } Z_s$
Set value Z_s is normally chosen to be twice the measuring loop, which corresponds to the entire line section on which the RANZA is to determine the distance to the fault, i.e., Z_s is chosen to about 4 times the positive sequence impedance of the supervised line. The general rule is to chose $\text{Re}Z_s = 2$ XIL and $\text{Im } Z_s = 4$ XIL, where XIL is the positive sequence impedance of the supervised line. A check should be made to ensure that $\text{Re}Z_s < 0.5 \min Z_{load}$, where min Z_{load} is the smallest load impedance.
The smallest load impedance is calculated from the relationship

$$\min Z_{load} = \frac{U^2}{S_{max}} \text{ ohm/phase}$$

where U = line-to-line voltage in kV

S_{max} = maximum transferred power in MVA.

The operating value in the forward direction Z_f will then be expressed in ohms per phase value

$$Z_f = C \cdot Z_s \text{ ohms/phase}$$

where the value of C, which depends on the type of fault, is given in table 3 where the different measuring quantities to the measuring elements are also given. 3-phase characteristic ($C=1/\sqrt{3}$) should be used when checking load discrimination.

The reverse reach Z_r is set as a multiple D (adjustable in steps of 0.1 between 0.1 and 1.9) of the forward reach and is normally chosen to be equally great, i.e., $Z_r = Z_f$.

When the circular characteristic cannot be used, due to problems with load, the modified lens characteristic can be used. The modified lens or the circular characteristic is selected with the aid of parameter 09, see section "Setting of parameters with thumb-wheel switches".

The phase selection characteristic must overreach the distance protection characteristic, due to the fact that the distance protection starts RANZA.

Table 3: Relay constant, C, and measuring quantities for different types of fault

Type of fault	Earth fault 1ØN,2ØN,3ØN	2-phase fault 2Ø	3-phase fault 3Ø
C-factor	$\frac{1}{1+K}$	$\frac{1}{2}$	$\frac{1}{\sqrt{3}}$
Meas.voltage	U_{RN} U_{SN} U_{TN}	U_{RT} U_{SR} U_{TS}	U_{RT} U_{SR} U_{TS}
Meas.current	I_R I_S I_T	T_R T_S T_T	I_R I_S I_T
Meas.element	R S T	R S T	R S T

$K = \frac{Z_0 - Z_1}{3Z_1}$ where Z_0 = zero sequence impedance

Z_1 = positive sequence impedance

The setting range for the forward reach, expressed in ohms per measuring loop, is from 0.1 to 999.9 ohms in both the reactive and the resistive direction which, for 2-phase faults, corresponds to about 0.05 to 500 ohms/phase.

Sorting of information stored in the memory

When a starting signal is transmitted to RANZA, 13 13/24 cycles of information is already stored in the memory, which is illustrated in Fig. 10, where about 2 cycles are stored after the reception of the starting signal.

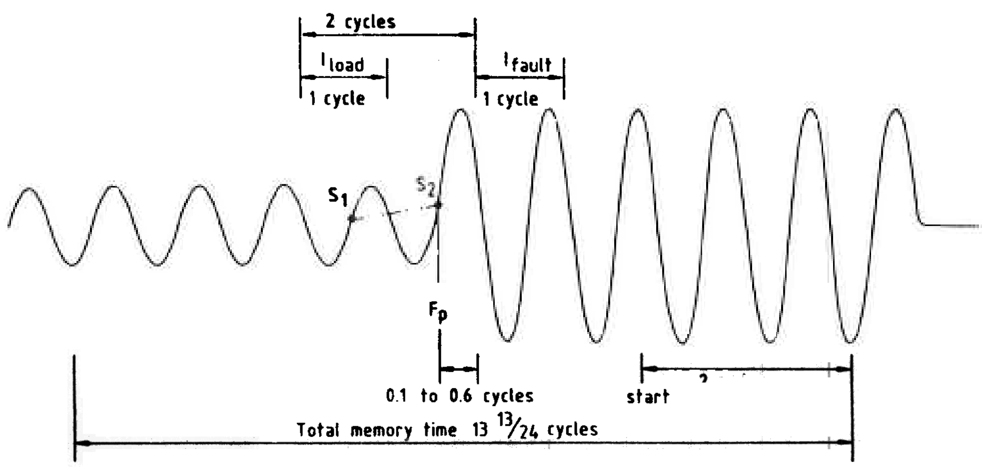


Fig. 10 Measured signals stored in memory, and the relationship between different time periods.

The collection of signals has been achieved in digital form with 24 measurements (sample checks) per cycle. The determining of the fault instart F_p is done by comparing if any significant change has taken place in the measured signal from one measurement, S_1, to one cycle later, S_2, commencing with the first measurement in the memory. If no change has taken place, a new comparison is made between the next two measurements at one cycle intervals until a change is detected. The threshold value of the current signal is dependent on the current prior to the fault while the value of the level of voltage change is fixed. The fault instant is determined first by analysing the current signals and, if no change is detected there, the voltage signals are analysed.

If the RANZA cannot find any point for the fault instant, the program replaces the normal calculation algorithm with a simpler impedance-calculating method which indicates with the printout "SLOW START" when a printer is conencted. This can occur during situations such as, breaker closure against a line fault, or delayed tripping. In both cases, the load current is not included in the memory space and, since the remote end of the line is already open, there is no reason to compensate for the in-feed of fault current from the remote end of the line.

When RANZA has detected the fault point F_p by the fact that (refer to Fig. 10) S_1 - S_2 is greater than the threshold value, it selects the parts of the measured signal which are to be filtered and restored in the memory.

As measured values for the fault condition, an interval of 1 cycle is selected which begins 0.1 to 0.6 cycles after detection of the fault instant. Normally, the RANZA is programmed so that the selection is made automatically but it can also be programmed to select fixed, 0.1 or 0.6, cycles after the occurrence of the fault.

As measured values for current and voltage prior to the fault, an interval of one cycle is selected and this commences two cycles before the interval selected for the fault condition.

During these two intervals, the signals are filtered to fundamental frequency. These signals are then stored in the memory for later use for phase selection, when this is incorporated, and for calculating the distance to the fault.

Operating conditions for the phase selector

The measured voltage and the measured current, specified in table 3 for the respective types of fault, are used as measuring elements for each phase. These measuring quantities are taken, after sorting and filtering, from the stored current and voltage values for the post-fault condition.

$U_1 = IZ_f - U$ $\qquad\qquad$ $U_2 = IZ_r - U$

$$U_3 = \frac{U_1 + U_2}{2} = I \times \frac{Z_f + Z_r}{2} - U$$

These signals are then routed to the microprocessor which, by comparing the phase positions of U_1, U_2 and U_3, determines if the measured impedance of the respective phase elements is within the set operating range.

When a circular characteristic is selected, the U_1 and U_2 signals are compared. Operation takes place, if the angular difference between the vectors of the signals fulfils the condition:

$$90^\circ < \arg U_2 - \arg U_1 < 270^\circ$$

The operating conditions are illustrated in Figs. 11 and 12

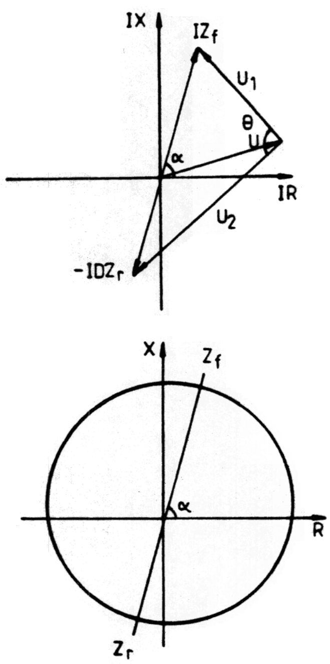


Fig. 11 Circular characteristic
$90^\circ < \arg U_2 - \arg U_1 < 270^\circ$

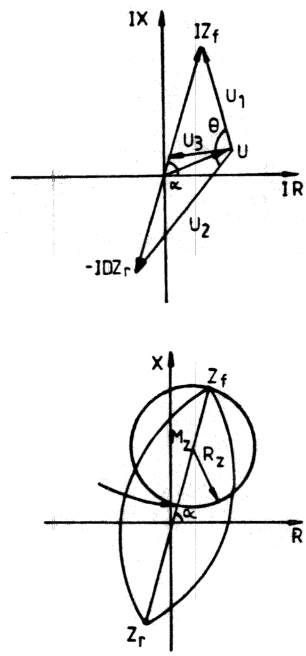


Fig. 12 Modified lens characteristic
$135^\circ < \arg U_2 - \arg U_1 < 225^\circ$
and that
$90^\circ < \arg U_3 - \arg U_1 < 270^\circ$

Solution of fault-localizing equation

The fact that D_A (distribution factor), according to equation (3) or (6), is a function of p, makes equation (5) a second-degree expression which can be written:

$$p^2 - p \times K1 + K2 - K3 \times RF = 0$$

where $K1 = \frac{U_A}{I_A \times Z_L} + 1 + \frac{Z_B}{Z_L + Z_{ADD}}$

$$K2 = \frac{U_A}{I_A \times Z_L} \quad \frac{Z_B}{Z_L + Z_{ADD}} + 1)$$

$$K3 = \frac{I_{FA}}{I_A \times Z_L} \left(\frac{Z_A + Z_B}{Z_L + Z_{ADD}} + 1 \right)$$

where $Z_{ADD} = Z_A + Z_B$ for parallel lines

I_A, I_{FA} and U_A are given by table 1 whereupon

$$K_N = \frac{Z_L - Z_{IL}}{3Z_{IL}} + \frac{3I_{0P}}{3I_{0A}} \times \frac{Z_{0M}}{3Z_L}$$

Z_A, Z_B, Z_{0M} and Z_L are set at commissioning.

For a single line is

$$Z_{0M} = 0 \text{ and } Z_{ADD} = 0$$

The equation (8) is thus applicable to both single and parallel lines.

By dividing equation (8) into a real and an imarginary part, two real equations where R_F is expressed in measured and set parameters will be obtained. From there equations the relative distance to the fault can be solved as a root of a quadratic equation.

Presentation of the results

The result is given on the display and is also transmitted as a BCD-code on the telemetric output for remote signalling. At the same time, the result can be transmitted for printout on an alphanumeric printer.

When a printer is used, a printout is made of the line number, the position of the fault as a percentage of the total line length, the phase selection obtained, the chosen measuring loop for determining the distance, and the current and voltage values, filtered to the fundamental frequency, before and after the occurrence of the fault. Furthermore, the time when the fault occurred and the calculating method used, can be obtained. A printout example is shown on page 20.

If the RANZA has not used the calculating method which compensates for infeed current from the opposite end, the printer writes "SLOW START" which can occur on two occasions.

1) SLOW START is printed out once in the following cases:
   a) Low fault current or breaker-closure against a fault (open circuit breaker at remote end)
   b) High fault current previous to the fault i.e. start at faults that occur simultaneous to an existing and not disconnected fault further out in the network.
2) SLOW START is printed out twice when RANZA cannot find the fault position within the space for the memory. The reason can be a slowly starting relay protection or tripping on the second time-step of the distance protection.

On these occassions, the distance is determined with a simpler impedance-calculation method which uses the measured values that are nearest the start from the protective relay.

When RANZA is furnished with a built-in phase selector and the latter cannot cope with the phase selection, the printout "PHASE SELECT. FAILED" is obtained, after which the printer writes out the current and voltage values which were measured when the starting signal was issued from the protective relay. These current and voltage values can be used for manual calculation of measured fault impedance. The printout "PHASE INFO NOT VALID" is obtained only when RANZA is intended for external phase selection and no phase selection is received.

During the printout of current and voltage values, use is made of symbols IRØ, URØ, ISØ, USØ etc, for the measured values prior to the fault, while IR, UR, IS, US etc are the measured values during the fault.

Printout examples are shown below

```
LINE NUMBER 0012  07

FAULT LOC. P=18%

PHASE=RN   , LOOP=RN

UR0=AMPL.=058.577 V
    ARG. =195.3 DEG.
IR0=AMPL.=000.793 A
    ARG. =153.0 DEG.
US0=AMPL.=058.531 V
    ARG. =075.6 DEG.
IS0=AMPL.=000.000 A
    ARG. =000.0 DEG.
UT0=AMPL.=058.798 V
    ARG. =315.5 DEG.
IT0=AMPL.=000.000 A
    ARG. =000.0 DEG.
UR =AMPL.=005.293 V
    ARG. =226.8 DEG.
IR =AMPL.=000.791 A
    ARG. =153.0 DEG.
US =AMPL.=005.256 V
    ARG. =107.7 DEG.
IS =AMPL.=000.000 A
    ARG. =000.0 DEG.
UT =AMPL.=005.343 V
    ARG. =346.6 DEG.
IT =AMPL.=000.000 A
    ARG. =000.0 DEG.
IN =AMPL.=000.789 A
    ARG. =153.2 DEG.

Un=110 V , In=1 A

OCT-09-15:34
```

```
LINE NUMBER 0012  07

FAULT LOC. P=17%

PHASE=TR   , LOOP=TR

UR0=AMPL.=058.903 V
    ARG. =090.9 DEG.
IR0=AMPL.=001.381 A
    ARG. =018.6 DEG.
US0=AMPL.=058.784 V
    ARG. =331.0 DEG.
IS0=AMPL.=000.000 A
    ARG. =000.0 DEG.
UT0=AMPL.=059.024 V
    ARG. =211.0 DEG.
IT0=AMPL.=001.386 A
    ARG. =198.6 DEG.
UR =AMPL.=005.503 V
    ARG. =128.5 DEG.
IR =AMPL.=001.378 A
    ARG. =018.6 DEG.
US =AMPL.=005.297 V
    ARG. =002.8 DEG.
IS =AMPL.=000.000 A
    ARG. =000.0 DEG.
UT =AMPL.=005.368 V
    ARG. =242.6 DEG.
IT =AMPL.=001.382 A
    ARG. =198.5 DEG.
IN =AMPL.=000.000 A
    ARG. =000.0 DEG.

Un=110 V , In=1 A

TIME W41 FR 15:44
```

TECHNICAL DATA

Rated frquency f_n	50 or 60 Hz
Rated voltage U_n	100-110V ± 10%, 50 Hz 110-130V ± 10%, 60 Hz
Rated current I_n Continuous for 1 s	1, 2 or 5A max 3 x I_n 100 x I_n, max 350A
Aux. voltage EL Tolerance	24, 48, 55, 110, 125, 220, 250 V D.C. +10 to -20%
Aux. voltage relays, RL	24, 48 - 55, 110-125, 220, 250 V D.C.
Phase selection	Selectable: built-in or external from protective relays to input relays
Minimum operating current for built-in phase selector	0.1 x I_n
Start	External from protective relay
Calculation time	< 15 seconds
Setting range	
Built-in phase selector:	
Forward	Z_f=0.0-999.9 ohms/loop
Reverse	Z_r=0.0-1.9 times Z_f
Earth fault current ($3I_o$)	INS=0.1-999.9 x I_n
Fault locator:	0.0-999.9 ohms/phase
Operating range	(0.1-20) x I_n (0.01-1.5) x I_n
Temperature range	0-55°C
Accuracy:	
At reference value of I_n and U_n (sinusoidal) and angle 80°	± 1% of line length
At fault resistance equal to total line impedance and within (0.05-1) x U_n and (0.5-20) x I_n	± 2% of indicated value but max ± 3 km
Telemetric output	24V, 0.1A
Current loop for printer supplied from external source (max 250V with outer series resistance)	20mA, 24V 20 columns ASCII, 300 baud
Power consumption:	
Current and voltage circuits	< 1 VA/phase
Auxiliary voltage EL	< 14W
Dielectric test:	
For 1 minute	2kV, 50 Hz
Surge voltage test	5kV, 1.2/50 us, 0.5J
Disturbance voltage test	2.5kV, 1MHz
Spark test	4-8kV as per SEN 36-1503

Printer data

Power supply	12 ± 2 V dc
Communication	300 baud, 8 bits, 1 stop bit, no parity, 20 mA current loop
Character size	Height: 2.4 mm Width: 1.7 mm
Paper type	Standard roll Width: 57 ± 1 mm Diameter: max 52 mm
Ink cassette (ribbon)	Single colour, purple
Battery back-up time for built-in clock	2 weeks if battery is fully charged

RECEPTION, STORAGE AND INSTALLATION

A general description on installation, testing and maintenance of products from ABB Relays is given in Information RK 926-100E.

Receiving

Remove RANZA from the transport case and make a visual inspection for possible transport damage. Check that all screws are firmly tightened and that all units are securely fastened.

Check that the delivered RANZA has correct rated data stamped on the rating plate of the test switch, i.e. rated ac values for current, voltage and frequency and also the dc voltages EL for the dc/dc converter and RL for signalcircuits.

Check also that all requested optional elements are included such as printer or phase-selector relays.

The list of apparatus delivered with the fault locator gives a summary of all included items.

Storage

If the fault locator is to be stored before installation this must be done in a dry and dust-free place, preferably in the original transport case.

Installation

Fault locator RANZA is built up of modular units according to the ABB COMBIFLEX mounting system. Fig. 5 page 7 shows the units and their location in RANZA.

RANZA can either be mounted in a 60C equipment frame. When RANZA is designed to receive phase information from external phase selection relays or a printer is included these may be mounted together with RANZA in an 4S 60C equipment frame. The connections to the measuring transformers and line protection should be done according to the terminal diagram. Fig. 13 shows the terminal diagram when RANZA is designed to be connected to external phase selection relays. Fig. 14 shows the terminal diagram when phase selection function is included in RANZA. All internal connections are wired prior to delivery why only the external connections have to be done at the installation.

A schematic diagram of the interconnections between the RANZAs of the two parallel lines is shown in Appendix 3 page 2.

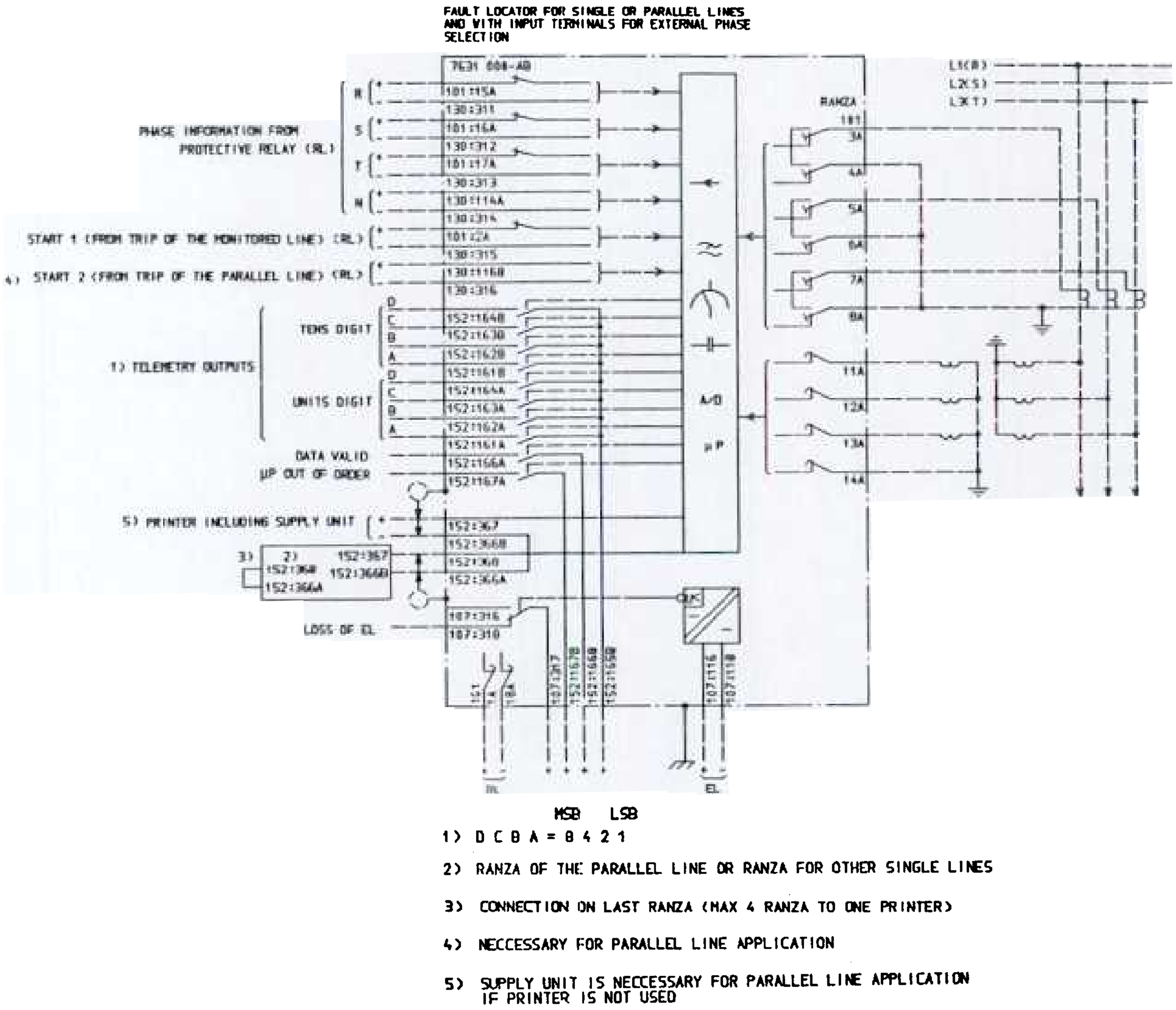


Fig. 13 Terminal diagram of RANZA, with input relays for additional phase information

The terminals 101:1A and 101:18A should always be connected to the dc auxiliary voltage RL positive (101:1A) and negative (101:18A).

The connections to the test switch (101) must be made with wires with 20 A COMBIFLEX socket leads. Wires with 10 A COMBIFLEX socket must be used to the remaining connection points. The leads can be ordered from the ABB Relays Buyer's Guide under the heading "Terminal sockets, leads and socket leads".

If RANZA is to be connected to a printer the connection wire between RANZA and the printer should be screened. The screen should be connected to ground on the side closest to the dc-supply.

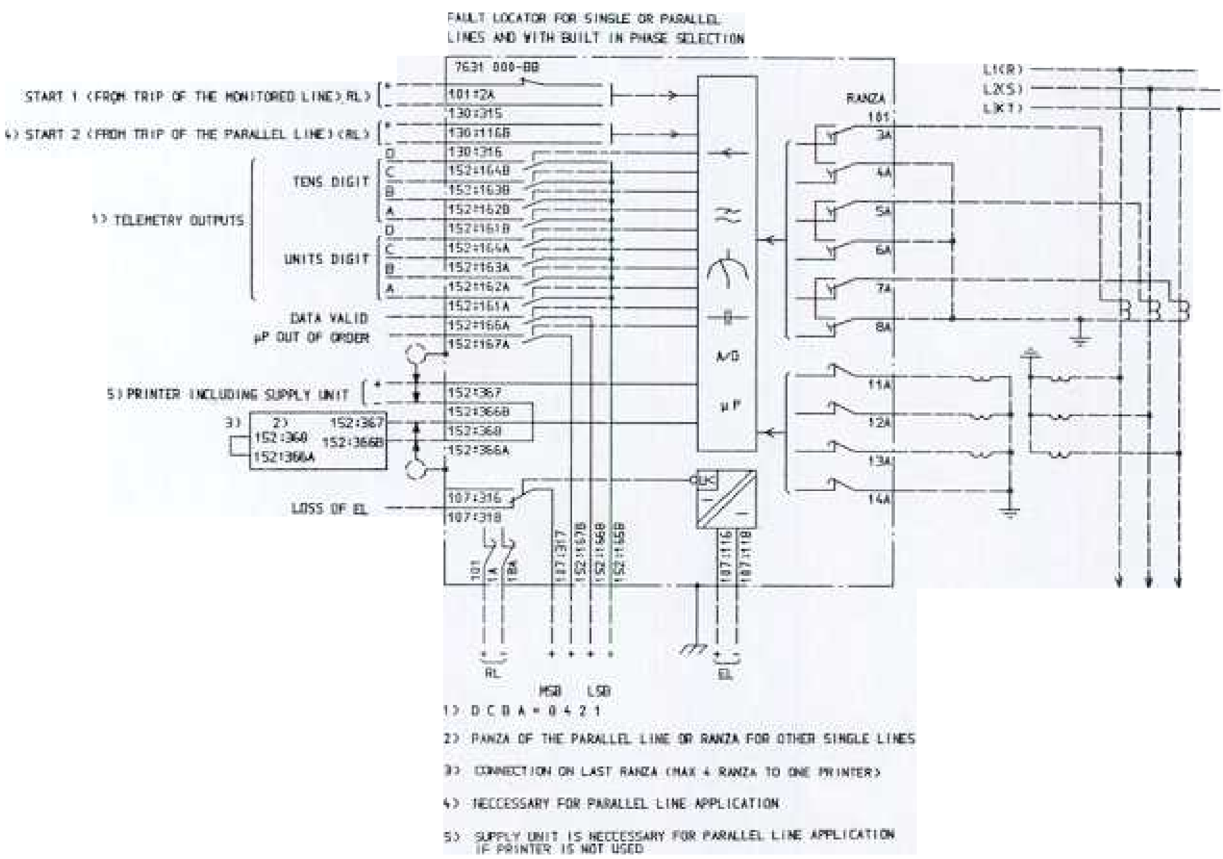


Fig. 14 Terminal diagram of RANZA with built-in phase selector unit

The connection guide Fig. 15 below shows RANZA from the rear and the position of the terminals for the external connection according to the terminal diagram.

Marked terminals that are interconnected show that side A and B are electrically the same point. Connection can then be made on either side. Terminals, which are not interconnected, show two different electrical connection points. Therefore must side A or B be given, e.g. 152:161A.

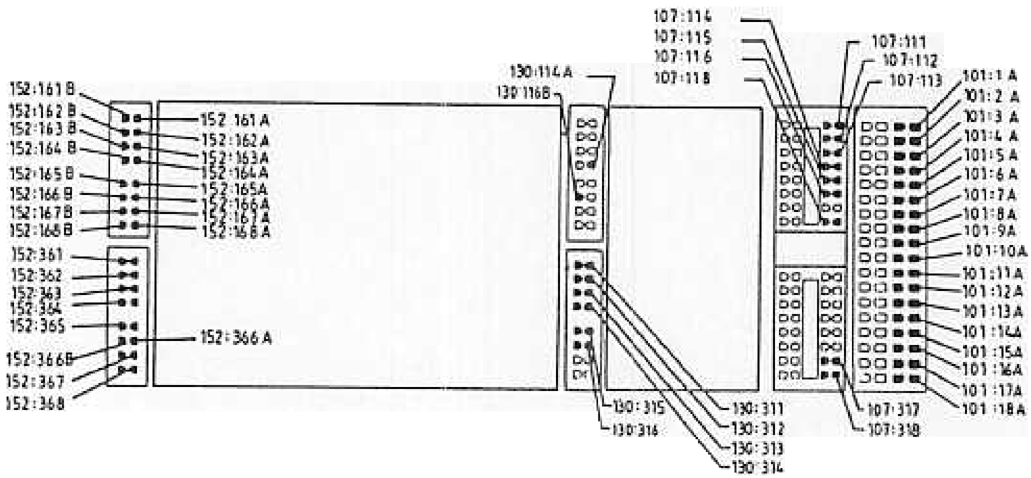


Fig. 15 RANZA connection guide

The rear of the fault locator should be accessible for inspection and possible future changes of connections. RANZA should not be installed in places which are dusty or moist or liable to rapid temperature variations or powerful vibrations.

Remarks regarding the terminal diagrams

The serial current loop is ASCII coded. ASCII stands for American Standard Code for Information Interchange.

The telemetry output signals are binary coded. An output signal can be read according to table 4 below

Terminal		Output signal: Tens digit	Output signal: Units digit	Figure
152 :	161 A		2^0	1
	162 A		2^1	2
	163 A		2^2	4
	164 A		2^3	8
	161 B	2^0		10
	162 B	2^1		20
	163 B	2^2		40
	164 B	2^3		80

Table 4 Telemetry output coding. If an output is found on many telemetry output terminals simultaneously this corresponds to a figure equal to the sum of these outputs. E.g. simultaneous output signals on terminals 152: 161 A, 152: 163 A, 152: 161 B and 152: 164 B corresponds to a figure 1+4+10+80 = 95. The figure should correspond to the figure shown on the display and is removed when the Reset/Test pushbutton is used to reset RANZA. The output signals may take some milliseconds to stabilize when they come.

The output signal "DATA VALID" will come when the telemetry outputs are valid and stable. It can be used for e.g. starting the printer.

The output signal "uP out of order" will come if something is wrong in RANZA unless there is a loss of dc supply. The fault may be transient which can be understood by the disappearance of the signal. It is advisable to test RANZA both with the built in test function by means of the Reset/Test pushbutton and secondary injection test. If the signal is permanent RANZA need to be repaired.

The input signal "START 2" should be obtained from the same contact that gives start (START 1) to the RANZA in the parallel line because of time coordination, see also Appendix 3 page 2

The input signal "START 1" is the normal input for start of RANZA when there is a fault on the line which is monitored by RANZA.

TEST EQUIPMENT

- Test plug handle RTXH 18.
- Three-phase impedance test apparatus e.g. ABB type TURH.
- Multipurpose instrument.
- Test wires and extractor type RTXD.
- A good, but not compulsory, instrument is a printer, if not included in the delivery, e.g. RTRS 180.

COMMISSIONING

The commissioning tests are:

- check of the external and internal wiring of RANZA
- setting of line and source data
- secondary injection test
- directional test to confirm the measuring direction

If any part of RANZA is faulty the complete module should be replaced. Field repair and replacement of faulty components is not recommended.

NOTE! Disconnect the dc auxiliary supply EL+ before any module is removed from RANZA.

Remember also that after the tests the temporary wires that have been added just for performing the tests should be removed.

Inspection

Although RANZA is of a robust design, mechanical damage can occur. Usually such damage can be discovered by visual inspection.

Visually inspect that no module or wiring is damaged. Check also that all screws are firmly tightened and that all internal wiring connections are securely fastened in the terminal bases.

Check that the ratings stamped on the rating plate of the test switch are correct concerning the measuring transformer current, voltage and frequency rating. Check also the rating for the dc auxiliary voltages that are to be connected to the relay.

Confirm by reference to the valid list of apparatus and the valid circuit diagram that all modules are included.

If you remove the output unit RGSF070 in any of the RANZAs, which are connected in the series current loop, the terminals 152:367 and 152:368 must be short circuited on the RANZA on which the output unit RGSF070 is removed.

Checking the external connections

Check by inspection that the sockets are properly crimped on to all external wires and that the sockets are securely fastened in the terminal bases.

Check that all external wiring is properly routed between RANZA and other equipment and terminates at the correct points in both ends by reference to the wiring diagram.

Check that the test switch contacts operate correctly during the test plug handle insertion and removal. Ensure that the current circuits are never open-circuited on the incoming (A) side of the test switch during insertion and removal of the test plug handle.

When it is necessary to remove a wire connected directly to the relay terminal base, the RTXD extract tool must be used. After removal of a wire it is a good practice to leave the tool in the terminal base to facilitate returning the wire to the correct terminal point.

Check the phase sequence and identify each phase both in the voltage and current circuits.

The connection wire for the series current loop between the two RANZAs and the series printer should be a screened wire if they are not mounted in the same cubicle. The screen should be connected to ground on one side of the wire. This is normally obtained by connecting the screen to the rack. Check that the series current loop is continous and that the short circuit connection between the terminals 152:366 A and 152:368 is connected on the last RANZA in the loop, see also Appendix 3 page 2.

Checking the internal connections

All internal connections are wired prior to delivery and consist of COMBIFLEX socket leads, and bus connection on printed circuit boards. The check is done in three ways: visually, test pushbutton check and secondary injection test.

The visual checking is to check that all COMBIFLEX socket leads are securely fastened in their terminals and also that no module is missing in RANZA.

Check that a suitable operating range for the auxiliary voltage EL has been selected for the dc/dc converter(s) RXTUG 21H. The selection should also consider the voltage level during normal service and fast charging of the station accumulators. The alternative connections for different input voltages are given in the circuit diagram.

Check that there is a shortcircuiting wire between 152:366A and 152:368 for the series current loop on the RANZA without printer. If there is no printer connected to RANZA, there still must be a dc supply for the series current loop. See also Appendix 3.

The test button "Reset/Test" checking gives a rapid check of all main functions and internal electronic circuits of RANZA, but not the input transformer unit, shunt unit and input unit. Switch on the dc auxiliary supply EL. Press once the "Reset/Test" push button on unit RGSE 050. The figure "1" should show in the lower part of the display on RGSF 070 and after five seconds the display should go out and remain dark. If the display starts flashing, go to section: "Reading the display and error codes" for further instructions.

The light emitting diode (LED) marked "PD" on the front of output unit RGSF 070 will blink when a signal is sent to the series current loop for the printer. Normally this LED is dark.

The secondary injection test will be a check of the whole fault locator including the transformer unit, shunt unit and input unit. It should be performed after setting of RANZA and is described in a separate section "Secondary injection test".

Settings

The settings on RANZA are made with thumb-wheel switches on the setting unit RGSE 050.
Valid line data are to be written on the lable which is fastened on the rear of the transformer unit, RTTI 150, front plate. In fig. 16 the lable is shown filled in with a line data example.
The line length is written on the back of the lable so that the length can be seen from the front of RANZA through a window in the front plate.

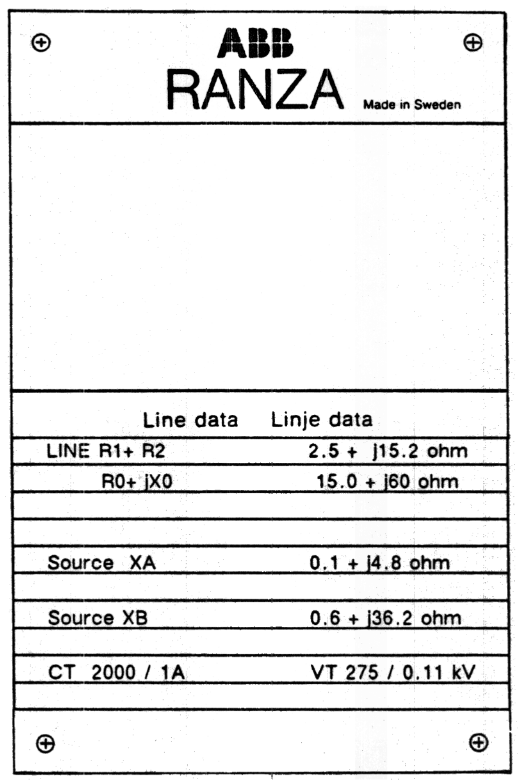


Fig. 16 Lable on the rear of the front plate of transformer unit RTTI 150

Parameter settings

Remove the front plate of the transformer unit RTTI 150. When removed fill in the line length in the window which is on the rear of the label . Line data should be written on the available space on the label. Also source data and instrument transformer ratios should be included. The line length can be seen in the window of the transformer unit front plate when the label is mounted on the plate. A jumper S1 on unit RGGC 070 p.c. board adapts RANZA to 50 or 60 Hz system frequency.See Fig.17 below.

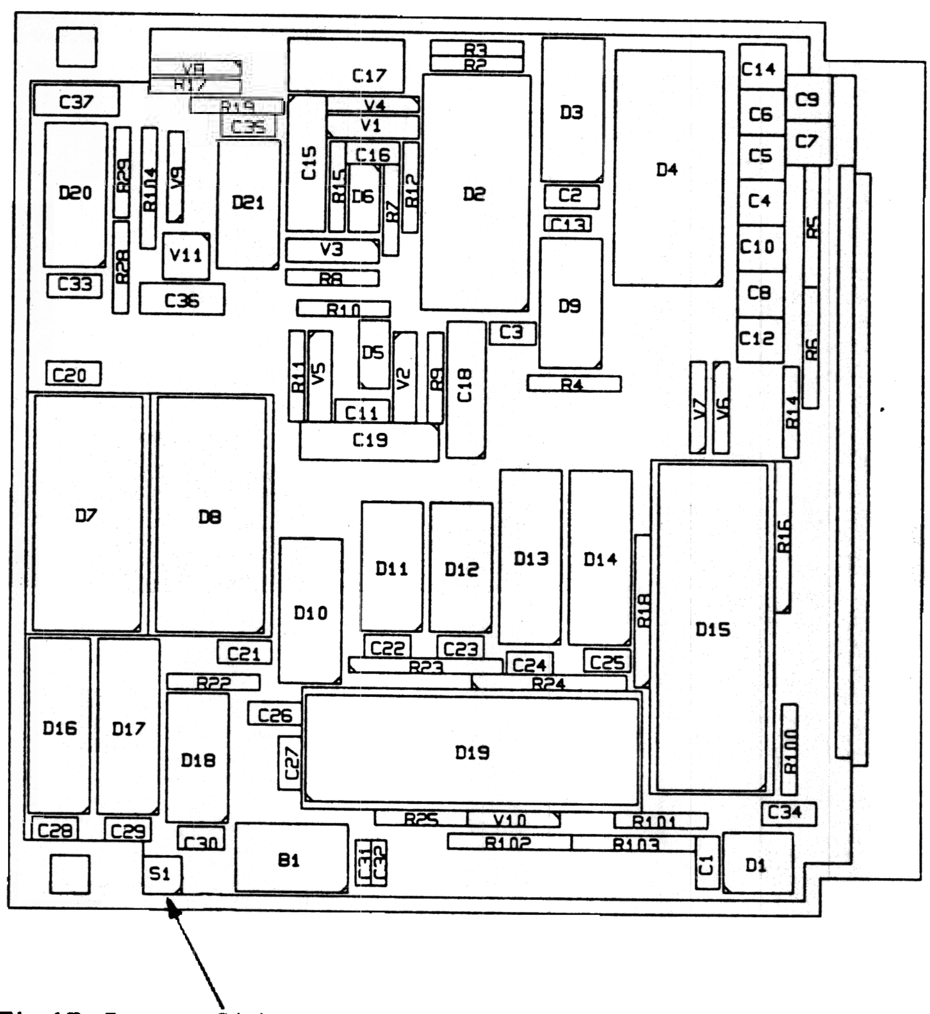


Fig.17. Jumper S1 in upper position adapts RANZA to 50 Hz and in the lower position to 60 Hz system frequency.

Operating parameters set with thumb-wheel switches on setting unit RGSE 050.

For the setting of parameters, the following data is required:

- The positive sequence impedance of the line
- The zero sequence impedance of the line
- The mutual zero sequence impedance between the parallel lines (if no parallel line the mutual zero sequence impedance is zero)
- The positive sequence impedance of the sources on both sides of the line (time average value)
- The ratio of the measuring transformers for current and voltage
- The location of the current transformer starpoint i.e. is the CT transformer starpoint towards the line or the busbar
- The earthing of the power transformer neutral: solidly or impedance. In case of impedance earthing you must also know if the phase-selection for the protective relays is cyclic (R-T-S-R) or acyclic (R-T-S). Same phase-selection as for the distance protection must be used.

The abbreviations used in the text below are explained in Fig. 18 and Table 5 and Table 6 below. All impedance values are secondary values when primary values are not specifically named in the text.

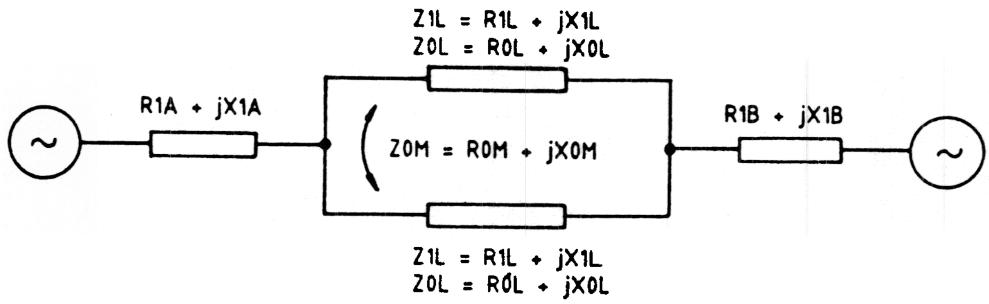


Fig. 18 Simplified network configuration with network data for setting of RANZA.

All impedance values must be converted to the secondary side and then be multiplied by the rated current value for RANZA. I.e. all values will be converted as though the CTs were rated 1 A secondary and the conversion factor of the impedances on the primary side, Z_{prim}, to impedance values on the secondary side Z_{sec} will be

$$Z_{sec}/Z_{prim} = \frac{U_{sec}}{U_{prim}} \times \frac{I_{prim}}{I_{sec}} \times \frac{I_n}{1}$$

where

U_{prim}/U_{sec} = ratio of the measuring voltage transformers

I_{prim}/I_{sec} = ratio of the measuring current transformers.

I_n = rated current of RANZA

Regarding the source impedance values the positive sequence values that are most frequent should be used.

Setting possibilities

Remove the front plate of unit RGSE 050 by removing the two cross-slotted screws on the front of the unit and after that loosen the two screws which normally are used for fixing the unit on top and bottom of the front plate. After removal of the front plate make sure that the printed circuit board is still fixed in its terminal base by pressing on the edge of the board.

When the front plate is removed you can see five thumb-wheel switches. These are together with the test push button at the bottom of the unit used for setting the parameters.

The setting is performed in two steps.

The switch at the top will be set to 9 during the setting. The parameter numbers will first be selected on the two lowest thumb-wheel switches and after one push on the push button the set parameter number will appear on the display after 5 seconds. Then the desired parameter value is set on the four lowest switches and it will enter the programming memory after another push of the push button. The second push must come within 20 seconds from the apperance of the parameter number on the display. A detailed description about the setting procedure is given under the heading "Setting procedure".

For each of the parameters 1 to 8 and 10, 11, 15 and 16 the parameter value is an impedance value where the lowest thumb-wheel switch is set to give the first decimal i.e. the tenth of the number. E.g. if you want to program parameter 15 to have a value of 2.5 the positions of the thumbwheel switches will be, from top to bottom 90015 at the first push of the pushbutton and 90025 at the second push on the push button, see Fig. 19.

Parameter 9 and 13 are settings to adapt RANZA to the network.

Parameter 12 is the line identification number.

Parameters 18 and 19 are used for time setting and can only be set together.

Table 5 gives the meaning of all parameters. Table 6 and 7 explain in more detail the meaning of parameters 9 and 13 respectively.

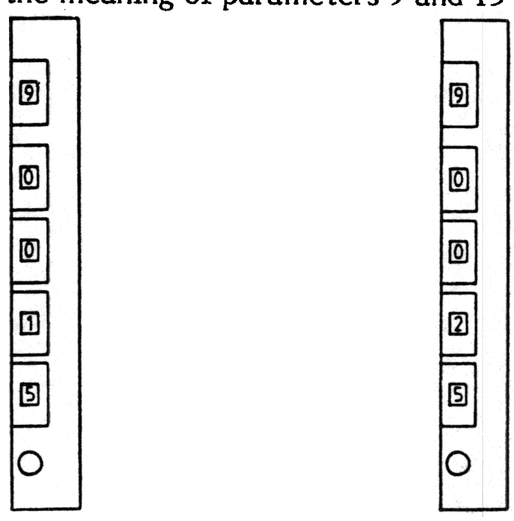


Fig. 19a Fig.19b

Fig. 19 Thumb-wheel switches seen when the front plate of unit RGSE 050 is removed. The Fig. 19a shows the switches set in a position for programming parameter 15. Fig. 19b shows the position of the switches for setting a parameter value equal to 2.5 ohms.

Table 5: Clarification of parameter numbers 1 to 19.
Parameter 14-17 valid only for RANZA with internal phase selection.

Parameter	Meaning	
01	R1L =	Positive sequence resistance of the line
02	X1L =	Positive sequence reactance of the line
03	R0L =	Zero sequence resistance of the line
04	X0L =	Zero sequence reactance of the line
05	R1A =	Positive sequence resistance of the source impedance of station end
06	X1A =	Positive sequence reactance of the source impedance of station end
07 (Note 1)	R1B =	Positive sequence resistance of the source impedance of the remote end
08 (Note 1)	X1B =	Positive sequence reactance of the source impedance of the remote end 1)
09	Adaption of RANZA to network conditions, see Table 6	
10 (Note 2)	R0M =	Mutual zero sequence resistance of the parallel line 2)
1 (Note 2)	X0M =	Mutual zero sequence reactance of the prallel line 2)
12	Identification number of the line. Selection possibilities 0000 to 9999.	
13	Adaption of printer cooperation and setting of measuring interval, see Table 7.	
14 (Note 3)	INS =	Operating value of the zero sequence current ($3I_0$). Selectable 0.1 to 999.9 x I_n.
15 (Note 3)	ReZ_S =	Real part of the operating value for the built in phase selection function in forward direction. Selection possibilities 0.0 to 999.9 ohms/loop.
16 (Note 3)	ImZ_s =	Imaginary part of the operating value for the built in phase selection function in forward direction. Selection possibilities 0.0 to 999.9 ohms/loop.

Parameter	Meaning
17 (Note 3)	D = Ratio of reverse to forward reach for the built in phase selection function. Selection possibilities 0 to 1.9 times set reach in forward direction (in steps of 0.1).
18	Time setting. Week and day, see "Setting procedure".
19	Time setting. Hour and minute, see "Setting procedure".

Note 1) If the line is a radial feeder i.e. there will be no infeed of current from the remote end of the line. Set R1B or X1B = 999.9. RANZA will then automatically set the remote end source angle equal to the line angle.

Note 2) When RANZA is used on a single lines set R0M = X0M = 0.0.

Note 3) To be set only if the built in phase selection function is included.

Table 6: Setting possibilities for **parameter 9.**
The table shows the meaning of thumbwheels 2 to 5 in the second programming step.

Thumbwheel No (counted from top)	Meaning	Set figure 1)	Selection possibilities
2	Phase-selection	1	Solidly earthed Circular phase selection characteristic (when applicable)
		2	Impedance earthed Cyclic R-T-S-R Circular phase selection characteristic (when applicable)
		3	Impedance earthed Acyclic R-T-S Circular phase selection characteristic (when applicable)
		4	Solidly earthed Modified lens as phase selection characteristic.
		5	Impedance earthed Cyclic R-T-S-R. Modified lens as phase selection characteristic.
		6	Impedance earthed Acyclic R-T-S Modified lens as phase selection characteristic.
3	CT polarity (starpoint location of the CTs)	1	Starpoint towards the line
		2	Starpoint towards the busbar

1) Figures 4 to 6 valid only for RANZA with internal phase selection

Thumbwheel No (counted from top)	Meaning	Set figure	Selection possibilities
4	Printer transcription Current loop information to the printer Code: ASCII	0	No printer connected
		1	Line number Relative distance to fault p percent Type of fault Measured loop
	For set code figure 1 to 3 and 5 to 7 start of a new line is given with signal CR= carriage return; For set code figure 4 new line command is given with CR+LF, (LF=line feed.) Set code figures 5 to 7 give the same printout as for figure 2		
		2	As for 1 above plus postfault and prefault currents and voltages given in rms-value and angle polar coordinates. ($A\ e^{j\theta}$)
		3	As for 1 above plus postfault and prefault currents and voltages given in peak-value rectangular coordinates. ($a + jb$)
		4	As for 2 above but new line command is given with CR+LF.
	Setting 5 to 6 apply to printer RTRS 180 (This printer has a battery backed-up internal clock.)	5	To printer with control character 14H and 0FH for start of new line on the printer
		6	The same control characters as for figure 5. Used when the printer has an internal watch that is activated with 13 H
		7	To printer with control character 00H for start of new line on the printer

5	Cooperation number of two RANZAs when used on parallel lines must be set equal on the co-operating RANZAs. Gives also the priority ranking for the printer loop.	0-9	As cooperation numbers an even number should be used (0,2,4,6 or 8). For priority ranking all RANZAs on the same printer loop should have different figures. 0 = highest priority 9 = lowest priority

Table 7: Setting possibilities for **parameter 13.** The table shows the meaning of thumbwheels 2 to 5 in the second programming step.

Thumbwheel No (counted from top)	Meaning	Set figure	Selection possibilities
2	Printing speed. Pause time between each line and time interval between start of each ASCII-sign	0	0.8 s pause time and minimum time interval
		1	0.8 s pause time and 80 ms time interval
	(Normal setting = 3)	2	1.6 s pause time and minimum time interval
		3	1.6 s pause time and 80 ms time interval
3	Rated current.	1	Rated current I_n=1A
	To obtain the primary current multiply printed current value with ratio of the CT.	2	Rated current I_n=2A
		5	Rated current I_n=5A
4	Adaption of different Measuring units RGGC 070 in RANZA when used in parallel line application.	0	Parameter 4 is set after a control of RANZA calculation according to the following: -Set all thumbwheels on 0 -Push test button 5 times within 5 s econds
	(Single line application setting = 0)	1	If the indicator, after showing 05 for number of pushings, shows a number of (01, 02, 03 etc) the setting shall be 0. If the indicator does not show any number the setting shall be 1.

Thumbwheel No (counted from top)	Meaning	Set figure	Selection possibilities
5	Selection of time interval for fault condition (Normal setting = 0)	0	RANZA tries to find the optimum for fault calculation. Start of time interval will be 0.1 or 0.6 cycles after the instant of the fault.
		1	Start of the time interval will be 0.6 cycles after the instant of the fault. Used when the breakers have closing resistors or in weak networks where a high degree of transients is expected in the beginning of a fault condition.
		2	Start of the time interval will be 0.1 cycles after the instant of the fault. Use to obtain best result when an early saturation of the CTs is expected.

Setting procedures

Setting of the parameters 1 to 17

Remove the front plate of unit RGSE 050 as described under "Setting possibilities" above.

The setting procedure is performed in two steps.

Step 1 Set the top thumb-wheel switch in position 9 and select the desired parameter number on the two lowest thumb-wheel switches (4 and 5 counted from top) from table 5. Press on the push button at the bottom of the unit once. The display on unit RGSF 070 will first show the figure "1" and after approximately 5 sec show the selected parameter number.

Step 2 During the time (approx 20 seconds) the display shows the parameter number, the parameter value of the selected parameter number should be set on the four lowest thumb-wheel switches and the push button be pressed once again. The top thumb-wheel should remain in the same position. The display will show 50 and go out. The setting of the selected parameter number is ready and next parameter number can be set in the same manner starting with step 1.

E.g. suppose that the positive sequence reactance value of the line is 8.4 ohms/phase (calculated to secondary value on a 1 A base). The setting sequence will be: Set the five thumb-wheel switches (counted from the top) in the positions 90002; press the push button once; when the display shows 02 set the thumb-wheel switches in the positions 90084 and press the push button once again. If the display goes dark , after having shown the number 50 for a short while, the setting of parameter number 02 is succesful.

If only one parameter value is to be changed it is only necessary to change that parameter.

E.g. Assume that parameter number 09 has a value 1131 and you want to change the printer transcription code from 3 to code 2 the sequence will be as follows: Set the thumbwheel switches in the position 90009 and press the push button once; when the display shows 09 set the thumb-wheel switches in the positions 91121 and press the push button once again. When the display goes out, and no flashing code has occured, the change of parameter value is completed.

If the display starts flashing $\frac{5}{0}$ for approx 5 seconds it is because the memory space is almost used up. When this warning appears for the first time, there is space for another nine setting of that parameter. If RANZA is connected to a printer it will printout "Memory space = Y "where Y will give the available number of parameters. In total it is possible to set more than 10 000 settings of each parameter value. Explanations for other flashing codes are given in a separate section "Reading the display and error codes".

When the parameters 1 to 17 are set all thumb-wheels should be put in position 0.

It is advisable to check that the parameters are correctly stored by the memories in RANZA before mounting the front plate on unit RGSE 050 again. This check is performed by pressing the push button three times. The check is described in a separate section "Test push button functions" below.

Should the check show that any of the parameter values does not agree with the selected value, a new setting must be performed as described above but only for the faulty parameter.

When all parameters have been stored with correct values all thumb-wheels must be left in position 0.

The programming of parameters 1 to 17 is then finished.

Time setting the parameters 18 and 19

Read the whole time setting instruction before you proceed. The auxiliary dc supply EL must not be removed after the time setting is performed since this will decommission the time function. The front plate on unit RGSE 050 must be removed as described in section "Setting possibilities" above, to give access to the thumb-wheel switches.

Set the upper thumb-wheel to number 9 and the remaining thumb-wheels from the top in position 0018. Press the button once and the number 1 is displayed. When number 18 shortly hereafter is displayed the number of the week is to be set on thumb-wheel 2 and 3 from the top and the number of day on thumb-wheel 4 and 5 (monday = 01, sunday = 07). Press the button once again. (The button must be pressed within 20 seconds from the time the number 18 is displayed). The display will now show number 60 in about one second and then the number 19.

Set the time for the hour on the thumb-wheels 2 and 3 from the top and the minutes on the thumb-wheels 4 and 5. The setting is made with 24 hours per day and 60 minutes per hour. Press once (within 20 seconds of the time that 19 is shown on the display) on the push-button and the display will show 61 during approx. 1 second and after that the display should go dark. The time setting is then finished.

E.g. Assume that the time for setting is tuesday in week 43 and it is 16.27 (i.e. 4.27 p.m.). The setting procedure will be as follows: Set the thumb-wheels (from top to bottom) in the position 90018 and press once on the push-button. The display will show 1. When the display changes to 18 set the thumb-wheels in position 94302 and press the push-button once again. The display will now during 1 second shows the number 60 and after that the number 19. The thumbwheels are then set in position 91627 and again the push-button is pressed once. The display will then show 61 during 1 second and then go out. The time setting is finished.

Mount the front plate of the setting unit RGSE 050 on the unit again.

If the number 18 or 19 goes out from the display during the setting of the thumb-wheels before a new pressing of the push-button is performed the setting of the time must start from the very beginning again. If the display starts flashing 00 during the setting operation, you have tried to set a not accepted value. For other flashing codes see section "Reading the display and error codes".

Function of test push button.
Error signal list

The test button on unit RGSE 050 can be used for setting of parameters (described in section "Settings"), reset and rapid check of main functions of RANZA, directional test (printout of actual power transfer) and check set parameter values.

To start up a function you have to give a certain number of pressings on the push button. The pressings must be completed within 5 seconds from the first pressing of the push button. The number of pressings is indicated in the lower part of the display.

Should you do a non defined number of pressings, RANZA will give no operations.

The LED "PD" on the front of output unit RGSF 070 will blink when an output signal is sent to the series printer loop. The LED "PD" is normally dark.

Note! The fault locator operation of RANZA is blocked during all types of test pushbutton operations.

Table 8 is a summary of all functions of the Test ⏚ Reset push-button.

Resetting and rapid checking of main functions

1 pressing
Pressing the test push button once gives a resetting of RANZA (i.e. interruption of a possible operation) and turns off the display. At resetting when no other operation is at hand RANZA will run a rapid check of the main functions.

After pressing the push button once the figure "1" will show in the lower part of the display and five seconds later the display will switch off when all main functions are all right.

If the display starts flashing there is a fault in RANZA. The display will also tell what part in RANZA is not correct, see section "Reading the display and error codes". The flashing fault-indication can be stopped to allow the test program to proceed by pressing the push button once again.

Directional tests

2 pressings
Pressing the push button twice within five seconds will start up this test which only can be performed with a printer connected. An alternative directional test, when there is no printer connected to RANZA, is described under "Directional test".

The lower part of the display will show the figure "2" during the test. The printer will give the actual values of the currents and voltages of each phase at the test moment. The selected type of printer transcription will determine whether the printer gives the values in rms- (the filtered fundamental frequency) and angle values or in rectangular coordinates (peak-values). The former transcription form is obtained when RANZA is set to give no transcription of currents and voltages after a start.

By comparing the obtained values from the printer with the information you can get from the station instrument regarding magnitude of current and voltage and transferred active and reactive power you can see if the fault locator is measuring out towards the line or in the reverse direction. This comparison is easy to do by plotting a phasor diagram of the fault locator values to see if the phase difference between the voltages and currents corresponds to the actual power flow. A rough calculation of transferred active power can also be compared with the station instrument data. An example is shown in Appendix 2.

Check of set parameter values

3 pressings
This check is started by pressing the push button three times within the five seconds. The lower part of the display will first show the figure "3".

The check is easier to perform if a printer is connected since the printer will first printout the parameter numbers and the parameter values before the presentation is made on the display, figure by figure. If there is no printer connected the display should be read as follows: First the figure 3 will be shown in the lower part of the display. The display will then show the parameters 1 to 19 with the parameter value being shown after the display of each parameter number. Each parameter is shown in a five step sequence. The parameters 1 to 17 are displayed according to the example below.

Assume parameter 8 has the value 054.3. The five steps seen on the display will be: step 1 $\frac{0}{8}$, step 2 $\frac{1}{0}$, step 3 $\frac{2}{5}$, step 4 $\frac{3}{4}$, step 5 $\frac{4}{3}$ i.e. first the parameter number is given, then the first, second, third and fourth figure respectively will be dark for approximately 0.8 seconds between each step.

The parameters 18 and 19 (the clock function) are displayed differently. Assume that the time is week 23, tuesday (=02), hours 09 and minutes 17. The display will then show the following signs, each during approximately 2.5 seconds, and give a 0.8 second break showing nothing between the displayed signs.
Step 1 $\frac{1}{8}$ nothing, step 2 $\frac{U}{1}$, $\frac{2}{3}$, nothing; step 3 $\frac{U}{2}$, $\frac{0}{2}$, nothing; step 4 $\frac{U}{3}$, $\frac{0}{9}$, nothing; step 5 $\frac{U}{4}$, $\frac{1}{7}$, nothing.

This means that the parameter number 19 is never displayed but the parameter value will be given together with parameter 18.

If the time never is set the error code $\frac{7}{5}$ will flash. This will also happen if there has been an interruption of the auxiliary dc supply EL.

Lighting of the display

4 pressings
Lighting of the display will come automatically after a start signal to RANZA but can also be obtained manually by pressing the push button four times within five seconds. The lower part of display will first show the figure "4". Then the display will show the last presented value, provided there has been no interruption of the dc auxiliary supply.

Definitions for the different functions which may be obtained by pressing the pushbutton

Table 8

Definition of different functions obtained by pressing the button "Reset/Test".

One pressing

- Parameter setting

  See "Setting procedure. Setting of the parameters 1 to 17".

- Time setting

  See "Setting procedure. Time setting, the parameters 18 and 19".

- Rapid check of main functions

  All thumb-wheels should be in position 0. The check includes the A/D converter, series current loop (when used), EPROM and RWM-circuits.

- A/D-converter check

  Thumb-wheel 1 to 4 shall be in position 0 and thumb-wheel 5 in position 1.

- Check of series current loop

  Thumb-wheel 1 to 4 shall all be in position 0 and thumb-wheel 5 in position 2.
  The check is a check of continuity of the loop and includes, when a printer is used, also a check of correct information interchange by printing the following two rows.
  Row 1 0123456789+-ABCDEFGH
  Row 2 IJKLMNOPQRSTUVWXYZ%!

  When RANZA is used for single line application without a printer the check is performed only when specially asked for.

  EPROM-check

  The thumb-wheel 1 to 4 shall all be in position 0 and thumb-wheel 5 in position 3.

  RWM-check

  Thumb-wheel 1 to 4 shall all be in position 0 and thumb-wheel 5 in position 4.

  Test of thumb-wheels
  The thumb-wheel 1 to 4 shall be in position 0 and thumb-wheel 5 in position 5.
  Press push button once. When the display shows 1, thumb-wheel one can be tested by changing the value from 0 to 9. The value of the thumb-wheel will be shown on lower digit on display. Set thumb-wheel 1 to 0.
  Press push-buttom once again. The display will show 2 after 5 seconds. Thumb-wheel 2 is tested in the same way as thumb-wheel 1.

Test thumb-wheel 3, 4 and 5 using the same method.
After checking of parameter 5 a press of the push button will put RANZA back in normal service.

- Check of set frequency.
  A check that the jumper, for selecting frequency, is set to correct position, is made as follows.
  Set thumb-wheels 1 to 4 to 0 and thumb-wheel 5 to 6.
  Press Test/Reset push button once.
  Afer 5 seconds the display will show the set frequency during about 1.6 seconds.

- Check of input relays.
  A test can be made to check that the phase selection and start signals from the protection reaches the processor.
  Set thumb-wheels 1 to 4 to 0 and thumb-wheel 5 to 7.
  Press Test/Reset push button once.
  After 5 seconds the activated inputs will be displayed according to the table below.

  Lower digit:
  0= No input activated
  1= Phase R
  2= Phase S
  3= Phases RS
  4= Phase T
  5= Phases RT
  6= Phases ST
  7= Phases RST

  Upper digit:
  0= No input activated
  1= Phase N
  2= Start from parallel line
  3= Start from parallel line and N
  4= Start
  5= Start and N
  6= Start and start parallel line
  7= Start, start parallel line and N

Two pressings

Calculation of currents and voltages fed to RANZA at the instant when the pushings are performed. All thumb-wheels shall be in position 0.

If a printer is connected there will be a printout of the calculations, which can be used for checking the measuring direction and the transformer ratio.

Three pressings — Check of parameter settings. When a printer is used there will be a printout of set parameter values and time. How to read the display is given above in section "3 pushings. Check of set parameter values".

Four pressings — The display will show the last presented distance to fault and the printer (if used) will printout the displayed value and the time the fault occured, provided all thumb-wheels are set in position 0.

If thumb-wheel 1 to 4 all are in position 0 and thumb-wheel 5 is in position 1 you will get the 10 last presented distance to faults on the display and a printout (if printer is used) of these and the times when they occured.

Five pressings — The display will show the version of the program in RANZA. The display will be lit up for 1.6 seconds.

Reading error codes

The display will start by showing $\frac{\mathrm{U}}{\mathrm{U}}$ and, when the calculation is finished, will show the distance to fault in percent of set line length.

During check of set parameter values the display will show the values as described above in section "3 pressings. Check of set parameter values".

The error codes are shown as flashing numbers and can be as follows:

$\frac{0}{0}$ means that an anacceptable value or a nondefined parameter number is set on the thumb-wheels. This can also be shown if the wrong number of pushings is given for the selected thumb-wheel setting.

$\frac{1}{\mathrm{I}}$ means error in the A/D-converter or the associated circuits.

Measures: Check that the printed circuit switches in unit RGGC 070 are correct positioned. If they are correct positioned change unit RGGC 070.

$\frac{2}{\mathrm{I}}$ means error in the series current loop used for the printer or parallel operating RANZA. (When the series current loop is not used the printer transcription code must be set to 0 to avoid this indicationg).

Measures: Check that there is no interruption in the current loop and that the dc supply for it operates. If the light emitting diode "PD" on the front of unit RGSF 070 does not blink when printout is expected the fault is most likely a broken optocoupler, in which case unit RGSF 070 should be replaced. If replacement of RGSF 070 does not remove the fault unit RGGC 070 should be replaced.

$\frac{3}{1}$ means error in the EPROM memory.

Measures: Change unit RGGC 070

$\frac{4}{1}$ means error in the RWM memory.

Measures: Change unit RGGC 070

$\frac{5}{0}$ can be obtained during programming and means that it is only possible to set another 9 parameter values when the indication appears for the first time.

Measures: Order new memories from ABB.

$\frac{5}{1}$ means that parameter memory is faulty or that communication with memory is not in operation.
Measures: Change unit RGGC 070.

$\frac{7}{5}$ can be obtained at the end of presentation of parameters on the display. Means that the time is not set. The reason can be an interruption of the dc auxiliary supply EL.

Measures: Perform a time setting.

$\frac{7}{7}$ means that a display or printout of the last or 10 last presented distances to fault is ordered but they are not stored. Loss of dc-auxiliary supply EL erases the earlier stored values.

$\frac{8}{8}$ is obtained when a programming attempt fails. The reason can be that a parameter setting memory is out of operation

$\frac{9}{9}$ means that the parameter memory is used up.

Measures: Order new memories from ABB.

$\frac{U}{U}$ is obtained when RANZA is used without printer and has received start signal but not received or has been able to calculate the phase information.

Secondary injection tests

The secondary injection test is performed for two reasons:

1) To check the distance to fault measuring accuracy

2) To check that information about the zero-sequence current on the parallel line is correct transmitted

The test procedure is described below under the heading "Test procedure" and the sub headings "Measuring accuracy check" and "Parallel cooperation check".

Preparation

The secondary injection test should be performed with a test set type TURH or similar. A short description of test set type TURH is given in Appendix 1. RANZA is assumed to be installed and have all ac and dc-circuits connected.

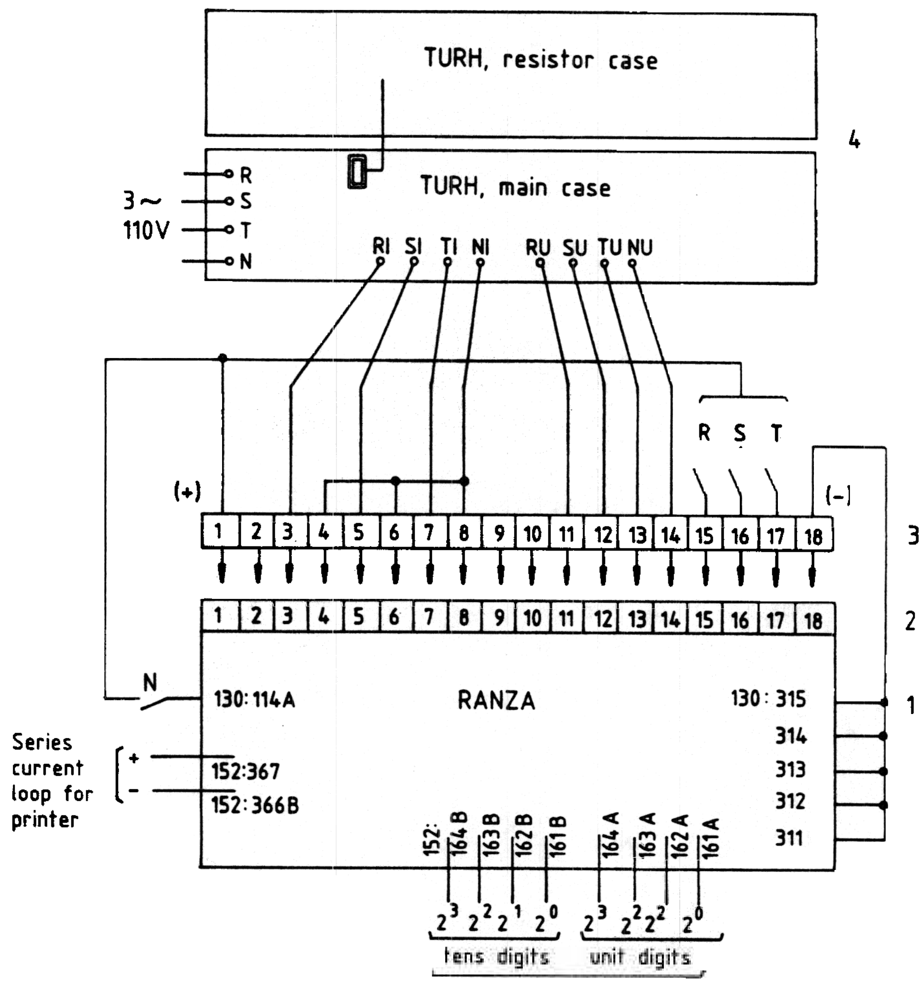
a) Prepare the test set for testing as described in Appendix 1, section "Preparation".

b) Connect RANZA to the test set according to Fig. 20 or Fig. 21 depending upon if RANZA is provided with phase selection function or input relays for external phase selection information. Some connections are made to the test plug handle RTXH 18 and some are made directly to the terminals at the rear of RANZA.

Table 9 below gives the connection details for obtaining correct phase selection in RANZA for the testing of different fault conditions. All terminal numbers without a colon (:) are terminals on the test plug handle. Terminal numbers with a colon (:) are terminals on the rear of RANZA.

Table 9 Connections for obtaining correct phase selection when testing RANZA with TURH according to Fig. 21.

Fault condition	Connect terminals
RN	1 - 15 - 130:114A
SN	1 - 16 - 130:114A
TN	1 - 17 - 130:114A
RS	1 - 15 - 16
ST	1 - 16 - 17
TR	1 - 15 - 17
RST	1 - 15 - 16 - 17



Fault locator type RANZA

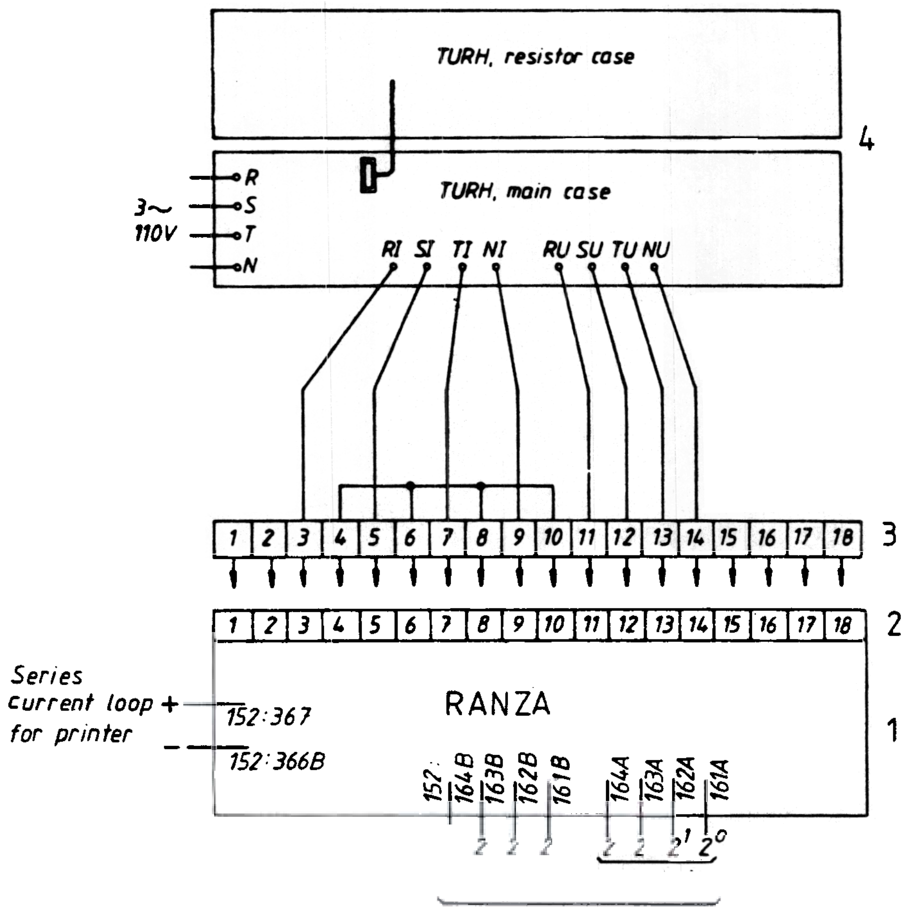
2. Test switch RTXP in RANZA

3. Test plug handle type RTXH 18

4. Test set type TURH

R, S, T, N Phase selection inputs, see table 9. (Not required when internal phase selection is provided)

Fig. 20 Connection for secondary testing of RANZA without internal phase selector relays.



1. Fault locator type RANZA
2. Test switch RTXP in RANZA
3. Test plug handle type RTXH 18
4. Test set type TURH

Fig. 21 Connection for secondary testing of RANZA with internal phase-selector relays

The printer must be connected with correct polarity for the series current loop. This is shown in Fig 20 and Fig 21.

When there is no printer connected to RANZA an external printer should be connected during the commissioning and testing to simplify the testing. A temporary connection of the suggested printer DATEL-INTERSIL type APP-20E, 220 V ac is show in Appendix 3.

When the telemetry outputs are used the reading on RANZA is given on these with a positive output signal binary coded.

c) Switch Q settings on TURH

The number of the switch Q setting gives the corresponding quadrant of the impedance plane when RANZA is set for connection to a current transformer group with the starpoint towards the line. (See table 3. Parameter 9 should be programmed with a code X1XX). Q = 1 corresponds to a fault in the line direction, forward.

When RANZA is set for connection to a current transformer group with the neutral star-point towards the bus-bars (See table 6. Parameter 9 should be set with a code X2XX) table 10 below gives the corresponding part of the impedance plane for different positions of the switch.
Q = 3 corresponds to a fault in the line direction, forward.

Table 10 Translation table for switch Q settings for testing RANZA with CT polarity setting code = 2. (CT starpoint towards the bus).

Position of Q	Corresponding quadrant in the plane	
3	1	Forward
4	2	Forward
1	3	Reverse
2	4	Reverse

d) The test procedure described under the heading "Test procedure" below is for simulating a fault in the forward direction on the monitored line. Suitable selection of test values X_t and R_t, reactance and resistance are e.g. 10, 50 or 90 percent of the positive sequence values of the line.

Other test values can also be used as well as testing for faults located in other parts of the impedance plane, i.e. testing with the switch Q in different positions.

Testing with impedance values in the 1st and 2nd quadrant will give a reading "p" on RANZA which should not deviate more than 5 percent from set test values when $X_t \leq X1L$, where X1L is the positive sequence value of the line. When $X_t \geq X1L$ the reading will be p = 99.

Testing with impedance values in the 3rd and 4th quadrant will give a reading p = 0.

The printer transcription will show "SLOW START" during the test with TURH.

If you want to interrupt or stop a test sequence in RANZA press the Test push button once.

Test procedure

Measuring accuracy check

Switch P on TURH should be set in position 1 during the testing.

a) RANZA connected according to Fig. 20:
Connect according to table 4 the wires between the terminals on the test plug handle and the terminals at the rear of RANZA to obtain phase selection for desired type of fault.

RANZA connected according to Fig. 21:
Proceed to point b below.

b) Set switch F on TURH in the position for desired type of fault.

c) Set switch Q on TURH in the position for simulating a fault in the forward direction. (Q = 1 when CT starpoint programming code = 1 and Q = 3 when CT starpoint programming code = 2).

d) Select a setting of G_X, F_X, G_R and F_R on TURH from the formulas below where X_t and R_t are required test values of reactance and resistance respectively:

50 Hz rated frequency

Three-phase fault

$$(G_X + \frac{F_X}{1000} = X_t \times \frac{S1 \times S2}{5 \times I_n}$$

$$(G_R + \frac{F_R}{1000}) = (R_t - \frac{K_Q \times X_t}{20}) \times \frac{S1 \times S2}{5 \times I_n}$$

Two-phase and single-phase fault

$$(G_X + \frac{F_X}{1000}) = X_t \times \frac{S1 \times S2}{2.5 \times I_n}$$

$$(G_R + \frac{F_R}{1000}) = (R_t - \frac{K_Q \times X_t}{20}) \times \frac{S1 \times S2}{2.5 \times I_n}$$

60 Hz rated frequency

Three-phase fault

$$(G_X + \frac{F_X}{1000}) = X_t \times \frac{S1 \times S2}{5 \times 1.2 \times I_n}$$

$$+ \frac{F_R}{1000}) = (R_t - \frac{K_Q X_t}{20}) \times \frac{S1 \times S2}{5 \times I_n}$$

Two-phase and single-phase fault

$$(G_X + \frac{F_X}{1000} = X_t \times \frac{S1 \times S2}{2.5 \times 1.2 \times I_n}$$

$$(G_R + \frac{F_R}{1000}) = (R_t - \frac{K_Q X_t}{20}) \times \frac{S1 \times S2}{2.5 \times I_n}$$

where

$S1 \times S2$ = current settings on TURH

I_n = rated current of RANZA

K_Q = +1 when Q = 1 or Q = 3 on TURH

-1 when Q = 2 or Q = 4 on TURH)

The setting S1 x S2 is best to select equal to rated current of RANZA. Should any of the calculated settings

$(G_X + \frac{F_X}{1000})$ or

$(G_R + \frac{F_R}{1000})$ give a value higher than 10, the setting of

S1 x S2 should be selected to the next lower setting.

e) Turn switch H to position 1. RANZA is now fed with currents and voltages giving the selected test values X_t and R_t.

f) Short-circuit temporarily terminal 1 and 2 on the test plug handle, i.e. give a start signal to RANZA.

The display will show $\frac{U}{U}$ during the time RANZA needs for calculation, approximately 15 seconds, and then show the result on the display.

g) Read the percentage p on the display.

h) Compare the reading "p" with the reactive test value X_t set on TURH and the programmed line data in RANZA (parameter 2 = X1L = the positive sequence reactance value and parameter 4 = X0L = the zero-sequence reactance value) according to the equations below. The formulas indicate that the error should be less than 5 percent.

Three-phase and two-phase fault

$$p - 5 \leq \frac{X_t \times 100}{X1L} \leq p + 5$$

Single-phase fault

$$p - 5 \leq \frac{2\,X_t \times 100}{\frac{X0L + 2X1L}{3}} \leq p + 5$$

i) When a printer is connected, check also that correct printout is obtained for distance to fault, type of fault and measured loop.

On the printer strip the notations IR, IS, IT, IN and UR, US, UT are given for currents and voltages during fault condition (after start of RANZA). The notations IRØ, ISØ, ITØ and URØ, USØ, UTØ are given for the currents and voltages during prefault condition (before start of RANZA). The prefault and postfault values will be approximately the same during the test with TURH.

j) Select other test values of X_t and R_t or change connections on the test plug handle for testing another type of fault and repeat the test procedure if required.

Parallel line cooperation check

To perform this test there must be a value set on parameter 10 and 11, the mutual zero sequence impedance.

When RANZA is used together with a printer the test A below is only a check that the zero-sequence current is correctly transmitted via the series current loop. When there is no printer connected test B below is sometimes possible to perform if the two cooperating RANZAs are mounted close to each other, in the same station. Test B will also give a possibility to check that compensation will be obtained when the zero-sequence current value is received from the parallel operating RANZA to the RANZA of the faulted line.

A. Check of zero-sequence current transmission on the series loop. A printer must be connected to perform the test.

   a) Connect one of the RANZA (line A) as for checking the measuring accuracy to the test set TURH. There is no need for phase selection.

   b) Set switch F in the position for a single-phase fault RN, SN or TN and connect an ammeter in series with the current in the neutral from TURH.

   c) Set switch Q on TURH in any position 1, 2, 3 or 4.

   d) Select a S1 x S2 setting equal to a value less than three times rated current I_n on RANZA.

   e) Turn switch H on TURH to position 1.

   f) Insert a test plug handle in the parallel line RANZA (line B). With the terminals 11, 12, 13 and 14 short circuited on the test handle.

   g) Connect terminal 15, 16, 17 to terminal 1 on the test plug handle (Phase selection three-phase fault).

   h) Connect terminal 2 on the test-plug handle of line B RANZA to the line A input relay "START 2" terminal 130:116B on the line A RANZA, now fed with current from TURH.

   i) Short-circuit temporarity the terminals 1 and 2 on the test plug handle inserted in the parallel line RANZA, line B i.e. give signal "START 1" to RANZA on line B and at the same time "START 2" to RANZA on line A.

j) The display of both RANZAs will show $\frac{\text{U}}{\text{U}}$. The printer will printout the line number of line B RANZA and "SLOW START".

After approximately 15 seconds the yellow LED "PD" on the RGSF 070 output unit of RANZA line A will blink and the printer will print out the line number of line A RANZA and the value of the zero-sequence current fed to line A RANZA. The value is given in reactangular coordinates, peak-value. It can be converted to RMS-value with the formula:

$$\text{INP} = \sqrt{\frac{(\text{real part})^2 + (\text{imaginary part})^2}{2}}$$

After that, line A RANZA is ready with the printout of INP, line B RANZA starts to printout currents and voltages. In the end of this printout you will find the received value of INP from line A RANZA. The received INP to line B RANZA, the send INP from line A RANZA and the indicated value on the ammeter shall not deviate more than 1% (all INP in RMS values according to formula above).

B. Check of compensation function. This check can also be done when there is no printer connected.

a) Connect the two RANZAs to one test set TURH as for checking the measuring accuracy. The current should be fed in series to have the same current flowing through the two RANZAs as shown in fig 12.

b) Connect an ammeter in series with the current in the neutral from TURH.

c) Set the switches on TURH for a test value as during the test procedure for checking the measuring accuracy. The fault switch should be set on a single phase fault RN, SN or TN.

d) If RANZA is without internal phase selection, give the corresponding phase information for the selected type of fault to one of the RANZAs (called line A).

e) Connect terminal 2 on the test plug handle of line A RANZA to the input relay "START 2", terminal 130:116B on the rear of the other RANZA, line B.

f) Short-circuit temporarily the terminals 1 and 2 on the test plug handle on line A RANZA, i.e. "START 1" signal is given to line A RANZA and "START 2" signal is given to line B RANZA simultaneously. The display on both RANZAs will show $\frac{\text{U}}{\text{U}}$.

After approximately 15 seconds the yellow LED "PD" on the front of line B RANZA will blink, which indicates that signals are given to the series current loop. When a printer is connected it will printout the zero-sequence current value detected in line B RANZA. The value is given in rectangular coordinates, peak value. It can be converted to RMS-value with the formula:

$$\text{INP} = \sqrt{\frac{(\text{real part})^2 + (\text{imaginary part})^2}{2}}$$

This calculated value should not deviate more than 1 percent from the INP-value obtained in the end of the printout.

The display on line A RANZA will show a calculated distance to fault p_l which should not deviate more than 5 percent from the test value X_t when compared according to the formula:

$$p = \frac{2\,X_t \times 100}{\frac{X0L+2X1L+X0M}{3}}$$

where

X_t = set test impedance in ohms/phase on TURH.

X0L = set line zero-sequence value on RANZA, parameter 4.

X1L = set line positive sequence value on RANZA, parameter 2.

X0M = set mutual zero sequence value on RANZA, parameter 11.

If you reverse the current fed to line B RANZA the displayed p-value should be compared with

$$p = \frac{2X_t \times 100}{\frac{X0L+2X1L-X0M}{3}}$$

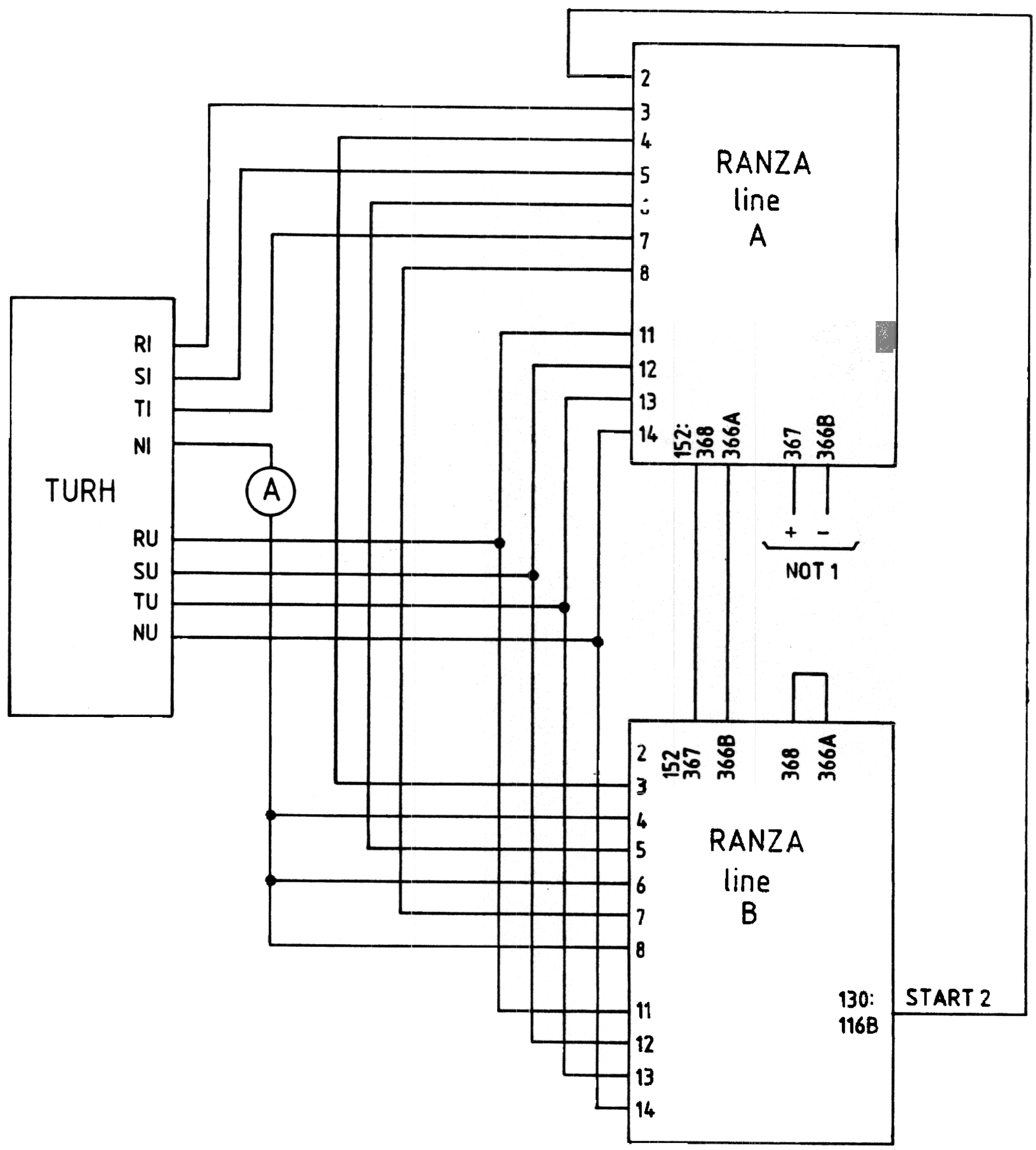


Fig. 22 Connection for secondary testing of RANZA when checking the compensation for parallel lines.

Directional test

RANZA must be connected to the measuring transformers as for normal service

Alternative 1:

This method can be used when RANZA is connected to a printer.

Record from the station instruments the actual power transfer on the line: import or export of active or reactive power and current level.

Press the pushbutton Reset/Test twice within five seconds during this system condition.

The display will show the figure "2" on the lower part of the display. The printer will give the values of the currents and voltages of each phase at the test moment. The selected type of printer transcription will determine whether the printer gives the values in rectangular or polar coordinates. The latter transcription form is obtained when RANZA is set to give, no transcription of currents and voltages after a normal start.

By comparing the obtained values from the printer with the information you can get from the station instrument regarding magnitude of current and voltage and transferred active and reactive power you can see if the fault locator is measuring out towards the line or in the reverse direction. This comparison is easy to do by plotting a phasor diagram of the fault locator values and checking to see if the phase difference between the voltages and currents corresponds to the actual power flow. A rough calculation of transferred active power can also be compared with the station instrument data.

An example of the test is given in Appendix 2.

Alternative 2:

This is a simplified method which can be used when RANZA is not connected to a printer. The load power flow must be known and the line should carry 10 percent of rated current.

A) Short circuit terminal 101:1 and 101:15 on the rear of the test switch which corresponds to a phase selection of phase R.

B) Make a temporary short-circuit between 101:1 and 101:2 on the test-switch to make the fault-locator start calculating. The display should show $\frac{U}{U}$. After approximately 15 seconds the display will show $\frac{0}{0}$ or a figure $\frac{0}{I}$ to $\frac{9}{9}$.

C) If the reading is a figure $\frac{0}{I}$ or higher the load condition should be either

C1 inductive load, active power flow out towards the line (i.e. the load in the first quadrant) or

C2 capacitive load, active power flow coming in from the line (i.e. the load in the second quadrant).

If the reading is $\frac{0}{0}$ the load condition should be either:

C3 inductive load, active power flow from the line towards the fault locator (i.e. the load in the third quadrant) or

C4 capacitive load active power flow out towards the line (i.e. the load in the forth quadrant).

D) If the reading does not correspond to the load condition check if the programming of CT polarity, parameter 9, is correct or that the polarity of the CT circuits has not been shifted in the connection wires between the CTs and RANZA.

E) Remove the short circuit between terminal 101:1 and 101:15 on the test switch and repeat the test from B) above with a short circuit on the test switch between terminal 101:1 and 101:16 for phase S and 101:1 and 101:17 for phase T.

F) When all phases are tested remove the temporary short circuits on the test switch.

Printer installation and operating instructions

The printer is mounted in a separate rack together with a separate dc-dc converter, RXTUG 21H, which provides the required auxiliary voltage (12 V dc). The printer and converter are fixed by screws to an apparatus bar 30C wide. See fig. 23.

The controls for date/time settings are accessed by opening the printer front door.

When power is applied, the front panel LED will illuminate.

The printer can be checked independently of a signal source by initiating a self test printout. The printer feeds paper when the "FEED" button is pressed. If this is done during the power up stage the self test printout commences.

If the printer prints correctly, system signals can then be applied.

To tear off the paper, pull downwards against the sharp edge at the bottom of the paper exit slot in the door.

Paper loading
Open the front door by rotating the knob anticlockwise. Remove the old roll by lifting it upwards and sliding it towards you. If there is any paper left on the roll, and/or still fed through the printer mechanism, tear it off near the paper entry slot and remove the remaining paper by depressing the "FEED" button. Do not pull the paper out by hand. Remove the spindle and slide the new roll on.

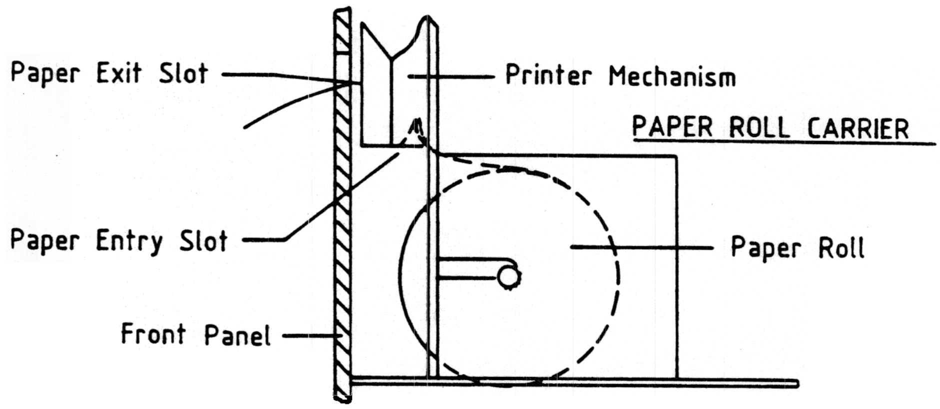


Fig. 23 Printer paper loading

With the paper coming off of the top of the new roll insert it into the roll carrier by pushing it backwards as far as it will go, at which point it will drop into the locating slot. Insert the end of the paper into the printer mechanism paper entry slot as far as it will go, and then depress the "FEED" button which will automatically thread the paper.

Ribbon cassette loading
Open the front door by rotating the knob anticlockwise. Remove the old cassette by pushing on the left hand edge, where marked, which will cause the right hand edge to lift away from the mechanism. Carefully lift the old cassette off the mechanism.

To fit a new cassette, push onto the mechanism, the left hand edge first and then push down the right hand edge carefully making sure that it clicks into place. If it does not fit easily on the right hand side, turn the small knob on the cassette, in the direction marked, until it fits.

Date and time setting
The date and time is set using 2 buttons DT1 and DT2 hidden behind the front panel. DT1 is the upper of the two buttons.

To change the time first ensure a 20 mA source is connected to the unit. Press DT1 once. This stops the normal print mode and enters the date time set up mode.

If the year is a leap year press DT2 else press DT1 then DT2. The month, day, hours and minutes must now be entered by first entering the tens of the value then units. A 24 hour clock is used. For each number press DT1 the required number of times followed by DT2 to enter it. Zero is given by pressing DT2 immediately. If an incorrect number is entered complete the sequence and then re-enter. After each stage the printer indicates the number entered.

MAINTENANCE TEST

Since most of the components in RANZA are of static design and these are automatically checked every time at resetting of the display, there will be an alarm if any component is broken. If there are very infrequent intervals between the start operations of RANZA it is suitable to perform this rapid check at least once a year. Should the display start flashing see section "Resetting and rapid check of main functions" to see what measures are to be taken.

A complete secondary injection test is not necessary to perform more than every second year, to check the operation of the phase selection input relays and the measuring accuracy.

A directional check can be performed not only to verify a correct measuring direction but also check a correct operation of the input transformers of RANZA.

A BRIEF DESCRIPTION OF THE TEST SET TYPE TURH

The front of the test set contains several controls, terminals, etc. The various functions of these are seen in Fig. 1.

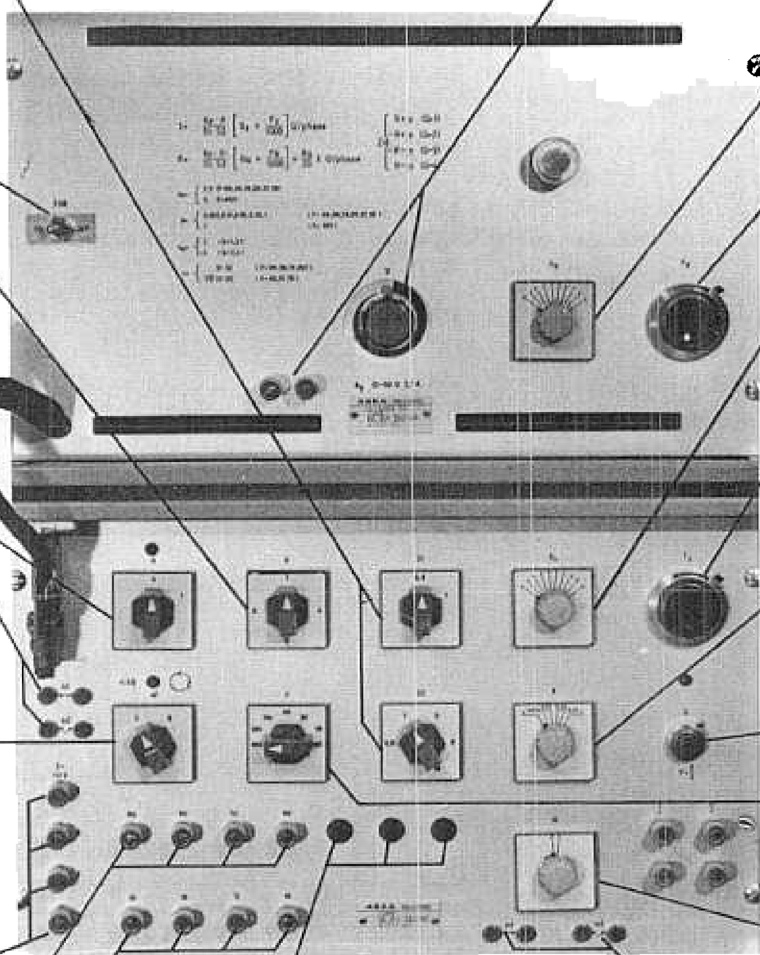


Fig. 1 Controls and terminals of TURH

Note The upper case, the resistor case, is sometimes supplied with a further four terminals marked R, S, T, N. These terminals must be shortcircuited during testing.

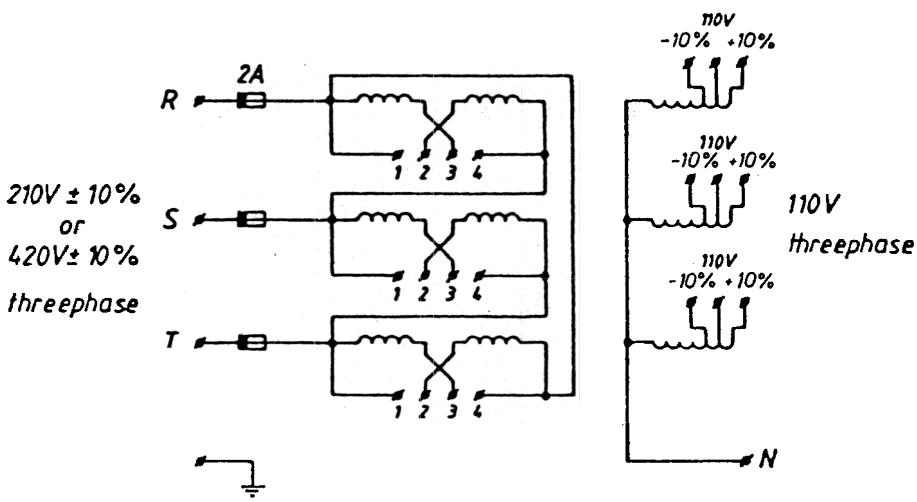
Preparations

(a) Place the two cases one on top of the other with the main case at the bottom.

Connect the two cases together by using the RTXG connector on the top case. Lock the connector.

Connect terminals RSTN of the test set to 110 V three-phase with neutral, 50/60 Hz, with known phase sequence, but allow the main switch H to remain open, position 0, until further notice.

If only 220 V or 380 V three-phase local supply is available a separate auxiliary transformer can be used to obtain 110 V to the test set. Fig. 2 shows the reconnection possibilities of an auxiliary transformer of ABB make.



Input	Connection	Terminals	Output
190V 210V 230V	1 2 3 4	110V + 10% 110V 110V - 10%	110V
380V 420V 460V	1 2 3 4	110V + 10% 110V 110V - 10%	110V

Transformer ratio 2×210V/64V, 50Hz, 200VA

Fig. 2 Reconnection possibilities of the ABB auxiliary transformer.

(b) Connect terminal RI, SI, TI, NI, and RU, SU, TU, NU of the test set to the corresponding test terminals of the test plug handle RTXH 18 as shown in the connection diagram on test set up diagram for the test object.

(c) Insert the test-plug handle into the test switch of the test object and check that all unnecessary signal or alarm circuits are opened. (See the connection diagrams for the test object).

(d) Set the switches:
Q in position 1, i.e. first quadrant in the impedance plane.
M in position 1 until further notice.
P in position 1, i.e. voltage transformer ratio equal to 1.

(e) Set the product of the setting of the current selector switches S1 and S2, approximately equal to the rated current of the test object i.e.

S1 x S2 = 1 x 1 = 1 for rated current 1 A
S1 x S2 = 1 x 2 = 2 for rated current 2 A
S1 x S2 = 1 x 5 = 5 for rated current 5 A

Turn the main switch H to position 1.

With the switch AF in position 1, the light-emitting diode, located above AF, is lit if all terminals R, S, T and N are supplied with voltage. The light-emitting diode remains dark if one or several phases are missing in the supplied voltage.

The phase sequence in the a.c. supply is checked with the switch AF in position 2, the light-emitting diode is lit if the phase sequence is R, S, T. The diode is dark if the phase sequence is reversed.

Set the switch AF in position 1 and turn switch H to position 0.

Calculation formulas and constants

At a power frequency of 50 Hz the formulas listed below are valid:

$$X_m = \frac{K_F \times P}{S1 \times S2} \left(G_X + \frac{F_X}{1000}\right) \text{ ohms/phase}$$

$$R_m = \frac{K_F \times P}{S1 \times S2} \left(G_R + \frac{F_R}{1000} + \frac{K_Q}{20} X_m \right. \text{ ohms/phase}$$

$$I_{50} = \begin{cases} 0.85 \times S1 \times S2 \text{ A} & (F = RN, SN, TN, RST) \\ \sqrt{3} \times 0.85 \times S1 \times S2 \text{ A} & (F = RS, ST, TR) \end{cases}$$

(b) At power frequency of 60 Hz the formulas listed below are valid:

$$X_m = 1.2 \frac{K_F \times P}{S1 \times S2} \left(G_X + \frac{F_X}{1000}\right) \text{ ohms/phase}$$

$$= \frac{K_F \times P}{S1 \times S2} \left(G_R + \frac{F_R}{1000}\right) + \frac{K_Q}{20} X_m \quad \text{ohms/phase}$$

$$0.9 \times I_{50}$$

(c) The constants valid at both 50 Hz and 60 Hz are:

$$K_F = \begin{cases} 2.5 & (F = RN, SN, TN, RS, ST, TR) \\ 5 & (F = RST) \end{cases}$$

$$K_Q = \begin{cases} 1 & (Q = 1,3) \\ -1 & (Q = 2,4) \end{cases}$$

$$P = \begin{cases} 0, 0.002, 0.01, 0.05, 0.25, 1 & (F = RN, SN, TN, RS, ST, TR) \\ 1 & (F = RST) \end{cases}$$

$$= \begin{cases} +R_m + jX_m & (Q = 1) \\ -R_m + jX_m & (Q = 2) \\ -R_m - jX_m & (Q = 3) \\ +R_m - jX_m & (Q = 4) \end{cases}$$

(d) The above calculated values, X_m and R_m, can be converted to loop impedance basis, X and R:

$X = 2 \times X_m$ ohms/loop

$R = 2 \times R_m$ ohms/loop

$Z = \sqrt{X^2 + R^2}$ ohms/loop

(e) The following table is applicable at nominal supply voltage (50 Hz) for test currents and the current transformer loads. The current will be 0.9 times the values listed in the table at a frequency of 60 Hz.

Selector switch position			Test current		Allowed burden	
			Single and three-phase faults	Two-phase faults		
S1	S2	S1 x S2	(A)	(A)	(VA/phase)	(ohms)
0.4	0.5	0.2	0.17	0.30	0.5	12.5
0.4	1	0.4	0.34	0.60	0.5	3.13
1	0.5	0.5	0.43	0.75	5	20
1	1	1	0.85	1.5	5	5
1	2	2	1.7	3.0	5	1.25
1	5	5	4.25	7.5	5	0.20
(1	10	10	8.5	15	5	0.05)

Table 1 Position S1 x S2 = 10 should not be used testing three-phase impedance measuring apparatuses.

DIRECTIONAL TESTS ON RANZA

Station instrument indications

Active power P = 250 MW export

Reactive power Q = 20 MVAr export

Voltage = 410 kV (voltage between lines)

Current = 350 A

Transformers ratios: 385/0.11 kV 2000/2 A

RANZA's (the printers) measured values

Rectangular coordinates peak values (a + jb)		Polar coordinates RMS-values (A ejθ) filtered rated frequency	
IRØ =	0000.1379 (a) 0000.4826 (b)	IRØ =	AMPL 000.354 A (A) ARG 074.0 DEG (θ)
ISØ =	0000.3408 0000.3113-	ISØ =	AMPL 000.326 A ARG 317.5 DEG
ITØ =	0000.4591- 0000.1354-	ITØ =	AMPL 000.338 A ARG 196.4 DEG
URØ =	0018.5287 0094.1418	URØ =	AMPL 067.845 V ARG 078.8 DEG
USØ =	0072.8286 0063.1842-	USØ =	AMPL 068.177 V ARG 319.0 DEG
UTØ =	0091.1317- 0031.5636-	UTØ =	AMPL 068.195 V ARG 199.1 DEG

Checking the operating angle (directional test):

From readings of the station instruments:

$$\tan^{-1} \frac{Q}{P} = \tan^{-1} \frac{20}{250} = +4.6^\circ$$

From RANZA printer printout:

= arg U - arg I Phase R: = $+4.8^\circ$
S: = $+1.5^\circ$
T: = $+2.7^\circ$

Conclusion: RANZA has correct direction.

Remark: If the measuring direction is wrong or one or many CTs have wrong polarity the difference in angle is about 180°.

Checking of the transformer ratios:

Station instrument readings (primary values)

$U_{phase} = 410/\sqrt{3}\ \text{kV} = 237 \cdot 10^3\ \text{V}$

$I = 350\ \text{A}$

From RANZA printer print out

$U_{phase} = 68\ \text{V (secondary)} = 68 \cdot \frac{385}{0.11}\ \text{V (primary)} =$

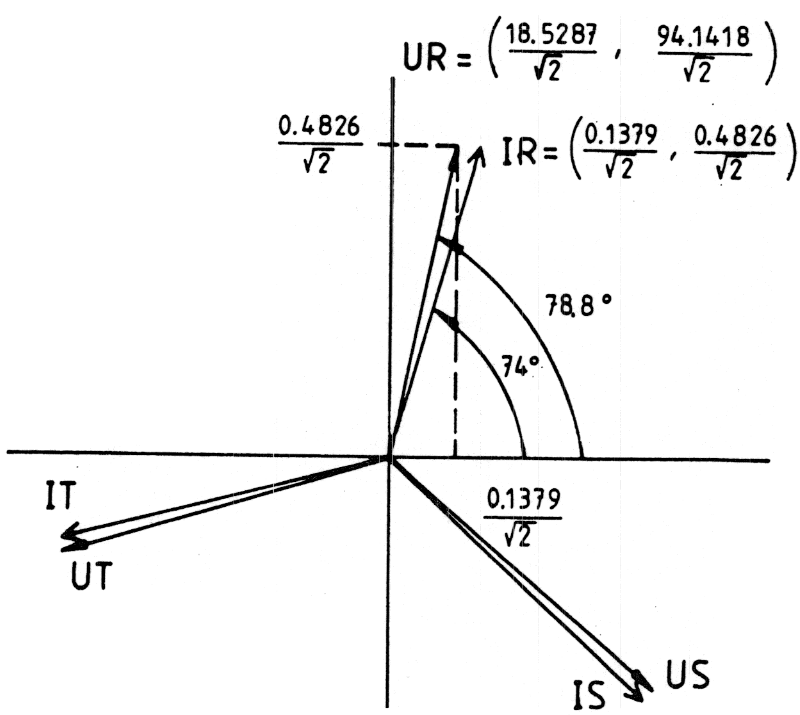
$238 \cdot 10^3\ \text{V (primary)}$

$I_{(average)} = 0.34\ \text{A (secondary)} = 0.34 \cdot \frac{2000}{2}\ \text{A (primary)} =$

$= 340\ \text{A primary}$

Conclusion: The ratio acceptable (accuracy must be considered and RANZA measured values are filtered rated fundamental frequency values).

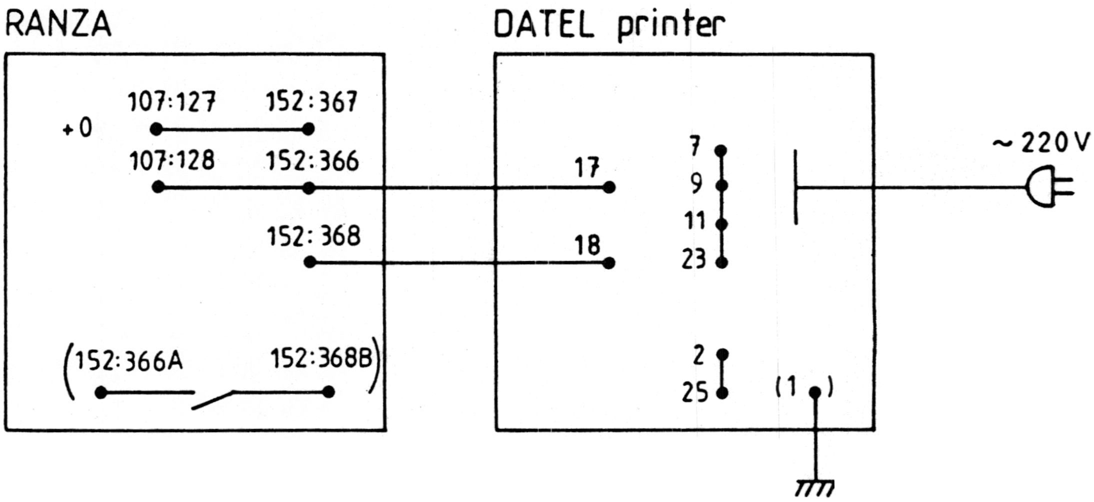
Checking the phase sequence and phase angles. Graphical checks



Conclusion: Phase sequence correct, phase angles approx. 120° between currents and between voltages. The voltage leading the current approx. equal to the power factor i.e. correct.

Remark: Wrong direction or polarity of one or many CTs will give a 180° phase shift.

CONNECTION OF DATEL-INTERSIL's PRINTER TYPE APP 20E, FOR 220 V AC



The figure above shows:

Remove connection (if present)
152:366 A - 152:368

Connect following terminals on RANZA
107:127 - 152:367
107:128 - 152:366 B

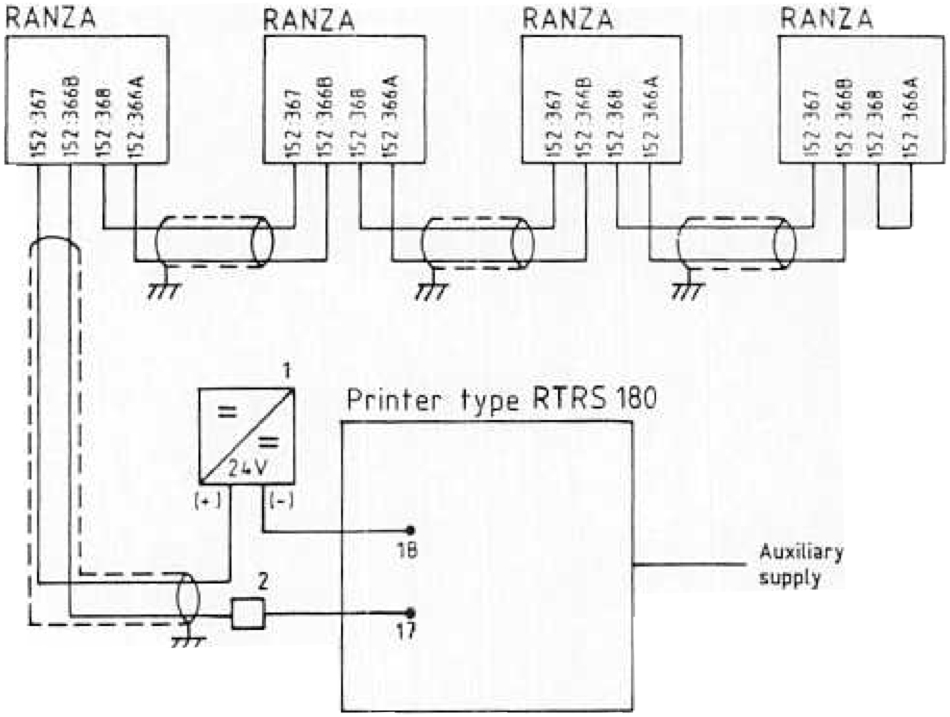
Connect following terminals on DATEL printer
7-9-11-23
2-25

Connect following terminals between RANZA and the DATEL printer

RANZA		DATEL printer
152:366 A	-	17
152:368	-	18

After temporary connection of printer, make sure that the connections are restored as intitial. E.g. restore connection 152:366 A - 152:368 if it was intially present.

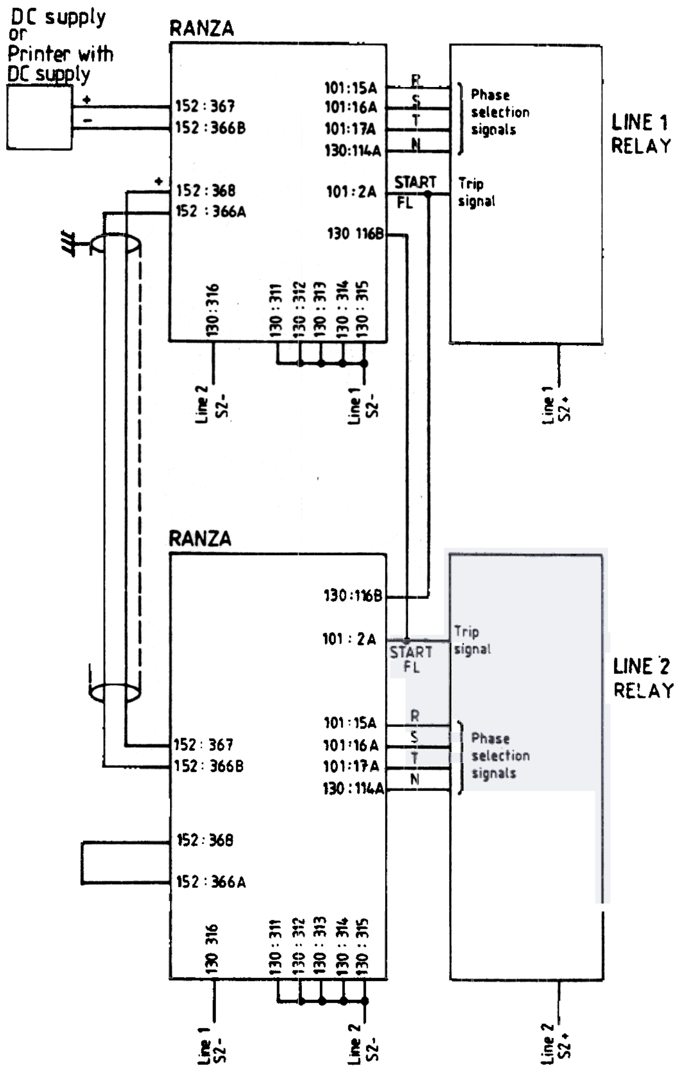
Simplified diagram for connection of many RANZA (max 4) to one printer



Note 1) Device for 24 V dc supply to current series loop for printer

Note 2) Disturbance filter and short circuit current limiting device

Connection diagram for start signals and series current loop to RANZA designed for use on parallel lines



As indicated by the figure above, the new RANZA can operate together with an old RANZA (with the exception of version RK 881 021, which has no circuits for zero sequence compensation) on a parallel line, and with both the old (DATEL INTERSIL) and the new (DED RTRS 180) printers.

Some RANZA versions require certain modifications (exchange of input and measurement units) before they can be connected to the DED RTRS 180 printer.

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