

A NEW DISTANCE PROTECTION SYSTEM

FOR SINGLE POLE RELAYING

by

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Introduction

Distance relays have been generally accepted as primary line protection in the H.V. and E.H.V. networks. The main advantage of distance protection compared with other methods of line protection is that it processes current and voltages measured at the relay location and does not rely on information from the opposite end of the line to detect faults. Apart from protecting the line it is connected to, it also provides back-up protection for the adjacent lines, bus and transformers to a limited extent. Communication between the distance relays at the ends of a line in a pilot scheme is more reliable because only on-off or frequency shift digital signals are exchanged. Any failure of communication does not prevent the relay from independently protecting the line. However, over the years the distance relays have been required to fulfill increasingly higher standards of performance to keep pace with growing power systems. Higher fault currents and fewer lines present increasing problems to system stability. The increased complexities of operation of the interconnected networks as well as the restrictions to the addition of new generating and transmission capacities have also contributed to the need for designing more sophisticated line protection equipment. Since a majority of faults on transmission lines involve only one phase and are transient in nature, single pole relaying with automatic reclosure is becoming more common. This method also allows the transmission of larger blocks of power using the existing transmission facilities without large additional investment. In cases where 3 pole tripping is used, a distance relay capable of phase selection can identify faulted phases and control selective reclosing, e.g. not allow reclosing for 3 phase faults or only allow reclosing for single phase faults. Taking into account the availability and reliability requirements of a modern power system, a modern line protection system has to fulfill the following additional criteria:

- reliability and speed in conformity with the system stability requirements
- security against false operation
- suitable for use in single pole relaying schemes
- flexibility in application to suit the diverse system needs
- easy testing and reduced downtimes

The introduction of static components in relay systems has enabled further important advances to be made. The new BBC line protection package Modures<sup>R</sup> Type LZ 96 combines decades of experience in the field of line protection with the new possibilities offered by modern technology (1). The variety of possible combinations and thereby resulting flexibility to adapt the relay to suit the diverse system needs are the main characteristics of Modures<sup>R</sup> design standards (2).

### Main Features of the LZ 96

The LZ 96 is a fully solid state one cycle line protection package suitable for application in solidly grounded high voltage and extra high voltage systems (cables and overhead transmission lines). Its main features are:

- separate systems based on different principles for fault detection and phase selection, and directional distance measurement
- memory action (minimum 150 msec) to assure selectivity during close-in three phase faults
- wide operating and setting ranges
- built-in low-set overcurrent supervision and line pick-up protection (including stub-bus protection)
- all digital settings and quartz reference oscillators for back-up timing functions and integration
- a comprehensive continuous supervision system to enhance reliability
- built-in testing and diagnostic facilities
- extremely versatile in application for user specific protection schemes through the addition of standardized modules:
  - supplementary fault detection (starter) and a polygonal characteristic to increase the reach in the resistive direction in case of ground faults (operates without load encroachment)
  - weak in-feed detectors to enhance sensitivity for two and three terminal lines
  - single and/or 3-phase automatic single or multi-shot reclosing units
  - programmable logic unit for pilot channel interface for adapting to different schemes such as directional comparison, permissive overreach and other types of pilot schemes
  - additional independent power swing detector for blocking during out of step conditions

## Principle of Operation

Figure 1 shows a simplified block diagram that illustrates the principle of operation:

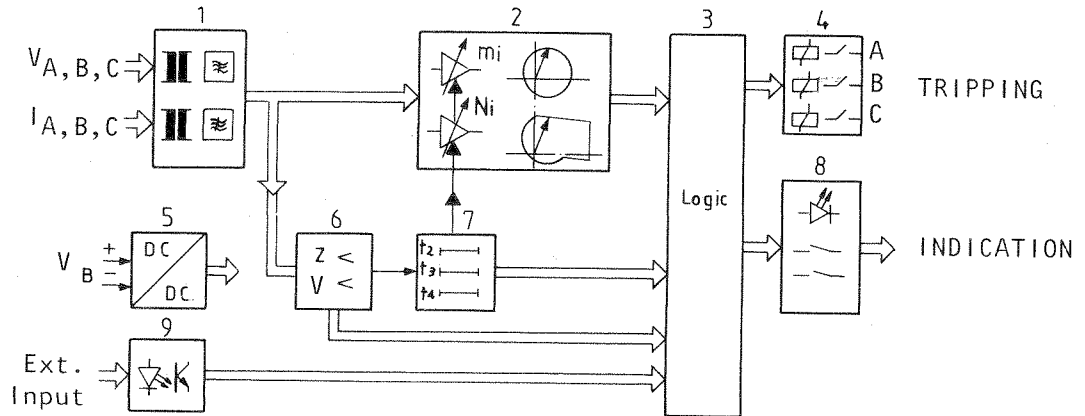
The current and voltages of the input quantities are transformed in a conditioning circuit 1 to the standardized levels of electronic circuits. This stage also provides the necessary DC isolation and contains the filtering and suppression arrangements. The interposing CTs in the current input circuits are transactors which suppress most of the DC component in the fault current. After conditioning, the measured quantities are processed simultaneously by the fault detector (starting) units 6 and the directional distance measuring units 2. The impedance fault detectors and in some cases the additional undervoltage units provide the identification of the faulted phase required in the case of single pole relaying and provide this information to the logic 3. There are 4 impedance type fault detector units and 4 independent measuring units. The measuring units determine positively the direction and the distance regardless of the type of fault with the help of replica impedances. The back-up timer started by the impedance fault detectors controls the input quantity amplifiers such that the reach of the measurement can be extended in accordance with the impedance settings set for different zones. Additionally, independent single zone measuring systems can be provided when required.

An adequate number of optocoupler inputs is available for the undelayed DC isolated conversion of external signals such as blocking, pilot channel interface, control switch contacts and others. All these signals plus those from the measurement, fault detector and timer are processed in the logic 3. For added security, tripping is only permitted when both the fault detector as well as the measuring unit pick up. Included in the relay is a comprehensive supervision system capable of detecting any possible defects in the relay by comparison of internal relay signals and of alarming these appropriately. The tripping unit 4 contains the heavy duty trip output contacts.

All important relay functions have "LED" signals on the front of the signaling unit 8, which also provides contacts for remote signaling. This includes a large number of high speed contacts as required, for input to fault recorders, event recorders and alarm purposes. The "LED" signals have memory storage for retaining the signal information in the event of auxiliary supply failure. They can be reset either by a push button on the front of the relay or by an external signal.

The power supply unit 5 supplies the relay with the auxiliary DC required. This is a DC/DC converter providing isolation from the station battery system and regulated output voltages. The DC/DC converters of this series have an extended input tolerance and ripple range. Where a redundant power supply is required, DC/DC converters can be connected in parallel as they contain their own decoupling and supervision arrangements.

Fig. 1 LZ 96 DISTANCE RELAY  
SIMPLIFIED BLOCK DIAGRAM



- |   |                                    |
|---|------------------------------------|
| 1. Input/Filtering                      | 6. Starting units (fault detector) |
| 2. Measurement                          | 7. Back-up timer                   |
| 3. Digital Signal Processing            | 8. Target and indication unit      |
| 4. Tripping Unit                        | 9. Input interface (optocouplers)  |
| 5. DC/DC Converter for auxiliary supply |                                    |

### Impedance Measurement

Figure 2a illustrates the operating principle of the impedance measuring units. The current  $I_p$  flows through the adjustable replica impedance  $Z_M$  and generates replica impedance voltage  $V_M$ . This voltage is subtracted from the phase voltage  $V_p$  which is first scaled to suit the settings. The phase angle between the difference voltage  $V_D$  and a reference voltage  $V_{ref}$  is determined by the phase comparator P. All the impedance measuring units take into account the value and argument of the zero sequence impedances for determining the forward reach thus making it possible to apply the distance relay even for cable networks.

### Criteria for the Choice of Measurement System

The measuring units of a distance relay must satisfy the following conditions in a wide variety of network configurations and for different kinds of short circuits:

- Every short circuit that occurs in the protected zone must be detected.
- When a fault occurs outside the protected zone, the units must not pick up.
- Only the measuring units of the phase or phases affected by the fault must pick up. Correct phase indication is particularly important, especially during a single phase autoreclosing cycle.

The relays must not only operate correctly in simple network configurations (e.g. with unilateral infeed), but also under difficult circumstances, such as:

- Short circuit between parallel lines
- Directional decision in the event of a close in fault near the relay location (fault in the forward or backward direction)
- Short circuit with arc resistance
- Single pole dead time of an autoreclosing cycle

It is advantageous to employ separate measuring units for phase selection (starting elements) and for determining the distance to the fault and the direction of the fault (measuring systems). Thus, the systems can be optimized with a specific aim in mind and, for instance, possess different characteristics in the impedance plane (non-directional characteristics for starting and an offset mho directional characteristic for the measuring system).

The starting elements perform the task of phase selection and, with the aid of a logic system, release the corresponding outputs of the measuring system. A measuring unit (starting or measuring system) may only pick up when the current reaches a definite level (e.g. 0.75A).

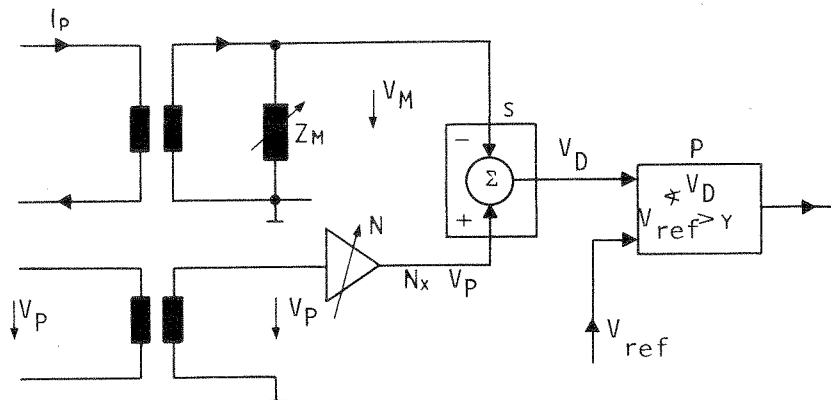
Measuring Principles

Replica Impedance

The basis of all relay characteristics and measurements is a replica impedance  $Z_M$ , which simulates the transmission line to be protected (see Figure 2a).

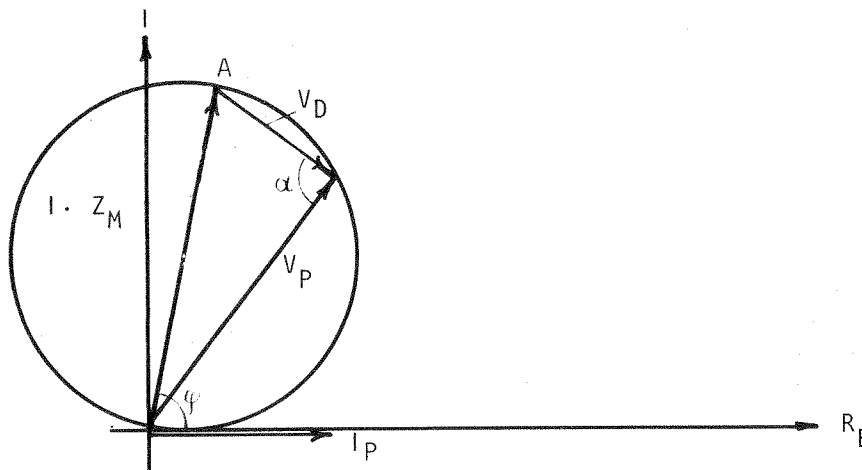
The incoming current  $I_p$ , after having been isolated and reduced to electronic levels, flows through the replica impedance  $Z_M$ . The voltage drop  $I \cdot Z_M$  is combined with the fault voltage  $V_p$  to form the different characteristics in the RX-plane.

Fig. 2a FORMATION OF IMPEDANCE MEASUREMENT



In the following it is explained how the RX-characteristic for a measuring element (phase-to-ground and three-phase faults) is derived.

Fig. 2b VOLTAGE AND CURRENT DIAGRAM



The voltage drop across  $Z_M$  (replica impedance) is subtracted from the fault voltage  $V_P$  and it results in the difference voltage  $V_D$  (see Figure 2b).

$$V_D = V_P - I \cdot Z_M$$

The absolute value of the phase angle  $\alpha$  between  $V_D$  and a reference voltage  $V_{ref}$  (which here was chosen as  $V_P$ ) is used to form the tripping characteristic in the RX-plane. For example, by detecting if the absolute value of  $\alpha$  is larger or smaller than  $90^\circ$ , a circle will result as tripping characteristic. This is shown in Figure 2b.

In Figure 2b the phasors are representing voltages; a division of all phasors through the Current  $I$  does not change the figure, but now the phasors represent impedances in the RX-plane. The position of the voltage phasor  $V_P$  in Figure 2b is, therefore, showing an impedance lying inside of the tripping characteristic because the absolute value of  $\alpha$  is greater than  $90^\circ$ .

By changing the angle  $\alpha$  of the replica impedance  $Z_M$ , it is possible to match the relay with the angle of the protected transmission line.

The setting of the reach of the tripping characteristic (i.e. the Point A in Figure 2b) is in this case done by varying the amplification  $N$  of the voltage  $V_P$ .

#### Filter

The signals, which are generated in Block 1 (Figure 1), are filtered and converted into square-wave signals before the angle evaluation is done in Block 2.

The applied type of filter is optimized to minimize transient oscillations and the attenuation of higher order harmonics. This has been made possible by using active filters.

To obtain best results in speed and accuracy, it is possible to match the filter response to certain network parameters. The criterion used is the possible ratios of line to source impedance.

#### Determination of mho-Characteristic

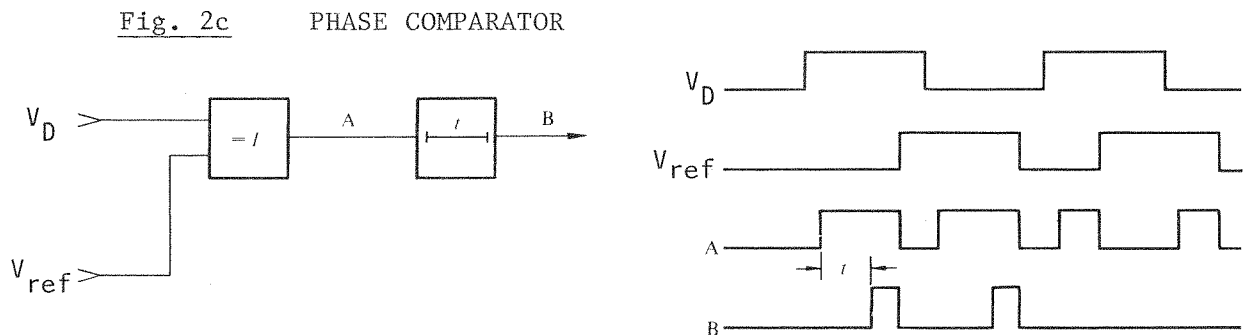
All characteristics are formed in Block 6 (Figure 1) by the starting and in Block 2 by the measuring systems. The evaluation is done in the following way:

The phase angle relationship of the signals  $V_D$  and  $V_{ref}$  after filtering and shaping is checked in a phase comparator, which delivers an output signal if the angle  $|\alpha|$  is larger than  $90^\circ$ .

The determination of the absolute value of the phase angle  $\alpha$  is based on a time measurement and is made with a digital technique.

The signal A is derived from the signals  $V_D$  and  $V_{ref}$  by means of the exclusive "or" function. The width of the pulses appearing at A, which is proportional to the absolute value of the phase angle  $\alpha$ , is measured with an integrator element. This is shown in Figure 2c.

The pulses resulting from the formation of an anticoincidence signal by an exclusive or gate have a width proportional to the phase angle  $\alpha$ . The pulse width is measured by a quartz integrator as shown in Figure 2c.



The output B of the phase comparator, therefore, delivers a signal only if the width of the signal A is larger than the time delay  $t$ . This method of measurement provides information about the value of  $\alpha$  every half-cycle.

The output of the phase comparator is connected to the logic (Block 3, Figure 1) where it is combined with other signals.

The digital signals are finally converted (in Block 4, Figure 1) into the desired commands for tripping and in Block 8, Figure 1 for signaling and visual indication.

Summary:

As an example, the method of signal processing of the distance relay LZ 96 was shown. This method is common for all starting and measuring systems and all optional modules. The principle is as follows: The measurements are formed into digital signals and their phase angle relationship is evaluated with digital techniques.

Starting Units (Fault Detectors)

The basic distance relay is equipped with three independent starting units connected to the phase quantities for detecting phase to ground and 3-phase faults (Block 6, Figure 1). Phase to phase faults are detected by an additional fourth unit. The three starting units have an offset mho tripping characteristic on the R-X plane. The setting ratio between the reverse and the forward reach can be varied in 4 steps from 1 to 0.1 thus making it possible to obtain either an impedance circle or a mho characteristic with varying degrees of offset. This characteristic is also independent of source impedance conditions, and the sensitivity is limited only by the setting on the low set overcurrent supervision unit (generally 0.75 Amps). In addition, the circular characteristic can be modified in the relay to a lens characteristic by changing the angle of integration of the phase angle comparator with a switch from 90° to 130°. Thus the relay can be adapted very easily depending upon the application to protect long or short transmission lines with a large power transfer without any additional components. The different possible characteristics are shown in Figure 3a. In the case of very short lines where an increased resistive reach is required to detect large arc resistances (low fault currents), the starting characteristic can be modified with the help of an additional module to give the maximum fault resistance coverage without load encroachment (Figure 4). As can be seen from Figure 4, the large starting area obtained fits very snugly around the load region.

The fourth fault detector unit detects the phase to phase faults by a separate measurement supervising the phase sequence of the difference voltages  $V_D$  of the 3 phases (3).

Since the fault detectors (starting units) also determine the faulted phase and prepare the signals for single pole tripping and subsequent reclosure of the opened phase, special attention has been given to the choice of the polarizing quantities used in the starting units. For example, in setting the reverse reach of the characteristic the influence of the zero-sequence current has been eliminated. Because of this particular choice of the reference quantity, the starting units are capable of correctly identifying the faulted phase(s) even under extreme operating conditions.

Starting Element Operating Principle for Phase-to-ground and Three-phase Faults

For each phase two measuring voltages are formed,

$$V_D = V_P - Z_A (I + k_o \cdot I_o) \qquad \text{Difference voltage}$$

$$V_\Sigma = V_P - Z_B \cdot I \qquad \text{Summation voltage}$$

and the phase angle relationship is analyzed.

The characteristics are defined through the impedances  $Z_A$  (reach in forward direction) and  $Z_B$  (reach in backward direction) and the angle  $\varphi$  of the replica impedance.

Fig. 3a

POSSIBLE STARTING ELEMENT (FAULT DETECTOR) CHARACTERISTICS FOR PHASE-TO-GROUND FAULTS

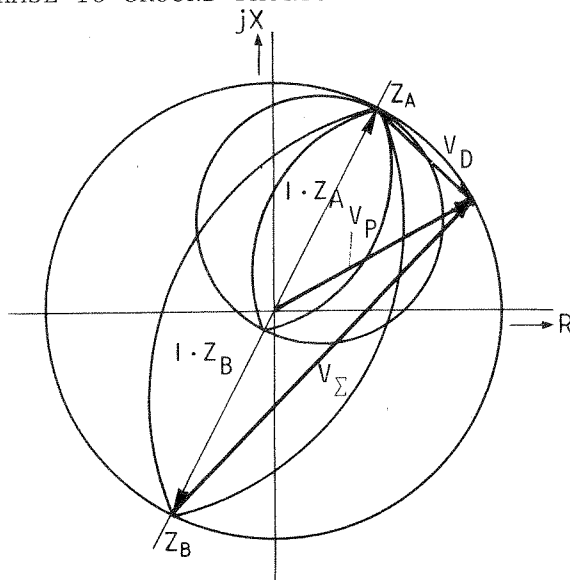
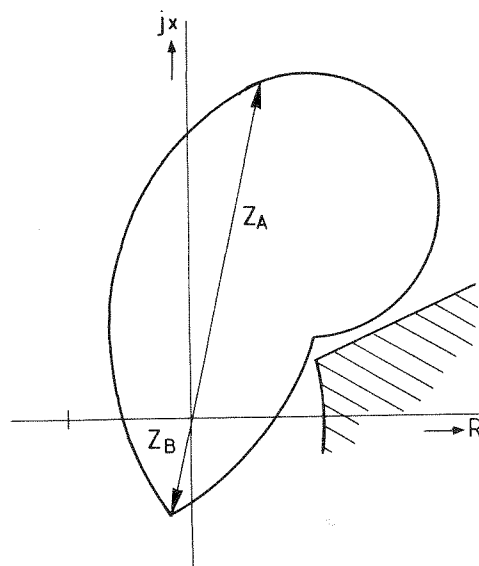


Fig. 4



Starting Element Operating Principle for Phase-to-phase Faults

The characteristic (circle) is derived by formation of the voltages:

$$V_{DAB} = V_{DA} - V_{DB}$$

$$V_{DBC} = V_{DB} - V_{DC}$$

$$V_{DCA} = V_{DC} - V_{DA}$$

and check of the phase relationships in a phase comparator. Figure 3b shows the characteristic for phase-to-phase faults, which is defined through the impedance  $Z_A$  and the angle  $\varphi$  of the replica impedance. The reach in the backward direction is given by negative sequence component  $Z_{S2}$  of the source impedance.

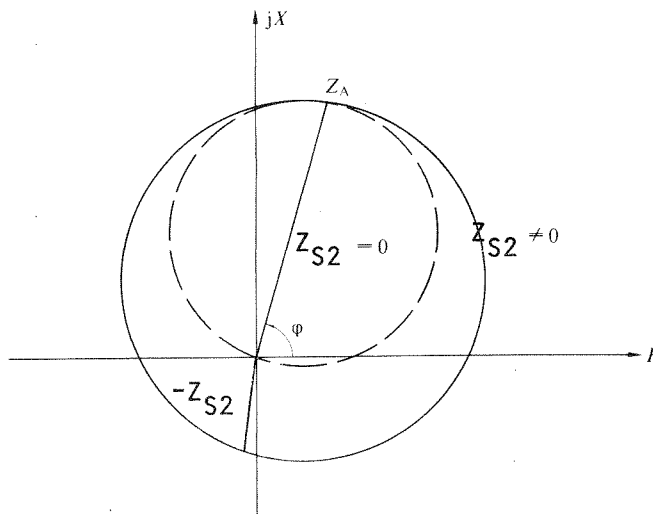


Figure 3b: Starting Characteristic for Phase-to-phase Faults

Directional Distance Measurement

Four independent impedance measuring systems are used for directional distance measurement of all faults. For three phase and phase-to-ground faults, three elements, one in each phase converted to phase quantities, with zero sequence compensation are used. A fourth element, converted to line quantities, measures all phase-to-phase faults.

For each of the phase elements, two voltages are used for measurement:

$$V_D = V - Z_M (I + K_o \cdot I_o) \quad \text{(Difference Voltage)}$$

$$V_{ref}: \text{ (I), (II) OR (III) } \quad \text{(Reference Voltage)}$$

The measurement is accomplished by means of the phase angle comparator as in the starting elements. The reference (polarizing) voltage can be selected from one of three possibilities depending on the application. The following example is given for the polarizing voltage possibilities in case of an A phase fault:

$$\text{(I) } V_{ref} = V_A \quad \text{(Faulted Phase Voltage)}$$

$$\text{(II) } V_{ref} = - (V_B + V_C) \angle -12^\circ \quad \text{(Combination of Healthy Phase Voltages)}$$

$$\text{(III) } V_{ref} = - \left[ (V_B \angle -30^\circ + V_C \angle +30^\circ) + pV_A \right] \angle -12^\circ$$

WHERE:

$V_A, V_B, V_C$ : Phase Voltages

$pV_A$  : Pre-fault phase voltage in memory

The choice of (II) or (III) as reference voltage results in cross polarized (directional) offset mho tripping characteristics. They assure full directional sensitivity for all types of asymmetrical faults virtually uninfluenced by transient voltage distortion as can be produced for example by capacitive voltage transformers. Even for close-in faults at the relay location the reference voltage does not become zero thus guaranteeing an unlimited directional sensitivity for all asymmetrical faults. The directional sensitivity in case of 3-phase faults is assured by the pre-fault voltage present in the memory circuit which is designed to last for approximately 150 msec. Because of the choice of the polarizing voltages as a combination of phase voltages not affected by the fault, the tripping characteristic of the measuring unit automatically adjusts itself to suit the source impedance conditions of the system. At times of weak generation (large source impedance), the characteristic has an extensive reach in the resistive direction while at times of heavy load and strong generation the characteristic is smaller and always has an adequate margin

between itself and the load region (4). Accurate distance measurement is assured through residual compensation which takes into account the differences in the value and phase angle between the positive and zero sequence components of line impedance. The fourth measuring element operates on the same principle of supervising the phase sequence of the three line difference voltages and has similar properties to the other measuring systems since for a phase-to-phase fault one of the difference voltages is equivalent to a healthy reference voltage. Figures 5 and 6 show the tripping characteristics of the measuring units on the R-X plane for a different type of faults in the forward and reverse directions.

#### High Resistance Ground Faults

When applied to very short lines, the tripping area of the measurement units can be extended by a polygonal characteristic superposed on the standard characteristic. This polygonal characteristic is produced by evaluating the phase relationships among:

$$V_{MO} : I_0 \cdot Z_M$$

$$V_M : Z_M (I_{ph} + k_0 \cdot I_0)$$

$$V_{DO} = V - V_{MO}$$

$$V_D = V - V_M$$

WHERE:

$V_{MO}$  = voltage drop of the zero sequence current  $I_0$  across the replica impedance  $Z_M$

$Z_M$  = replica impedance

$I_{ph}$  = phase current

$V$  = phase voltage

$k$  = residual compensation factor =  $\frac{1}{3} \cdot \frac{Z_{0L} - Z_{1L}}{Z_{1L}}$

Since  $V_{MO}$  appears only during ground faults, this additional polygonal characteristic exists only for ground faults. Figure 7 shows the total tripping characteristic obtained from using this optional unit.

#### Choice of Polarizing Voltage

The polarizing quantities have to be chosen depending on the application such as cable networks, lines with series compensation, long or short lines, possibility of interline short circuits in case of double lines on the same tower etc. (5). For example, whereas for EHV overhead transmission lines the choice of healthy phase voltages as reference quantity is indicated. For cable networks or for resistance grounded networks the faulted phase voltage as polarizing quantity may be appropriate.

Because of such possibilities in choosing the tripping characteristic and the adaptability of the filtering modes, the distance relay LZ 96 is extremely flexible and its versatility makes it ideal for application to the transmission line protection of H.V. and E.H.V. electrical networks.

#### Trip Circuits and Programmable Logic

A tripping command is only issued when all the following three conditions are fulfilled:

- pick-up of one or more starting systems
- pick-up of one or more measuring systems
- pick-up of low set overcurrent check unit

Since all these criteria are independent and operate in parallel, high security is achieved without loss in operating times. Figure 8 shows the minimum operating time of the relay (including the trip output relays capable of being connected directly to the circuit breaker trip coils without an additional auxiliary contactor) as a function of the set impedance.

#### Application with Pilot Schemes

A specially designed module with programmable logic consisting of "AND", as well as "OR" logic gates and timers, enables a number of line protection functions to be achieved virtually without limits, as for example:

- direct transfer trip
- permissive underreach transfer trip
- permissive overreach transfer trip
- zone acceleration
- directional comparison with blocking or unblocking system
- transient blocking when applied to parallel line protection

The logic functions are normally set on the diode matrix programed at the factory in accordance with the user's specification. Field modification is also possible.

### Self Monitoring and Diagnostics

To enhance the reliability and security of the protection system, the distance relay LZ 96 is equipped with a comprehensive internal supervision system, the purpose of which is to detect and signal failures that occur in the different functional modules of the system. Internal voltages are monitored to check that they remain within prescribed limits and the signals are compared with respect to symmetry and logical plausibility. Inadmissible deviations are signaled and block the operation of the relay. Also, the secondary leads from the voltage transformers are continuously supervised against fuse failure. A special diagnostic unit that forms part of this supervision system helps to identify the defective module and its replacement thus enabling to reduce the downtime to a minimum.

### Testing

Push buttons on the front of the relay enable it to be functionally tested. The test buttons are interlocked with the low current check and the under-voltage units, so that testing is only possible when the line is de-energized. A switch is provided for reversing the direction of measurement to facilitate simple testing of the relay connections.

Quantitative testing of the relay can be performed with a test set which can be connected to a special test socket provided in the relay by means of a test plug. All the necessary interruptions of trip command and short circuiting of CT circuits etc. take place automatically and in the correct sequence when the test plug is inserted. With this procedure it is possible not only to test the basic distance zones but also to check the functioning of the complete line protection including functions such as the communication channel, autoreclosure, breaker failure protection and others.

### Optional Units

The distance protection system can be equipped with the following optional units as may be necessary to enhance its capability:

- automatic reclosing devices for single shot single/three pole reclosure and/or multishot three phase reclosure with or without synchrocheck unit
- special signal coupling mode such as block before trip schemes using pilot wires which employ digital signals
- additional measuring units to provide a channel independent Zone 1 operation
- additional starting/measuring units to provide an increased resistive coverage when applied to very short lines
- external input/output interface modules for receiving/transmitting signals to external equipment such as carrier/microwave links, fault recorders, fault locators etc.

- outputs for controlling additional circuit breakers
- independent power swing detection module for blocking or tripping functions (6)
- sensitive directional high resistance ground fault protection module with phase identification (up to 300 ... 500 ohms depending upon network conditions)

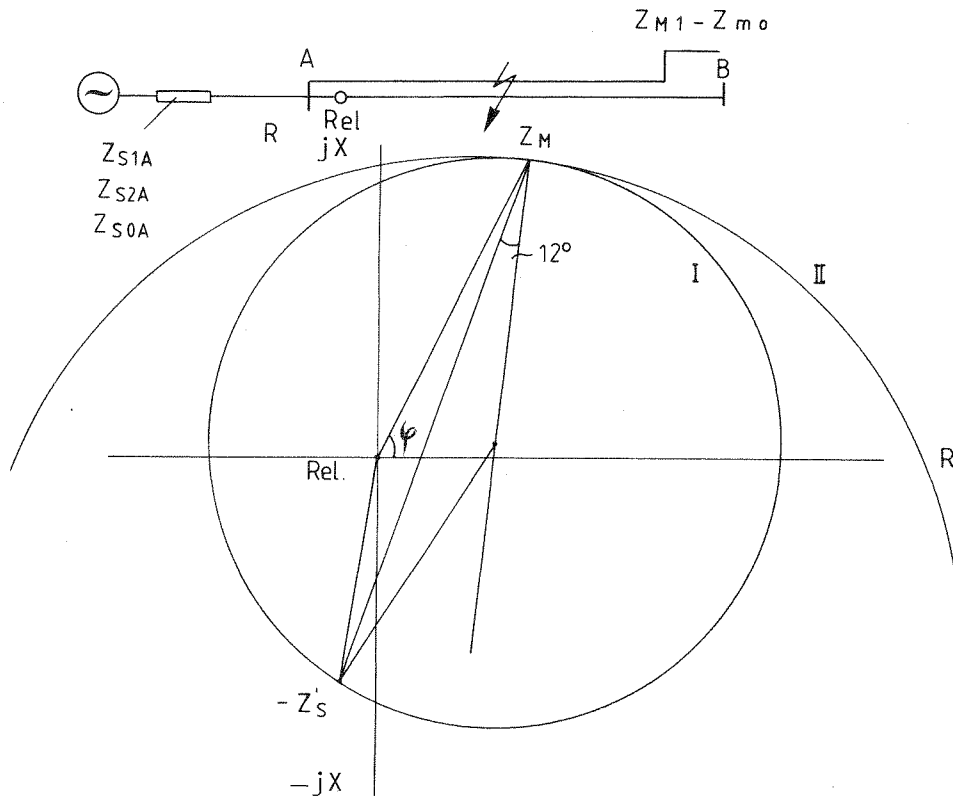
In order to facilitate the choice of a complete line protection, standard packages incorporating different optional units are available. These are prewired and, depending upon need, selected additional modules can be plugged in.

#### Mechanical Design

The basic distance relay LZ 96 including the auxiliary DC power supply unit can be accommodated in less than two standard 19" equipment racks. Additional units such as autoreclose, power swing units, synchrocheck relays, etc. can be mounted on additional racks which can be assembled together with the basic relay to form a single block. This can either be mounted in separate cases (up to 4 racks) or mounted on a hinged frame on a panel. Figure 9 shows the front view of distance relay Type LZ 96 mounted in a case.

#### Conclusion

The line protection scheme Modures<sup>R</sup> Type LZ 96 has been designed on the basis of experience gained over the past 30 years of experience with distance relays. In developing the hardware the advantages of latest technology have been exploited and the modular design with separate units for each function permit the protection engineer to optimally choose and combine the modules to suit the particular needs of his application.



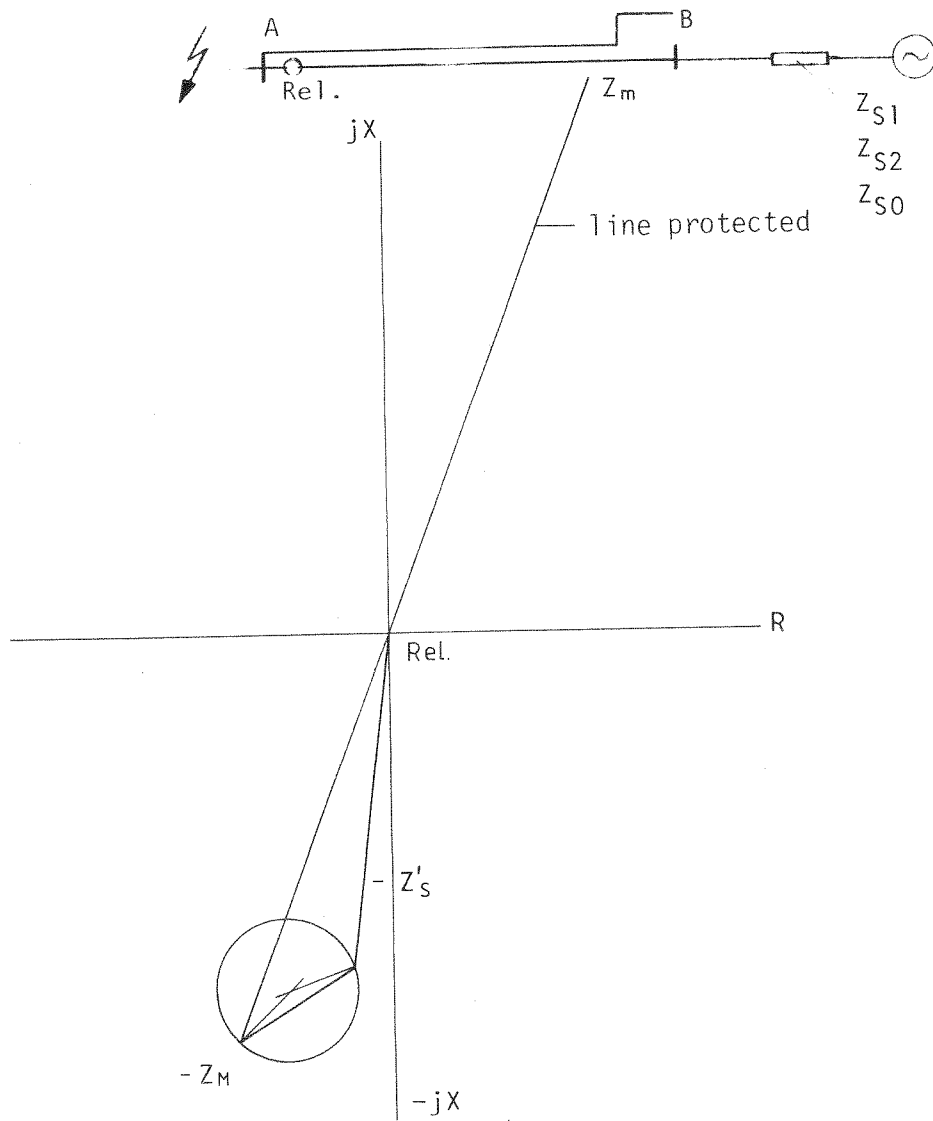
Tripping characteristic for faults in the relaying direction (Relay A)

- $Z_{S1A}$  : positive sequence source impedance behind Rel. A.
- $Z_{S2A}$  : negative sequence source impedance behind Rel. A.
- $Z_{S0A}$  : zero sequence source impedance behind Rel. A.
- $Z_{M1}$  : positive/negative sequence step impedance of line protected
- $Z_{M0}$  : zero sequence step impedance of line protected
- $k_0$  :  $\frac{1}{3} \left[ \frac{Z_1}{Z_0} - 1 \right]$  of the line protected
- I : characteristic for strong source
- II : characteristic for weak source

$V_{ref}$	Single phase-ground faults		ph - ph faults	Three ph. faults	
	$Z'_S$ at $t = 0$	$Z'_S$ at $t = \infty$	$Z'_S^*$	$Z'_S$ at $t = 0$	$Z'_S$ at $t = \infty$
(I)	0	0	$-Z_{S2}$	0	0
(II)	$\frac{2 Z_{S0} + Z_{S1} + Z_{S2}}{3(1 + k_0)}$	same as at $t = 0$	$-Z_{S2}$	0	0
(III)	$\frac{Z_{S0}(2+p) + Z_{S2}(1+p) + Z_{S1} \cdot p}{3(1+k_0)(1+p)}$	$\frac{2 Z_{S0} + Z_{S2}}{3(1+k_0)(1+p)}$		$\frac{p}{1+p} \cdot Z_{S1}$	0

\*)  $12^0$  shift exists only for the 3 measuring elements connected to phase quantities.

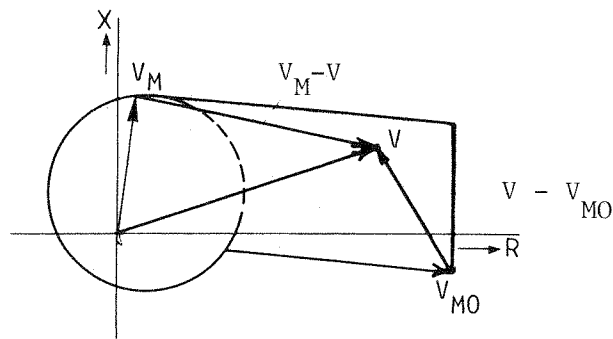
Fig. 6 Tripping characteristic for faults in the reverse direction (Relay A)



Symbols have same significance as in Fig. 5.

Fig. 7

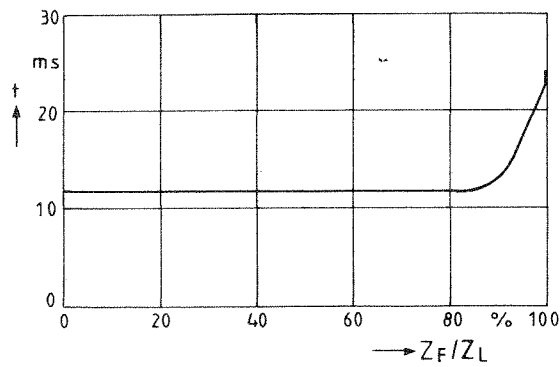
OPTIONAL POLYGON CHARACTERISTICS FOR HIGH RESISTANCE GROUND FAULTS (NOT RESPONSIVE TO LINE QUANTITIES)



Tripping criteria  $V_M - V$  and  $V - V_{MO}$  must lie within  $\angle V_M - V_{MO}$

Fig. 8

MINIMUM OPERATING TIME OF THE LZ 96 RELAY



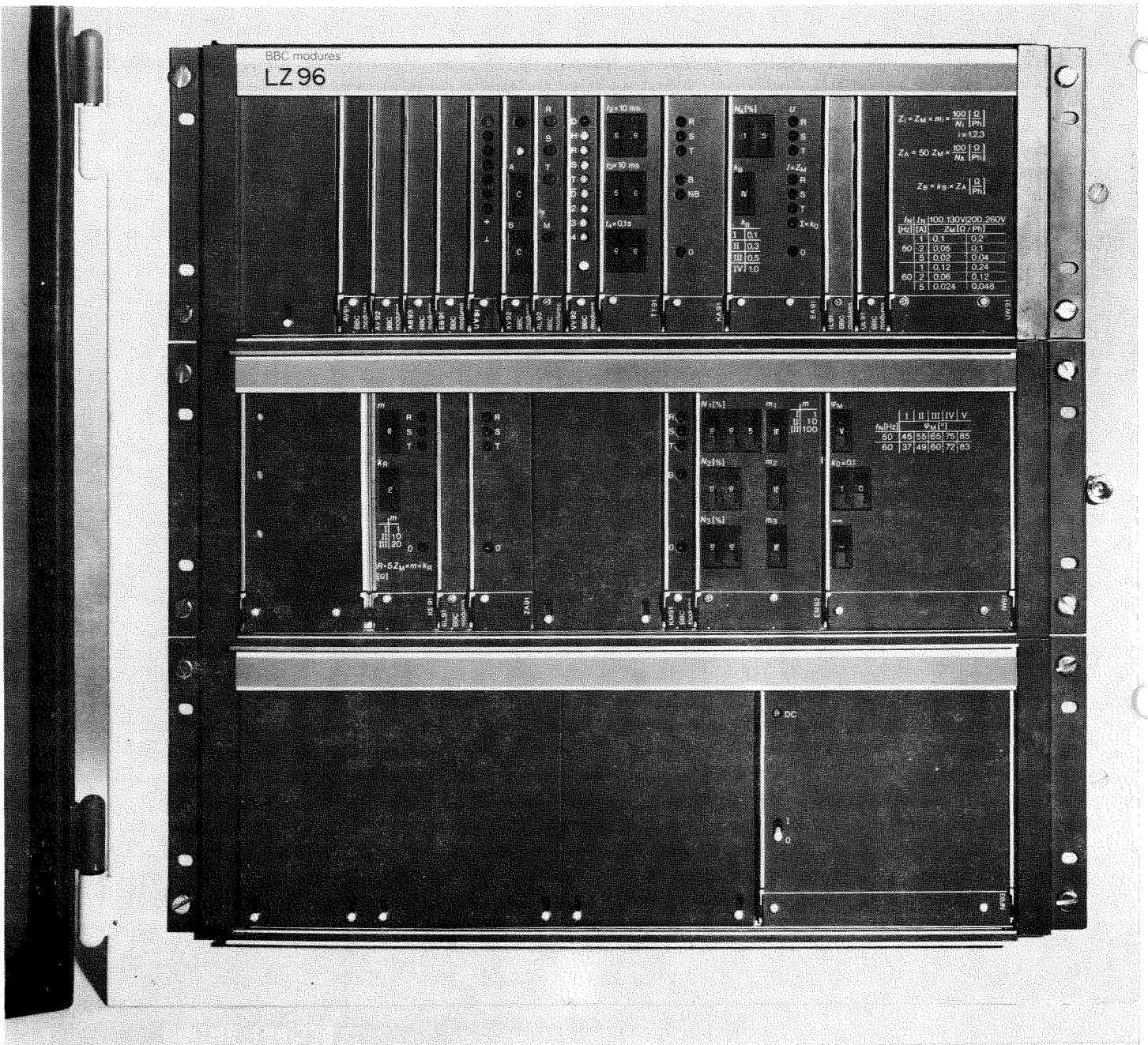


Fig. 9

FRONT VIEW OF DISTANCE RELAY TYPE LZ 96

MOUNTED IN A CASE

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